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A Comparison of the 1980s and 1990s

Abstract

The U.S. commercial banking industry is undergoing a tremendous transformation. The number of banks has declined from more than 14,000 in 1980 to about 9000 in 1996. Consolidation is expected to continue in the wake of the Riegle-Neal Interstate Banking and Branching Efficiency Act, which allows nationally chartered banks to branch across state lines, effective June 1, 1997. Some predict that when the transformation of the industry is complete, fewer than 4000 banks will remain. This would represent a decline of more than 10,000 institutions over two decades. This relaxation of entry barriers, and the attendant increase in competitive pressures, is expected to drive institutions toward becoming more efficient providers of financial services, with higher productivity.

In addition to the Riegle-Neal Act, the industry has seen many other changes over the past twenty years that could be expected to affect its efficiency, including the expansion of bank powers, changes in capital requirements, increased volatility of interest rates, the removal of deposit rate ceilings, the increased importance of off-balance-sheet banking, and increased competition from nonbank rivals. This paper investigates how the efficiency and productivity of the U.S. banking industry has changed over the latter half of the 1980s and first half of the 1990s using a comprehensive and consistent data set of commercial banks in the U.S. We find some decrease in cost efficiency between the 1980s and 1990s. Considering all banks, there is little change in profit efficiency between the 1980s and 1990s, but large banks did show a sizeable decline. The total predicted cost of production increased over the 1980s and over the 1990s. This reflected a decline in productivity. Costs declined as a result of changes in business conditions over the two periods. Total predicted profits increased in the 1980s and 1990s, with the entire change reflecting increased productivity. Changing business conditions led to small declines in profits.

Efficiency and Productivity Trends in the U.S. Commercial Banking Industry: A Comparison of the 1980s and 1990s

1. Introduction

The U.S. commercial banking industry is undergoing a tremendous transformation. The number of banks has declined from more than 14,000 in 1980 to about 9000 in 1996. The average of 190 bank mergers per year in the 1960-82 period increased to an average of 423 per year in 1980-94. Over 1980-94 there were 6347 mergers, representing 43 percent of all U.S. banks in 1980 (Rhoades, 1996). Consolidation is expected to continue in the wake of the Riegle-Neal Interstate Banking and Branching Efficiency Act, which allows nationally chartered banks to branch across state lines, effective June 1, 1997. Some predict that when the transformation of the industry is complete, fewer than 4000 banks will remain. This would represent a decline of more than 10,000 institutions over two decades. This relaxation of entry barriers, and the attendant increase in competitive pressures, is expected to drive institutions toward becoming more efficient providers of financial services, with higher productivity.

In addition to the easing of geographical restrictions on banking and branching, the industry has seen many other changes over the past twenty years that could be expected to affect its efficiency and productivity, including the expansion of bank powers, changes in capital requirements, increased volatility of interest rates, the removal of ceilings on the deposit rates banks could pay, the increased importance of off-balance-sheet banking, increased competition from nonbank rivals, and the application of new computer and communication technologies in banking. This paper investigates how the efficiency and productivity of the U.S. banking industry—which constitutes almost 20 percent of the U.S. finance, insurance, and real estate service sector in the national income accounts—has changed over the latter half of the 1980s and first half of the 1990s, using a comprehensive and consistent data set of commercial banks in the U.S.

Various techniques, bank output and input definitions, and efficiency concepts have been used in the past to measure bank efficiency, and the results obtained in such studies have varied. Berger and

Humphrey (1997) provided a comprehensive review of the literature on financial institution efficiency, documenting 130 studies that used data from 21 countries. Since the studies have varied in so many dimensions, it has been difficult to access what have been the important factors leading to the differences. To get around this problem, Berger and Mester (1997) undertook a study of the sources of differences in efficiency across financial institutions using data on almost 6000 U.S. commercial banks that were in continuous existence over the six-year period 1990-95. By using a single data set, they were able to focus on three potential sources of efficiency differences: (1) differences in the efficiency concept used—cost, standard profit, and alternative profit efficiency; (2) differences in measurement methods used to estimate efficiency within the context of these concepts; and (3) potential correlates of efficiency—bank, market, and regulatory characteristics that are at least partially exogenous and may explain some of the efficiency differences that remain after controlling for efficiency concept and measurement method. Their findings suggest that each of the efficiency concepts adds some independent informational value. The efficiency results were remarkably robust (in terms of average efficiency or efficiency rankings) to the different measurement techniques (e.g., the distribution-free method vs. the stochastic frontier method), different functional forms, and various treatments of output quality used. What was found to be important was the treatment of equity capital: omitting it from consideration in the cost and profit functions yielded a strong scale bias making large banks appear to be more efficient than small banks.

Using what was learned from that paper, here we extend the analysis to compare changes in efficiency between the 1980s and 1990s and to explore the productivity of banks in the two periods. Our data set includes annual information for each year from 1984 through 1995 on all U.S. commercial banks; thus, we have over 145,000 observations (over 80,000 observations for the 1980s and over 65,000 for the 1990s) and can consider the efficiency and productivity results we obtain to be representative of the industry.

We measure cost, standard profit, and alternative profit efficiencies using the distribution-free method. We use each of the three efficiency concepts: cost efficiency takes a bank's input prices and output levels as given, and indicates which bank is able to produce a particular level of output at least cost. The benefit of such an approach is that no assumption needs to be made about the degree of market power in the banks' output markets. The drawback is that the concept cannot capture inefficiencies due to a bank's choosing the wrong levels of outputs, given output prices—so-called revenue inefficiencies. Efficiency measures based on the standard profit function can capture such inefficiencies, but at the cost of assuming that banks take their output prices as given (i.e., that they do not have market power in product markets) and that output prices are accurately measured. The alternative profit function relaxes some of the maintained assumptions of the standard profit function; thus, efficiency measures based on it are useful to compare to those derived from the standard profit function. A comparison of cost and profit efficiencies can reveal some information on the degree of mismeasurement of bank output quality. In particular, if output quality is not measured accurately, then a bank could appear to be a cost-efficient provider because it is producing low-quality output. Such a bank would not necessarily appear to be profit efficient, since the price it would obtain for low-quality output would presumably be lower.

Measures of productivity change in banks' costs and profits between 1984 and 1995 are derived from cost, standard profit, and alternative profit functions estimated using all of the banks, i.e., the average-practice functions. Productivity change in the industry, as reflected by the percentage change in costs or profits, entails two aspects: (1) changes in the costs or profits of the banks on the efficient frontier, i.e., the best-practice banks, and (2) changes in the average degree of efficiency, i.e., the dispersion of banks' costs or profits from the frontier. Productivity changes can be driven by technological change, e.g., improvements in information technologies that banks use in their roles as monitors, or changes in regulations that affect bank production, e.g., the deregulation of interest rates and relaxation of geographic entry barriers, or actions the best-practice banks took to lower their costs, perhaps being spurred by increased competition. These effects will be captured by shifts in the frontier, i.e., the cost or profit function of the best-practice banks. Changes in the degree of inefficiency over time, i.e., in the dispersion, will be included in shifts in the average-practice cost and profit functions estimated using all the banks. By holding constant the exogenous variables but allowing the parameters of the cost or profit frontiers to vary over time, we are able to calculate a pure technological change component of productivity change. Holding the parameters of the frontiers constant, but evaluating the frontiers at the different levels of an exogenous variable in two time periods allows us to isolate the effect of changes in a particular exogenous variable on costs and profits.

Typically, the literature provides estimates of efficiencies and productivity change based on the cost function, or even just simple ratios of cost to asset size. But we believe measures of efficiency and productivity change based on the profit function are better for evaluating overall firm performance, since the profit function accounts for the bank’s choice of outputs as well as inputs. The profit function measures take into account differences in banks’ product mixes and are more reflective of how banks’ output choices respond to changes in relative prices than are the cost measures. Profit maximization requires that the same amount of managerial attention be paid to raising a marginal dollar of revenue as to reducing a dollar of costs. The cost measures, in turn, are superior to simple ratios, because they control for the level of outputs and input prices across banks.

The tremendous changes banks have experienced, starting with the deregulation in the early 1980s and then the merger wave in the later 1980s into the 1990s, should have affected both bank efficiency and productivity. While increased competition, which resulted from deregulation and which is providing an impetus for industry consolidation, should eventually lead to a more efficient and productive industry, it is not clear that such has been the case yet. With deregulation, banks have lost market power over the liability side of their balance sheets, which results in higher costs of production. Similarly, working through an acquisition can be disruptive to normal operations, so in the short run (which can last several years), efficiency and productivity might be adversely affected, even if the long-run effects are positive.

2. A (Very) Brief Review of the Bank Productivity Literature

Berger and Humphrey (1997) provide an extensive review of the literature on efficiency in the financial services industry, so we omit a review here. The 130 different studies they documented provide an array of efficiency estimates, ranging from lows near 40 percent to highs near 95 percent. But since the studies use data on banks operating in different countries and time periods and different models of bank production and different estimation techniques, it is difficult to draw general conclusions about important determinants of bank efficiency or how efficiency has changed over time. Studying U.S. commercial banks in the 1990-95 period, Berger and Mester (1997) find average cost efficiency on the order of 86 percent and average profit efficiency in the 45-55 percent range. These estimates were robust over the estimation techniques, functional forms, and various specifications of the functions used. Accounting for financial capital in the banks' production technology was found to have a significant effect on the estimates. We based our specification of the cost and profit frontiers estimated below on what we learned in Berger and Mester (1997).

The literature on productivity growth in U.S. banking is less extensive than that on efficiency. We review a handful of studies here to give a flavor of the type of work that has been done, but this is by no means a comprehensive review. Berger and Humphrey (1992) use the thick frontier approach to compare bank cost efficiency and to study movements in the frontier between 1980, 1984, and 1988 using a complete sample of U.S. banks. These three years correspond to pre-, mid-, and post-deregulation of the deposit side of banking. Shifts in the frontier between the years reflect technological change and changes, such as deregulation, that affect banks' production costs. The authors find that when the shifts are not adjusted for changes in market factors, average costs increased for all but the very largest efficient banks in the 1980-84 interval, followed by decreases in average costs for all sizes in the 1984-88 period. The increase in costs in the earlier period was larger for the smaller banks in the sample. This reflected the increase in deposit rates that occurred in the 1980-84 period because of deregulation, and the fact that smaller banks use a larger proportion of deposits to fund their assets than do larger banks. The decline in average costs in the later interval reflects a general decline in market rates that affected deposit rates and rates on purchased funds about equally. When the shifts in the average cost frontiers were adjusted for changes in the exogenous variables in the cost function and market rates, an increase is still shown for the 1980-84 period, but a decrease is no longer shown for the 1984-88 period.

Bauer, Berger, and Humphrey (1992) use a panel data set of 683 banks with over $100 million in assets from states that allowed branching and that were continuously in existence during 1977-88 to estimate total factor cost productivity growth for the best-practice banks. (They also estimate cost efficiency and changes in cost efficiency over time.) Total factor productivity comprises technological change and scale economies. They find basically constant returns to scale over the period so that their total factor productivity estimates reflect technological change. These estimates range from an average annual growth rate over the period of −2.28 percent to 0.16 percent, depending on the estimation method used. The poor productivity growth was attributed to higher costs of funding due to high market rates, elimination of deposit rate ceilings, and increased competition from nonbank financial intermediaries, which increased demand for funds and reduced the supply of deposits. Instead of compensating for this increase in input price by closing branches or substituting ATMs, increased competition forced banks to provide more in the way of convenience. Hence, the number of bank branches increased over the 1980s. The increase in deposit rates, increase in nonbank competition, and better convenience all made consumers of bank services better off, but because quality of service was not accounted for in the estimation, the higher quality showed up as a decrease in productivity growth.

Humphrey (1993) used the same data set to investigate net technological change, based on the cost function, from 1977-88. Measures of technological change were derived in three ways: from a simple time trend; from a time-specific index; and from annual shifts in cross-section cost functions. All three methods yielded similar estimates, with net technological change averaging −0.8 percent to −1.4 percent per year, and small banks (with assets of $100-$200 million) experiencing a larger decline than large banks. Humphrey attributed the decline in productivity to deregulation of deposit rates. As the cost of deposits rose, banks found themselves to be “overbranched,” and the productivity of their deposit base declined. As support for this hypothesis, he found that in the pre-deregulation period (1977-80), productivity increased, while during deregulation (1981-82), productivity declined substantially, and in the post-deregulation period (1983-88), it showed little change.

Devaney and Weber (1996) investigated whether the market structure of rural banking markets affected the banks’ productivity growth, in terms of technological optimization, over 1990-93. They used linear programming, rather than stochastic techniques, to calculate the Malmquist productivity index, which decomposes productivity changes into changes in efficiency and changes in technology (which comprises technological change and scale changes). Since these measures are based on quantities of inputs and outputs without regard to prices, there is no way to determine whether banks’ choices are optimal in an economic sense. The authors found that productivity growth at rural banks over 1990-93 averaged about 3.6 percent per year. Technological change was the driving force of this productivity growth.

Wheelock and Wilson (1996) also used the linear programming approach to investigate bank productivity growth, decomposing the change in productivity (based on technological optimization, rather than economic optimization) into its change in efficiency and change in technology components. They found that larger banks, with assets over $300 million, experienced productivity growth between 1984-93, while smaller banks experienced a decline. Average inefficiency remained high in the industry, since banks were not able to adapt quickly to technological change.

Humphrey and Pulley (1997), the only paper to examine profits, estimate changes in predicted bank profits in the 1977-88 period and decompose the changes that occurred after deregulation (1984-88) into internal, bank-initiated adjustments to the new regulatory structure and external, contemporaneous changes in banks' business environment. The authors find that for banks with assets over $500 million, the rise in profits from the 1977-81 period to the 1981-84 period resulted from a change in technology, by changing deposit and loan prices, and changes in the use of labor, capital, and funding inputs in response to deregulation. In contrast, technological change did not account for the rise in larger banks' profits from 1981-84 to 1985-88. Rather, this rise was due to higher levels of deposits, loans, other assets, and changes in input prices. For smaller banks, with assets between $100 million and $500 million, the authors find that there was little increase in profits between 1977-81 and 1981-84, and what increase there was was not due to technological change. In the later period, small banks' experience was the same as larger banks'. Repeating their analysis abstracting from changes in bank efficiency, they find larger changes in profits from 1977-81 to 1981-84 and from 1981-84 to 1985-88 than they did when they allowed for changes in efficiency, but the pattern was the same, with improvements in technology dominating the earlier period and changes in business conditions dominating the latter.

3. The Efficiency and Productivity Concepts

We focus on three economic concepts from which efficiency and productivity measures will be derived—cost, standard profit, and alternative profit.[1] We prefer these concepts as they are based on economic optimization in reaction to market prices and competition, rather than being based solely on the use of technology.

3.1 Cost. The cost function relates variable costs to the prices of variable inputs, the quantities of variable outputs and any fixed inputs or outputs, environmental factors, and random error, as well as efficiency. We can write the log cost function as:

$$\ln C = f_C(w,y,z,v) + \ln u_C + \ln \epsilon_C , \qquad (1)$$

where C measures variable costs, f_C is some functional form, w is the vector of prices of variable inputs, y is the vector of quantities of variable outputs, z indicates the quantities of any fixed netputs (inputs or

[1]This section summarizes the fuller discussion in Berger and Mester (1997).

outputs), v is a set of environmental or market variables that may affect performance, u_C denotes an inefficiency factor that may raise costs above the best-practice level, and ϵ_C denotes the random error that incorporates measurement error and luck that may temporarily give banks high or low costs. The term, $ln\, u_C + ln\, \epsilon_C$, is treated as a composite error term, and the various efficiency measurement techniques (such as the stochastic frontier estimation, distribution-free method, or thick frontier method) differ in how they distinguish the inefficiency term, $ln\, u_C$, from the random error term, $ln\, \epsilon_C$.

We define the cost efficiency of bank b as the estimated cost needed to produce bank b's output vector if the bank were as efficient as the best-practice bank in the sample facing the same exogenous variables (w,y,z,v) divided by the actual cost of bank b, adjusted for random error, i.e.,

$$\text{Cost EFF}^{\,b} = \frac{\hat{C}^{\min}}{\hat{C}^{\,b}} = \frac{\exp[\hat{f}_C(w^{\,b},y^{\,b},z^{\,b},v^{\,b})] \times \exp[\,ln\,\hat{u}_C^{\min}]}{\exp[\hat{f}_C(w^{\,b},y^{\,b},z^{\,b},v^{\,b})] \times \exp[\,ln\,\hat{u}_C^{\,b}]} = \frac{\hat{u}_C^{\min}}{\hat{u}_C^{\,b}}, \tag{2}$$

where $\hat{u}_C^{\min}$ is the minimum $\hat{u}_C^{\,b}$ across all banks in the sample. Cost efficiency ranges over (0,1], and equals one for a best-practice firm within the observed data.

The total change in costs in an industry reflects changes in productivity, and changes in exogenous conditions that affect costs. Changes in productivity reflect both changes in the technology used by the best-practice firms in an industry and changes in the degree of efficiency with which the technology is used. The change in predicted total costs (with random error removed) between periods t and t+1 is given by:

$$\text{Total Cost Change} = \frac{\hat{C}_{t+1}(X_{t+1})}{\hat{C}_t(X_t)} = \frac{\hat{C}_{t+1}(X_t)}{\hat{C}_t(X_t)} \times \frac{\hat{C}_{t+1}(X_{t+1})}{\hat{C}_{t+1}(X_t)}, \tag{3}$$

where $X_t \equiv (w_t, y_t, z_t, v_t)$ and $\hat{C}$ is the estimated average-practice cost function. (We evaluate the change at the average values of w_t, y_t, z_t, and v_t over all the banks in our sample.) This predicted cost change embodies inefficiency, $ln\, u_C$, and the frontier, $\hat{f}_C$, from equation (1), but omits the random error, $ln\, \epsilon_C$. Note that this is a gross cost change, so, e.g., if costs go up by 5 percent, our total cost change would be 1.05.

The first term on the right-hand-side of (3) represents productivity change, i.e.,

$$\text{Productivity Change}_{\text{Cost}} = \frac{\hat{C}_{t+1}(X_t)}{\hat{C}_t(X_t)}, \tag{4}$$

where $\hat{C}$ is the estimated average-practice cost function. When this is calculated using the best-practice cost frontier, $\hat{f}$, instead, then this term represents technological change, i.e.,

$$\text{Technological Change}_{\text{Cost}} = \frac{\exp[\hat{f}_{Ct+1}(X_t)]}{\exp[\hat{f}_{Ct}(X_t)]}, \tag{5}$$

where $\hat{f}_C$ is the estimated best-practice cost frontier. Note that technological change abstracts from changes in efficiency over time, i.e., from changes in the degree of dispersion from the best-practice technology, while productivity change does not. We can also calculate the total change in costs based on the best-practice cost frontier by substituting $\exp \hat{f}_C$ for $\hat{C}$ in equation (3).

The second term on the right-hand-side of (3) represents changes in business conditions, i.e., in the exogenous variables in the cost function or frontier:

$$\text{Business Conditions Change}_{\text{Cost}} = \frac{\hat{C}_{t+1}(X_{t+1})}{\hat{C}_{t+1}(X_t)}. \tag{6}$$

This, too, can be calculated using the best-practice frontier, $\hat{f}$, in place of $\hat{C}$, in which case it would abstract from any changes in efficiency over time that might have occurred.

To focus on the contribution of a change in a subset of the X variables (say X^I) to the change in costs due to changes in business conditions, one can decompose the second term into:

$$\frac{\hat{C}_{t+1}(X_{t+1})}{\hat{C}_{t+1}(X_t)} = \frac{\hat{C}_{t+1}(X^I_{t+1},X_t^{-I})}{\hat{C}_{t+1}(X_t)} \times \frac{\hat{C}_{t+1}(X_{t+1})}{\hat{C}_{t+1}(X^I_{t+1},X_t^{-I})}, \tag{7}$$

where X^{-I}_t represents the variables in the vector X_t less those in X^I_t, and the first term on the right-hand-side gives a measure of the contribution of a change in X^I to the change in cost due to changes in business conditions.

3.2 Standard Profit. The standard profit function takes variable output prices as given but allows output quantities to vary, so that it accounts for revenues that can be earned by varying outputs as well as inputs. The standard profit function, in log form, is:

$$ln\,(\pi + \theta) = f_\pi(w,p,z,v) + ln\,u_\pi + ln\,\epsilon_\pi\,, \tag{8}$$

where π is the variable profits of the firm, which includes all the interest and fee income earned on the variable outputs minus variable costs, C, used in the cost function; θ is a constant added to every firm's profit so that the natural log is taken of a positive number; p is the vector of prices of the variable outputs; $ln\,\epsilon_\pi$ represents random error; and $ln\,u_\pi$ represents inefficiency that reduces profits.

Standard profit efficiency measures how close a bank is to producing the maximum possible profit given a particular level of input prices and output prices (and other variables). Efficiency measures based on the profit function allow for inefficiencies in the choice of inputs (like the cost function does) but also in the choice of outputs when responding to output prices or to any other arguments of the profit function. Thus, profit efficiency is more comprehensive than cost efficiency and gives a better measure of the overall performance of the firm.

We define standard profit efficiency as the ratio of the predicted actual profits to the predicted maximum profits that could be earned if the bank was as efficient as the best bank in the sample, net of random error, or the proportion of maximum profits that are actually earned:

$$\text{Std } \pi \text{ EFF}^{b} = \frac{\hat{\pi}^{b}}{\hat{\pi}^{max}} = \frac{\left\{\exp[\hat{f}_{\pi}(w^{b},p^{b},z^{b},v^{b})] \times \exp[\ln \hat{u}_{\pi}^{b}]\right\} - \theta}{\left\{\exp[\hat{f}_{\pi}(w^{b},p^{b},z^{b},v^{b})] \times \exp[\ln \hat{u}_{\pi}^{max}]\right\} - \theta} \tag{9}$$

where $\hat{u}_{\pi}^{max}$ is the maximum value of u_{π}^{b} in the sample.[2] Profit efficiency ranges over $(-\infty,1]$, and equals one for a best-practice firm within the observed data. Unlike cost efficiency, profit efficiency can be negative, since firms can throw away more than 100 percent of their potential profits.

In terms of standard profit, the total gross change in predicted profit between periods t and t+1 reflects changes in profits when facing given output prices, input prices, netputs, and environmental factors, which may differ between t and t+1; it is given by:

$$\text{Total Std } \pi \text{ Change} = \frac{\hat{\pi}_{t+1}(X_{t+1})}{\hat{\pi}_{t}(X_{t})} = \frac{\hat{\pi}_{t+1}(X_{t})}{\hat{\pi}_{t}(X_{t})} \times \frac{\hat{\pi}_{t+1}(X_{t+1})}{\hat{\pi}_{t+1}(X_{t})}, \tag{10}$$

where $X_t \equiv (w_t, p_t, z_t, v_t)$ and $\hat{\pi}$ is the estimated average-practice standard profit function. We expect that there will be more variability in profits from year to year than in costs, and profits can be negative, so that these changes can be quite large or small depending on the movement in profits.

Standard profit productivity change, technological change, and change in business conditions are given by substituting $\hat{\pi}$ for $\hat{C}$ and $\hat{f}_{\pi}$ (adjusted for θ) for $\hat{f}_{C}$ in equations (4)-(7).

3.3 Alternative Profit. The concept of alternative profit may be helpful when some of the assumptions underlying cost and standard profit functions are not met. The alternative profit function employs the same dependent variable as the standard profit function and the same exogenous variables as the cost function. The alternative profit function in log form is:

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[2]The profit efficiency does not simplify to a ratio of $\hat{u}_{\pi}$'s as in the case of cost efficiency because the addition of θ to the dependent variable before taking logs means that the efficiency factor is not exactly multiplicatively separable in the profit function. A bank's efficiency will vary somewhat with the values of the exogenous variables, so for our efficiency estimates we average the values of the numerator and denominator in (9) over the sample period before dividing to measure the average efficiency of the bank over the sample period.

$$ln(\pi + \theta) = f_{a\pi}(w,y,z,v) + ln\, u_{a\pi} + ln\, \epsilon_{a\pi}, \quad (11)$$

which is identical to the standard profit function in (8) except that y replaces p in the function f, yielding different values for the inefficiency and random error terms, $ln\, u_{a\pi}$ and $ln\, \epsilon_{a\pi}$, respectively.

Efficiency here is measured by how close a bank comes to earning maximum profits given its output levels rather than its output prices. Thus, instead of counting deviations from optimal output as inefficiency, as in the standard profit function, variable output is held constant as in the cost function while output prices are free to vary and affect profits. As with standard profit efficiency, alternative profit efficiency is the ratio of predicted actual profits to the predicted maximum profits for a best-practice bank:

$$\text{Alt } \pi \text{ EFF}^b = \frac{a\hat{\pi}^b}{a\hat{\pi}^{max}} = \frac{\left\{\exp[\hat{f}_{a\pi}(w^b,y^b,z^b,v^b)] \times \exp[ln\, \hat{u}^b_{a\pi}]\right\} - \theta}{\left\{\exp[\hat{f}_{a\pi}(w^b,y^b,z^b,v^b) \times \exp[ln\, \hat{u}^{max}_{a\pi}]\right\} - \theta} \;. \quad (12)$$

Here, efficiency values are allowed to vary in an important way with output prices, but errors in choosing output quantities do not affect alternative profit efficiency except through the point of evaluation $\hat{f}_{a\pi}(w^b,y^b,z^b,v^b)$ to the extent that the best-practice bank is not operating at the same (w,y,z,v) as bank b.

In terms of alternative profit, productivity change between periods t and t+1 reflects changes in profits when facing given output levels, input prices, netputs, and environmental factors, which may differ between t and t+1. Alternative profit productivity between periods t and t+1 is given by:

$$\text{Total Alt } \pi \text{ Change} = \frac{a\hat{\pi}_{t+1}(X_{t+1})}{a\hat{\pi}_t(X_t)} = \frac{a\hat{\pi}_{t+1}(X_t)}{a\hat{\pi}_t(X_t)} \times \frac{a\hat{\pi}_{t+1}(X_{t+1})}{a\hat{\pi}_{t+1}(X_t)}, \quad (13)$$

where $X_t \equiv (w_t, y_t, z_t, v_t)$ and $a\hat{\pi}$ is the average-practice alternative profit function.

Alternative profit productivity change, technological change, and change in business conditions are given by substituting $a\hat{\pi}$ for $\hat{C}$ and $\hat{f}_{a\pi}$ (adjusted for θ) for $\hat{f}_C$ in equations (4)-(7).

The alternative profit function provides useful information beyond that provided by the cost and standard profit functions when one or more of the following conditions hold: (i) there are substantial unmeasured differences in the quality of banking services; (ii) outputs are not completely variable, so that a bank cannot achieve every output scale and product mix; (iii) output markets are not perfectly competitive, so that banks have some market power over the prices they charge; and (iv) output prices are not accurately measured, so they do not provide accurate guides to opportunities to earn revenues and profits in the standard profit function.

The alternative profit function provides a way of controlling for unmeasured differences in output quality, since it considers the additional revenue that higher quality output can generate. So it does not penalize high-quality banks in terms of their efficiency or productivity measure, whereas the cost function might. The alternative profit function might also prove useful if the variable outputs are not completely variable. It takes time for banks to significantly change their scale of operations, either via asset growth or through mergers and acquisitions, but the standard profit function essentially treats these large and small banks as if they should have the same variable outputs when facing the same input and output prices, fixed netputs, and environmental variables specified in the standard profit function. Large banks may be labeled as having higher standard profit efficiency or productivity than smaller banks simply because small banks cannot reach the same output levels. This potential problem is alleviated somewhat by the alternative profit function, which compares ability of banks to generate profits for the same levels of output.

The third case in which the alternative profit function may be helpful is when firms exercise some market power in setting output prices. Output prices are assumed to be exogenous in the standard profit function, which assumes the bank can sell as much output as it wishes without having to lower its prices. Standard profit efficiency and productivity might be understated to the extent that firms have to reduce prices to increase output. When a bank has some market power, it might be more appropriate to consider output levels as being fixed in the short run, while the bank sets prices and chooses service quality.

Alternative profit efficiency and productivity measure the extent to which banks are able to optimize in their choices of prices and service quality, as well as their abilities to keep costs low for a given output level.

Finally, the alternative profit function might be appropriate when there are inaccuracies in the output price data, which is almost surely the case with the available banking data.

4. Empirical Design

Our data set includes for each year from 1984 through 1995 all the U.S. commercial banks that operated in the year; thus, we have over 145,000 observations (over 80,000 observations for the 1980s and over 65,000 for the 1990s). Most of the bank-specific data come from the quarterly Reports of Income and Condition (Call Reports). By including all the banks, we are able to consider the efficiency and productivity results we obtain to be representative of the industry.[3]

4.1 Variables Included in the Cost and Profit Functions. Table 1 gives the definitions of all the variables specified in the cost, standard profit, and alternative profit functions, as well as their sample means and standard deviations for the periods 1984-89 and 1990-95. The variable input prices, w, include the interest rates on purchased funds and core deposits as well as the price of labor. These prices are calculated as exogenous market-average prices that a bank faces. In each MSA or non-MSA county in which a bank operates we constructed the weighted average of the prices of the other banks in the market excluding the bank's own price, where the weight is given by a bank's input level and the bank's price is its expenditures on the input divided by its level of the input. The bank's input price is then the weighted average of the prices faced in each of its markets, where the weight is the bank's share of deposits in the market.[4] Note that expenditures on these three inputs comprise the vast majority of all banking costs. The

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[3]Major Call Report changes implemented in 1984 made it difficult to include the earlier part of the 1980s.

[4]The state-average input price is used instead of the market-average price if the market-average price is likely to be, or appears to be, unreliable. We use the state-average price if the bank's deposit market share

variable outputs, y, include consumer loans, business loans, real estate loans, and securities, the latter category being measured simply as gross total assets less loans and physical capital, so that all financial assets are considered to be outputs.[5] This specification of financial assets as outputs and financial liabilities and physical factors as inputs is consistent with the "intermediation" approach or "asset approach" to modeling bank production (Sealey and Lindley, 1977).[6] The prices of these outputs, which appear in the standard profit function, are constructed as market-average prices, similar to the way in which input prices are constructed.[7]

We specify risk-weighted off-balance-sheet items, physical capital, and financial equity capital as fixed netputs, z. We include off-balance-sheet items, since some of these, such as loan commitments and letters of credit, are often effective substitutes for directly issued loans. The use of the Basle Accord risk weights implies that these items have approximately the same perceived (according to the Accord) credit risk and, therefore, approximately the same origination, monitoring, and control costs as loans to these same parties. Banks use other off-balance-sheet items, like derivatives, to hedge risk and to generate income, thus, costs and profits can be affected by their use. Excluding off-balance-sheet items might also lead to a scale-bias, since they are concentrated in large banks. We specify these items as fixed instead of variable primarily because of the difficulty of obtaining accurate output price information for use in

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in the market is over 90 percent (so that excluding the bank leaves banks that are less representative of the market). For the price of purchased funds or core deposits, we also use the state-average price if the calculated market price of purchase funds or core deposits is more than 10 percentage points over the one-year Treasury rate or is less than the one-year Treasury rate.

[5]From the Call Reports, Consumer loans are loans to individuals, real estate loans are loans secured by real estate, and business loans are all other loans net of unearned income.

[6]Studies have found that efficiency and productivity measures are not very sensitive to the different approaches that have been used in measuring bank output and input (see, e.g., Berger and Humphrey, 1992, and Humphrey, 1992).

[7]For output prices our tolerance range for using the market-average price as opposed to the state-average price is 0 percent to 25 percentage points over the one-year Treasury rate; recall the range was 0 to 10 percentage points for input prices.

specifying the standard profit function. Similarly, since physical capital is slow to adjust, we treat it as a fixed input too.

Although it is not standard, a number of recent papers (including Berger and Mester, 1997, Hughes and Mester, 1993 and 1997, and Hughes, et al. 1995, among others) have argued for the importance of including equity when estimating cost and profit functions. Equity serves as an alternative source of funding for bank operations, so it can directly affect costs. It may have an indirect effect via the risk premium a bank pays for uninsured deposits and nondeposit funds, since financial capital provides a cushion against insolvency. A failure to control for equity may lead to a scale bias in estimates of efficiency or productivity to the extent that larger banks are relatively more reliant on debt financing and the cost of debt is included in costs but dividends are not. We include a bank's level of equity as a fixed netput in the model rather than the price of equity to allow for the possibility that banks are not using the cost-minimizing level of financial capital (perhaps due to regulatory constraints or risk-aversion on the part of bank managers) and because we do not have a measure of the cost of capital. Our specification includes equity by expressing variable costs, variable profits, and the other fixed netputs as ratios to the equity level. This helps control for heteroskedasticity in the model. It also allows us to interpret the profit functions as return on equity relationships; maximization of ROE may be closer to the goals of bank shareholders than profit maximization.

Since unmeasured differences in product quality may be incorrectly measured as differences in cost efficiency, we include the market-average nonperforming to total loan ratio (*ln* MNPL) and its square ($(ln\ \text{MNPL})^2$). (These are the first of our environmental variables, denoted as v above.) This market-average is constructed similarly to market-average prices, where the state average is used if the deposit market share of the bank is over 90 percent. Berger and Mester (1997) found that how nonperforming loans were entered into the empirical model—either as the bank's own ratio or the state's ratio—had little effect on the efficiency measures, but we use the market-average ratio here, as it is more likely to be exogenous and provides some control for bad luck in a bank's environment. Berger and Mester found that poor loan performance was associated with higher costs and lower profits, lending some support to the "bad management" hypothesis of Berger and DeYoung (1997), i.e., that banks that are inefficient at managing their operations are bad at managing their loan portfolios.

The other variables in vector v control for various characteristics of the bank and its environment. Since geographic restrictions on bank expansion, which differ across states, can limit the competitive forces banks face and, therefore, affect costs and profitability, we included controls for the degree of branching restrictions (unit banking (UNITB) and limited branching permitted (LIMITB), with the base case being statewide branching); the degree of in-state holding company expansion permitted (LIMITBHC); whether out-of-state holding company expansion is allowed or not (NOINTST); and the proportion of the banking industry's assets held in states allowed to enter the bank's own state (ACCESS and $ACCESS^2$). Other controls used to account for market competition include the Herfindahl index that measures the degree of local deposit market concentration (HERF); state income growth (STINC and $STINC^2$) to proxy for growth in market demand for banking services; and whether the bank is located in a metropolitan area (INMSA), which may be more competitive than a rural area. To account for the regulatory regime banks are facing we included the identity of a bank's federal regulator (FED and FDIC, with the base case being the OCC). To control more directly for risk than we have done already with our nonperforming loan ratio and inclusion of equity, we included SDROA, the standard deviation of a bank's annual return on assets over the five, four, or three years prior to the date in question (choosing the longest for which data were available) and NOSDROA, which equals one if there were fewer than three years of data for the bank and zero otherwise.[8]

Many of these environmental variables were included as correlates of efficiency in earlier studies (including Berger and Mester, 1997). Here, we prefer to include these mostly exogenous factors directly

[8]If fewer than three years of data were available, then SDROA was set equal to zero.

in the cost and profit functions to control for the conditions facing banks, since our goal is to obtain the best estimates of efficiency and productivity growth rather than to test which are the most important correlates of efficiency as in our earlier study.

4.2 Functional Form. The results presented below are based on the translog functional form, which has been the most popular in the literature.[9]

Our specification of the cost function is:

$$
\begin{aligned}
ln\,(C/w_3z_3) = {} & \alpha + \sum_{i=1}^{2} \beta_i\, ln\,(w_i/w_3) + \frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2} \beta_{ij}\, ln\,(w_i/w_3)\, ln\,(w_j/w_3) + \sum_{k=1}^{4} \gamma_k\, ln\,(y_k/z_3) \\
& + \frac{1}{2}\sum_{k=1}^{4}\sum_{m=1}^{4} \gamma_{km}\, ln\,(y_k/z_3)\, ln\,(y_m/z_3) + \sum_{r=1}^{2} \delta_r\, ln\,(z_r/z_3) + \frac{1}{2}\sum_{r=1}^{2}\sum_{s=1}^{2} \delta_{rs}\, ln\,(z_r/z_3)\, ln\,(z_s/z_3) \\
& + \sum_{i=1}^{2}\sum_{k=1}^{4} \eta_{ik}\, ln\,(w_i/w_3)\, ln\,(y_k/z_3) + \sum_{i=1}^{2}\sum_{r=1}^{2} \rho_{ir}\, ln\,(w_i/w_3)\, ln\,(z_r/z_3) \\
& + \sum_{k=1}^{4}\sum_{r=1}^{2} \tau_{kr}\, ln\,(y_k/z_3)\, ln\,(z_r/z_3) + \sum_{i=1}^{17} \xi_i v_i + ln\, u_C + ln\, \epsilon_C
\end{aligned}
\tag{14}
$$

where we have suppressed time subscripts; (y_k/z_3), (z_r/z_3), and the MNPL variables (included in v) have 1 added for every firm in order to avoid taking the natural log of zero; and the standard symmetry restrictions apply (i.e., $\beta_{ij} = \beta_{ji}$, $\gamma_{km} = \gamma_{mk}$, $\delta_{rs} = \delta_{sr}$).[10]

The standard and alternative profit functions use essentially the same specification with a few changes. First, the dependent variable for the profit functions replace *ln* (C/w_3z_3) with *ln* $[(\pi/w_3z3) +$

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[9]In future work we plan to check the robustness of our results by re-estimating them using Fourier-flexible functional form, which is a global approximation that includes a standard translog plus Fourier trigonometric terms. Several studies found that the Fourier-flexible form provided a better fit than the translog (Berger and Mester, 1997, offers a review). But Berger and Mester (1997) found that the improvement in fit was very small and not significant from an economic viewpoint. Both functional forms yielded essentially the same average level and dispersion of measured efficiency, and both ranked the individual banks in almost the same order.

[10]We exclude consideration of factor share equations, which embody restrictions imposed by Shephard's Lemma or Hotelling's Lemma, because this would impose the undesirable assumption of no allocative inefficiencies.

$|(\pi/w_3z_3)^{min}| + 1]$, where $|(\pi/w_3z_3)^{min}|$ indicates the absolute value of the minimum value of (π/w_3z_3) over all banks for the same year. Thus, the constant $\theta = |(\pi/w_3z_3)^{min}| + 1$ is added to every firm's dependent variable in the profit function so that the natural log is taken of a positive number, since the minimum profits are typically negative. Thus, for the firm with the lowest value of (π/w_3z_3) for that year, the dependent variable will be ln(1) = 0. For the alternative profit function, this is the only change in specification, since the exogenous variables are identical to those for the cost function. For the standard profit function, the terms containing the variable output quantities, *ln* (y_k/z_3), are replaced by the corresponding output prices, *ln* (p_k/w_3).

As shown in equation (14), all of the cost, profit, input price, and output price terms are normalized by the last input price, w_3, in order to impose linear homogeneity on the model.[11] We also specify all of the cost, profit, variable output quantities, and other fixed netput quantities as ratios to the fixed equity input, z_3, to control for heteroskedasticity, to help control for scale biases in the estimation, and to give the models more economic interpretation, since the dependent variable in the profit functions becomes ROE (see Berger and Mester, 1997, for a full discussion).

4.3 Technique for Estimating Efficiency. We estimate bank efficiency for our two subperiods, 1984-89 and 1990-95, using the distribution-free method. This method was used in Berger and Mester (1997) and allows us to compare the earlier results with those obtained here derived from a larger sample that covers a greater time span. A benefit of the method is that it uses less arbitrary assumptions than the more popular stochastic frontier approach to disentangle inefficiencies from random error; another benefit is that it gives a better idea of a bank's longer-term performance, since the method bases efficiency estimates on several years of data. The method assumes there is a core efficiency or average efficiency for each firm over time. The core inefficiency is distinguished from random error by assuming that core

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[11]The homogeneity restriction does not have to be imposed on the alternative profit function, but it is imposed to keep the functional forms equivalent.

inefficiency is persistent over time, while random errors tend to average out over time. Our efficiency estimates for the 1980s and for 1990s are averages over six years. One banking study (DeYoung, 1997) found that this length of time balanced out concerns that the period be long enough so that random errors average out and that the period be short enough so that core efficiency was constant over the period.

We follow the following procedure to obtain efficiency estimates. The cost, standard profit, and alternative profit equations are estimated separately for each year, 1984-95, allowing the coefficients to vary to reflect changes in technology, regulation, and market environment. For each subperiod (1984-89 and 1990-95), the average residual for each bank b in the subperiod is formed, which is an estimate of $ln\ u_C^b$, $ln\ u_\pi^b$, or $ln\ u_{a\pi}^b$ for the subperiod, depending on the equation. Despite the assumption that random error averages out to zero over time, extreme values of these inefficiency estimates may reflect substantial random components. Thus, we use truncation to reassign less extreme values to banks with the most extreme values in each of ten bank size categories for each subperiod. We assign to each bank in the top and bottom 5 percent of the distribution of the average residuals in a size category the value for the bank that is just at the 5th or 95th percentile, respectively. Truncation is performed within size class deciles (by gross total assets) to reduce the effects of persistently good or bad luck for these banks relative to firms of their size. The resulting estimates of the inefficiency terms, $ln\ \hat{u}_C^b$, $ln\ \hat{u}_\pi^b$, and $ln\ \hat{u}_{a\pi}^b$, for the two subperiods, along with their minimum or maximum values $ln\ \hat{u}_C^{min}$, $ln\ \hat{u}_\pi^{max}$, and $ln\ \hat{u}_{a\pi}^{max}$ in the subperiod, are then substituted into the formulas (2), (9), and (12) above, to obtain each bank's efficiency ratio for the subperiod. Estimates of the average efficiencies of the industry for the 1980s are obtained by dividing the average value for the 1984-89 subperiod of the numerator in (2), (9), or (12) by the average value of the corresponding denominator. Similarly, average efficiencies for the 1990s are obtained by taking the averages over 1990-95.[12] We also compute efficiency measures for small banks (banks with assets under

[12]Because the costs and profits in the dependent variables are expressed in terms of the ratios to w_3z_3, the $\exp[\hat{f}(\cdot)]$ terms in the efficiency ratios are replaced by $w_3z_3\times\exp[\hat{f}(\cdot)]$ for cost efficiency and $w_3z_3\times\exp[\hat{f}(\cdot)]-\theta$ for profit efficiency, where $\hat{f}(\cdot)$ is the predicted part of the cost or profit function. To offset the nonlinearities

$1 billion, in 1994 dollars, over the six-year subperiod in question) and large banks (banks with assets over $1 billion, in 1994 dollars, over the six-year subperiod in question) separately, in two different ways. The first method uses the residuals based on the frontier estimated using the full sample, and sums the numerators and denominators over small banks to obtain the efficiency measures for small banks, and over large banks to obtain the efficiency measure for large banks. The second method calculates our efficiency measures based on separately estimated frontiers for small and large banks. This second method takes into account that small and large banks may be using different production technologies or are producing slightly different products. For example, the typical $1 million of commercial loans for a small bank may represent services to three customers, whereas for a large bank it might represent one-tenth of one customer.

4.4 Technique for Estimating Total Change in Costs and Profits, Productivity Change, and Business Conditions Change. Our estimates of the total change in costs or profits, productivity change, and change in business conditions are based on the average-practice cost, standard profit, and alternative profit functions. These measures take into that, in addition to technological change, efficiency in the industry might have changed over time, i.e., they account for changes in the dispersion of banks from the best-practice frontier. To derive these measures, for each year separately, we estimate functions (1), (8), and (11) assuming a two-sided normally distributed error term instead of the composite error term. Then we use equations (3), (4), and (6) for the cost function, and the comparable equations for the standard profit and alternative profit functions to estimate the total change in costs or profits, and its components—productivity change and business conditions change—over 1984-95, 1984-89, 1989-95, and for each pair of consecutive years between 1984 and 1995.

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introduced by exponentiating and including the θ terms, in all but one case the predicted costs and profits are multiplicatively adjusted so that the average predicted cost or profit for each year equals the average actual cost or profit for the same year. In one case (the standard profit function for 1990), this adjustment is not made, since the profit numbers are close to zero and the multiplicative adjustment distorted the efficiency ratio.

In addition to examining the effects of a change in all business conditions variables on costs and profits, we also examine the contribution of changes in certain subsets of the business conditions variables. We examine the contribution of each of the following to changes in costs and profits: price of purchased funds (w_1), price of core deposits (w_2), price of labor (w_3), off-balance-sheet items (z_1), physical capital (z_2), financial equity capital (z_3), nonperforming loan ratio (MNPL), the other environmental variables (v), the loan outputs (y_1,y_2,y_3 for the cost and alternative profit functions and p_1,p_2,p_3 for the standard profit function), and securities (y_4 or p_4).

Because different sized banks might have exhibited differences in productivity growth, we repeat the above analysis for small banks and large banks separately.

4.5 Technique for Estimating Technological Change and the Total Change in Costs and Profits and Business Conditions Change (Abstracting from Changes in Efficiency). The distribution-free method used to obtain our efficiency measures gives a single set of cost, standard profit, and alternative profit efficiency measures for each bank over the 1984-89 and over 1990-95, but a best-practice frontier is not estimated for each year. Thus, to estimate changes in total costs or profits, abstracting from changes in efficiency, we use the thick-frontier method to estimate a frontier for each year in our sample period.

The thick frontier method (Berger and Humphrey, 1991) first separates banks in the sample into four quartiles usually based on total cost (or total profit) per unit of assets. Here, we divide the banks into four groups based on their residuals obtained from the estimation of the cost or profit function with a two-sided error (as opposed to the composite error in equation (14)).[13] Banks with residuals in the lowest 25 percent in their size decile are assumed to be cost efficient. Similarly, for profits, banks with residuals in the highest 25 percent in their size decile are assumed to be profit efficient. We then reestimate the cost

[13]Note that the ordering of banks by this residual is the same ordering that would be obtained from a stochastic frontier estimation of (14).

and profit functions for banks in the lowest and highest quartiles, respectively. The error terms on these regressions are assumed to represent only random measurement error and luck instead of differences in efficiency, and the estimated functions are treated as the cost and profit frontiers.

Having obtained the yearly frontiers, we use equations (3), (11), and (14), to calculate the total change in predicted frontier costs and profits—abstracting from changes in efficiency—over 1984-95, 1984-89, 1989-95, and for each pair of consecutive years between 1984 and 1995. We also decompose these changes into their technological change and change in business conditions components. Again, we repeat this analysis for small banks and large banks separately.

Note that these measures analyze shifts in the frontiers over time or the effects of changing business conditions on banks using the best-practice technology and are not contaminated with changes in the degree to which banks are using the best-practice technology. If the average level of efficiency in the industry has varied over time, then these measures are likely to differ from those derived from the average-practice functions.

5. Efficiency Results

Table 2 shows the means and standard deviations of the efficiencies estimated for all banks and for large and small banks for the 1984-89 period (hereafter, the 1980s) and 1990-95 period (hereafter, the 1990s) periods. The means and standard deviations are weighted by the denominators of the efficiency ratios (estimated cost or potential profits) to represent the proportion of the entire sample's (or subsample's) resources that are used efficiently or potential profits that are earned.[14] The mean cost efficiency for banks of all sizes in the 1980s is 0.806, which suggests that about 19.4 percent of costs were wasted, on average, relative to a best-practice firm. The 0.806 figure is consistent with the range found in the literature; the most typical finding is about 80 percent cost efficiency for the 1980s. For the 1990-95

[14]The cost, standard profit, and alternative profit function coefficient estimates are available from the authors upon request.

period, we estimate average cost efficiency decreased to 0.770, i.e., 77 percent. This estimate is lower than the one found in Berger and Mester (1997), which used a similar model specification but a less comprehensive set of banks. The decrease in cost efficiency between the 1980s and 1990s might be attributed to banks having to readjust after the large numbers of mergers they were involved in at the end of the 1980s and early 1990s. It should be remembered that the efficiency estimates give a measure of the dispersion of the banks from the best-practice frontiers for the 1980s and for the 1990s. These frontiers may be different. The lower efficiency estimate for the 1990s need not indicate that banks are using more resources to produce a given level of output than they were in the 1980s, since the frontier may have shifted down. Our estimates of technological change, presented below, will indicate the extent to which the cost frontier has shifted.

Looking at the estimates for small and large banks separately, we find that the difference between the efficiency estimates for large and small banks was 1.2 percentage points in the 1980s and 2.5 percentage points in the 1990s. (These estimates are based on the estimation that included all-sized banks.) The lower efficiency of smaller banks might be due to the fact that these banks tend to operate in more concentrated markets and are more insulated from competitive pressures that can drive firms toward efficiency. It might also reflect the fact that small banks are producing slightly different products from large banks or are using a different technology. To check this possibility, we reestimated the efficiencies of the small and large banks based on their own frontiers; these estimates are also shown in Table 2. In general, the estimates are fairly similar to those obtained using the frontier estimated for all banks. As can be seen, relative to their own frontiers, small banks and large banks had nearly identical efficiency measures in the 1980s, and small banks showed higher average efficiency, i.e., were less dispersed from their own frontier, than were large banks in the 1990s. Again, it remains to examine the shifts in the frontiers before one can determine whether small or large banks spend more to produce a given level of output.

The mean efficiencies for the standard and alternative profit functions for the 1980s and 1990s for all banks are similar to each other, both showing that about half of the potential profits that could be earned by a best-practice firm are lost to inefficiency. The point estimate for standard profit efficiency is the same in the 1980s and 1990s, while there is only a small increase for alternative profit efficiency. Our estimates are well within the observed range from the few other profit efficiency studies. There do appear to be differences between small and large banks. In the 1980s, as was true for cost efficiency, larger banks appear to be slightly more profit efficient than small banks. In other words, they are less widely dispersed from the frontier than are small banks. But in the 1990s, this reverses, so that the small banks are considerably more profit efficient than the large banks, with efficiency estimates nearly 17 percentage points higher. Since the larger banks are more cost efficient than smaller banks in the 1990s, the difference in the profit efficiencies must reflect differences in revenue efficiencies. Hence, large banks appear to be less efficient either in setting output prices or output levels than smaller banks are. This may reflect differences in the types of customers large banks serve or the types of products offered. In fact, as seen in Table 2, relative to their own frontiers, large banks are seen to have lower average standard profit efficiency than small banks in both the 1980s and 1990s. That is, taking into account the production technology being used by the large banks, these banks showed a higher dispersion from their frontier than did small banks. And the degree of dispersion for large banks increased between the 1980s and 1990s: standard profit efficiency for large banks, measured relative to their own frontier, fell from about 50 percent in the 1980s to under 40 percent in the 1990s; similarly, alternative profit efficiency for large banks declined from about 57 percent in the 1990s to 44 percent in the 1990s. For small banks, the change in efficiency between the 1980s and 1990s is quite minor (and in a positive direction).

It is interesting to note that the standard deviations of the profit efficiencies are about 23 percentage points, suggesting that these efficiencies are quite dispersed, with many firms earning considerably more or less than the average figure. By contrast, the cost efficiencies are more tightly distributed with a standard deviation of 6 to 8 percentage points.[15]

Table 3 shows the rank-order correlations among the different X-efficiency measures and some other commonly used financial ratios that may be considered raw-data measures of efficiency. The general picture is the same for the 1980s and 1990s. Standard and alternative profit efficiency are highly positively and statistically significantly correlated with each other ($\rho = 0.914$ in the 1980s and 0.929 in the 1990s), as expected. The correlation of cost efficiency and the two profit efficiencies is statistically significant but at a much lower level, in the 0.2 range for the 1980s and in the 0.15 range for the 1990s.[16]

The correlations between the efficiencies and each of the raw-data measures follow the expected pattern—efficiency by any definition is negatively and significantly correlated with the standard average cost ratio, C/GTA ≡ total cost/gross total assets, and positively and significantly correlated with the standard profitability ratios, ROA and ROE. C/GTA is more highly correlated with cost efficiency than with profit efficiency and ROA and ROE are more highly correlated with profit efficiency than with cost efficiency. These findings suggest that our efficiency measures are robust and are not simply the consequences of our specifications or methods.

6. Total Change in Cost and Profits, Productivity and Technological Change, and Change in Business Conditions Results

Table 4 reports the total predicted change in costs and profits (as in equations (3), (10), and (13)), and the decomposition of this total change into productivity change and change in business conditions (equations (4) and (5) for cost and comparable equations for standard and alternative profits). (The measures are evaluated at the mean levels of the exogenous variables in the appropriate year.) The

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[15] Although the average profit efficiencies appear to be lower than the average cost efficiency, these ratios are not directly comparable because they are reported in terms of different denominators (predicted actual costs versus potential profits). Berger and Mester (1997) recast their estimates in terms of similar denominators and found that profit efficiency was lower than cost efficiency.

[16] Berger and Mester (1997), using a different sample, found that in the 1990s, cost and alternative profit efficiency were negatively correlated.

statistics in Table 4 allow for the dispersion of banks from the frontier to change over time, as well as for the frontier to shift. In Table 5 we report similar estimates but here they reflect only shifts in the frontier, i.e., they abstract from any changes in dispersion. The first row in each table shows changes for the entire period 1984-95 (at an annual rate), with 1984 serving as base year. The next two rows show the changes for the subperiods, 1984-89 (the "1980s"), and 1989-95 (the "1990s") (both at an annual rate). The other rows in the tables give the yearly changes. The subperiod changes are the geometric means of the yearly changes. The first thing to note about these yearly changes is that there is substantial volatility from year to year, and this is especially true for the change in profits. For example, 1990 was a particularly bad year for bank profitability, and this is shown in the very large change in profit between 1990 and 1991. Realized average profit was actually negative in 1990, but predicted profit evaluated at the mean of the exogenous variables was a small positive number, resulting in a ten-fold increase in profit between 1990 and 1991. Because predicted profit was so low in 1990, it was relatively easy for a bank to earn ten times the amount the next year. We expect the change in profit and profit productivity to be more volatile than the change in costs and cost productivity, since profit is more volatile from year to year than is cost. To abstract from the volatility of the measures, we will focus on the changes for the 1980s and 1990s.

As can be seen in Table 4, the total predicted cost of producing banks' output was little changed over the entire period. Cost rose in the 1980s by about 1 percent and then fell about the same amount in the 1990s. Looking at the decomposition, we see that changes in productivity and changes in business conditions worked in opposite directions. For the cost function, changes in productivity reflect changes in the way banks use their inputs, while changes in business conditions reflect changes in the input prices banks face or the output levels they produce. Cost productivity decreased in both subperiods, with the 1980s showing a 6 percent increase in costs and the 1990s showing a nearly 10 percent increase. In terms of business conditions, banks were better off in the 1990s than in the 1980s. In the 1980s, because of changes in the exogenous variables that affect costs, bank costs fell about 5 percent, while in the 1990s, costs fell about 10 percent.

The results shown in Table 5 are based on banks operating on the frontier; therefore, the results abstract from any change in dispersion from the frontier. As shown, changes in technology increased bank costs in the 1980s and more so in the 1990s. Comparing Tables 5 and 4, we see that the changes in technology using the frontier are generally less than the productivity changes that allow for dispersion from the frontier. In other words, the technology shifted toward more costly production on average, and at the same time, the dispersion from this frontier increased. This result is consistent with what we reported in Table 2, that the degree of efficiency decreased between the 1980s and 1990s. Both the shift in technology and the decrease in efficiency worked to reduce productivity between the 1980s and 1990s.

While these decreases in cost productivity and technological change might seem surprising, our results for the 1980s are consistent with those of Bauer, Berger, and Humphrey (1992) and Humphrey (1993). Both papers attribute the poor productivity growth of banks in the 1980s to the effects of deregulation of deposit rates. Bauer, Berger, and Humphrey argue that as banks lost some of their market power over depositors, their costs rose. Instead of being able to offset these costs with lower operating costs, e.g., by closing branches and replacing them with ATMs, the increased competition the banks faced for deposits caused them to increase the convenience offered to depositors in the form of a larger number of branches. This increase in convenience would not appear as increased cost productivity, but should show up as increased profit productivity, if banks were able to capture some of the benefit. It is possible that banks have been forced to increase convenience (one aspect of output quality) but have not been able to capture the benefit; instead, bank customers would have gained. We look at this momentarily.

What is surprising in our cost results is that there is negative cost productivity and technological change even in the 1990s, when one would have thought the effect of deregulation of deposit rates would have worked itself through. There are several possible explanations: (i) competitive pressures on banks have continued to increase and banks have continued to react by increasing output quality, which raises costs; i.e., all of the benefits from any improvements in technology have been given to consumers; (ii) increased competition might also have changed the banks' clientele to one that is more costly to serve; (iii) new technology, e.g., computers, has changed the way banks do business and the fixed costs of this new technology have not yet been recovered; (iv) the mergers a large number of these banks have experienced might also have caused disruptions in production, temporarily raising costs (even if in the long run the mergers will lead to reduced costs);[17] and (v) differences in the productivity of small and large banks over time and differences in the proportions of these banks in the industry over time might be affecting the average productivity measures reported for all banks. We turn to these differences in the next subsection.

Before turning to our profit results, it might be useful to compare our cost productivity results with the BLS measures of commercial bank (SIC code 602) productivity. One might expect that our measures would agree, but the BLS measures indicate productivity increased 2.65 percent per year in the 1984-89 period and 6.21 percent per year in the 1989-93 period. Why do our results show decreased productivity while the BLS statistics show increases? One reason is that the BLS measures labor productivity and we are measuring the change in costs including all the inputs (labor, purchased funds, core deposits, accounting for physical capital and equity) and we allow for changes in the proportions used of these inputs. Thus, our measure proxies total factor productivity. Given the deregulation, changes in the degree of competition in banking markets, and increased reliance on technology over the period studied, there were shifts in the proportion of inputs used (e.g., the ratio of employment to operating costs has fallen, see Berger and Humphrey, 1992), which the BLS measure would miss. Also, the BLS uses transactions flows to measure bank output, so it does not account for changes in product mix or change in business conditions (and our results above indicate that changes in business conditions have had a profound effect on bank

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[17] In order to test this theory, we are planning to reestimate our measures using a sample of banks that were not involved in mergers for the year in question and at least the three previous years.

costs and profits). Our cost function measures control for bank output mix and our profit function measures account for it, whereas the BLS measures do neither. This could also explain the differences between our results and the BLS estimates.

Turning to profits, the change in predicted standard profit and in predicted alternative profit are quite similar over the entire period 1984-95, with standard profit showing an increase close to 12 percent and alternative profit an increase of almost 9 percent. The decomposition shows that the increase in profits came entirely from increased productivity. Changing business conditions led to a small decline in profits in the 1980s and in the 1990s, of about 4 to 5 percent in each subperiod. Note that since there was little change in the level of profit efficiency between the 1980s and 1990s, the change in profit productivity mainly reflects technological change, i.e., an upward shift in the profit frontier. In terms of the standard profit function, changes in technology reflect changes in the banks' choice of output levels and use of inputs, while changes in business conditions reflect changes in output and input prices, and other exogenous variables. In contrast, for the alternative profit function, changes in technology reflect changes in output prices and the use of inputs, while changes in business conditions reflect changes in output levels, input prices, and other exogenous variables. Our results differ from those of Humphrey and Pulley (1997), who did not find positive technological change between 1981-84 and 1985-88.

Comparing the change in profit estimates with our estimates for cost shows that while costs increased over the period, revenues increased even more, so that profitability increased. This suggests that banks were receiving some payment for the increased convenience they were offering their customers.

While the change in predicted standard profit and the change in predicted alternative profit are similar over the entire period, the pattern over the subperiods of the 1980s and 1990s differs. Standard profit showed a 24 percent increase in the 1980s and a much smaller 2 percent increase in the 1990s, while alternative profit showed roughly similar changes of 11 percent in the 1980s and 7 percent in the 1990s. This difference in patterns might reflect the fact that banks' market power and output quality changed over the 1980s and 1990s (and they changed at different rates).[18] However, in the next subsection we will see that the relative magnitudes of standard and alternative profit changes do not hold up when we separate small and large banks.

7. Total Change in Cost and Profits, Productivity and Technological Change, and Change in Business Conditions: Large vs. Small Bank Results

We next examined whether small and large banks had different experiences in terms of cost and profit changes and productivity and technological changes over the 1980s and 1990s. The estimates reported in Tables 6 and 7 are based on functions and frontiers estimated for small and large banks separately. Comparing the two tables, one can see that the pattern for cost and profit changes and their components differs only a little for average-practice versus best-practice banks. But we do find some difference for small and large banks, the main one being that the differences between the 1980s and 1990s are more pronounced for the large banks than for the small banks (some of this might be due to the sample of large banks being small), even though on average over the entire period from 1984-95 small and large banks experienced similar changes in costs and profits.

There is little difference in the total change in costs for small and large banks over the 1980 and 1990 subperiods. Cost productivity declined for both small and large banks in both subperiods, but the decline was considerably larger for large banks in the 1990s, with large banks experiencing a 15 percent increase in costs due to technological change in the 1990s. A countervailing effect was that changing

[18]If market power were decreasing, then for a given level of output, banks would be earning less. This decrease in profits would be reflected in the change in alternative profit productivity but not in the change in standard profit productivity. Similarly, if banks were offering higher output quality, then for a given level of output, banks would be earning more. This increase in profits would be reflected in the change in alternative profit productivity but not in the change in standard profit productivity. Given the increase competition banks now face, it is likely that banks' market power has been declining over the entire period, while their output quality has been increasing. If the decline in market power had a more important effect on profits in the 1980s than the increase in quality, but the increase in quality dominated in the 1990s, this might explain the pattern we see. If banks' market power was declining strongly in the 1980s, this would tend to hold down alternative profit productivity relative to standard profit productivity in the 1980s. If banks' output quality was increasing relatively strongly in the 1990s, this would tend to push up alternative profit productivity relative to standard profit productivity in the 1990s.

business conditions were more beneficial to large banks than to small banks in terms of their costs. The results for standard profits are similar to those for alternative profits. The change in predicted profits was either negligible (for alternative profits) or slightly negative (for standard profits) for large banks in the 1980s, but profits recovered more strongly in the 1990s for large banks than for small banks. This was driven by productivity change: profit productivity showed little change in the 1980s for large banks, but then it rose strongly for these banks in the 1990s. In contrast, the productivity change for small banks was relatively stable for the 1980s and 1990s.

8. Components of the Change in Business Conditions

Tables 8 and 9 report changes in cost and profits when we change only one (or the specified group) of the exogenous variables.

[TO BE COMPLETED LATER]

9. Conclusions

This paper investigates differences in the cost, standard profit, and alternative profit efficiencies and productivity changes for U.S. banks for the latter half of the 1980s and the first half of the 1990s. We find that cost efficiency for banks of all sizes averaged about 80 percent in the 1980s and declined to 77 percent in the 1990s. The decrease in cost efficiency appears to be more pronounced for large banks than for small banks. Profit efficiency estimates are similar for the standard and alternative profit function with banks showing about 50 percent efficiency in both subperiods. In the 1980s, larger banks appear to be more profit efficient than small banks, but in the 1990s they are considerably less profit efficient.

Efficiency measures the degree of dispersion of banks from the best-practice frontier, but does not tell us how the frontier has changed over time. Technological change does. In terms of costs, banks experienced negative technological change and productivity change in both the 1980s and 1990s, with the frontier shifting toward higher costs on average. A countervailing effect was the change in business conditions, which led to lower costs. On net, there was little change in total costs. The profit story is different, with banks experiencing positive technological change and productivity growth over the 1980s and 1990s. Changes in business conditions hurt the banks in terms of profits. The pattern of productivity change differs for small and large banks: for the small banks, productivity grew fairly evenly across the 1980s and 1990s, while for the large banks, productivity showed only little growth in the 1980s and stronger growth in the 1990s.

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Table 1

Variables Employed in the Cost, Standard Profit, and Alternative Profit Functions
Means and Standard Deviations for 1984-89 and 1990-95

(All financial variables measured in 1000's of constant 1994 dollars,
Prices of financial assets and liabilities are measured as interest rates.)

		1984-89 (80,014 obs.)		1990-95 (65,560 obs.)	
Symbol	**Definition**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
	Dependent Variables				
C	Variable operating plus interest costs, includes costs of purchased funds, deposits, and labor.	18,439	236,847	17,118	224,197
π	Variable profits, includes revenues from loans and securities less variable costs.	3615	36,853	3835	53,901
	Variable Input Prices				
w_1	Market-average price of purchased funds (jumbo CDS, foreign deposits, federal funds purchased, all other liabilities except core deposits).	0.0623	0.0155	0.0446	0.0157
w_2	Market-average price of core deposits (domestic transactions accounts, time and savings).	0.0533	0.0148	0.0319	0.0129
w_3	Market-average price of labor (1000's of constant dollars per employee).	31.6	5.45	33.2	6.24
	Variable Output Quantities (Cost and Alternative Profit Functions Only)				
y_1	Consumer loans (installment and credit card and related plans).	29,973	233,319	34549	270,195
y_2	Business loans.	86,519	1,310,505	84,762	1,333,755
y_3	Real estate loans.	49,881	412,305	82,457	652,836
y_4	Securities (all non-loan financial assets, i.e., Gross Total Assets $- y_1 - y_2 - y_3 - z_3$).	105,593	1,072,634	138,480	1,423,613
	Variable Output Prices (Standard Profit Function Only)				
p_1	Market-average price of consumer loans.	0.102	0.0273	0.0971	0.0241
p_2	Market-average price of business loans.	0.125	0.0420	0.106	0.0359
p_3	Market-average price of real estate loans.	0.0899	0.0174	0.0799	0.0145
p_4	Market-average price of securities.	0.0616	0.0117	0.0368	0.0167

Table 1, con't.

Symbol	Definition	1984-89 (80,014 obs.) Mean	Std. Dev.	1990-95 (65,560 obs.) Mean	Std. Dev.
	Fixed Netput Quantities				
z_1	Off-balance-sheet items (commitments, letters of credit, derivatives, etc.) measured using Basle Accord risk weights to be risk-equivalent to loans.	28,802	620,588	39,429	847,100
z_2	Physical capital (premises and other fixed assets).	4004	38,063	5102	52,371
z_3	Financial equity capital.	16,790	138,960	25,196	212,944
	Environmental Variables				
MNPL	Market-average of nonperforming loans (past due at least 90 days or on nonaccrual basis) divided by total loans.	0.0480	0.0253	0.0315	0.0174
UNITB	Dummy, equals one for unit banks in states.	0.249	0.433	0.0146	0.120
LIMITB	Dummy, equals one for limited branching states.	0.593	0.491	0.475	0.499
STATEB	Dummy, equals one for statewide branching states. Excluded from the regressions as the base case.	0.150	0.357	0.501	0.500
LIMTBHC	Dummy, equals one for states with limits on expansions of multibank holding companies. As of 1990, all states permitted some multibank holding company activity, so the excluded case is that the state allows statewide holding company powers.	0.556	0.497	0.481	0.500
NOINTST	Dummy, equals one for states that do not allow interstate expansions of multibank holding companies.	0.509	0.500	0.0344	0.182
ACCESS	Proportion of nation's banking assets in states that are allowed to enter the state (equals proportion of national assets in the state for states that do not allow interstate banking).	0.121	0.144	0.503	0.318
HERF	Deposit Herfindahl index of local market concentration.	0.227	0.164	0.233	0.155
STINC	Real state income growth (decimal)	0.0241	0.0300	0.0286	0.0231
INMSA	Dummy, equals one if the bank is in a Metropolitan Statistical Area.	0.443	0.497	0.436	0.496
FED	Dummy, equals one if the bank's primary federal regulator is the Federal Reserve.	0.0772	0.267	0.0893	0.285
FDIC	Dummy, equals one if the bank's primary federal regulator is the FDIC.	0.587	0.492	0.603	0.489
OCC	Dummy, equals one if the bank's primary federal regulator is the OCC. Excluded from the regressions as the base case.	0.336	0.472	0.308	0.461

Table 1, con't.

		1984-89 (80,014 obs.)		1990-95 (65,560 obs.)	
Symbol	**Definition**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
SDROA	Standard deviation over past five, four, or three years (longest for which data are available) of the bank's annual return on assets.	0.00519	0.00687	0.00499	0.0117
NOSDROA	Dummy, equals one if fewer than three years of data are available with which to construct SDROA.	0.0425	0.202	0.0199	0.140

Notes: All stock values are real quantities as of the December Call Report and all prices market-averages of flows over the year divided by these stocks. The market-average is the weighted average of the prices of the other banks in the market excluding the bank's own price, where the weight is given by a bank's level of the input or output. The bank's price is then the weighted average of the prices in each of the bank's markets, where the weight is the bank's level of deposits in the market. We substitute the state-average price if the bank's deposit share in the market is over 90 percent, or if the calculated market prices of liabilities and assets are more than 0.10 above or 0.25 above the one-year Treasury rate, respectively. We also eliminated observations in which equity was below 1 percent of gross total assets because the data for such banks are suspicious. All of the continuous variables that can take on the value 0 have 1 added before taking logs in specifying the cost and profit regressions. This applies to the y's, z's, and MNPL. For π, an additional adjustment was made because profits can take on negative values (see text).

Table 2
Measured Bank X-Efficiency
U.S. Banks
(weighted mean efficiencies, standard deviations in parentheses)

		Cost Efficiency	Standard Profit Efficiency	Alternative Profit Efficiency
1984-89	All Banks	0.806	0.567	0.558
		(0.0661)	(0.233)	(0.233)
	Number of Observations	11,040	10,997	10,982
	Small Banks (based on all-sizes frontier)	0.806	0.567	0.557
		(0.660)	(0.232)	(0.232)
	Number of Observations	10,693	10,659	10,640
	Large Banks (based on all-sizes frontier)	0.818	0.577	0.592
		(0.0684)	(0.242)	(0.251)
	Number of Observations	347	338	342
	Small Banks (based on small-bank frontier)	0.800	0.561	0.547
		(0.0655)	(0.230)	(0.227)
	Number of Observations	10,654	10,619	10,598
	Large Banks (based on large-bank frontier)	0.801	0.497	0.572
		(0.0710)	(0.225)	(0.248)
	Number of Observations	291	289	290
1990-95	All Banks	0.770	0.567	0.579
		(0.0848)	(0.229)	(0.230)
	Number of Observations	9281	9275	9267
	Small Banks (based on all-sizes frontier)	0.769	0.572	0.585
		(0.0842)	(0.223)	(0.223)
	Number of Observations	8970	8969	8960
	Large Banks (based on all-sizes frontier)	0.794	0.415	0.408
		(0.0996)	(0.337)	(0.345)
	Number of Observations	311	306	307
	Small Banks (based on small-bank frontier)	0.792	0.575	0.583
		(0.863)	(0.222)	(0.223)
	Number of Observations	8901	8901	8894
	Large Banks (based on large-bank frontier)	0.752	0.374	0.444
		(0.0891)	(0.337)	(0.313)
	Number of Observations	255	251	246

Small banks are banks with less than $1 billion in total assets (in 1994 dollars) over the six-year period in question Large banks are banks with greater than $1 billion in total assets (in 1994 dollars) over the six-year period in question.

Table 3

Correlations Among the Efficiency Measures and Raw-Data Measures of Performance†

1984-89

	Cost Efficiency	Standard Profit Efficiency	Alternative Profit Efficiency	C/GTA	ROA
Standard Profit Efficiency	0.228 (0.000)				
Alternative Profit Efficiency	0.208 (0.000)	0.914 (0.000)			
C/GTA	−0.591 (0.000)	−0.241 (0.000)	−0.290 (0.000)		
ROA	0.125 (0.000)	0.306 (0.000)	0.319 (0.000)	−0.306 (0.000)	
ROE	0.159 (0.000)	0.500 (0.000)	0.481 (0.000)	−0.265 (0.000)	0.867 (0.000)

1990-95

	Cost Efficiency	Standard Profit Efficiency	Alternative Profit Efficiency	C/GTA	ROA
Standard Profit Efficiency	0.165 (0.000)				
Alternative Profit Efficiency	0.135 (0.000)	0.929 (0.000)			
C/GTA	−0.615 (0.000)	−0.145 (0.000)	−0.237 (0.000)		
ROA	0.158 (0.000)	0.197 (0.000)	0.240 (0.000)	−0.232 (0.000)	
OE	0.168 (0.000)	0.435 (0.000)	0.383 (0.000)	−0.196 (0.000)	0.782 (0.000)

C/GTA is average cost, i.e., total cost divided by gross total assets, a raw-data version of cost efficiency. It had an unweighted mean of 0.0642 and a standard deviation of 0.00736 over 1984-89 and an unweighted mean of 0.0474 and a standard deviation of 0.00740 over 1990-95.

ROA is return on assets, i.e., net income divided by gross total assets. It had a mean of 0.00759 and a standard deviation of 0.00679 over 1984-89 and a mean of 0.00986 and a standard deviation of 0.00557 over 1990-95.

ROE is return on equity, i.e., net income divided by equity. It had a mean of 0.0767 and a standard deviation of 0.116 over 1984-1989 and a mean of 0.106 and a standard deviation of 0.0754 over 1990-95.

†Spearman correlation coefficients, with p-values of the tests for zero correlation in parentheses.

Table 4

Measured Bank Changes in Cost, Standard Profit, and Alternative Profit: Total Change, Productivity Change, Business Conditions Change

Average-Practice U.S. Banks

All Banks

	Cost			**Standard Profit**			**Alternative Profit**		
	Total Change	Prod. Change	Bus. Cond. Change	Total Change	Prod. Change	Bus. Cond. Change	Total Change	Prod. Change	Bus. Cond. Change
1984-95†	0.999	1.093	0.914	1.117	1.130	0.989	1.088	1.122	0.970
1984-89†	1.012	1.062	0.953	1.242	1.293	0.961	1.107	1.173	0.944
1989-95†	0.989	1.099	0.900	1.022	1.050	0.973	1.073	1.131	0.948
1984-85	0.975	1.072	0.909	1.105	1.260	0.877	1.055	1.125	0.938
1985-86	0.983	1.051	0.935	1.662	1.922	0.865	1.731	1.993	0.869
1986-87	0.911	1.071	0.851	0.784	0.687	1.141	0.465	0.492	0.946
1987-88	1.098	1.084	1.013	1.320	1.253	1.053	1.621	1.572	1.032
1988-89	1.107	1.007	1.100	1.556	1.459	1.066	1.207	1.076	1.122
1989-90	1.057	1.065	0.992	0.095	0.104	0.920	0.442	0.442	1.001
1990-91	0.895	1.020	0.877	10.107	10.069	1.004	1.548	1.726	0.897
1991-92	0.721	1.446	0.499	1.084	0.712	1.521	1.603	1.753	0.914
1992-93	1.168	1.412	0.827	0.737	0.931	0.791	1.199	1.830	0.655
1993-94	1.029	1.016	1.012	1.737	1.363	1.275	1.552	1.190	1.304
1994-95	1.142	1.001	1.141	0.854	0.791	1.080	0.747	0.627	1.191

Total Change = $\hat{C}_{t+1}(X_{t+1})/\hat{C}_t(X_t)$ for cost; $\hat{\pi}_{t+1}(X_{t+1})/\hat{\pi}_t(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X_{t+1})/a\hat{\pi}_t(X_t)$ for alternative profit.

Prod. Change = $\hat{C}_{t+1}(X_t)/\hat{C}_t(X_t)$ for cost; $\hat{\pi}_{t+1}(X_t)/\hat{\pi}_t(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X_t)/a\hat{\pi}_t(X_t)$ for alternative profit. For cost, a positive number indicates a decrease in productivity.

Bus. Cond. Change = $\hat{C}_{t+1}(X_{t+1})/\hat{C}_{t+1}(X_t)$ for cost; $\hat{\pi}_{t+1}(X_{t+1})/\hat{\pi}_{t+1}(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X_{t+1})/a\hat{\pi}_{t+1}(X_t)$ for alternative profit.

X_t = average value of X_t over all banks in the sample in year t.

†Annualized (i.e., ratio raised to (1/no. of years) in the subperiod).

Table 5

**Measured Bank Changes in Cost, Standard Profit, and Alternative Profit:
Total Change, Technological Change, Business Conditions Change**

Best-Practice U.S. Banks

All Banks

	Cost			**Standard Profit**			**Alternative Profit**		
	Total Change	Tech. Change	Bus. Cond. Change	Total Change	Tech. Change	Bus. Cond. Change	Total Change	Tech. Change	Bus. Cond. Change
1984-95†	0.980	1.072	0.914	1.097	1.110	0.988	1.079	1.100	0.980
1984-89†	0.993	1.042	0.952	1.250	1.298	0.963	1.081	1.130	0.957
1989-95†	0.969	1.079	0.898	0.984	1.012	0.973	1.076	1.135	0.949
1984-85	0.840	0.916	0.917	0.963	1.042	0.924	0.848	0.891	0.951
1985-86	1.001	1.074	0.932	1.950	2.071	0.942	2.639	2.745	0.961
1986-87	0.996	1.185	0.849	0.560	0.560	1.000	0.378	0.407	0.928
1987-88	1.039	1.020	1.019	1.723	1.706	1.010	1.544	1.529	1.010
1988-89	1.109	1.015	1.092	1.686	1.592	1.059	1.132	1.038	1.090
1989-90	1.194	1.191	1.003	0.816	0.902	0.904	1.401	1.416	0.989
1990-91	0.849	0.970	0.875	1.251	1.284	0.975	0.902	1.005	0.898
1991-92	0.943	1.040	0.926	1.334	0.703	1.897	1.387	1.556	0.892
1992-93	0.934	1.092	0.855	0.711	0.856	0.830	1.457	2.070	0.704
1993-94	1.121	1.087	1.032	1.273	0.956	1.332	0.943	0.699	1.349
1994-95	0.825	0.741	1.114	0.737	0.674	1.094	0.646	0.550	1.173

Total Change = $\exp[\hat{f}_{Ct+1}(X_{t+1})]/\exp[\hat{f}_{Ct}(X_t)]$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X_{t+1})]-\theta\}/[\exp[\hat{f}_{\pi t}(X_t)]-\theta\}$ for standard profit; and $\{\exp[\hat{f}_{a\pi t+1}(X_{t+1})]-\theta\}/\{\exp[\hat{f}_{a\pi t}(X_t)]-\theta\}$ for alternative profit.

Tech. Change = $\{\exp[\hat{f}_{Ct+1}(X_t)]-\theta\}/\{\exp[\hat{f}_{Ct}(X_t)-\theta]\}$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X_t)-\theta]\}/\{\exp[\hat{f}_{\pi t}(X_t)-\theta]\}$ for standard profit; and $\{\exp[\hat{f}_{a\pi t+1}(X_t)-\theta]\}/\{\exp[\hat{f}_{a\pi t}(X_t)-\theta]\}$ for alternative profit. For cost, a positive number indicates a decrease in technological change.

Bus. Cond. Change =$\{\exp[\hat{f}_{Ct+1}(X_{t+1})-\theta]\}/\{\exp[\hat{f}_{Ct+1}(X_t)-\theta]\}$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X_{t+1})-\theta]\}/\{\exp[\hat{f}_{\pi t+1}(X_t)-\theta]\}$ for standard profit; and $\{\exp[\hat{f}_{a\pi t+1}(X_{t+1})-\theta]\}/\{\exp[\hat{f}_{a\pi t+1}(X_t)-\theta]\}$ for alternative profit.

X_t = average value of X_t over all banks in the sample in year t.

†Annualized (i.e., ratio raised to (1/no. of years) in the subperiod).

Table 6

Measured Bank Changes in Cost, Standard Profit, and Alternative Profit: Total Change, Productivity Change, Business Conditions Change

Average-Practice U.S. Banks

Small Banks

	Cost			**Standard Profit**			**Alternative Profit**		
	Total Change	Prod. Change	Bus. Cond. Change	Total Change	Prod. Change	Bus. Cond. Change	Total Change	Prod. Change	Bus. Cond. Change
1984-95†	0.969	1.060	0.914	1.066	1.087	0.981	1.055	1.092	0.966
1984-89†	0.988	1.038	0.952	1.077	1.119	0.962	1.062	1.127	0.942
1989-95†	0.953	1.057	0.902	1.057	1.090	0.970	1.049	1.109	0.946

Large Banks

	Cost			**Standard Profit**			**Alternative Profit**		
	Total Change	Prod. Change	Bus. Cond. Change	Total Change	Prod. Change	Bus. Cond. Change	Total Change	Prod. Change	Bus. Cond. Change
1984-95†	0.965	1.122	0.860	1.061	1.094	0.970	1.074	1.066	1.008
1984-89†	1.001	1.062	0.944	0.949	1.000	0.040	1.005	1.012	0.993
1989-95†	0.935	1.154	0.810	1.165	1.183	0.984	1.136	1.148	0.990

Total Change = $\hat{C}_{t+1}(X_{t+1})/\hat{C}_t(X_t)$ for cost; $\hat{\pi}_{t+1}(X_{t+1})/\hat{\pi}_t(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X_{t+1})/a\hat{\pi}_t(X_t)$ for alternative profit.

Prod. Change = $\hat{C}_{t+1}(X_t)/\hat{C}_t(X_t)$ for cost; $\hat{\pi}_{t+1}(X_t)/\hat{\pi}_t(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X_t)/a\hat{\pi}_t(X_t)$ for alternative profit. For cost, a positive number indicates a decrease in productivity.

Bus. Cond. Change = $\hat{C}_{t+1}(X_{t+1})/\hat{C}_{t+1}(X_t)$ for cost; $\hat{\pi}_{t+1}(X_{t+1})/\hat{\pi}_{t+1}(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X_{t+1})/a\hat{\pi}_{t+1}(X_t)$ for alternative profit.

X_t = average value of X_t over all banks in the sample in year t.

†Annualized (i.e., ratio raised to (1/no. of years) in the subperiod).

Table 7

Measured Bank Changes in Cost, Standard Profit, and Alternative Profit:
Total Change, Productivity Change, Business Conditions Change

Best-Practice U.S. Banks

Small Banks

	Cost			**Standard Profit**			**Alternative Profit**		
	Total Change	Tech. Change	Bus. Cond. Change	Total Change	Tech. Change	Bus. Cond. Change	Total Change	Tech. Change	Bus. Cond. Change
1984-95†	0.967	1.060	0.912	1.037	1.051	0.987	1.032	1.071	0.963
1984-89†	0.995	1.046	0.951	1.037	1.077	0.963	1.028	1.075	0.957
1989-95†	0.945	1.052	0.898	1.037	1.069	0.970	1.035`	1.098	0.943

Large Banks

	Cost			**Standard Profit**			**Alternative Profit**		
	Total Change	Tech. Change	Bus. Cond. Change	Total Change	Tech. Change	Bus. Cond. Change	Total Change	Tech. Change	Bus. Cond. Change
1984-95†	0.929	1.065	0.872	1.030	1.113	0.925	1.084	1.051	1.031
1984-89†	0.972	1.022	0.951	0.853	0.746	1.142	1.020	1.093	0.933
1989-95†	0.894	1.148	0.779	1.204	1.298	0.928	1.140	1.137	1.003

Total Change = $\exp[\hat{f}_{Ct+1}(X_{t+1})]/\exp[\hat{f}_{Ct}(X_t)]$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X_{t+1})]-\theta\}/[\exp[\hat{f}_{\pi t}(X_t)]-\theta\}$ for standard profit; and $\{\exp[\hat{f}_{a\pi t+1}(X_{t+1})]-\theta\}/\{\exp[\hat{f}_{a\pi t}(X_t)]-\theta\}$ for alternative profit.

Tech. Change = $\{\exp[\hat{f}_{Ct+1}(X_t)]-\theta\}/\{\exp[\hat{f}_{Ct}(X_t)-\theta]\}$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X_t)-\theta]\}/\{\exp[\hat{f}_{\pi t}(X_t)-\theta]\}$ for standard profit; and $\{\exp[\hat{f}_{a\pi t+1}(X_t)-\theta]\}/\{\exp[\hat{f}_{a\pi t}(X_t)-\theta]\}$ for alternative profit. For cost, a positive number indicates a decrease in technological change.

Bus. Cond. Change = $\{\exp[\hat{f}_{Ct+1}(X_{t+1})-\theta]\}/\{\exp[\hat{f}_{Ct+1}(X_t)-\theta]\}$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X_{t+1})-\theta]\}/\{\exp[\hat{f}_{\pi t+1}(X_t)-\theta]\}$ for standard profit; and $\{\exp[\hat{f}_{a\pi t+1}(X_{t+1})-\theta]\}/\{\exp[\hat{f}_{a\pi t+1}(X_t)-\theta]\}$ for alternative profit.

X_t = average value of X_t over all banks in the sample in year t.

†Annualized (i.e., ratio raised to (1/no. of years) in the subperiod).

Table 8
Change in Specific Business Conditions: Average-Practice U.S. Banks

All Banks	**Cost**		**Standard Profit**		**Alternative Profit**	
	1984-89	1989-95	1984-89	1989-95	1984-89	1989-95
Price of Purchased Funds (w_1)						
Price of Core Deposits (w_2)						
Price of Labor (w_3)						
Off-Balance Sheet Items (z_1)						
Physical Capital (z_2)						
Financial Equity Capital (z_3)						
Nonperforming Loan Ratio (MNPL)						
Other Environmental Variables (v)						
Loan Outputs (y_1 ,y_2 ,y_3 or p_1 ,p_2 ,p_3)						
Securities (y_4 or p_4)						

Small Banks	**Cost**		**Standard Profit**		**Alternative Profit**	
	1984-89	1989-95	1984-89	1989-95	1984-89	1989-95
Price of Purchased Funds (w_1)						
Price of Core Deposits (w_2)						
Price of Labor (w_3)						
Off-Balance Sheet Items (z_1)						
Physical Capital (z_2)						
Financial Equity Capital (z_3)						
Nonperforming Loan Ratio (MNPL)						
Other Environmental Variables (v)						
Loan Outputs (y_1 ,y_2 ,y_3 or p_1 ,p_2 ,p_3)						
Securities (y_4 or p_4)						

Large Banks	**Cost**		**Standard Profit**		**Alternative Profit**	
	1984-89	1989-95	1984-89	1989-95	1984-89	1989-95
Price of Purchased Funds (w_1)						
Price of Core Deposits (w_2)						
Price of Labor (w_3)						
Off-Balance Sheet Items (z_1)						
Physical Capital (z_2)						
Financial Equity Capital (z_3)						
Nonperforming Loan Ratio (MNPL)						
Other Environmental Variables (v)						
Loan Outputs (y_1 ,y_2 ,y_3 or p_1 ,p_2 ,p_3)						
Securities (y_4 or p_4)						

Change in business conditions in subset $X^I = \hat{C}_{t+1}(X^I_{t+1},X_t^{-I})/\hat{C}_{t+1}(X_t)$ for cost; $\hat{\pi}_{t+1}(X^I_{t+1},X_t^{-I})/\hat{\pi}_t(X_t)$ for standard profit; and $a\hat{\pi}_{t+1}(X^I_{t+1},X_t^{-I})/a\hat{\pi}_{t+1}(X_t)$ for alternative profit, where X^{-I} is the vector of all exogenous variables excluding the subset X^I and X_t = average value of X_t over all banks in the sample in year t.

Table 9

Change in Specific Business Conditions: Best-Practice U.S. Banks

All Banks	**Cost**		**Standard Profit**		**Alternative Profit**	
	1984-89	1989-95	1984-89	1989-95	1984-89	1989-95
Price of Purchased Funds (w_1)						
Price of Core Deposits (w_2)						
Price of Labor (w_3)						
Off-Balance Sheet Items (z_1)						
Physical Capital (z_2)						
Financial Equity Capital (z_3)						
Nonperforming Loan Ratio (MNPL)						
Other Environmental Variables (v)						
Loan Outputs (y_1, y_2, y_3 or p_1, p_2, p_3)						
Securities (y_4 or p_4)						

Small Banks	**Cost**		**Standard Profit**		**Alternative Profit**	
	1984-89	1989-95	1984-89	1989-95	1984-89	1989-95
Price of Purchased Funds (w_1)						
Price of Core Deposits (w_2)						
Price of Labor (w_3)						
Off-Balance Sheet Items (z_1)						
Physical Capital (z_2)						
Financial Equity Capital (z_3)						
Nonperforming Loan Ratio (MNPL)						
Other Environmental Variables (v)						
Loan Outputs (y_1, y_2, y_3 or p_1, p_2, p_3)						
Securities (y_4 or p_4)						

Large Banks	**Cost**		**Standard Profit**		**Alternative Profit**	
	1984-89	1989-95	1984-89	1989-95	1984-89	1989-95
Price of Purchased Funds (w_1)						
Price of Core Deposits (w_2)						
Price of Labor (w_3)						
Off-Balance Sheet Items (z_1)						
Physical Capital (z_2)						
Financial Equity Capital (z_3)						
Nonperforming Loan Ratio (MNPL)						
Other Environmental Variables (v)						
Loan Outputs (y_1, y_2, y_3 or p_1, p_2, p_3)						
Securities (y_4 or p_4)						

Change in business conditions in subset $X^I = \exp[\hat{f}_{Ct+1}(X^I_{t+1}, X_t^{-I})]/\exp[\hat{f}_{Ct+1}(X_t)]$ for cost; $\{\exp[\hat{f}_{\pi t+1}(X^I_{t+1}, X_t^{-I})] - \theta\}/\{\exp[\hat{f}_{\pi t}(X_t)] - \theta\}$ for standard profit; and $\{\exp[\hat{f}_{\pi t+1}(X^I_{t+1}, X_t^{-I})] - \theta\}/\{\exp[\hat{f}_{\pi t+1}(X_t)] - \theta\}$ for alternative profit, where X^{-I} is the vector of all exogenous variables excluding the subset X^I and X_t = average value of X_t over all banks in the sample in year t.