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Cost and Technical Change: Effects from Bank Deregulation

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David B. Humphrey
Federal Reserve Bank of Richmond

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David B. Humphrey

Federal Reserve Bank of Richmond

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ABSTRACT.

Banks were substantially deregulated during the 1980s. Interest costs rose faster than operating expenses (capital, labor) were reduced. As a result, measured technical change in banking was negative: it averaged -0.8% to -1.4% a year over 1977-88. Technical change was measured three different ways and for both equilibrium and disequilibrium factor input specifications. All three approaches--a standard time trend, an index approach, and shifts in cross-section cost functions--gave consistent results. These results were robust whether measured at the banking firm or office level, or at the cost frontier.

Cost and Technical Change: Effects from Bank Deregulation

I. Introduction.

U.S. banking activities were substantially deregulated during the 1980s. Most of this activity took place on the liability side of the balance sheet where deposit interest rate ceilings were removed and new types of interest bearing transactions accounts were authorized. At the same time, expenditures on information technology were quite high. Industrywide, these expenditures comprised perhaps as much as 20 percent of total (noninterest) operating costs or around $20 billion annually (Cooper, 1989).

Both of these events would be expected to be associated with rapid technical change and productivity growth in banking. Yet over 1977-86, the Bureau of Labor Statistics (BLS) measured an 11.1 percent increase in bank (single factor) labor productivity, or only 1.2 percent per year (BLS, 1989, p.170). But even this growth is seen to be overstated when it is (crudely) transformed into a more comprehensive multifactor measure. The average multifactor productivity growth rate (derived below) is only 0.5 percent a year over this period. Many researchers find such a low growth (in either measure) surprising given the very significant expenditures on information technology which have occurred (Baily and Gordon, 1988). The question, of course, is why has bank productivity growth been so low? This is the question we attempt to answer. The culprit seems to be the negative, cost increasing response by the banking industry to the recent deregulation. This disequilibrium response increased considerably the (secular) interest cost of loanable funds, an event in banking not unlike the oil price shock in manufacturing.

Technical change and productivity in banking are investigated using a consistent panel of 683 of the largest U.S. banks in a pooled time-series, cross-section analysis over 1977-88. These banks represent only 5 percent of all banks but accounted for $2 trillion out of the $3 trillion of U.S. banking assets. Three alternative methods of estimating technical change econometrically are utilized: the standard time trend approach, an index of technical change (Caves, Christensen, and Swanson, 1981; Baltagi and Griffin, 1988), and yearly shifts in cross-section cost functions (Berger and Humphrey, 1990b). These three approaches serve to demonstrate the robustness of our results. They also illustrate the superiority of the latter two methods when disequilibrium conditions exist. This is reinforced by separately contrasting the modeling results using equilibrium and disequilibrium versions of these three modeling approaches. Technical change at both the banking firm and average office level are derived.

The above issues are investigated using data on all banks in the panel and again for a set of the most efficient banks. Such a dual approach is necessary because cost efficiency in banking is quite variable even for similarly sized banks producing a similar product mix. Results for the banks on the cost frontier (the "efficient" banks) can be compared with those for all banks. This will indicate changes in dispersion toward or away from the frontier (for the "inefficient" banks). As a result, technological change can be identified separately from its dispersion, an identification not possible with existing studies which confound the two influences.

In what follows, we briefly discuss the bank regulatory changes which occurred during the 1980s and outline the nature of the industry's response in Section II. Existing estimates of bank technical change and productivity growth are then presented in Section III and it is shown how most of them have been overstated. Next, the three alternative modeling structures for estimating bank technical change are derived and compared (Section IV). These approaches are then adjusted for possible disequilibrium behavior in banking when deregulation occurred. The results of these alternative methodologies are presented and discussed in Section V. The effect that deregulation has had on measured technical change and bank productivity is also estimated, as is the effect of possible disequilibrium response to the deregulation which occurred. Lastly, the paper is summarized in Section VI and conclusions are drawn as to why banking has experienced such a low rate of technical change. Implications for the future are also noted.

II. Background of Bank Regulatory Change and Response.

Three Regulations That Were Changed. During the 1970s, the Federal Reserve pressed Congress for the power to assess reserve requirements on all depository institutions, not just member banks. The purpose was to improve monetary control. The result was the Depository Institutions Deregulation and Monetary Control Act (MCA) of 1980. In addition to making reserve requirements universal, the MCA: (a) required pricing for previously free Federal Reserve payment services (in order to maintain U.S. Treasury revenues); (b) phased-out Regulation Q interest rate ceilings on savings and small denomination (less than $100,000) time deposits; and (c) established interest bearing consumer checking accounts.[1] While the last change had already been successfully implemented for thrift institutions and banks in New

[1]Initially, interest bearing consumer checking accounts included only NOW (negotiable order of withdrawal) and ATS (automatic transfer of savings) accounts. ATS accounts could automatically transfer funds from interest bearing accounts to demand deposits when demand balances were drawn down. The MCA also permitted federally insured credit unions to issue share drafts, which were equivalent to checking accounts. Checkable business accounts were excluded and do not receive interest even today.

England as a regional experiment, a major impetus for this (and later) deregulation was the tremendous rise in market interest rates and the corresponding explosive growth in Money Market Mutual Funds (MMMFs). MMMFs had (limited) check writing privileges and were viewed as a strong substitute for bank consumer deposits.[2]

A major result of this deregulation was the rapid secular expansion of bank deposit interest expenses. As seen in Figure 1, inflation and deposit interest rate decontrol combined to push up deposit interest rates, and deposit interest cost per dollar of assets, by 42% between 1980, when the MCA was passed, and 1984. This occurred even after market rates hit their peak (of 14.0%) in 1981, after rising by over 160% from 1977 (when market rates were only 5.3%).

The climb in market rates (90 day Treasury bills) over the entire period 1977-88 is shown by the solid line in Panel A. This fluctuation is closely followed by the change in the average rate paid on bank purchased funds (bold dashed line).[3] The change in the average rate paid on demand, savings, and small time deposits had considerably less fluctuation (dashed line).[4] Importantly, however, the <u>spread</u> between these controlled rates and purchased

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[2]While the nationwide NOW accounts authorized by the MCA at the beginning of 1981 were competitive with the MMMFs, in 1982 the Garn-St Germain Depository Institutions Act directly authorized banks to develop a new account designed to be the equivalent of and directly competitive with MMMFs. This was the money market demand account (MMDA). MMMFs, which started in 1973, grew to $211 billion by 1982 (just less than 15% of household deposits). However, these balances fell by 27% in 1983 as depository institutions were able to offer this new and more competitive account (Fraser and Kolari, 1985, Table 2-3, p. 31).

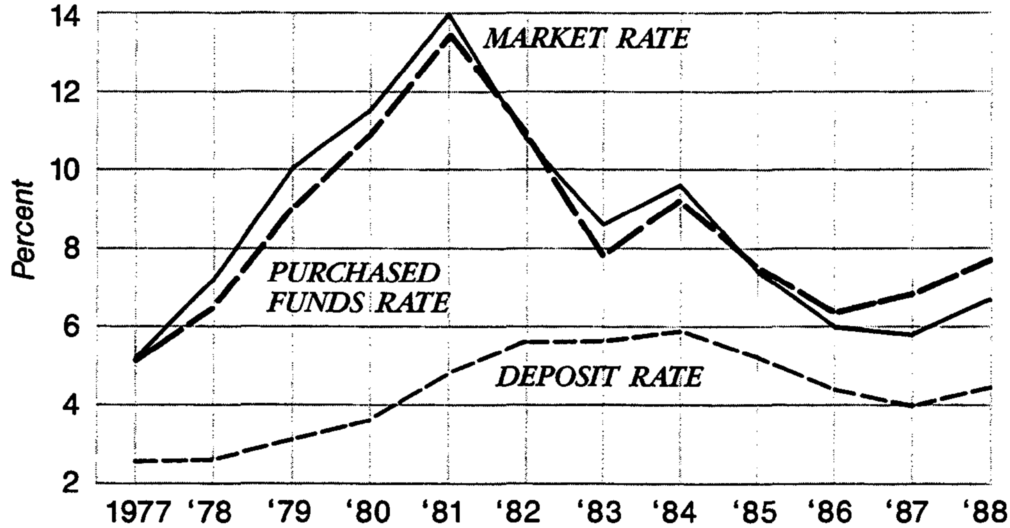
[3]Purchased funds include federal funds, large denomination (more than $100,000) CDs, Eurodollars, and other liabilities for borrowed money.

[4]Demand, savings, and small time deposits are usually demanded jointly and, since interest expenses are not allocated between these three types of deposits in the report forms used, the interest rates shown represent the average for all three types together.

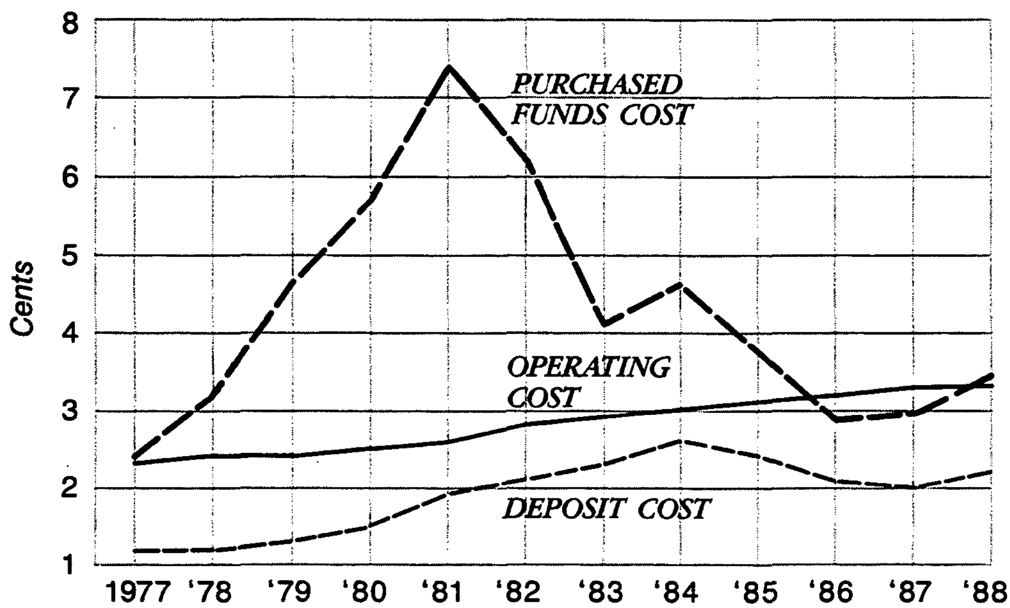
Figure 1

INTEREST RATES AND COSTS PER DOLLAR OF ASSETS: 1977-88

Panel A: Market, Purchased Funds, and Deposit Interest Rates (Percent)



Panel B: Deposit, Operating, and Purchased Funds Cost Per Dollar of Assets (Cents)



funds before decontrol (1977-80) and just before and after decontrol was completed (1985-88) was substantially narrowed from its pre-deregulation level.[5]

For the panel data set, 49% of assets are currently funded by produced deposits (demand, savings, and small time deposits) while 45% are funded by purchased funds.[6] Because these funding shares are similar and have not been subject to dramatic fluctuation, the effects from changing rates (Panel A) are largely duplicated in funding costs per dollar of assets. These costs are shown in Panel B for purchased funds (bold dashed line) and deposit interest costs (dashed line). On average, half (49 percent) of operating costs (solid line) are used to "produce" deposits, through the application of physical capital and labor for offices and check and information processing and related materials expenses, while virtually no operating costs are used to (directly) produce purchased funds.[7]

Comparing pre- and post-deregulation periods, it is seen that the cost of purchased funds per dollar of assets rose by 14 percent between 1977-78 and 1987-88 while operating costs (capital, labor, and related expenses) rose by 40 percent. Importantly, deposit interest costs per dollar of assets rose by

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[5]The average market rate in 1977-78 and 1987-88 was 6.25% while the average deposit rate was 2.6% and 4.2%, respectively. The spread was 3.65 percentage points in 1977-78 but fell to 2.05 percentage points in 1987-88. Thus the spread was reduced by 1.6 percentage points after deregulation (a drop of 44%).

[6]The remainder is comprised of equity capital, subordinated notes and debentures and certain reserves. The levels of these expensive sources of funds are largely determined as regulatory imposed minimums, although they have fluctuated over time.

[7]Many purchased funds are obtained from other banks who sell their produced deposits to larger institutions. Thus purchased funds are, indirectly, produced deposits. These allocations rely on the cost allocations shown for large banks in the <u>Functional Cost Analysis</u> reports for 1980, 1984, and 1988 (Board of Governors of the Federal Reserve System).

75 percent, showing the relative impact of deregulation. Thus interest rate decontrol on deposits and the establishment of interest earning checking accounts have significantly increased the long-term cost of an important component of loanable funds in the banking system.

Banking Industry Response. The response has been twofold. First, there was an attempt to pass on to borrowers some of the increased cost of loanable funds resulting from inflation and deregulation. Except for medium sized business borrowers with floating rate loans or those borrowers with few alternatives (e.g., consumer installment credit, small business loans, and credit card and home loans), this approach met with limited success.[8] This is because the main alternative to a large bank business loan is the commercial paper market. Here large business borrowers have increasingly dealt directly with large lenders and have lowered funding costs by leaving out the bank intermediary. This substitute market for the most profitable class of bank loans has grown from $124 billion in 1980, the time that interest rate deregulation was passed, to $455 billion in 1988 (an 18% annual compound rate of growth).[9]

A second banking industry response has been to cut back on the growth of operating costs. Many banks have sold or closed hundreds of branch offices and labor has been redeployed or let go.[10] Instead of providing new branch

[8]At this time, only 41% of surveyed bank loans were tied to a floating rate. The other loans carried a fixed rate, although their average maturity was short--only 7 months (Board of Governors of the Federal Reserve System, statistical release E.2, February 1981 and 1982).

[9]Commercial paper is an effective substitute for commercial and industrial (C&I) loans, which have grown only about half as fast (10% a year). By 1988, the value of commercial paper was 76% of the value of bank C&I loans.

[10]For example, Bank of America has cut staff by 34% and number of branches by 27% (or 350 offices). Manufacturers Hanover has cut staff by 24%. Many other large banks have implemented similar, if less drastic cuts (Bennett, 1987; Weiner, 1989).

offices at a rate equal to or greater than that at which deposits grew, so that the deposit/branch ratio would remain roughly constant or fall as it did prior to interest decontrol, lifting the interest rate ceilings had the result that the (real) deposit/branch ratio rose by 27% over 1982-88. This conserved physical capital and led to more intensive use of existing bank offices than before.

Prior to interest rate deregulation, banks substituted convenient branch offices, service personnel, and nonpriced services (e.g., free checking) for their inability to pay something close to a market rate on demand, savings, and small time deposits (Evanoff, 1988).[11] Once the interest rate ceilings were removed and consumer interest checking was offered, banks quickly paid the higher rates. From a cost standpoint, they subsequently found themselves to be "overbranched", so the substitution was reversed over time. Because deposit interest expenses rose with a short lag, while reductions in overbranching took considerably longer, there was a divergence of short-run equilibrium (where an excess of bank offices and service personnel can exist) from long-run equilibrium (where all inputs are close to being fully employed).

III. Existing Bank Productivity Estimates and Why They are Overstated.

Total Cost Technical Change And Single Factor Bank Productivity. A simple comparison of existing bank productivity estimates is given in the table below. The technical change results shown can understate total factor

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[11]The case of airlines was similar. Since airline fares were regulated while service quality was not, competition prior to deregulation took the form of providing more frequent flights for customer convenience. Thus airline costs rose to meet the regulated fares being charged, rather than fares falling to meet the lower cost of less frequent or convenient flights (Sickles, Good, and Johnson, 1986, p. 145).

productivity (TFP) since they only reflect one of (at least) three components of a decomposed banking TFP (Kim and Weiss, 1989).[12] The other two components are a scale effect, which could increase TFP, and a branching effect, which could decrease it. These two effects, in our view, are likely to largely offset each other or be small and thus not unduly bias the simple comparison we wish to make.[13]

All three of these bank technical change studies employed a standard time trend to capture the effect of technical change. In the first study, total banking costs over 1980-86 are used. Total costs are composed of operating costs (capital, labor, and other noninterest operating costs) as well as interest expenses, which are 68 percent of total costs for all banks (in 1987). When total cost is used, estimated technical change is

A Comparison of Bank Productivity Estimates
(percent, annual averages)

Time Period	Technical Change	Single Factor
1980-1986	1.0	3.3
1972-1987	2.0	1.8
1972-1982	1.4	0.4

Sources: Technical change results are from Hunter and Timme, 1988; Evanoff, et. al., 1989; and Hunter and Timme, 1986, respectively. Single factor results are output per employee, BLS, 1989.

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[12]Other components identified in other industry applications have concerned the deviation of prices from marginal costs in the output market and deviations of shadow prices from market prices in the input market (e.g., Denny, Fuss, and Waverman, 1981).

[13]Flat or slightly U-shaped average cost curves are evident for the large banks in this and other banking studies when total (operating plus interest) costs are employed. Cost curves relating only to operating costs (as in the last two technical change studies shown in the text table) typically yield significant scale economies. However, this is because the larger banks in these studies increasingly rely on purchased funds so that operating costs per dollar of assets (an approximation to average costs) will necessarily fall for this reason alone. This conclusion follows because when total costs are used, incorporating as they do the substitution of purchased funds for produced deposits, these scale economies typically disappear (see Hunter and Timme, 1986, pp.163-4 for an example).

considerably lower (1.0 percent)[14] than the single factor (labor) estimate provided by the BLS (3.3 percent).[15] But technical change is effectively a multifactor measure, covering the contribution to output of both capital (K) and labor (L). If K and L both grow at the same rate, then the single factor productivity measure will equal the multifactor measure. However, when the growth of real capital (39.9 percent) exceeds that of labor (13.8 percent) over the 6 years 1980-86, then the single factor measure will always exceed the multifactor measure. And this is the main reason for the difference between the total cost technical change measure and the single factor productivity measure shown in the table. When the BLS single factor measure is (crudely) transformed into a multifactor measure for 1980-86,[16] the result is a 1.5 percent annual average rate of growth in bank multifactor productivity, closer to the econometric estimate of total cost technical change.[17] Thus it is seen, because the growth rate of bank capital stock has

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[14]This 1.0% figure is from estimating a third-order translog cost function. When a (more standard) second-order function is used, the rate of estimated technical change falls to 0.4% annually.

[15]The BLS measure divides an index of bank output by an index of bank employment. The output index is a weighted average of flow measures of banks' check and electronic payment volume, number of deposits/withdrawals, number of new loans, and number of trust accounts serviced. The weights, whether employment, cost, or revenue, are from various Functional Cost Analysis reports and other sources.

[16]The single factor BLS measure can be alternatively derived by subtracting the log of the BLS labor input index over the 6 years 1980-86 (109.2) from their output index (132.3), with 1980 = 100.0, and solving for the implied compound annual growth rate (giving 3.3% a year). In our panel data set, the number of employees rose by 13.8% while the real (GNP "price" deflated) book-value of bank capital stock grew by 39.9%. The cost share weighted average growth rate of these labor and capital inputs over 1980-86 is 20.8% (= 13.8%(.73) + 39.9%(.27)). The implied annual growth in multifactor productivity is thus only 1.5% (= exp ((ln 132.3 - ln 120.8)/6) - 1.0).

[17]Unfortunately, the Hunter and Timme (1988) econometric result of a 1% average yearly rate of technical change is not duplicated by our results below. Their study specified only two outputs--all deposits excluding purchased funds and all loans--and looked only at banks with assets greater than $750 million, but excluded money center banks. Ours is a broader based analysis and results for large and small banks are contrasted below.

exceeded that of employment, that the BLS single factor measure is substantially overstated and not a good indicator of overall bank productivity during this period.

Total Cost Versus Operating Cost Technical Change. The two remaining econometric studies determined technical change from a model employing the standard time trend related to bank operating cost, not total cost.[18] If the 68 percent of total costs which comprise interest expenses is assumed to experience no technical change, then technical change associated with total cost will only be around 32 percent as high as the technical change associated with the operating costs in these two studies (or 0.6 and 0.4 percent, respectively).[19] Thus estimates of bank technical change drawn from time-related percent decreases in operating costs likely overstate the percent decreases actually accruing to total cost for the same degree of overall technical advance.[20]

The issue of operating cost versus total cost technical change raised here highlights an important conceptual problem, one probably not faced in other industries. Banks routinely purchase loanable funds from each other in

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[18]These two studies cover different time periods. As well, the last one (Hunter and Timme, 1986) was estimated assuming no quasi-fixed inputs while the previous one (Evanoff, et. al, 1989) utilized one of the modeling structures permitting capital to be quasi-fixed. In this study, the relative shadow price of capital was found to be only around half of its market price, suggesting substantial excess capital capacity in banking sometime over 1972-87.

[19]This illustrative computation assumes that total cost technical change ($TECH_{TC}$) is a simple weighted sum of operating cost technical change ($TECH_{OC}$) and interest cost technical change ($TECH_{IC}$). Since $TECH_{TC} = .32\ TECH_{OC} + .68\ TECH_{IC}$, and $TECH_{IC} = 0$ by assumption, then estimates of $TECH_{TC}$ will only be 32% as large as the estimate of $TECH_{OC}$ shown in the table.

[20]Hunter and Timme (1986) did compute technical change using total cost rather than only operating cost and found it to be negative (but insignificant). However, in adding interest expenses to the LHS, they failed to hold the average interest rate constant on the RHS and so these results can not be relied upon.

the interbank market, with smaller banks being net sellers and larger banks being net buyers. Indeed, the vary largest banks purchase more than half of their funds rather than produce them internally. As a result, the on-going consolidation of the banking industry through mergers would alter the average proportions of operating and interest expenses in total cost over time for this reason alone, even if nothing else changed. The purchased funds interest cost share would necessarily fall while the cost shares for produced deposit interest and for capital and labor operating costs would rise.[21]

Bank mergers and acquisitions have increased significantly during the 1980s. However, their pace will accelerate considerably when many existing interstate and interregional barriers to acquisitions are phased out in the mid 1990s. At the extreme, the U.S. could look like Canada or certain European nations where 90 percent of all banking assets and deposits are concentrated in 5 to 10 large institutions.[22] Such a consolidation would lead to increases in measured total cost technical change due solely to a reduction in the purchased funds interest expense weight in total cost (assuming, as seems reasonable, that these interest expenses experience little or no positive technical change). This potential bias is accounted for in the modeling structure proposed below through the specification of a dummy variable for the year in which the 391 bank mergers in the panel data set occurred.

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[21]At the limit, never to be achieved, there would be one bank which would produce all of its own deposits rather than purchase significant portions of them from other banks. Here, the proportion of operating costs to total costs would be at its highest possible level.

[22]Only 6 banks account for over 90 percent of banking assets in Canada while in the U.S. it currently would take over 3,000. Current industry guesstimates are that nationwide interstate banking could reduce by two-thirds the number of banks accounting for 90 percent of U.S. banking assets by the turn of the century.

IV. Three Econometric Models of Bank Technical Change.

Technical Change From A Time Trend. A basic problem with measuring technical change in a service industry like banking is that there is no unique indicator or proxy for measuring technical progress, such as the real value of research and development expenditures or the average age or vintage of capital equipment used in other industry studies. Thus it is not surprising that all banking studies have to date chosen to model technical change as a simple time trend. Within the context of a general translog cost function, the time trend model we estimate is as follows:

$$(1)\ \ln TC = \alpha_o + \sum_i^5 \alpha_i \ln Q_i + \sum_k^4 \alpha_k \ln P_k + \alpha_B \ln B + \alpha_M M + \alpha_U U + \alpha_T T$$

$$+ 1/2 \sum_i^5 \sum_j^5 \delta_{ij} \ln Q_i \ln Q_j + 1/2 \sum_k^4 \sum_l^4 \gamma_{kl} \ln P_k \ln P_l + \beta_{BB}\, 1/2(\ln B)^2$$

$$+ \beta_{TT}\, 1/2\, (T)^2 + \sum_i^5 \sum_k^4 \rho_{ik} \ln Q_i \ln P_k + \sum_i^5 \theta_{iB} \ln Q_i \ln B + \sum_i^5 \theta_{iM} \ln Q_i\, M$$

$$+ \sum_i^5 \theta_{iU} \ln Q_i\, U + \sum_i^5 \theta_{iT} \ln Q_i\, T + \sum_k^4 \phi_{kB} \ln P_k \ln B + \sum_k^4 \phi_{kM} \ln P_k\, M$$

$$+ \sum_k^4 \phi_{kT} \ln P_k\, T + \pi_{BM} \ln B\, M + \pi_{BU} \ln B\, U + \pi_{BT} \ln B\, T + \rho_{MT}\, M\, T + \rho_{UT}\, U\, T$$

$$(2)\ \ S_k = \alpha_k + \sum_l^4 \gamma_{kl} \ln P_l + \sum_i^5 \rho_{ik} \ln Q_i + \phi_{kB} \ln B + \phi_{kM} M + \phi_{kT} T + \mu$$

where: TC = total cost (interest and operating expenses);

Q_i= output (i = value of demand deposits, small time and savings deposits, real estate loans, installment loans, and commercial and industrial loans, all deflated by the GNP deflator);

P_k= input prices(k = labor, physical capital, deposit interest rate, purchased funds interest rate);

B = number of banking offices;

M = bank merger dummy variable;

U = unit bank dummy variable, to capture the effects of moving from unit banking to intrastate branching in 8 states over 1977-88;

T = a time trend dummy variable, $T = 1,2,\ldots,12$ for the 12 years; and

S_k= input cost share $\partial \ln TC/\partial \ln P_k$ (only k-1 shares are used in estimation).[23]

As shown in Caves, Christensen, and Swanson (1981), technical change in a multiproduct framework can either be defined as (a) the common rate of output expansion holding inputs fixed or (b) the common rate of input reduction holding outputs fixed. The latter is expressed as $-(\partial \ln TC/\partial T)$ while the former is $-(\partial \ln TC/\partial T)/\sum_i(\partial \ln TC/\partial \ln Q_i)$.[24] If banking experiences constant returns to scale (i.e., $\sum_i(\partial \ln TC/\partial \ln Q_i)=1.0$), then the two expressions are the same. While the value of (a) is noted below, our focus is on (b) or $-(\partial \ln TC/\partial T)$ derived from (1) and (2):

$$(3)\ TREND = \alpha_T + \beta_{TT}\, T + \sum_i^5 \theta_{iT} \ln Q_i + \sum_k^4 \phi_{kT} \ln P_k + \pi_{BT} \ln B + \rho_{MT}\, M + \rho_{UT}\, U.$$

The growth in technical change arises from the pure effect of technical advance which saves or uses inputs in constant proportions (neutral technical change or $\alpha_T + \beta_{TT}$), effects associated with saving or using inputs in

[23]The standard symmetry and homogeneity of degree 1.0 in input prices is imposed in estimation, as are the cross-equation coefficient restrictions between (1) and (2). It was maintained, because of competitive factor markets and a lack of any strong monopsony power by banks, that the movement from unit to intrastate branching was unlikely to affect input prices. Thus the interaction between $\ln P_k$ and U is not specified, nor is there an interaction term between M and U.

[24]In effect, when output expands but inputs are held constant, the effects on costs of the output expansion need to be controlled so that what remains is only the effect on costs of the change in technology, not technology and scale together.

nonconstant proportions (nonneutral technical change or $\sum_{k}^{4} \phi_{kT} \ln P_k$), and effects associated with changes in outputs (scale augmenting technical change or $\sum_{i}^{5} \theta_{iT} \ln Q_i$). A number of recent studies in the electric utilities area have suggested that, while the rate of technical change obtained using the time trend is probably accurate when evaluated at the mean of a time series data set, it will poorly reflect the year-to-year variation in technical change when this process is not constant or smoothly increasing or decreasing (Kopp and Smith, 1983; Nelson, 1986). Because of the dearth of indicators of technical advance in banking, two other alternative representations of technical change are also estimated: an index approach and shifts in cross-section cost functions. The purpose is both to demonstrate the robustness (if any) of the technical change results as well as contrast the effects of different approaches, since the time trend method has been the only one used in banking to date.

An Index of Technical Change. The time trend approach specifies and yields a smooth rate of technical advance. The index approach effectively permits technical change to be nonsmooth, so that substantial year-to-year variations can occur if they exist in the data. This approach, initiated in Caves, Christensen, and Swanson (1981) and developed more completely by Baltagi and Griffin (1988), is a generalization of Solow's index of technical change $A(t)$. Our approach utilizes a time-specific shift variable (D_t) which enters by itself as an intercept (for neutral technical change) as well as interacting with outputs (for scale augmentation) and input prices (for nonneutral change).[25] As applied in this comparative study, the cost

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[25]This follows Caves, Christensen, and Swanson (1981). Baltagi and Griffin (1988) did this and also specified numerous nonlinear restrictions for implementation, in order to obtain the same $A(t)$ effect for neutral,

(continued...)

function system (1) and (2) becomes:

$$(4)\ \ln TC = \sum_{t}^{12} n_t D_t + \sum_{i}^{5}\sum_{t}^{12} \alpha_{it} D_t \ln Q_i + \sum_{k}^{4}\sum_{t}^{12} \alpha_{kt} D_t \ln P_k + \sum_{t}^{12} \alpha_{Bt} D_t \ln B + \alpha_M M + \alpha_U U$$

$$+ 1/2 \sum_{i}^{5}\sum_{j}^{5} \delta_{ij} \ln Q_i \ln Q_j + 1/2 \sum_{k}^{4}\sum_{l}^{4} \gamma_{kl} \ln P_k \ln P_l + \beta_{BB}\, 1/2(\ln B)^2$$

$$+ \sum_{i}^{5}\sum_{k}^{4} \rho_{ik} \ln Q_i \ln P_k + \sum_{i}^{5} \theta_{iB} \ln Q_i \ln B + \sum_{i}^{5} \theta_{iM} \ln Q_i\, M$$

$$+ \sum_{i}^{5} \theta_{iU} \ln Q_i\, U + \sum_{k}^{4} \phi_{kB} \ln P_k \ln B + \sum_{k}^{4} \phi_{kM} \ln P_k\, M$$

$$+ \pi_{BM} \ln B\, M + \pi_{BU} \ln B\, U + \epsilon$$

$$(5)\ S_k = \alpha_{k1} + \sum_{l}^{4} \gamma_{kl} \ln P_l + \sum_{i}^{5} \rho_{ik} \ln Q_i + \phi_{kB} \ln B + \phi_{kM} M + \mu$$

where: D_t = a shift dummy variable which equals 1.0 in period t and zero in other periods, t=1,2,..,12 years.

In this specification the growth rate of technical advance is expressed yearly as $-(\partial \ln TC/\partial D_{t+1} - \partial \ln TC/\partial D_t)$:

$$(6)\ INDEX = n_{t+1} - n_t + \sum_{i}^{5} \ln Q_i\, (\alpha_{it+1} - \alpha_{it}) + \sum_{k}^{4} \ln P_k\, (\alpha_{kt+1} - \alpha_{kt}) + \ln B\, (\alpha_{Bt+1} - \alpha_{Bt}).$$

The index for period 1, the base period, is zero so the estimated parameters n_1, α_{i1}, α_{k1}, and α_{B1} do not reflect technical change but represent, respectively, the overall equation intercept (α_o) and slope parameters for each output and input price plus the branching variable.[26] In period 2,

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[25](...continued) nonneutral, and scale augmenting technical change, in a manner similar to that for T in the time trend model above.

[26]Thus $n_1 = \alpha_o$ and the slope parameters are $\Sigma\, \alpha_{i1} \ln Q_i$, $\Sigma\, \alpha_{k1} \ln P_k$ and $\alpha_{B1} \ln B$ in period 1 and all following periods.

INDEX is positive or negative, reflecting technical advance or retrogression, and equals $n_2 - n_1 + \sum_{i}^{5} \ln Q_i \, (\alpha_{i2} - \alpha_{i1}) + \sum_{k}^{4} \ln P_k \, (\alpha_{k2} - \alpha_{k1}) + \ln B \, (\alpha_{B2} - \alpha_{B1})$, and so on for later periods.[27]

<u>Technical Change from Shifts in Cross-Section Cost Functions.</u> In the time-specific index approach to technical change it was maintained that technical change is only reflected in pure intercept shifts and possible interactions with outputs, input prices, and number of branch offices. A more general approach, possible when there are sufficient cross-section observations, would be to allow all cost function parameters to be affected by technical change (Berger and Humphrey 1990b). Because all parameters are permitted to vary over time, the time-specific index approach using D_t above is essentially nested within it.[28] The model is equivalent to the equation system (1) and (2) with all time variables set to zero and the resulting specification separately estimated for each cross-section time period.[29] The growth rate of technical change is reflected in the percentage difference in predicted average costs *($\hat{AC}$)* using the estimated parameters from periods t_{t+1}

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[27]While the actual sign of technical advance is negative, since a fall in costs is associated with the positive passage of time in either (3) or (6), it will always be expressed here as a positive value to be consistent with measures of productivity advance.

[28]This would not include the general index approach of Baltagi and Griffin (1988) since theirs requires nonlinear restrictions for implementation.

[29]The cross section model also equals equations (4) and (5) with α_o replacing $\sum_{t}^{12} n_t D_t$, $\sum_{i}^{5} \alpha_i \ln Q_i$ replacing $\sum_{i}^{5} \sum_{t}^{12} \alpha_{it} D_t \ln Q_i$, $\sum_{k}^{4} \alpha_k \ln P_k$ replacing $\sum_{k}^{4} \sum_{t}^{12} \alpha_{kt} D_t \ln P_k$, *and* $\alpha_B \ln B$ replacing $\sum_{t}^{12} \alpha_{Bt} D_t \ln B$. In estimation, the variables U and $\ln Q_i \, U$ were deleted because of collinearity problems in the smaller sample set when each cross-section was separately estimated.

and t but evaluated using data from the base period t:

$$(7)\ SHIFT = -(\hat{AC}^{*}_{t+1} - \hat{AC}_{t})/\hat{AC}_{t}$$

where: $\hat{AC}_t$ = exp $(\hat{\beta}_t(X_t))/TA_t$ or predicted average total cost per dollar of assets;

$\hat{\beta}_t$ = the estimated cost function parameters of period t;

X_t = data from period t (in logs) used to evaluate the parameters;

TA_t = total value of bank assets; and

$\hat{AC}^{*}_{t+1}$ = exp $(\hat{\beta}_{t+1}(X_t))/TA_t$ or predicted average total cost using parameters from t+1 evaluated with t period data.

In effect, these three models of technical change range from specifying a smooth rate of technical advance (*TREND*) to a rate of advance that can be quite discontinuous (*SHIFT)*, with the middle ground covered by a model that blends elements of both approaches (*INDEX*).[30]

Equilibrium Versus Disequilibrium Specifications. Models of bank behavior assume that banks move from one equilibrium position to another (Evanoff, et. al., 1989 being the exception). Such an assumption is probably appropriate as long as changes in output demand and/or input prices are relatively small and/or smooth, and therefore forcastable. But such a situation clearly does not apply to banking deregulation in the 1980s. The value of funds in the new and decontrolled accounts rose from $165 billion in 1980 (and were located only in New England) to almost $500 billion three years later. They leveled off at $677 billion by 1988 and funded almost one-fourth of all bank assets.

The pre-deregulation equilibrium was one where a given level of bank

[30]In *TREND*, all estimated parameters are stable over time while in *SHIFT* all parameters can change at each point in time. In *INDEX*, the D_t parameters change at each point in time while all other parameters are stable over time (hence the "blend").

service output was provided using relatively large amounts of operating inputs (in the form of convenient branches and free, or substantially below cost, deposit services) and small amounts of interest inputs. The high amount of operating inputs effectively compensated depositors for the regulated inability of banks to pay something close to a market interest rate on deposits. The post-deregulation equilibrium is one where the deposit rate paid more closely reflects the market rate, both in terms of level and fluctuation. As well, net operating costs have fallen to help offset the rise in interest expenses, through reductions in overbranching and imposition of explicit fees (or minimum balance requirements) for previously free deposit services. Since interest rates rose more rapidly than operating costs were reduced, the deregulation induced shift in equilibrium positions has likely been one of disequilibrium during the transition.[31]

The cost functions specified above have assumed that all inputs were fully utilized and reflected equilibrium usage. But, from a cost standpoint after interest rates were deregulated, banks found themselves "overbranched" and cut back on their earlier rates of expansion. This allowed deposit growth to exceed that of branches so that the (real) deposit/branch ratio rose, reducing excess branch capacity. One way to model this disequilibrium behavior is through use of a restricted cost function where capital is treated as a quasi-fixed input and variable costs are minimized subject to the level of capital in place. In effect, the quantity of the capital input replaces

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[31]As shown by Berndt and Fuss (1986) and others, a temporary or short-run equilibrium model structure can significantly affect estimates of productivity. In this work, where capital is the quasi-fixed input, adjustments for variations in capacity utilization in U.S. manufacturing can account for between one and three fifths of this sector's conventionally measured decline in total factor productivity. In banking, capital costs are only 15 to 20% of total costs so the effects of a quasi-fixed capital input would be expected to be correspondingly smaller.

the price of capital in the equilibrium total cost functions above and this quantity enters the equation as a separate argument (with own, squared, and interaction terms with the other variables). When bank physical capital is treated as a quasi-fixed input in the time trend model above we have:

$$(8)\ \ln VC1 = (1) + \alpha_F \ln F + \beta_{FF}\, 1/2(\ln F)^2 + \sum_k^3 \gamma_{kF} \ln P_k \ln F$$

$$+ \sum_i^5 \rho_{iF} \ln Q_i \ln F + \phi_{FB} \ln F \ln B + \phi_{FM} \ln F\, M + \phi_{FT} \ln F\, T$$

$$(9)\qquad S_k = (2) + \gamma_{kF} \ln F$$

where $VC1$ = variable cost (total cost minus expenditures on capital);

F = quasi-fixed input, capital K;

$S1_k$ = input cost share in variable cost (not total cost) for the variable inputs; and

all summations for the 4 variable input prices in (1) and (2) are now done over 3 input prices (as the price of capital has been deleted). Similar adjustments to the equilibrium index and shift models will transform them into disequilibrium specifications. The three technical change measures now reflect changes in variable cost *VC1* and have a correction factor which permits the technical change measure from *VC1* to equal that from a total cost function (e.g.,equations 3, 6, or 7) if total costs--not just variable costs--are being minimized. These variable cost measures of technical change are denoted as *TREND1*, *INDEX1*, and *SHIFT1*.[32]

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[32]As shown in Caves, Christensen, and Swanson (1981), technical change in the time trend model ($TREND = -(\partial \ln TC/\partial T)$) becomes $TREND1 = -(\partial \ln VC1/\partial T)/[1.0 - \partial \ln VC1/\partial \ln K]$. The alternative definition of time trend technical change--the common rate of output expansion holding inputs fixed--is correspondingly altered from $-(\partial \ln TC/\partial T)/\Sigma(\partial \ln TC/\partial \ln Q_i)$ to $-(\partial \ln VC1/\partial T)/\Sigma(\partial \ln VC1/\partial \ln Q_i)$. As well, the index measure becomes $INDEX1 = -(\partial \ln VC1/\partial D_{t+1} - \partial \ln VC1/\partial D_t)/[1.0 - \partial \ln VC1/\partial \ln K]$ and the shift measure $SHIFT1 = -((\hat{AC}1^*_{t+1} - \hat{AC}1_t)/\hat{AC}1_t)/[1.0 - \partial \ln VC1_t/\partial \ln K_t]$,

(continued...)

For completeness, labor as well as capital is treated as a quasi-fixed input. The specification is the same as (8) except that *F* refers to two quasi-fixed inputs (involving a summation over capital and labor whenever *F* is specified); *VC2* replaces *VC1* and only contains interest expenses; and all summations for the variable input prices are done over only the two interest rates.[33]

V. Estimates of Bank Technical Change.

The three alternative specifications of bank technical change, for both the equilibrium and disequilibrium models, were all estimated using an iterative, seemingly unrelated regression procedure. For the time trend and index models, an autocorrelation correction was necessary.[34] A brief description of the panel data set is given in the Appendix.[35]

A Comparison of Results for the Banking Firm. Technical change can be derived for the banking firm as well as for the average branch office. For our purposes, the former is more interesting as it recognizes that bank output

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[32](...continued)
where $\hat{AC1}$ is predicted average variable cost from *VC1*. In general, the term in brackets is .90 and raises the technical change result by around 10%.

[33]Correspondingly $TREND2 = -(\partial \ln VC2/\partial T)/[1.0 - \partial \ln VC2/\partial \ln K - \partial \ln VC2/\partial \ln L]$, $INDEX2 = -(\partial \ln VC2/\partial D_{t+1} - \partial \ln VC2/\partial D_t)/[1.0 - \partial \ln VC2/\partial \ln K - \partial \ln VC2/\partial \ln L]$, and $SHIFT2 = -((\hat{AC2}^*_{t+1} - \hat{AC2}_t)/\hat{AC2}_t)/[1.0 - \partial \ln VC2_t/\partial \ln K_t - \partial \ln VC2_t/\partial \ln L_t]$.

[34]The autocorrelation parameter ρ was estimated using the pooled 683 cross-section by 12 time-period panel data set, but excluding the relation between ϵ_t and ϵ_{t-1} when the data shifted from a set of observations on one bank over 12 years to another bank in the cross-section over the same 12 years. The data were transformed using the standard generalized differences approach (see Wonnacott and Wonnacott, 1979, pp. 216-18). The resulting $\hat{\rho}$, a slightly different one for each of the three models, was around .87. The same $\hat{\rho}$ was used for all equations in each system estimated (following Berndt and Savin, 1975).

[35]The Appendix also discusses the results of estimation with a different price of capital and justifies the use of the GNP deflator in deriving real bank outputs from value measures. Other data problems are also addressed.

can be expanded in two different ways. First, more output can be supplied when deposits and loans grow at each existing branch. Second, deposits and loans can grow if new branches are added in new market areas. To examine technical change at the level of the banking firm we would not wish to hold the number of branches constant. Thus, in deriving the following results, the branching variable (B) has correspondingly been set to zero in all of the above equations. This permits the technical change results to reflect the variation in B as well as the variation in output per office. When technical change at the average banking office is examined (below), B is not set to zero in these equations and technical change is measured holding B constant.[36]

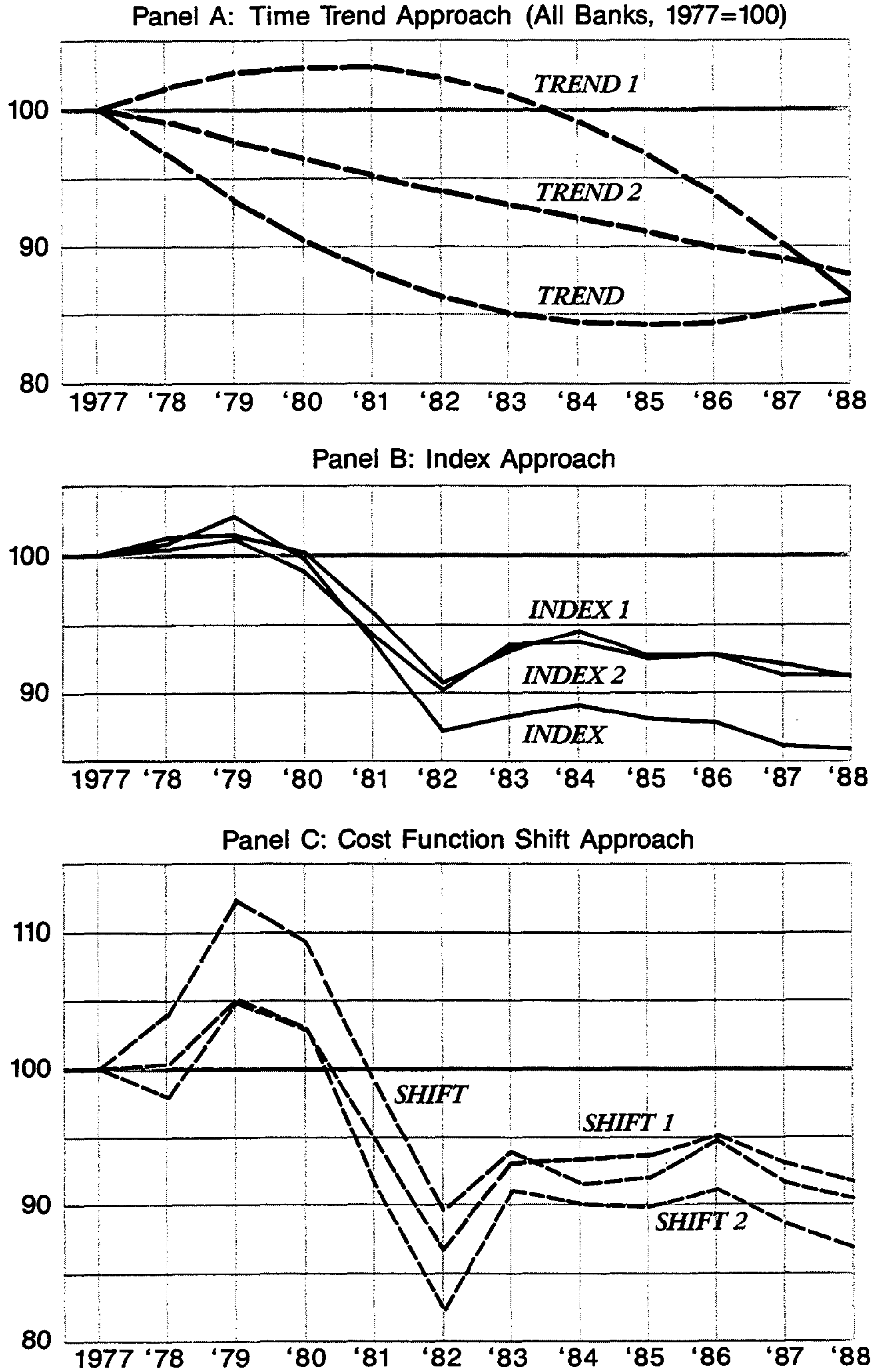
Indices of bank technical change for the banking firm over 1977-1988 are shown in Figure 2, where the *TREND*, *INDEX*, and *SHIFT* technical change specifications are each contrasted across three model types. Thus Panel A shows the time trend results for the equilibrium model where all factor inputs are presumed to be variable (*TREND*), the model where capital is the single quasi-fixed input (*TREND1*), and the model where both capital and labor are assumed to be quasi-fixed (*TREND2*). Similarly, Panels B and C show all three model types for the *INDEX* and *SHIFT* specifications of technical change.

Overall, there is a basic similarly in the banking firm results: bank technical change was generally positive during the pre-deregulation period 1977-80, turned strongly negative when deregulation was initiated in 1981, adjusted somewhat two years later, but flattened out from 1983-88 to finish up the period in an overall negative position. This pattern, with some variation, holds for all three of the technology specifications and all three

[36]This distinction between branch office and banking firm applies as well to bank scale economies, where significant differences were observed (Benston, Hanweck, and Humphrey, 1982).

Figure 2

INDICES OF BANK TECHNICAL CHANGE 1977-88: Comparison of Time Trend, Index, and Cost Function Shift.



of the equilibrium/disequilibrium models used.[37] As would be expected if some inputs were in disequilibrium during this period, the model which presumes equilibrium usage of all inputs typically shows a larger reduction in bank technical change during the period of adjustment than models which explicitly account for the possibility of disequilibrium behavior.

Which specification of bank technical change is best? It all depends on whether one wishes to capture "accurately" the year-to-year behavior and identify turning points or whether one is satisfied in describing the period in question with a single number, such as the average yearly rate of technical change. As seen in Figure 2, the index and cost function shift approaches show significant year-to-year variation in rates of technical change and identify similar time periods for the important turning points. The time trend approach, of course, is unable to show such variation.

Alternatively, if one merely wishes to represent technical change as a single average yearly value over the period in question, then it would seem that any of the models shown in the table below could be selected without much difference in the results obtained. As seen in the following table, all the average yearly rates of technical change have the same sign and a similar value for each of the equilibrium or disequilibrium models estimated.[38] Overall, technical change in banking was negative and ranged from -0.8 to -1.4 percent a year over 1977-88.[39]

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[37]On average, the terms reflecting nonneutral and scale augmenting technical change were offset by the terms reflecting pure or neutral technical change, which showed retrogression.

[38]Similarly, in the Baltagi and Griffin (1988) study of electric utilities, the average yearly rates of technical change for the time trend and (more general) index specifications were almost identical.

[39]The alternative definition of technical change in the time trend models--the common rate of output expansion holding outputs fixed--yielded

(continued...)

<u>Average Yearly Rates of Bank Technical Change</u>
(1977-88)

Model:	Time Trend	Index	Cost Function Shift
Equilibrium	-1.4%	-1.4%	-0.9%
Disequilibrium			
K quasi-fixed	-1.3	-0.9	-0.8
K, L quasi-fixed	-1.2	-1.0	-1.0

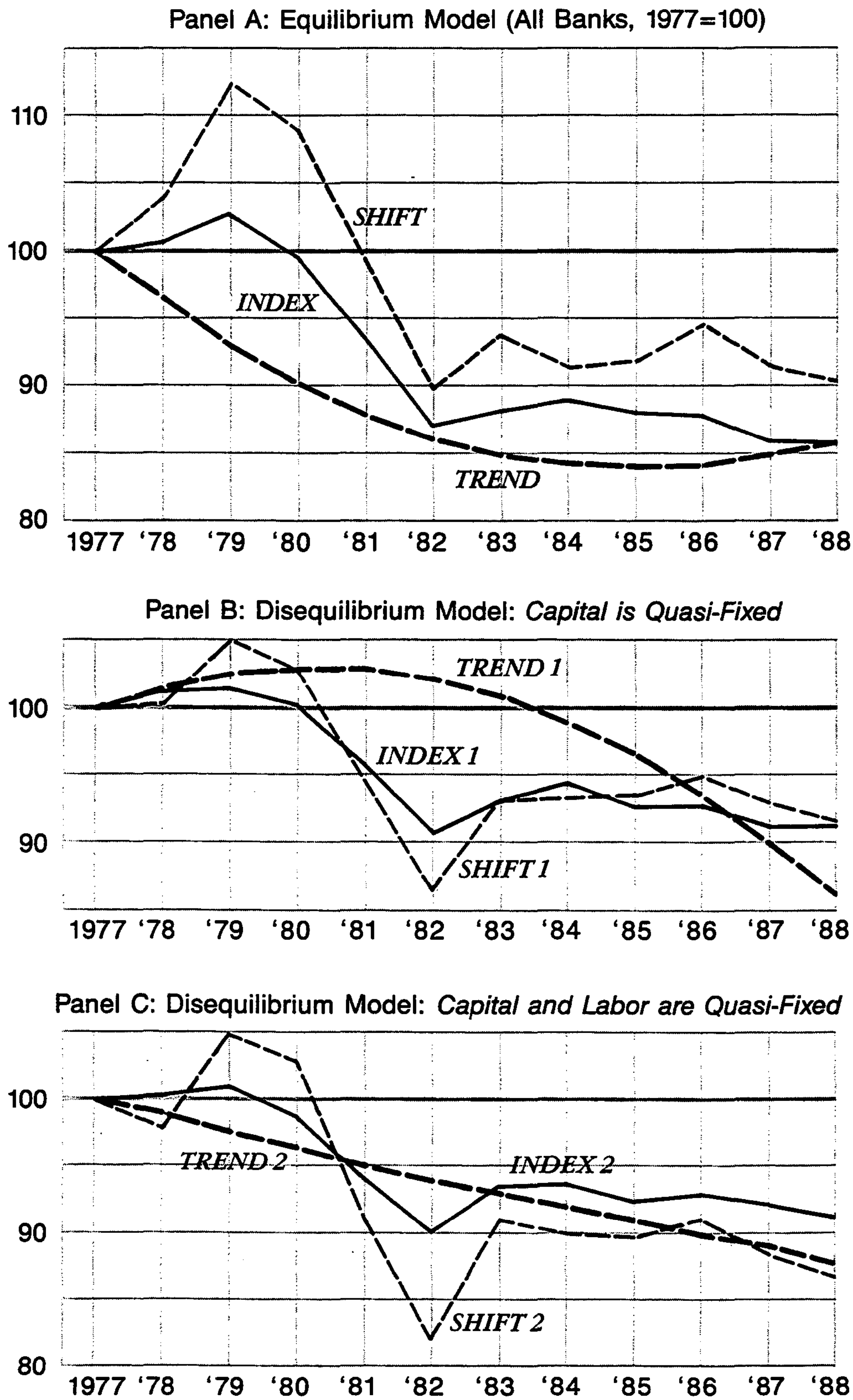
Source: Computed from Figure 2. K = physical capital in constant dollars, L = number of employees.

While Figure 2 compared the *TREND*, *INDEX*, and *SHIFT* technical change specifications across the three models used, Figure 3 takes the same data and directly compares these three specifications for each model separately. The purpose is to more clearly contrast each firm level technical change specification for the same equilibrium or disequilibrium model. Thus Panel A in Figure 3 shows the *TREND*, *INDEX*, and *SHIFT* results for the equilibrium model, and so on for the other two panels which show the disequilibrium models. Overall, the two disequilibrium models appear to have the most similar results across the three technical change specifications shown, a result not unexpected if, as appears likely, disequilibrium existed during the period. The results from the equilibrium model thus should be discounted in favor of the disequilibrium specification. The similarity seen between the two disequilibrium models in Panels B and C of Figure 2 would seem to support the conclusion that labor, but not capital, is close to being in equilibrium. Otherwise, the differences seen between *INDEX1* and *INDEX2* or *SHIFT1* and *SHIFT2*

[39](...continued)
-1.5%, -1.2%, and -0.9% in place of the three figures shown in first column of the text table. Thus the two alternative definitions of technical change (see discussion preceding equation (3), above) give very similar results, both overall and in identifying the turning points (not shown).

Figure 3

INDICES OF BANK TECHNICAL CHANGE 1977-88: Comparison by Equilibrium or Disequilibrium Model



should be larger and more on the order of those seen between *INDEX (SHIFT)* and *INDEX1 (SHIFT1)*.[40]

Technical Change at Large Versus Small Banks. The pattern of technical change by bank size class mirrors that shown in Figures 2 and 3. The only difference lies in the levels of technical change achieved and is seen in the following table. Large banks (with assets more than $10 billion) experienced far less negative technical change than did small banks (with assets of $100-$200 million).[41] Two reasons may contribute to this difference. First, large banks derive a smaller proportion of their loanable funds from those deposits that were decontrolled than do smaller banks. Thus the negative effects of interest decontrol on total costs at large banks should be less. Second, large banks typically experience more rapid deposit growth than small institutions and also have much larger branch networks which could be cut back and/or restructured. Thus the ability of large banks to reduce operating costs through more intensive use of branch offices (measured by the deposit/branch ratio) should be greater as well.[42]

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[40]The estimated models were not always well-behaved. In some instances, negative predicted marginal costs were observed and the second order condition for cost function convexity was not met. While troubling, these problems are not rare events in multiproduct banking data sets. However, the technical change results seem to be little influenced. For example, the equilibrium *INDEX* model met the second order condition while the disequilibrium *INDEX1* did not but the technical change results are quite similar (see Figure 2, Panel B).

[41]While the table shows only the results for large and small banks using the disequilibrium model where capital is quasi-fixed, the same divergence by size class is also evident in the other two models. Hunter and Timme (1988) also found that larger banks experienced greater technical change than smaller banks, although their study concerned banks with assets greater than $750 million.

[42]The results shown in the text table were based on estimates where large and small banks are pooled together. When the data are not pooled and the index model was reestimated using only banks with more than $1 billion in assets, the -0.5% figure for the largest sized banks shown in the table rises slightly to -0.6%, while the average for all of the large banks in the sample is -1.2. Thus,

(continued...)

Average Yearly Rates of Bank Technical Change at Large and Small Banks (1977-88)

Disequilibrium: K quasi-fixed	Time Trend	Index	Cost Function Shift
Large banks	-0.9%	-0.5%	-0.6%
Small banks	-1.5	-1.2	-1.4

Source: Computed from Figure 2 and evaluated at means of size class data.

Effects of Deregulation on Bank Technical Change. As seems clear from Figures 2 and 3, the fall in bank technical change generally starts in 1981. This was the first year that deposit interest rates began to be phased-out and nationwide NOW accounts were authorized. Technical change continued to decline in 1982, the year that banks first offered money market demand accounts. It is likely that the improvement in technical change which occurred after this was due to reductions in branch operating costs (to offset the rapid rise in deposit interest expenses following deregulation) along with the rise in bank output as funds shifted from MMMFs to banks without an offsetting net increase in interest and operating costs.[43]

An effort was made statistically to identify more directly the effects of deregulation on the technical change results presented above. An explicit measure of one aspect of the cost of deregulation to banks was computed from unpublished sources. This reflected the value of total deposit balances which had their interest ceiling lifted plus the balances of newly authorized

[42](...continued) pooling small with large banks or using large banks separately still yields the conclusion that the very largest banks experienced greater technical change.

[43]MMMFs supply funds to banks through CDs. As MMMF deposits shifted to banks, the rise in bank deposit interest and operating costs would be offset by a decrease in CD interest expenses.

interest earning checking accounts (e.g., NOWs and MMDAs). Unfortunately, the statistical results were unsatisfactory because of high collinearity between this measure and time. Thus the technical change results presented above reflect the net effect of ongoing technical change, deregulation, and cost cutting adjustments by banks in the deregulated environment.

Some idea of the separate effect of deregulation on bank costs is, however, seen in Column 1 of the table below. The numbers indicate that in 1980 (when deregulation was still essentially a regional experiment in New England) the estimated extra interest expenses on the deregulated balances raised the total cost of banks in this panel data set by 1.0 percent. Thus, if ongoing technical change in the banking system was, for example, 2.0 percent, then net technical change measured in a statistical model would have been only half as large. The estimated extra interest expenses as a percent of bank total cost rise sharply up to 1986 and then level off.[44] Considering

Effects of Bank Deregulation

Year:	Estimated Cost of Deregulated Balances (% of total cost) (1)	Deposit/Branch Ratio (million constant $) (2)	Number of Employees/ Branch Ratio (3)
1980	1.0%	$33.0	44.8
1982	1.5	27.9	42.0
1984	2.6	31.7	40.5
1986	3.8	36.1	38.3
1988	3.6	35.5	35.2

that bank profits (net income) as a percent of total costs only averaged 7.0

[44]Deregulated balances, as a percent of total national savings and small time deposit (TS) balances at all banks, were applied to TS balances for the panel data set. The extra interest expense was assumed to be equal to the actual reduction in the spread between the market and deposit rates shown in Panel A of Figure 1 between 1977-78 and 1987-88, or 1.6 percentage points (see footnote 5, above). This extra interest expense was then expressed as a percent of total cost for the set of panel banks.

percent over the entire period, the cost impact of deregulation is seen to have been quite large.

One response banks made, after a lag, was to cut operating expenses through more intensive use of branch offices. This is seen in Column 2. While the total number of branch offices continued to grow in the aggregate, the rate of increase was reduced by 1982 so that thereafter each branch supported a larger value of (real) deposits. As a result, the deposit/branch ratio rose by 27 percent over 1982-88. While one can argue that the cost impact of deregulation could have been minimized if all banks had pared their branch operations more rapidly and to a greater degree, market share concerns apparently inhibited this response.[45] Instead, most banks seemingly chose to sacrifice short-term profits in order to maintain market share and hope that long-term profit would follow as deposit growth continued to exceed the establishment of new branches.

A related response was to decrease the labor intensity of banking. This is shown in Column 3 where the labor/branch ratio is seen to fall by 21 percent over 1980-88, partly by shifting many full-time branch positions to part-time status to only cover peak use. Thus at the time that branches were being more intensively utilized, so was labor in these operations. Both of these responses mitigated, but have not yet reversed, the negative effect of deregulation on measured bank technical change.

Technical Change for the Average Branch Office. The results presented so far apply to technical change at the level of the banking firm. For the

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[45]Since choice of a bank by a depositor is largely based on convenience (according to industry surveys), a dramatic and profitable reduction in one bank's branching network would serve also to expand market share and profits at those banks which retained their branch networks. In the end, both sets of banks would have been more profitable in the short-run but market shares would have been redistributed away from those banks which cut their branch networks the most.

time trend and index models, the average yearly rates shown above ranged from -0.8 to -1.4 percent a year. At the office level, these results are improved by 2 percentage points over the entire 12 year period.[46] While technical change is still negative, the range for the time trend and index models is now -0.6 to -1.2 percent a year, showing a slight improvement. For the cost function shift model, the improvement was larger: 9 percentage points over the 12 year period. For this model only, technical change at the office level was such that it was no longer negative but rather was, on balance, zero (or very close to it) over the 1977-88 period.

This difference between technical change at the office and firm levels, while not great, can be explained as follows. At the office level, although the deposit/branch and employee/branch ratios (presented above) indicate that more intensive use is being made of both capital and labor, it still has not been sufficient (except in the shift model) to fully offset the negative cost effects of deregulated deposit interest rates. In effect, too little bank output emanates from the average branch office and the net effect over 1977-88 has been negative or zero technical change. At the firm level, an additional negative effect is added; namely, too many branches in the highly disaggregated U.S. banking system. Hence technical change at the firm level will reflect both too many branches and the less than optimal output level (given deregulated interest rates) at each one. Technical change at the average office level essentially only reflects the latter.

This conclusion has support in the industry. A recent consultant study done for the American Bankers Association concluded that about half of all

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[46]Technical change at the office level was obtained by estimating all equations with the branching variable (B) in the equation. Thus the partial derivative of cost with respect to time gives results where B is held constant. Technical change thus will not reflect output expansion from adding new branches, only by adding more output at each existing office.

bank branches are not profitable (Booz-Allen and Hamilton, 1987). Sometimes this results from keeping unprofitable branches open in areas where they meet "community needs", and if they were closed would lead to a low regulatory rating under the Community Reinvestment Act (CRA) guidelines. At other times, this results from an emphasis on market share and firm size to the detriment of current profits.

<u>Cost Frontier Versus All Banks</u>. So far, the technical change results apply to all 683 banks in the panel data set which, in turn, account for two-thirds of all the assets at U.S. banks. But all banks are not equally cost efficient. Thus some of the variation in measured technical change could have come from changes in the diffusion of existing technology from the most efficient banks to all the others, rather than reflecting new technical change. To account for this possibility, all the above estimations at the level of the banking firm were redone using only the quartile of banks which experienced the lowest average cost over the entire 1977-88 period. In effect, this set of "best practice" banks is used to estimate a thick cost frontier, as opposed to a frontier edge as is typically done in the frontier literature (e.g., Ferrier and Lovell, 1990). The logic of this approach has been discussed elsewhere (Berger and Humphrey, 1990a).

The cost differences observed between banks in the lowest and highest average cost quartiles in the panel data set averaged 24 percent.[47] These cost differences are not temporary or random since they refer to the same set of low and high cost banks over the 12 year period, and thus the chance effects which temporarily raise or lower costs should have averaged out.

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[47]The range of these cost differences over 8 size-classes of banks (from $100 million to over $10 billion in total assets) over 12 years was 11% to 41%. Similar results were obtained for all banks in the U.S. for selected individual years (Berger and Humphrey, 1990b).

Surprisingly, these persistent cost differences are strongly related to persistent differences in bank profits. Fully 47 percent of the banks in the lowest cost quartile were also in the highest profit quartile over the entire period. As well, 72 percent of these lowest cost banks had profits above the median. Only 8 percent of these banks had profits in the lowest quartile.[48] In sum, there appears to be a consistent and stable difference across banks in terms of cost efficiency and realized profits, and this difference could also mean that low cost banks experienced different rates of technical change compared to the other banks in the panel.

As it turns out, this apparently did not occur. In both the time trend and index approaches to measuring technical change, the technical change results for the lowest cost quartile of banks were so similar to those shown in Figures 2 and 3 that it is not worth graphing the results as the overlap would be too great. This similarity covers both the levels of technical change as well as their turning points for all three of the equilibrium/disequilibrium models specified above. The same holds for the shift approach but only after data on banks in the largest size class were deleted prior to evaluating (7).

VI. Conclusions.

The deregulation of banking which took place in the early 1980s led to a substantial negative effect on bank costs. Interest rate ceilings on time and savings instruments were removed and new interest earning checking accounts were established. In both instances, banks incurred higher interest costs

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[48]Similarly, banks in the highest cost quartile over 1977-88 also had the lowest profits. Fully 71% of them had profits below the median over the entire period while 45% were in the lowest profit quartile. Only 10% of these high cost banks had profits in the highest quartile.

more rapidly than (substitute) capital and labor operating expenses could be reduced, leading to a substantial net increase in costs. This cost increase more than offset any underlying positive influence of technical advance. Thus the net effect over 1977-88 was that banks, at the firm level, experienced a negative measured average rate of technical change of between -0.8 to -1.4 percent a year.

Three alternative approaches to determining technical change were estimated. The standard time trend approach, which has been the only approach used to date in banking, was used along with two others. Unlike the time trend, these other approaches can display substantial year-to-year variation in technical change if it exists in the data. One alternative was a time-specific index of technical change (Caves, Christensen, and Swanson, 1981; Baltagi and Griffin, 1988) and the other relied on shifts in separately estimated cross-section cost functions (Berger and Humphrey, 1990b). On a yearly average basis, the three approaches yielded the range of results noted above, while the latter two methods identified similar year-to-year variations in technical change. Specifically, prior to deregulation, technical change was positive at perhaps 1 to 2 percent a year. This turned strongly negative in 1981 and 1982 when, first, interest rates were decontrolled and, second, new interest earning checkable accounts were established. Technical change improved the following year as operating costs--labor and capital--were more intensively used and output expanded as banks became more competitive with money market mutual funds. Thereafter, technical change was essentially flat and ended the period in 1988 in an overall position lower than where it started in 1977.

In general, greater negative technical change was measured when all factor inputs were assumed to be fully utilized (an equilibrium model) than when either one or both of the capital or labor inputs were permitted to be quasi-fixed (a disequilibrium model). The most likely situation following deregulation is that capital was quasi-fixed. Qualitatively, however, the conclusions noted above are robust to the equilibrium/disequilibrium specifications, although the level of measured negative technical change did differ in a manner consistent with the existence of excess capital capacity in banking.

Large banks experienced less negative technical change than did smaller ones. Larger banks experienced greater deposit growth and had larger branch networks, both of which offer greater opportunities for (relative) cost reductions through more intensive use of factor inputs (e.g., a higher deposit/branch ratio, which is roughly equivalent to a higher output/capital ratio in banking). As well, technical change at the average banking office or branch was somewhat less negative than that for the entire banking firm. The office level measure reflected the low (but improving) deposit/branch ratio while the firm level measure reflects this influence and the negative effect of having too many branches (given deregulated interest rates).

While there are substantial and persistent cost differences among similarly sized banks, averaging 24 percent between banks in the lowest and highest cost quartiles over 1977-88, these differences did not bias the estimates of technical change. That is, these results were very similar whether all 683 banks in the panel data set were used or whether the estimates were from those banks in the lowest cost quartile. Put differently, the dispersion of technical change from the "best practice" banks to all the others apparently proceeded at a constant enough rate so that the technical change experienced for the set of most efficient banks was essentially the same as that experienced by all banks.[49]

The banks in the panel data set account for $2 trillion out of the $3 trillion of U.S. banking assets. Thus our results regarding negative technical change following deregulation may generalize to the banking industry as a whole. These results, however, conflict with those of other banking studies (Hunter and Timme, 1986 and 1988, and Evanoff, et. al., 1989) as well as with the single factor (labor) productivity series computed by the Bureau of Labor Statistics (1989). Some reasons for these differences are offered in the text.

In the future, two effects seen during the 1980s will be accelerated. First, while the shocks from interest rate deregulation will have passed, new shocks will be associated with the rapid pace of interstate merger and acquisition activity expected to occur as barriers to such combinations are removed in most states. Second, this restructuring should lead to a continuation of disequilibrium behavior in banking as branching networks of merged/acquired banks are increasingly consolidated in overlapping market areas. The end result, over the next decade, will likely be a more competitive and cost-efficient banking system but one that will not be associated with much positive technical change during the transition.

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[49]Similar results for all banks and those with the lowest costs were shown to also occur for scale and product mix efficiency measures (Berger and Humphrey, 1990a).

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Appendix

Means and standard deviations are shown in Table A1 for the 683 banks in the panel data set over 1977-88.[50] All data are from the Consolidated Report of Condition and Income (Call Reports) except as noted. The flow figures are the annual totals from the year-end (December) Call Report, while the stock figures are averages of the December and June Calls from a current year plus the December report of the immediately preceding year (to avoid biases from growth or decline over the year). Major changes in these reports made it advisable to start the study in 1977 rather than earlier. Only banks that were in continuous operation over the 12 year period were used in the panel. In addition, the smallest banks (those with assets <$100 million) were excluded. These banks are the most numerous (over 11,500) but account for only a small portion of bank output. The resulting sample accounted for $2 trillion of the $3 trillion in total U.S. banking assets.

Since branch banking is clearly the dominant organizational form, panel banks were drawn exclusively from states that permitted some form of intrastate branching (limited or statewide) during any year over 1977-88. Banks in the four remaining unit banking states which still existed in 1988 were excluded (Colorado, Illinois, Montana, and Wyoming). The 391 bank mergers for the panel banks were treated as the acquisition of new deposits, assets, and factor inputs by the larger of the institutions involved.[51] A dummy variable was added to account for the one year potential cost effects of this acquisition. Banks were placed in size-classes consistent with their average size over the 12 year period. Thus, when statistical results were

[50]These means are for the average bank in the data set. They will differ from some values shown in Figure 1 which reflect asset share weighted averages and, in effect, treats all the banks as a single entity.

[51]This follows the treatment of airline mergers in Sickles, Good, and Johnson (1986), p. 151.

evaluated by size-class over time, a given size-class always contained the same banks.

All value data were put into real terms prior to estimation using the GNP deflator. Thus real bank costs are dependent on real input prices and real output levels. Choice of bank output categories was based on their contribution to bank value added. The 5 output categories chosen contributed from 71 to 80% of bank value added during the 1980s (see Berger and Humphrey, 1990b, for details).

The choice of a proper deflator for the 5 bank outputs--values of demand, savings and small time deposits, real estate, installment, and commercial and industrial loans--is important. Our purpose was to approximate, with deflated deposit and loan value data, the unobserved underlying physical production processes for <u>individual</u> banks that are captured in the aggregate for <u>all</u> banks by the BLS in their physical index measure of bank output. In effect, when the value of deposits and loans grow they reflect (a) more checks being written and processed and more loans being made as well as (b) the fact that average deposit and loan balances rise as the prices of the goods purchased with these funds increase over time. The wide range of goods and services purchased out of deposit and loan funds suggested that the GNP deflator would be appropriate, as no price index for bank output exists for the 1977-88 period.

On an aggregate basis, there was a good correspondence between our deflated output series and that of the BLS, which is based on actual physical measurements of checks processed, deposit and withdrawal activity, number of new loans made, and trust accounts serviced. Over 1977-86, the BLS series on bank output rose by 40.4%. The aggregate, cost share weighted series for the panel data set showed an increase of 43.8% over the same 10 year period.[52]

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[52]The BLS bank output series was only available up to 1986, not 1988.

As well, the technical change results seem to be rather insensitive to the amount of deflation used. The index model of technical change was reestimated with each year's GNP deflator reduced by 25% and the technical change estimates were hardly at all affected.

The value of operating expenses in total costs includes depreciation and capital expenditures, labor cost, and "other noninterest expenses." This last category is a hodgepodge of data processing expenses, management fees paid by a bank to its holding company, as well as various materials, utility, and other expenses. No data exists on the overall composition of this cost category. Because banks were required to separately identify "other noninterest expenses" exceeding 25% of the total, and data processing expenditures and management fees comprised 74% and 17%, respectively, of the value of those expenditures listed,[53] the prices of capital and labor were used in the econometric model to approximate the variation of the (unobserved) prices of the items in this expense category. When the index model of technical change was reestimated with "other noninterest expenses" deleted from total costs, the technical change results improved: instead of averaging -1.4% a year, they averaged -0.7% a year. These altered results apply only to the full equilibrium specification as "other noninterest expenses" were not included in either of the two variable cost (disequilibrium) specifications for *VC1* or *VC2*.

Total deposit costs were not adjusted for any compensating revenues collected through deposit fees or service charges. If such service charges are viewed as a direct offset to paying out higher deposit interest expenses,

[53]An "other" category, mainly related to materials and advertising expenses, made up the remainder. These figures apply to the top 200 banks in the U.S., of which 70 incurred single category costs of 25% or more of the total and listed the category involved.

then these deposit revenues may be subtracted from deposit interest costs.[54] This would both lower the (net realized) deposit interest rate paid and reduce total costs. Such an adjustment was made in the index model and the only change was in the average level of negative technical change experienced. The technical change results for the three equilibrium/disequilibrium specifications of the index model reported in the text table were -1.4%, -0.9%, and -1.0% (see table on p.23). These three results became -1.5%, -1.3%, and -1.1%, respectively, when the adjustment for deposit service charge revenue was made.

Lastly, there is the possibility of measurement error in the price of capital variable. The price we used was based on the new contract cost (per square foot) of office space in 9 regions across the U.S. (from F.W. Dodge). This is preferred to the capital price used in other bank studies which involves the (depreciated) expenses of bank furniture, equipment, and structures expressed as a percent of the book-value of bank physical capital. While this alternative price measure is available by individual bank, it rises by much less (19%) than the GNP deflator (80%) over 1977-88. The preferred replacement cost measure, in contrast, experienced a more realistic increase (113%) but is observable only over 9 regions. While these differences are important, they do not affect our results. When the index model was reestimated using the alternative price of capital measure, the technical change results were virtually identical. This is likely due to the fact that, unlike other industries, expenditures on capital (even including "other

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[54]While it could be argued that deposit minimum balance requirements, largely implemented after interest rate deregulation, are also an offset to paying out higher deposit interest costs, no comprehensive information on changes in these requirements exists by individual bank. To the extent minimum balance requirements resulted in a net increase in bank deposits, this influence will be captured as an expansion of bank output. There would be little or no corresponding direct increase in costs associated with this deposit expansion, as the balances are essentially idle, so technical change will have increased. This effect is already reflected in the estimated results.

noninterest expenses" in capital) only accounts for 15% to 20% of total cost. As a result, the capital stock or price of capital measurement problems which have proved to be so important in other industries, have a much smaller impact on the banking results.

Table A1
Summary of Data
(All 683 panel banks, 1988)

		Mean	Std. Dev.
Cost Variables			
TC	Total cost (as a percent of assets).*	8.4%	1.3%
S_L	Labor share of total costs (percent).	18.6	4.5
S_D	Deposit share of total cost (percent).	40.1	11.8
S_p	Purchased funds share of total cost (percent).	19.0	12.9
$S1_D$	Deposit share in variable cost VC1 (percent).	51.6	14.1
$S1_p$	Purchased funds share in variable cost VC1 (percent).	24.2	15.4
$S2_p$	Purchased funds share in variable cost VC2 (percent).	31.5	18.8
(Other Cost Variables of Interest)			
OC	Operating cost (as a percent of assets).*	3.5	1.1
ID	Interest on deposits (as a percent of assets).*	3.3	0.9
IPF	Interest on purchased funds (as a percent of assets).*	1.6	1.1
Output Variables			
DD	Demand deposits (as a percent of assets).*	16.7	5.5
TS	Retail (small) time and savings deposits (as a percent of assets).*	52.9	14.5
RE	Real estate loans (as a percent of assets)*	24.0	10.2
CI	Commercial and industrial loans (as a percent of assets).*	20.8	9.1
IN	Installment loans (as a percent of assets).*	13.4	8.1
Other Variables (not in percent)			
B	Number of banking offices.	40.3	70.2
P_L	Price of labor, $000 per year, 1988 dollars.	27.1	7.4
P_k	Price of physical capital, 1988 dollars (assumed to be proportionate to the per square foot replacement cost of office space in the region, taken from F.W. Dodge)	84.3	11.4
P_D	Interest rate on deposits	4.8	1.4
P_p	Interest rate on purchased funds	6.5	1.2

*Numbers are expressed relative to assets for exposition only. Regressions are based on raw data in $000.