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Banks' Responses to Deregulation: Profits, Technology, and Efficiency

The deregulation of interest rates in the early 1980s raised bank funding costs and lowered profits. In response, banks raised fees for deposit services, reduced branch operating costs, and shifted to higher earning assets. Rates of return did not regain their prederegulation levels until the early 1990s.

Our goal is to decompose the change in bank profits following deregulation into (i) internal, bank-initiated adjustments to the new regulatory structure and (ii) external, contemporaneous changes in banks' business environment. This decomposition will depend, in part, on the assumed competitive structure of the banking industry. With perfect competition, output and input prices are part of the external environment and banks' responses are limited to changes in output and input quantities. An alternative approach assumes imperfect competition where banks have some control over output prices (deposit fees, minimum balance requirements, and interest rates on certain loans) and output quantities and input prices comprise the external environment.

The alternative model is supported by the data. Using this model, large banks—but not smaller banks—are found to have relied primarily on changing output prices and input use to mitigate and reverse the negative effects of deregulation on profits. The adjustment to deregulation was essentially complete after four years. Following this, additional changes in bank profitability (during the late 1980s) were primarily due to changes in banks' business environment.

THE INTEREST RATE DEREGULATION of the early 1980s sharply raised costs and lowered profits of the U.S. banking industry. Bank-initiated adjustments to deregulation were quite broad and included raising fees for deposit services, reducing operating costs at branch offices, shifting asset mix toward floating-rate loans, and taking on greater asset risk in search of higher revenue. While many of these adjustments were successful in offsetting the deregulation-induced structural increase in bank funding cost, others were not. Profits were stabilized, but at a lower rate than had existed previously, and annual rates of return did not regain their pre-deregulation levels until 1992.

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Changes in bank profits following deregulation were influenced by two things: (i) internal, bank-initiated adjustments to the altered regulatory structure and (ii) external, contemporaneous changes in banks' business environment. Our purpose is to separate these two effects and determine both the relative importance of bank-initiated adjustments as well as the length of the adjustment period. This task is complicated by the fact that the measurement of both bank adjustments to deregulation and changes in external environment will depend on assumptions about the nature of the overall competitive structure of the banking industry. The standard methodology assumes perfect competition, where output and input prices are part of the external environment, and banks' responses are limited to choices among output and input quantities. An alternative approach, which we embrace, views banks as exercising some degree of control over output prices. Here the external business environment (that is, the exogenous variables in the induced indirect profit function) consists of input prices and banking output quantities, which are measured more completely than output prices. Under this scenario banks adjust to the changing regulatory and business environments through choices among output prices and input quantities.

In truth, the current structure of the banking industry lies somewhere in between. Banks exploit local market power in setting deposit fees, minimum balance requirements, and interest rates on consumer, small business, and middle-market corporate loans. They are essentially price takers in markets for large corporate loans and for nationally traded bank assets (government securities and federal funds sold). Correspondingly, we examine the role of both output prices and output quantities in our alternative specification, permitting the data to shed light on whether banking output prices or output quantities have been the primary avenue by which the adjustment to deregulation has been initiated. Existing studies of bank profits have neither focused on the effects of the interest rate deregulation nor attempted to determine the proper competitive environment for modeling bank profits.[1]

In our analysis, we resist the common—but unrealistic—assumption that profits are maximized in each and every year. Instead, we assume that profit maximization occurs over a longer time horizon. Profits are averaged over three separate and successive four-year time intervals over 1977–1988 that comprise the periods before, concurrent with, and after deregulation. This approach markedly reduces the number of banks that experience negative profits and better reflects actual planning and decision making within the banking industry. Local identification of the profit function is improved by including influences that can affect profits but have been left out of earlier specifications—such as business conditions and a direct measure of factor productivity.

There is significant empirical support for specifying a profit function consistent with banks having some control over output prices. With such a model, we find that large banks—but not smaller banks—relied primarily on changing output prices and input use to mitigate and reverse the negative effects of deregulation on profits.

1. Existing studies have investigated the association between bank size, subadditivity, and profits (Hancock 1992); estimated postderegulation profit efficiency (Berger, Hancock, and Humphrey 1993); and assessed the effects of mergers on rate of return and profits (Akhavein, Berger, and Humphrey 1997).

As the beneficial effects of bank-initiated adjustments were basically complete within four years after deregulation first occurred, changes in bank profitability in the late 1980s were driven primarily by improvements in the business environment, as reflected in output quantities, input prices, and the other variables in the model. These findings are robust to different measures of profit, different sets of included variables, and estimation on and off an efficient frontier.

In section 1, the major effects of and responses to interest rate deregulation are outlined, setting the stage for a more formal empirical analysis. The theoretical and empirical motivation for the alternative profit function used is presented in section 2, along with a brief description of the data. Our results on separating bank-initiated adjustments to deregulation from contemporaneous changes in business environment are presented in section 3. For completeness, results for the alternative profit function are contrasted with those from a standard profit function specification, as well as a profit function representing the efficient frontier. Section 4 contains a summary and conclusion.

1. INTEREST RATE DEREGULATION AND BANKS' RESPONSE

Effects of Deregulation on Interest Costs

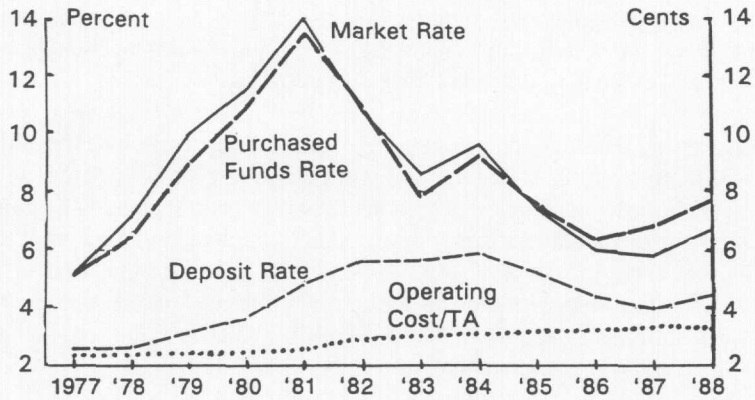
Congress passed the Depository Institutions Deregulation and Monetary Control Act (DIDMCA) in late 1980 and the Garn-St Germain Depository Institutions Act (DIA) in late 1982. In addition to improving monetary control by making reserve requirements universal and requiring the Federal Reserve to price payment services supplied previously without charge, the DIDMCA (a) established interest-bearing negotiable order of withdrawal (NOW) consumer checking accounts and (b) phased-out Regulation Q interest rate ceilings on savings and small denomination (less than $100,000) time deposits. Two years later the DIA authorized the development of a consumer money market deposit account (MMDA) structured like a money market mutual fund (MMMF). This permitted banks to compete better with these nonbank alternatives.

The effect of deregulation on bank costs can be seen in Panel A of Figure 1, which displays the average core deposit and purchased funds interest rates and the ratio of operating cost to assets for our panel of banks over 1977–88. The rise and fall in the average rate paid for purchased funds (thick dashed line in Panel A) mirrored the increase and decrease in market rates (ninety-day Treasury bills—solid line) during 1977–88 and was not really affected by the deregulation legislation.[2] Although the variation in the average rate paid on core deposits was considerably less dramatic (thin dashed line),[3] the *spread* between the rates on core deposits and

2. Purchased funds include federal funds, large denomination (more than $100,000) CDs, Eurodollars, and other liabilities for borrowed money. Bank interest rates and prices were constructed from Call Report data.

3. Core deposits are demand, savings, and small denomination (less than $100,000) time deposits. Interest expenses are not allocated between savings and time deposits in the Call Report and thus could not be shown separately in Figure 1.

Panel A: Purchased Funds and Deposit Interest Rates (Percent) plus Operating Cost Per Dollar of Assets (Cents)



Panel B: Deposit Fees and Two Measures of Net Income Per Dollar of Assets (Basis Points)

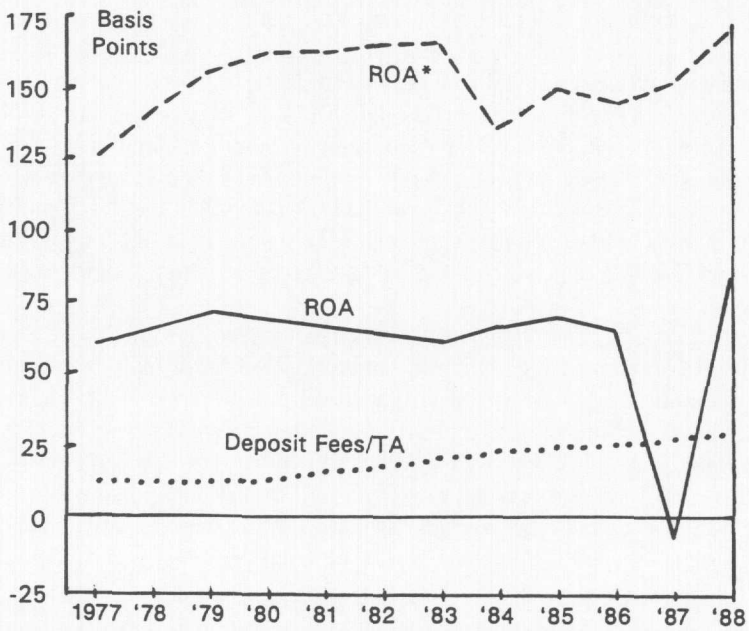


FIG. 1. Interest Rates and Costs and Returns per Dollar of Assets (1977–1988)

purchased funds before and after deregulation was narrowed substantially—falling by 45 percent, principally as a result of higher interest rates on deposits.[4]

Table 1 presents information on the cost effect of deregulation and certain indicators of the banking industry's response for the prederegulation (1977–80), concurrent (1981–84), and postderegulation (1985–88) time periods. Comparing pre- and postderegulation time periods, the average interest rate on core deposits rose by 52 percent (from 2.96 percent to 4.50 percent). This increase far exceeded the rise in either the rate on purchased funds (which fell by 8 percent) or the rise in operating cost as a percent of assets (34 percent) shown in Panel A of Figure 1. At the end of our time period, 49 percent of assets were funded by core deposits (demand, savings, and small time deposits) while 45 percent were funded by purchased funds.[5] Thus the removal of interest rate ceilings on deposits and the establishment of interest-earning checking accounts have served to raise the long-term structural cost of the source of approximately one-half of loanable funds in the banking system.

Bank Responses to Deregulation

There were three primary responses to the deregulation-induced structural change in bank funding costs. The first response—cost offset and reduction—was an attempt (a) to offset higher deposit interest costs with higher explicit and implicit prices for previously free or below-cost deposit services and (b) to reduce branch operating expenses. The second response—cost shifting—was to transfer some of the higher funding cost and interest rate risk to borrowers (via floating rate loans) and to purchasers of securities (by securitizing fixed-rate loans). The third response—revenue augmentation—was to expand asset risk in order to reap a higher expected return on loans to a more concentrated, but riskier, set of borrowers. Thus higher-earning less-developed-country (LDC) and commercial real estate loans were added to bank portfolios (partly in response to large inflows of new deposits from OPEC countries after various increases in oil prices). Although these responses limited the reduction in profits, the rate of return on assets was lower than had existed previously. While the cost offset, cost reduction, and cost shifting responses to deregulation were quite successful, attempts to augment loan revenues were more than completely reversed by unexpectedly large loan losses. This was the primary reason why bank rates of return did not regain their prederegulation level until 1992.

Bank adjustments that can be directly measured are given in Table 1 and Panel B of Figure 1; other adjustments have to be inferred. In terms of cost offset, deposit service fees per dollar of assets (dotted line) rose markedly with deregulation, rising by 126 percent between the pre- and post-deregulation time periods (Table 1). As well, various surveys by consultants and banking associations indicated that mini-

4. The average purchased funds rates in 1977–80 and 1985–88 were 7.80 percent and 7.15 percent, respectively, while the average deposit rates were 2.96 percent and 4.50 percent. The spread fell from 4.84 to 2.65 percentage points, a reduction of 2.19 percentage points or 45 percent.

5. The remainder is comprised of equity capital and long-term debt, subject to regulatory minimums.

TABLE 1

INDICES OF BANK COST AND RESPONSE TO INTEREST RATE DEREGULATION

	Prederegulation 1977–80	Concurrent 1981–84	Postderegulation 1985–88
Cost Effect of Deregulation:			
Interest Rate on Core Deposits	100.0	184.3	152.1
Bank Response to Deregulation:			
Deposit Fees/*TA*	100.0	157.4	225.5
Labor/Branch Ratio	100.0	96.5	87.0
Net Interest Margin/*TA*	100.0	111.5	128.2
*ROA** (Adjusted ROA)	100.0	107.0	105.3
ROA	100.0	96.6	80.4

NOTE: The indices represent averages for our panel of all branching banks with $100 million or more in total assets (TA).

mum balance requirements were also raised substantially, especially for the newly authorized interest-earning transaction accounts (NOWs and MMDAs). In terms of cost reduction, banks lowered operating expenses by closing redundant offices and reduced labor used per office.[6] Indeed, the number of full-time equivalent workers per branch fell by 13 percent after deregulation (Table 1), even though the real value of core deposits per office was stable between pre- and postderegulation periods.[7]

Direct information on cost shifting (through floating-rate loans and loan securitization) and revenue augmentation (by adding risky commercial real estate and LDC debt) are not available for our panel of banks. Survey information suggests, however, that after deregulation floating-rate loans comprised 68 percent of all loans with maturities longer than one year. Overall, the ability of banks to shift funding costs to borrowers and take on greater asset risk to cover deregulated deposit interest rates is reflected in the net interest margin/asset ratio (total interest income minus total interest expense divided by total assets). As seen in Table 1, the net interest margin per dollar of assets did not fall after deregulation but instead modestly expanded: rising 12 percent by 1981–84 and 28 percent by 1985–88.

The net effect of all responses to deregulation (and other contemporaneous influences) is reflected by the standard bank profitability measure of return on assets (*ROA*). *ROA* is the ratio of net income—after provision for loan losses and after taxes and extraordinary items—to assets (Table 1 and the solid line in Panel B). Over the three time periods shown in Table 1, *ROA* fell by 20 percent.[8] However, if we look at net income before loan loss provisions, taxes, or extraordinary items, this

6. Many banks reduced their branch office network. Bank of America cut the number of branches by 27 percent (or 350 offices) and reduced staff by 34 percent. Manufacturers Hanover also reduced branch offices and cut staff by 24 percent. Many other large banks implemented similar, if less drastic cuts (Bennett 1987; Weiner 1989).

7. Over the 1977–88 period, the real value of bank capital (book-value divided by the GNP deflator) expanded by 68 percent while the number of full-time equivalent employees rose by 34 percent. This reflected an attempt to replace labor with capital [such as ATMs, as described by Humphrey (1994)], an effort to replace full-time tellers with lower-cost part-time workers, and the out-and-out reduction of clerical and middle-management labor inputs used to produce banking services in general. Indeed, total labor employed in the banking industry peaked in 1986.

8. The reduction in *ROA* was primarily due to historically high loan losses, a large portion of which were written off in 1987, as seen in Panel B.

adjusted return on assets (ROA^*) rose by 5 percent. Thus *if* banks had experienced only historical loan losses (and taxes and extraordinary items), rather than the larger losses due to high concentrations in commercial real estate and LDC loans, then the net effect of the three bank responses to deregulation would have been positive. As it was, losses associated with the high-earning but risky assets more than offset the benefits from the other responses and thereby lowered realized bank returns. In what follows, we estimate indirect profit functions and separate the internal, bank-initiated adjustments from the external, contemporaneous changes in banks' business environment. This separation permits us to identify the major effect deregulation has likely had on bank profits, technology, and efficiency.

2. PROFIT FUNCTION MODEL, DATA, SPECIFICATION, AND TEST

The Indirect Profit Function under Perfect Competition

The indirect profit function is generally derived under the assumption of perfect competition, for example, price-taking behavior in both output and input markets. We refer to this as the *standard* indirect profit function. More formally, let $\mathbf{y}$ and $\mathbf{x}$ be the vectors of outputs and inputs, respectively, and let $\mathbf{Q} \equiv (\mathbf{y}, -\mathbf{x})' = (y_1, \ldots, y_m, -x_1, \ldots, -x_n)'$ be the vector of netputs, with negative signs applied to inputs. Profits are given by $\pi = \mathbf{P}'\mathbf{Q}$, where $\mathbf{P} \equiv (\mathbf{p}, \mathbf{r})' = (p_1, \ldots, p_m, r_1, \ldots, r_n)'$ with p denoting output prices and r input prices. In a competitive environment prices are exogenous and profits are maximized when firms solve

$$\underset{\mathbf{Q}}{\text{Max}}\ \pi = \mathbf{P}'\mathbf{Q} \qquad \text{s.t. } h(\mathbf{y}, \mathbf{x}) = 0$$

where $h(\mathbf{y}, \mathbf{x})$ is a production transformation from input quantities, $\mathbf{x}$, into output quantities, $\mathbf{y}$. The Lagrangian yields the optimal choice of output and input quantities as functions of output and input prices, $\mathbf{Q} = Q(\mathbf{P})$. Since profit is the product of netput prices and netput quantities, $\mathbf{P}'\mathbf{Q}$, the standard indirect profit function is given by: $\pi = \mathbf{P}'Q(\mathbf{P}) = \pi(\mathbf{P})$.[9]

An Alternative Indirect Profit Function under Imperfect Competition

We do not believe that the standard assumption of perfect competition for banks well represents actual experience; instead, we permit banks to exercise a form of market power in choosing output prices. This market power is limited to output markets; banks remain competitive purchasers of inputs. In practice, banks exploit local market power for certain deposit and loan services and have the ability to differentiate output prices among customer groups, across geographic areas, and over time.

9. For the conditions on $h(\cdot)$ such that the profit function exists and for a complete discussion of the relationships among the profit, cost, and revenue functions for multiproduct firms, see Laitenin (1980) or Fuss and McFadden (1978).

Local market power on the deposit side derives from (a) the desire by consumers to turn deposits into cash at low cost—and at convenient times—along with (b) the virtual requirement to use local banks to obtain local acceptability of checks for everyday transactions.[10] On the loan side, market power follows from the generation of private information about loan customers that is costly to duplicate by other lenders (Diamond 1984; Boyd and Prescott 1986). Indeed, the relationship between borrower and lender tends to grow stronger over time, tying the customer even more tightly to a given bank and enhancing the bank's position (Petersen and Rajan 1994).

Empirical studies have shown that banks with larger shares of the local market have some control over price, paying lower rates to small depositors (Berger and Hannan 1989) and charging higher rates to small borrowers (Hannan 1991). These results are supported by studies that have tested price-taking versus price-setting behavior for banks, most often finding the latter (Hancock 1986; Hannan and Liang 1990; English and Hayes 1991).[11] Dividing banking services into price-setting versus price-taking behavior suggests that perhaps two-thirds of banking revenues are associated with services where price setting occurs while one-third is associated with services where price-taking behavior is expected.[12]

How should we model banks' mix of price-taking and price-setting behavior? Any approach will doubtless involve simplification and distortion. We have described our objections to viewing the market for bank services as perfectly competitive. Neither do we consider it appropriate to apply the monopoly model to banking since we believe the truth lies somewhere in between. Under monopoly, the demand curve (assumed to be known) would be exploited to determine output prices and levels jointly, and the corresponding profit maximization problem would induce profits as a function of exogenous input prices only. Aside from concerns about the underlying assumptions of the monopoly model, the resulting specification for the profit function is too sparse for our purposes, providing insufficient structure for bank profit decisions. Our objectives here are best served by the simplifying assumption that banks treat output as essentially exogenous at the time of decision,

10. While MMMFs offer transaction services in competition with banks, the actual use of these transaction services by consumers is so slight (averaging two transactions per account per month) that regulatory agencies have classified these funds as savings substitutes rather than transactions balances in the money supply definitions. In contrast, the average family writes sixteen checks per month on their main checking account (Avery et al. 1986).

11. Although most banks price their loans based on an essentially nationally determined prime loan rate, the positive and negative spreads from that rate (along with the size of required average idle compensating deposit balances, collateral, and loan commitment fees) differ both within and across borrower groups and geographic areas and are influenced by local demand conditions. Only for loans to large, low-credit-risk corporate borrowers is there a truly national loan rate, a rate determined by the opportunity cost of issuing commercial paper or borrowing from nonbank financial firms, both of which are strong substitutes for these types of bank loans (as evidenced by a declining bank market share for these types of loans).

12. We believe price-setting behavior applies to revenues from real estate loans, installment and credit card loans, and commercial and other loans to small business and middle market corporate customers. It also applies to direct fees on deposits and revenues from safe deposit, trust, and data processing services. These categories account for 68 percent of bank revenues of large banks in the Federal Reserve's *Functional Cost Analysis* survey. Price-taking behavior applies to securities and other investment revenues and to low-risk loans to large corporate borrowers (together accounting for 32 percent of revenues).

since we view banks as having far greater ongoing flexibility with regard to output prices than with output levels. Deposit outputs expand through growth in the local market, through mergers and acquisitions, or through use of purchased funds. All three offer only limited flexibility to bank managers attempting to maximize profits over the intermediate term.[13] Balance sheet equalities provide similar restrictions on loan outputs. Therefore, we view banks as focusing not on output quantities but on negotiating prices and fees—where feasible—to maximize profit.[14] As we shall see, this assumption induces a profit function that stands in stark contrast to that from the standard competitive model and sets up the empirical comparisons we wish to perform.

We assume that banks maximize profits for given output quantities, $\mathbf{y}$, and input prices, $\mathbf{r}$, by choosing output prices, $\mathbf{p}$, along with input quantities, $\mathbf{x}$. The associated indirect profit function is derived as the solution to the problem:

$$\underset{\mathbf{p},\,\mathbf{x}}{\text{Max}}\ \pi = \mathbf{P}'\mathbf{Q} = (\mathbf{p}, \mathbf{r})(\mathbf{y}, -\mathbf{x})' \qquad \text{s.t. } g(\mathbf{p}, \mathbf{y}, \mathbf{r}, \mathbf{z}) = 0,\ h(\mathbf{y}, \mathbf{x}) = 0$$

where $g(\mathbf{p}, \mathbf{y}, \mathbf{r}, \mathbf{z})$ represents a bank's *pricing* opportunity set for transforming given values of $\mathbf{y}$, $\mathbf{r}$, and $\mathbf{z}$ into output prices. This reflects the bank's assessment of its competitive position as well as its assessment of the willingness of customers to pay the prices the bank wishes to charge. The influences incorporated in $\mathbf{z}$ are discussed in the empirical section below. The function $g(\cdot)$ also reflects any conjectural variations incorporated in pricing rules the bank may follow, such as differentially marking up the cost of funds; hence, the inclusion of input prices. The associated indirect profit function is derived by solving the Lagrangian for the optimal choice for output prices $\mathbf{p} = p(\mathbf{y}, \mathbf{r}, \mathbf{z})$ and input quantities $\mathbf{x} = x(\mathbf{y}, \mathbf{r})$. Thus our alternative indirect profit function is given by

$$\pi = \mathbf{P}'\mathbf{Q} = [p(\mathbf{y}, \mathbf{r}, \mathbf{z}), \mathbf{r}][\mathbf{y}, -x(\mathbf{y}, \mathbf{r})]' = \pi(\mathbf{y}, \mathbf{r}, \mathbf{z}).[15]$$

While the primary benefit of our alternative profit function is that it represents a more appropriate specification when market power exists, a second benefit is that it permits the use of a more accurately measured metric—output quantity ($\mathbf{y}$)—for improved local identification of revenues, and hence profits. Output prices ($\mathbf{p}$), which appear in the standard indirect profit function, are less accurately measured since certain important components of depositor and borrower prices are not reported in the available data. We will return to this point later. Other benefits of the alter-

13. The expansion of purchased funds is restricted by position limits imposed by lending banks on borrowing institutions. These limits are only infrequently reviewed and altered over a year.

14. Some readers may wish to consider this the final stage of a multistage decision process or as depicting a short-run or restricted version of the textbook monopoly model (see, for example, Varian 1992).

15. The function $\pi = \pi(\mathbf{y}, \mathbf{r})$ need not be homogeneous of degree one in $\mathbf{y}$ and $\mathbf{r}$. There is no reason to require that a doubling of output quantities and input prices lead to a doubling of profits—this is an empirical issue.

native model are described in Berger, Humphrey, and Pulley (1997), who estimate the associated indirect revenue function.

Data Issues

Our empirical analysis of banks' responses to deregulation relies on a panel of 683 U.S. banks all having assets over $100 million in 1988 dollars and located in states that had some form of within-state branching during the 1980s.[16] This panel accounts for almost 45 percent of all U.S. bank assets and represents the future of banking, especially now that restrictions on both regional interstate banking and branching have been removed (in 1994) and nationwide branching is possible (in 1997).

In contrast with other studies, we believe it unrealistic to assume that profit-maximizing behavior is manifested annually. To that end, we average the data for individual banks over three successive four-year intervals (1977–80, 1981–84, 1985–88), corresponding to the pre-, concurrent, and post-deregulation periods. Two profit (π) measures are used as dependent variables: adjusted net income (NI^*), which is the numerator of ROA^*, and total net income (NI), which is the numerator of ROA. ROA and ROA^* are defined above and appear in Figure 1 and Table 1. Banks are considered to produce two main categories of financial services: (1) payment, liquidity, and safekeeping services (y_1), measured by the real value (in 1988 dollars) of core deposits (demand deposits plus savings and small denomination time deposits); and (2) intermediation and loan services (y_2), measured by the sum of the real values of real estate, commercial and industrial, and installment (including credit card) loans.[17] A measure of other assets (OA), composed of securities, investments, and vault cash, is also included since other assets help account for revenue differences among banks, but they are not considered an output since they only weakly reflect financial services provided to bank customers. Three input prices are specified: the price of labor (r_1), the cost of funds (r_2)—composed of core deposits plus purchased funds, and the cost of physical capital (r_3).[18] We also include four additional influences excluded from earlier analyses but known within the banking industry to affect profitability. These are contained in the vector $\mathbf{z}$ and reflect region-

16. Bank mergers in the panel data set are treated as an expansion of assets and deposits for the acquiring bank in the year the merger occurs and thereafter. This is the only way an acquired bank enters the data set. *Call Report* data were used.

17. Off-balance-sheet activities, although included in profits, could not be specified as an output as this information was not collected until recently. However, the most important off-balance-sheet component—loan commitments—is already proxied in our loan data since over 70 percent of all commercial loans are made under a loan commitment (*Survey of Terms of Bank Lending*). Thus growth in outstanding loans will also reflect the growth in revenues from loan commitments. Loan commitments and standby letters of credit are believed to account for the vast majority of the revenues from off-balance-sheet activities.

18. The controversy over whether deposits are an input or an output is not an issue here as both aspects are incorporated in our model. We specify the real value of dollars in deposit accounts as reflecting the service flow associated with deposits and the interest paid on deposits as part of the price of the funds input. In any event, recent studies treating deposits first as an input, then as an output, have found that estimates of cost scale economies and subadditivity are little affected either way (Hunter, Timme, and Yang 1990).

al business conditions (measured by the growth in real personal income by state), the funding-loan rate spread, the loan/asset ratio, and a direct measure of operating productivity (employee/branch ratio).[19]

Specification of the Composite Profit Function

We adopt the composite specification of Pulley and Braunstein (1992) and Pulley and Humphrey (1993) as our model for the profit function. The general composite profit function combines a quadratic structure for outputs with a log quadratic structure for input prices. Output quantity and input price structures are linked through interaction terms so separability is not imposed. The general composite model for the alternative specification of the indirect profit function would be expressed as

$$\pi^{(\phi)} = \{[\alpha_0 + \alpha_1 OA + \Sigma\alpha_m z_m + \Sigma\alpha_i y_i + {}^1/_2\Sigma\Sigma\alpha_{ij} y_i y_j + \Sigma\Sigma\delta_{ik} y_i \ln r_k] \cdot \exp[\Sigma\beta_k \ln r_k + \Sigma\Sigma\beta_{kl} \ln r_k \ln r_l]\}^{(\phi)} + u$$

where the superscript (ϕ) refers to the Box-Cox transformation[20] and represents an application of the "transform-both-sides" (TBS) approach of Carroll and Ruppert (1984, 1988) to increase the flexibility of the model.[21] The composite model is best viewed as a flexible, second-order approximation to a wide class of specifications. We adopt it here because it has been shown to offer advantages over the translog model in the analysis of bank costs and because it yields a very flexible specification when combined with the TBS procedure. The multiplicative specification for input prices has particular appeal in this application since an increase in input prices has a scaling effect on both components of profits: revenues and costs. Costs, given by $\mathbf{r}'\mathbf{x}$, will be affected directly; revenues will be influenced indirectly as input prices affect output prices through $g(\cdot)$.

Although the variables in $\mathbf{z}$ are expected to influence profitability, their effects are specified to be linear and neutral with respect to outputs (and the other variables). While these simplifications could be tested empirically, adding a full set of second-order terms for the four variables in $\mathbf{z}$ along with interaction terms with outputs would add eighteen coefficients and greatly increase the likelihood of multicollinearity problems. Even without these added coefficients there were some esti-

19. The average annual growth in state personal income reflects both population growth and per capita income, and thus is an indicator of the "oversupply" of deposits and the "intensity" of loan demand that banks respond to in determining deposit interest rates and fees as well as loan conditions and rates. An imperfectly measured direct indicator of these effects is the funding-loan rate spread, which varies over the business cycle. The loan/asset ratio crudely reflects bank risk while the labor/branch ratio indicates operating cost efficiency.

20. The Box-Cox transformation of the variable y is $(y^{\phi} - 1)/\phi$.

21. The expression in the text is $\{F(OA, \mathbf{z}, \mathbf{y}, \ln\mathbf{r}) \cdot \exp[G(\ln\mathbf{r})]\}^{(\phi)} + u$. When $\phi = 1$, the general composite model reduces to $\pi = F(OA, \mathbf{z}, \mathbf{y}, \ln\mathbf{r}) \cdot \exp[G(\ln\mathbf{r})] + u$ and when ϕ approaches 0, it reduces to $\ln\pi = \ln[F(OA, \mathbf{z}, \mathbf{y}, \ln\mathbf{r})] + G(\ln\mathbf{r}) + u$. The application of the Box-Cox transformation to the dependent variable and to *the entire right-hand side of the profit function* (excluding the error term u) preserves the composite structure. This differs from the common practice of applying Box-Cox transformations to the individual right-hand-side variables. Interpretation is easy as the underlying composite structure is not altered by the transformation.

mation difficulties. It was necessary to delete the second-order input price coefficients in the above function because of convergence problems, presumably resulting from the lack of input price variability.

In addition, while the logarithmic transformation applied to input prices renders the composite function easily restricted to be linear homogeneous in input prices, as is required theoretically of an indirect cost function, the alternative indirect profit function need not be homogeneous in its arguments. Empirically, removing the logarithmic transformation applied to input prices yields virtually identical values for the likelihood functions in all estimated models and generally leads to much higher asymptotic t statistics for the individual coefficients of the profit function. Presumably, this results because the logarithmic transformation further reduces the already limited variability across measured prices for bank inputs: labor, physical capital, and funds. Therefore, we report results without the logarithmic transformation, a modification that does not affect any of our conclusions. We also find that separability is generally supported by our bank data.[22] With these simplifications, our specification for the alternative indirect profit function becomes

$$\begin{aligned}\pi^{(\Phi)} &= \{[\alpha_0 + \alpha_1 OA + \Sigma\alpha_m z_m + \Sigma\alpha_i y_i + {}^1/_2\Sigma\Sigma\alpha_{ij} y_i y_j] \cdot \exp[\Sigma\beta_k r_k]\}^{(\Phi)} + u \\ &= \{F(OA, \mathbf{z}, \mathbf{y}) \cdot \exp[G(\mathbf{r})]\}^{(\Phi)} + u \ . \qquad (1)\end{aligned}$$

Replacing output quantities, y_i and y_j, in (1) with output prices, p_i and p_j, yields a composite specification of the standard profit function. For readers who remain attached to the standard model, we provide the following statistical support for our alternative specification. We would argue that adding first- and second-order output price terms to our alternative specification in (1) should contribute little to the model's explanatory power. As discussed, we contend that banks have market power over many of their outputs. Since banks are viewed as treating output quantities and input prices as exogenous and choosing output prices and input quantities to maximize profit, the role of output prices is subsumed through the estimated coefficients. Therefore, inserting output prices as an exogenous right-hand-side variable in the profit function would be both a misspecification and redundant. Furthermore, bank output prices are poorly measured. While the average rates paid on deposits or charged for loans can be computed from the available data along with the direct fees assessed for certain deposit services, other price elements are unreported. For borrowers, up-front loan fees, compensating balance requirements, and collateral conditions all raise the realized borrowing cost, but these cost elements are not reported. The same problem exists for depositor minimum balance requirements, which vary by type of deposit account and across banks and alters the effective rate paid for the same service flow.

22. As described in the next section, we estimate alternative and standard profit functions for three time periods and for two measures of profit. In only three of the twelve models is separability rejected at the .05 level on the basis of likelihood ratio tests. Therefore, we delete the output quantity-input price interaction terms from our models, noting that doing so does not alter any findings or conclusions.

To illustrate, we added output prices explicitly to the alternative profit function in (1), rather than only allowing them to be reflected implicitly in the variable coefficients:

$$\pi^{(\Phi)} = \{[\alpha_0 + \alpha_1 OA + \Sigma\alpha_m z_m + \Sigma\alpha_i y_i + {}^1/_2\Sigma\Sigma\alpha_{ij} y_i y_j + \Sigma\tau_i p_i + {}^1/_2\Sigma\Sigma\tau_{ij} p_i p_j] \cdot \exp[\Sigma\beta_k r_k]\}^{(\Phi)} + u \,. \quad (1')$$

Measured output prices add little: restricting the τs to be zero in (1′) is supported by likelihood ratio tests (.05 level) in two of the three time periods. On the other hand, the restrictions imposed on (1′) by the standard model (for example, dropping the terms involving output quantities, y, and allowing their influence to be reflected in the coefficients on the other variables) are strongly rejected by the data.[23] Hence the data support the full alternative specification of the profit function shown in (1). For completeness and comparison, we report results using both the standard and alternative profit functions (where **p** substitutes for **y** in (1) and vice versa).

3. EFFECTS OF DEREGULATION ON PROFITS, TECHNOLOGY, AND EFFICIENCY

Change in Profits at Large Banks

The composite profit function (1) was separately estimated for each of the three time periods noted above: (1) pre-deregulation, (2) concurrent, and (3) post-deregulation (using data averaged within each period). The first set of estimations apply to large branching banks (those with greater than $500 million in assets in 1988 dollars). Profits were defined as adjusted net income (NI^*).[24]

The median of the individual ratios of predicted profits for large banks ($\hat{\pi}_{t+1}/\hat{\pi}_t$) for periods 1 to 2 was 1.12, showing a 12 percent rise.[25] For periods 2 to 3, the median ratio of predicted profits was even higher at 1.45, a 45 percent rise.[26] The underlying source of these profit changes by large banks can be seen more clearly when the profit index $\hat{\pi}_{t+1}/\hat{\pi}_t$ is decomposed into its associated changes in technology (as reflected in the profit function coefficients β_t) and business environment (as observed in the profit function data X_t). Since $\pi = \mathbf{p}'\mathbf{y} - \mathbf{r}'\mathbf{x}$, changes in "technolo-

23. This exercise is not a direct test of the assumptions of the alternative versus the standard model. As mentioned, output prices are measured poorly. In addition, the alternative specification in (1) is actually a "mixed" model; output prices are partially reflected in the funding-loan rate spread variable in **z**.

24. NI^* is total operating and interest revenues minus total operating and interest expenses but before deductions for loan losses, taxes, or extraordinary items. When these deductions are made to NI^*, net income (NI) is obtained. This is our second profit measure and one that is standard in the industry. Seven banks with negative average profits were deleted from our sample of 343 large banks (giving 336 observations).

25. The profit ratio $\hat{\pi}_{t+1}/\hat{\pi}_t$ is measured by $\beta_{t+1}X_{t+1}/\beta_t X_t$ where β_t represents the estimated parameters of the profit function and X_t represents the values of the variables in period t (t = 1977–80, 1981–84, 1985–88).

26. Although profits rose in real terms by 45 percent from periods 2 to 3, the average ROA^* was only 5 percent higher due to asset growth over the same period (Table 1).

gy" in our alternative profit function reflect principally bank-initiated adjustments in deposit and loan output prices and use of labor, capital, and funding inputs (**p** and **x**). In contrast, changes in "business environment" reflect contemporaneous variations in output quantities (**y**), input prices (**r**), and other included variables.

Changes in Technology and Business Environment

Decomposition of the profit index can occur in either of two ways, depending on how the beginning and ending periods are used as bases. For changes from periods 1 to 2 (1977–80 to 1981–84) the decomposition is

$$\hat{\pi}_2/\hat{\pi}_1 = \beta_2 X_2/\beta_1 X_1 = \frac{(\beta_2 X_1)(\beta_2 X_2)}{(\beta_1 X_1)(\beta_2 X_1)} = \frac{(\beta_2 X_2)(\beta_1 X_2)}{(\beta_1 X_2)(\beta_1 X_1)} \tag{2}$$

and the resulting changes in technology and business environment are shown in column 1 of Table 2.[27] If business environment is held constant at its beginning value of X_1, the change in technology (β_2/β_1) would have generated a profit ratio of 1.13 ($\beta_2 X_1/\beta_1 X_1$). Since the median of the actual profit indices was 1.12, this implies that the business environment (index value = .99) generated a slight offsetting change of one percentage point, shifting the 1.13 value back down to 1.12. Alternatively, if business environment is held constant at its ending value of X_2, then the change in technology (β_2/β_1) would have generated a profit index of 1.07 ($\beta_2 X_2/\beta_1 X_2$) for the median bank, implying a change in business environment that raises the 1.07 value up to 1.12, which is accomplished by a corresponding median business environment index of 1.05.

Overall, the rise in bank profits from 1977–80 to 1981–84 results from altering technology ($\beta_2 \neq \beta_1$) by changing deposit and loan prices and use of labor, capital, and funding inputs in response to deregulation (and by changes in the coefficients on other assets and the variables in **z**). The effect of a changing business environment in terms of deposit and loan quantities, input prices, other assets, and the variables in Z, averaged over the beginning and ending base periods, contributes little to the profit change. This is in contrast to the determinants of the profit change between 1981–84 to 1985–88 (periods 2 to 3), which compares the time period of deregulation with the post-deregulation period. Here the profit index jumps to 1.45 but is entirely due to the change in business conditions ($X_3 \neq X_2$), which yields profit ratios of from 1.47 (with the initial technology β_2) to 1.65 (with ending technology β_3). Since total assets increase enough to limit the growth rate of the ratio of profits to total assets to 5 percent (*ROA** in Table 1), it is not surprising to see the growth in profits driven mostly by higher levels of deposit and loan outputs, other assets, changes in the variables in **Z**, and changes in input prices. As the effect of technolo-

27. In order to reflect changes for the representative bank in the sample, the profit, technology, and business environment ratios are computed for each bank in the sample, with the medians across all banks reported in the tables. While the relationships in (2) above hold exactly for a given bank, they are not necessarily preserved for the medians across banks.

TABLE 2

CHANGES IN PROFIT, TECHNOLOGY, AND BUSINESS ENVIRONMENT: ALTERNATIVE PROFIT FUNCTION FOR LARGE BANKS (ADJUSTED NET INCOME *NI** USED AS PROFIT)

	Periods 1 to 2 (1977–81 to 1981–84)		Periods 2 to 3 (1981–84 to 1985–88)	
PROFITS	$\hat{\pi}_2/\hat{\pi}_1$	1.12	$\hat{\pi}_3/\hat{\pi}_2$	1.45
Technology				
Beginning Base	$\frac{(\beta_2 X_1)}{(\beta_1 X_1)}$	1.13	$\frac{(\beta_3 X_2)}{(\beta_2 X_2)}$	.90
Ending Base	$\frac{(\beta_2 X_2)}{(\beta_1 X_2)}$	1.07	$\frac{(\beta_3 X_3)}{(\beta_2 X_3)}$	.97
Business Environment:				
Beginning Base	$\frac{(\beta_1 X_2)}{(\beta_1 X_1)}$	1.05	$\frac{(\beta_2 X_3)}{(\beta_2 X_2)}$	1.47
Ending Base	$\frac{(\beta_2 X_2)}{(\beta_2 X_1)}$	.99	$\frac{(\beta_3 X_3)}{(\beta_3 X_2)}$	1.65

NOTES: Median values are reported. Large banks have assets > $500 in 1988 dollars. Adjusted net income (*NI**) is net income (*NI*) before provision for loan losses, taxes, or extraordinary items.

gy was relatively small (and "in the wrong direction") from periods 2 to 3, this suggests that the benefits of banks' structural adjustment to deregulation were essentially achieved by 1985: only between periods 1 to 2 was there a strong positive effect on profits from a change in technology.

This same pattern of dominating technical change—output prices and input quantities—from 1977–80 to 1981–84 and dominating business conditions—output quantities and input prices—from 1981–84 to 1985–88 for large banks was also obtained when net income (*NI*) is used as profits in place of adjusted net income (*NI**). As an additional check, a parallel set of models using the profitability ratios *ROA** (=*NI**/*Total Assets*) and *ROA* (=*NI*/*Total Assets*) as the dependent variable in (1) were estimated. Here again the changes in profits over periods 1 to 2 were dominated by changes in technology; those from periods 2 to 3 by changes in business environment.

Large versus Smaller Banks

The results shown above for 336 large banks (assets > $500 million) differ from those for the 330 smaller banks (assets between $100 and $500 million) in our sample.[28] The contrasting experience between large and smaller banks is shown in Table 3 and concerns the response to deregulation between periods 1 to 2. (From this point on we report the technology and business environment results as geometric averages of beginning and ending period results, effectively expressing the relationships in terms of an average base.) First, the profit index over periods 1 to 2 indicates that smaller banks realized very little of the rise in profits experienced by large banks—1.01 versus 1.12. Second, the rise in profits for smaller banks was not the result of

28. Ten smaller banks that had negative average profits were deleted from the sample of 340 smaller banks (giving 330 observations).

TABLE 3

CHANGES IN PROFIT, TECHNOLOGY, AND BUSINESS ENVIRONMENT: ALTERNATIVE PROFIT FUNCTION FOR LARGE AND SMALLER BANKS (ADJUSTED NET INCOME *NI** USED AS PROFIT)

	Periods 1 to 2 (1977–81 to 1981–84)	Periods 2 to 3 (1981–84 to 1985–88)
Profits: $\hat{\pi}_{t+1}/\hat{\pi}_t$		
Large Banks	1.12	1.45
Smaller Banks	1.01	1.39
Technology:		
Average Base		
Large Banks	1.10	.93
Smaller Banks	.96	.84
Business Environment:		
Average Base		
Large Banks	1.02	1.56
Smaller Banks	1.04	1.60

NOTES: Geometric averages of the medians of the beginning and ending period values gave the average base results reported. Large (smaller) banks are those branching banks with assets > $500 million ($100–$500 million) in 1988 dollars.

technology changes, but rather due to improved business conditions—just the opposite of that for large banks.

In sum, large banks bore the brunt of changing output prices and input use in adjusting to deregulation and, judging from the profit gain that resulted, appear to have responded more effectively as well. Large retail-orientated banks had the most comprehensive branch networks and thus the greatest investment in the status quo prior to deregulation. These banks were disproportionately affected when deregulation altered the previous "social contract" where convenient branch offices and below-cost or zero deposit service fees and balance requirements had substituted for zero interest on transaction accounts and interest rate ceilings on savings and time deposits. This greater absolute vulnerability to deregulation, augmented by the fact that large banks are concentrated in the most competitive city and suburban banking markets, is probably the reason for the greater change in technology. Smaller banks, in contrast, are in generally less-competitive markets and were probably less affected, apparently making fewer adjustments to their technology—perhaps as a result of having fewer options. This differential response to deregulation is only evident for the early period: both sets of banks relied on an improved business environment for the large profit increases realized from periods 2 to 3, as seen in column 2 of Table 3.

Alternative versus Standard Profit Functions

While we believe we have made a good case for preferring our alternative profit function $\pi(\mathbf{y}, \mathbf{r})$, in which banks have some discretion in setting output prices as well as altering input use, for completeness these results are contrasted with those obtained from a standard profit function $\pi(\mathbf{p}, \mathbf{r})$ where banks are instead assumed to act only as price takers. In the two columns labeled "Full Model" in Table 4 we report the large bank results for the alternative profit function (1) along with a stan-

TABLE 4

CHANGES IN PROFIT, TECHNOLOGY, AND BUSINESS ENVIRONMENT: ALTERNATIVE AND STANDARD PROFIT FUNCTIONS FOR LARGE BANKS (ADJUSTED NET INCOME *NI** USED AS PROFIT)

	Periods 1 to 2 (1977–81 to 1981–84) Model Specification:		Periods 2 to 3 (1981–84 to 1985–88) Model Specification:	
	Full Model	Restricted Model	Full Model	Restricted Model
Profits: $\hat{\pi}_{t+1}/\hat{\pi}_t$				
Alternative: $\pi(\mathbf{y}, \mathbf{r})$	1.12	1.09	1.45	1.42
Standard: $\pi(\mathbf{p}, \mathbf{r})$	1.10	1.11	1.42	1.43
Technology:				
Average Base				
Alternative:	1.10	1.20	.93	.90
Standard:	1.10	.81	1.17	1.24
Business Environment:				
Average Base				
Alternative:	1.02	.92	1.56	1.56
Standard:	1.03	1.36	1.23	1.15

NOTES: Geometric averages of the medians of the beginning and ending period values gave the average base results reported.

dard profit function that is identical to (1) except output prices (p) replace output quantities (y). The standard and alternative models should produce similar values for the profit indices across periods. This is confirmed in the top portion of Table 4.

Consider now the decomposition of the overall profit index. In the standard model output and input prices are given in the external environment and banks adjust output and input quantities whereas the situation in the output market is reversed in the alternative model: output quantities—rather than prices—are part of the external environment and banks adjust output prices. Thus, where deposit and loan outputs are concerned, we should see a symmetry in the effects of technology and business environment across the two models. However, this is not seen in the two columns labeled "Full Model."

The improvement in profits attributed to altered technology from both the alternative (1.10) and standard (1.10) profit functions accounts for almost all of the profit variation between periods 1 to 2 (1.12 and 1.10, respectively). Recall, however, that measured output prices in the standard model do not reflect many of the adjustments banks made in response to deregulation—higher up-front fees, compensating and minimum balance requirements, and collateral conditions. Furthermore, the added variables in $\mathbf{z}$ in (1) reflect both output price and quantity components and can proxy for excluded influences as well as misspecification in included variables.

In the two columns labeled "Restricted Model" we report results for models that exclude all of the variables in $\mathbf{z}$. Excluding these four additional influences significantly reduces the explanatory power of the regression; the restrictions are resoundingly rejected in likelihood ratio tests. Referring to the restricted model results for periods 1 and 2, however, we now observe the anticipated symmetry: the alternative specification attributes most of the change in profit to technology (principally changes in output prices) while the standard model captures the change as business

environment (here again, principally changes in output prices). The expected symmetry of the restricted model is less evident for periods 2 to 3. Even so, the alternative model attributes most of the profit improvement to business environment (principally expanded output quantities) while the standard model attributes it to technology (again, expanded output).

The Profit Frontier and Changes in Profit Efficiency

We applied the thick frontier approach to determining profit efficiency (Berger and Humphrey 1991) to our alternative model in (1).[29] The thick frontier approach determines the interquartile range of unexplained differences in profitability between preselected sets of the most- and least-profitable banks, an effect attributed to unspecified efficiency differences. Separate profit functions are estimated for the highest- and lowest-profit quartile of banks for each of the three time periods shown in Table 1.[30] For each time period, the predicted adjusted return on assets ($R\hat{O}A^*$) is computed for the highest (Q1)- and lowest (Q4)-profit quartiles as $R\hat{O}A^*_{Qi} \equiv \beta_{Qi}X_{Qi}/TA_{Qi}$ where the numerator—predicted adjusted net income (NI^*) for a given quartile—is obtained by multiplying the parameters of the profit function for that quartile (β_{Qi}) by the median value of each variable across all banks in that quartile (X_{Qi}), and TA_{Qi} represents the medians of total assets across banks in the quartile. The difference in predicted profitability between the high- and low-profit banks $(R\hat{O}A^*_{Q1} - R\hat{O}A^*_{Q4})/ROA^*_{Q1}$—was 22 percent, 24 percent, and 19 percent, respectively, for periods 1, 2, and 3. These values represent the differences in predicted profit between the most-profitable and least-profitable quartiles. Of course, the measures commingle changes in technology (parameters) and changes in business environment (data). Using the data for the efficient quartile as base, we measure the difference between the efficient technology used by the high-profit banks (β_{Q1}) and the inefficient technology used by the low-profit banks (β_{Q4}):

$$\begin{aligned} INEFF &= \{(\beta_{Q1}X_{Q1}/TA_{Q1}) - (\beta_{Q4}X_{Q1}/TA_{Q1})\}/(\beta_{Q1}X_{Q1}/TA_{Q1}) \\ &= \{R\hat{O}A^*_{Q1} - R\hat{O}A^*_{Q4*Q1}\}/R\hat{O}A^*_{Q1} \,. \end{aligned} \tag{3}$$

For our sample of large banks, the values of inefficiency ($INEFF$) were 19 percent, 18 percent, and 15 percent, respectively, for periods 1, 2, and 3. Thus approx-

29. All frontier approaches—from the linear programming methods (DEA and FDH) to the stochastic econometric (half normal composed error and distribution free) as well as the thick frontier—require (different) arbitrary assumptions to be implemented. See Bauer, Berger, and Humphrey (1993) for a comparison of results using different frontier methods in a cost function context.

30. The quartiles are determined by (1) computing each bank's average adjusted return on assets (ROA^*) over the entire period 1977–88; (2) ranking all the banks by their average ROA^*; and (3) selecting banks that were in the highest (lowest) quartiles. The set of banks in each quartile is kept constant for each of the three time periods. The idea is that differences in profits between banks in the highest and lowest profit quartiles that are unexplained by their respective profit functions and are persistent are likely to reflect efficiency differences. The use of ROA^* to rank (and hence filter) the banks prior to estimating (1) will not bias the results because ROA^* is uncorrelated with either profits or total assets (the adjusted R^2s are .00 in both cases).

imately 70 to 90 percent of the difference in bank profitability is apparently accounted for by differences in technological efficiency, as captured by (3).[31] Overall, differences in profitability between high-profit and low-profit banks have remained fairly constant throughout the period.

We also used the frontier procedure to decompose the profit indices of high- and low-profit banks into their technology and business environment components, as was done above for all banks together. The high-profit banks on the thick frontier experienced a much larger rise in profits (1.23 and 1.52, respectively, for time periods 1 to 2 and 2 to 3) than did the low-profit banks (.90 and 1.30). Even so, the pattern identified earlier still held: namely, improvements in technology—output prices and input use—dominated periods 1 to 2 while an improved business environment dominated periods 2 to 3.

4. CONCLUSIONS

Bank-initiated adjustments to the deregulation of the early 1980s took three main forms: cost offset and reduction, cost shifting, and revenue augmentation. Higher interest costs were partly offset by reductions in branch operating expenses and by imposing higher explicit fees and larger minimum balance requirements for previously free or below-cost deposit services. As well, some of the higher funding cost and interest rate risk was shifted to borrowers through floating-rate loans and to purchasers of securitized assets. Finally, revenue was augmented by expanding asset risk to obtain a greater expected return on loans to a more concentrated (and risky) set of borrowers. Although these responses limited the reduction in profits, the rate of return was lower than had existed previously. While the cost offset, cost reduction, and cost shifting responses to deregulation were quite successful, attempts to augment loan revenues were more than completely reversed by unexpectedly large loan losses.

Our purpose has been to outline the above responses to deregulation briefly and then to use a profit function to separate statistically the internal, bank-initiated adjustments to deregulation from the external, contemporaneous changes in banks' business environment. Results based on our alternative profit function—which is supported by the data—indicated that large banks (those with assets over $500 million) bore the brunt of adjusting to deregulation. Between 1977–80 and 1981–84, these banks adjusted deposit and loan output prices and their use of labor and capital inputs to minimize the negative impact on profits from the deregulation-induced rise in funding costs. The effects of changes in business environment during this period—for example, changes in the level of deposit and loan outputs, the prices of

31. Virtually identical results were obtained when inefficiency (*INEFF*) is measured using the data for the inefficient banks in quartile 4 as base. For comparison, we also computed profit differences and technological efficiency using the standard profit function. The differences in predicted profitability for the high- and low-profit quartiles were 12 percent, 16 percent, and 17 percent, respectively, for periods 1, 2, and 3. Of these, inefficient use of technology as measured by *INEFF* accounted for 16, 13, and 13 percentage points.

inputs, and the other included variables—were minimal. Between 1981–84 and 1985–88 the situation was reversed for large banks and an improved business environment was by far the major reason for the profit improvements that occurred. In contrast, smaller banks (with assets between $100 and $500 million) apparently initiated few important adjustments in response to deregulation and instead relied only on an improved business environment to stabilize profitability.

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