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Capital Requirements and Shifts in Commercial Bank Portfolios

by Joseph G. Haubrich and Paul Wachtel

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Introduction

A dramatic and virtually unprecedented shift in the portfolio structure of U.S. commercial banks has taken place since 1989. Specifically, government securities as a share of total loans has risen from 15 percent in 1989 to more than 22 percent today. This portfolio shift has coincided with an important change in the financial regulatory structure. Bank regulators around the world agreed to a common set of risk-based capital requirements in mid-1988. These requirements were phased in gradually in the United States and became fully effective this year.

Some have suggested a connection between the regulatory changes and the portfolio shift, although this claim has not been substantiated. In this paper, we will present some rather strong evidence that the portfolio shift is consistent with regulatory change, which has increased the attractiveness of government securities as an asset.[1] The evidence comes from an examination of the quarterly "call report" data on commercial banks from the Federal Financial Institutions Examination Council (FFIEC).

Though bankers and their regulators find the portfolio shift interesting in itself, it also has broader implications. Our results provide evidence that regulation matters—a point of considerable debate for capital requirements in particular (Keeley [1988]) and for public policies in general (Stigler [1975]). The reason is that bank portfolio risk strongly affects the chance of financial collapse and an associated government bailout. Concerns about this possibility motivated the risk-based capital standards in the first place. Furthermore, by altering the credit available to businesses and consumers, a shift in bank portfolios may slacken the pace of economic recovery.

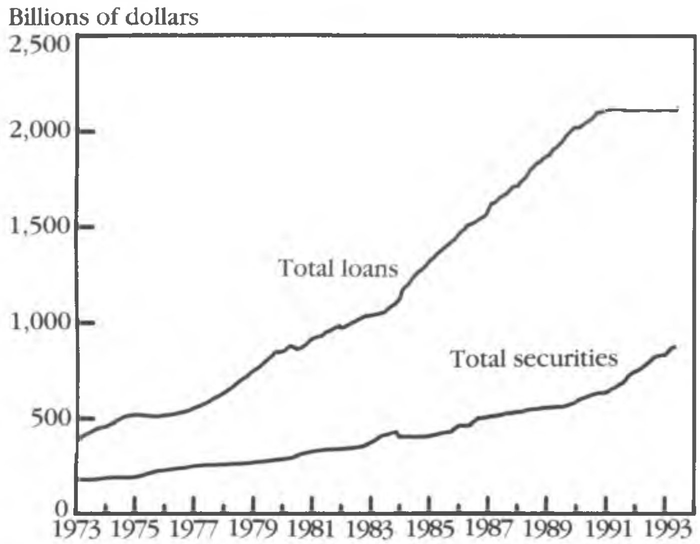
The new risk-based capital requirements classify bank assets. Government securities are deemed to be riskless and therefore have a zero weight when the bank determines its required capital.[2] Thus, a bank that finds it difficult to meet its capital requirements can do so by shifting its asset portfolio away from loans and other high-risk-weighted assets toward government securities.

■ 1 For some other interesting approaches to the same problem, see Furlong (1992), Jacklin (1993), and Hancock and Wilcox (1992).

■ 2 U.S. government securities have a zero risk weight because there is no default risk. However, they are subject to interest-rate risk, and the new capital requirements have been criticized for ignoring this component.

FIGURE 1

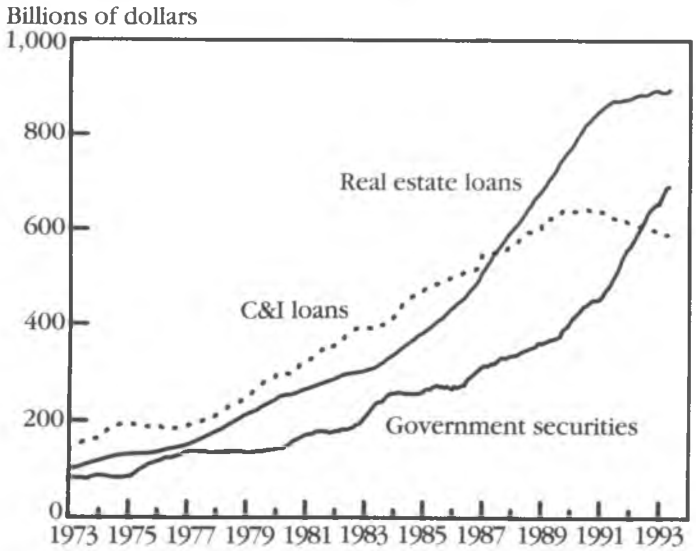
Growth in Loans and Securities for Commercial Banks, 1973–93



SOURCE: Board of Governors of the Federal Reserve System, statistical release G.7.

FIGURE 2

Growth in Government Securities, C&I Loans, and Real Estate Loans for Commercial Banks, 1973–93



SOURCE: Board of Governors of the Federal Reserve System, statistical release G.7.

There are, of course, other plausible reasons why bank portfolios have shifted toward government securities. First, the large loan losses of the 1980s made business lending appear more risky and less attractive. Second, the business slowdown that coincided with the introduction of risk-based capital requirements weakened loan demand. The decline in loan demand was exceptionally large in the recent recession because of the boom in business and consumer leverage in the mid-1980s. Thus, the shift toward government securities could also be the result of these factors.

We submit that the changes in portfolio composition are strongly related to the introduction of risk-based capital requirements. Specifically, banks with the largest increases in government securities holdings tend to be those with the lowest capital–asset ratios when the new capital requirements were introduced. The conclusion is unaffected when we control for the weakness of the bank's loan portfolio.[3] Thus, the change in bank portfolios does not seem to be the result of this weakness.

I. Aggregate Trends in Bank Assets

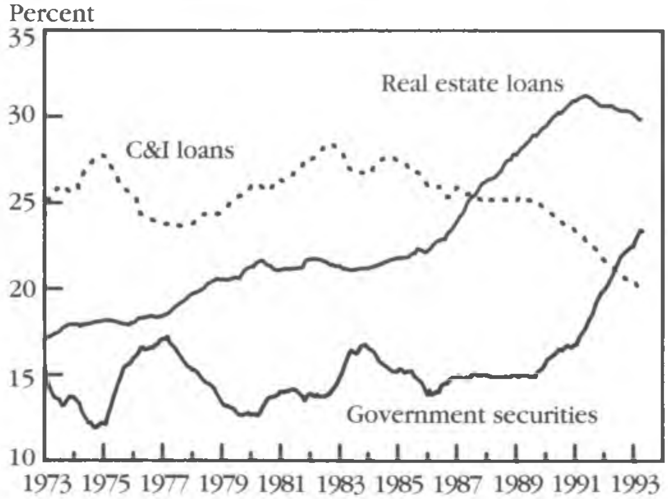
The composition of commercial bank portfolios has changed dramatically over the years. For the first two postwar decades, banks reduced the proportion of their assets in securities and increased the proportion in loans. Part of the reason was the need to liquidate large holdings of government securities accumulated during World War II. Moreover, the development of highly liquid and active money markets as sources of funds reduced the precautionary need to hold both government securities and cash assets (see Boyd and Gertler [1993]). These secular shifts in banks' activities were completed by the early 1980s.

Some dramatic changes have taken place more recently, however. Figure 1 shows the growth of total loans and total securities since 1973. After rapid gains beginning in 1973, the outstanding stock of bank loans has been constant for the last three years. Total securities holdings expanded less rapidly through the 1980s and began to speed up in the last three years.

■ 3 It is more difficult to control for the influence of loan demand on portfolio shifts because we lack any bank-specific measures of the strength of demand. Still, while other factors may explain part of the portfolio shift, they do not overturn the importance of the new capital requirements.

FIGURE 3

Government Securities, C&I Loans, and Real Estate Loans as a Share of Total Loans and Securities, 1973–93



SOURCE: Board of Governors of the Federal Reserve System, statistical release G.7.

More detail is provided in figure 2, which shows three critical categories—government securities, commercial and industrial (C&I) loans, and real estate loans. The rapid increase in government securities holdings since the late 1980s has clearly coincided with a substantial decline in the volume of C&I loans outstanding.

Finally, figure 3 presents the proportions of these three critical categories in total loans and securities. The share of C&I loans began to decline around 1984. Real estate loans as a percent of the total began to increase in 1986 and then leveled off around 1990. Most important, the proportion of U.S. government securities in total loans and securities rose dramatically in the three years following 1989. The bank portfolio shifts of the last decade thus occurred in two stages: Banks initially turned from C&I loans to real estate loans, but then shifted from loans to U.S. government securities in recent years.

II. Changes in Bank Portfolios

Regulation mandating commercial-bank capital requirements has evolved over the years. In 1985, regulators established a required ratio of book value of equity (primary capital) to assets of 5.5 percent. There was also a total capital requirement of 6 percent for the ratio of primary and secondary capital to assets. U.S. and foreign regulators agreed in 1988 to implement risk-based capital requirements. The new requirements were phased in gradually beginning in 1990 and became fully effective at the end of 1992 (see Saunders [1993]).

U.S. commercial banks are now required to have a minimum ratio of total (Tier 1 + Tier 2) capital to risk-adjusted assets of 8 percent.[4] In order to calculate risk-adjusted assets, each asset is assigned to one of four risk categories and given a weight of 0, 20, 50, or 100 percent. U.S. government securities are in the first category, with a risk weight of zero. C&I loans and most real estate loans (except securitized mortgage pools and regular residential mortgage loans) are assigned a weight of 100 percent. Risk-adjusted assets are thus simply a weighted average of the bank's portfolio of assets. In addition, the entire portfolio faces a leverage restriction: Total capital must be 4 percent of total assets (unweighted).[5]

Thus, a commercial bank that moves its asset holdings from loans with a full 8 percent capital requirement to government securities with no capital requirement eases the associated regulatory burden. Clearly, banks that are inadequately capitalized have an incentive to increase the proportion of their assets in government securities. Our central hypothesis is simply that the large changes in bank balance sheets observed in the last three years represent a response to these incentives.

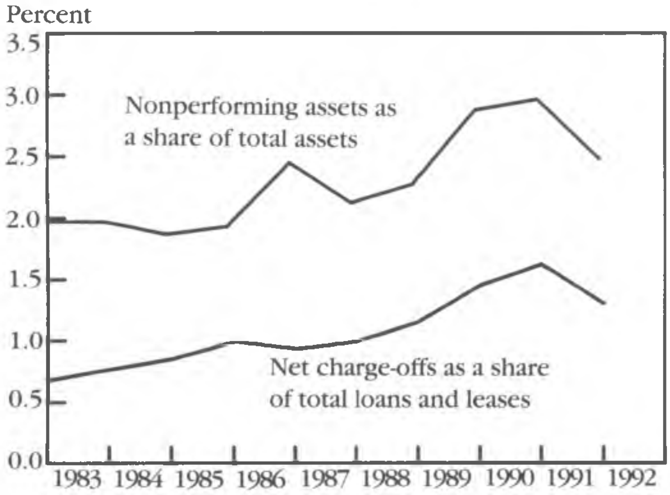
One alternative hypothesis is that the shift into government securities was an effort to avoid risk as bank asset portfolios weakened in general. Because banks found it more difficult to manage their risky asset portfolios, they viewed government securities more favorably, and there was a flight to quality. This hypothesis is credible in light of the documented deterioration in the condition of commercial bank portfolios in the 1980s.

4 The minimum ratio of Tier 1 capital (primarily common stock equity) to risk-adjusted assets is 4 percent. Tier 2 capital includes certain types of preferred stock and subordinated debt. The details of the new rules are published in the *Federal Register*, January 27, 1989, pp. 4186–221.

5 The Basel agreements themselves specify only Tier 1 risk-based and total risk-based ratios. Outside the United States, banks face only those capital requirements. U.S. banks have an additional constraint: minimum leverage. While the capital guidelines implementing the Basel Accord specified a constraint of 3 percent, the prompt corrective action guidelines of the FDIC Improvement Act of 1991 (FDICIA) mandated a constraint of 4 percent, except for banks with a regulatory CAMEL rating of 1. For a discussion, see Huber (1991), chapter 15, or Carnell (1992).

FIGURE 4

Nonperforming Assets and Net Charge-offs as a Share of Totals, 1983–92



SOURCE: Federal Deposit Insurance Corporation.

This downtrend is illustrated in figure 4. Nonperforming assets as a percent of total assets and net charge-offs as a share of total loans and leases both began to rise in the mid-1980s. However, this portfolio deterioration preceded the change in asset composition by several years. The shift of assets into government securities started in the late 1980s when banks' condition began to recover. The increasing net charge-off rate and nonperforming loan rates in 1990 and 1991 stemmed not from an upturn in bad loans, but rather from a decline in total loans outstanding.

As a final check, we control for the effects of loan quality in section V. Though we cannot rule out this factor, our results do indicate a risk-based capital effect independent of loan quality.

An alternative explanation is that the change in bank portfolios was related to loan demand and overall economic conditions. Indeed, cyclical changes in bank portfolio preferences are quite common. For example, when monetary policy eased in the mid-1970s and again at the end of the 1980–82 recessions, the government securities proportion of total loans and securities headed upward. The episode in the early and mid-1980s is similar to the current situation. Although monetary policy eased, banks were reluctant to boost lending, and the proportion of government securities in their portfolios increased. At that time, the debt crisis in less-developed countries influenced bank behavior. In both of the earlier cases, however, a growing economy generated loan demand and the run-up in government securities holdings lasted only about two years.

In the recent episode, the rise in government securities holdings has continued for almost four years without any sign of abatement, placing the proportion of these securities in commercial bank portfolios at unprecedented levels. This situation may be unique because the recovery that began two years ago has been particularly sluggish. Despite an expansionary monetary policy, the persistently weak economy has held down loan demand, and as a result, banks continue to augment their holdings of government securities. Although it is difficult to distinguish between the effects of weak loan demand or risk-based capital requirements on bank holdings of government securities, a cyclical response to demand is unlikely to be entirely responsible for the enormous portfolio shifts observed.

A third alternative is that government securities became more profitable in the late 1980s. The combination of a steep yield curve and a large supply of government securities, driving prices down, may have made banks eager customers. This term-structure argument requires more justification than is usually given: Many bank loans are long term, and thus could also be profitable for banks.

The story appears to rest on some shift not in the term structure, but in the risk structure, between Treasury bonds and bank loans. This is less obvious than the initial statement, however. Perhaps the explosion in government debt drove down the price of Treasuries (though this point itself is controversial). In either case, such general factors should not affect individual banks differently. Therefore, our strategy of comparing well-capitalized and weakly capitalized banks is not sensitive to this shift. The lower prices for Treasuries may explain the portfolio shift of well-capitalized banks.

III. Relationship between Capital and Portfolio Shifts

Our hypothesis indicates that a bank's incentive to satisfy the newly introduced risk-based capital requirements by adjusting its portfolio is larger if the institution initially fails those new requirements. That is, banks that will be capital constrained under the new standard if they

TABLE 1

Asset Allocations for Commercial Banks by Size Class, March 1990 (percent)

Proportion of Total Assets Held as:	Size Class 1	2	3	4	5	6
Cash assets	8	6	6	7	8	10
Total securities	30	30	26	19	19	15
Treasuries (book value)	10	9	8	6	5	4
Total loans	51	54	59	65	65	65
C&I loans	9	11	13	16	18	21
Real estate loans	30	30	30	28	24	19
Mortgages (1–4 family)	13	14	14	11	9	7
Consumer loans	11	12	14	17	17	14

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

TABLE 2

Capital Ratios by Size Class, March 1990–September 1992 (percent)

	Size Class 1	2	3	4	5	6
A. Capital Ratios and Changes						
Total capital/ risk-adjusted assets, March 1990	18.38	16.41	13.95	11.44	10.82	8.67
Change, 1990–92	0.12	1.14	1.27	1.41	1.45	2.71
Tier I capital/ risk-adjusted assets, March 1990	17.20	15.27	12.77	10.04	9.38	6.79
Change, 1990–92	0.12	1.09	1.21	1.37	1.28	2.37
B. Distribution of Banks by Capital Class, March 1990						
Capital Class						
0–4%	6.8	0.5	0.6	1.0	0.0	0.0
4–8%	2.2	2.1	3.6	10.9	14.6	32.4
8–10%	3.7	5.8	12.9	28.8	37.7	53.3
10–14%	23.7	33.6	44.9	46.7	40.4	11.4
>14%	63.6	58.0	38.0	13.5	7.3	1.9

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

do nothing will thus take greater actions to comply. In this section, we present the data used to examine the relationship between the initial risk-based capital ratio of individual banks (in either 1988 or 1990) and the banks' portfolio changes. Our data source is the quarterly call reports on all U.S. commercial banks. In addition, we show that a bank's incentive to hold government securities increases even if it was not initially capital constrained.

Although the risk-based capital requirements were announced in July 1988 and began to be implemented in March 1989, the call reports were not revised to reflect the new definitions until March 1990. Prior to 1990, however, it is possible to approximate the risk-based capital ratio of the bank from the available data. In both instances, we use algorithms developed at the Federal Reserve Board by Avery and Berger (1991) to derive the risk-adjusted assets of the bank. Thus, we will be able to look at the changes in bank portfolios over two periods: from June 1988 (when the new capital requirements were announced) to September 1992, and from March 1990 (when the phase-in of the new capital requirements began) to September 1992.

Our data set consists of 12,187 commercial banks divided by asset size (as of March 1990) as follows:[6]

1. Less than $50 million	6,558
2. $50–100 million	2,685
3. $100–500 million	2,350
4. $500 million–1 billion	229
5. $1–5 billion	260
6. More than $5 billion	105

Table 1 shows that commercial bank asset allocations differ according to bank size. For example, the smallest banks had only 9 percent of their assets in C&I loans, while the proportion for the largest banks was 21 percent. However, the asset allocation changes that occurred over the two-and-a-half-year period beginning in March 1990 were common to all sizes of banks (the very smallest were sometimes an exception). Holdings of securities, particularly Treasury securities, rose and loans (except for real estate loans) decreased.

The top part of table 2 shows the ratios of capital to risk-adjusted assets at the start of the period and the change for banks in each size class over the sample period. On average,

6 Banks were removed from the sample if the data seemed to be erroneous, if extreme outliers were present, or if the banks had greater than 50 percent capital.

TABLE 3

Bank Adjustment to Risk-Based Capital Requirements: Portfolio Shifts, Growth, and Raising Capital

Capital Class	Size Class 1	2	3	4	5	6
	Portfolio Shift $\hat{P}$					
0	−0.08	0.59	−0.20	—	—	—
1	−0.11	−0.10	−0.13	−0.14	−0.10	−0.08
2	−0.06	−0.10	−0.06	−0.08	−0.08	−0.07
3	−0.01	−0.03	−0.03	−0.02	−0.06	0.00
4	0.06	0.01	0.01	0.07	0.30	−0.10
	Size Shift $\hat{TA}$					
0	0.87	0.70	−0.20	—	—	—
1	0.09	0.01	0.15	0.04	0.17	0.00
2	0.24	0.38	0.20	0.19	0.20	0.10
3	0.25	0.28	0.22	0.16	0.20	0.27
4	0.31	0.19	0.19	0.36	0.10	0.28
	Capital Shift $\hat{C}$					
0	48.55	12.01	2.42	—	—	—
1	0.89	0.46	0.48	0.35	0.56	0.34
2	0.47	0.48	0.30	0.31	0.30	0.30
3	0.32	0.31	0.28	0.20	0.22	0.30
4	0.24	0.20	0.21	0.24	0.15	0.29

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

banks of all sizes were sufficiently well capitalized; the minimum total capital requirements were 8 percent. Finally, in every size class, banks augmented capital in this period.

To explore the relationship between portfolio changes and capital requirements, we classified banks by total capital to risk-adjusted asset groups at the start of the period. The capital requirement classes and the distribution of banks by size class are shown in the bottom part of table 2. Most smaller banks had very high capital–asset ratios, although there were a significant number of exceptions. As bank size increases, the proportion of banks with capital ratios under 8 percent rises as well. When we reach the largest size class, very few banks exceeded the minimum capital requirement by a comfortable margin.

Under this classification scheme, banks that are severely undercapitalized (0 to 4 percent capital ratio) or moderately undercapitalized (4 to 8 percent capital ratio) must meet the new requirements to stay in business. They may downsize, raise new capital, or rebalance their portfolios to take advantage of the different risk weights. The explicitly undercapitalized banks are not the only ones facing incentives to increase their capital, however. Regulators require banks to hold capital well in excess of the minimum requirements in order to expand or to be able to acquire new entities or businesses.[7] A bank that just satisfies the 8 percent minimum capital ratio and wishes to sell mutual funds, for example, would probably need to increase its capital ratio before obtaining regulatory permission.

To assess how banks responded to the new capital requirements, we explore the nature of capital. Capital satisfies the following identity:

(1) Capital = (capital/risk-weighted assets) x (risk-weighted assets/total assets) x total assets.

In other words, $C = R \times P \times TA$, where C = capital, R = the risk-weighted capital ratio, P = the portfolio factor, and TA = total assets.

Using the standard circumflex notation for proportionate changes ($\hat{C} = \frac{\Delta C}{C}$), we get $\hat{C} = \hat{R} + \hat{P} + \hat{TA}$, or

(2) $\hat{R} = \hat{C} - \hat{P} - \hat{TA}$.

Because the risk-adjusted capital requirements are a constraint on R, we see that equation (2) descriptively allocates the adjustment of banks to three possible courses of action: raise capital (increase C), adjust the portfolio (lower P), or shrink total assets (lower TA). Table 3 reports this breakdown.

Three patterns stand out in table 3. Banks did shift their portfolios in a way that reduced their capital requirements. Furthermore, this shift was more pronounced for undercapitalized banks at every size level. Banks likewise responded by raising capital, although the well-capitalized banks apparently raised more. Finally, on average, banks did not shrink, and in fact grew over this period in every size and capital class. These patterns confirm our primary emphasis on the portfolio effects of the new capital requirements.

7 FDICIA directs bank regulators to use the risk-based capital requirements in making supervisory decisions. The Act established five categories based primarily on the bank's capital position. To be considered well capitalized, a bank would have to exceed the minimum capital requirements by a substantial margin. We caution the knowledgeable reader that the capital classes we use are *not* FDICIA prompt-corrective-action zones.

BOX 1

Why ANOVA?

Though commonly used in many areas of statistics, analysis of variance (ANOVA) is less popular among economists, who generally prefer regression analysis. For evaluating bank portfolio shifts, however, ANOVA has several advantages.

First, it does not require assumptions about the nature of the functional form of the statistical relation: In particular, it does not impose a linear relation between capital and portfolio shifts. A difference in the response of well-capitalized and undercapitalized banks assumes a nonlinear response by definition. The different degrees of capital constraint (for example, deeply undercapitalized, barely capitalized) coupled with our ignorance about the correct form of the relation (linear, logarithmic, quadratic) make the ANOVA specification particularly attractive.

ANOVA might also be called "comparison of means." It statistically estimates the effects due to various factors (here, they are size and capital class) and then allows comparison of those effects—analyzing how and why the cells of table 6 differ from each other.

ANOVA has a further advantage in that it facilitates the estimation and interpretation of interaction effects. Our analysis considers two *main effects*, size and capital. Accounting for each one separately may not provide the whole story: The main effects may not be additive, and there may be interaction effects. For example, undercapitalized large banks may receive more scrutiny from the regulators or find it easier to invest in certain markets, and so may adjust their portfolios differently.

Banks had another reason to adjust portfolio shares. The new requirements changed the returns on different types of investments. Relative to business and commercial real estate loans, government securities became more profitable because they required less capital backing. A simple calculation shows that the difference can be substantial.

The standard way to approach these issues is with a version of the Miller (1977) debt model as extended to banks by Orgler and Taggart (1983). Banks have two sources of funds: deposits and equity. Deposits have a tax advantage in that banks may deduct interest paid as a business expense, but cannot deduct dividends paid on equity. Deposits have an additional cost of reserve requirements, but in general banks would prefer to raise funds using debt. Banks cannot fund themselves exclusively with deposits, however, because they face a constraint on their funding, namely a capital requirement that the ratio of debt (for example, deposits) to equity not exceed a limit ζ. If we denote the return on deposits as r_d and the return on equity as r_e, the marginal cost of raising funds, r, is given by

$$(3)\qquad r = \frac{r_e/(1-t) + \zeta\, r_d}{1 + \zeta(1-\rho)},$$

where t is the corporate tax rate and ρ is the reserve requirement. The bank lends until the return on the loan equals the cost of funds needed to fund the loan.[8]

The capital requirements impose a different ζ on different assets, and thus induce a different rate of return. As an example, consider a return on equity r_e of 10 percent, a return on deposits r_d of 4 percent, a corporate tax rate t of 28 percent, and required reserves ρ of 12 percent. A U.S. Treasury bond has a ζ of 24 (a zero risk weighting and the 4 percent leverage requirement that becomes a debt-to-equity ratio of 0.96/0.04), while a C&I loan has a ζ of 11.5 (a 100 percent risk weighting). In this case, the cost of raising funds internally (r_I) to buy a Treasury bond is 4.9 percent, while the cost of raising funds internally to make a loan is 5.4 percent. The relative cost of loans has increased, making their inclusion in a portfolio less attractive.[9]

IV. Analysis of Variance

The relationship between portfolio changes and the risk-adjusted capital ratio prior to the introduction of risk-based capital requirements is examined with an analysis of variance (ANOVA, detailed in box 1). We investigate the relationship for the asset categories outlined in table 4.

8 A little more intuition on the exact form of equation (3) can be gained as follows. Assume that the bank wishes to raise one dollar as cheaply as possible. The bank would like to use debt, for which it pays r_d, but it faces a capital constraint, so it can raise only a fraction of the funds using debt. It also must raise equity, and must pay more than r_e because of corporate income tax. This explains the first term in the numerator. Because the bank raises money from two different sources, the actual cost is a weighted average of the cost of funds from those sources, and a little algebra shows that the 1/1 + ζ and ζ /1 + ζ terms provide the proportion of equity and debt to total assets. Finally, some of the debt must be invested in required reserves, so to invest one full dollar, the bank must raise slightly more than that, which accounts for the ρ term in the denominator.

9 The general situation is more complicated, of course. For example, some banks can meet their capital requirement by increasing their Tier 2 capital. This includes subordinated debt, which despite being more expensive than deposits avoids the corporate tax penalty of equity.

TABLE 4

Proportion of Total Assets (percent)

	March 1990	September 1992
Cash assets	7.3	6.0
Total securities	28.7	31.7
Treasuries	9.3	10.3
Other securities	19.3	21.4
Total loans	53.8	54.2
C&I loans	11.0	9.3
Mortgages (1–4 family)	13.2	14.5
Other loans (includes other real estate)	29.6	30.4

SOURCE: Authors' calculations.

TABLE 5

Analysis of Variance Results— Probability that Observed Effect Is Due to Chance

Difference across Classes by:	Size and Capital	Size	Capital
Asset Changes, 1988–92			
Cash assets	0.003	0.0017	0.0384
Total securities	0.0	0.0	0.8049
Treasuries	0.0	0.0	0.3661
Other securities	0.0047	0.0003	0.7267
Total loans	0.0	0.0	0.0072
C&I loans	0.0	0.0	0.0005
Mortgages	0.178	0.708	0.9200
Other loans	0.0	0.0	0.0894
Asset Changes, 1990–92			
Cash assets	0.2578	0.9709	0.0215
Total securities	0.0	0.0	0.6090
Treasuries	0.0	0.0	0.0176
Other securities	0.006	0.0	0.2811
Total loans	0.0	0.0	0.0003
C&I loans	0.0	0.0	0.0017
Mortgages	0.1553	0.1272	0.6553
Other loans	0.0	0.0	0.0270

SOURCE: Authors' calculations.

The ANOVA was performed for the change in the ratio to total assets for each category for two time periods. The first period begins in June 1988, just before the risk-based capital requirements were announced, and the second one starts in March 1990, the first available data after the requirements were phased in. This process shows whether the changes in the asset ratios differ significantly across size or capital classes.

The ANOVA F-tests for the effects of size and capital class are summarized in table 5, which presents the probabilities at which the null hypothesis of no significant effect can be rejected. That is, it gives the probability that all effects of the given type are zero. The first column provides the overall test on all the effects and interactions. The next two columns are tests that depend on the ordering of the variables. The second column tests for the significance of the size effects alone. This test is based on the sum of squares, putting the size effect in the estimation first. The third column is a stringent test for the significance of the capital class effects. It is based on the sum of squares when the capital class is added last; it tests the significance of the additional effect of this variable, having already controlled for the size and interaction effects.[10]

In most instances, there are significant differences in asset changes among banks of various size classes. This reflects a wide divergence in portfolio allocations between large and small banks. More important, the differences across capital classes are significant even at the 5 percent level for only a handful of asset categories.

For the asset changes between 1988 and 1992, there are substantial differences across risk-adjusted capital ratio classes for only cash assets and C&I loans. The changes in Treasury-to-total-asset ratios do not vary much across capital ratio classes ($p = 0.3661$). However, when we examine changes from the introduction (rather than the announcement) of the risk-based capital requirements, 1990 to 1992, additional significant changes arise. For this period, the changes in the Treasury-to-asset ratios vary widely by capital ratio class ($p = 0.0176$). In addition, there are substantial differences at the 5 percent level for cash assets, C&I loans, mortgages, and other loans.

The ANOVA results indicate a strong relationship between the initial capital ratio and

■ **10** For a theoretical background, see Searle (1971); for a discussion of the tests, see the SAS/STAT User's Guide (1990), chapters 9 and 24. The SAS system refers to the last two columns in table 5 as type I and type III tests.

TABLE 6

Change in Selected Asset Ratios, 1990–92

Capital Class	Size Class 1	2	3	4	5	6
	Government Securities					
0–4%	0.04	0.03	0.09	0.00	0.00	0.00
4–8%	0.04	0.03	0.03	0.02	0.03	0.03
8–10%	0.03	0.02	0.02	0.03	0.02	0.02
10–14%	0.01	0.02	0.02	0.02	0.03	0.02
>14%	−0.01	0.00	0.01	−0.02	0.01	−0.03
	Cash					
0–4%	−0.01	0.00	0.01	—	—	—
4–8%	−0.01	−0.01	−0.01	0.00	−0.01	−0.01
8–10%	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01
10–14%	−0.01	−0.01	−0.01	−0.02	−0.01	−0.01
>14%	−0.01	−0.01	−0.01	−0.02	−0.04	−0.07
	C&I Loans					
0–4%	−0.05	−0.02	−0.05	—	—	—
4–8%	−0.03	−0.03	−0.05	−0.04	−0.04	−0.02
8–10%	−0.03	−0.03	−0.04	−0.03	−0.04	−0.03
10–14%	−0.02	−0.02	−0.03	−0.03	−0.03	−0.02
>14%	−0.01	−0.01	−0.02	−0.01	−0.01	−0.02
	Mortgages					
0–4%	−0.00	0.02	−0.02	—	—	—
4–8%	0.01	0.02	0.02	−0.03	0.00	0.02
8–10%	0.01	0.01	0.02	0.01	0.02	0.01
10–14%	0.01	0.01	0.01	0.02	0.01	0.03
>14%	0.01	0.01	0.01	0.01	0.01	0.00

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

bank portfolio changes. In particular, the changes emerge more clearly when the phase-in of the new regulations began rather than at the time they were announced. Two reasons account for this delay: First, risk-based capital requirements represented a radical change in U.S. banking regulation, so a period of learning about their consequences is not surprising. Second, if portfolio changes were made to improve banks' capital position, they were not necessary until the phase-in began. In addition, government security portfolios can be changed quickly and easily.

The ANOVA significance tests suggest that there are important differences across asset ratio categories, but do not imply any particular direction in the relationship. For the four asset categories with significant differences across capital–ratio classes, we show the actual mean changes in each capital class for the two-and-a-half-year period after the introduction of risk-based capital requirements in table 6.

The evidence is clear for both government securities and C&I loans. The extent to which the ratio of government bonds to assets increased diminishes as the initial capital position of the bank improves. In fact, in four of the six size groups, the extremely well-capitalized banks (capital ratios greater than 14 percent) did not even boost their holdings of government securities. The evidence for C&I loans is equally compelling. Banks in all categories decreased their portfolio share in C&I loans. In each size class, the fall in the C&I loan share was larger for the poorly capitalized banks.

For banks with initial total-to-risk-adjusted capital of less than 8 percent, the share of government securities in total assets increased on average by 4 percentage points, and the share of C&I loans in total assets decreased by 4 percentage points. Thus, there is a strong indication that poorly capitalized banks responded to the new capital requirements by shifting from C&I loans to government securities. Because the movement away from C&I loans is at least partially due to the deteriorating quality of loan portfolios, it is important to see if the results are robust when we hold the quality of the portfolio constant. The mortgage results are more ambiguous, as expected. With a 50-percent risk weight, they fall between commercial loans and Treasury securities.

Tables 5 and 6 do not completely make the case that a greater portfolio shift took place among undercapitalized banks. The F-test suggests that the means differ, and the means themselves show greater portfolio shifts for un-

TABLE 7

Tukey Multiple Comparison Tests for Differences in Means

A. Total Securities
Alpha = 0.05, Confidence = 0.05,
Degrees of Freedom = 10861,
Mean Square Error = 0.009487,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	1	−0.062459	−0.008804	0.044850
0	2	−0.046423	0.005599	0.057620
0	3	−0.039369	0.011973	0.063316
0	4	−0.019429	0.031819	0.083068
1	0	−0.044850	0.008804	0.062459
1	2	−0.004421	0.014403	0.033228
1	3	0.003920	0.020778	0.037635[a]
1	4	0.024055	0.040624	0.057192[a]
2	1	−0.033228	−0.014403	0.004421
2	0	−0.057620	−0.005599	0.046423
2	3	−0.004188	0.006375	0.016937
2	4	0.016125	0.026220	0.036316[a]
3	1	−0.037635	−0.020778	−0.003920[a]
3	0	−0.063316	−0.011973	0.039369
3	2	−0.016937	−0.006375	0.004188
3	4	0.014214	0.019846	0.025477[a]
4	1	−0.057192	−0.040624	−0.024055
4	0	−0.083068	−0.031819	0.019429
4	2	−0.036316	−0.026220	−0.016125[a]
4	3	−0.025477	−0.019846	−0.014214[a]

B. Treasury Book
Alpha = 0.05, Confidence = 0.95,
Degrees of Freedom = 10861,
Mean Square Error = 0.005965,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	1	−0.028772	0.013774	0.056321
0	2	−0.018189	0.023062	0.064313
0	3	−0.011794	0.028919	0.069632
0	4	0.003935	0.044573	0.085211[a]
1	0	−0.056321	−0.013774	0.028772
1	2	−0.005640	0.009287	0.024215
1	3	0.001777	0.015145	0.028512[a]
1	4	0.017660	0.030799	0.043937[a]
2	0	−0.064313	−0.023062	0.018189
2	1	−0.024215	−0.009287	0.005640
2	3	−0.002518	0.005857	0.014233
2	4	0.013506	0.021511	0.029516[a]
3	0	−0.069632	−0.028919	0.011794
3	1	−0.028512	−0.015145	−0.001777[a]
3	2	−0.014233	−0.005857	0.002518
3	4	0.011188	0.015654	0.020120[a]
4	0	−0.085211	−0.044573	−0.003935[a]
4	1	−0.043937	−0.030799	−0.017660[a]
4	2	−0.029516	−0.021511	−0.013506[a]
4	3	−0.020120	−0.015654	−0.011188[a]

a. Significant at the 0.05 percent level.
SOURCE: Authors' calculations.

dercapitalized banks, but neither approach indicates which means differ from which other means. To do so properly requires a multiple comparison procedure, which introduces a complication. The significance level (say 0.05) of the standard t- and F-tests applies only to that particular test, and not to a series of tests. Thus, it would be inappropriate to use the standard t-test to determine if the mean of capital class 1 *and* capital class 2 differed from the mean of capital class 6. The standard statistic is further inappropriate if the comparison is suggested by the data, say comparing the highest and the lowest means. For example, in comparing the highest and lowest means, with six classes the standard 5 percent test is in fact a 60 percent test (Neter and Wasserman [1974], section 14.2). Table 7 corrects for these problems by using the Tukey method for multiple comparison, which is based on the studentized range distribution (see Neter and Wasserman [1974], section 14.3, and SAS/STAT User's Guide [1990], volume 2, chapter 24). For example, the first line of table 7 compares the mean change in the proportion of total securities for capital class 0 with the same mean for capital class 1.

TABLE 7 (CONT.)

Tukey Multiple Comparison Tests for Differences in Means

C. Total Loans
Alpha = 0.05, Confidence = 0.95,
Degrees of Freedom = 10861,
Mean Square Error = 0.008611,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	4	−0.103050	−0.054225	−0.005401[a]
0	3	−0.071166	−0.022252	0.026663
0	2	−0.046760	0.002801	0.052363
0	1	−0.038886	0.012231	0.063349
1	4	−0.082242	−0.066457	−0.050672[a]
1	3	−0.050543	−0.034483	−0.018423[a]
1	0	−0.063349	−0.012231	0.038886
1	2	−0.027364	−0.009430	0.008504
2	4	−0.066644	−0.057027	−0.047409[a]
2	3	−0.035116	−0.025053	−0.014990[a]
2	0	−0.052363	−0.002801	0.046760
2	1	−0.008504	0.009430	0.027364
3	4	−0.037339	−0.031974	−0.026608[a]
3	0	−0.026663	0.022252	0.071166
3	2	0.014990	0.025053	0.035116[a]
3	1	0.018423	0.034483	0.050543[a]
4	3	0.026608	0.031974	0.037339[a]
4	0	0.005401	0.054225	0.103050[a]
4	2	0.047409	0.057027	0.066644[a]
4	1	0.050672	0.066457	0.082242[a]

D. C&I Loans
Alpha = 0.05, Confidence = 0.95,
Degrees of Freedom = 10861,
Mean Square Error = 0.002579,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	4	−0.0656967	−0.0389768	−0.0122569[a]
0	3	−0.0514908	−0.0247219	0.0020471
0	1	−0.0409112	−0.0129366	0.0150380
0	2	−0.0398953	−0.0127722	0.0143508
1	4	−0.0346787	−0.0260402	−0.0174016[a]
1	3	−0.0205744	−0.0117853	−0.0029961[a]
1	2	−0.0096505	0.0001644	0.0099792
1	0	−0.0150380	0.0129366	0.0409112
2	4	−0.0314679	−0.0262045	−0.0209411[a]
2	3	−0.0174567	−0.0119496	−0.0064426[a]
2	1	−0.0099792	−0.0001644	0.0096505
2	0	−0.0143508	0.0127722	0.0398953
3	4	−0.0171911	−0.0142549	0.0113187[a]
3	1	0.0029961	0.0117853	0.0205744[a]
3	2	0.0064426	0.0119496	0.0174567[a]
3	0	−0.0020471	0.0247219	0.0514908
4	3	0.0113187	0.0142549	0.0171911[a]
4	1	0.0174016	0.0260402	0.0346787[a]
4	2	0.0209411	0.0262045	0.0314679[a]
4	0	0.0122569	0.0389768	0.0656967[a]

a. Significant at the 0.05 percent level.
SOURCE: Authors' calculations.

The difference between the means is positive, but the confidence limits include 0, so we cannot reject equality of the means.

The results in table 7 confirm the significance of the portfolio change. The undercapitalized banks shifted toward securities and away from loans more than did the adequately capitalized and well-capitalized banks.

But another possibility is yet unaccounted for. Low-capitalized banks might have different portfolio shifts even without a change in capital requirements. For example, suppose a bank has low capital because of takedowns of loan commitments that had been funded by purchased money. That is, the bank ends up with an unexpectedly high proportion of loans. Over time, the bank might lower its loan level to restore the desired balance between loans and securities. We wish to demonstrate that low-capital banks do not normally increase their securities holdings in the years following a change in requirements.

To provide some evidence on this, we compare the behavior of banks from 1988 to 1990 with their behavior from 1990 to 1992. Specifically, we compare the portfolio changes in low-

TABLE 8

ANOVA Comparison of Portfolio Shifts between Periods

Capital Class	Asset Components 1988–90	1990–92
	Cash	
0–4%	0.001 (0.044)	−0.003 (0.031)
4–8%	−0.015 (0.047)	−0.010 (0.047)
8–10%	−0.012 (0.035)	−0.010 (0.039)
10–14%	−0.016 (0.045)	−0.013 (0.042)
>14%	−0.019 (0.050)	−0.015 (0.050)
	Government Securities	
0–4%	−0.003 (0.037)	0.046 (0.099)
4–8%	−0.003 (0.048)	0.032 (0.068)
8–10%	−0.001 (0.042)	0.032 (0.057)
10–14%	−0.004 (0.046)	0.017 (0.067)
>14%	−0.014 (0.065)	0.001 (0.085)
	C&I Loans	
0–4%	−0.038 (0.069)	−0.047 (0.072)
4–8%	−0.017 (0.062)	−0.035 (0.060)
8–10%	−0.019 (0.059)	−0.035 (0.061)
10–14%	−0.012 (0.051)	−0.023 (0.056)
>14%	−0.002 (0.040)	−0.008 (0.046)
	Mortgages	
0–4%	0.013 (0.065)	−0.006 (0.062)
4–8%	0.007 (0.042)	0.014 (0.067)
8–10%	0.007 (0.050)	0.013 (0.065)
10–14%	0.005 (0.043)	0.012 (0.053)
>14%	0.007 (0.039)	0.014 (0.051)

NOTE: Standard deviations are in parentheses.
SOURCE: Authors' calculations.

capital banks from 1988 to 1990 with portfolio changes in all other banks from 1990 to 1992 and with low-capital (as of 1990) banks from 1990 to 1992. By using this method, we control for portfolio shifts due to both macroeconomic effects and low capitalization.

Table 8 reports these results. Capital requirements certainly appear to have had an impact. Across each capital class, banks reduced their C&I loans more from 1990 to 1992 than from 1988 to 1990. Low-capital banks even *decreased* their bond holdings in the earlier period, but raised them in response to capital requirements from 1990 to 1992. A large caveat goes along with this work, however, in that most of the differences (even between negative and positive terms) are not statistically significant, even at the 10 percent level.

V. Regression Analysis

We examine the influence of deterioration in the quality of the loan portfolio on bank portfolio allocation changes with a regression model that is a simple extension of the ANOVA framework. The regression equation includes dummy variables for each of the size and capital classes and a measure of the quality of the i^{th} bank's loan portfolio:

$$\Delta \text{ asset ratio}_i = \alpha + \Sigma\ \beta_j \text{ size dummies}_i + \Sigma\ \gamma_k \text{ capital dummies}_i + \delta \text{ loan quality}_i .$$

The charge-off ratio (as of March 1990)—the ratio of net charge-offs to assets—is used to measure loan quality.

A summary of the regression results for the asset ratio changes between 1990 and 1992 for each category is presented in table 9. The charge-off rate has a significant influence on each asset category. The largest effects of poor loan quality are on the increase in Treasury securities and on the decrease in real estate loans. In both of these instances, a 0.5 percentage-point increase in the charge-off ratio (which is about equal to the increase in the aggregate ratio over the 1980s, as shown in figure 4) results in an absolute change in the asset ratio of about 0.01 percentage point. Significant differences between size classes and capital classes appear in all but one category. Finally, the regressions explain only a small proportion of the interbank variation in asset ratios.

The bottom part of table 9 shows the estimated coefficients for the capital dummies. They represent differences from the omitted category: banks with initial risk-adjusted capital ratios in excess of 14 percent. The relationship between the initial capital position and the extent to which the bank increased government securities holdings and reduced loans is still substantial. That is, even with the influence of the quality of the loan portfolio held constant, poorly capitalized banks made large portfolio adjustments away from both C&I and real estate loans and toward holdings of government securities.

TABLE 9

Summary of Regression Results

	Coefficient and t-statistic	F-test Probability		
	Charge-Off Ratio	Size Dummies	Capital Dummies	R^2
Cash assets	0.051 (2.1)	0.3592	0.0499	0.002
Total securities	4.60 (9.2)	0	0	0.028
Treasuries	2.78 (7.0)	0	0	0.021
Other loans	1.83 (3.7)	0.0002	0.6557	0.004
Total loans	−5.06 (10.6)	0	0	0.068
C&I loans	−0.86 (3.3)	0	0	0.038
Mortgages	−0.009 (3.4)	0.635	0.163	0.002
Other loans	−0.03 (8.1)	0	0	0.032

Capital Dummy Coefficients
(Difference from omitted category — Ratio >14%)

	0–4%	4–8%	8–10%	10–14%
Cash assets	0.01	0.00	0.00	0.00
Total securities	0.03	0.03	0.02	0.02
Treasuries	0.04	0.02	0.02	0.01
Other loans	−0.01	0.01	0.00	0.00
Total loans	−0.05	−0.05	−0.04	−0.03
C&I loans	−0.04	−0.02	−0.02	−0.01
Mortgages	−0.02	−0.02	−0.00	−0.02
Other loans	0.01	−0.03	−0.02	−0.01

NOTE: Standard deviations are in parentheses.
SOURCE: Authors' calculations.

VI. Conclusion

The evidence presented here strongly suggests that bank portfolio changes since 1990 are at least in part a response to the introduction of risk-based capital requirements. Qualitatively, at least, the regulations succeeded. Comprehending the changes improves our general understanding of the effects of bank regulation. The particular effect of capital requirements on bank portfolios merits special interest. The shift in bank portfolios can affect their overall risk, and therefore the risk of financial collapse and the liability of the federal government acting as the lender of last resort. On the other hand, the reduction in loans may (under the "credit view") have macroeconomic consequences and reflect on overall economic growth, income, and unemployment.[11]

11 The credit view argues that changes in bank lending—and in credit more generally—have an important effect on the aggregate economy above and beyond any effect on the money supply.

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FDICIA's Emergency Liquidity Provisions

by Walker F. Todd

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Is there any reason why the American people should be taxed to guarantee the debts of banks, any more than they should be taxed to guarantee the debts of other institutions, including the merchants, the industries, and the mills of the country?

Senator Carter Glass (1933)[1]

Introduction

The Federal Reserve Banks' discount window advances to failing depository institutions have become an increasingly controversial issue within the last 20 years or so. This debate culminated in congressionally mandated limitations on Reserve Banks' advances to undercapitalized banks in the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA), previously the subject of a Federal Reserve Bank of Cleveland *Economic Commentary*.[2]

In a comparatively little-noticed amendment of the Reserve Banks' lending authority, FDICIA made potentially significant revisions to the emergency liquidity provisions of the Federal Reserve Act. In particular, the Act now permits all nonbank firms — financial or otherwise (called "nonbanks" here for simplicity) — to borrow at the discount window for emergency purposes under the same collateral terms afforded to banks. Ironically, while the principal thrust of FDICIA was to limit or reduce the size and scope of the federal financial safety net, at least as applied to insured depository institutions, this provision effectively *expanded* the safety net. This article describes the historical and theoretical backgrounds of the Reserve Banks' emergency lending authority for nonbanks and analyzes the changes made by FDICIA that affect that authority.

1 See Smith and Beasley (1972), p. 357. Senator Glass offered these remarks during the Senate debate on the Banking Act of June 20, 1933 (Glass–Steagall Act), which established, among other things, the first plan of federal deposit insurance.

2 See Todd (1992a). FDICIA is Public Law No. 102-242 (December 19, 1991). The provisions of FDICIA principally affecting Reserve Banks' discount window operations are Sections 131–133 (prompt corrective action) and Sections 141–142 (least-cost resolutions, systemic-risk exceptions, and lending limitations). On prompt corrective action, see Pike and Thomson (1992); on systemic risk, see Wall (1993); on lending limitations, see Todd (1992a, 1993a).

I. Background of Emergency Lending Provisions for Nonbanks

Since the creation of the first central banks in Western Europe in the seventeenth century, parliaments have often asked them to rescue enterprises sponsored by the state or sovereign, favored private-sector enterprises, and even, occasionally, the state itself.[3] In the United States, Congress understood quite early that it should avoid the expediency of direct funding of the Treasury by borrowings from the central bank.[4] This maxim of fiscal propriety ("central banks should not undertake fiscal activities") also makes theoretical sense and has been explained as follows regarding the central banks of developing countries:

> Fiscal activities [such as implementing selective credit policies or recapitalizing insolvent financial institutions] involve expenditures that reduce central bank profits and may even produce losses. If central bank losses are not met from government budget appropriations, they must eventually lead to an expansion in central bank money and the abandonment of any monetary policy goal of price stability.[5]

Fiscal and monetary authorities in the United States generally followed this view of the division of their responsibilities during peacetime from 1791 until sometime during 1931–33.[6]

The extension of governmental credit directly to nonbank enterprises historically has been a fiscal operation in the United States, not a monetary policy operation of the type ordinarily undertaken by a central bank.[7] For example, the original Federal Reserve Act of 1913 provided for the extension of Reserve Banks' credit directly to member banks, but did not allow for such credit to or for the account of the Treasury, nonmember banks, or nonbanks. Borrowing by member banks was governed by the applicable sections of the Federal Reserve Act (originally, Section 13), and borrowing by other entities simply was not permitted. The Federal Reserve Act was enacted in an era in which peacetime federal budgets regularly were in surplus, and it apparently was intended that the Reserve Banks' money-creating powers should not be substituted for explicit congressional decisions on the Treasury's funding.

During the presidential election year of 1932, economic pressures generated by the Great Depression caused President Herbert Hoover to propose changing the previously indirect credit relationship between Reserve Banks and nonbanks (the Reserve Banks could lend to banks, but only banks could lend to nonbanks) to a more direct one. Although he had vetoed a prior version of the Emergency Relief and Construction Act that summer because it would have authorized the former Reconstruction Finance Corporation (RFC) to make loans directly to individuals,[8] Hoover allowed Section 13 (3) to be added to the Federal Reserve Act as part of a road construction measure designed to relieve unemployment. Subject to certain restrictions, Section 13 (3) authorized Reserve Banks, "in unusual and exigent circumstances," to extend credit directly to "individuals, partnerships, and corporations."[9]

Section 13 (3) proved to be so restricted that it did not open the floodgates of Reserve Banks'

3 See, for example, Fry (1993), Bordo (1992), Todd (1988), and Humphrey and Keleher (1984).

4 Our Founding Fathers were well aware of the problems created by Treasury borrowings from central banks. Alexander Hamilton, the first Secretary of the Treasury, recommended, and Congress later passed, a bill providing that the First Bank of the United States, our first central bank, should be prohibited from lending more than $50,000 to the Treasury or to any state or foreign prince without the prior, explicit consent of Congress. When the Second Bank of the United States was chartered in 1816, this limit was raised to $500,000. See Hamilton (1967), pp. 31–32, 34.

5 See Fry (1993).

6 See Todd (1993b). Beginning in early October 1931, President Hoover proposed that the Reserve Banks expand their lending authority to include the rescue of insolvent banks during peacetime, but the principal proposals for use of the Reserve Banks' lending authority for fiscal purposes were not enacted until the early months of the New Deal, after March 4, 1933. The most noteworthy of those proposals was the Thomas Amendment to the Agricultural Adjustment Act of May 12, 1933, revised on May 27, 1933, and on many subsequent occasions, added as Sections 14 (b)(3) and 14 (h) of the Federal Reserve Act (expired in 1981). See Moley (1966), pp. 300–03; and Hoover (1952), pp. 395–99.

7 See Todd (1992b) and Martin (1957), pp. 768–69.

8 On the RFC, see generally Todd (1992b), Keeton (1992), and Olson (1988). Strange as it may seem to modern readers, banks' lending to individuals (as opposed to farmers or business associations) before 1933 was commonly regarded as either a kind of speculation more appropriate for investment bankers than for commercial bankers or a charitable act more appropriate for mutual savings banks or benevolent societies than for commercial banks. For a colorful account of this phenomenon, see Grant (1992), pp. 76–95, 267–68.

9 The text of the Emergency Relief and Construction Act of July 21, 1932, Public Law No. 72–302, is found in *Federal Reserve Bulletin,* vol. 18 (August 1932), pp. 520–27. Section 210 of that Act [Section 13 (3)] is at p. 523. The Board's circular authorizing emergency discounts under Section 13 (3) for six months beginning August 1, 1932, is at ibid., pp. 518–20.

liquidity to the general public in 1932. At least five members of the Board of Governors (the "Board," which then included six regularly appointed and two ex officio members) had to vote affirmatively to find that "unusual and exigent circumstances" warranting implementation of Section 13 (3) existed. The collateral offered by borrowers had to consist of "real bills" and certain Treasury obligations "of the kinds and maturities made eligible for discount for member banks under other provisions of [the Federal Reserve] Act."[10] In essence, the only acceptable collateral would have been near substitutes for cash. The final statutory restriction required the Reserve Banks to find evidence that the borrower was unable to "secure adequate credit accommodations from other banking institutions."[11]

These restrictions made it unlikely that many nonbanks could qualify for emergency advances from Reserve Banks. In fact, due to these restrictions and the availability of credit elsewhere,[12] the Reserve Banks "made loans to only 123 business enterprises [from 1932 until 1936] aggregating only about $1.5 million [under Section 13 (3)]. The largest single loan was for $300,000."[13]

In 1935, the Board requested, and Congress approved, an amendment of Section 13 (3) intended to make nonbanks' borrowing somewhat easier. Despite that statutory change, no such loans actually have been made since the amendment became effective in 1936.[14] Prior to the 1935 amendment, a borrower had to satisfy two relevant conditions: a satisfactory endorsement (by either the borrower or a third-party surety) on the borrower's own note pledged to the Reserve Bank, *and* security (eligible collateral) for the borrower's discounted note or notes. After the 1935 amendment, *either* an endorsement *or* additional security for such notes was required. This change made it easier for a borrower to discount his own note.

After 1935, however, borrowers had a clear choice between the distinct concepts of eligible collateral (what security could be pledged to secure the Reserve Bank's advance) and eligible purpose (the use to which the Reserve Bank's advance would be put). That is, nonbanks could borrow for any purpose as long as they pledged eligible *collateral*. Failing that, they could borrow on their own notes against any satisfactory collateral, including ineligible collateral, as long as they had eligible *purposes* for their borrowings.

Securities firms, mutual funds, and insurance companies, the greater part of whose asset portfolios included ineligible collateral, could not be said to have eligible purposes for borrowing to fund those particular assets. The payment of an ordinary business firm's general operating expenses could qualify as an eligible purpose for borrowing from a Reserve Bank, but eligible expenses normally included such things as the payment of utility bills, regular taxes, payroll, and the purchase of raw materials. Activities deemed speculative, such as the purchase of a portfolio of common stocks or investment securities generally (other than government securities), or the financing of permanent fixed investments with instruments maturing in more than 90 days, were ineligible purposes.[15] As the principal historian of the subject explained this point,

10 Real bills, for the purposes discussed here, are "notes, drafts, and bills of exchange arising out of actual commercial transactions," with remaining maturities of not more than 90 days [therefore, self-liquidating], "issued or drawn for agricultural, industrial, or commercial purposes, or the proceeds of which have been used, or are to be used, for such purposes," as distinguished from "speculative," investment, or working-capital purposes. See Section 13 (2) of the Federal Reserve Act (12 U.S.C. Section 343) and Hackley (1973), pp. 37 and 129.

11 See Hackley (1973), pp. 127–28. Under another provision of the Federal Reserve Act, Section 13 (13)(12 U.S.C. Section 347c), added in 1933, nonbanks may borrow directly from Reserve Banks without a finding of financial emergency ("unusual and exigent circumstances") by the Board, but only on the security of the U.S. government or (since 1968) U.S. government agency obligations.

12 In particular, after 1934, the Federal Reserve was authorized to mount a rival program to extend credit directly to individuals, partnerships, and corporations "for working capital purposes" under former Section 13b of the Federal Reserve Act (expired in 1958). However, the operations of the RFC expanded greatly after 1933 and displaced the direct credit extension role earlier foreseen for the Reserve Banks under Sections 13 (3), 13b, and 13 (13). Regarding former Section 13b, see discussions in Schwartz (1992), pp. 61–62, and Hackley (1973), pp. 133–45.

13 Hackley (1973), p. 130.

14 The Board has reactivated Section 13 (3) rarely since the 1930s, but this emergency lending authority has not actually been used since 1936. It was activated for savings and loan associations, mutual savings banks, and nonmember commercial banks in 1966 and 1969 (Hackley [1973], p. 130). Its use also was contemplated for assistance to New York City (said to be a "municipal corporation") in 1975. The potential use of Section 13 (3) for depository institutions became unnecessary when the Monetary Control Act of 1980 added Section 19 (b)(7) to the Federal Reserve Act (12 U.S.C. Section 461) to authorize routine advances of Reserve Banks' credit to "any depository institution in which transaction accounts or nonpersonal time deposits are held." Such routine advances are secured by any satisfactory assets (not limited to eligible collateral) and are available at nonpenalty rates, even for nonmember depository institutions. Thus, there has been no need for emergency discounts for those institutions that could be secured only by collateral that was a near substitute for cash.

15 See generally Hackley (1973), pp. 34–38. At p. 129, he discusses the use of a borrower's own note under Section 13 (3).

> [T]he reason why the Reserve Banks were prohibited from extending credit on stocks and bonds [under Section 13] was that the [Reserve] Banks were intended to assist commercial banking and not investment banking. Paper eligible for discount was confined to self-liquidating paper arising out of commercial rather than investment transactions.[16]

While securities firms and other nonbank financial firms could borrow for the eligible purpose of funding the types of current operating expenses described above, their liabilities for such expenses normally would constitute only a small fraction of their balance sheets. In contrast, their loans to carry customers' accounts invested in securities (other than government securities) are ineligible purposes but potentially require much greater funding than the proportion of their assets related to eligible purposes. It apparently was the intent of Congress to remove these ineligible collateral/ineligible purpose restrictions on nonbanks' borrowings from Reserve Banks that underlay the 1991 amendment of Section 13 (3).

II. Amendments of Section 13 (3) in FDICIA

Section 13 (3) has been discussed very little since the 1930s, so it might seem unusual to find Section 473, amending Section 13 (3), inserted in the final stages of the congressional deliberations on FDICIA in November 1991. Increasingly, however, since the stock market crash of October 1987, some policymakers had been discussing the potential use of the Reserve Banks' discount windows to relieve nonbank financial firms' liquidity crises directly. Procedurally, there were enough obstacles to such use of the discount window to discourage financial firms from relying on Section 13 (3) to rescue them in a liquidity crisis: The procedural starting point always was an emergency declaration approved by at least five members of the Board. Also, the practical obstacles appeared insurmountable: For borrowings secured by eligible collateral, nonbank financial firms typically held comparatively few unpledged assets that would qualify, and borrowings said to be for eligible purposes typically would be quite limited.

Another issue that was not, but probably should have been, raised explicitly during congressional deliberations on FDICIA was that any consideration of altering the Reserve Banks' collateral or purpose of borrowing standards to accommodate nonbanks' asset portfolios under Section 13 (3) clearly would shift a portion of the risk of loss previously borne by the nonbanks' creditors onto the Reserve Banks and, thus, indirectly onto the taxpayer.[17] One of the potentially troublesome aspects of the FDICIA amendment of Section 13 (3) is that it appears to reflect a motive or spirit that contradicts that of the FDICIA provisions intended both to limit Reserve Banks' loans to undercapitalized depository institutions and to make it more difficult for the Federal Reserve to treat an institution as too big to fail. If the amendment was intended to provide a vehicle for possible Federal Reserve treatment of a failing securities firm as too big to fail, then it arguably constitutes a contradictory extension of the same federal safety net that was retrenched in other parts of FDICIA and apparently enlarges the moral hazard problem of deposit insurance.

Of the issues just identified regarding the amendment of Section 13 (3), only restrictions based on the types of collateral that nonbank borrowers could offer were discussed explicitly during the congressional deliberations on FDICIA in 1991. It appears that, having satisfied itself that the risks from expanding the collateral limits were minimal and that it might prove helpful to provide the Reserve Banks with this additional, liquidity-maximizing policy tool for a financial emergency, Congress adopted the revisions of Section 13 (3) as Section 473 of FDICIA without extensive discussion or debate, leaving a rather sketchy legislative history for this statute. However, by altering the collateral standards explicitly, FDICIA implicitly rendered Section 13 (3)'s purpose of borrowing restrictions largely superfluous because the prior standards for eligible purposes were binding only on nonbanks that could not pledge eligible collateral.

■ **16** Hackley (1973), p. 38. Depository institutions may, however, obtain extensions of Reserve Bank credit under Section 10B (12 U.S.C. Section 347b) even on ineligible stock or bond collateral ("any satisfactory assets"), but the amounts available might be limited under Section 11 (m)(12 U.S.C. Section 248 [m]), added in 1916.

■ **17** The Reserve Banks' operations create an indirect gain or loss for the taxpayer because the operating profits are rebated to the Treasury as a miscellaneous receipt offsetting part of the federal government's operating expenses. In fiscal year 1992, those receipts were $27.1 billion, of which the Reserve Banks contributed $22.9 billion (Council of Economic Advisers [1993], p. 437). Losses incurred on Reserve Banks' operations would reduce those receipts. While material losses for Reserve Banks have been rare since World War II, they are not inconceivable for central banks that attempt to subsidize fiscal operations on their balance sheets. See Fry (1993).

The actual statutory language change made by Section 473 of FDICIA was comparatively minor. The restrictive phrase in quotation marks below was deleted from the part of Section 13 (3) that described the collateral acceptable for emergency discounts for nonbanks. Prior to the change, a Federal Reserve Bank could discount for any individual, partnership, or corporation any notes, drafts, and bills of exchange when these instruments were endorsed or otherwise secured to the satisfaction of the Reserve Bank and, when endorsed, were "of the kinds and maturities made eligible for discount for member banks under other provisions of this Act ...." It generally was understood that this reference was primarily to the types of financial instruments meeting the eligible purpose standards as illustrated in Section 13 (2), but also included instruments described in other parts of Sections 13 and 14 of the Federal Reserve Act.

Since FDICIA, Reserve Banks' emergency advances to nonbanks may be based on the types of collateral acceptable for depository institutions under an entirely different provision of the Federal Reserve Act, Section 10B, which permits "advances ... secured to the satisfaction of ... [the] Federal Reserve Bank," or "any satisfactory assets."[18] Because nonbanks' emergency borrowings need not be secured by eligible collateral, eligibility of purpose of borrowing has become moot. The only collateral test remaining under revised Section 13 (3) is "satisfactory security," the same test that applies to borrowings by depository institutions under Section 10B.

III. Analysis of Potential Ramifications

The changes made by FDICIA expanded emergency discount window access for nonbanks of all types, not merely securities firms, because any satisfactory assets (not just marketable securities, for example) may be pledged to secure the borrower's own note. Whether these changes will have practical consequences is an open question. After all, Section 13 (3) is an *emergency* lending provision that has been and presumably will continue to be invoked very rarely and that requires the affirmative vote of five Federal Reserve Board governors. It is important to keep in mind that nonbanks' behavior depends in part on how they expect the Federal Reserve to manage its emergency lending powers.

The few, scattered public statements regarding congressional intent with respect to Section 473 of FDICIA do indicate that the intended beneficiaries were securities firms, and no other type of nonbank was mentioned explicitly.[19] Although a brief reference was made during the FDICIA deliberations to the absence of any discounts under Section 13 (3) since 1936, the potentially increased taxpayer risk from alteration of the collateral and purpose standards was not discussed.[20]

How could a new element of taxpayer risk arise? One possible source is derived from the *moral hazard* aspects of the increased availability of Reserve Banks' loans to nonbanks during financial emergencies. Nonbanks lacking eligible collateral or eligible purposes for borrowing must manage their affairs and conduct their relations with creditors and clients so as to be able to survive financial market emergencies. Now, with increased potential for assistance during emergencies, nonbanks' managers might have less incentive to avoid recourse to the Federal Reserve. Although nonbanks still have strong incentives to run their firms prudently, their managers now have potential access to another funding source during financial crises. Whether this potential access alters nonbanks' business decisions — so as to make their calling upon that funding source more likely — remains to be seen.

More troubling, however, are the macro implications of these incentive changes. The extension of the federal financial safety net to nonbanks may increase the probability of market liquidity crises that appear to require Federal Reserve emergency lending. This could happen during periods of market stress if the costs of risky investment and funding strategies are not fully borne by the managers and shareholders of nonbank firms, but instead are perceived as being partially or fully underwritten

■ **18** See Hackley (1973), pp. 109–12, and Eccles (1951), pp. 171–73.

■ **19** During the floor debate in the Senate on the version of FDICIA that was enacted, Senator Christopher Dodd of Connecticut spoke as follows in support of the bill:

> It [FDICIA] also includes a provision I offered to give the Federal Reserve greater flexibility to respond in instances in which the overall financial system threatens to collapse. My provision allows the Fed more power to provide liquidity, by enabling it to make fully secured loans to securities firms in instances similar to the 1987 stock market crash.

See *Congressional Record* (1991), p. S18619. For similar legal interpretations of Section 473 of FDICIA, see FDICIA (1992), pp. 37 and 92. See also Holland (1991).

■ **20** See U.S. Senate Report No. 102-167 (October 1, 1991), pp. 202–03.

by U.S. taxpayers.[21] Self-correcting market forces that help to insulate financial markets from macroeconomic shocks could be eroded by what nonbanks regard as implicit taxpayer guarantees of nonbank losses and, thereby, increase the probability that a real-sector shock would become translated into a financial crisis.

A certain amount of *adverse selection* also might compound the Federal Reserve's difficulties: It becomes increasingly likely that better-capitalized firms would remain outside the Reserve Banks' lending net (in order to avoid the perceived stigma of borrowing). It also is likely that only the worst-capitalized firms could not raise adequate funds during financial market emergencies.

The other main source of taxpayer risk from the revision of Section 13 (3) is derived from the accounting principles that would be used in evaluating the collateral offered for emergency loans. Nonbanks' previously ineligible assets, including corporate equity securities and mortgages on real estate in the case of securities firms and institutional investors, tend to be illiquid under the market emergency conditions that would conceivably give rise to the Board's authorization of Section 13 (3) loans. In an emergency, whatever market value satisfactory (but formerly ineligible) assets that nonbanks already had could undergo severe downward market pressures, triggering wide gaps between par and market collateral valuations. Although all discount window advances are expected to be extended against collateral that is thought to be both sound and ample, there is reason to be concerned about accurate valuation of nonbanks' assets in periods of intense financial distress.

The expansion of the collateral limits for Reserve Banks' extensions of credit under Section 13 (3) might appear to be somewhat at odds with the principal thrust of the other discount window provisions of FDICIA, Sections 141 and 142, which, together with the prompt corrective action provisions, Sections 131–33, were intended to reduce taxpayers' potential risk of loss due to loans to insured banks. The lending criteria applicable to undercapitalized depository institutions were tightened, and more exacting and publicly accountable procedures for such lending decisions were established. In Section 141 of FDICIA, provision for a "systemic risk" exception to normal supervisory intervention and closing requirements was limited to circumstances in which both two-thirds of the Board and two-thirds of the FDIC's Board of Directors approved the exception, with the further concurrence of the Secretary of the Treasury, after consultation with the President.[22] The clear objective of that provision was limiting the taxpayer's potential exposure to loss through increased procedural hurdles that had to be overcome to invoke the exception.

IV. Conclusion

The removal of the collateral barriers for Reserve Banks' extensions of credit under Section 13 (3) seems to conflict with the spirit of the other discount window provisions of FDICIA, Sections 141 and 142. These provisions, along with the Act's prompt corrective action provisions, Sections 131–133, were intended to lessen taxpayers' potential exposure to loss resulting from loans to insured banks.

In contrast, Section 473, by removing the eligible collateral threshold, may have marginally increased taxpayers' potential risk of loss. This risk could arise from the moral hazard associated with the perceived availability of the equivalent of a federal guarantee for nonbanks. Consequently, increased access to the discount window by nonbanks carries with it some of the same kinds of risks that arose during the savings and loan debacle: Adverse selection and misaligned agency incentives could increase, together with the probability of use of the emergency lending facility and the implicit underwriting of nonbank losses by taxpayers.

The increased degree of discount window access for nonbanks was not accompanied by some of the safeguards normally applicable to discount window access, such as annual examinations by the federal bank supervisory authorities, maintenance of required reserves and clearing balances at Reserve Banks, and requirements to meet minimum regulatory capital adequacy standards. Moreover, by extending a component of the federal safety net, the Reserve Banks' discount windows, to nonbanks without limitations on too-big-to-fail rescues, Section 473 of FDICIA contradicts the spirit of the limitations on the too-big-to-fail doctrine enacted for depository institutions in FDICIA.

■ **21** Comparable perverse incentives for insured depository institutions' behavior are described in the deposit insurance literature. See Barth and Brumbaugh (1992), pp. 7–12; National Commission (1993), pp. 62–68; and Kane (1989), pp. 95–114.

■ **22** See Todd (1992a). Systemic risk, as described in Section 141 of FDICIA, is a condition in which the closing of an insured institution, without redemption of uninsured claims at par, "would have serious adverse effects on economic conditions or financial stability." The connection between systemic risk for banks and for securities firms is made strikingly and explicitly in Wall (1993), p. 10.

Finally, it is unclear that there was a real (as opposed to a perceived) need for revision of Section 13 (3). Section 473 of FDICIA apparently was intended to deal primarily with situations like the aftermath of the stock market crash of October 19, 1987, in which securities firms, mutual funds, and other nonbank holders of large investment portfolios consisting of ineligible collateral would have found it helpful to obtain credit from Reserve Banks instead of from banks, insurance companies, investment banks, and other usual providers of funds to nonbank financial firms.

Normally, financial markets treat eligible collateral as high-quality instruments that are close substitutes for cash. Firms holding large, unpledged amounts of such collateral ordinarily could be expected to be able to obtain sufficient extensions of credit without having recourse to direct loans from Reserve Banks, even during market conditions approximating financial emergencies, as long as financial markets had adequate supplies of liquidity that the Federal Reserve could ensure through open-market operations. In fact, aggressive use of open-market operations in October 1987 provided sufficient aggregate liquidity to prevent the stock market crash from generating substantive harm to the economy.

The changes effected by Section 473 of FDICIA should prove quite harmless if the statute is implemented in a straightforward, risk-averse manner. However, perverse incentives, continued observance of a too-big-to-fail doctrine (in this case, for nonbanks), and the absence of adequate procedural safeguards could increase Reserve Banks' and, ultimately, taxpayers' losses from Section 13 (3) lending activities in the future. Furthermore, greater potential access to the federal financial safety net could boost the risk-taking incentives for nonbanks, thereby increasing the probabilities that they will request discount window lending during financial emergencies.

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Efficiency and Technical Progress in Check Processing

by Paul W. Bauer

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Introduction

By lowering the transaction costs associated with barter, a payments system greatly facilitates the exchange of goods and services.[1] Although vastly improved over the years, the process of transferring funds remains costly, and the evolution of the payments system has been at least partially determined by efforts to trim these costs further.[2] Increasing the productivity of the payments system improves economic welfare both by releasing resources to other sectors of the economy and by lowering the effective purchase price of goods and services.

In addition to its roles as the nation's central bank and as the primary federal regulator of state member banks and bank holding companies, the Federal Reserve System is also a major provider of payment services. Ordered by the Federal Reserve Act of 1913 to ensure the efficiency of the payments system, the central bank has directly participated in the market since its inception. Initially, it provided a national mechanism for clearing and settling checks — two major components of payment services — and instituted regulations that eliminated the incentive for the circuitous routing of checks.[3]

Prior to passage of the Depository Institutions Deregulation and Monetary Control Act (MCA) of 1980, the Federal Reserve did not charge fees for its payment services and provided them only to member banks. Consequently, it faced little competition from private providers serving nonmember financial institutions. Starting in 1981, the MCA required the Federal Reserve to make its services available to all depository institutions and to charge fees that would recover its costs. The goal was to foster a more efficient payments system by giving private providers of payment services the opportunity to compete.

Given this new competitive environment, it became even more important for the Federal Reserve to be able to track the performance of its various offices. Over the years, an extensive accounting system has been developed to identify costs associated with each of its services.

■ 1 The payments system refers to such activities as the provision of currency and coin, processing and clearing of checks, providing for settlement of checks and other types of payments, and wire transfers of funds. See Board of Governors of the Federal Reserve System (1984).

■ 2 See Garbade and Silber (1979), Niehans (1971), and Brunner and Meltzer (1971).

■ 3 See Garbade and Silber (1979) and Humphrey (1980).

This has allowed unit cost performance measures (total service costs divided by service volume) to be calculated for each service offered.

This article examines the costs of providing check-processing services at 47 Federal Reserve offices (District Banks, branch offices, and regional check-processing centers) from 1983:IQ to 1990:IVQ by estimating a multiproduct cost function using an econometric frontier approach. After briefly discussing the advantages and disadvantages of the Federal Reserve's unit cost measures, I demonstrate how they can be decomposed into separate effects related to differences in cost efficiency, output mix, input prices, and environmental variables (these control for various site-specific characteristics) using estimates derived from the cost function.[4] The cost-function approach provides much more complete information about the sources of office performance than do unit cost measures, but it is more difficult and time-consuming to calculate.

In order to explore how the cost frontier may have shifted over time in response to technological and regulatory changes, the article also presents estimates of technical progress, as measured by whether the cost of producing a given level of output declines over time. This technique provides valuable insights into the technological constraints faced by the Federal Reserve.

It should be remembered, however, that research such as this is a continuing process and that a more complete understanding of the production and cost efficiencies associated with check processing will require multiple investigations. Consequently, the numerical estimates presented here must be interpreted with caution, understood in the context of stated caveats, and viewed as only a partial effort to model one aspect of the payments system.

Section I describes the central bank's provision of check-processing services and summarizes some previous studies of the payments system. Section II then discusses how the econometric frontier approach is used to estimate the multiproduct cost function, and explains how a unit cost measure of performance can be decomposed into its various components. After describing the data employed in the study, I analyze estimates of cost efficiency, scale economies, and technical change. Unit costs are decomposed for each office using the estimated multiproduct cost frontier. The final section considers the future of Federal Reserve check processing in light of new technologies, such as same-day settlement and electronic check truncation.[5]

I. Background

Description of Check Processing

Check processing is, in some ways, a fairly straightforward operation: A payor writes a check to a payee, who deposits it at his bank or other depository institution. This is all most of us ever think about, and if the payor and the payee are customers of the same bank (which occurs about 30 percent of the time), this is almost the end of the story. For these "on-us" items, the only step left is for the bank to debit the payor's account and credit the payee's account. But if both parties have accounts at different banks, then the payee's bank must forward the check to the payor's bank —a situation that occurs roughly 45 billion times a year. For these items, a bank can send checks directly to the payor's institution or route them indirectly through a local clearinghouse, a correspondent institution, or a Federal Reserve office. The Fed processes about 35 percent of these interbank checks.

In the relatively rare event that the check is returned for insufficient funds (less than 1 percent of checks), the process repeats itself, only in reverse. The return process is more labor intensive and costly. In contrast to forward volumes, the Federal Reserve handles the vast majority of payment system return items. This lack of private-sector competition suggests that the Fed's prices for handling returned checks may be too low, a subject discussed in more detail below.

Thus, the central bank provides two types of check-processing services, forward items and return items, and has a separate price schedule for each. Although the end result is the same for all checks, this description fails to reveal the myriad products offered by a typical processing center. Items can be differentiated by the location of the payor bank, the times of presentment and settlement, and the amount of presorting performed by the institution submitting the checks.

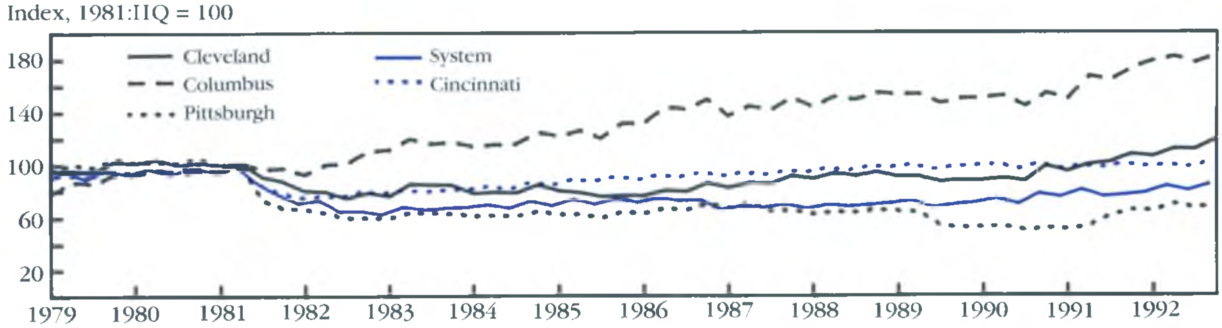
Costs can vary significantly as a result of these product characteristics. Fine-sort items, for instance, are fully presorted by the submitting

■ 4 Output mix includes the effects of scale economies, whether average cost rises or falls as output expands, and the effects of the relative production of the various outputs. Cost efficiency determines how closely firms operate to the cost frontier.

■ 5 Under same-day settlement, banks will have access to funds on the same day they are deposited, as long as the checks are presented before 8:00 a.m. Electronic check truncation refers to sending only an electronic image of the check, rather than the check itself, through the settlement process.

FIGURE 1

Check-Processing Volumes



SOURCE: Author's calculations.

institution and use only the Federal Reserve's transportation, settlement, and adjustment services, meaning that they cost very little to handle. At the other extreme, an item can be submitted without any presorting during the peak period of check processing (in Cleveland, from 10:00 p.m. to 1:00 a.m., but this varies significantly across offices), when the check reader-sorters are operated at close to maximum capacity. The incremental costs of these items are much higher.

Sorting checks and forwarding them to payor institutions (or returning them to depositing institutions) involves a variety of resources, or inputs. Transit (transportation and communication) is required to get the items to the processing site and on to their final destination once sorted. At the processing site, which must meet certain security standards, labor employs a variety of capital goods (mainly high-speed sorters and computers) to sort the checks and keep track of the settlement operation.

Monetary Control Act

While not changing the physical process of check clearing in the United States, the MCA altered the institutional environment profoundly. Federal Reserve payment services prior to passage were available at no charge, but only to member banks. The MCA required the Fed to begin charging for its services and to offer them to all depository institutions, including those that are not members of the System.[6] Based on guidelines established by the Board of Governors, prices for each payment service are designed to recover direct and indirect costs as well as a markup (known as the Private Sector Adjustment Factor [PSAF]) that imputes other costs typically incurred in the private sector. In check processing, each Federal Reserve District offers a slightly different mix of products, and District Banks have some flexibility in pricing.

Although the MCA increased the number of institutions that could employ the Federal Reserve's payment services, a large drop in volume was expected because fees were imposed on previously "free" services. When pricing was implemented, the Fed's share of interbank check processing fell from approximately 45 percent in 1981 to 38 percent in 1982. Currently, the System processes about 35 percent of all interbank items.

The drop in volume that immediately followed pricing can be seen in figure 1. In the first year, systemwide and Fourth District processing volumes plunged 15 and 18 percent, respectively. However, not all Fourth District offices experienced similar declines: In Pittsburgh, check volume dived almost 40 percent and has grown relatively little since, yet in Columbus, check volume recovered within the first year and expanded rapidly thereafter.[7]

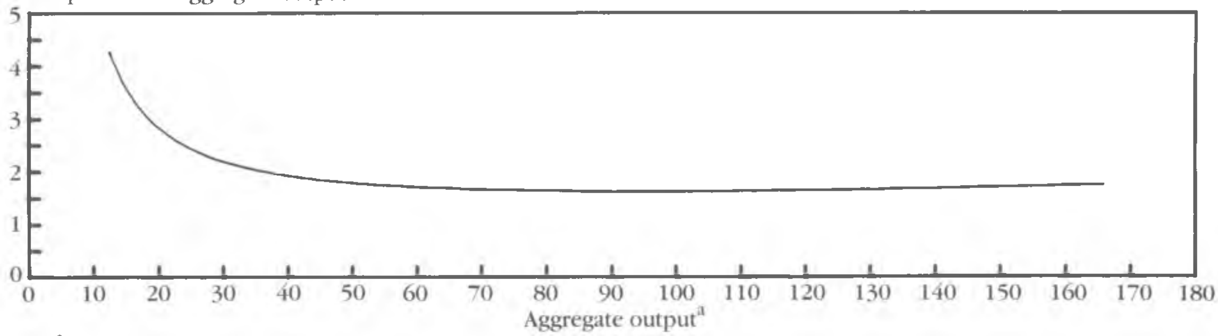
Even with this overall drop in Federal Reserve volume following the onset of pricing, the national allocation of resources improved because banks that already owned their own reader-sorters frequently found it less expensive to process more of their own checks and even to offer the service to others. Pricing boosted the efficiency of resource allocation in

6 These firms include savings and loans, credit unions, and foreign banks.

7 Unusual local economic factors accounted for much of the check volume growth in Columbus.

FIGURE 2

GLS Estimates of Ray Average Cost



a. Millions of items per quarter.
SOURCE: Author's calculations.

another way. Humphrey (1981) estimates scale economies in check processing at 36 Federal Reserve Banks and branches for the 1974–76 period. He concludes that 78 percent of checks deposited with the Fed during that time were processed at offices with significant scale diseconomies, a finding he attributes to a lack of market competition.

The increase in competition after pricing began led to greater cost-control incentives and improved resource allocation. By 1982, constant (rather than decreasing) returns to scale were the rule in Federal Reserve check-processing operations (see Humphrey [1980, 1985]).

II. Frontier Estimation and Unit Cost Decomposition

The cost function, $C(y,w,z)$, for a firm simply yields the minimum cost of producing any specified level of outputs (y) given technological constraints, input prices (w), and environmental effects (z). Foreshadowing our results somewhat, figure 2 plots the generalized least squares (GLS) estimates of the ray average cost function for check processing using the System's averages for output mix, input prices, and site-specific characteristics.[8] The curve indicates the lowest ray average cost that can be achieved for a given level of output, provided the site is operated efficiently.[9]

The concept of a frontier is quite natural in the context of a cost function. Even allowing for random events that may lead to temporarily lower or higher unit costs, we would expect most offices to operate on or above the cost function. In the context of this theoretical construct, there are many ways for things to go wrong and only one way to get them *exactly* right. Thus, observed costs will tend to be above the corresponding ray average cost curve.

The cost function is a particularly useful concept because many characteristics of the technological constraints facing the firm can be derived from it. For example, from figure 2 we can see that for low levels of output, check-processing services face scale economies—that is, ray average costs fall as both outputs are increased proportionally. For the average mix of outputs, the advantages of running a larger operation are almost exhausted after about 105 million aggregate items per quarter. Increasing the level of output from about 76 million items per quarter (the mean value from 1983 to 1990) to the level required for scale efficiency (holding the output mix constant) lowers ray average costs only 2.6 percent. Once these levels of output are reached, we will see that cost efficiency (the ratio of the cost on the frontier to observed cost) becomes a more important consideration.

8 Ray average cost is defined as

$$C(\lambda y, w, z)/\lambda = C(y, w, z)/\sum_{i=1}^{M} y_i .$$

Although the denominator appears to be arbitrarily summing over the various outputs, since the output mix is held constant for this calculation, the rather arbitrary output aggregator function imposes no additional restrictions.

9 Holding the mix of outputs constant by increasing them proportionally is extremely restrictive. In the results section, I demonstrate how the scale-efficient level of output depends crucially on the mix of outputs.

Given this demonstration of the usefulness of cost functions, there is one problem—these functions must be estimated from data generated by sites in operation. A number of empirical techniques have been developed to estimate frontier cost functions. Generally, they can be divided into two classes: 1) estimators based on econometric techniques, such as maximum likelihood estimation and panel data estimation, or 2) estimators based on linear programming techniques, such as data envelopment analysis.[10] In this paper, I report only estimates derived from the GLS approach.[11]

Econometric Techniques

Broadly speaking, econometric techniques employ a specific (although flexible), functional form for the cost function and impose some additional assumptions about the statistical properties of the inefficiency terms. As a category, these techniques assume a compound error term that comprises both cost inefficiencies and statistical noise. Within the category, the techniques differ in the assumptions used to decompose this error term to obtain estimates of cost efficiency.

All of the econometric techniques impose an explicit functional form for the cost function. The translog functional form is employed because it is a second-order approximation to any cost function about a point of approximation (here, the sample mean). Essentially, this means that it can model many different possible relationships among outputs, inputs, and environmental factors, depending on its parameter values. The translog cost function can be written as

$$(1)\quad \ln C_{it} = \beta_o + \sum_{m=1}^{M} \beta_m \ln y_{mit} + 1/2 \sum_{m=1}^{M} \sum_{l=1}^{M} \beta_{ml} \ln y_{mit} \ln y_{lit} + \sum_{k=1}^{K} \gamma_k \ln w_{kit} + \sum_{m=1}^{M} \sum_{k=1}^{K} \theta_{mk} \ln y_{mit} \ln w_{kit} + 1/2 \sum_{k=1}^{K} \sum_{l=1}^{K} \delta_{kl} \ln w_{kit} \ln w_{lit} + \sum_{m=1}^{L} \lambda_m \ln z_{mit} + \sum_{j=1984}^{1990} \phi_j D_{jt} + u_i + v_{it},$$

where y is a vector of M outputs, w is a vector of K input prices, z is a vector of L environmental variables, D is a set of $T-1$ dummy variables (one for every year except the first), u $(u \geq 0)$ measures cost inefficiency, and v represents statistical noise.

Estimation of this function involves finding the values of the parameters that best fit the observed data given the imposed assumptions. Equation (1) is estimated, along with the corresponding equations for input shares, imposing the usual mathematical restrictions of symmetry and linear homogeneity in input prices. The symmetry constraints come from assuming that the cost function is twice differentiable, so that

$$(2)\quad \frac{\partial^2 C}{\partial w_i \partial w_j} = \frac{\partial^2 C}{\partial w_j \partial w_i}$$

and

$$\frac{\partial^2 C}{\partial y_i \partial y_j} = \frac{\partial^2 C}{\partial y_j \partial y_i}.$$

This forces $\delta_{kl} = \delta_{lk}$ and $\beta_{kl} = \beta_{lk}$, for every k and l. Linear homogeneity in input prices, $t \cdot C(y, w) = C(y, t \cdot w)$, stems from defining the cost function as yielding the minimum cost of producing a given output level when faced with a particular set of input prices. Proportional changes in input prices affect only the cost level, not the cost-minimizing input bundle. This property imposes constraints on all parameters related to the $\ln w_{kit}$'s:

$$(3)\quad \sum_k \gamma_k = 1$$

and

$$\sum_k \theta_{mk} = \sum_k \delta_{kl} = 0, \ \forall\ l, m.$$

10 A more detailed description of the techniques employed in this paper can be found in Bauer and Hancock (1993). For a thorough treatment of these two classes of techniques, see Greene (1993) and Ali and Seiford (1993).

11 Bauer and Hancock (1993) report estimates using a variety of econometric and linear programming techniques. Here, I choose to concentrate on one set of results in order to provide a sharper focus.

The use of longitudinal data often allows us to avoid assuming a specific distribution for the inefficiency terms. Repeated observations over time identified site-specific, time-invariant inefficiencies.[12]

For the GLS technique, the inefficiency terms are calculated by using the average of the residuals by site, $\hat{\alpha}_i$. The most efficient site in the sample is taken to be the best estimate of where the cost frontier lies and is thus assumed to be fully efficient. The inefficiency of the i^{th} site is measured by the proportionate increase in predicted costs over the predicted costs of the most efficient site. An index bounded by zero (costs are incurred, but no output is produced) and one (a site on the cost frontier) can be calculated as

$$(4) \qquad \exp\left(\min_{l} \hat{\alpha}_l - \hat{\alpha}_i\right).$$

The GLS technique runs an iterative, seemingly unrelated regression (ITSUR) on the system of cost and K - 1 input share equations using panel data. One of the share equations, which are derived using Shephard's lemma, must be dropped in order to avoid singularity of the system.[13] However, since the estimates are obtained using ITSUR, the numerical estimates are the same no matter which one is dropped.

Unit Cost Decomposition

For the moment, assume that only one output is produced. In this case, unit cost is just C/y, where C is observed cost and y is observed output. If we wanted to compare one site to the average of all sites, we could do so by taking the ratio of that site's unit costs to the overall average. This would readily tell us whether a site's costs were above or below average, but we would not know why.

Using the definition of the cost function and the error specification developed for the GLS estimation technique, we can rewrite the ratio of a site's average unit costs to the overall average unit costs as follows in order to derive a more informative set of measures.[14]

$$(5) \quad \ln[\overline{(C_i/y_{1i})}/\overline{(C/y_1)}] = 1/T\sum_{t=1}^{T} \ln[C(y_{it}, w_{it}, z_{it}) \exp(u_i + v_{it})/y_{1it}] - 1/TN\sum_{T=1}^{T}\sum_{i=1}^{N} \ln[C(y_{it}, w_{it}, z_{it}) \exp(u_i + v_{it})/y_{1it}].$$

Equation (5) can be rearranged to

$$(6) \quad \ln[\overline{(C_i/y_i)}/\overline{(C/y)}] = \{\overline{u}_i - \overline{u}\}$$
$$+ \left\{ \left[\sum_{m=1}^{M} \beta_m(\overline{\ln y_{mi}} - \overline{\ln y_m}) + 1/2\sum_{m=1}^{M}\sum_{l=1}^{M} \beta_{ml}(\overline{\ln y_{mi}\ln y_{li}} - \overline{\ln y_m \ln y_l}) \right] + \left(\overline{\ln y_{1i}} - \overline{\ln y_1}\right) \right\}$$
$$+ \left\{ \sum_{k=1}^{K} \gamma_k(\overline{\ln w_{ki}} - \overline{\ln w_k}) + 1/2\sum_{k=1}^{K}\sum_{l=1}^{K} \delta_{kl}(\overline{\ln w_{ki}\ln w_{li}} - \overline{\ln w_k \ln w_l}) \right\}$$
$$+ \left\{ \sum_{m=1}^{M}\sum_{k=1}^{K} \theta_{mk}(\overline{\ln y_{mi}\ln w_{ki}} - \overline{\ln y_m \ln w_k}) \right\}$$
$$+ \left\{ \sum_{m=1}^{L} \lambda_m(\overline{\ln z_{mi}} - \overline{\ln z_m}) \right\},$$

where the expressions in braces can be defined as effects resulting from differing cost efficiencies, outputs, input prices, the interaction of outputs and input prices, and environmental effects.[15]

■ 12 See Schmidt and Sickles (1984) for further explanation. Berger (1993) contains some possible extensions.

■ 13 For more details on the treatment of the share equations, see Bauer, Ferrier, and Lovell (1987).

■ 14 Although any two observations could be chosen to compare unit costs, comparing the sample mean for the i^{th} site to the overall sample mean causes the term involving statistical noise, v, to drop out.

■ 15 I derive the decomposition for the general case when there are M outputs and arbitrarily use the first output (forward items) as the denominator in the construction of unit costs. Empirically, the resulting measure of unit cost is highly correlated with the Federal Reserve's measure because forward processing appears to account for more than 80 percent of the costs of processing services, but has the advantage that this specification can be exactly decomposed into the various effects described below.

While these are logarithmic differences, as long as the numerical values are close to zero, they can be roughly interpreted as the percentage difference in costs stemming from these various effects.[16]

Clearly, unit costs provide a useful measure of a site's relative ability to produce a given level of output at the lowest possible cost, because it summarizes the overall effect of a variety of cost factors. Once the trouble and expense of collecting the data have been incurred, the unit cost measures are easy to calculate. On the other hand, the cost-function approach imposes greater structure and requires more effort to calculate, but it also provides a much more detailed set of information.

Now one must explicitly consider the complications posed by the presence of multiple outputs. The Federal Reserve constructs unit cost measures for each of its services and then weights them by cost shares to obtain an overall measure of performance across service lines. A potential problem is that the accounting rules employed to allocate the costs of joint inputs (those used to produce more than one service, like computer systems) may not accurately reflect the flow of services from these inputs to the various services. This will cause the calculated unit cost measures to be biased up or down, depending on whether the service in question receives more or less of its share of costs associated with the joint inputs. In the case of some joint inputs, there may be no simple accounting rule that could accurately allocate their costs because of nonlinear technological relationships among the various outputs and inputs.

Rather than relying on arbitrary accounting rules, the cost-function approach allows the data (combined with the imposed assumptions) to allocate costs to the various outputs by finding the parameters that best fit the cost model. Marginal costs for each of the outputs can then be readily calculated by differentiating the estimated cost function. For pricing and output decisions, marginal costs should be more relevant than unit costs.

III. Data Construction

Quarterly data for the 1983–90 period were collected on total costs, check volume, input prices, and environmental variables for 47 Federal Reserve check-processing sites.[17] The primary data source was annual functional cost accounting reports, which are prepared by the Federal Reserve via its Planning and Control System to monitor costs and improve resource allocation within the System. These data were supplemented by other cost and revenue figures, information from occasional Federal Reserve surveys, price index data from the Commerce Department's Bureau of Economic Analysis and the Labor Department's Bureau of Labor Statistics, and pricing data from industry sources.

Production costs for forward items, return items, and adjustments were included in total costs, but certain overhead expenses, such as special District projects, were excluded. The two measures of output were the total number of forward items and return items processed at each site. Reflecting the earlier discussion of the vast array of products offered by the various offices, this measure is at best an approximation. Some of the environmental variables discussed below attempt to adjust for the different product mixes across offices. Inputs to the check-processing function fall into the categories of buildings, materials, transit, and labor. Labor expenditures—salaries, retirement, and other benefits—accounted for 47.1 percent of total costs in 1990:IVQ.

Buildings' total cost share was only 5.6 percent in 1990:IVQ, in part because the interest expenses associated with the acquisition of buildings are not represented in the cost-accounting framework (these are included in the PSAF rather than in direct and indirect costs).

Expenditures for materials (office equipment and supplies, printing and duplicating, data processing, computers, and check reader-sorters) accounted for 29.8 percent of total costs in 1990:IVQ. Transit expenditures—the expenses associated with data and other communications, shipping, and travel—made up just over 17.5 percent.

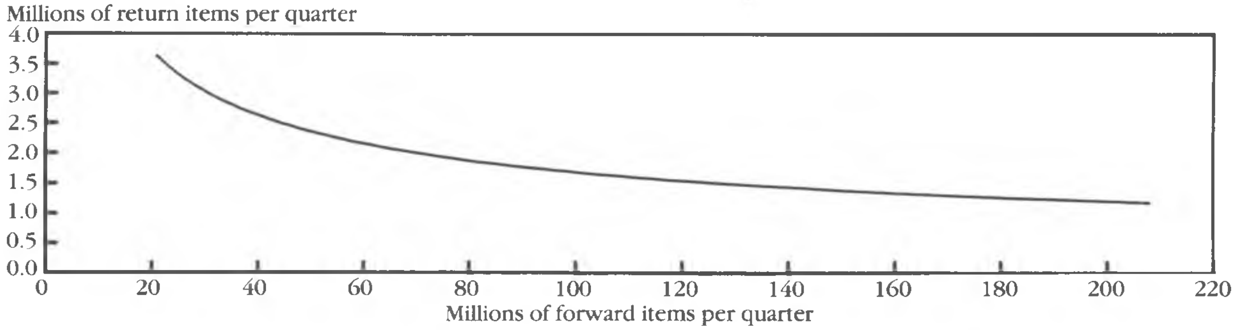
Environmental variables, which control for a variety of site-specific characteristics, include the item-pass ratio, the number of endpoints, the machine error rate, and the type of machine used. The item-pass ratio, defined as the average number of times a check must pass through a reader-sorter, is a measure of the exogenous check-sort pattern and has been found in previous studies to influence costs significantly. The number of endpoints is the number of locations

■ 16 For the exact percentage difference, one must take the antilog minus one.

■ 17 For complete details, see Bauer and Hancock (1993). The New York check-processing operation was omitted because it was closed in 1988.

FIGURE 3

***M*1 Locus**



SOURCE: Author's calculations.

to which checks must be sorted and delivered. The machine error rate is the number of incoming errors per 100,000 checks at each office and is largely a matter of poor MICR (magnetic ink character recognition) encoding. The last environmental variable indicates whether the site used IBM or Unisys machines and allows for differences in maintenance expenses, failure rates, and downtime.

IV. Empirical Results

Scale Efficiency

A scale-efficient office operates at the output level at which ray average costs are minimized for its output mix or, equivalently, at the output level at which cost elasticity equals one (that is, a 1 percent increase in output would cause costs to rise by 1 percent).[18] Conversely, a scale-inefficient office operates at an output level larger or smaller than the scale-efficient level. If the office processes less than the scale-efficient volume, the cost elasticity is less than one (a 1 percent increase in output would raise costs by less than that amount), meaning that the office could achieve lower unit costs by boosting output. Alternatively, a scale-inefficient office that processes more than the scale-efficient volume has a cost elasticity greater than one, and unit costs can be lowered by reducing output. Thus, estimates of cost elasticities yield direct estimates of scale efficiency.

When multiple outputs are produced, the mix of outputs must also be considered when examining scale efficiency. The *M* locus (see figure 3) is defined as the set of all outputs with unitary cost elasticities.[19] For any level of forward items, the *M* locus reveals the corresponding level of return items required to achieve scale efficiency. A site operating below (above) the *M* locus experiences scale economies (diseconomies). The estimated *M* locus indicates that a site processing a large number of return items relative to forward items reaches scale efficiency at a lower level of forward items.

It may not be possible for every office to achieve scale efficiency, despite the best efforts of managers. The volume of checks and return items processed at an office depends on the size of the market and the prices charged. The economic size of managers' payments markets is outside their control, and although managers may have some authority over prices, their need to recover costs may prevent them from setting a price low enough to attract a scale-efficient volume of output. In short, even the best-run office will be scale inefficient if it is in a market too small to achieve scale efficiency.

Figure 2 demonstrated that the ray average cost curve for check and return processing was U-shaped (meaning that at low levels of aggregate output, ray average cost falls as outputs are increased proportionally, but that scale econo-

■ **18** Cost elasticity is defined as $\partial \ln C(\lambda y, w, z)/\partial \ln \lambda|_{\lambda=1}$. This turns out to be identical to the sum of the cost elasticities with respect to each output.

■ **19** The *M* locus in figure 3 is drawn with the input prices equal to their values at the sample mean. Unfortunately, the estimated *M* locus becomes increasingly speculative as it moves away from the output ratio found at the sample mean.

mies are exhausted at some point, so further increases result in higher ray average costs). In table 1, we present estimates of cost elasticities using site-specific characteristics for 1990:IVQ. Most sites are fairly close to achieving scale efficiency—given their individual output mixes, input prices, and environmental variables. Even so, these estimates suggest that the average office could lower its costs about 12 percent if it could generate scale-efficient volumes. Full scale efficiency would require the average office to increase its scale of operations significantly. However, as revealed by the ray average cost function in figure 2, most of the gains occur before 76 million items per quarter are processed.

Although some smaller offices appear to be operating in the output range where further scale economies could be exploited in the future, additional float costs that are not incorporated in our model may make this infeasible. As items from more-distant banks are processed, additional shipping costs and delays will be incurred that may outweigh the associated cost savings.

Estimates of marginal cost, or the incremental cost of processing one more item, can provide additional information for pricing. One of the beneficial outcomes of competitive markets is that competition forces prices to be set equal to marginal costs. In other words, the price that consumers pay for a good or service equals a firm's incremental cost of producing it. If the Federal Reserve set its actual prices for forward and return items in 1990:IVQ to equal estimated marginal costs, those prices would have averaged $0.009 and $0.643 per item, respectively (see table 1). In practice, prices are based on accounting data, and the Federal Reserve's calculated unit costs for forward and return items averaged $0.0135 and $0.159, respectively.

Neither unit costs nor marginal costs can be directly used for pricing because they fail to account for several characteristics (such as the time the checks are submitted for processing), yet to the extent that pricing is based on unit costs, the estimated marginal costs imply that forward items could be regarded as overpriced, whereas return items could be regarded as underpriced. Even though the Federal Reserve sets prices to recover costs, econometric estimates indicate that the accounting data appear to assign too much of the costs to forward items and too little to return items. Market conditions are consistent with econometric estimates, since there are no entry barriers into either market, yet the Federal Reserve faces little competition for return items, and there are many private-sector competitors for forward items. Clearly, this is an issue that requires further study.

Cost Efficiency

Cost inefficiencies appear to raise costs more than does scale inefficiency. If all offices could be operated on the cost frontier, costs could be lowered by about 23.5 percent. Table 2 compares GLS estimates of the cost efficiencies calculated using the multiproduct cost function employed here with the single-product estimates reported in Bauer and Hancock (1993). Overall, the results change remarkably little when return items are treated as a separate output: On average, estimated cost efficiency rises only 3.5 percent. However, one site with a relatively large number of return items (FR27) saw its estimated efficiency increase by 16.3 percentage points.

Many of the top-ranked offices were in the same Federal Reserve District, indicating that management differences may be important. Aside from superior managerial skill, estimated cost efficiency could vary across sites because some Districts may focus on cost performance while others may stress customer service, which is largely uncontrolled for in this study. For example, one District may specify precisely how checks must be submitted and refuse to accept them otherwise, while another may accept checks in any form but charge higher fees for packages that require more attention. The former District will appear to be more efficient than the latter, other things being equal, because it receives the checks exactly as it wants them. However, the latter District receives a higher fee by providing a service desired by its customers.

Unit Cost Decomposition

The average unit cost measure for each of the 47 offices over the 1983–90 period relative to the overall sample mean is presented in table 3, along with estimates of each of the component effects. Unit costs vary substantially across offices, from −0.388 to 0.309, or from about a third below to a third above the overall average. The largest single component appears to be the cost-efficiency effect, with a correlation between it and unit cost of more than 80 percent.

TABLE 1

Estimates of Marginal Costs and Cost Elasticities, 1990:IVQ

	Cost Elasticities			Marginal Costs	
Office	Forward Items	Return Items	Overall	Forward Items	Return Items
FR1	0.381	0.568	0.949	0.007	0.738
FR2	0.400	0.568	0.968	0.010	0.797
FR3	0.416	0.439	0.855	0.007	0.655
FR4	0.392	0.565	0.958	0.011	1.011
FR5	0.464	0.333	0.797	0.010	0.618
FR6	0.483	0.240	0.723	0.009	0.520
FR7	0.405	0.501	0.906	0.007	0.657
FR8	0.359	0.670	1.029	0.009	0.865
FR9	0.444	0.436	0.880	0.009	0.584
FR10	0.418	0.443	0.860	0.009	0.817
FR11	0.469	0.424	0.893	0.012	0.525
FR12	0.450	0.388	0.838	0.007	0.486
FR13	0.391	0.590	0.982	0.010	0.907
FR14	0.382	0.629	1.011	0.011	0.902
FR15	0.412	0.506	0.918	0.009	0.700
FR16	0.429	0.421	0.850	0.008	0.631
FR17	0.396	0.526	0.922	0.008	0.767
FR18	0.533	0.219	0.752	0.015	0.433
FR19	0.489	0.162	0.651	0.010	0.561
FR20	0.439	0.556	0.996	0.011	0.466
FR21	0.436	0.495	0.932	0.009	0.473
FR22	0.381	0.548	0.929	0.006	0.662
FR23	0.407	0.519	0.926	0.012	1.077
FR24	0.439	0.500	0.939	0.012	0.673
FR25	0.509	0.198	0.706	0.006	0.296
FR26	0.492	0.303	0.795	0.008	0.331
FR27	0.375	0.708	1.083	0.011	0.653
FR28	0.493	0.402	0.896	0.011	0.346
FR29	0.502	0.362	0.864	0.013	0.389
FR30	0.393	0.519	0.912	0.005	0.531
FR31	0.452	0.130	0.582	0.006	0.601
FR32	0.371	0.528	0.899	0.009	1.258
FR33	0.427	0.400	0.827	0.006	0.570
FR34	0.413	0.470	0.882	0.006	0.531
FR35	0.453	0.430	0.883	0.010	0.547
FR36	0.473	0.341	0.814	0.010	0.534
FR37	0.366	0.604	0.971	0.010	1.131
FR38	0.485	0.382	0.867	0.013	0.496
FR39	0.473	0.312	0.784	0.008	0.480
FR40	0.415	0.463	0.878	0.009	0.805
FR41	0.480	0.378	0.859	0.010	0.457
FR42	0.448	0.467	0.915	0.009	0.481
FR43	0.403	0.576	0.979	0.009	0.631
FR44	0.442	0.445	0.887	0.007	0.475
FR45	0.450	0.491	0.941	0.013	0.601
FR46	0.421	0.378	0.799	0.006	0.671
FR47	0.414	0.447	0.861	0.009	0.895
Average	0.433	0.446	0.880	0.009	0.643

SOURCE: Author's calculations.

The output and input price effects can also exert a significant influence on some offices' unit costs, but the correlations with unit costs are much lower. In fact, the correlation between unit costs and the input price effect is negative, hinting that some input quality may vary across sites and that higher-priced inputs may be more productive. By construction, input prices and estimates of cost efficiency are uncorrelated, so in this case, the unit cost measures have revealed an issue that requires further study.

The environmental effects tend to be minimal across all sites except FR25, which serves an unusually small number of endpoints. The interactive effect is slight for all offices, with the largest estimated effect shifting relative unit costs only about 6.8 percent.

Productivity Growth

Including year dummies in the cost function allows us to estimate whether it shifts down (or up) over time as a result of changes in technology or in the regulatory environment. Estimates of a technical change index are presented in figure 4. For 1983, the index equals 100; for later years, it rises or falls depending on the behavior of the estimated cost function. As of 1990, costs had risen about 8.7 percent. Most of the upward shift that occurred in 1989 appears to have stemmed from transitory costs related to the implementation of regulations designed to post checks more quickly, since costs fell sharply in 1990.

Measured productivity growth in check processing has been anemic for two main reasons: 1) some of the cost savings have been plowed back into producing a higher-quality product (such as expedited funds availability), and 2) even though prices for computer equipment and other office machinery have fallen precipitously over the last 10 years, the price of high-speed check reader-sorters has remained roughly unchanged in real terms. Apparently, the limit of how quickly paper checks can be read and sorted has nearly been reached, and further advances will have to await the increased use of electronics in collecting checks.

TABLE 2

GLS Cost Efficiency Estimates, 1983–90 Average

Office	Single Product GLS	Single Product Rank	Multiproduct GLS	Multiproduct Rank	Change in Efficiency	Change in Rank
FR1	0.864	7	0.884	8	0.020	1
FR2	0.535	46	0.604	45	0.069	−1
FR3	0.997	2	0.998	2	0.002	0
FR4	0.587	42	0.615	44	0.028	2
FR5	0.625	37	0.708	25	0.083	−12
FR6	0.669	25	0.687	29	0.018	4
FR7	0.634	31	0.689	28	0.056	−3
FR8	0.633	32	0.696	26	0.063	−6
FR9	0.656	28	0.673	33	0.017	5
FR10	0.629	35	0.632	43	0.003	8
FR11	0.581	43	0.668	34	0.086	−9
FR12	0.765	11	0.861	9	0.095	−2
FR13	0.717	16	0.736	19	0.019	3
FR14	0.713	19	0.718	24	0.005	5
FR15	0.715	17	0.737	18	0.022	1
FR16	0.714	18	0.721	22	0.007	4
FR17	0.754	12	0.728	20	−0.026	8
FR18	0.647	29	0.645	39	−0.002	10
FR19	0.645	30	0.679	32	0.034	2
FR20	0.707	21	0.770	15	0.063	−6
FR21	0.683	24	0.694	27	0.011	3
FR22	0.919	5	0.928	5	0.009	0
FR23	0.530	47	0.585	46	0.055	−1
FR24	0.612	39	0.661	36	0.048	−3
FR25	0.802	9	0.837	10	0.035	1
FR26	0.880	6	0.927	6	0.047	0
FR27	0.627	36	0.790	14	0.163	−22
FR28	0.738	15	0.798	13	0.060	−2
FR29	0.615	38	0.665	35	0.050	−3
FR30	0.969	3	0.961	3	−0.008	0
FR31	0.693	22	0.720	23	0.027	1
FR32	0.630	34	0.636	42	0.006	8
FR33	0.939	4	0.939	4	0.000	0
FR34	1.000	1	1.000	1	0.000	0
FR35	0.711	20	0.756	16	0.045	−4
FR36	0.660	27	0.685	31	0.025	4
FR37	0.574	44	0.656	38	0.082	−6
FR38	0.610	40	0.644	40	0.034	0
FR39	0.792	10	0.815	12	0.023	2
FR40	0.557	45	0.567	47	0.011	2
FR41	0.747	13	0.820	11	0.074	−2
FR42	0.742	14	0.721	21	−0.021	7
FR43	0.668	26	0.745	17	0.078	−9
FR44	0.843	8	0.914	7	0.071	−1
FR45	0.610	41	0.659	37	0.049	−4
FR46	0.630	33	0.685	30	0.055	−3
FR47	0.689	23	0.638	41	−0.051	18
Average	0.708		0.742		0.035	

SOURCE: Author's calculations.

TABLE 3

Unit Cost Decomposition[a]

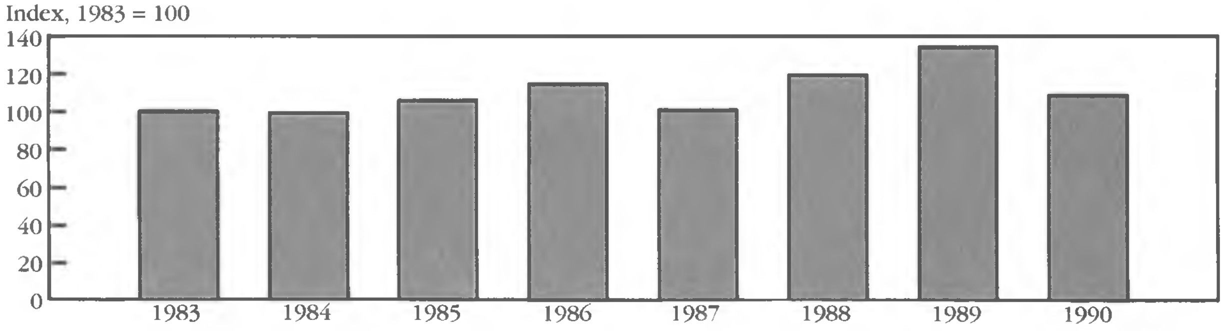
Office	Unit Cost ($)	Logarithmic Differences from Sample Means, 1983-90					
		Unit Cost	Cost Efficiency	Total Output	Direct Input Price	Interactive Effect	Environmental Effect
FR1	0.015	−0.179	−0.185	−0.054	0.017	−0.006	0.048
FR2	0.021	0.176	0.195	0.001	0.061	0.003	−0.084
FR3	0.013	−0.349	−0.307	−0.110	0.038	0.005	0.024
FR4	0.023	0.242	0.178	−0.163	0.225	0.008	−0.005
FR5	0.018	0.022	0.037	−0.136	0.213	−0.022	−0.070
FR6	0.018	0.028	0.067	0.010	0.012	−0.006	−0.054
FR7	0.016	−0.087	0.064	−0.133	0.068	0.000	−0.086
FR8	0.022	0.212	0.054	−0.122	0.211	0.019	0.050
FR9	0.019	0.047	0.087	0.018	−0.046	0.006	−0.018
FR10	0.020	0.133	0.151	−0.119	0.086	0.002	0.013
FR11	0.020	0.131	0.096	0.174	−0.044	0.004	−0.099
FR12	0.014	−0.221	−0.159	−0.038	0.083	−0.002	−0.106
FR13	0.018	0.023	−0.002	−0.148	0.223	0.001	−0.051
FR14	0.018	0.029	0.022	0.053	−0.167	−0.023	0.143
FR15	0.017	−0.036	−0.003	−0.125	−0.029	0.001	0.119
FR16	0.015	−0.145	0.019	−0.085	−0.084	0.000	0.005
FR17	0.018	−0.017	0.009	−0.155	0.073	0.000	0.055
FR18	0.024	0.304	0.130	0.278	−0.159	0.030	0.026
FR19	0.021	0.182	0.078	0.054	0.076	−0.029	0.002
FR20	0.018	−0.007	−0.047	0.149	−0.183	0.004	0.070
FR21	0.016	−0.112	0.057	0.005	−0.156	0.002	−0.020
FR22	0.012	−0.376	−0.234	−0.191	0.078	0.002	−0.031
FR23	0.022	0.193	0.227	−0.081	0.113	−0.001	−0.066
FR24	0.022	0.219	0.106	0.188	−0.167	−0.002	0.094
FR25	0.014	−0.217	−0.130	0.134	0.404	−0.068	−0.556
FR26	0.016	−0.124	−0.232	0.149	−0.136	0.020	0.075
FR27	0.020	0.120	−0.073	0.357	−0.233	−0.047	0.117
FR28	0.020	0.134	−0.083	0.356	−0.270	0.020	0.111
FR29	0.024	0.309	0.100	0.375	−0.275	0.028	0.080
FR30	0.012	−0.388	−0.269	−0.193	0.065	0.002	0.008
FR31	0.019	0.042	0.019	−0.027	0.024	−0.003	0.029
FR32	0.020	0.122	0.145	−0.288	0.219	0.012	0.034
FR33	0.014	−0.269	−0.245	−0.165	0.101	0.003	0.038
FR34	0.013	−0.352	−0.308	−0.179	0.124	0.001	0.010
FR35	0.018	0.025	−0.029	0.117	−0.189	0.008	0.119
FR36	0.021	0.155	0.070	0.105	−0.151	0.016	0.115
FR37	0.021	0.162	0.113	−0.093	0.034	0.001	0.107
FR38	0.021	0.141	0.132	0.029	0.076	−0.004	−0.092
FR39	0.016	−0.086	−0.103	0.017	−0.004	0.004	0.001
FR40	0.019	0.038	0.258	−0.126	0.031	0.001	−0.126
FR41	0.017	−0.051	−0.111	0.102	−0.058	0.008	0.008
FR42	0.017	−0.036	0.018	0.187	−0.338	0.019	0.077
FR43	0.019	0.046	−0.014	0.152	−0.150	−0.018	0.076
FR44	0.013	−0.288	−0.218	0.001	−0.005	0.003	−0.069
FR45	0.023	0.259	0.109	0.133	−0.130	0.002	0.144
FR46	0.016	−0.104	0.069	−0.252	0.217	−0.007	−0.132
FR47	0.017	−0.049	0.142	−0.162	0.101	0.003	−0.133

a. Office mean relative to overall sample mean.

SOURCE: Author's calculations.

FIGURE 4

Technical Change Index



SOURCE: Author's calculations.

V. Conclusions and Prospects for the Future

This study finds scale economies to be sufficiently large to enable most offices to proportionally increase their forward and return volumes, yet still lower their ray average costs by roughly 12 percent. Costs appear to increase much more rapidly as more return items are processed than as more forward items are processed. Although there appear to be opportunities for most offices to improve their performance by further exploiting scale economies, costs could be lowered even more (up to 23.5 percent overall) if all offices could operate closer to the cost frontier.

It is necessary to keep in mind three important caveats. First, some offices may be located in areas where it may not be possible to expand output enough to achieve scale efficiency. Second, the cost-efficiency measure is relative to the most efficient office observed in the sample. Third, although I use the concise term "cost efficiency," the concept is more fully described as "once factors included in the cost function are controlled for, there remain unexplained cost differences across processing sites." Every effort has been made to control for the factors that affect the costs of check-processing offices, but no one can hope to account for every factor that *might* significantly affect costs. Future research will extend the analysis by trying to control for product quality in a more detailed way.[20]

The multiproduct cost-efficiency estimates for the 47 offices covered here are highly correlated with earlier single-product estimates presented in Bauer and Hancock (1993). On average, cost efficiency rose only 3.8 percentage points when returns were treated as a separate output. However, one office that processed an atypically high level of returns had its cost-efficiency index increase by 16.3 percentage points. The overall level of cost efficiency is roughly the same as that found for private financial institutions, using similar estimation techniques.[21]

In the single-product setting, unit cost measures provide an easily calculated overall indicator of relative office performance. Unfortunately, they do not reveal the sources of superior or inferior performance. In the multiproduct setting, unit cost measures could be biased if the costs of joint inputs are misallocated across services. The cost-function approach overcomes both of these drawbacks, but requires imposing a number of potentially restrictive assumptions. The decomposition of unit costs reveals that, for this sample, cost efficiency tends to be the largest single component, but considerable office-specific variation results from the other components. Only the interaction effect between output levels and input prices is consistently small in magnitude for all offices.

■ **20** Product quality can affect cost efficiency measures because it is expensive to provide higher quality. If output is not adjusted for product quality, sites providing lower-quality output will, other things being equal, appear to be more cost efficient.

■ **21** For example, see Bauer, Berger, and Humphrey (1993), Ferrier and Lovell (1990), Fried, Lovell, and Vanden Eeckaut (1993), and Mester (1993), to name just a few. While these studies examine the cost efficiency of producing outputs other than check-processing services, their estimated efficiency levels suggest that the Federal Reserve pursues its behavioral goal about as well as private financial institutions pursue theirs.

The net effect of technological and regulatory changes seems to have shifted the multiproduct cost frontier up slightly over time, a finding that supports the prevailing view that much greater use of new technologies, such as check truncation and imaging, will be required to achieve significant technical change in check processing. This finding is also consistent with earlier work by Bauer and Hancock (1993).

In the coming years, check processing at the Federal Reserve will face a number of new challenges, since volume is likely to rise less rapidly, and may even fall. One cause is mergers and acquisitions in the financial service sector, which have resulted in more on-us items that can be cleared internally. Other causes include bilateral agreements among banks to swap checks directly, the emergence of private nationwide check processors, same-day settlement, and technological advances such as electronic check presentment and the shift to electronic payments.

The introduction of pricing, the evolution of technology, and the consolidation of the banking industry during the past few years have led to many changes in the check-processing market. Moreover, increased competition between bankers and nonbank providers of financial services, along with more competition between checks and other payment media, indicates that more changes will follow. In the future, market forces will largely determine the number and location of check-processing sites across the country. Research studies can contribute to a more complete understanding of developments in this dynamic payment service.

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