Economic Review

Federal Reserve Bank of San Francisco

Winter 1988 Number 1

Table of Contents

The Federal Reserve Bank of San Francisco's Economic Review is published quarterly by the Bank's Research and Public Information Department under the supervision of Jack H. Beebe, Senior Vice President and Director of Research. The publication is edited by Gregory J. Tong, with the assistance of Karen Rusk (editorial) and William Rosenthal (graphics).

For free copies of this and other Federal Reserve publications, write or phone the Public Information Department, Federal Reserve Bank of San Francisco, P.O. Box 7702, San Francisco, California 94120. Phone (415) 974-2163.

Bank Capital Regulation in the 1980s: Effective or Ineffective?

Michael C. Keeley

Research Officer, Federal Reserve Bank of San Francisco.

Comments from Barbara Bennett, Christopher James and Frederick Furlong and research assistance from Alice Jacobson are appreciated.

During the early 1980s, objective minimum capital-to-asset ratio requirements replaced the earlier peer group type of capital regulation. This empirical study of the effects on the capital positions of the 100 largest BHCs finds that the regulations succeeded in causing banks with low capital ratios to increase their book value capital ratios both absolutely and relative to banks with initially high capital ratios, and that the banks did so primarily by slowing asset growth.

However, evidence on changes in market value capital ratios, while not necessarily inconsistent with the apparent book value capital increase induced by regulation, lends little independent support to the idea that regulation caused an actual increase in capital ratios.

As guarantor of a large portion of bank deposits, the Federal Deposit Insurance Corporation (FDIC) has a strong interest in ensuring that banks maintain adequate capital. Bank capital serves two purposes: it limits the exposure of the insurance fund to bank losses, and it limits banks' incentives to take excessive risks. Pursuant to this interest, the FDIC and the other banking regulatory agencies (the Office of the Comptroller of the Currency and the Federal Reserve) try to influence bank capital through supervision and regulation.

Prior to the 1980s, subjective capital standards, based on the results of the regulatory agencies' examinations of individual banking organizations, were the main form of capital regulation. Typically, regulators compared capital-to-asset ratios for bank peer groups (banks grouped by common characteristics such as asset size) and tried to ensure that banks with capital ratios lower than their peer group's average raised their capital ratios.

Largely because of the heightened concern over the risk exposure of the insurance system during the 1980s, the peer group type of capital regulation was replaced by specific minimum requirements. The risk exposure was increasing, it was believed, because of deteriorating asset quality, increases in off-balance sheet activity and declining capital ratios. The new capital requirements were intended to deal with these problems by causing banks with low capital ratios to increase them. Moreover, there was a desire to bring about more uniformity and objectivity in capital regulation. Consistent with these objectives, all banks and bank holding companies were required to hold primary capital at least equal to 5.5 percent of assets by June 1985.

There has been considerable debate over whether capital regulation is effective – specifically, whether regulators have succeeded in causing capital-deficient banks to increase their capital ratios. In the seminal paper on this subject, Peltzman (1970), using data from the 1963-1967 period, found no evidence that regulation affected banks' capital ratios. Although a later study by Mingo (1975), that examined the 1969-1970 period, seemed to find evidence of an effect, Dietrich and James (1973) argue that Mingo's findings were due to a failure to account for the effects of Regulation Q (deposit-rate ceilings) on banks' capital decisions.

In particular, during the 1969-1970 period analyzed by Mingo, banks were not permitted to raise interest payments to market-clearing levels even on large, uninsured deposits. As a result, banks may have boosted their capital ratios, thereby making their deposits safer and raising the expected yield, to compete for uninsured deposits. Consistent with this hypothesis, Dietrich and James find no evidence that capital regulation affected capital ratios during the 1971-1975 period when ceilings on most large deposits were not binding.[1]

This paper contributes to the literature on the effectiveness of capital regulation by examining the changes that took place in the 1980s. In many ways, this recent period is ideal for such a study because of the exogenous, explicit, and sweeping nature of those changes in capital regulation.

As in the previous literature, this study examines whether the new capital requirements caused banks with capital ratios below the minimum to raise their book value capital ratios to meet the new standards. However, unlike previous studies, this study also analyzes whether observed increases in book value capital represent an actual, market value capital infusion or whether they merely result from accounting changes. To address these questions, I examine, first, changes in banks' book value capital ratios caused by regulation; second, the sources of those changes; and third, the effects on market value capital-to-asset ratios using a measure based on stock prices.

The issue of whether a market value capital infusion took place is particularly important in judging the effectiveness of the capital regulations because the risk exposure of the insurance fund depends on the market values of banks' assets and liabilities – not their book values. For example, when a bank fails and is liquidated by the FDIC, the FDIC's loss equals the bank's liabilities minus the market value of its assets.

However, only book value capital-to-asset ratios – that is, ratios calculated using historical accounting values – are subject to regulation, and, there need not be a close correspondence between book and market values. For example, banks might respond to more stringent capital regulation by selling and then repurchasing appreciated assets. This would have the effect of increasing book value capital and assets by the amount of the capital gain and thereby increasing the book value capital-to-asset ratio, but it would not affect the market value ratio or the risk exposure of the deposit insurance system.

Even if the capital regulations of the 1980s succeeded in causing at least some banks to bolster their capital-to-asset ratios as my analysis suggests, a second related and important question remains: Did those banks that increased their capital ratios in response to the regulations react by increasing the asset risk of their portfolios in an effort to maintain a given rate of return? This question is addressed in an upcoming article in the Summer *Review* (Furlong, 1988). This issue is important because increased asset risk, potentially at least, could offset the beneficial effects of higher capital ratios on reducing the risk exposure of the deposit insurance system.

This paper is organized as follows. In Section I, I examine the effects of the capital regulations on book value capital ratios. I find that banks with low book value capital ratios did increase their ratios to meet the new standards introduced in the 1980s, apparently in response to the regulations. Therefore, it appears as though capital regulation is effective on average, at least in a book value sense.

Section II analyzes how the increase in book value capital was accomplished in order to assess whether it was the result of a true reduction in leverage or simply the result of accounting changes. The evidence indicates that banks increased their book value capital ratios mainly by slowing asset growth. This suggests that an actual increase in capital ratios did take place.

Section III then examines the effects on market value capital ratios to see if they are consistent with this interpretation. Although the patterns of changes in stock-price-based measures of market value capital ratios are consistent with an increase in actual capital under certain assumptions, they are consistent with several other hypotheses as well. Finally, Section IV presents a summary and conclusions.

I. Effects on Book-Value Capital Ratios

This Section analyzes whether the 1981-1985 capital regulations caused banks with capital below the minimum levels to raise (book value) capital, and thus whether the regulations reduced the disparity in capital ratios as intended. A brief description of the regulations is presented, after which their effects are analyzed.

Bank Capital Regulation: 1981-1985

In December of 1981, in a sharp departure from the past subjective form of capital regulation, the three federal bank regulatory agencies announced specific minimum capital standards. With the exception of the 17 largest banking organizations – the multinationals – minimum primary capital was set at 6 percent of assets for banks and bank holding companies with assets less than $1 billion, and 5 percent for organizations with assets of $1 billion or more.[2]

One of the stated purposes of this regulation was "...(to) address the sizable existing disparity in capital ratios among banking organizations of different size."[3] However, at the time the regulation was promulgated, actual differences in capital ratios were taken into account and the (trichotomous) capital standards apparently were set so that most organizations would meet the minimums.

Although the multinationals had very low capital levels and initially were exempted from the explicit minimum requirements for banks with assets over $1 billion (requirements which almost none of them would have met),[4] the agencies announced that their policies with respect to the multinationals would be amended "...(to) insure that appropriate steps are taken to improve over time the capital positions of banking organizations in this group."[5] Consistent with this goal, in June 1983, the 5 percent requirement was extended to the multinationals. Moreover, reflecting the original stated purpose of instituting objective and uniform minimum capital standards, in June of 1985, a uniform 5.5 percent minimum primary capital ratio was required for all banking organizations regardless of size.

Although a minimum primary capital ratio of 5.5 percent was set for all banks and bank holding companies (BHCs), a typical banking organization was expected to operate above the minimum ratio. Moreover, high-risk organizations were expected to hold even more additional capital.[6] Thus, if the regulations were effective, one would expect to see actual primary capital ratios average somewhat above the 5.5 percent level.

The evolution in capital regulation from trichotomous to dichotomous, and finally to uniform standards is consistent with the stated goals of the 1981 regulations – to bring uniformity over time in capital regulation. Thus, one might argue that the 1985 uniform standards were the ultimate objective even as early as December 1981. In keeping with this interpretation, this paper distinguishes the behavior of banks that would have met the 1985 requirements in 1981 from those that would not have. Throughout the paper, I refer to the former as capital-sufficient, and the latter as capital-deficient banks.

I also focus on primary capital (which consists mainly of common equity, loan loss reserves, and perpetual preferred stock) instead of total capital (which includes primary capital plus limited life preferred stock and subordinated notes and debentures) because primary capital requirements must be met in order to meet total capital requirements and because primary capital is somewhat easier to measure.

Data

The data used in my study come from the quarterly Bank Call Reports and the Compustat bank tapes, which contain balance sheet and income statements for the 150 largest bank holding companies whose stock is publicly traded. Although this sample of 150 BHCs is not representative of the entire population of all banks or bank holding companies, which consists of many smaller and often privately held banks and bank holding companies as well, the BHCs in this sample hold about 40 percent of all bank assets and thus are of interest in their own right.

The Compustat sample also is subject to selectivity (survivor) bias since it consists only of banks currently in existence. Thus, banks that have failed or that were acquired are not included in the sample. The exclusion of failed or acquired banks might bias the study toward finding that capital regulation was effective since banks not meeting the requirements would be more likely to fail or be acquired and thus not be included in the sample. Moreover, complete historical data are not available for the entire sample of 150 banks. To deal with this second problem, I focus on a subsample of 103 banks for which data are available over the entire analysis period. Thus, the results may only apply to a subsample of large publicly traded banks that have not failed or been acquired.

Effects of Regulations on Book Capital Ratios

Chart 1 shows an overall downward trend until 1981 in the mean of the primary book capital ratio for a sample of large, publicly traded banks over the 1965-1986 period. This downward trend is part of a longer downward trend that began as early as 1956 (see Keeley and Furlong, 1987).

However, the downward trend apparently has reversed since 1982, perhaps partly as a result of the imposition of objective capital regulation in December 1981.[7] An alternative explanation is that some external factor, such as a change in the economic environment, caused the capital ratios of banks to increase on average. However, if capital regulation itself had an effect, one would expect the capital ratios of those banks initially not meeting the requirements (that is, the capital-deficient banks) to rise relative to those meeting them (the capital-sufficient banks). Moreover, one would expect that, eventually, the capital ratios of the two groups would be indistinguishable.

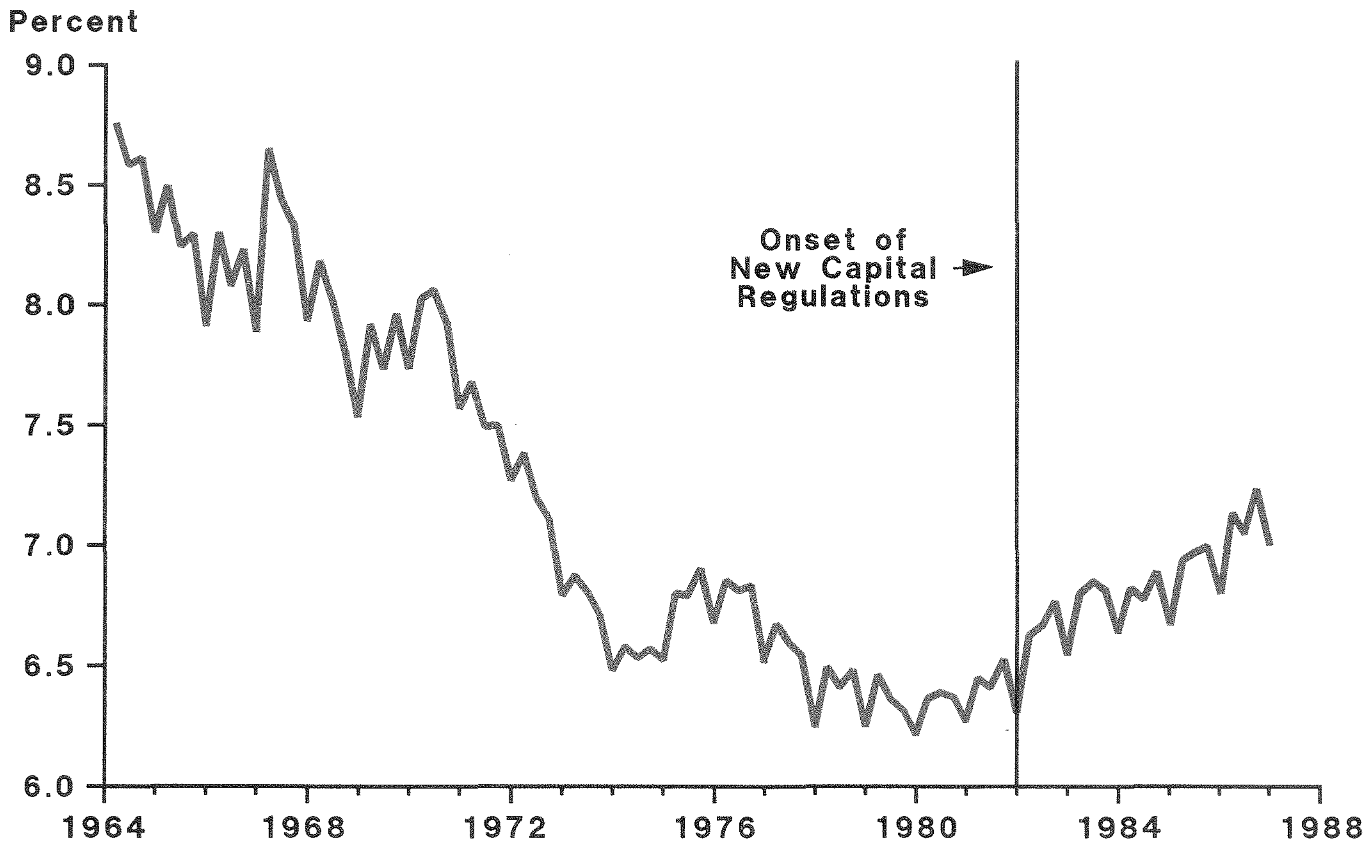
In Chart 2, mean primary book capital-to-asset ratios are plotted separately for capital-sufficient and capital-deficient banks. The chart shows that capital-deficient banks did increase their capital ratios relative to the capital-sufficient banks – a pattern consistent with the hypothesis that regulation caused the increase in capital ratios. Moreover, the increase was gradual over the 1982-1986 period, which is consistent with the stated goal of the 1981 requirements to induce capital-deficient banks to augment capital over time.

Chart 3 plots the percent of banks in each group meeting the 1985 requirements over time. This chart confirms that by 1986 about 90 percent of the capital-deficient banks were meeting the 1985 capital requirements. Thus, it appears that by 1986, capital requirements were effective in the sense that virtually all of the banks in the sample were complying with the minimum book requirements. While the increase in capital standards over this period might have been a reaction by regulators to a perceived increase in bank risk (due perhaps to the LDC debt crisis) and thus was not fully exogenous, the results nevertheless suggest that capital regulation was effective in boosting banks' capital ratios higher than they would have been in its absence.

In the next part of this section, an overview of some of the key differences in the characteristics of the capital-deficient and capital-sufficient banks is presented. Then

CHART 1

PRIMARY BOOK CAPITAL-TO-ASSET RATIO REVERSED DOWNWARD TREND IN 1982



the group of capital-sufficient banks is used as a control group against which the behavior of the capital-deficient banks is compared. This comparison permits statistical estimation of the response of the capital-deficient banks to the capital regulations of the 1980s.

Bank Characteristics

Mean values of several characteristics of both capital-deficient and capital-sufficient banks are presented in Table 1. Perhaps the most overriding difference is that 63 percent of the capital-deficient banks are multinationals, in contrast to only 1 percent of the capital-sufficient banks. As a result, the capital-deficient banks are much larger ($129 billion of assets compared to $19 billion), have more foreign deposits (35 percent of total deposits compared to 8 percent), have a smaller fraction of retail-type deposits (demand and savings), and are more heavily involved in issuing standby letters of credit (SLCs).

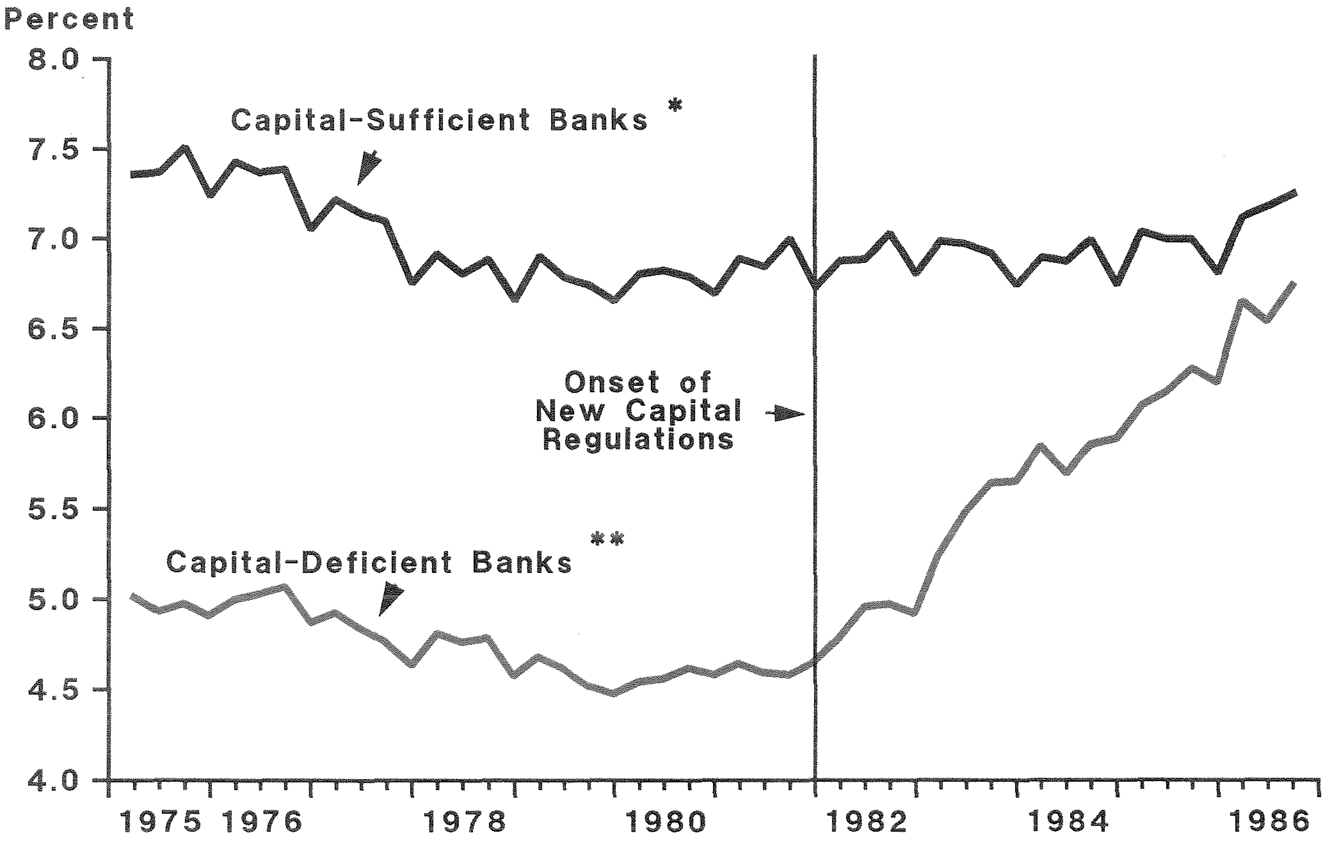
One of the possible reasons the capital-deficient group had lower capital ratios in 1981 was that, prior to that time, this group of banks was believed to have been less risky. The group therefore would have required less capital because their larger size and multinational scope allowed for more diversified portfolios. However, the onset of the LDC debt crisis and other economywide shocks called for a re-evaluation. Thus, it appears that one of the major goals of the series of new capital regulations promulgated in the early 1980s was to bolster the capital ratios of the multinationals as well as other banks with low capital ratios.

Statistical Analysis of Book Capital Ratios

Chart 3 suggests that capital-deficient banks gradually adjusted their capital ratios over the 1982-1986 period to eventually meet or exceed the 1985 require-

CHART 2

CONVERGING TRENDS IN PRIMARY BOOK CAPITAL-TO-ASSET RATIOS



** Banks that met 1985 requirements in 1981.*

*** Banks that did not meet 1985 requirements in 1981.*

ments. Table 2 confirms this with a comparison of mean primary book capital ratios at selected points in time for the capital-sufficient and capital-deficient groups.

Table 2 shows that the difference in the means of the two groups fell from 2.27 percentage points in 1981 to just .56 percentage points by 1986. Moreover, the difference declined each year, mostly due to increases in the capital ratios of the capital-deficient group. In fact, the mean capital ratio of the capital-deficient banks increased by 2.02 points in comparison to only a .31 point increase for the capital-sufficient banks over the 1981 through 1986 period — a statistically significant difference of 1.71 points. The apparent rise of .31 points of the capital-sufficient group, which took place mainly between 1984 and 1986, may have been due to the .50 point rise in minimum primary capital for BHCs with assets of $1 billion or more (a characteristic of most of the capital-sufficient banks in the sample) that became effective in June of 1985.

Desired Book Capital Ratios

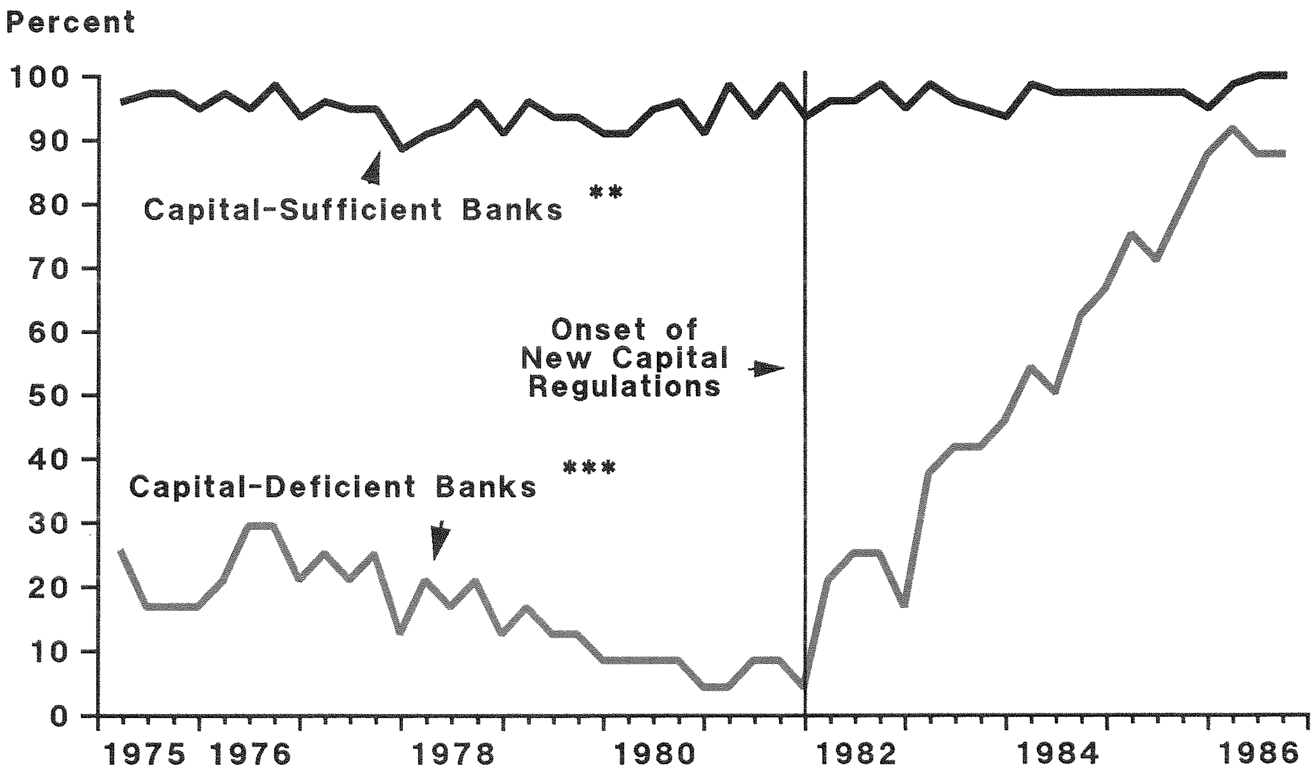
This pattern of gradual adjustment is exactly what might be expected given that the new regulations were phased in over the 1982-1985 period and that the 5.5 percent statutory minimum requirement did not become effective until June of 1985. Because adjustment of capital is costly and thus takes places slowly, the actual average capital ratios over the 1982-1986 period presented in Table 2 may not reflect the long-run levels toward which the banks apparently were aiming. However, by making some assumptions about the adjustment process, it is possible to estimate statistically the long-run level. The model follows.

Assuming that a bank has a target capital-to-asset ratio of c* and that in each period it adjusts a fraction, b, of the difference between its actual and target ratio, the change in the actual capital ratio would be:

$$c_t - c_{t-1} = b(c^* - c_{t-1}). \quad (1)$$

CHART 3

PERCENT OF BANKS MEETING THE 1985 REQUIREMENTS INCREASES AFTER 1982*



* *The percent of capital sufficient banks is less than 100% and the percent of capital sufficient banks is greater than zero in each quarter of 1981 because capital sufficiency is defined on an annual basis.*

** *Banks that met the 1985 requirements in 1981.*

*** *Banks that did not meet the 1985 requirements in 1981.*

Moving c_{t-1} to the righthand side of equation 1 and allowing for other unrelated (random) influences on capital ratios, e_t, gives:

$$c_t = bc^* + (1-b)c_{t-1} + e_t. \quad (2)$$

Equation 2 is used to estimate both the desired or target capital level, c*, and the speed of adjustment, b, separately for the capital-deficient and capital-sufficient banks both before and after the period of changing capital regulation that began in 1982.

If the new capital regulations had their intended effects, one would expect the target capital ratios of both groups of banks to exceed the guidelines during the post-1982 period. Moreover, one would expect the target capital ratios in the post-1982 period for capital-deficient banks not to differ significantly from the target capital ratios of the capital-sufficient banks.

Table 1

1981 Characteristics of Capital-Deficient and Capital-Sufficient Banks
(Standard Errors in Parentheses)

Characteristics	Capital-Deficient Banks	Capital-Sufficient Banks	Difference
n	24	79	
Assets (in billions of dollars)	$129.2 (27.57)	$18.6 (1.63)	−110.6** (27.62)
Percentage Multinational	63% (10%)	1% (1%)	−62%** (10%)
Demand Deposits & Savings Deposits / Total Deposits	0.38 (.036)	0.50 (.0094)	.12** (.04)
Foreign Deposits / Total Deposits	0.35 (.044)	0.080 (.011)	−.27** (.05)
Treasury Securities & Cash & Other Government Securities / Total Assets	0.28 (.012)	0.26 (.0077)	−.02 (.014)
Loan Loss Reserves / Total Loans	0.011 (.00056)	0.011 (.00024)	0.00 (.00078)
SLCs* / Assets	.049 (.0074)	.019 (.0015)	−.030** (.0008)
Primary Capital Ratio*	4.63 (.13)	6.73 (.13)	2.10** (.18)
Market Value Capital Ratio*	2.82 (.23)	4.88 (.18)	2.06** (.29)

** 4th Quarter 1981*
*** Significant at the 1 percent level*

In Table 3, estimates are presented of the model described by Equation 2. The estimates are from four pooled-time-series-cross-section nonlinear regressions for the two periods (before and after 1982) and for the two groups (capital-deficient and capital-sufficient banks). The equations are estimated by nonlinear least squares, and the standard error of each difference is equal to the square root of the sum of the variances of the two parameters since the covariances are zero.

The results suggest that capital-deficient banks did increase their target capital levels by a statistically significant (at the 1 percent level) 2.5 percentage points compared to only a .48 percentage point increase for the banks for which the requirements were not binding. (The .48 point increase for the capital-sufficient banks may be due to the rise in minimum primary capital requirements from 5 to 5.5 percent in June 1985 for banks with $1 billion or more in assets.)

Moreover, although prior to the imposition of the new capital standards, the capital-deficient group had target capital ratios 2 percentage points below that of the capital-sufficient group, during the 1982-1986 period there was no statistically significant difference between the two groups. Thus, the .56 point difference in 1986 actual capital ratios shown in Table 2 appears to be due to incomplete adjustment.

The larger increase in the capital ratios of the capital-deficient banks is consistent with the hypothesis that the new capital requirements were the cause of most of the increased capital. Moreover, the lack of a statistically significant difference in the target ratios of the two groups suggests that the requirements will eventually eliminate the disparity in actual capital ratios.[8]

The results in Table 2 and 3 suggest that, after the new regulations became effective, banks' actual and target book capital ratios on average exceeded the minimum

Table 2

Mean Primary Book Capital Ratios, Selected Points in Time

(Standard Errors in Parentheses)

Period	Capital-Deficient Banks	Capital-Sufficient Banks	Difference*
1974Q4–1981Q4	4.73	7.00	2.27
	(.029)	(.028)	(.040)
1982Q1–1986Q3	5.75	6.95	1.20
	(.044)	(.029)	(.053)
1981	4.60	6.87	2.27
	(.066)	(.066)	(.093)
1982	4.89	6.90	2.01
	(.062)	(.077)	(.099)
1983	5.48	6.90	1.42
	(.076)	(.072)	(.10)
1984	5.80	6.88	1.08
	(.088)	(.058)	(.10)
1985	6.15	6.95	.80
	(.077)	(.053)	(.093)
1986Q1–Q3	6.62	7.18	.56
	(.099)	(.054)	(.11)

* *All estimates significant at the 1 percent level.*

Table 3

Book Value Primary Capital-to-Asset Ratio Long-Run Desired or Target Level of Capital and Speed of Adjustment

(Standard Errors in Parentheses)

	1975Q1–1981Q4	1982Q1–1986Q3	Difference
Capital-Deficient Banks			
Desired Level (percent)	4.68*	7.18*	2.50*
	(.13)	(.47)	(.49)
Speed of Adjustment (percent/quarter)	7.67*	7.08*	–.59
	(1.29)	(1.85)	(2.26)
Capital-Sufficient Banks			
Desired Level (percent)	6.68*	7.16**	.48**
	(.19)	(.11)	(.22)
Speed of Adjustment (percent/quarter)	3.82*	11.59*	4.77*
	(.53)	(1.13)	(1.25)
Difference			
Desired Level	2.00*	–.02	–2.02*
	(.23)	(.23)	(.54)
Speed of Adjustment	–3.85**	4.51**	5.36**
	(1.39)	(2.17)	(2.58)

* *Significant at the 1 percent level*
** *Significant at the 5 percent level*

required ratio (which was only 5.5 percent). During a period of explicit minimum requirements such a capital buffer might be expected for several reasons.[9] First, as mentioned previously, regulators expected typical banks to maintain primary capital ratios somewhat above the minimum, and they expected banks with riskier portfolios to maintain capital ratios substantially above the minimum. Moreover, minimum total capital required was 6 percent and "adequate" total capital was 7 percent, which some banks met by holding primary capital of 6 percent or more.

Second, capital ratios are not perfectly predictable. As a result, banks might want to hold a buffer stock to avoid regulatory penalties should a random shock cause them to fall below the required ratio. Third, it may be costly to raise capital, at least over a short period. Thus, banks may want to hold a capital buffer to allow for unexpected growth opportunities without violating the capital guidelines. Finally, bankruptcy and agency costs may provide a nonregulatory explanation for why at least some banks would want to hold capital in excess of the required amount.

The results in Table 3 also suggest that the speed of adjustment toward target capital levels increased substantially for the capital-sufficient banks (from 3.82 to 11.59 percent per quarter) but did not significantly change for the capital-deficient banks.

One interpretation of these findings is simply that regulators may have become less tolerant of capital ratios below the statutory minimum requirements once they were in place. Capital-deficient banks, in essence, were allowed the entire December 1981 through June 1985 period to adjust to the new requirements, whereas capital-sufficient banks, for the most part, had to meet the requirements immediately. If this were true, one would expect the speed of adjustment to increase after 1981, as I found it did for capital-sufficient banks. However, this same type of increase did not occur for the group of capital-deficient banks because capital requirements for the multinationals, which comprise the bulk of this group, were set in two phases in June 1983 and June 1985.

Table 4

Quarterly Standard Deviations of Primary Book Value Capital Ratios Across Banks: Averages Over Time

(Standard Errors in Parentheses)

Categories of Banks	1975Q1–1981Q4	1982Q1–1986Q3	Difference
All Banks	1.54	1.16	–0.38*
	(.037)	(.045)	(.059)
Capital-Deficient Banks	0.76	0.76	–0.01
	(.024)	(.029)	(.37)
Capital-Sufficient Banks	1.30	1.10	–0.20*
	(.037)	(.045)	(.058)

* *Significant at the 1 percent level*

The Standard Deviation of Book Capital Ratios

One of the goals of the new capital regulations was more uniform capital regulations, as reflected in the uniform minimum 1985 requirements. If these requirements were a major determinant of capital ratios, one would expect to see a decline in the dispersion of capital ratios across banks as all banks aimed to reach capital ratios near the minimum required level (plus a buffer).

Moreover, since the previous results suggest that capital regulations had their intended effects of causing increases in the capital levels of the capital-deficient banks relative to capital-sufficient banks, one would expect the standard deviation of capital ratios across all banks to decline after uniform minimum standards were introduced, especially after they had completed their adjustment to the new minimum requirements. Also, since the speed of adjustment increased for capital-sufficient banks, as long as the target ratios of different banks were similar, one might expect a larger decrease in the standard deviation of their capital ratios than in those of the capital-deficient banks. The reason is that a faster speed of adjustment toward a uniform target ratio means that more banks will be near the target ratio at any time.

Table 4 presents evidence relating to the changes in the standard deviation of capital ratios across banks for three groups of banks: 1) all banks in the sample, 2) capital-deficient banks, and 3) capital-sufficient banks. First, I computed the standard deviation of the primary book capital-to-asset ratio across the banks in a particular group for each quarter. Then I tested whether the average over time of these cross-sectional standard deviations during the 1982-1986 period is lower than the average during the 1975-1981 period.

The results in Table 4 suggest that the mean standard deviation of the primary capital ratio across all banks fell from 1.54 to 1.16. Moreover, they do not allow the hypothesis that the standard deviation across capital-deficient banks was unchanged to be rejected, whereas they do indicate that the standard deviation across capital-sufficient banks declined by a statistically significant amount. In addition, the standard deviation across all banks declined more than the standard deviation of capital-sufficient banks, suggesting that differences among banks in the two groups also declined – a result consistent with the intent of the regulations.[10]

One would expect the standard deviation of capital ratios of the capital-sufficient group of banks to exceed that of the capital-deficient group before the change in regulation took place. The reason is that capital-sufficient banks' capital ratios all exceeded 5.5 percent and had no upper limits. However, the capital-deficient group had capital ratios between zero and 5.5 percent. After the new regulations were promulgated, one might expect a tighter clustering of the capital ratios of the capital-sufficient group around the new target level if some of the banks with high capital ratios allowed the ratios to fall below the minimum. One also would expect little change in the dispersion of capital ratios for banks that had an incentive to operate at the minimum allowed ratio – apparently a characteristic of many of the capital-deficient banks.

II. How the Increase in Book Capital Ratios Came About

The previous results suggest that capital regulation, in keeping with its stated objectives, did have an influence on book capital ratios. However, they leave open the question of whether this result was due to a market-value capital infusion (relative to assets) or to accounting gimmicks. As mentioned previously, this issue is important because the risk-exposure of the insurance fund depends on the market value capital-to-asset ratio, not the book value ratio.

One commonly used accounting technique that would boost book capital without a change in market-value capital is the selective realization of capital gains through the sale of appreciated assets and the purchase of other assets with the proceeds. The difference between the book and current values of the appreciated asset would raise book capital and assets each by the amount of the gain, and thereby cause the book capital ratio to increase even though nothing changed on the bank's market-value balance sheet.

Another possible method of disguising leverage is through off-balance sheet banking. For example, by issuing standby letters of credit (SLCs) banks can in effect fund assets off balance sheet with off-balance sheet liabilities issued with recourse. Doing so has identical effects on banks' market value leverage as funding assets on their balance sheets.

Thus, it is at least possible that banks met the new capital standards simply by using accounting techniques, and that no real change in banks' balance sheets occurred.

Alternatively, banks may have increased their capital-to-asset ratios either through an increase in market value capital, holding assets constant, or through a decrease in assets, holding capital constant. Capital may be increased, holding assets constant, either by issuing additional equity or by retaining earnings. Assets may be reduced, holding capital constant, by selling assets and using the proceeds to retire liabilities.

Perhaps the easiest way to see how the capital-to-asset ratio can change over time is to differentiate the ratio of capital, C, to assets, A, with respect to time:

$$\frac{d(C/A)}{dt} = (C/A)\left[(1/C)\frac{dC}{dt} - (1/A)\frac{dA}{dt}\right] \qquad (3)$$

Equation 3 indicates that the rate of change of the capital-to-asset ratio equals the percentage growth rate of capital minus the percentage growth rate of assets times the initial capital-to-asset ratio. Thus, banks can increase their capital ratios by either increasing capital growth relative to asset growth or vice versa.

Capital and Asset Growth Rates

The data in Table 5 indicate that capital-deficient banks increased their capital ratios mainly by slowing asset growth. In the table, both mean annual capital and asset growth rates (continuously compounded) before and after the change in regulation were calculated separately for capital-deficient and capital-sufficient banks.

Capital-deficient banks dramatically lowered their rate of asset growth, both relative to their asset growth rates during the 1975-1981 period and relative to the growth rates of capital-sufficient banks, by a large (6.44 point) statistically significant amount. Thus, slower asset growth appears to be the main way that capital-deficient banks increased their capital-to-asset ratios relative to capital-sufficient banks.[11]

Capital-deficient banks also increased their rate of capital growth from 9.13 to 14.40 percent per year. This increase appears to be somewhat greater (.42 points) than the increase in the growth rate of capital for capital-sufficient banks, but the difference is not statistically significant. Thus, higher capital growth alone only partly explains the increase in capital ratios of capital-deficient banks relative to capital-sufficient banks.

One reason that slowing asset growth may have been used to increase capital ratios is that the method probably involves few, if any, transactions costs, and may not send the same types of adverse signals to the capital market that are claimed to be associated with new equity issuance or a reduction in dividend payout rates.[12]

Since slower asset growth would not result from selectively realizing capital gains and using the proceeds to acquire new assets (that would result in more rapid asset growth), the results suggest, but certainly do not prove, that this accounting method does not solely account for the increased capital-to-asset ratios of the capital-deficient group of banks relative to the capital-sufficient group. Although appreciated assets could have been sold and used to retire liabilities, thereby overstating the resultant decrease in book value leverage, such actions still would reduce market value leverage.[13]

Table 5

Means of Continuously Compounded Annual Growth Rates of Book Capital and Book Assets

(Standard Errors in Parentheses)

	1975Q1–1981Q4	1982Q1–1986Q3	Difference
All Banks			
Primary Book Capital	9.78	14.72	4.94*
	(.44)	(.74)	(.86)
Primary Book Assets	10.94	12.08	1.14
	(.43)	(.84)	(.94)
Capital-Deficient Banks			
Primary Book Capital	9.13	14.40	5.27*
	(1.03)	(1.10)	(1.51)
Primary Book Assets	10.07	7.14	-2.93
	(1.13)	(1.44)	(1.83)
Capital-Sufficient Banks			
Primary Book Capital	9.97	14.82	4.85*
	(.47)	(.90)	(.99)
Primary Book Assets	11.21	13.58	2.37
	(.46)	(.94)	(1.05)
Difference			
Primary Book Capital	0.84*	0.43	-0.42
	(1.13)	(1.42)	(1.81)
Primary Book Assets	1.14**	6.44**	5.30**
	(1.22)	(1.72)	(2.11)

* *Significant at the 1 percent level*

** *Significant at the 5 percent level*

Off-Balance-Sheet Banking

As mentioned above, banks could have evaded the capital regulations while still slowing asset growth by shifting existing assets and liabilities off their balance sheets or by funding new assets off balance sheet with off-balance-sheet liabilities issued with recourse. Loans sold with recourse and standby letters of credit (SLCs), for example, have cash flows identical to funding loans on balance sheet with no capital. Although loans sold with recourse are included in the balance sheet measures, SLCs are not.

Thus, if the increase in book capital ratios simply represents shifts of assets and liabilities (with recourse) off balance sheet, the capital regulations would have been ineffective. To test for this possibility, I recomputed capital ratios as if the loans backed by SLCs had been funded with on-balance-sheet bank liabilities. The results are displayed in Table 6.

Table 6 shows that incorporating SLCs on the balance sheet does lower capital ratios, especially for the capital-deficient banks. However, there is still an increase in average book capital from 4.45 percent in the last quarter of 1981 to 6.06 by the third quarter of 1986 for capital-deficient banks. Thus, while the increases in traditional on-balance-sheet measures of book capital somewhat overstate the true book capital increase (by about 27 percent), consolidated (on-and-off-balance-sheet) book capital ratios increased for the capital-deficient banks both absolutely and relative to the capital-sufficient banks by a statistically significant amount.

III. Market-Value Capital

The above results suggest that banks did comply with the capital regulations, at least in a book-value sense. If deposit insurance were fairly priced and no accounting tricks were used to augment book-value capital-to-asset ratios, then, *ceteris paribus,* one would expect market-value capital-to-asset ratios to increase one-for-one with book measures. Thus, the behavior of market-value capital ratios also potentially provides information on whether the change in book capital-to-asset ratios was genuine or the result of accounting changes.

Ideally, one would like to measure the market value of each bank asset (not including the potential value of underpriced deposit insurance) and liability to compute the market-value capital-to-asset ratio. Unfortunately, such a procedure is not possible because neither detailed

Table 6

Primary Capital-to-Asset Ratios, Actual and Adjusted to Incorporate SLCs
(Standard Errors in Parentheses)

	1977Q1	1981Q4	1982Q1	1986Q3	1986Q3 minus 1981Q4*
Capital-Deficient Banks (n = 19)					
Actual	4.81 (.16)	4.65 (.13)	4.78 (.14)	6.59 (.20)	1.94 (.23)
Adjusted	4.73 (.16)	4.45 (.14)	4.55 (.15)	6.06 (.23)	1.53 (.27)
Capital-Sufficient Banks (n = 65)					
Actual	7.17 (.18)	6.71 (.14)	6.85 (.14)	7.27 (.11)	.56 (.18)
Adjusted	7.12 (.18)	6.60 (.14)	6.73 (.14)	7.03 (.11)	.43 (.18)
Differences*					
Actual	−2.36 (.25)	−2.06 (.19)	−2.07 (.20)	−.68 (.23)	1.38 (.29)
Adjusted	−2.39 (.25)	−2.15 (.20)	−2.18 (.21)	−.97 (.25)	1.10 (.32)

* *All estimates significant at the 1 percent level.*

balance sheet data nor data on the market value of bank assets are available.

However, it is possible to measure the market value of bank equity (price per share times number of shares). And, assuming liabilities have par (book) value, the market value of assets equals the sum of the market value of equity plus the book value of liabilities. Thus, it is possible to compute a stock-price-based measure of the market value capital-to-asset ratio.

The problem with this measure, however, is that the *ceteris paribus* condition may not hold. Many factors including changing regulatory taxes and subsidies can affect bank stock prices yet not directly affect the risk exposure of the insurance fund. Nevertheless, changes in this measure may provide useful information.

Chart 4 shows that the means of the equity-based market value capital ratios rose rather dramatically for both capital-deficient and -sufficient banks. However, unlike the results for book capital ratios, the increase for capital-deficient banks is not apparently larger.

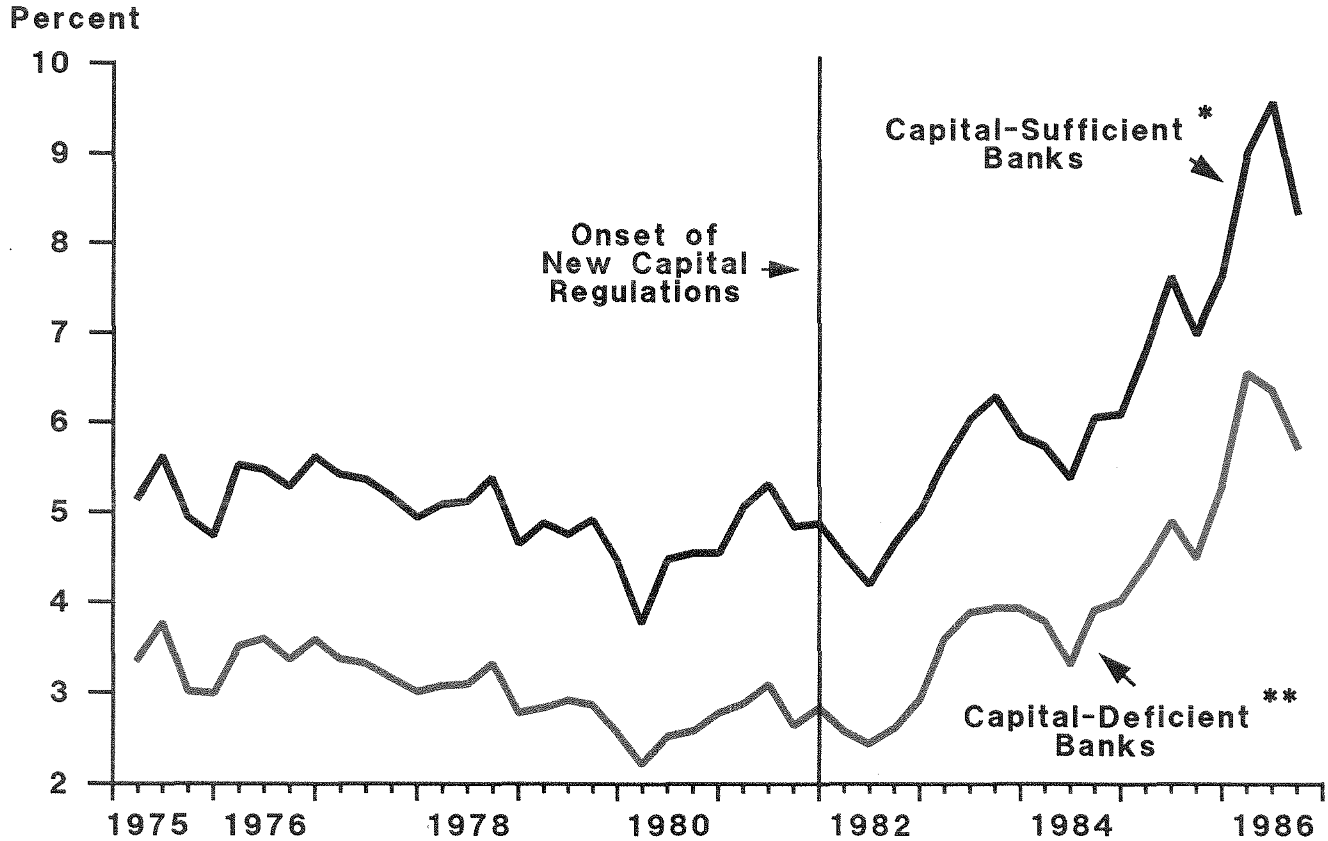
Table 7, which contains estimates of the mean market value capital-to-asset ratio for the two groups of banks at selected points in time, confirms the impression given by Chart 4. It shows that market value capital ratios increased significantly for both groups, but if anything, the increase was larger for the capital-sufficient group. Thus, unlike the results for book value capital-to-asset ratios (in Tables 2 and 3), capital-deficient banks did not experience a statistically significantly larger increase in their market value capital ratios.[14]

Since the market value capital ratios of the "control" group of capital-sufficient banks rose substantially, it seems likely that the *ceteris paribus* condition does not hold. That is, forces other than regulation were influencing equity-based measures of banks' market value capital ratios during the 1982–1986 period.

This raises the question of how to interpret the increases in market value capital ratios of the capital-deficient group. Were they the result of regulatory action or were they the result of other forces perhaps common

CHART 4

MARKET VALUE CAPITAL-TO-ASSET RATIOS



* *Banks that met 1985 requirements in 1981.*
** *Banks that did not meet 1985 requirements in 1981.*

to all banks? The answer depends on whether the forces affecting the capital-sufficient group had similar effects on the capital-deficient group. And there are several reasons they might have had differential effects, including 1) differential effects of overall stock price and interest rate trends on the two groups of banks, and 2) differential changes in regulatory taxes or subsidies.

Stock Market and Interest Rate Trends

It is possible that the market-value ratios of the capital-deficient group of banks did rise relative to the capital-sufficient group once the differential effects of changes in overall stock price and interest rates are taken into account. During the post-regulation period, overall stock prices rose dramatically and interest rates fell. Both of these changes are likely to cause, or to be associated with factors that would cause, bank stock prices to rise, and thereby raise equity-based measures of market-value capital-to-asset ratios. However, banks' stock prices may respond differently to such changes due to differences in their portfolios' credit and interest rate risk and market value leverage.

To investigate whether these trends can explain the apparently similar rise in equity-based market value capital ratios, the following test was performed. First, for the pre-regulatory change period, 1975Q1 through 1981Q4, each bank's market value capital ratio was regressed on the New York Stock Exchange Composite Index, the 20-year Treasury Bond rate, and the 3-month Treasury Bill rate. (Also, a dummy was included for the

Table 7

Mean Market-Value Capital Ratios, Selected Points in Time

(Standard Errors in Parentheses)

Period	Capital-Deficient Banks	Capital-Sufficient Banks	Difference
1974Q4–1981Q4	3.03 (.046)	4.97 (.036)	1.94* (.058)
1982Q1–1986Q3	4.14 (.084)	6.39 (.065)	2.25* (.11)
1981	2.86 (.11)	5.02 (.096)	2.16* (.15)
1982	2.64 (.099)	4.60 (.093)	1.96* (.14)
1983	3.84 (.14)	5.93 (.11)	2.09* (.18)
1984	3.76 (.13)	5.81 (.097)	2.05* (.16)
1985	4.77 (.17)	7.26 (.12)	2.49* (.21)
1986Q1–Q3	6.20 (.28)	8.97 (.18)	2.77* (.33)
1986 minus 1981	3.34* (.30)	3.95* (.20)	.61 (.36)

* *Significant at the 1 percent level.*

Table 8

Mean Forecast Errors: Market-Value Capital Ratios

(Standard Errors in Parentheses)

Period	Capital-Deficient Banks	Capital-Sufficient Banks	Difference
1982Q1–1986Q3	.39* (.090)	.17** (.070)	–.22** (.11)
1981	.090** (.039)	.18* (.032)	.090*** (.050)
1982	–.42* (.070)	–.60* (.072)	–.18*** (.10)
1983	.20 (.13)	–.12 (.11)	–.32*** (.17)
1984	.22 (.14)	–.14 (.12)	–.36*** (.18)
1985	.71* (.21)	.58* (.17)	–.13 (.27)
1986Q1–Q3	1.53* (.37)	1.43* (.28)	–.10 (.46)

* *Significant at the 1 percent level.*
** *Significant at the 5 percent level.*
*** *Significant at the 10 percent level.*

credit control period that affects the second quarter 1980 observation.) The resulting 103 regressions were used to forecast each bank's market value capital ratio for each quarter of the post-regulatory period.

Then the mean of the forecast errors (the actual market value capital ratio minus the forecast value) was computed separately for the two groups of banks for each year. A positive mean forecast error indicates that the capital ratio rose more than would be expected based on the historical relationship between that bank's equity-based market value capital ratio and overall stock prices and interest rates.

If regulation caused market value capital ratios to rise, larger positive forecast errors for the capital-deficient group would be expected. That is, capital-deficient banks' market value ratios should rise by more than would be predicted on the basis of the ratios' historical relationship to overall stock prices and interest rates, and also by more than capital-sufficient banks' market value capital ratios would be predicted to rise.

The results of this analysis, reported in Table 8, lend little support to this regulatory hypothesis. The positive forecast errors for the capital-deficient group suggest that some factor other than stock price or interest rate trends was positively influencing market value capital ratios, although the effect was not large until 1986.

Consistent with the hypothesis that regulation was the factor, the forecast errors for the capital-deficient group for the 1982-1986 period are somewhat larger than those of the capital-sufficient group. However, the magnitude of the difference is just .22 points, which sharply contrast with a difference of 1.20 points in the rise in book value capital ratios between the groups. Moreover, during 1986, when one would expect the largest difference in forecast errors (because of the effect of the 1985 regulations), the difference between the two groups is not statistically significant.

In sum, the rise in the market value capital ratios of capital-deficient banks relative to capital-sufficient banks is very small, even though controlling for the rise in stock prices and fall in interest rates provides some support for a relative rise. Moreover, the pattern of the increases does not parallel the differential rise in book value ratios. Taken as a whole, it does not appear that differential responses of capital-deficient and -sufficient banks to stock price and interest rate trends provide strong support for the regulatory hypothesis.

Regulatory Subsidies and Taxes

Another difficulty in interpreting the behavior of the equity-based market value capital ratio (using a bank's equity to measure its market value capital ratio) is that a bank's observed equity value can be affected by changes in regulatory subsidies and taxes.

For example, for a bank with subsidized deposit insurance (which underprices risk), an increase in true capital of a dollar reduces the deposit insurance subsidy by less than a dollar.[15] Since the decreased value of the subsidy in turn would be reflected in the bank's stock price, the total market value of the bank's observed equity-based capital would rise by less than a dollar and the observed market value capital ratio would rise less than the book ratio.[16]

If capital-deficient banks received larger capital infusions and their subsidies fell more than that of the capital-sufficient banks, it is possible that their true market value capital ratios would have risen more than those of the capital-sufficient banks (even though the equity-based measures rose by approximately the same amount).

Changes in asset risk also can alter the value of the deposit insurance subsidy, which depends positively on asset risk.[17] In particular, if capital-sufficient banks were to increase risk, their observed market value capital could increase even without a true capital infusion. This result would make it difficult to compare the changes in market value capital ratios between the two groups of banks, and thereby determine whether the capital-deficient banks actually increased capital.

Moreover, changes in relative taxes also can affect relative market values. For example, if the increase in capital ratios represented a higher tax for the capital-deficient group, perhaps because their asset portfolios were more heavily regulated, their per share stock prices would be depressed. As a result, the true market capital ratios of the capital-deficient group could have risen more, but the observed equity-based measure would not have reflected the higher value because the corresponding rise in regulatory taxes would have depressed per share stock prices.

Thus, from observed changes in the stock-price-based market value capital-to-asset ratio alone, one cannot determine whether asset risk changed, relative taxes changed, or capital ratios net of the subsidy changed. This issue is the subject of a companion paper in an upcoming *Review* (Furlong, 1988), which presents estimates of changes in regulatory subsidies/taxes over the period for the two groups of banks by estimating the option value of deposit insurance.

In sum, even though the changes in stock-price-based market value capital ratios are consistent with regulatory increases in capital for the capital-deficient banks, they are also consistent with several other hypotheses and thus do not provide independent support for the regulatory hypothesis.

VI. Summary and Conclusions

The evidence presented in this paper strongly suggests that uniform capital requirements achieved their intended effects on book or accounting measures of banks' capital-to-asset ratios. By 1986, virtually all banks were meeting the book value capital requirements. Moreover, the disparity of book capital ratios was reduced substantially – an effect consistent with the goals of the capital regulations.

Capital-deficient banks – those originally not meeting the requirements – increased their capital ratios primarily by slowing asset growth relative to capital growth. This suggests that the increase in book capital-to-asset ratios reflected a true reduction in leverage and not just an accounting gimmick.

Because of a rise in off-balance-sheet activity, primarily increased issuance of SLCs, standard book-value measures of capital ratios somewhat overstate the increase in capital ratios. However, even if the loans backed by SLCs had been funded on the balance sheet, book capital ratios for capital-deficient banks would have risen substantially over the 1982-1986 period.

Observed market value capital ratios (based on banks' stock prices) did increase overall, but there is no strong indication of a larger increase for capital-deficient banks. There are several explanations for this pattern consistent with a regulatory-induced increase in capital ratios for the capital-deficient banks. They include increased regulatory taxes or reduced subsidies, differential responses to overall stock price and interest rate changes, and differential changes in bank risk-taking. Although differential responses to stock price and interest rate trends do not appear to play a large role, this paper is unable fully to distinguish among the other hypotheses.

FOOTNOTES

1. A more recent study by Wall and Peterson (1985) presents indirect evidence from a complex structural two-regime model (which assumes that banks' capital ratios are determined either by regulatory or market forces) that, for the 1982 to 1984 period, most large BHCs' book value capital-to-asset ratios were influenced by regulatory forces. However, it appears that these findings may be very sensitive to model specification and validity, both of which are untested.

2. Minimum total capital requirements were also set at 5.5 percent and 6.5 percent for large and small banks, respectively.

3. Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin,* January 1982, p. 33.

4. 94 percent of the sample of multinationals did not meet the 1985 requirements in 1981, whereas only 10 percent of other banks in the sample did not meet the requirements. (The sample includes 16 of the 17 multinationals. Crocker Bank is excluded because Compustat does not maintain historical data on acquired banks.)

5. Board of Governors, *op cit.*

6. Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin,* June 1985, p. 446.

7. An interesting and important research question is why book capital had been declining over so long a period. However, since the objective of this paper is to analyze the effects of the 1981-1985 capital regulations, I restrict the analysis to the 7-year period, 1975-1981, before the onset of objective capital regulation and the 5-year period, 1982-1986, after. These periods were chosen partly because capital ratios were relatively stable during the 1975-1981 period and partly because more data are available for this period. Thus, I leave to future research the question of explaining the generally declining capital ratios before 1975.

8. I also examined the effects of the capital regulations on banks ranked by their 1981 book capital ratios. Estimates of the model similar to that described by equation 2 were obtained for banks in the lower half and the upper half of both the capital-deficient and capital-sufficient categories.

As expected, capital-deficient banks in the lower half of the rankings appeared to increase their target ratios more than those in the upper half. Moreover, unlike the pre-regulation period, there was no statistically significant difference in target levels during the 1982 through 1986 post-regulation period.

Similarly, those capital-sufficient banks in the upper half of the rankings may have reduced their target capital ratios (although not by a statistically significant amount), while those in the lower half did increase their target ratios by a statistically significant amount. Taken as a whole, these results suggest that all banks were trying to achieve book capital ratios closer to a given target level than in the pre-1982 period.

9. It is unclear whether a capital buffer would exist or even whether the concept of a buffer would be meaningful during the pre-1982 peer group type of capital regulation. If buffers did exist, it is likely that the target ratio being buffered would vary among different peer groups.

10. A similar test of whether the uniform capital regulations caused a decline in the overall standard deviation in capital

ratios (both across banks and over time) was also conducted. The results parallel those in Table 4 and suggest strongly that standard deviations declined, especially when the 1986 period is compared to the pre-regulation period. As in Table 4, there was a reduction in the dispersion of capital ratios among capital-sufficient banks as well as a narrowing of differences between the capital-deficient and -sufficient groups.

11. Another explanation is that the capital requirements in effect represented an increased regulatory tax which, in turn, caused these banks to shrink. However, since both groups of banks faced the same capital requirements, it is hard to see why these banks should face a higher regulatory tax than the capital-sufficient group unless they had much less risky asset portfolios and were constrained by regulators to maintain less risky portfolios—a hypothesis that seems unlikely, at least in retrospect.

12. Another reason is that a bank with underpriced deposit insurance will benefit from increasing asset size while holding constant the capital-to-asset ratio (see Furlong and Keeley, 1987b). Thus, regulators must impose asset growth restrictions on such banks to limit the potential exposure of the deposit insurance system. However, the gain from increasing asset size decreases as the capital-to-asset ratio increases. Thus, if deposit insurance were underpriced for this group of banks and if the stringency of asset size regulation remained unchanged, then one would expect banks to meet the new capital requirements through a decrease in asset growth relative to capital growth rather than through an increase in capital growth.

I also examined the sources of new capital growth. First, there was an increase in the rate of new equity issuance (scaled by initial assets) both for banks meeting and those not meeting the 1985 requirements in 1981.

Second, I found that dividend payout rates (as a fraction of net income before extraordinary items) were basically unchanged over the period. Moreover, there were no apparent differences in dividend payout rates between those banks meeting and those not meeting the 1985 requirements in 1981.

Finally, the rate of earnings retention (earnings available for common minus common dividend payments) scaled by initial assets was somewhat lower during the 1982-1986 period than during the 1975-1981 period.

13. It is possible for banks to sell appreciated assets and pay out part of the capital gains to stockholders and to use the remainder to boost bank capital. Although the bank's book capital ratio would rise and book assets would decline, the market capital ratios would fall. However, there is no strong evidence of increased payouts, either through dividends or stock repurchases to suggest that such a phenomenon occurred.

14. To test statistically whether the market ratio rose less than one-for-one with the rise in the book ratio for capital-deficient banks as Chart 4 suggests, the market-to-book ratio was regressed on the change in the book capital ratio (using 1981 as a base year) separately for capital-deficient and -sufficient banks. The hypothesis that an increase in book capital due to regulation should result in a smaller increase in observed equity-based market capital for capital-deficient banks than for capital-sufficient banks was confirmed.

There is a negative relation between increases in book capital and the market-to-book ratio for capital-deficient banks. In contrast, there is a zero, or even a small positive, relationship for capital-sufficient banks, and the difference in responses was statistically significant.

15. The reason the subsidy, which is the current value of a payout from the deposit insurance fund in the bankruptcy state, falls by less than one dollar is that even though a dollar of capital reduces the payout by one dollar (holding asset risk constant) when bankruptcy occurs, the current value of this one dollar reduction in the payment is less than one because the probability of bankruptcy is less than one.

16. Mathematically, the observed market-value capital-to-asset ratio would be:

$$R_0 = [C + S]/[A + S]$$

where:

C = market capital, not including deposit insurance

A = market assets, not including deposit insurance

S = market value of deposit insurance

Taking the derivative of R_0 with respect to C holding assets, A, and the risk of assets constant, yields:

$$dR_0/dC = [A(1 + dS/dC) + S - dS/dC]/(A + S)^2 > 0$$

17. That is, the observed ratio R_0 (see footnote 16) increases because:

$$dR_0/ds = [(A + S)dS/ds - (C + S)dS/ds]/(A + S)^2 > 0.$$

s = standard deviation of return on assets.

REFERENCES

Dietrich, J. Kimball and Christopher James. "Regulation and the Determination of Bank Capital Changes: A Note", *Journal of Finance*, Vol. 38, 1983.

Furlong, Frederick T. and Michael C. Keeley. "Bank Capital Regulation and Asset Risk," *Economic Review*, Federal Reserve Bank of San Francisco, No. 2, Spring 1987a.

Furlong, Frederick T. and Michael C. Keeley. "Does Bank Capital Regulation Affect Risk-Taking?", Federal Reserve Bank of San Francisco, Working Paper 87-08, October 1987b.

Furlong, Frederick T. "Banks' Reaction to Capital Regulation," *Economic Review*, Federal Reserve Bank of San Francisco, forthcoming, Summer 1988.

Keeley, Michael C. and Frederick T. Furlong. "Bank Capital Regulation: A Reconciliation of Two Views," Federal Reserve Bank of San Francisco, Working Paper 87-06, September 1987.

Mingo, John H. "Regulatory Influence on Bank Capital Investment," *Journal of Finance*, Vol. 30, 1975.

Peltzman, Sam. "Capital Investment in Commercial Banking and its Relationship to Portfolio Regulation," *Journal of Political Economy*, Vol. 78, 1970.

Wall, Larry D. and David R. Peterson. "The Effect of Capital Adequacy Guidelines on Large Bank Holding Companies," Federal Reserve Bank of Atlanta, Working Paper 85-3, December 1985.

A Vector Autoregression Model of the Nevada Economy

Thomas F. Cargill and Steven A. Morus

Thomas F. Cargill is professor of economics at the University of Nevada, Reno and Steven A. Morus is a graduate student and formerly Research Associate at the Federal Reserve Bank of San Francisco.

The paper was initiated when Cargill was a Visiting Scholar at the Federal Reserve Bank of San Francisco. The authors wish to thank James Hanna and Michael Magura for comments on an early draft, and Bharat Trehan for technical advice. In addition, appreciation is extended to the Bureau of Business and Economic Research and the Nevada Small Business Development Center at the University of Nevada-Reno, which provided computational support for the project.

A vector autoregression time series model of the Nevada economy is developed and used to forecast key measures of economic activity for a two-year period beyond the third quarter of 1986. The results have three important implications. First, a relatively simple forecasting model can be developed for a regional economy that incorporates considerable economic theory and flexibility. Second, the forecasting performance of such a model appears promising. Third, the vector autoregression approach should generate a reconsideration of traditional approaches to modeling and forecasting the regional economy.

A vector autoregression (VAR) forecasting model of the Nevada economy is developed in this article. The use of the VAR in the context of analyzing this region is motivated by two considerations. First, Nevada's economy has attracted considerable attention because of its structure uniquely based on gaming and the fact that it has been, and continues to be, one of the fastest growing states in terms of employment and income. At the same time, the economy has become increasingly sensitive to national influences, the gaming industry is exhibiting signs of slower growth and feeling the effects of increased competition, and in response, the state has embarked on an extensive effort to diversify the economy away from gaming. Understanding the future prospects for Nevada's economy and having a mechanism for forecasting changes in the economy thus are important.

Second, the VAR method of modeling offers a number of advantages over traditional alternatives based on structural equation systems. It is both more parsimonious in its use of data and offers theoretical advantages over structural representations.

The remainder of the paper is organized into four sections. The next section outlines key elements of the Nevada economy. Section II presents the basic features of the VAR approach. Section III outlines the development steps of the Nevada VAR model and reports in-sample and out-of-sample performance of the model. A short concluding section summarizes the main results of the study and compares the model's forecasts with the most recent data available at the time of this writing.

I. Nevada's Economy

Nevada's gaming-based economy was established by legislation in 1931 that permitted casino gaming statewide. Not until after World War II, however, did the gaming industry come to dominate the state's economy.[1] Estimates indicate that gaming activity directly and indirectly accounts for over 60 percent of Nevada employment. Gaming tax revenues provide about 45 percent of state revenues to the general fund in any given year.

The dominant role of gaming and the service orientation of the Nevada economy sharply differentiates it from other regional economies. In 1985, the service sector in Nevada accounted for 44.0 percent of total industrial employment, of which 64.0 percent was employed in the hotel-gaming-recreational sector. The service sector in Nevada is proportionately almost twice as large as that in the U.S.

There are five characteristics of the Nevada regional economy that make it unique and interesting to study. First, the state is less diversified than most other states and remains highly dependent on the gaming industry as its economic base. Second, the geography and the uneven spatial distribution of economic activity present policymakers with a set of problems that are simultaneously urban and rural. Despite the physical size of the state, population and economic activity are concentrated in three regions: Las Vegas (Clark County) in the southern part of the state, and, in the northern part, Reno-Sparks (Washoe County) and South Lake Tahoe (Douglas County and Carson City).

Third, the federal government owns approximately 87 percent of the land in Nevada. Nevada is viewed as a likely location of the high-level nuclear waste facility just as it was several years ago for the controversial MX missile system. As a result, the role of the federal government as a large landowner adds a unique economic and political dimension to the state's future economic growth.

Fourth, the gaming industry is exhibiting signs of market saturation as it matures in Nevada and as new competitors emerge in the forms of casino gaming in Atlantic City, New Jersey and state lotteries such as that in California lottery introduced in late 1985.

Fifth, despite the recent slowdown in the gaming industry, Nevada has had and is projected to have one of the highest employment growth rates through the end of the century. Total civilian employment grew at an average annual rate of 5.5 percent from 1960 to 1985, compared to an employment growth rate of 2.0 percent for the U.S. In 1986, employment in Nevada was the fastest growing among the states making up the Twelfth Federal Reserve District (Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington).

In fact, the past and projected performance of the Nevada economy have been used to rationalize proposals to initiate or expand gaming activities in other regions to solve local employment and/or fiscal problems. In addition, gaming often has been portrayed as an activity less sensitive to national influences than others. These are mistaken views.

Gaming has not rendered Nevada recession-proof[2] nor has gaming provided a stable revenue base. A close reading of Nevada's performance suggests that gaming will neither be a panacea for fiscal problems nor a means of insulating other regions from national cyclic swings. Nevada's economic performance in the late 1970s and especially in 1981 and 1982 demonstrated once and for all that the region was not immune to changes in the national economic environment. The sharp national recession from July 1981 to November 1982 was clearly reflected in reduced economic activity in Nevada. The unemployment rate increased from 6.7 percent in July 1981 to 10.8 percent in November 1982.

The growing sensitivity of Nevada's economy to national economic forces and the lower prospects for growth in the gaming sector have led to efforts throughout the state to diversify the economy away from dependence on gaming. There is now widespread recognition within Nevada that gaming no longer is capable of supporting stable long-term growth and stable tax revenues for an expanding economy. Thus, other regions that look to gaming as a solution to their economic problems should be less optimistic about the economic benefits of gaming.

II. Approaches to Modeling the Nevada Economy

Structural and time series methods represent two possible ways of classifying the variety of methods that have been employed or could be employed to model and forecast Nevada's economy.

Structural economic models are loosely defined as systems of equations that specify behavioral, technological, institutional, definitional, and equilibrium relationships among a given set of economic variables. In these models certain variables — "exogenous variables" — are seen as affecting, but not being affected by, economic behavior as defined in the model. The affected — or "endogenous" — variables are linked to the exogenous variables by behavioral equations. Thus, the structural approach imposes an explicit causal ordering among the variables and predicts future values of the endogenous variables by relating them to other variables in which the causal relationships are explicitly defined by the structure of the model.

Traditionally, structural models of the regional economy have followed the Keynesian macroeconomic framework of sectoral aggregate demand analysis. They look much like national macroeconomic models, modified to fit the available data set or to deal with issues specific to the regional aspect of the economy, such as migration. Multi-equation Keynesian models, input-output models, economic base models, and a variety of demographic models incorporate the structural approach. Structural models are used not only to forecast but also to explore the features of the underlying behavioral relationships.

Time series methods, in contrast, are designed primarily to *forecast,* and rely on either the past behavior of the variable and/or correlations with other variables to generate those forecasts. Time series methods are not "structural" since they rely on autocorrelations and cross correlations to forecast future values rather than specified, causal behavioral relationships among the variables. In addition, they adopt a methodology using few parameters to simplify modeling and estimation, and to limit errors associated with the statistical specification.

In the 1970s, a class of linear time-series models introduced by G. E. P. Box and G. M. Jenkins (1970) referred to as autoregressive-integrated-moving-average (ARIMA) models found wide application in economic and business forecasting. These models essentially rely on the assumption that the process that causes an economic variable to move can be described by a properly weighted sum of past values of the variable plus a random disturbance of some kind.

Previous Efforts to Model the Nevada Economy

The overwhelming majority of modeling and forecasting applications in Nevada have used the structural approach. S. Chu (1974) provided the first large (42 equation) structural model of Nevada's economy. Thomas F. Cargill and James Walker (1981) estimated single equation models using national variables to forecast Nevada's state revenues. Robert Barone (1979) and Barone *et al* (1979) applied a modeling framework incorporating an extensive demographic sector for a rural area of Nevada. John Hester and William Rosen (1981) and Steve Ghiglieri (1986) constructed large structural models of Washoe County (Reno, Sparks, and Lake Tahoe area).

To date, Cargill and William Eadington (1978) provide the only application of time series modeling to the Nevada economy. They estimated ARIMA models for gross gaming revenues for the three major regions of Nevada, and these models were subsequently used for a limited period by the Budget Division in Nevada to forecast gaming revenues.

These various efforts have provided important insights into the Nevada economy and have been used on occasion to develop forecasts of key measures of economic activity. At the same time, they have not proven flexible enough to meet the requirements of timely and accurate forecasts. The ARIMA models possess the advantage of cost effectiveness and flexibility, relying as they do on a simple, weighted sum only of past values of a variable. They ignore, however, important relationships *among* variables and have little basis in economic theory. In addition, they can be nonlinear in form, a fact that causes some estimation and statistical inference problems.

Recently, the VAR method of time series analysis has attracted considerable attention because it possesses advantages in a number of dimensions over both ARIMA models and traditional structural approaches.[3] In addition, the forecasting performance of VAR models of the national economy has been good relative to several well-known structural models (Stephen K. McNees, 1986), suggesting that the VAR method offers considerable potential as a forecasting instrument for the regional economy as well.[4]

The VAR Approach

A VAR model represents a vector of variables as a general autoregressive structure in which the relationship between a number of variables and their past values is employed. The general mathematical structure of a VAR model is:

$$Y(t) = D(t) + B_1 Y(t-1) + \ldots + B_m Y(t-m) + e(t) \quad (1)$$

where Y is an n × 1 vector of variables, D is an n × 1 vector of deterministic components, B is an n $\times$ n matrix of coefficients, e is an n $\times$ 1 vector of residuals, and m is the lag length. Deterministic ("exogenous") components include a constant term, seasonal dummies, or other dummy variables that represent discrete shifts in the relationships at a specific point in time.

Equation 1 is an unconstrained or UVAR model since the equations are estimated without any constraints on the coefficients or the lag pattern. Unfortunately, even relatively small UVAR models (those with few variables and short lag lengths) can quickly become quite large in terms of the number of parameters that need to be estimated. For example, each equation of a UVAR system using a 3 $\times$ 1 matrix of variables and just 4 lags of each variable would have 12 parameters to estimate, plus any parameters on deterministic variables. This poses problems not only of data availability (a particular crucial issue in regional modeling) but also of the resultant quality of the forecasting device. Too many parameters typically cause UVAR models to have large out of sample forecast errors.

Using an approach developed by Robert B. Litterman (1979) and Thomas A. Doan and Litterman (1986), the modeler can improve the forecast performance of a VAR model by restricting its parameters in a particular manner. Using such restrictions is known as "imposing a prior" on the model. This terminology is rooted in Bayesian statistical theory, which provides guidance to a modeler who wishes to combine optimally the sample data with which the model will be estimated with information or beliefs known independently of the sample.

In Bayesian parlance, the modeler is said to know this independent information "prior to" any knowledge of the informational content of the unrestricted model. Litterman, in fact, goes as far as to call a UVAR model, upon which he has imposed such a prior, a Bayesian vector auto-regression, or BVAR model.

While in principle almost any kind of restriction could be imposed upon a UVAR model, when Litterman speaks of BVAR models, he has a particularly clever choice of prior in mind. This prior is known as the random walk prior. (It is also known as a "Minnesota prior" since it has been used extensively in the modeling efforts of the Federal Reserve Bank of Minneapolis.)

The random walk prior is based on the empirical finding that the simple time series model $x(t) = x(t-1) + u(t)$ is a reasonable representation of a large number of economic variables. Notice in equation 1 that there are n variables appearing in Y, the n $\times$ 1 matrix of variables. Each of these n variables will appear once as the dependent variable in one of the n equations that forms the vector autoregressive system.

To begin with, the random walk prior sets equal to 1.0 the value of the first "own" lag in each individual equation. ("Own lags" are the lagged values of the dependent variables in the equation under consideration.) All other coefficients on lagged variables in that equation, called "other lags", as well as own lags of more than one period, are restricted to zero. The value to which individual coefficients have been restricted is known as those coefficients' point value.

The second step in forming a random walk prior is to set the degree to which the coefficients in each equation will be allowed to vary away from their point values. This is known as setting the "tightness" of the prior. An extremely tight prior allows little or no variance from the pre-selected point values. Conversely, an extremely loose prior allows the full freedom inherent in a completely unrestricted VAR.

The modeler's beliefs about the suitability of the random walk model is reflected in the tightness set for the prior. A modeler can, by adjusting the prior's overall tightness, adjust the degree to which the model responds in general to the randomness in the data set over which the model is estimated. Obviously, setting most of the parameters in each equation to point values of zero would also greatly alleviate the problem of too many parameters.

Further sophistication can be achieved by fine tuning the relative tightness of groups of parameters. Within each equation, a different relative tightness can be assigned to coefficients on own lags versus other lags. This procedure is known as cross-weight tightness, and it reflects the degree to which the other variables are implicitly employed in predicting the dependent variable of each equation. (In essence, the researcher is making a judgment about how much useful information is contained in other variables.)

A second kind of variation in tightness operates on lags of the same variable in each equation and may be called a distributed lag prior. The intuition here is that higher numbered lags should contain less useful information about the dependent variable, and hence should be assigned greater relative tightness. For example, the third lag of any variable will be set tighter than the second, and so on. The tighter the prior on a particular parameter, the more its coefficient is pushed towards its point value. Hence, except for the first own lag of each equation, the coefficients of lags are increasingly pushed towards zero as the lags increase in length.

The ability to set both point values and tightness is one crucial feature that distinguishes BVARs from traditional structural models. While structural models often will restrict coefficients to specific point values, they typically do not have the ability to allow any variance away from those values. VAR models by their very nature allow the inclusion of a large number of variables. BVAR techniques then give the modeler the ability to adjust *the degree* to which the many variables influence forecast performance. In contrast, traditional structural techniques also force the modeler to control *the number* of included variables. This restriction is equivalent to setting the excluded variables to a point value of zero with infinite tightness, which is rarely a realistic reflection of the modeler's knowledge or beliefs.

Structural techniques, as their very name suggests, also require the modeler to specify equations that mirror as closely as possible the actual structure of the economic system under study. Again, it is rarely realistic to believe that the modeler knows the structural details of an economic system in sufficient detail to make such specifications. Likewise, the initial prior imposed on a BVAR model is, at best, an educated guess. In practice, a very large number of estimations are performed, in each of which the prior varies slightly. A choice among the numerous estimations is made by identifying the setting that minimizes the BVAR model's out-of-sample forecast error. In this way, the modeler uses a BVAR model subtly to exploit the statistical regularities hidden in the available data. An explicit knowledge of the structure of the economic system is not necessary, although, to the extent it is known, it can be used to shape the imposed prior.

III. VAR Model of Nevada's Economy

Three sets of variables constitute the eight-vector Nevada VAR Model. The first set consists of three variables that represent key measures of economic activity: total industrial employment, taxable sales, and gross gaming revenues. Gross gaming revenues are the net winnings of gaming operations, and, together with taxable sales, provide the major tax base for the state. Establishment-based employment is used rather than civilian employment because civilian employment depends on population estimates, which themselves are subject to question in the Nevada context. Because of its proximity and the interrelatedness of their economies, some measure of the influence of California on Nevada's economy is included in the second set of variables. We include California civilian employment in the system of VAR equations. Four national variables assumed to influence Nevada's economy comprise the third set of variables: real gross national product, the annualized rate of inflation measured by the GNP deflator, total civilian employment, and the 6-month commercial paper rate.

The development of the Nevada VAR model can be summarized by considering the types of interactions between the Nevada variables and the national variables, data transformations, specific priors imposed on the estimation process, model evaluation, and forecasts for the period from the fourth quarter of 1986 to fourth quarter of 1988.

Interaction with the National Economy

The role of national variables in the Nevada VAR model raises two considerations: first, the extent to which they influence economic performance in Nevada, and second, how they should be treated in generating forecasts of Nevada variables beyond the estimation interval.

The coefficient estimates of VAR models are not subject to straightforward interpretation. However, the influence of national variables on the Nevada economy can be investigated by estimating the model and analyzing the interactions among the eight variables. A useful approach is to forecast the VAR model beyond the estimation interval and then to decompose the observed variance in the forecast error of a given variable into the parts due to the shocks in each variable in the vector.

The UVAR Model is based on quarterly, seasonally adjusted data over the period from the first quarter of 1965 to the fourth quarter of 1984, with forecasts generated for the period from the first quarter of 1985 to the third quarter of 1986. The variance decomposition is sensitive to the order of the variables in the vector since a variable in the first few elements of the matrix has fewer opportunities to interact with other variables than a variable further down the order. By definition, the variable placed first in the ordering explains all of its own variance for the first quarter forecast.

Table 1 presents the variance decomposition for each of the eight variables for forecasts 1, 4, and 8 quarters beyond the fourth quarter of 1984. They suggest several important observations. First, the Nevada and California variables play a less important role in explaining the variance of the national variables than the national variables play in explaining the variance of the Nevada and California variables. This suggests that the statistical causation runs from the national economy to the regional economy.

Second, the Nevada variables are less sensitive than the California variable to national variables. This implies that, although both are closely linked to national developments, Nevada's economy is less closely linked

Table 1

Decomposition of Variance for Each Variable in the Eight-Vector UVAR Nevada Model

Forecasted Variable	Quarters Ahead	Percentage of Variance of Error due to Disturbance to: Real GNP	GNP Deflator	6-Mo. Comm. Paper Rate	U.S. Employ	CA Employ	Gross Gaming Revenues	Taxable Sales	Total Industry Employment
Real GNP	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	67.6	5.7	13.4	1.6	1.4	1.3	0.2	8.8
	8	27.0	10.1	43.9	1.1	4.8	1.3	3.0	8.9
GNP Deflator	1	0.1	99.9	0.0	0.0	0.0	0.0	0.0	0.0
	4	8.5	44.2	13.1	4.3	3.6	14.6	7.1	4.6
	8	10.4	29.5	11.1	12.9	6.6	12.1	14.4	3.1
6-Month Commercial Paper Rate	1	0.8	17.4	81.8	0.0	0.0	0.0	0.0	
	4	10.3	7.8	52.2	2.8	2.9	0.5	4.7	18.8
	8	9.0	4.9	40.4	4.6	8.9	1.7	3.9	26.5
U.S. Employment	1	28.7	3.5	0.1	67.6	0.0	0.0	0.0	0.0
	4	41.5	4.4	5.9	33.2	5.9	1.8	2.5	4.8
	8	14.6	12.6	42.3	12.9	3.5	1.3	2.7	10.1
CA Employment	1	8.3	8.4	9.2	3.1	71.0	0.0	0.0	0.0
	4	10.8	7.5	20.1	1.4	47.9	6.7	0.9	4.7
	8	10.0	3.3	34.2	7.2	23.8	6.4	5.7	8.5
Gross Gaming Revenues	1	1.3	0.0	11.0	0.0	0.5	87.2	0.0	0.0
	4	7.1	2.0	8.2	6.0	15.5	52.5	4.6	4.1
	8	4.8	4.0	11.5	4.7	10.5	41.0	4.8	18.9
Taxable Sales	1	2.3	1.9	2.9	0.8	0.9	0.0	91.0	0.0
	4	12.6	2.7	4.5	1.0	5.0	4.7	67.9	1.4
	8	6.1	3.5	13.0	10.1	4.0	1.9	32.3	29.1
Total Industry Employment	1	0.1	1.0	3.7	0.1	0.3	3.5	22.0	69.4
	4	19.1	1.6	1.5	2.7	0.9	2.2	31.8	40.2
	8	18.4	2.1	17.6	3.6	2.2	1.8	24.7	29.6

Note: Estimation period: First quarter 1965 to fourth quarter 1984
Forecast period: First quarter 1985 to fourth quarter 1986
Seasonally adjusted data (Except 6-Month Commercial Paper Rate)

than California's economy. Third, the California variable contributes to the forecast variance of the Nevada variables. This verifies the notion that the large, prosperous neighbor state is influential in Nevada's economic life.

Fourth, despite the influence of the national and California variables in explaining the forecast errors for each of the Nevada variables, the forecast errors of each variable are significantly explained by their own innovations. The inference from this finding is that the random walk model is not an unreasonable approximation for Nevada time series data.

The issue of the direction of causation is usually not raised in single sector VAR models such as national models or models of a single large region. However, general considerations suggest that national variables should play a larger role in explaining the forecast errors of Nevada and California variables than the reverse. That is, it seems reasonable to suppose that national economic events have a greater impact on a small region than the reverse, and the results reported in Table 1 lend some support to this supposition. Because Nevada's economy is so small compared to the nation's, there is little question about the direction of causation between Nevada and national variables.

Unfortunately, the VAR method treats all variables as endogenous, and typical VAR forecasts are based on dynamically forecasted values of all variables in the system. While the direction of causation is not a problem in the estimation stage, allowing a sizable amount of feedback from Nevada variables to national variables can be viewed as at least a conceptual problem in the forecasting stage. The solution adopted in this study was to employ a separate BVAR model of the national economy to generate forecasts of the four national variables used in the Nevada model.[5] The four national variables are thus treated as exogenous when the Nevada model is used to generate forecasts beyond the interval of estimation.

The national model itself consists of a vector of nine variables: real GNP, the GNP deflator, U.S. employment, the commercial paper rate. Standard and Poor's 500 stock index, nonresidential fixed investment, import unit value index, export unit value index, and the monetary aggregate M3. This national model incorporates a fairly complex set of priors and specifications, and is, of course, a modeling exercise that we could discuss at length on its own. We will not do so here, however. Suffice it to say that this national BVAR model is capable of forecasting real GNP growth and inflation with reasonably small forecast errors over the period from the first quarter of 1982 to the third quarter of 1986.

Model Estimation and Evaluation: Two Stages

There were two stages to the estimation and evaluation of the Nevada model in terms of the forecast period selected to evaluate the model: the first stage focused on the period from the first quarter of 1982 to the third quarter of 1986, whereas the second stage focused on the period from the first quarter of 1985 to the third quarter of 1986 for reasons to be explained below.

First Stage A large number of variations of the Nevada model were estimated that differed in terms of data transformations, lag length, treatment of seasonality, and type and tightness of the priors imposed on the coefficients. The models were evaluated in terms of absolute mean errors, root mean square errors, and other statistics or measures of performance over the forecast interval. They were estimated over the period from the first quarter of 1965 through the fourth quarter of 1981, and forecasted over the period from the first quarter of 1982 through the third quarter of 1986, which was the most recent data available at the time.

The most promising version of the Nevada VAR model from the first stage estimation and evaluation process was a six-lag model of seasonally adjusted data with an overall random walk tightness prior of .075, a harmonic decay pattern on the distributed lags with a decay parameter of 2.0, and a cross weight prior of .4. The final priors were consistent with the UVAR model results (Table 1) and with prior understanding of Nevada's economy.[6]

Second Stage The second stage estimation and evaluation focused on a more recent period, from the first quarter of 1985 through the third quarter of 1986. This was a period of increased economic uncertainty in Nevada resulting partly from the October 1985 introduction of a statewide lottery in California. The behavior of key measures of economic activity in Nevada during 1986 suggest that the California lottery is indeed affecting Nevada's economy.

The data suggest that the shift toward gaming in California has had a greater impact than the 1978 introduction of casino gaming in Atlantic City, New Jersey. The impact of casino gaming in Atlantic City was mitigated by the East Coast's distance from the western states, which constitute Nevada's most significant market area. The California lottery in contrast represents a more direct competitive threat since California is the major state in Nevada's market area. The rapid growth of the California lottery (1986 gross sales of slightly more than $2 billion), the introduction of a parimutuel lotto game in late 1986, and indications that the California Lottery Commission is considering expanded gaming activities throughout the state have raised considerable concern in Nevada. Focusing the VAR model on this more recent period therefore would provide meaningful information on the impact of the California lottery on the Nevada economy.

Initial regressions for the more recent period — from the first quarter of 1985 to the third quarter of 1986 — suggested that some improvement could be achieved by tightening the random walk prior. Table 2 presents the percentage forecast error for each quarter forecasted based on the actual values of the national variables.[7] The forecast errors are reasonable with the exception of gross gaming revenues which is consistently overestimated, with the size of the error increasing over the forecast period. This growing overestimation is likely due to the failure to incorporate any measure of the California lottery.

Table 3 provides additional information about the forecast performance of the VAR model without the influence of the California lottery. The model in Table 3 was estimated through the fourth quarter of 1984, and then used to develop forecasts for each of seven quarters by re-estimating the coefficients of the model for each quarter via the Kalman filter method. A resultant statistic — the Theil U statistic — provides insights into the forecasting performance of the model by giving a comparison of the root mean square error for each forecast step to the root mean square error of a no change or "naive" forecasting model.[8] With the exception of gross gaming revenues, the Theil U statistics are less than one and tend to decline the longer the forecast period.

The Theil U statistics for gross gaming revenues suggest that the VAR model does a poor job of forecasting a key measure of economic activity in Nevada; however, two considerations indicate that concluding the model does a poor job would be premature. First, for every variation of the model used in the first stage of model estimation and evaluation, the Theil U statistics for gross gaming revenues were less than one. Secondly, the failure to incorporate some measure of the influence of the California lottery could be expected, a priori, to cause negative and increasingly large forecast errors for gaming revenues.

Thus, the influence of the California lottery should be incorporated into the estimation process before the VAR model is used to forecast beyond the third quarter of 1986. This can be accomplished by including a dummy variable (DUMMY = 0 before the fourth quarter of 1985 and DUMMY = 1 from the fourth quarter of 1985 on) as a deterministic component of the model. The California lottery has existed for too short a period of time to permit useful forecast evaluation information such as reported in Tables 2 and 3.

Table 2

Forecast Errors of Nevada Variables

Quarter	Percent Forecast Error [(Actual — Forecast)/Actual] × 100: Gross Gaming Revenues	Taxable Sales	Total Industry Employment
1985 First	0.5%	−0.9%	−1.1%
Second	−1.0	0.4	1.0
Third	−4.7	−4.1	−0.2
Fourth	−8.0	−4.3	−2.4
1986 First	−8.3	−4.9	−3.8
Second	−9.1	−7.8	−2.3
Third	−13.0	−5.0	−3.3

Note: Estimation period: First quarter 1965 to fourth quarter 1984
Seasonally adjusted data (Except 6-Month Commercial Paper Rate)

Table 3

Theil U Statistics for Nevada VAR Model

Forecast Horizon	Number of Forecasts	Theil U Statistics: Gross Gaming Revenues	Taxable Sales	Total Industry Employment
1	7	1.3	0.8	0.8
2	6	1.5	0.6	0.7
3	5	2.1	0.7	0.7
4	4	2.8	0.7	0.7
5	3	2.4	0.7	0.7
6	2	2.0	0.6	0.3
7	1	2.1	0.4	0.4

Note: Estimation period: First quarter 1965 to fourth quarter 1984
Seasonally adjusted data (Except 6-Month Commercial Paper Rate)

Forecasts for the Period 1986 to 1988 Prior to developing forecasts for the Nevada variables, it was necessary to generate forecasts of the four required national variables since they are treated as exogenus to the Nevada and California variables. According to forecasts made by the U.S. VAR model of the Federal Reserve Bank of San Francisco, real GNP will grow at approximately 3.5 percent per year over the two-year period, civilian employment will grow approximately 3.2 percent per year, interest rates are to remain fairly constant, and inflation will increase gradually to an annual rate of 5.89 percent in the fourth quarter of 1988.

The VAR Nevada model was re-established from the first quarter of 1965 to the third quarter of 1986 with a California lottery dummy for the fourth quarter of 1985 and beyond. Forecasts of gross gaming revenues, taxable sales, and employment along with California employment were generated, treating the national forecasted variables as exogenous. The forecasted values of the seasonally adjusted data were transformed into annualized quarterly growth rates reported in Table 4 with and without the influence of the California lottery.

The effect of the California lottery is clearly reflected in the results in Table 4. The dummy variable significantly lowers the forecasted growth rates of gross gaming revenues and employment as anticipated. The forecasted growth of employment is reduced because gaming represents about 25 percent of industrial employment. It was also anticipated that the growth rate of taxable sales would not be as significantly affected by the California lottery because statistics on such characteristics as traffic flows, airport activity, and special events suggest that there has been a continued increase in the number of visitors to the state. It does appear, however, that the visitors are spending less on gaming activities than in the past.

Table 4

Forecasted Growth Rates of Nevada Variables and the California Lottery Dummy Variable

(Annual)

	California Dummy Excluded			California Dummy Included		
Quarter	Gross Gaming Revenue	Taxable Sales	Total Industry Employment	Gross Gaming Revenue	Taxable Sales	Total Industry Employment
1986 Fourth	10.3%	12.1%	6.6%	3.9%	12.0%	4.3%
1987 First	10.3	12.4	6.7	4.2	12.2	4.5
Second	10.1	12.2	6.6	4.2	11.9	4.4
Third	10.4	12.5	6.7	4.7	12.2	4.7
Fourth	10.5	12.8	6.8	5.1	12.5	5.0
1988 First	10.5	12.7	6.8	5.2	12.3	5.1
Second	10.4	12.5	6.7	5.2	12.0	5.1
Third	10.5	12.6	6.8	5.6	12.1	5.3
Fourth	10.6	12.8	6.8	5.9	12.2	5.5

Note: Estimation period: First quarter 1965 to third quarter 1986
Seasonally adjusted data (Except 6-Month Commercial Paper Rate)

IV. Concluding Comments

The technical problems with estimating large structural models combined with the lack of a detailed and reliable data base at the regional level strongly argue that an alternative modeling methodology be applied to regional economic forecasting. Time series techniques offer an alternative that deserves consideration. While the enthusiasm for ARIMA time series models has waned, the VAR method offers many of the same advantages with the additions of being more flexible and capable of incorporating economic considerations about the underlying structure of a regional economy.

In this paper we have developed a vector autoregressive time series model of the Nevada economy and used it to forecast key variables out to the fourth quarter of 1988. The forecasts suggest continued growth in Nevada. However, the California lottery is anticipated to have a negative impact on the growth rate of Nevada employment and gaming revenue, at least in the short run. Taxable sales, in contrast, appear only slightly affected by the lottery, perhaps because tourists still visit Nevada to enjoy its many recreational attractions despite having spent some of their gaming dollars elsewhere. These results also suggest that gaming may no longer be the engine of economic growth it once was, and that other regions looking for relief from fiscal distress may be well-advised to consider options beyond gaming.

Intuition and the results presented in Tables 3 and 4 suggest that the influence of the California lottery should be incorporated into developing forecasts of gaming revenues, taxable sales, and employment in Nevada. The need to consider the lottery's impact becomes more apparent when the forecasts presented in Table 4 are compared with recent performance of the forecasted variables (Table 5). That comparison suggests that the dummy variable used to represent the influence of the lottery may have overemphasized the lottery's adverse impact.

Gaming revenues have grown much faster than forecasted with the influence of the California lottery incorporated into the VAR model. In fact, the forecasted gaming revenue growth is fairly close to the forecast generated when the lottery variable was omitted. The same observation can be made for employment, although the difference between forecast (with lottery influence) and actual growth is not as large as it is for gaming revenue. The taxable sales forecast was not significantly influenced by the inclusion or exclusion of the lottery variable and, in either case, the VAR model provided a reasonable forecast of taxable sales growth.

These different impacts suggest that additional work needs to be directed toward incorporating the effects of the California lottery. Unfortunately, the short time period for which the lottery has been in existence limits the number of ways one can incorporate its influence. The dummy variable will likely overemphasize the lottery's influence since it is incapable of differentiating between short run and long run impacts. One would reasonably anticipate a difference between the short run and long run response of gaming revenues to the initiation of the California lottery. Perhaps gaming has recovered from the initial impact of the California lottery, or perhaps the lottery never had a significant effect on gaming revenues, although the latter explanation is difficult to accept on a priori grounds.

The growth of gaming revenue in the fourth quarter of 1986 and the first quarter of 1987 has surprised most observers in Nevada and it is too early to determine whether Nevada will continue to experience such high gaming growth rates. In any event, Tables 4 and 5 illustrate the difficulty of forecasting a regional economy on a quarter-by-quarter basis.

While it may be too early to assess fully the merits of the Nevada VAR model, the initial results are promising and the areas of future research are well-defined. Considering that there presently exists no other quarterly forecasting model for Nevada that is widely accepted or has proven as flexible, the Nevada VAR model can be regarded as a meaningful forecasting framework for the regional economy.

Table 5

Actual Growth Rates of Nevada Variables
(Annual)

Quarter	Gross Gaming Revenues	Taxable Sales	Total Industry Employment
1986 Fourth	11.8%	14.0%	5.9%
1987 First	14.4	11.3	6.9

Note: Growth rate calculated as one-year quarter percentage change.

FOOTNOTES

1. The Nevada economy and Nevada gaming are discussed in more detail in Thomas F. Cargill (1982) and William R. Eadington (1982), respectively. Recent developments are discussed in various issues of the *Nevada Review of Business and Economics,* published by the Bureau of Business and Economic Research, College of Business Administration, University of Nevada, Reno.

2. Thomas F. Cargill (1979) analyzed growth rates of various categories of industrial employment over business cycle phases from 1960 through 1975 and found that Nevada employment was sensitive to national swings in the economy.

3. A general discussion of VAR methods is provided by Richard M. Todd (1984) while a theoretical discussion is provided by Robert B. Litterman (1979). Christopher Sims (1980), Thomas J. Sargent and Sims (1977), and Sargent (1979) provided early applications. T. F. Cooley and S. F. LeRoy (1985) provide a critical appraisal of VAR methods.

4. There are several regional VAR models in existence; for example, see Hossain Amirizadeh and Richard M. Todd (1984) and Anatoli Kuprianov and William Lupoletti (1984).

5. The national model was developed at the Federal Reserve Bank of San Francisco by Bharat Trehan with the assistance of one of the authors (Morus). The authors express appreciation to Bharat Trehan and Jack Beebe, Director of Research, for permission to use the national model in this paper.

6. Calculations were performed on an IBM PC-AT using the RATS econometric software package (Thomas A. Doan and Robert A. Litterman, 1986).

7. Actual values of the national variables were employed rather than forecast values because of the desire to use the best available information to evaluate the Nevada VAR model. The relative ranking of various versions of the model would not be affected by the use of forecasted national variables.

All data with the exception of the rate of inflation were transformed into natural logs. The Nevada and California variables were seasonally adjusted via the Commerce Department's X-11 method. Seasonally adjusted values of the national variables (except the interest rate) were used as they are provided by the Commerce Department or other sources.

8. The Theil U statistic is the ratio of the root mean squared error (RSME) of the VAR model to the RSME of the naive model. Thus, values less than one suggest the VAR model outperforms a very simple forecast procedure.

REFERENCES

Amirizadeh, Hossain and Todd, Richard M. "More Growth Ahead for Ninth District States." *Quarterly Review.* Federal Reserve Bank of Minneapolis, Fall 1984.

Barone, Robert. "A Modeling Technique for Rural Economies," *Review of Regional Studies.* 9 (Winter 1979).

Barone, Robert, Gano Evans, William Hallagan, and James Walker. *Socioeconomic Analysis of the White Pine Power Project.* Bureau of Business and Economic Research, College of Business Administration, University of Nevada, Reno, July 1979.

Box, G. E. P. and G. M. Jenkins. *Time Series Analysis.* San Francisco: Holden-Day, 1970.

Cargill, Thomas F. "Is the Nevada Economy Recession Proof?" *Nevada Review of Business and Economics.* 3 (Summer 1979).

__________. "The Nevada Economy: Past, Present, and Future," *Southwestern Review.* 2 (Fall 1982).

__________ and William R. Eadington. "Nevada's Gaming Revenues: Time Characteristics and Forecasting," *Management Science.* 24 (August 1978).

__________ and James Walker. "Forecasting Nevada State Government Revenues," *Nevada Review of Business and Economics.* 5 (Spring/Summer 1981).

Chu, S. *An Econometric Model for the State of Nevada.* Bureau of Business and Economic Research, College of Business Administration, University of Nevada, Reno, 1974.

Cooley, T. F. and S. F. LeRoy. "Atheoretical Macroeconomics: A Critique." *Journal of Monetary Economics.* 12 (November 1985).

Doan, Thomas A. and Robert A. Litterman. *User's Manual: Regression Analysis for Time Series — Version 2.00.* Minneapolis: VAR Econometrics, 1986.

Eadington, William R. "The Evolution of Corporate Gaming in Nevada." *Nevada Review of Business and Economics.* 6 (Spring 1982).

Ghiglieri, Steve. *An Econometric Model of Washoe County and Forecasts for 1984-2006.* M.A. Thesis, University of Nevada, Reno, November 1986.

Hester, John and William Rosen. "The Washoe County Annual Econometric Model." *Nevada Review of Business and Economics.* 3 (Fall 1981).

Kuprianov, Anatoli and William Lupoletti. "The Economic Outlook for Fifth District States in 1984: Forecasts from Vector Autoregression Models," *Economic Review.* Federal Reserve Bank of Richmond, January/February 1984.

Litterman, Robert B. "Techniques of Forecasting Using Vector Autoregressions." Working Paper 115, Federal Reserve Bank of Minneapolis, November 1979.

McNees, Stephen K. "Forecasting Accuracy of Alternative Techniques: A Comparison of U.S. Macroeconomic Forecasts," *Journal of Business and Economic Statistics.* 4 (January 1986).

Sargent, Thomas J. "Estimating Vector Autoregressions Using Methods Not Based on Explicit Economic Theories," *Quarterly Review.* Federal Reserve Bank of Minneapolis. 3 (Summer 1979).

Sargent, Thomas J. and Christopher Sims. "Business Cycle Modeling without Pretending to Have Too Much A Priori Theory." in Christopher Sims, ed., *New Methods of Business Cycle Research: Proceedings from a Conference.* Federal Reserve Bank of Minneapolis, 1977.

Sherwood-Call, Carolyn. "The Western Region in 1986," *Weekly Letter.* Federal Reserve Bank of San Francisco, February 6, 1987.

Sims, Christopher. "Macroeconomics and Reality," *Econometrica.* 48 (January 1980).

________. "Policy Analysis with Econometric Models." *Brookings Papers.* (1:1982).

Todd, Richard M. "Improving Economic Forecasting with Bayesian Vector Autoregressions," *Quarterly Review.* Federal Reserve Bank of Minneapolis (Fall 1984).

Should M2 Be Redefined?

Brian Motley

Senior Economist, Federal Reserve Bank of San Francisco.

Marc Charney provided excellent research assistance throughout this project. John Judd and Bharat Trehan provided valuable comments.

For an indicator of monetary policy, this paper proposes "Nonterm M3" as an alternative to M2. With the removal of ceilings on the yields of its assets, the M2 aggregate has become a grouping of dissimilar assets. Nonterm M3 excludes small time deposits and thus contains only monetary instruments with no set maturity date. The demand for this aggregate has been reasonably stable and is more sensitive to interest rates than is the demand for M2.

We can draw the line between "money" and "debt" at whatever point is most convenient for handling a particular problem.

J. M. Keynes, *The General Theory of Employment Interest and Money.*

Over most of the period since the mid-1970s, the Federal Reserve System has expressed its intentions for monetary policy in terms of the growth rates of various monetary and credit aggregates. The Full Employment and Balanced Growth (Humphrey-Hawkins) Act of 1978 requires the System to set annual target ranges for the aggregates and to report these targets to the Congress twice a year. These reports also review the actual behavior of the aggregates relative to their targets and to the conditions in the economy that influenced both the attainment and the appropriateness of the targets.[1]

The Federal Reserve has used three principal monetary aggregates as policy indicators: M1, which consists of currency and checkable deposits; M2, which adds a variety of small-denomination savings-type instruments issued by banks and other financial intermediaries; and M3, which also includes certain large-denomination instruments, such as large certificates of deposit. Since it includes only currency and fully checkable funds, M1 traditionally was regarded as primarily a "transactions" aggregate, whereas M2 and M3 also contained "savings" balances.

When the present definitions of the aggregates were adopted in 1980, the principal distinction between the two broader aggregates was that the deposit rates on most instruments in M2 were regulated by the Federal Reserve, whereas those on instruments outside M2 were unregulated. The regulation of deposit rates meant that banks were not able to manage closely the amounts of their M2 liabilities, but instead were forced, at least in the short run, to accept the quantities offered by their customers at the regulated yields. In contrast, the amounts outstanding of instruments outside M2 could be controlled closely, since by altering their offering rates, banks could attract more or less funds into these so-called "managed liabilities."

Following the deregulation of deposit rates in recent years, the differences between the aggregates have become less clear-cut. Individuals now use interest-bearing checking accounts not only for transactions purposes, but also as repositories for savings balances, thus blurring the distinction between M1 and M2. At the same time, the deregulation of the yields on small time deposits has made it possible for banks to manage their small- as well as their large-denomination liabilities, thus reducing the difference between M2 and M3.

This article suggests an alternative classification of monetary assets based on the distinction between those that have a stated term to maturity and those that do not. In the new environment of deregulated deposit rates, this classification may be more useful than that embodied in the present definitions of the aggregates. M2, as currently defined, includes some assets that have no specified term to maturity, and others – small time deposits – that have a fixed term. The suggested classification would alter the definition of M2 by excluding small time deposits and combining them with large time deposits in the non-M2 portion of M3.

The following Section I describes the present monetary aggregates, explains their use as indicators for monetary policy, and discusses how deregulation has altered their behavior. Section II introduces the proposed decomposition of M3 based on the distinction between term and nonterm assets.

Section III reviews the received theory of the demand for money, and argues that this theory applies more closely to the alternative monetary aggregates than to the measures that the Federal Reserve currently uses. Sections IV and V develop and estimate empirical demand relations for both the official aggregates and the alternatives. The results suggest that the demand for the alternative measure of M2 has been more stable in the face of deregulation. Section VI concludes.

I. Deregulation and the Behavior of the Monetary Aggregates

The practice of relying on monetary aggregates as guides to policy assumes that there is a reasonably close and predictable relation between monetary growth and the macroeconomic variables that the policymaker cares about: income, prices, and interest rates.

Until recently, the Federal Reserve focused its attention on M1, which comprises the outstanding stock of currency and fully checkable deposits, and corresponds closely to the theoretical concept of "money" used by many economists. Both economic theory and empirical evidence suggested that M1 would be a reliable leading indicator of real GNP and inflation. Since M1 was found also to be subject to a reasonable degree of control by the Federal Reserve, it made sense to conduct monetary policy in terms of the growth of this aggregate.

An important necessary condition for the use of any monetary aggregate as a guide to policy is that the public's demand to hold it be a stable function of a small number of variables that are of interest to policymakers – income, prices, and interest rates. Until recently, M1 was considered more likely to satisfy this condition because it was used primarily as a transactions rather than a savings medium, and so was likely to have few close substitutes.

This unique feature of M1 was fostered by regulations that set a ceiling on the rate of return that depository institutions were permitted to pay on checkable deposits. This rate-ceiling on checking accounts gave members of the public a strong incentive to limit their holdings of these accounts to the minimum level needed for transactions purposes, and to hold their savings balances in other forms that yielded higher returns. As a result of M1's unique role as a transactions medium with a regulated yield, changes in M1's rate of growth had predictable effects on the interest yields on other financial instruments, and thus, ultimately, on the levels of real GNP and prices.

The broader monetary aggregates, M2 and M3, were expected to be less useful than M1 as indicators for monetary policy since they contained a mixture of savings funds and transactions balances and included a number of financial instruments with market-determined yields. Since these aggregates lacked M1's unique features, the public's demand to hold them was thought likely to be affected both by difficult-to-predict shifts in investor preferences among alternative instruments and by changes in the rates paid on those instruments by their issuers. These problems were thought to be less severe in the case of M2 than of M3. The deposit rates on most instruments in M2 were subject to regulatory ceilings, making them more similar to M1 than to instruments outside M2 — all of which bore yields that were fully deregulated and market-determined.

Reducing Distinctions

Since 1978, virtually all of the restrictions on the interest yields paid by banks and other depository institutions on their deposit liabilities gradually have been phased out.[2] This process of deregulation has had the effect of significantly reducing the distinctions between the various monetary aggregates. For example, the introduction of interest-bearing checking accounts has reduced the incentive for households to monitor carefully the distribution of their liquid assets between transactions and nontransactions accounts. As a result, it seems likely that checkable deposits now contain not only transactions funds but also savings balances, thus undermining the uniqueness of M1.

Apparently as a result of the commingling of transactions and nontransactions funds induced by deregulation,[3] the formerly close relation between M1 and the behavior of real GNP and prices seems to have broken down in early 1985. This breakdown led the Federal Reserve to downgrade M1,[4] and to put greater emphasis on M2 and M3 as policy indicators. In 1987, no formal target was set for M1 growth.

Deposit-rate deregulation also has lessened the distinction between M2 and M3. When the present definitions of the monetary aggregates were adopted in 1980, the assets in M2 were thought to be similar[5] even though they included both savings deposits that could be liquidated more or less on demand, and small time deposits that had fixed terms to maturity. M2 assets were thought to be unlike the large-denomination instruments outside M2, partly because those instruments are not covered by federal deposit insurance, but also, and more importantly, because the returns on most M2 assets were regulated, whereas those on instruments outside M2 were not.

The removal of this regulatory distinction has made M2 assets, especially small time deposits, more like those outside M2[6] than they were in 1980. Now that they are free to vary their offering rates on small as well as on large time deposits, banks can and do use both as managed liabilities; this was not possible when the yields on small time deposits were limited by regulatory ceilings. As a result, small time deposits now are held by investors who, prior to deregulation, would have shunned them in favor of market instruments providing higher yields.

Term vs. Nonterm

In light of these institutional developments, several economists at the San Francisco Reserve Bank have argued that the present dividing lines between M1, M2, and M3 may be less important than the single distinction between deposits that have a specified term to maturity (term accounts) and those that have no fixed term and are, for practical purposes, withdrawable on demand (nonterm accounts).[7] The aggregates formed by grouping financial instruments into these two classes are described as *Term M3* and *Nonterm M3*.[8] Nonterm M3 includes all the assets in M1, overnight repurchase agreements and eurodollars, money market deposit accounts, passbook savings accounts, and money market mutual funds. Term M3 represents the remainder of M3, and includes both small- and large-denomination time deposits, term repurchase agreements, and term eurodollars.

This grouping of financial assets differs from that used by the Federal Reserve in two respects. First, the distinction between transactions (M1) and other nonterm instruments is de-emphasized. Second, small-denomination time deposits are grouped with other term accounts to form Term M3, rather than with nonterm assets in M2. Currently, nonterm M3 represents about 55 percent of total M3, whereas M2 represents about 80 percent.

Evidence of a change in the behavior of monetary aggregates since the deregulation of deposit yields is found in Charts 1, 2 and 3. In Chart 1, the right panel shows that the transactions (M1) and nontransactions components of Nonterm M3 have moved together quite closely in recent years, whereas the left panel shows that in earlier years the growth of M1 was not closely related to that of other nonterm instruments. The visual impression gained from these panels is confirmed by statistical evidence. The correlation coefficient between the monthly growth rates of the M1 and non-M1 components of Nonterm M3 was only 0.24 (t-statistic 2.31) between January 1971 and June 1978, but increased to 0.59 (t-statistic 7.05) between July 1978 and December 1986.[9] This evidence suggests that, during much of the 1970s, the public regarded M1 as a unique transactions vehicle, but that since deregulation, the behavior of M1 has been similar to that of other liquid nontransactions accounts.

The two panels of Chart 2 show that there has been a strong tendency for the term and nonterm components of M3 to move in opposite directions since 1978, but that this inverse relation was much weaker in the 1970s. The correlation coefficient between the monthly growth rates of term and nonterm M3 more than doubled from –0.39

Chart 1

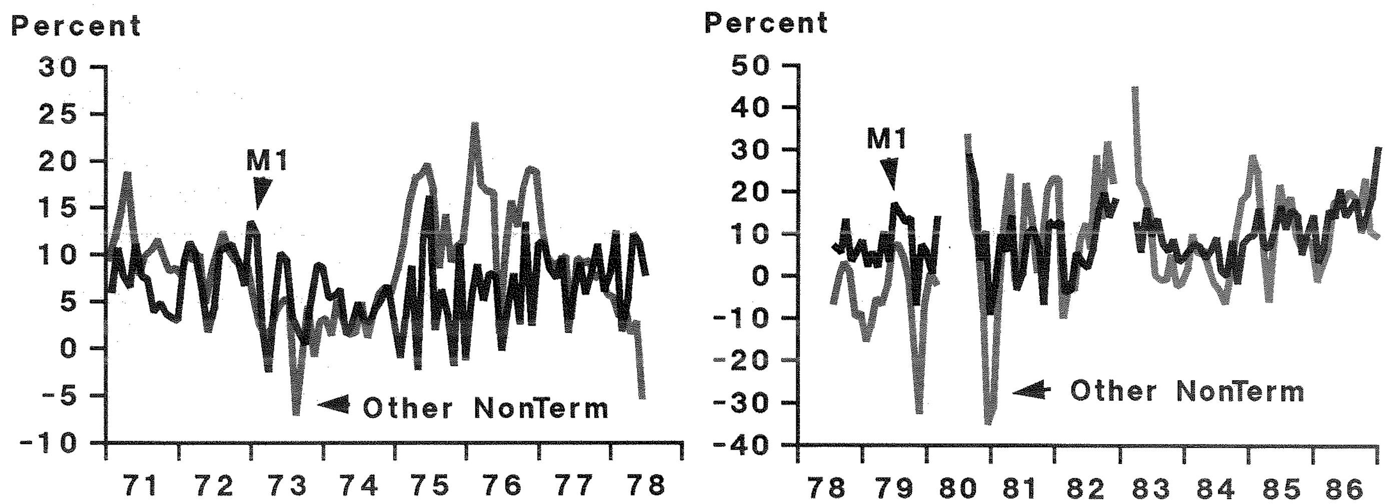


Chart 2

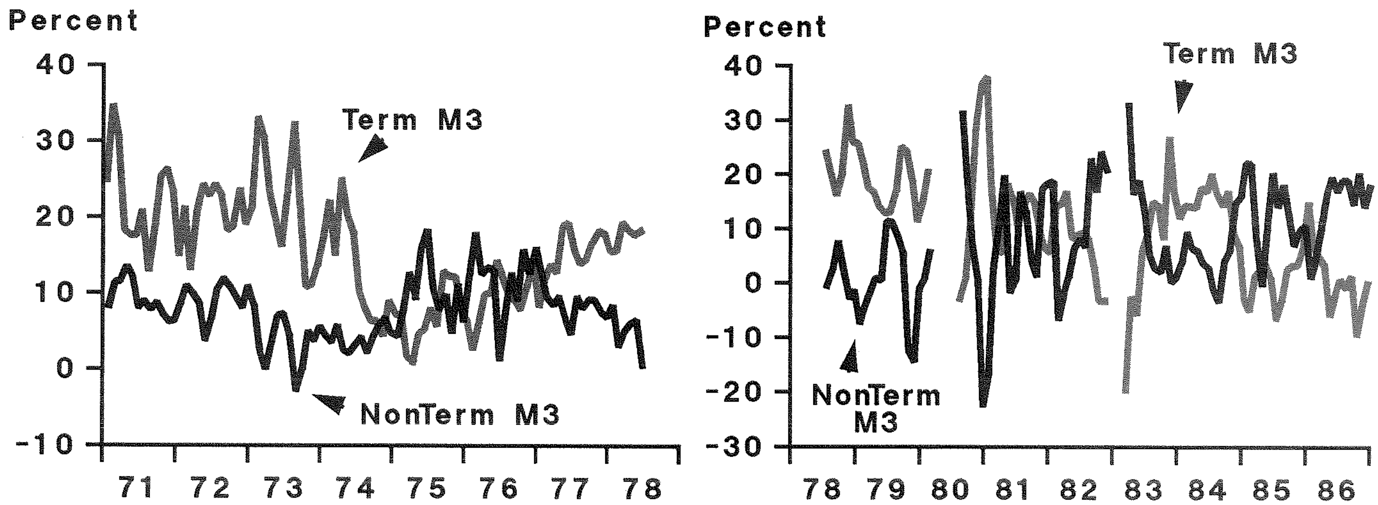
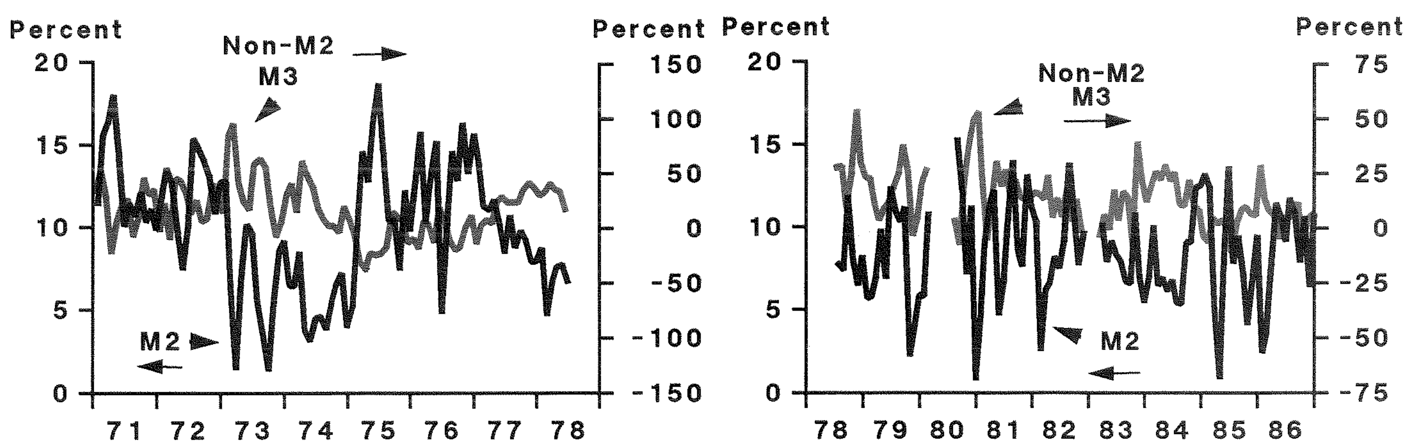


Chart 3



(t-statistic 3.95) between January 1971 and June 1978 to –0.84 (t-statistic 14.75) between July 1978 and December 1986.[10] This evidence suggests that nonterm and term M3 each now represents a grouping of similar assets. This was less true before 1978 because small time deposits, being regulated, behaved more like nonterm saving accounts than like large term assets.

Conversely, Chart 3 shows that the tendency for the M2 and non-M2 components of M3 to vary inversely was quite strong in the period before deregulation, but has been weaker in recent years. The correlation between the growth rates of M2 and non-M2 M3 went from –0.61 (t-statistic 7.14) in the 1971 to 1978 period, to –0.36 (t-statistic 3.70) between 1978 and 1986.[11, 12] This evidence suggests that, in the earlier period, M2 and non- M2 M3 each represented an aggregate of similar assets, but that their similarity has been reduced since deregulation because small time deposits now behave more like large term accounts than nonterm accounts.

Further evidence that small time deposits now behave more like large-denomination term accounts than like other components of M2 was presented in a recent paper in this *Review*.[13] Using a vector autoregression approach, this paper showed that, in the post-deregulation period, the response of the growth rate of small time deposits to interest rate shocks was similar to that of large term accounts, but quite different from that of either M1 or the non-M1 nonterm components of M2. In contrast, before deregulation, the response of the growth of small time deposits to interest rate shocks was similar to that of M1 and of other components of M2, and quite different from that of large-denomination term accounts. The authors attributed the changed behavior of small time accounts to the deregulation of deposit rates on these accounts, which has transformed them into managed liabilities.

Additional evidence that depository institutions use small time deposits as managed liabilities comes from examining how the yield on these deposits responds to changes in market rates on competing short-term instruments. The second and third columns of Table 1 report regression equations explaining the response of offering rates on small and large time deposits to current and lagged values of the one-month commercial paper rate (CP1) in the period since early 1983. These equations show that banks now adjust their offering rates on both classes of time deposits quickly and fully to changes in other short-term yields. Within two months of a rise in the commercial paper rate, yields on both short- and long-term time deposits rise by a roughly equal amount. The response is only slightly less rapid in the case of small time deposits, indicating that banks manage these small-denomination liabilities almost as closely as large CDs.

In contrast, rates on MMDAs, passbook savings, and NOW accounts are adjusted more slowly. The fourth column in Table 1, for example, shows a regression of the MMDA yield on the commercial paper rate that indicates that this rate adjusts slowly and incompletely to changes in competing yields.[14]

All this evidence suggests that since the deregulation of deposit rates, the Federal Reserve's distinction between M2 and M3 may have become less meaningful than that between nonterm and term assets. Today, it appears that the term and nonterm components of M3 each represents a relatively homogeneous group of financial instruments. Each group is managed differently by the intermediaries that issue it, and, as discussed in the following section, performs a different function in the public's portfolio of wealth.

II. The Theory of Money Demand

Although economists and policymakers have not emphasized the distinction between *term* and *nonterm* instruments in the postwar period, this way of classifying assets is not a new one. It underlay much of John Maynard Keynes's discussion of the demand for money in his *General Theory*[15] more than a half-century ago. Instead of "the demand for money," Keynes used the term "liquidity preference," and made it clear that this was a broad concept that was not limited to the demand for assets that function as means of payment.

In distinguishing between "money" and "debts," Keynes emphasized the difference between those assets that can be converted into spendable cash quickly and without risk of capital loss, and those that have a stated term to maturity and can be liquidated before maturity only at some risk or cost. Although many later economists equated liquidity preference with the demand for *transactions* balances,[16] Keynes himself made it clear that it referred to a demand to hold assets that give immediate command over goods and services in preference to ones that require parting with that command for a period of time. Thus, liquidity preference referred to a demand for nonterm assets in general, and not only for those that are used as means of payment.[17]

Holding Wealth as Money

For Keynes, the principal reason for holding money as a store of wealth (that is, over and above the amount needed for purely transactions purposes) was uncertainty regarding the future rate of interest on securities. He argued that if there were no uncertainty about future rates of interest, the present and future values of all securities also would be known, and hence an investor would have no incentive to hold his wealth in the form of money.[18]

Since the future rate of interest is in fact uncertain, "there is a risk of a loss being incurred in purchasing a

Table 1

Yields on Managed and Non-Managed Liabilities

Dependent Variable	Large Time Deposit Yield	Small Time Deposit Yield	MMDA Yield
Constant	0.0074 (0.629)	−0.007 (0.339)	−0.037 (3.920)
CP1	0.999 (26.95)	0.567 (8.755)	0.272 (9.339)
CP1(−1)	0.030 (0.673)	0.243 (3.091)	0.153 (4.362)
CP1(−2)	0.005 (0.126)	0.137 (1.742)	0.118 (3.361)
CP1(−3)		−0.074 (0.956)	0.030 (0.844)
CP1(−4)		0.084 (1.296)	0.005 (0.141)
CP1(−5)			0.086 (2.883)
CP1(−6)			−0.009 (0.383)
Sum of Coefficients:	1.034 (24.49)	0.957 (10.03)	0.655 (13.31)

All data are expressed as monthly first-differences.
Sample period: 1983.03–1986.12.

long-term debt and subsequently turning it into cash, as compared with holding cash," and it is because of this risk of loss on securities that investors hold part of their wealth in the form of money. Keynes described this "desire for security as to the future cash equivalent of a certain proportion of total resources" as the "precautionary motive" for holding money.

A second reason for holding wealth in the form of money, Keynes argued, was to speculate on future movements of the rate of interest. According to this "speculative motive," an investor will prefer to hold money if he expects interest rates to rise, since the holding of securities will expose him to a capital loss. Conversely, if he expects interest rates to fall, an investor will anticipate obtaining a capital gain on holdings of securities, and hence will tend to switch out of money into securities. Since the speculative motive for liquidity preference depends on the investor believing that he knows the future better than the market,[19] it too depends on the presence of uncertainty and would not exist if all future interest rates were known for sure.

Although Keynes emphasized the role of uncertainty about future rates of interest, he did recognize that an individual also will have a motive to hold money when he is uncertain about his future receipts or expenditures. If these flows were hard to predict, an individual would want to hold a stock of liquid funds to "provide for contingencies requiring sudden expenditure and for unforeseen opportunities of advantageous purchases" (*General Theory*, p. 196).

Uncertainty about future needs for liquid funds and about future interest rates both provide "precautionary" motives to hold money.[20] These motives are not independent. The effects on an individual of being uncertain whether or when he will need to sell securities, in order to obtain liquid funds to spend, are compounded when future security prices also are uncertain. Conversely, the effects of interest rate uncertainty would be significantly reduced if there were no uncertainty about future incomes and outlays because an investor could tailor the maturities of the securities in his portfolio to ensure that he never had to sell securities before they matured.

However, theorists since Keynes have argued that uncertainty about future needs for spendable funds will lead to a demand for money even if there were no interest rate uncertainty. This is because there are *transaction costs* in exchanging non-money assets for money, even when there is no uncertainty about the value of those assets. These transaction costs of liquidating assets include not only explicit "brokerage fees," but also implicit "shoe-leather" and "inconvenience" costs. If the individual were uncertain of how frequently he would need to liquidate assets to obtain cash to make payments, he might find it advantageous to hold part of his wealth in the form of money to reduce the risk of incurring those transaction costs. This precautionary demand[21] would depend not only on the degree of uncertainty about future needs for cash, but also on the size of the transaction costs[22] avoided by holding money rather than non-money assets.

Money as a Nonterm Asset

Each of these motives for holding wealth in the form of "money" is more closely related to money's being a *nonterm* asset, that gives more or less immediate command over goods and services, than to its being the medium of exchange. All are motives for holding liquid assets in general, and not only assets that are means of exchange.

This clearly is the case in the environment envisioned by Keynes, in which "money" and "securities" are the only assets available. Securities are *term* assets, and Keynes assumed that all securities are traded in organized markets. An investor can liquidate his security holdings before maturity only by selling them in these markets. He would then sustain a capital loss if interest rates have risen (security prices have declined), and obtain a capital gain if rates have fallen.

The larger the proportion of his wealth that he has in securities with a fixed term to maturity, the greater are both his risk of capital loss and his opportunity for speculative gain if he sells them before maturity. Hence, when deciding how much of his portfolio to hold in securities and how much in other assets, the investor must consider the trade-off between risk and return and make judgments about the future course of interest rates and security prices. In making this decision, the crucial choice is between assets that have a fixed term to maturity and that can be liquidated only by being sold at an uncertain and varying market price, and those that can be liquidated at their face value more or less on demand. Whether the latter function as a medium of exchange is of secondary importance.

In fact, "securities" are not the only term assets available. Investors also can hold wealth in the form of time deposits for which, except in the case of large CDs issued by money center banks, there is no organized market in which an investor can liquidate his holdings before maturity. Thus, the interest rate uncertainties emphasized by Keynes do not apply to time deposits. However, although there is no "secondary market" in time deposits, in most cases the investor can withdraw his funds before maturity by paying an "early withdrawal" penalty. This penalty represents the transaction cost of liquidating his deposit early. As discussed earlier, if the investor were uncertain of his future needs for spendable funds, the presence of a transaction cost would provide an incentive to hold a portion of wealth in liquid form rather than in time deposits. Again, however, this motive for liquidity applies to *all* nonterm assets and not only to those that are used as the medium of exchange. This is because all such assets may be liquidated with little risk[23] and at low cost.

Most depository institutions permit depositors to shift funds among different types of nonterm savings deposits and between savings and transactions accounts at no cost and with only minor restrictions.[24] Since these various nonterm assets are easily converted into the medium of exchange, there is little need for the individual investor either to consider carefully his future needs for spendable cash or to make judgments about future interest rates when deciding how to allocate wealth between them. In other words, the factors that give rise to the precautionary and speculative demands for "money" in preference to "debts" apply mainly to decisions between holding "nonterm assets" and "term assets," and are less important to decisions regarding the various kinds of transactions and other nonterm instruments.

Fundamental Distinction

This discussion suggests that the distinction between nonterm and term assets may be a fundamental one and those between transactions and nontransactions accounts or between M2 and non-M2 accounts may be of secondary importance. Because term assets can be liquidated only at an uncertain price or at the cost of an early withdrawal penalty, whereas nonterm assets give more or less immediate command over goods and services with little risk and at low cost, there are sound economic reasons for investors to separate their stocks of wealth into holdings of term and nonterm assets.

By contrast, in the absence of government regulation, there would be little incentive for individuals to separate their transactions funds from the rest of their nonterm balances. Thus, the uniqueness of M1 may have been an artifact of the regulation that prohibited banks from paying a market-determined rate of return on checkable deposits, and thus may have disappeared with the removal of that restriction. As Chart 1 illustrates, the change in the relation between the transactions (M1) and nontransactions components of nonterm M3 coincided approximately with the phasing out of that regulation.

The regulation of interest yields on other classes of deposits may have had a similar effect in contributing to the uniqueness of M2. Before 1978, the rates that financial institutions were permitted to pay on most accounts included in M2 — including both nonterm and small-denomination time deposits — were regulated. During that period, the risk of holding a small time account instead of a nonterm account was confined to the early withdrawal penalty that was levied if the investor wished to liquidate it before maturity. Because the rate ceilings on term and nonterm M2 assets were seldom changed, there was little difference in the interest rate risk to holding nonterm or small time deposits, that would have given an investor a "precautionary" or "speculative" motive for preferring nonterm deposits. This may have reduced the importance of the distinction between term and nonterm accounts and contributed to the uniqueness of M2.

The deregulation of deposit rates on small time deposits should have reversed these effects, strengthening the distinction between term and nonterm M3 and reducing the uniqueness of M2. As discussed in the preceding section, this deregulation has made it possible for depository institutions to use small time deposits as "managed liabilities." And, as a result, the deposit rates on these accounts now change more frequently and follow market yields more closely. Small time deposits now are more similar to the large-denomination term accounts outside M2 than to most of the nonterm assets in M2. Although there are no regulatory constraints on the yields on nonterm deposits, banks adjust these rates sluggishly.[25] Thus both term and nonterm M3 now consist of a grouping of similar assets, whereas M2 contains a mixture of different kinds of instruments, including both managed and non-managed liabilities.

Statistical Evidence

The statistical evidence presented earlier in connection with Charts 1-3 supports this argument that deregulation has weakened the uniqueness of M2 and made the distinction between term and nonterm M3 a more significant one. That evidence showed that the negative correlation between the M2 and non-M2 components of M3 weakened between the 1971-1978 and 1978-1986 periods, while that between nonterm and term M3 strengthened.

In addition, there is evidence that these changes in the behavior of the aggregates were the result of the impact of deregulation on small time deposits. Before 1978, there was only a small and negative correlation between the monthly growth rates of small time deposits and the non-M2 component of M3 (correlation coefficient –0.30, t-statistic 3.00), whereas since 1978, this relation has been positive and highly significant (correlation coefficient 0.62, t-statistic 7.02). Similarly, the correlation between the monthly growth rates of nonterm M3 and small time deposits was significantly positive (correlation coefficient 0.43, t-statistic 4.53) in the pre-deregulation period, but has been strongly negative (correlation coefficient −0.85, t-statistic 15.37) since deregulation. Thus, it appears that the deregulation of small time deposits has caused them to behave more like large CDs and not like nonterm instruments.

The argument of this section suggests that a definition of "money" that is based on the distinction between nonterm and term assets might yield an aggregate that would provide a better indicator for monetary policy than those currently in use. A grouping of assets that are similar, in the sense that they perform similar functions in the public's asset portfolio and are treated similarly by the institutions that issue them, is more likely to provide useful information than one, such as the present M2, that contains dissimilar assets. Moreover, a grouping, such as the present M1, that excludes some assets that are similar to those that it includes, also is likely to be less useful. In the next sections of this paper, these ideas are tested by estimating demand functions for nonterm and term M3 and comparing them with similar functions for the traditional aggregates.

III. Empirical Considerations

The preceding section argued that the uniqueness of both M1 and M2 may have been partly the result of the regulation of deposit rates, and that, since deregulation, a decomposition of M3 into its nonterm and term components is likely to produce more homogeneous groups of assets. Simple correlation tests supported these hypotheses. To provide stronger tests, demand functions for alternative aggregates were estimated over two samples that correspond approximately to the pre- and post-deregulation periods.

Roughly speaking, the deregulation process proceeded in two partially overlapping phases. In the first phase, which began in July 1978, financial institutions were authorized to issue small-denomination time deposits of varying maturities yielding market rates of return.[26] By the end of 1982, this phase was largely complete, and most restrictions on the deposit rates payable on term accounts in M2 (that is, small time deposits) had been removed.[27] The deregulation of yields on nonterm accounts began in January 1981, when depository institutions nationwide were permitted to offer interest-bearing checkable deposits (NOW accounts). Two years later, money market deposit accounts and checkable (Super-NOW) accounts with no minimum maturity and no ceilings on their yields were authorized. This second phase of deregulation was completed in 1986, with the removal of minimum balance limitations on Super-NOW accounts and of interest rate ceilings on passbook saving accounts. These last changes eliminated the final restrictions on nonterm deposits.

Sample Periods

For estimation purposes, the sample periods chosen were January 1971 to June 1978 and January 1981 to December 1986. In the first period, the rates on most small-denomination deposits, both term and nonterm, were regulated, making M2 somewhat unique. These regulations therefore favored the traditional decomposition of M3 and made a breakdown between term and nonterm assets less useful.[28] In the second period, the deregulation of most deposit rates favored the term-nonterm decomposition.

During the two-and-a-half years between these sample periods, growth in the monetary aggregates was influenced not only by a series of deregulation measures but also by certain special factors, including the change in the Federal Reserve's short-run operating procedures in October 1979 and the imposition of credit controls between March and July 1980. Hence, this period was excluded from both samples. In addition, in view of the huge swing that occurred in the demand for nonterm assets when Money Market Deposit Accounts and Super-NOW accounts were introduced, the three-month period from December 1982 to February 1983 was excluded[29] from the second sample.

Inertia

All empirical specifications of the demand for the monetary aggregates must take account of the apparent inertia in the response of the public's demand for money assets to changes in the macroeconomic variables that determine that demand. The most common ways of handling this inertia are either the partial adjustment specification or the use of explicit distributed lags.

In this paper the *error-correction* specification proposed by David Hendry[30] is used. This specification is similar to the partial adjustment approach in distinguishing between the *equilibrium money demand function*, which defines the long-run relation between the public's desired holding of money assets and the macroeconomic variables that determine it, and a *short-run adjustment model*, which describes the dynamic process by which money demand adjusts to its long-run equilibrium in response to changes in those determining variables.

Modeling

The long-run relation used here is of the form:

$$\log M_t = a + b \log Y_t + c R_t + e_t \qquad (1)$$

where M_t = monetary aggregate, Y_t = nominal income, R_t = a short-run market interest rate, and e_t is an error term representing the extent to which the public's actual money stock diverges from its equilibrium level.

The short-run adjustment of money demand in a given month is assumed to depend both on the divergence between its actual and equilibrium levels at the beginning of the month, e_{t-1}, and on current and lagged *changes* in the determining variables:

$$\Delta\log M_t = f + g e_{t-1} + \sum_p h_p \Delta\log M_{t-p} + \sum_q k_q \Delta\log Y_{t-q} + \sum_s m_s \Delta R_{t-s} \qquad (2)$$

Two comments are in order with regard to the long-run relation in Equation 1. First, the "scale" variable is assumed to be *nominal personal income* . Standard money demand relations employ income as a determining variable on the theory that money serves as the medium of exchange and income is a proxy measure of the flow of transactions that use money. Although the emphasis of this paper on monetary aggregates as stores of value suggests using some measure of the stock of *wealth* as a scale variable, this was not done because no monthly measure of wealth is available. Quarterly estimates of a variety of wealth concepts do exist and have been used in the estimation of quarterly demand functions for monetary aggregates.[31]

Over the period since 1970, the long-run trend growth rate of nominal wealth has been close to that of personal income, suggesting that the estimated long-run elasticity of money demand with respect to wealth would be similar to its income elasticity. However, the quarterly wealth data indicate that short-run fluctuations in total wealth are not closely related to variations in income, probably because those fluctuations reflect changes in the market value of assets, especially equities. In the equations estimated in this paper, the level of income may serve as a proxy for the long-run growth of wealth, and changes in the interest rate as a proxy for short-run variations in its market value.[32]

A second comment with regard to Equation 1 concerns the interest rate variable. In general, the demand to hold a monetary aggregate is affected not only by the *market rate* on competing instruments but also by the *own-rate* of return on the instruments in the aggregate, since the *spread* between these rates represents the opportunity cost of holding the aggregate. When deposit rates were strictly regulated, changes in the market rate produced equal changes in this spread. Since deregulation, movements in the yield on competing market instruments no longer imply equal changes in the spread because depository institutions alter their deposit rates in response to changes in market yields.

This institutional change suggests that econometric estimates of the demand for monetary aggregates should include a measure of the own-rate as well as the market rate. In preliminary estimates of the equations presented in this paper, this approach was tried, but the estimates were found to be either unstable or implausible. The source of this problem may be that each monetary aggregate consists of a variety of instruments that bear different yields. As a result, no single empirical measure captures fully the own-rate on a given aggregate, or the opportunity cost of holding that aggregate.[33]

Since own-rates respond[34] – albeit at varying rates – to changes in market rates, the demand to hold each aggregate may be expressed as depending only on market rates in the long run. This is the approach[35] adopted in Equation 1. This long-run relation represents an equilibrium not only in the sense that investors have fully adjusted their asset portfolios to the market conditions they face, but also that depository institutions have adjusted the yields on the instruments they issue.[36]

In the equations estimated in this paper, the standard error-correction adjustment specification represented by Equation 2 was extended to include an additional variable to capture the indirect effect on the monetary aggregates of variations in the demand for loans from depository institutions.[37]

Suppose there is an increase in the demand for bank loans. This increase gives banks an incentive to attract additional funds by raising their deposit rates, thereby increasing the public's demand to hold monetary assets. If the estimated equations were to include the own-rates on the monetary aggregates in addition to the market rate, this "bank loan" effect would be captured in a narrowing of the spread between the market rate and the own-rates. However, since the equations include only the market rate, this effect is captured instead by adding the change in the volume of bank loans as an additional variable. This variable is expected to be more important in the demand equations for time deposits, since banks manage these deposits (by varying their deposit rates) more closely in the short run.

When Equation 1 is substituted into Equation 2, and the bank loans variable is added, we obtain Equation 3.

$$\begin{aligned}\Delta \log M_t = {} & f - g(\log M_{t-1} - a - b \log Y_{t-1} - c R_{t-1}) \\ & + \sum_p h_p \Delta \log M_{t-p} + \sum_q k_q \Delta \log Y_{t-q} \qquad (3) \\ & + \sum_s m_s \Delta R_{t-s} + n\, \Delta LOANS_t\end{aligned}$$

where $\Delta LOANS_t$ represents the monthly change in bank loans.[38] In this equation, b represents the long-run income elasticity of demand for the aggregate, and c multiplied by the level of the interest rate is the long-run interest elasticity. The stock of the monetary aggregate approaches its long-run equilibrium level more quickly when the coefficient on the lagged *level* of the aggregate, g, is large, and those on the *changes* in the aggregate, income and the interest rate (h_p, k_q and m_s) are small.[39]

Equations in the form of Equation 3 were estimated for two pairs of monetary aggregates: (i) Nonterm and Term M3, and (ii) M2 and Non-M2 M3. The income variable used was nominal personal income and the market interest rate was the one-month commercial paper rate adjusted to a bond-yield basis. For each pair of aggregates, the demand equations were estimated by "seemingly-unrelated regression," an estimation method that assumes that the errors in the two equations are contemporaneously correlated.[40] This estimation method was suggested by the theoretical discussion in the previous section. Since different monetary aggregates are substitutes in the investor's asset portfolio, a random shock that affects the demand for one aggregate would be expected also to affect the other aggregate.

IV. Results

The estimation results are shown in Tables 2 and 3. In both tables, estimates are shown both for the pre- and post-deregulation sample periods separately and for the two periods together. Both pairs of equations fit the data closely with plausible values for the coefficients. None of the equations exhibits significant evidence of autocorrelation in the residuals that would indicate misspecification or the omission of important variables.

As expected, the response of the aggregates to market interest rates has changed significantly in the wake of deregulation. Both term and nonterm M3 have become more homogeneous aggregates and more responsive to market interest rates since 1981. In the case of M2 and non-M2 M3, deregulation has had the opposite effect.

Table 2 shows that in the 1981-86 sample period, the long-run demand for term M3 was significantly and positively related to market interest rates. Interest rate

Table 2
Estimation Results

	Nonterm M3			Term M3		
Dependent Variable Δ LOG M(t)	**1971.01-1978.06**	**1981.01-1986.12**	**1971.01 - 1978.06, 1981.01 - 1986.12**	**1971.01-1978.06**	**1981.01-1986.12**	**1971.01 - 1978.06, 1981.01 - 1986.12**
Constant	0.047 (2.103)	−0.073 (1.167)	−0.012 (2.566)	−0.088 (2.038)	−0.010 (0.178)	−0.029 (1.74)
Δ LOG M(t−1)	0.221 (1.610)	0.386 (8.499)	0.390 (9.573)	0.351 (4.129)	0.417 (7.248)	0.464 (10.330)
Δ LOG Y(t)	0.057 (0.965)	0.190 (2.114)	0.070 (1.428)	—	—	—
Δ CP1(t)	−0.0013 (1.603)	−0.0026 (5.758)	−0.0023 (5.580)	−0.00022 (0.257)	0.0010 (1.972)	0.00081 (1.818)
Δ CP1(t−1)	−0.0005 (0.574)	−0.0018 (3.890)	−0.0017 (4.280)	0.0011 (1.330)	0.0007 (1.602)	0.00107 (2.650)
Δ LOANS(t)	—	—	—	0.261 (4.080)	0.166 (1.759)	0.198 (3.720)
Δ LOANS(t−1)	—	—	—	0.080 (1.100)	0.169 (1.704)	0.047 (0.850)
LOG M(t−1)	−0.053 (2.377)	−0.028 (3.160)	−0.019 (3.876)	−0.026 (2.960)	−0.033 (3.256)	−0.0185 (3.850)
CP1(t−1)*	−0.025 (3.619)	−0.042 (3.920)	−0.050 (6.802)	0.008 (0.914)	0.029 (2.720)	0.034 (4.990)
LOG Y(t−1)*	0.819 (26.550)	1.291 (5.418)	1.072 (22.970)	1.341 (15.370)	0.910 (4.318)	1.067 (14.909)
SEE	0.0033		0.0034	0.0035		0.0036
DW	1.88		1.84	1.89		1.84
SEE/MEAN (Δ LOG M)	0.390		0.403	0.353		0.369

M(t) represents the monetary aggregate in each equation.

* *The estimated coefficients in these rows represent the* long-run *interest rate and income elasticities of demand. That is, the parameters b and c in Equation 1.*

changes also had a significant positive short-run impact on term M3.[41] Conversely, the demand for nonterm M3 responded negatively to market interest rates in both the short and the long run. These results reflect the fact that, since deregulation, depository institutions have adjusted their offering rates on all term accounts, including small-denomination time deposits, quickly and fully in response to changes in market rates, whereas rates on nonterm accounts have been adjusted more slowly. As a result, an increase in the general level of short-term interest rates makes term instruments more attractive relative to nonterm assets, and causes investors to shift from nonterm into term M3.

By contrast, in the pre-1978 period, the impact of interest rate changes on term M3, although positive, was very small and not statistically significant in either the short or the long run. Similarly, changes in market rates had negative, but small, effects on nonterm M3. Because the yields on small-denomination time deposits in term M3 were regulated in this period, the term M3 aggregate included a mixture of regulated and unregulated instruments. As a result, a rise in market rates made the hold-

Table 3
Estimation Results

	M2			Non-M2 M3		
Dependent Variable Δ LOG M(t)	**1971.01-1978.06**	**1981.01-1986.12**	**1971.01 - 1978.06, 1981.01 - 1986.12**	**1971.01-1978.06**	**1981.01-1986.12**	**1971.01 - 1978.06, 1981.01 - 1986.12**
Constant	0.0075 (1.113)	−0.0225 (0.650)	−0.00096 (0.245)	−0.245 (2.354)	−0.399 (1.489)	−0.129 (2.395)
Δ LOG M(t−1)	0.320 (3.464)	0.226 (2.869)	0.379 (6.686)	0.250 (3.663)	0.097 (0.713)	0.267 (4.433)
Δ LOG Y(t)	0.042 (1.196)	0.115 (2.124)	0.070 (2.330)	–	–	–
Δ CP1(t)	−0.00097 (2.086)	−0.0010 (3.753)	−0.00123 (5.144)	−0.0006 (0.231)	0.0013 (0.827)	0.0014 (0.996)
Δ CP1(t−1)	−0.00098 (2.046)	−0.00078 (2.718)	−0.0005 (2.099)	0.0068 (2.497)	0.0009 (0.603)	0.0021 (1.696)
Δ LOANS(t)	–	–	–	0.248 (4.244)	0.092 (0.796)	0.228 (4.381)
Δ LOANS(t−1)	–	–	–	0.123 (1.899)	0.128 (1.087)	0.163 (2.882)
LOG M(t−1)	−0.031 (2.310)	−0.021 (0.098)	−0.038 (3.513)	−0.029 (2.186)	−0.063 (1.821)	−0.018 (2.280)
CP1(t−1)*	−0.031 (2.976)	−0.0074 (1.077)	−0.0149 (7.702)	0.128 (3.819)	0.023 (1.280)	0.082 (2.512)
LOG Y(t−1)*	0.978 (33.580)	1.127 (6.060)	0.994 (93.260)	1.742 (8.704)	1.560 (4.650)	1.584 (12.300)
SEE	0.00188		0.00200	0.0109		0.0113
DW	1.85		1.744	1.878		1.892
SEE/MEAN (Δ LOG M)	0.236		0.251	0.820		0.847

M(t) represents the monetary aggregate in each equation.

* *The estimated coefficients in these rows represent the long-run* interest rate and income elasticities of demand. That is, the parameters b and c in Equation 1.

ing of *large* term deposits more attractive (because their yields rose in line with market rates), but simultaneously increased the opportunity costs of holding small time deposits making them less attractive. Since an increase in market rates had opposing effects on the demands for small and large term deposits in this period, it did not cause a significant net shift of funds between nonterm and term M3.

In the case of the M2 and non-M2 components of M3, the deregulation of deposit rates has made M2 a *less* homogeneous aggregate and caused it to become *less* responsive to interest rate changes. Table 3 shows that before deregulation, both the immediate and long-run effects of a rise in market rates were to reduce M2. Conversely, the effect of an increase in market rates on non-M2 M3 was significantly positive. Since the components of non-M2 M3 were unregulated, a rise in market rates induced depository institutions to raise their yields and made these assets more attractive relative to both the nonterm and the small-denomination term instruments in M2 – the rates on which were regulated. As a result, a rise in market rates led investors to substitute out of M2 into non-M2 M3.

The M2 equation estimated for the period since 1981 shows that the long-run negative effect of market rates on M2 is now small and not statistically significant, but that a small, although statistically significant, negative impact remains in the short run. This short-run impact persists because the yields on most of the nonterm assets in M2 respond slowly to changes in market rates. Hence, the immediate effect of higher market rates is to increase the opportunity costs of holding these components of the aggregate, and therefore to slow overall M2 growth. As the deposit yields adjust to market levels, this short-run effect dissipates.

The long-run demand for each of the four monetary aggregates is positively related to income.[42] Although the most obvious effect of deposit rate deregulation has been to alter the response of the demands for these aggregates to changes in market interest rates, there also has been some change in the effects of income on money demand. Since 1981, the long-run demand for nonterm assets has become more responsive to income, and that for term assets less responsive. *Changes* in the level of income ($\Delta \log Y$) had an immediate positive impact on the demand to hold nonterm M3 in the 1981-86 sample period; this impact effect was smaller and not statistically significant in the earlier period.

The increased responsiveness of nonterm M3 to changes in income since deregulation is consistent with Keynes's view that, in the absence of government restrictions on their yields, all nonterm assets are similar because all give more or less immediate command over goods and services.

Although not a principal concern of this paper, it is notable that changes in bank loans had a significant effect on the demand for the term aggregates. An acceleration of bank loans increases the growth rate

Table 4
Errors in Projecting M3 Growth

Year	M2 vs. Non-M2 Split: Mean Error	M2 vs. Non-M2 Split: Root Mean Squared Error	Nonterm vs. Term Split: Mean Error	Nonterm vs. Term Split: Root Mean Squared Error
1981	2.49	3.40	–0.67	2.71
1982	1.08	2.20	–0.12	1.86
1983	0.14	1.50	–0.15	1.83
1984	0.28	1.45	0.25	2.01
1985	–1.37	2.97	–1.04	2.71
1986	0.34	1.49	0.68	1.83
Mean 1981–86	0.49	2.17	–0.18	2.16

of both term M3 and non-M2 M3, confirming the hypothesis that banks do respond to increases in the demand for loans by adding to their managed liabilities.

Although the preceding discussion has focused attention on the effects of deregulation in altering the estimated coefficients of the equations in Table 2 and 3, these changes were not large. Only in the case of the demand for M2 may the hypothesis that the coefficients remained unchanged between the two sample periods be rejected at a reasonable significance level.[43] It was argued in the previous section that the deregulation of the yield on small time deposits undermined the unique nature of M2 and thus could be expected to cause the demand for that aggregate to shift. The empirical results bear out this expectation.

The earlier argument also suggests deregulation would have affected the demand for term M3, but not that for non-M2 M3, since the former was a mixture of regulated and unregulated instruments before 1978 while the latter was fully deregulated. There is some indication that the demand for non-M2 M3 was more robust in the face of deregulation than was nonterm M3, but the evidence is not strong.[44]

Since deregulation, both the short- and long-run effects of interest rate changes on the demand for nonterm M3 have been stronger than they were in the 1970s.[45] Although changes in market rates still have a short-run impact on the demand for M2, the estimated long-run interest rate elasticity of this demand has declined since deregulation and is no longer statistically significant. Since the principal link between monetary policy actions and the economy is through changes in short-term interest rates, it may be preferable to use as a policy indicator an aggregate that is systematically and negatively related to rates. However, the interest-rate elasticity of the demand for nonterm M3 is larger than that of other aggregates used as indicators in the past. This could cause problems in setting a target range for nonterm M3 because its growth would tend to be more volatile than that of the traditional aggregates.

As a final test of the usefulness of the term-nonterm distinction, the two pairs of equations estimated over the second period were simulated dynamically from 1981 to 1986. The results of these in-sample simulations were combined to yield two sets of simulated values of total M3. The monthly growth rates of simulated M3 were computed and compared with actual M3 growth. If the division of M3 along term-to-maturity lines were more meaningful, one would expect to find that the simulated values of M3 growth constructed from the simulation of the nonterm and term equations exhibit smaller errors than those constructed from the M2 and non-M2 equations.

The results of this test were inconclusive. Table 4 shows the mean errors and root mean squared errors from these simulations for each year. In four out of the six years since 1981, the term-nonterm decomposition yielded slightly more accurate (that is, lower mean error) forecasts of the annual growth rate of aggregate M3, but the differences are not large. In terms of root mean squared error, there was no difference between the two models' monthly forecasting accuracy.

V. Conclusions

Since de-emphasizing M1, the Federal Reserve has used the broader monetary aggregates – M2 and M3 – as indicators for policy. During the 1970s, the principal differences between these two aggregates was that the rates of return on the instruments in M2 were mostly regulated, whereas those on instruments outside M2 were unregulated. The deregulation of deposit rates since 1978 has ended this distinction.

This paper has examined an alternative pair of monetary aggregates formed by decomposing M3 into assets that have a stated term to maturity and those that do not. Instruments with a stated maturity are described as term assets, while those with no set maturity date are nonterm assets.

The distinction between nonterm and term assets is similar to that between money and debts used by Maynard Keynes in the discussion of liquidity preference in his *General Theory*. Keynes argued that all nonterm assets are similar because they give (more or less) immediate command over goods and services. Today, investors may substitute between nonterm instruments at low transaction costs and with little risk. Thus, nonterm M3 represents a grouping of similar types of assets.

The uniqueness of M2 (and of M1) appears to have resulted from the existence of regulatory ceilings on the yields that depository institutions paid on their deposit liabilities. These rate ceilings not only gave investors an incentive to minimize the amounts of their wealth held in the regulated instruments, all of which were contained in M2, but also made it impossible for depository institutions to use small time deposits as managed liabilities. With the removal of these rate ceilings, these unique features of M2 have disappeared. This aggregate now includes both term and nonterm instruments and both managed and nonmanaged liabilities; its components are no longer similar either from the viewpoint of their holders or their issuers.

Empirical estimates of the demand for nonterm M3 suggest that this "aggregate" has been somewhat more robust in the face of deregulation than the demand for M2, as would have been expected if the unique features of M2 were the result of regulation. While the interest rate elasticity of M2 has become small and insignificant in the aftermath of deregulation, the elasticity of nonterm M3 remains negative and highly significant. These results support the theoretical arguments for preferring nonterm M3 over M2 as a policy indicator, although the greater volatility of nonterm M3 could make it more difficult to set targets for this aggregate than for M2. These considerations suggest that both aggregates deserve to be monitored in the future.

FOOTNOTES

1. The Humphrey-Hawkins law does not require that the Federal Reserve's targets for the monetary aggregates be achieved, but only that the System explain to Congress the reasons for any revisions to or deviations from those plans.

2. Today, the sole remaining regulatory restriction on deposit yields is that depository institutions are not permitted to pay interest on traditional demand deposits. However, since most such deposits are held by businesses that receive implicit returns in the form of bank services provided below cost, even this restriction may not be a binding one.

Households have the option of either noninterest-bearing demand deposits or interest-bearing NOW accounts. Presumably those who select the former do so because of lower fees or minimum balance requirements and thus are, in effect, receiving an implicit return that exceeds the explicit yield they would earn on a NOW account. The regulatory ceiling on demand deposits therefore is not a binding constraint on households either. Hence, the only effective interest rate "restriction" is the zero return on the public's holdings of currency.

3. Some evidence that the changed behavior of M1 may be attributed to the process of deregulation is presented in John P. Judd and Bharat Trehan, "Portfolio Substitution and the Reliability of M1, M2 and M3 as Monetary Indicators," *Economic Review*, Federal Reserve Bank of San Francisco, Summer 1987.

4. The relation between the growth of M1 and the behavior of real GNP and prices also appeared to go off track in 1982-83. Although at the time this led the Federal Reserve to deemphasize M1 in its policy deliberations, there is strong evidence that the "great velocity decline" was not caused by a shift in the demand for M1 but rather by the unusually sharp decline in nominal interest rates associated with the winding down of inflation in 1982. See John P. Judd and Brian Motley, "The 'Great Velocity Decline' of 1982-83: A Comparative Analysis of M1 and M2," *Economic Review*, Federal Reserve Bank of San Francisco, Summer 1984.

5. The rationale for the present definitions of the aggregates is discussed in Thomas D. Simpson, "The Redefined Monetary Aggregates," *Federal Reserve Bulletin*, February 1980.

6. These assets still are not perfect substitutes since the instruments outside M2 are not federally insured, whereas small time deposits are insured.

7. See, for example, John P. Judd, Brian Motley and Bharat Trehan, "Financial Change and the Design of Monetary Policy: Lessons from the U.S. Experience," paper presented for the Seventh Pacific Basin Central Bank Conference on Economic Modeling, Reserve Bank of Australia, Sydney, Australia, 1986; Judd and Trehan, "Portfolio Substitution...," *op. cit.*; and Judd and Trehan, "Velocity in the 1980s: An Analysis of Interactions among Monetary Components," paper presented at Western Economics Association International Conference, Vancouver, B.C., July 1987.

8. See Judd and Trehan, "Portfolio Substitution...," *op. cit.*, 1987.

9. This second correlation coefficient excludes the credit control period, from March to July 1980, and the period immediately following the introduction of Money Market Deposit Accounts and Super-NOW Accounts, from December 1982 to February 1983.

10. See footnote 9.

11. See footnote 9.

12. If the Federal Reserve were to follow a policy of closely controlling the growth of total M3, *any* pair of components of this aggregate would tend to be negatively correlated, and it would be difficult to draw conclusions from these charts and correlations. In fact, however, although the System has set annual targets for M3, it has not conducted policy with a view to controlling its growth closely in the short run.

13. Judd and Trehan, "Portfolio Substitution...," *op. cit.*, 1987.

14. For a careful discussion of the rate-setting behavior of depository institutions in recent years, see Richard D. Porter, Paul A. Spindt and David E. Lindsey, "Econometric Modeling of the Demands for the U.S. Monetary Aggregates: Conventional and Experimental Approaches," paper presented at the Seventh Pacific Basin Central Bank Conference on Economic Modeling, Reserve Bank of Australia, Sydney, Australia, 1986.

15. John Maynard Keynes, *The General Theory of Employment Interest and Money*, London, Macmillan, 1936.

16. Not all economists have taken this approach. Milton Friedman, for example, has consistently argued that money should be defined broadly.

17. See, for example, the quotation from the *General Theory* at the beginning of this article. Although Keynes did not say so specifically, it is clear that his concept of "money" was not limited to assets yielding a zero or regulated rate of return. No such regulations existed in Britain at the time Keynes was writing the *General Theory*.

18. "If the current rate of interest is positive for debts of every maturity, it must always be more advantageous to purchase a debt than to hold cash as a store of wealth," *General Theory*, p. 169. Keynes is assuming here that the yield on money is zero and also that there are no transaction costs in buying or selling securities. If money bears interest or if there are costs involved in exchanging securities for money, investors may have an incentive to hold money even if securities provide a positive return with no risk. The role of transaction costs is discussed in more detail below.

19. The speculative motive has "the object of securing profit from knowing better than the market what the future will bring forth," *General Theory*, p. 170.

20. In the *General Theory*, Keynes uses the phrase "precautionary motive" in two senses. In his early discussions of liquidity preference (Chapter 13), he stresses the uncertainty of future rates of interest as a motive for holding a portion of total wealth in the form of money. Later (Chapter 15), he ascribes the precautionary motive to uncertainty with regard to future spending streams.

21. For a theoretical discussion of this motive, see David E. W. Laidler, *The Demand for Money: Theories, Evidence and Problems*, Third Edition, New York, Harper and Row, 1985, pp. 64-69.

22. Keynes did recognize the role of these costs but chose not to analyze them in detail. For example, in a clear reference to what later economists described as "transaction costs," he pointed out that "there is no need to hold idle cash...if it can be obtained without difficulty at the moment when it is actually

required," *General Theory*, p. 196.

23. That is, there is no *interest rate risk*. In the case of uninsured deposits, there is some default risk, whether these are nonterm or term assets.

24. Several types of nonterm assets available (for example, money market deposit accounts and money market mutual funds) permit a limited number of payments or funds transfers to be made each month by check or electronically. Thus, the "shoe-leather" or "inconvenience" costs of liquidating these assets are small.

25. This may be because increases in deposit rates on nonterm deposits must be paid to *all* holders, whereas higher yields on time accounts apply only to new holders. This explanation suggests that banks should respond more slowly to increases than to decreases in market yields. There is some evidence that in setting their offering rates on MMDAs and NOW accounts, banks move more rapidly to reduce their offering rates when market rates fall than they do to increase them when market rates rise. See Porter, Spindt and Lindsey, "Econometric Modelling of the Demands for the U.S. Monetary Aggregates...," *Opus cit.* However, this conclusion is based on only a short sample period, during most of which interest rates were falling.

26. Initially this was done by tying the regulatory ceilings on deposit rates to the yields on market instruments rather than by completely abolishing them.

27. Complete deregulation of all time deposits with maturities of more than 7 days occurred in October 1983.

28. Before 1978 the non-M2 component of M3 consisted entirely of deregulated instruments, but the term component included a mixture of regulated and deregulated assets.

29. That is, three dummy variables were included in the estimated equations that took the value one in December 1982, January 1983, and February 1983, respectively, and zero at all other dates. Preliminary equations indicated that additional dummy variables for later dates were not statistically significant, implying that both the public and depository institutions adjusted rapidly to the authorization of the new instruments.

30. David F. Hendry, "Predictive Failure and Econometric Modelling in Macroeconomics: The Transactions Demand for Money" in P. Omerod (editor), *Economic Modeling*, London 1979.

The advantage of this specification is that it does not require the long sample period needed for the estimation of explicit distributed lags, but it implies fewer restrictions on the response of money demand to its determinants than the partial adjustment model. In particular, the error-correction model allows changes in the macroeconomic variables to have a short-run impact on money demand that may differ from their long-run equilibrium effect.

31. In the MPS model of the U.S. economy, for example, which is estimated using quarterly data, the demand to hold the non-M1 component of M2 is assumed to be linearly homogeneous in nominal wealth. In that model, changes in the stock of wealth due to current savings and to changes in the value of equities both are assumed to have short-run impacts on the proportion of wealth held in the form of non-transactions M2. See Flint Brayton and Eileen Mauskopf, "The Federal Reserve Board MPS Quarterly Econometric Model of the U.S. Economy," *Economic Modelling*, Volume 2, Number 3, July 1985.

32. To provide a rough test of the role of wealth in the demand for the aggregates, a monthly wealth series was constructed from the quarterly data by interpolation. When this series was added to the equations estimated in Tables 2 and 3, neither the level nor the growth rate of wealth was statistically significant. However, this lack of significance may have been due to the crudeness of the measure of wealth used. Further research is planned in this area.

33. In an attempt to deal with this problem, the preliminary equations were estimated using both the *average* return and the *maximum* return on the instruments in each aggregate as measures of the own-rate. In addition, the equations were estimated both using the own and market rates as separate variables and using the spread between these rates as a single variable. None of these various approaches yielded fully satisfactory results.

34. Obviously the extent and speed of this response has changed as deposit rate ceilings have been progressively removed.

35. The same approach was used in Judd and Motley, "The Great Velocity Decline...," *op. cit.*

36. As pointed out earlier, since the estimated equations include no explicit wealth variable, changes in the interest rate also may proxy for the effects on money demand of changes in the market value of investors' portfolios of wealth.

37. An argument similar to the following one also has been applied to the demand for M1. See John P. Judd and John L. Scadding, "Liability Management, Bank Loans and Deposit 'Market' Disequilibrium," *Economic Review*, Federal Reserve Bank of San Francisco, Summer 1981.

38. For each aggregate, the change in bank loans is scaled by the level of the aggregate in the preceding month. The variable included is of the form:

$$\triangle LOANS_t = (\text{Bank Loans}_t - \text{Bank Loans}_{t-1})/M_{t-1}$$

where M represents the appropriate monetary aggregate. This scaling of the loans variable ensures that it has the same dimension as the dependent variable of Equation 3.

39. In particular, the adjustment to equilibrium would be immediate if g were unity and h_p, k_q and m_s all were zero.

40. Arnold Zellner, "An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias," *Journal of the American Statistical Association*, Vol. 57, June 1962.

41. In Tables 2 and 3, the long-run effect of the market interest rate is represented by the coefficient on the lagged interest rate *level*; this coefficient corresponds to the parameter c in Equation 3. The interest rate elasticity is this coefficient multiplied by the level of the interest rate. The average level of the commercial paper rate was 6.2 percent in the first sample period and 10.3 percent in the second period. The short-run impact of the interest rate is given by the coefficients on the current and lagged *changes* in the rate (△CPI).

42. In Tables 2 and 3, the long-run income elasticities are represented by the coefficients on lagged income. These coefficients represent the parameter b in Equation 3. The short-run

impact is represented by the coefficients on the change in income ($\Delta \log Y$). The coefficients on the change in income were small and statistically insignificant in the equations for both term and non-M2 M3 in both sample periods. Hence, this variable was excluded from the equations reported in the tables.

43. The F-statistics for the hypothesis that the estimated coefficients did not change between sample periods were:

Nonterm M3	2.27
Term M3	2.56
M2	3.61
Non-M2 M3	2.11

The critical values for rejecting the hypothesis at the five percent level of significance are 2.54 in the case of term M3 and non-M2 M3 and 2.63 in the case of nonterm M3 and M2.

44. The F-statistic for rejection the hypothesis of constant coefficients was larger in the case of term M3 and just significant at the five percent level. See footnote 43.

45. This may be because for many investors the main substitutes for nonterm assets are small-denomination time deposits. When the yields on both nonterm assets and small time deposits were regulated, changes in market rates had no impact on them and thus did not cause much shifting of funds. Since deregulation, variations in market rates cause larger and faster changes in time deposit yields than in nonterm deposit rates, so making the demand for nonterm assets more responsive to interest-rate changes.