# A Probabilistic Approach to Early Warning of Changes in Bank Financial Condition

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The subject of early warning is one that challenges our understanding of the nation's financial system. In the perspective of the strains imposed on banks by virulent inflation and severe recession during the past few years, it is clear that improved methods of early detection of financial weaknesses in our banking system could help bank regulatory authorities to anticipate and mitigate future problems. An effective early warning system could make a substantial contribution to a more smoothly functioning financial system.

The Federal Reserve Bank of New York has for some years had under study statistical techniques to assist in the supervision of banks in the Second Federal Reserve District. This research has been aimed at the development of early warning indicators from financial reports that banks file routinely with regulatory agencies. The results thus far strongly suggest that substantial improvements in the allocation of supervisory resources could be achieved by focusing attention primarily on banks designated vulnerable by the criteria set forth in the early warning procedures. These procedures also can provide estimates of the probability that any single bank will, under varying economic circumstances, develop severe financial weakness at some future date. Earlier investigations have been described in the September 1974 and July 1975 issues of the Federal Reserve Bank of New York *Monthly Review*. This article brings those reports up to date and comments more broadly on the role that early warning research can play in improving bank supervision.

## EARLY WARNING AS AN AID TO SUPERVISION

The financial turbulence of the 1970's clearly highlighted an important new dimension of the problems of bank supervision. The failure of the United States National Bank of San Diego, the Franklin National Bank, and the Security National Bank dramatized the consequences of high risks and imprudent management, if not fraud, even for large institutions. Each of these banks had assets in excess of $1 billion. While failures on this scale have been relatively few, the general problems that have surfaced in banking in recent years clearly indicate that large banks are not immune to failure and that improved techniques of spotting financial deterioration at an early stage could make an important contribution to the stability of our financial system.

Many of the problems that have affected banks in recent years are the direct result of the twin shocks of severe inflation and recession. In some cases, a willingness to extend the normal limits of risk taking for the sake of enhanced profits during the 1960's and early 1970's contributed to a degree of risk exposure which, in retrospect, proved to be unwise. Clearly, banks must be prepared to take risks if they are to serve the financial needs of the nation's economy, but these risks must be tempered by the public's interest in a sound and stable banking system, since the potential costs of widespread instability in banking extend far beyond the banks directly concerned.

The achievement of an appropriate balance between risk taking and the preservation of comfortable margins of safety with respect to earnings, capital, and liquidity is a goal that both bankers and bank supervisors have a vital stake in pursuing. From this point of view, it is

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important to recognize what bank supervisors have always known: that on-site examinations provide accurate insight into developing, as well as actual, financial problems at banks. The experience of supervisors and the results of financial research indicate that financial deterioration typically does not occur overnight. A decline in earnings, capital, liquidity, and asset quality and inadequate management, as reflected in poor internal controls and auditing procedures, usually develop over a period of time. Thus, regularly scheduled bank examinations normally would uncover these adverse developments.

Regular examinations not only probe a bank's financial condition but also provide valuable information on whether banks are complying with regulatory policies and procedures. An on-site examination has strong precautionary and psychological influences on a bank and is the major cutting edge of supervisory policy.

There are, nonetheless, a number of factors that make an effective statistical early warning system important for responsive and efficient bank supervision. First, significant changes in a bank's management policies and financial condition can occur between examinations. Second, an on-site examination is a lengthy and expensive process and not always the most cost-effective method of tracking small, but important, changes in a bank's financial condition. Third, although examiners generally are sensitive to developing trends that indicate potential future management or financial problems and normally comment on such matters in their reports, they must necessarily emphasize their findings concerning the actual condition of the bank rather than the estimated impact of potential problems. Fourth, an examiner's findings are part of the official record and could provide the basis for enforcement or other supervisory actions. In contrast, statistical early warning measures can be informal, affording the opportunity for experiments with techniques to uncover financial weakness at its earliest stages.

In short, early warning analysis can be a valuable adjunct to the process of bank examination and supervision. By providing accurate and timely information on changes in bank financial condition between examinations, it could make possible a more efficient use of supervisory resources. Moreover, an efficient early warning system can be a useful tool of analysis in the ongoing appraisal of bank financial condition.

## DETECTING POTENTIAL DETERIORATION

Early warning research at the Federal Reserve Bank of New York has recently focused on the problem of detecting potential financial deterioration in banks rather than on studying the characteristics of banks that have already undergone severe deterioration. This approach required a substantial modification of the methodology employed in the earliest stages of the project.[1]

Measures of vulnerability were investigated, using financial data that are reported routinely to bank regulatory agencies, so that the condition of banks could be closely monitored in periods between scheduled on-site examinations. A number of financial variables were selected for testing. These were variables that past experience had indicated were closely associated with financial strength or weakness. The objective was to find the smallest set of variables that could be used to detect early signs of financial deterioration. Since overall economic conditions can have a substantial impact on a bank's ability to withstand unexpected shocks or strains, the analysis was structured to take into account the external environment.

For each variable employed, a standardized deviation was computed for every bank. The values of the variables were compared with the averages for all member banks in the District, and the differences were divided by the respective standard deviations of each of the variables. The resulting standardized deviations were added algebraically to form an overall bank score in which the component variables were weighted equally. A score was obtained for each member bank from financial data for an appropriate base year. We expected that the higher the bank score the more resistant the institution would be to adverse economic or financial developments while the lower the score the greater its vulnerability.

The performance measure thus obtained for any given base year promised to provide a stable indication of financial strength or weakness for all member banks in the Second Federal Reserve District. The 350 or so member

[1] See Leon Korobow and David P. Stuhr, "Toward Early Warning of Changes in Banks' Financial Condition: A Progress Report", *Monthly Review* (Federal Reserve Bank of New York, July 1975), pages 157-65. See also David P. Stuhr and Robert Van Wicklen, "Rating the Financial Condition of Banks: A Statistical Approach to Aid Bank Supervision", *Monthly Review* (Federal Reserve Bank of New York, September 1974), pages 233-38; Joseph F. Sinkey, Jr., and David A. Walker, "Problem Banks: Identification and Characteristics", *Journal of Bank Research* (Bank Administration Institute, Winter 1975); Joseph F. Sinkey, Jr., "A Multivariate Statistical Analysis of the Character of Problem Banks", *The Journal of Finance* (American Finance Association, March 1975); Joseph F. Sinkey, Jr., "Early-Warning System: Some Preliminary Predictions of Problem Commercial Banks", *Proceedings of a Conference on Bank Structure and Competition* (Federal Reserve Bank of Chicago, May 1975), pages 85-91.

banks comprising this group included banks which varied widely in size, scope of banking business, and propensity for taking risks. Among these banks were a large number whose management policies were known to be conservative and whose balance sheets and income statements would lead most observers to conclude that they had a low tolerance for risk. The overall group also included a number of large banks, as well as many that were active practitioners of liability management.

We rejected performance comparisons based on banks that are similar in size and scope of banking activities. The risk exposure in a group of similarly situated banks might be uniformly high or low, and thus be misleading as a basis for determining the degree to which a particular bank might be vulnerable to economic and financial strains.

The scoring approach provides a means for comparing and tracking bank financial performance over varying periods of time. However, one of the main problems in applying these procedures to the supervisory process is the need for a link between the bank scores and an independent measure of a bank's soundness. In other words, it is important to know the significance of a low score and the degree of vulnerability indicated by progressively lower standings in the list of scores.

## MEASURING EFFICIENCY

One measure of the effectiveness of the procedures is suggested by the role of the bank score as an aid to bank supervision. That measure is the extent to which the bank scores in a base year provide an accurate indication of those banks that deteriorated seriously in subsequent years, as evidenced by receipt of a low rating from supervisory personnel.

The scoring procedure made it possible to divide Second District member banks into two groups—*i.e.*, resistant and vulnerable. This division suggested that the efficiency of supervision could be improved by allocating resources primarily to the banks designated vulnerable. The dividing line, in terms of bank scores, between the banks designated vulnerable and those designated resistant was drawn with the aid of a cost function that minimized the costs of two types of error—*i.e.*, drawing the line too high and examining more banks than necessary, and drawing the line too low, thus failing to identify banks that were likely to deteriorate or fail.

The cost of the first type of error for a given bank is based on its size, since the cost of examining a large bank usually far exceeds the cost of examining a small bank. The cost of the second type of error is assumed to be a large multiple of the cost of examining the bank and reflects the high social costs of failing to identify and to examine a bank that subsequently undergoes substantial deterioration.[2] The optimal dividing line between resistant and vulnerable banks is the one that minimized these costs.[3]

The gain in efficiency represents the reduction in examination expenses, less the cost of failing to identify correctly banks that subsequently deteriorated. In this article, the gain is expressed as the percentage reduction in costs from examining only banks designated vulnerable, compared with the costs of examining all banks annually, as at present. In the comparison, total costs are comprised of the costs of the two types of errors described above.

## AN EARLY WARNING FUNCTION

Using the cost function, it was possible to compare alternative sets of variables in terms of their value in identifying as vulnerable banks that would be given a low supervisory rating in a subsequent period. The set of variables that yielded the most efficient allocation of supervisory resources was selected after experimentation with many different combinations. The set of six variables discussed below was more efficient than any other combination tested thus far, including the twelve-variable combination employed in the July 1975 report. The six variables are shown in Table I, where the contributions to resistance and vulnerability are indicated by plus and minus signs, respectively.

The first variable, total operating expenses/total operating revenues, is a measure of a bank's ability to generate

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[2] We assumed that the cost of correct classification is zero. This implies that the examination costs associated with designating as vulnerable and, therefore, examining banks that deteriorated seriously is matched by the benefits of identifying the source of, and possibly arresting, the deterioration. See Korobow and Stuhr, *op cit.*, pages 160-63.

[3] The total cost of the two types of errors can be expressed as follows:

$$TC = \sum_{i=1}^{m} (\text{cost r:w})_i + \sum_{j=1}^{n} (\text{cost v:s})_j$$

where:

$TC$ = Total cost

$m$ = Number of banks receiving low summary ratings classified as resistant

$(\text{cost r:w})_i$ = Cost of classifying as resistant the $_i$th bank when it receives a low summary rating

$n$ = Number of banks with high or intermediate summary ratings classified as vulnerable

$(\text{cost v:s})_j$ = Cost of classifying as vulnerable the $_j$th bank when it retains a high or intermediate summary rating

Table I

THE SIX EARLY WARNING VARIABLES

| Variable | Sign* |
|---|---|
| Total operating expenses/total operating revenues | − |
| Total loans/total assets | − |
| Commercial and industrial loans/total loans | − |
| Provision for loss/total loans and investments | − |
| Net liquid assets/total assets† | + |
| Gross capital/risk assets‡ | + |

* A plus sign means that an increase in the value of the variable is indicative of resistance, a minus sign means that an increase in the variable is indicative of vulnerability.

† Net liquid assets are defined as United States Treasury securities maturing in less than one year plus Federal funds sold plus loans to brokers and dealers minus Federal funds purchased minus other liabilities for borrowed money.

‡ Gross capital = Equity capital plus capital notes and debentures plus loss reserves.
Risk assets = Total assets minus cash and due from banks minus United States Treasury securities.

revenues from normal banking operations and to control total expenses in an efficient manner. Operating expenses include all costs except securities losses or extraordinary items. The importance of this variable in relation to various measures of income or rate of return, which had proved less efficient, is that it reflects the limits on bank revenues imposed by market competition. Thus, internal cost control is an especially critical means of maintaining or increasing operating efficiency.

The next two variables—total loans/total assets and commercial and industrial loans/total loans—measure the risk of loss inherent in business lending. The inclusion of both variables is, in effect, a means of emphasizing different aspects of the bank's loan portfolio. Two of the six —provision for loss/total loans and investments and net liquid assets/total assets—are new variables. The former represents a measure of prospective losses envisioned by bank management in relation to the bank's overall loans and investments; the latter measures the bank's ability to meet unexpected deposit or other drains. Finally, the ratio of gross capital/risk assets is a modified version of an earlier measure of bank capital, the main function of which is to cushion losses.

The efficiency of the six variables in classifying banks as resistant or vulnerable is indicated in Table II. Two separate periods are shown: (1) base year 1969, identifying vulnerable banks in 1970-72, and (2) base year 1971, identifying vulnerable banks in 1972-74. In the first period, the inflationary boom in the economy generated a high level of loan activity and sustained many borrowers whose underlying financial position was not strong. Many banks, therefore, showed good financial results. In the latter period, severe financial strain and recession presented a stringent test of financial staying power for borrowers and lenders alike.

In each estimation period, the calculation to determine the most efficient cutoff score involved the comparison of each bank's score in the base year with its supervisory rating in the subsequent three-year period. A comparison was made of the gains and losses at various cutoff points.[4] At the optimal cutoff point, which gives the highest gain in efficiency, the six-variable early warning function produced a 47 percent increase in efficiency in the 1970-72 period and 42 percent in 1972-74. Moreover, about 87 percent of the banks that received low supervisory ratings in 1970-72 and 93 percent in 1972-74 were correctly identified as vulnerable in the respective base years.

These gains are well in excess of those that could be expected from following several naive decision rules for allocating supervisory resources. For example, Naive forecast 1 in Table II is based on the assumption that bank supervisory ratings will not change over the estimation period. This assumption gives rise to a decision rule that banks with high or intermediate supervisory ratings would not be examined annually. Only low-rated banks in the base year would be subject to annual examinations. This rule yielded a small gain in efficiency in 1970-72 and a substantial loss in 1972-74.

Naive forecast 2 is a broader rule that would exempt from annual on-site examination banks having the highest supervisory ratings. All banks with intermediate or low supervisory ratings in the base year would be examined annually. In this case, the gain in efficiency was much lower than the gain achieved using the optimal decision rule of the early warning function estimated over the period 1970-72 and was negligible over the period 1972-74. Thus, the early warning function developed from the six variables possesses a significantly greater capacity to isolate vulnerable banks than any simple rule based on the tendency of supervisory ratings to remain unchanged over time. The function is also more efficient than the simple assumption that severe deterioration among banks would

[4] A bank was considered to have had a low supervisory rating if it received a low rating in at least one of the three years subsequent to the base year, although it may not have received a low rating in all three years. In general, approximately three quarters of the banks that received low supervisory ratings during the periods studied had high or intermediate ratings in the base years.

be confined in subsequent periods to those banks with intermediate and low supervisory ratings in any base year. Of course, the value of early warning procedures in improving the efficiency of bank supervision depends on the applicability of the cutoff points, developed from past estimation periods, to the economic conditions expected in the future. Research conducted thus far indicates a good degree of stability.

### A PROBABILITY INTERPRETATION OF THE SCORING PROCEDURE

While the division of banks into resistant and vulnerable groups was useful in appraising the efficiency of alternative early warning functions, it made no distinction as to the likelihood that individual banks would deteriorate or fail in each group. A study of the bank scores for various base years indicated that many of the banks at the low range of scores subsequently deteriorated, although some did not, and a few that ranked high did meet difficulty. The outcome owed much to the composition of each bank's loan portfolio, the economic influences affecting the bank's borrowers, as well as its investments, and the capacity of bank management to adjust its financial position quickly and effectively to a changing economic environment. While these factors are reflected in the indicators of financial vulnerability that were employed, it must be emphasized that we are dealing with probabilistic events in the sense that many of the management initiatives that can strongly affect the soundness and future condition of both resistant and vulnerable banks cannot be forecast reliably.

Nonetheless, study of the bank scores and the location in the listing of banks that received low supervisory ratings in the period subsequent to the base year clearly indicates a high concentration of low-rated banks at the bottom of the list. This observation suggests that vulnerability increases with diminished financial performance as measured by the early warning indicators we employed. It also suggests that the bank scores can be translated into a probability estimate using regression methods.

In estimating the probability of banks receiving a low supervisory rating as a function of their scores, we constructed an "observed probability" for each member bank in the Second District. These probabilities were obtained by determining for banks whose scores were within a selected interval in the base year the proportion of banks that received low supervisory ratings over the estimation period subsequent to the base year.[5] That proportion was taken to be a proxy for the given bank's probability of receiving a low supervisory rating. The observed probabilities were then used as the dependent variable of a regression equation.

The purpose of the regression was to estimate the relationship between the bank scores and the observed probabilities. This relationship was assumed to be a continuous function, approaching zero for large positive scores and approaching one for large negative scores. Furthermore, the function was assumed to be monotonic, that

[5] The interval was one bank score unit on either side of each bank's score.

Table II

ANALYSIS OF GAINS IN EFFICIENCY FROM CLASSIFICATION OF BANKS INTO RESISTANT AND VULNERABLE GROUPS ON THE BASIS OF THE SCORING PROCEDURE

In percent

| Cutoff bank score based on: | Base year 1969: estimation period 1970-72 | | Base year 1971: estimation period 1972-74 | |
|---|---|---|---|---|
| | Percentage of banks having low supervisory ratings correctly identified | Gain in efficiency | Percentage of banks having low supervisory ratings correctly identified | Gain in efficiency |
| Optimal cutoff point | 86.8 | 47.2 | 92.9 | 42.2 |
| Naive forecast: 1* | 26.3 | 11.9 | 26.8 | —75.4 |
| Naive forecast: 2† | 89.5 | 31.7 | 75.0 | 7.6 |

*All banks with low supervisory ratings in the base years of 1969 or 1971 are assumed to retain these ratings in the subsequent three years, with no other banks receiving low ratings.

† All banks with low or intermediate supervisory ratings as of 1969 or 1971 are assumed to be vulnerable in the next three years. Banks with high ratings in 1969 or 1971 are assumed to be resistant.

Table III

ESTIMATED COEFFICIENTS OF THE ARCTANGENT REGRESSIONS

| Base year | Estimation period | Coefficients | | $\bar{R}^2$ |
|---|---|---|---|---|
| | | $a_0$* | $a_1$† | |
| 1969 | 1970-72 | −2.7 | −.62 | .94 |
| 1971 | 1972-74 | −1.9 | −.60 | .91 |

*Coefficents $a_0$ are constant terms.
†Coefficients $a_1$ relate changes in bank scores to changes in probabilities.

is, for any two banks the one with the lower score (meaning that it is more vulnerable) should have a higher probability of receiving a low supervisory rating subsequent to the base year.

A conveniently available trigonometric function having the required properties is:

$$P_i = 0.5 + \frac{1}{\pi} \arctan (a_0 + a_1 S_i),$$

where $P_i$ is the probability that each bank will receive a low supervisory rating, $a_0$ and $a_1$ are the coefficients to be estimated from the regression, and $S_i$ is each bank's score. A simple transformation yields an equation that can be estimated using linear regression techniques:

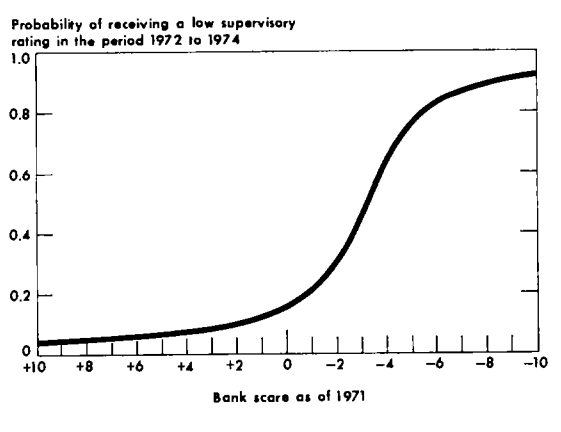
$$\tan (\pi(P_i - 0.5)) = a_0 + a_1 S_i$$

Changes in the value of $a_0$ shift the curve to the left or right, without changing the function's shape, while a larger absolute value of $a_1$ increases the steepness of the curve (see chart).[6]

The estimated coefficients of the arctangent regressions for the base year 1969 (estimating probabilities of deterioration in 1970-72) and the base year 1971 (estimating probabilities of deterioration in 1972-74) are shown in Table III. The fit is good in both periods, as indicated by values of $\bar{R}^2$ in excess of .90. While the $a_1$ coefficients, which relate changes in bank scores to changes in probability, are not significantly different, the constant terms, $a_0$, do differ significantly between the two base years. The shift appears to reflect overall changes in banking practices as well as differences in the external economic environment during those years. The lower negative value of $a_0$ in the later period suggests that banks faced a higher risk of deterioration or failure for any given level of bank score as a result of the generally more difficult economic and financial conditions at the time. The chart illustrates the relationship between bank scores and the probability of receiving a low supervisory rating, given the bank scores in the base year 1971 and the supervisory ratings assigned to these banks over the subsequent three years.

The probability function can be related to the earlier efficiency measurement in which banks were designated either as resistant or vulnerable, and supervisory resources were allocated primarily to the vulnerable group. Essentially what was done was to classify as vulnerable all banks whose probability of receiving a low supervisory rating was greater than a certain cutoff probability level. If these optimal cutoff points are translated into the probability of a bank receiving a low supervisory rating subsequent to the base year, then all banks with a probability of about 15 percent or greater would be

RELATIONSHIP BETWEEN BANK SCORES IN 1971 AND THE PROBABILITY OF RECEIVING A LOW SUPERVISORY RATING IN THE PERIOD 1972 TO 1974




[6] The choice of the arctangent function is arbitrary and was heavily influenced by convenience for programming the regressions. Other estimating procedures are being explored and will be reported on in subsequent papers. Of particular interest is logit analysis, a technique that treats the actual occurrence or nonoccurrence of an event as a dependent variable without the construction of observed probabilities. It also dispenses with the intermediate step of combining the independent variables into a single bank score; the relative weights of the variables in the estimated probability function are computed within the regression itself. The technique is described by Strother H. Walker and David Duncan, "Estimation of the Probability of an Event as a Function of Several Independent Variables", *Biometrika* (1967), and is applied to credit analysis in *The Journal of Commercial Bank Lending* (August 1974) by Delton L. Chesser.

Table IV

ANALYSIS OF GAINS IN EFFICIENCY FROM CLASSIFICATION OF BANKS INTO RESISTANT AND VULNERABLE GROUPS ON THE BASIS OF VARIOUS PROBABILITY LEVELS

In percent

| Cutoff probability level | 1970-72 | | 1972-74 | |
|---|---|---|---|---|
| | Percentage of banks having low supervisory ratings correctly identified | Gain in efficiency | Percentage of banks having low supervisory ratings correctly identified | Gain in efficiency |
| 10 | 94.7 | 34.3 | 96.4 | 14.1 |
| Optimal* | 86.8 | 47.2 | 92.9 | 42.2 |
| 20 | 55.3 | 34.7 | 75.0 | 25.6 |
| 30 | 39.5 | 19.5 | 58.9 | 6.6 |
| 40 | 21.1 | 3.4 | 41.1 | —41.1 |
| 50 | 15.8 | 3.2 | 26.8 | —74.8 |
| 60 | 13.2 | — 1.5 | 21.4 | —89.6 |
| 70 | 5.3 | —13.9 | 16.1 | † |
| 80 | 2.6 | —15.9 | 10.7 | † |
| 90 | 0 | —15.6 | 3.6 | † |

* For 1970-72 the optimal cutoff probability level was 13 percent; for 1972-74 it was 16 percent.
† Large loss.

considered vulnerable. As shown on Table IV, the efficiency of other specific probability levels can be determined. For example, the first line on the table indicates that, if banks with a 10 percent or higher probability of receiving a low supervisory rating were examined, the gain in efficiency relative to annual examinations would have been 34 percent in the 1970-72 period and 14 percent in 1972-74.

## FORECASTING SUPERVISORY RATINGS

The forecasting ability of the early warning function must be tested in periods that extend beyond those used to estimate the function. This test is not yet possible for the function estimated over the 1972-74 period, since the data for a comparable three-year period are not yet available. Nonetheless, we conducted preliminary tests, assuming economic conditions similar to those of 1972-74, and the results are encouraging. The results of one test are shown in Table V. Using the function computed over the period 1971-74, the estimated probability of a bank receiving a low supervisory rating in 1975-77 was obtained for each Second District member bank, based on 1974 financial reports. The banks were classified into five ranges of probabilities. We expected that the proportion of banks that actually received low supervisory ratings in 1975 would increase as the range of estimated probability increased to higher levels. Table V shows that this is in general what happened, although 1975 represented only one third of the forecast period. Only 2.2 percent of the banks with probability estimates of 20 percent or less received low ratings in 1975, but 41.5 percent of banks with probability estimates of 80 percent or more had low ratings.

Since this test included some banks that had low supervisory ratings not only in 1975, but also in earlier years on which the function was originally estimated, a further test was conducted. In this test, low-rated banks in each probability range were included only if they had received low supervisory ratings for the first time in 1975. These are the banks that, on the basis of a naive decision rule employed in 1974, might have been expected to continue to receive high or intermediate supervisory ratings in 1975. The third column of Table V shows that only 0.7 percent of the banks in the probability range of 20 percent or less received low supervisory ratings for the first time in 1975, compared with 19.5 percent for those with probabilities of over 80 percent. More than half the banks that received low supervisory ratings for the first time in 1975 were in the highest probability range in 1974. This test, while rough and based on the relatively small number of banks that received low supervisory ratings in 1975, suggests that the early warning function has a significant capability for identifying vulnerable banks in years subsequent to the estimation period.

Table V

PERFORMANCE OF AN EARLY WARNING FUNCTION IN PREDICTING BANKS LIKELY TO RECEIVE LOW SUPERVISORY RATINGS IN 1975

In percent

| Estimated probability of receiving a low rating as of 1974* | Percentage of the banks in various probability ranges as of 1974, which: | |
|---|---|---|
| | Had a low supervisory rating in 1975† | Received a low rating for the first time in 1975‡ |
| 0 to 20 | 2.2 | 0.7 |
| 20 to 40 | 10.2 | 1.5 |
| 40 to 60 | 17.3 | 6.9 |
| 60 to 80 | 16.1 | 6.5 |
| 80 to 100 | 41.5 | 19.5 |

* Assumes an economic environment similar to that of 1971-74. Probability estimates are derived from 1974 financial statements of Second District member banks.
† All banks with low supervisory ratings in 1975, regardless of previous ratings.
‡ Banks with low supervisory ratings in 1975 that did not have low ratings in 1974.

## CONCLUDING REMARKS

The probability approach shows considerable promise as a useful guide to the degree and intensity of supervision appropriate for banks within an overall group designated vulnerable in any base year. Those banks with relatively high probabilities of deterioration could be considered candidates for the most immediate and intensive supervisory attention. However, to achieve substantial overall gains in efficiency, supervisory resources must also be allocated to banks with relatively low probabilities of deterioration subsequent to the base period. While the precision and efficiency of the forecasts can be expected to improve with more sensitive measures to detect financial weakness at an early stage, some uncertainty is bound to remain in view of the probabilistic nature of financial early warning systems.

New approaches are in process of development. For example, we are exploring methods to estimate the probabilities of failure or a low supervisory rating directly from the early warning variables involved without the intermediate step of the bank score. This change involves a specific weighting of variables and may lead to improvements in the sensitivity of the probability functions. A great deal more must be done to sharpen the measures employed as early warning indicators, thus ensuring that future areas of weakness do not escape unnoticed.

There is also a need in early warning research for a far more thorough analysis of the structure of bank loan portfolios than has been available thus far. In particular, the consequences of industry or geographic concentrations of loans and investments during a period of adverse economic or financial developments are areas that deserve careful study. The balance-sheet and income data which banks are now providing in greater detail and frequency should prove valuable in future early warning research. We are optimistic, however, that the approaches outlined here can do much to assist bank supervisors in spotting potentially vulnerable banks before the problems of these institutions threaten their viability.