Toward Early Warning of Changes in Banks' Financial Condition: A Progress Report

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It has always been the responsibility of bank supervisors to identify and investigate a weakening financial situation at any bank under their jurisdiction and to require bank management to take remedial action. An important supervisory aid in fulfilling this responsibility is the on-site examination, and practically all the nation's banks are subject to on-site examinations at regular intervals. Yet, it is clearly desirable for bank regulatory authorities to have current information on a bank's underlying financial condition in the periods between examinations. To some extent, this need is met by the detailed balance-sheet and operating data that are reported by the banks to regulatory authorities and by other financial information which is available generally. Recently this current financial information has begun to be probed systematically for possible use in developing early warning indicators to assist bank supervisors. The events of the recent past, when a few large banks had to be absorbed by other banks, have reemphasized the need for a continuing effort to improve our techniques for identifying a deteriorating situation at an early stage.

The Banking Studies Department of the Federal Reserve Bank of New York has been engaged in ongoing research to develop a statistical procedure that would aid in the evaluation of the financial soundness or weakness of banks from a specific set of financial variables. The initial results of these efforts, reported elsewhere, are promising.[1] In brief, they show that financial variables obtained from empirical data can be used in a discriminant function to distinguish, with a high degree of accuracy, between banks that were accorded high summary (or composite) ratings by bank supervisory authorities and banks that were given low summary ratings.

The purpose of this paper is to report the results of further research into the use of statistical procedures, including discriminant analysis, to provide bank supervisory authorities with advance warning of possible deterioration in the financial condition of banks under their jurisdiction. The overall thrust of our research has been to identify banks that are potentially vulnerable to financial difficulty, compared with those that can be considered resistant. One of our aims is to provide an indication of a bank's ability to withstand adverse economic or financial developments from data that are regularly available without an on-site examination. Through these approaches, we believe efficiencies can be achieved in the allocation of supervisory resources devoted to preserving and encouraging a sound and competitive banking system. The results thus far indicate that the statistical

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[1] See 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. See also Joseph F. Sinkey, Jr., and David A. Walker, "Problem Banks: Identification and Characteristics", *Journal of Bank Research* (Bank Administration Institute, Winter 1975), and Joseph F. Sinkey, Jr., "A Multivariate Statistical Analysis of the Character of Problem Banks", *The Journal of Finance* (American Finance Association, March 1975).

procedures described in this article can make a significant contribution to this objective.

HOW DISCRIMINANT ANALYSIS CAN BE USED TO CLASSIFY BANKS

The latest results of the discriminant project are very much an outgrowth of the work described in the September 1974 *Monthly Review*. It is useful, therefore, to summarize how discriminant analysis was applied in the earlier research. In brief, discriminant analysis is a procedure for studying two or more distinct groups of observations. This process involves the estimation of an equation that simultaneously takes into account the effects of the variables considered to be important in distinguishing between the groups. Once the equation is estimated, it can be used to classify individual observations in a group by multiplying the values of the variables in the equation by their respective coefficients and obtaining a "discriminant score" for the particular observation. The discriminant score determines the group into which the observation is classified.[2]

The coefficients for the variables are determined so as to maximize the squared difference between the mean scores of the groups, relative to the degree of variability of the scores within each group. A small difference in means, relative to this variability, will result in a large overlap between the distributions of the discriminant scores and a relatively high probability that the function will not classify correctly.

In the early phase of the work, banks that received a high summary rating ("1") from Federal Reserve Bank of New York supervisory personnel over a specified period formed a group of banks considered financially sound, and banks that received a low ("3" or "4") summary rating were considered the weak group. A sample of banks from each of these two respective groups was chosen, and various data pertaining to these banks were employed to estimate a discriminant function. (Banks with intermediate ("2") summary ratings were not used to estimate the function.) With the sample data chosen, a discriminant function was estimated by means of a computer program that calculated weights for the given set of financial variables being used in the function. Once the function was computed, it was used to calculate a discriminant score for each member bank in the Second Federal Reserve District. Since the analysis was designed to separate two distinct groupings (*i.e.*, financially sound *vs.* weak), we expected —as proved to be the case—that the discriminant scores of banks given an intermediate summary rating by supervisory personnel (*i.e.*, a rating of "2") would, in general, fall between the scores of the high and low groups.

In this earlier work, the discriminant functions were obtained from data for 1967 and 1968. After studying the discriminating power of many types of variables thought to be important factors in determining financial soundness or weakness as defined by supervisory personnel, we concluded that eight variables yielded superior discrimination with respect to the ability of a discriminant function to distinguish between the two broad groups (*i.e.*, sound and weak) based on the summary ratings given banks by supervisory personnel. Several of these variables were intended to measure each of the factors considered by bank supervisors to be important determinants of bank soundness. For example, certain aspects of general bank management ability were included. Net income before taxes, as a percentage of total capital, and dividends, also as a percentage of total capital, were expected to reflect overall bank performance. Further, bank borrowing (*e.g.*, gross purchases of Federal funds) as a percentage of total capital was designed to capture one type of risk exposure. Asset quality was measured by the ratio of classified loans and securities plus one half of specially mentioned loans to total loans and securities. (This information was obtained from examination reports of state-chartered member and national banks.) Capital adequacy was measured by the ratio of total capital to total assets. Three other variables were introduced to hold constant several major factors that could be expected to affect the financial condition of a bank: (1) total deposits, suggesting that a large bank can benefit from portfolio diversification and, with its greater resources, may be in a position to attract highly qualified personnel; (2) net occupancy expense as a percentage of net income, introduced as a proxy for branch structure as well as the efficiency of that structure; and (3) the loan-asset ratio, to measure the risks inherent in the asset portfolio.

Earlier this year we employed these same discriminant functions, as estimated from data for 1967 and 1968, to obtain discriminant scores for the state-chartered member banks in the Second Federal Reserve District by entering 1974 data for the variables in the function. We had two purposes in mind: first, to test whether the same discriminant functions with coefficients developed from the data for 1967 and 1968 could distinguish the banks that had high summary ratings in 1974 from those that had low summary ratings and, second, to investigate in-

[2] See Stuhr and Van Wicklen, *op. cit.*, pages 235-36, and the references cited therein.

stances in which banks that had received high or intermediate summary ratings from supervisory personnel in 1974 nonetheless received low scores from the discriminant functions. In these latter cases, either the functions were in error or, on the contrary, were suggesting weakness in advance of a change in the banks' respective summary ratings.

With regard to the first objective, we found that the discriminant functions correctly classified all the banks with low summary ratings and virtually all the banks with high summary ratings. With regard to the second objective, we found that several banks having intermediate summary ratings in 1974 received low discriminant scores when 1974 data were entered for these banks in both the 1967 and 1968 functions estimated earlier. On further investigation we found that most of them were being subjected to special scrutiny by supervisory personnel. In general, our analysis indicated that the failure of the discriminant score to confirm a bank's current summary rating was cause for further investigation of the bank's condition, particularly when the discriminant score was suggestive of a weakening situation.

DEVELOPING AN EARLY WARNING PROCEDURE

PROBLEMS IN OBTAINING APPROPRIATE DATA AND SAMPLE BANKS. The experience with the 1967 and 1968 discriminant functions just described clearly showed that certain financial statistics can be used successfully to classify banks according to the summary ratings given by supervisory personnel. Moreover, these functions also demonstrated an ability to anticipate changes in a bank's summary rating. The apparent misclassifications of several banks that had not been given low summary ratings by supervisory personnel were validated when these banks' ratings subsequently were downgraded. Thus, there seemed to be significant evidence to suggest that there are decided differences between banks that are sound financially and likely to remain so for some time in the future and banks that, while enjoying a high or intermediate summary rating in any current period, may be vulnerable to deterioration in the future.

In extending the earlier research, our objective has been to develop a statistical procedure or function that could provide an accurate indication of a bank's "resistance" or "vulnerability" to financial difficulty in the future. The possible use of the earlier discriminant functions to identify banks that are either "resistant" or "vulnerable", however, raised a number of questions. First, it was evident that the quality-of-assets variable based on data from on-site examinations was very important in distinguishing banks with high summary ratings from those with low summary ratings in any current period. It was not clear whether resistance or vulnerability could be determined accurately from the information in an examination report many months old. Data for the quality-of-assets variable would normally be available only after an on-site examination was completed. Thus, it would usually not be possible to obtain discriminant scores more than once annually if such data were needed in the discriminant function.

One approach to remove the dependence on examination data was to investigate proxy variables for the quality-of-assets variable, *i.e.*, to use regularly reported financial data to obtain variables that were sensitive indicators of a potential decline in a bank's asset quality. We expected such variables to contribute to low discriminant scores for those banks that were vulnerable to general economic adversity and likely to be accorded low summary ratings in the future, even though the banks' current summary ratings might indicate high or intermediate appraisals by supervisory personnel. In other words, we reasoned that a good early warning function might be likely to accord low discriminant scores to banks with intermediate or even high summary ratings in the current period, if those banks evidenced vulnerability that could result in low summary ratings in the future.

A second problem in using the functions we estimated earlier deals with the samples that might be used to distinguish between banks that are resistant to financial difficulty and those that are potentially vulnerable. In the earlier work, discriminant functions were estimated from sample banks grouped according to high and low summary ratings awarded by supervisory personnel. A discriminant function based on the data of such sample banks might be expected to emphasize variables that are important in making that distinction. While it is reasonable to expect that banks with high summary ratings can be considered resistant to financial difficulty and banks with low ratings nonresistant, we believed it possible that sample data from such banks might tend to reflect differences that are important in simulating current summary ratings given by supervisory personnel. Since our goal is to detect banks that are vulnerable to a weakening in their financial condition in the future, rather than merely to simulate the current summary ratings determined by supervisory personnel, we decided to explore a method of defining resistant and vulnerable banks independently of these supervisory ratings. We expected that a sampling of banks that are relatively resistant to financial difficulty as distinguished from banks that are potentially vulnerable might yield different information than that obtained from bank samples based on high and low current summary ratings.

DEFINING RESISTANCE AND VULNERABILITY INDEPENDENTLY OF SUPERVISORY RATINGS. We investigated a number of financial variables, excluding data from examination reports, which most bank analysts and bank supervisors would agree are important indicators of bank performance and financial strength. Our initial set of variables included many that were studied at an earlier stage in estimating discriminant functions to classify banks according to their current summary ratings, whether or not these variables had proved useful in making that distinction. These variables were included in this analysis if there was a theoretical basis for believing that high or low values of the variable would be suggestive of resistance to financial difficulty or of potential vulnerability. For example, liquidity variables that had not proved useful in classifying banks in a current year by means of discriminant analysis were investigated on the grounds that bank illiquidity may indicate a willingness of bank management to undertake above-average risk. Further, the return on loans was added as a proxy for the quality-of-assets variable, since the former variable is likely to be correlated with, and possibly be a leading indicator of, actual loan losses. A higher than average nominal return can represent compensation for possible increased losses in the future if economic conditions become adverse. The full set of variables, described below, is intended to be sensitive to a bank's: (a) management quality, as indicated by income earned and dividends paid; (b) efficiency, as indicated by operating expenses in relation to revenues; (c) capital adequacy, as reflected in gross capital to total assets and in gross capital to total loans; (d) risk exposure, as reflected in the bank's use of Federal funds and other such borrowed funds, but exclusive of certificates of deposit, average interest cost of time and savings deposits, the level of total loans in relation to total assets, the rate of return on loans, and the ratio of commercial and industrial loans to total loans; (e) liquidity, as reflected in a bank's holdings of United States Government securities; and (f) size, as measured by total deposits.

The variables described above were employed to define two distinct groups of banks, one that is resistant to adverse economic conditions and one that is vulnerable, without resort to supervisory ratings.[3] In using specific variables for this purpose, we expected that the independent effects of certain of them (those listed below denoted by a plus sign) would be positively associated with resistance to financial difficulty, while others (denoted by a minus sign) would be positively associated with vulnerability.

(1)	Net income before taxes/Total capital	+
(2)	Dividends/Total capital	+
(3)	Gross capital/Total assets	+
(4)	Holdings of Government securities/Total assets	+
(5)	Size, in terms of deposits	+
(6)	Operating expenses/Total revenues	−
(7)	Loans/Gross capital	−
(8)	Gross Federal funds purchased and other such borrowed funds/Total capital	−
(9)	Loans/Total assets	−
(10)	Commercial and industrial loans/Total loans	−
(11)	Rate of return on loans (as a proxy for risk)	−
(12)	Average interest rate paid on time and savings deposits	−

These variables were combined by means of a relatively simple index procedure. First, we calculated the mean and standard deviation of each variable in order to obtain a measure of each bank's performance in relation to a large number of other banks with respect to the particular variable. Then we subtracted from the specific value of each variable for each bank the overall mean of that variable and divided the result by the standard deviation. The resulting standardized deviations were summed for each bank.[4] The sums then were arrayed from highest to lowest, forming a ranking in which we expected the resistant banks to be at the top and the vulnerable banks at the bottom. This ranking was used in two ways, as described further below: (1) to place banks with low rankings in a group designated as vulnerable and to place banks with high rankings in a group designated as resistant and (2) to obtain samples of banks from which a function was estimated for the purpose of dividing banks into these two groups.[5]

[3] The variables just described are not meant to be an exhaustive list of indicators of resistance to financial difficulty or vulnerability. It is likely that other variables may be important discriminators.

[4] This procedure implies an equal weighting of all the variables.

[5] The discussion of these two groups does not include an independent test of resistance or vulnerability, but rather focuses on how this approach can improve the efficiency with which supervisory resources are allocated.

THE PERIOD AND THE DATA. The period studied covered 1969 to early 1975, years in which there were significant financial strains in our economy and a deterioration in the financial condition of some banks that consequently were given low summary ratings. Financial data were obtained from the Reports of Income and Reports of Condition for all banks in the Second Federal Reserve District for 1969-71. Information from examination reports was employed for 1968.[6] In addition, the summary ratings for all the member banks in the Second District were obtained from Federal Reserve Bank of New York supervisory personnel for the period 1969 to early 1975.

SEPARATING BANKS INTO VULNERABLE AND RESISTANT CLASSES. Several alternative procedures were employed to divide all the member banks in the Second Federal Reserve District into two groups—*i.e.,* resistant and vulnerable—in each of the several selected years. The multivariate ranking, based on the twelve variables described earlier, and a function based on that ranking were used to separate banks into resistant and vulnerable groups in each of those years. In addition, for comparative purposes, discriminant functions were estimated from a sample of banks that were given high and low summary ratings by supervisory personnel in the selected years. One function employing examination data was estimated for 1969, and one without such information was estimated for each of the years 1969, 1970, and 1971. All these procedures yielded discriminant or rank scores for all the member banks in each of the years studied.

Once these scores or rankings were obtained, it was necessary to determine a cutoff point that divided the banks into the two groups. Before describing in detail how this cutoff point was determined, it is useful to note that the separation between banks deemed resistant and those considered vulnerable can be expected to be imperfect. Thus, any decision rule establishing a cutoff point between resistant and vulnerable banks will be associated with a particular probability that some banks which are financially resistant will be included in the vulnerable group, and a particular probability that some banks which are vulnerable will be included in the resistant group. Given the probability of error, the decision rule involves some judgment of the relative importance to bank supervisors of avoiding such misclassification errors.

In specifying the relative importance of these misclassification errors, we recognized that the value to bank supervisors of the procedures we investigated had to be based on the ability to identify the banks that received low summary ratings from supervisory personnel over the period studied, including those that had low ratings in the initial year of the period as well as those that received low ratings in subsequent years. In this regard, we expected most of the banks receiving low summary ratings during the period studied would be in the bank group designated vulnerable, along with a number of banks having intermediate summary ratings and perhaps a very small number of banks with high summary ratings. In contrast, we expected the resistant group to consist of very few banks with low summary ratings, most of the banks with high summary ratings, and the remainder comprised of banks with intermediate summary ratings.

In aiming at this objective, we proceeded on the assumption that the cost of failing to classify as vulnerable a bank that subsequently received a low summary rating from supervisory personnel is considerably greater than the cost of misclassifying as vulnerable a bank that will retain a high or intermediate supervisory rating. It is clear that early warning of a weakening situation could facilitate the introduction of timely corrective measures which could help to preserve the institution in question as an ongoing entity. The social costs involved in a bank failure would seem far greater than the costs involved in investigating a potentially vulnerable bank only to find no evident signs of weakness.

Accordingly, we attached a high cost to the failure to identify a vulnerable bank that subsequently received a low summary rating, and these costs were deemed to increase with the size of the bank. These costs were considered substantially higher than the cost of misclassifying as vulnerable a bank that retained a high or intermediate supervisory rating. To help measure these costs, we established a cost function which reflected the estimated dollar costs of examining banks of varying size. That is, the cost function reflected not only the social costs involved in the failure to identify banks that subsequently deteriorated in financial condition, but also recognized that examining a large bank is much more costly than examining a small one. By this means, we ensured that the procedures employed would be likely to identify correctly a large percentage of the banks that received low summary ratings between 1969 and early 1975, although it also meant that the size of the bank group designated vulnerable would be relatively large, depending on the efficiency of the particular procedure.

[6] Examination data for member banks in the Second Federal Reserve District for 1969 instead of 1968 would have been more desirable, but these data were not readily available at the time of publication.

MINIMIZING THE COST OF CLASSIFICATION ERRORS. It is important to remember that no information was available in 1969, or in any of the initial years of the subperiods studied, regarding the probability of a function failing to include in the bank group designated vulnerable those banks that would actually receive low summary ratings in the subsequent years. We, therefore, made use of the distribution of the scores or rankings of the banks that subsequently received low summary ratings during each of the periods studied to establish a cutoff score that minimized the cost of misclassification errors. The use of this information in no way changed any of the scores or relative positions of the banks in the rankings.

The cost-minimizing cutoff score or rank was obtained for each of the procedures employed by calculating the cost of calling a bank vulnerable when, in fact, it subsequently retained a high or intermediate summary rating and the cost of assigning to the resistant group a bank that subsequently received a low summary rating. The cost was calculated for all decision rules, ranging from designating all banks as vulnerable to designating all banks as resistant. Each cost calculation assumed that all banks designated vulnerable would be examined and all banks deemed resistant would not be examined.[7] In each of the calculations the classification errors (*i.e.*, the percentage of banks called vulnerable that did not subsequently receive low summary ratings and the percentage of banks called resistant that did receive low ratings) were weighted by a factor from a cost function and the total cost of all the errors was calculated.[8] The cutoff score that minimized this cost was considered a guide to the efficiency of each of the procedures employed. To avoid possible bias in these calculations, all the sample banks from which functions were estimated were removed from the resistant and vulnerable bank groupings into which all member banks in the Second Federal Reserve District were divided by means of the scores obtained from those functions.[9]

POSSIBILITIES FOR GAINS IN EFFICIENCY IN THE ALLOCATION OF SUPERVISORY RESOURCES. Were supervisory resources allocated only to the bank group designated vulnerable—assuming that an efficient cutoff score could be obtained from past experience—the procedures described in this article could lead to sizable economic efficiencies, compared with examining each member bank once a year. Such annual examinations would be indicated by these procedures, if the discriminant scores or rankings of the banks that received low summary ratings were randomly distributed. The possible gains in efficiency are suggested by a comparison of the total costs of the classification errors from use of the procedures described in this article with once-a-year examinations of all banks,

[7] It is important to note that a bank's presence in the vulnerable group which did not subsequently receive low summary ratings is not necessarily an indication of error, inasmuch as the banks involved may have been vulnerable at the time of estimation of the function but, in the intervening years, improved their condition so that they would no longer be considered vulnerable if the function were reestimated. Further, a vulnerable bank may not manifest the signs of deterioration that would warrant a low summary rating from supervisory personnel as long as general economic or other conditions are favorable. Nonetheless, the vulnerability of banks is a matter of concern to bank supervisors, since any adverse change in the overall economic environment is likely to impact most severely on the banks that are vulnerable.

[8] The total cost of misclassification errors is as follows:

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

Footnote 8 (continued):
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 ith bank when it receives a low summary rating
n = Number of banks with high summary ratings classified as vulnerable
$(\text{cost v:s})_j$ = Cost of classifying as vulnerable the jth bank when it retains a high or intermediate summary rating.

We assumed that the cost of correct classification is zero. This implies that the examination costs associated with correctly classified vulnerable banks are at least matched by the benefits in arresting the deterioration. It is possible that such benefits exceed the cost of examination but, in the absence of a concrete measure of those benefits, we assumed that detection of a deteriorating situation offsets the examination costs. In effect, the v:s error results in conducting an examination when one was not required and the r:w error in the failure to conduct an examination when one was required. The cost of the v:s error for a given bank is based on the cost of examining the bank, and the cost of the r:w error is a multiple of the examination cost for the particular bank to reflect the greater social cost of the r:w error. To find the cost-minimizing cutoff point, the value of TC was computed for every possible decision rule, ranging from classifying all banks as vulnerable to classifying all banks as resistant for each function or procedure.

[9] The ability of each of the functions to identify banks that received low summary ratings was evaluated, in effect, on a "holdout" group. While biased results are likely where the same observations are chosen both to estimate and to test a function, the ranking procedure does not use the same criterion for choosing these two samples. Therefore, it was not theoretically necessary in connection with the function based on our ranking procedure to exclude the estimation sample from the test sample, though we did so nonetheless.

taking into account that examination costs and the cost of misclassification errors both are related to bank size.[10] It should be noted that the gain in efficiency does not represent a comparable percentage reduction in total examination costs; as noted earlier, the costs of examining vulnerable banks that receive low summary ratings are deemed to be offset by the benefits of detection, while the costs of failing to classify correctly a bank that subsequently receives a low summary rating are considered substantially higher than the costs of examining that particular bank.

Much would depend, of course, on reasonable stability in the relationships measured by the functions or bank rankings employed; the results described below suggest that there is such stability. However, the decision rule to examine only banks designated vulnerable is not realistic. It tends to overstate the relative gain in efficiency from adoption of the rule, since there would of necessity be a continuing need for some schedule of on-site examinations —probably less frequently than annually—to obtain firsthand information on the financial condition of other than vulnerable banks and to implement corrective measures where needed. In addition, supervisory authorities might wish to examine certain vulnerable banks more frequently than once a year, so that implicit cost savings would be realized through more effective use of supervisory resources rather than through reductions in actual expenditures. Nonetheless, the standard employed is a useful base for evaluating the efficiency of the approaches discussed in this article.

THE RESULTS OF ALTERNATIVE PROCEDURES

Four functions or procedures, each falling into one of two categories were tested for their ability to identify banks that received low summary ratings in the period 1969 through early 1975. Two functions were estimated from sample data obtained from banks that had either high or low summary ratings as determined by supervisory personnel in 1969 and in the initial years of several subperiods. These we called the Exam functions.[11] Further, a rank index and a function were obtained from our multivariate ranking procedure. While we believe the results are suggestive of the efficiencies that could be realized in the allocation of supervisory resources, we note that the details of the procedures discussed here are by no means exhaustive of the possibilities and that we have not explored fully the ability of each of the functions or procedures to provide early warning over varying periods of time.

Exam-1. Using pooled data for state-chartered member banks and national banks in the Second Federal Reserve District for 1969, we reestimated a discriminant function from bank samples grouped according to high and low summary ratings determined by supervisory personnel for that year. We used the same estimation techniques and eight variables described in connection with the original 1967 and 1968 discriminant functions, but selected the cutoff point as described earlier in this article. The ability of this function to identify banks that received low summary ratings is shown in the accompanying table for the period 1969 through early 1975. As shown in the table, Exam-1 correctly identified about 89 percent of all the banks that received low summary ratings (after excluding the banks from which the function was estimated). The group of banks the function designated as vulnerable (percentage of total member banks not shown) contained a sizable percentage of banks that were accorded low summary ratings during the period under review. The allocation, therefore, of supervisory resources only to a bank group designated as vulnerable by this function could be expected to yield a sizable gain in efficiency, compared with a proportional allocation of these resources to all member banks in the Second Federal Reserve District. Data limitations prevented a meaningful reestimation of this function over any of the subperiods. In any case, the use of this function requires data that are available only from on-site examinations.

Exam-2. This function was estimated from sample banks grouped according to the high and low summary ratings given by supervisory personnel in each of the three years 1969-71. However, no variables requiring data from examination reports were employed. Instead, a number of proxy variables were used in place of the quality-of-assets variable employed in the Exam-1 function. The

[10] When supervisory resources are apportioned to all banks, based on size, all present and future weak banks are detected, but all resistant banks are "unnecessarily" examined. Then the total cost of classification errors is $\sum_{k=1}^{R} (\text{cost v:s})_k$, where R is the total number of banks (from both the groups designated resistant and vulnerable) that did not subsequently receive low summary ratings from supervisory personnel.

[11] The Exam functions were the best performing functions from among several variations in simulating summary ratings given banks by supervisory personnel in selected years.

EFFICIENCY RATIOS WITH RESPECT TO IDENTIFICATION OF BANKS THAT HAD LOW SUMMARY RATINGS IN SELECTED PERIODS, BASED ON SAMPLE DATA FOR INITIAL YEAR OF EACH PERIOD

Functions or procedures employed	1969-early 1975			1970-early 1975			1971-early 1975		
	Percentage of banks		Percentage gain in efficiency*	Percentage of banks		Percentage gain in efficiency*	Percentage of banks		Percentage gain in efficiency*
	called vulnerable that received low summary ratings	with low summary ratings correctly identified		called vulnerable that received low summary ratings	with low summary ratings correctly identified		called vulnerable that received low summary ratings	with low summary ratings correctly identified	
Sample data based on supervisory definitions									
Exam-1: 8 variables, including examination data†	19.0	88.7	28.7	‡	‡	‡	‡	‡	‡
Exam-2: 12 variables†	17.2	94.3	19.3	15.4	95.2	25.7	16.6	95.2	34.0
Sample data based on rank index									
MISR: 11 variables (excludes size)§	34.1	89.7	37.3	31.2	92.2	35.4	33.1	96.7	49.1
MISF: 11 variables (excludes operating expenses)‖	17.4	76.9	41.8	13.8	95.0	20.0	15.6	97.4	33.7

Note: Financial data obtained from Reports of Income and Reports of Condition for all member banks in the Second Federal Reserve District for 1969 through 1971, and from examination reports of state-chartered member and national banks for 1968; summary ratings of all member banks in the Second Federal Reserve District obtained from Federal Reserve Bank of New York supervisory personnel for the period 1969 through early 1975.

* The estimated gain in economic efficiency from the allocation of supervisory resources by the procedures described in this paper, compared with the allocation of supervisory resources to all banks (see pages 162-63).

† The Exam functions were the best performing functions from among several variations in simulating summary ratings given banks by Federal Reserve Bank of New York supervisory personnel in selected years.

‡ Not available at the time of publication.

§ MISR = Multivariate index standard ranking.

‖ MISF = Multivariate index function.

function presented in the table is one of several that showed relatively consistent results over the entire period and in each of the subperiods (after the banks used to estimate the function were excluded). As can be seen in the table, gains in efficiency varied from about 19 percent over the period 1969-early 1975 to 34 percent for the shorter subperiods.

MULTIVARIATE INDEX STANDARD RANKING (MISR). As described earlier, standardized deviations for the twelve variables for each of the member banks in the Second Federal Reserve District in 1969, 1970, and 1971 were added for each bank, and all the banks placed in order according to each bank's value in this multivariate index. The cutoff point to separate the vulnerable banks from those that were resistant was determined, as explained earlier, to minimize the costs of misclassification errors. The MISR shown here omits size from the index, since

the eleven-variable index yielded somewhat more consistent percentage gains in efficiency between 1969 and early 1975 and in the subperiods studied. As can be seen in the table, these efficiencies varied from 35 percent to 49 percent.

THE FUNCTION BASED ON THE MULTIVARIATE RANKING (MISF). The MISR provided reasonably good separation throughout most of the period studied. However, each of the variables influenced the ranking process with equal weight, and it seems reasonable to suppose that some variables may be more important than others in defining resistant and vulnerable banks. Further, the number of variables in the ranking used thus far would not be expected to be the most complete or efficient set for purposes of defining resistant and vulnerable banks. It is likely that other variables in addition to those employed could be useful. Also, it is likely that a smaller subset of the variables used in any initial ranking would be sufficient to achieve the desired separation. To explore these possibilities, we raised the question whether discriminant analysis might be of aid.

To utilize the statistical tests available in discriminant analysis, it is necessary to show that the sample is composed of independent groups. Relating this requirement to our MISR, it means that the presence of independently distributed groups of vulnerable and resistant banks would have to be established. Using the MISR ranking described above as a guide, we attempted to determine if "natural groups" of vulnerable and resistant banks could be identified. Natural groupings in the MISR rankings might be evidenced in the data comprising the ranking, provided the procedure and the data were sensitive enough to detect such natural groupings. We expected that banks performing in the extreme high and low ranges of the ranks might represent separate distributions of banks with unique characteristics, each with its own mean standard of behavior as measured by its multivariate rank.

In our preliminary research aimed at identifying distinctly defined groups, the evidence was mixed, based on relatively simple methods. Nonetheless, there is a reasonable presumption that resistant banks are markedly different from banks that are vulnerable and that such natural groups can be identified. In any event, the analysis did not depend on the statistical probabilities derived from the discriminant functions but rather provided a way of weighting our variables. We decided, therefore, to explore discriminant techniques to evaluate the overall importance of the variables in the MISR in identifying banks that received low summary ratings during the period studied. In evaluating the discriminant techniques employed in this manner, we minimized the costs of classification errors as described earlier; these procedures do not utilize any statistical probabilities based on a discriminant function.

The discriminant technique was employed in conjunction with the MISR to yield a function (MISF) as follows. Several alternative segments of the ranking were sampled to obtain data from which to estimate a function. This function then was used to obtain scores for all the banks in the Second Federal Reserve District for selected years, with banks in the estimation group excluded from the overall list. The results reported here are based on a random sample drawn from the bottom and top 10 percent of the MISR ranking. Entering all twelve variables stepwise in a predetermined order, we found that one variable—*i.e.,* operating expenses-total revenues—impeded the function's ability to identify vulnerable banks that subsequently received low summary ratings over the entire period 1969-early 1975 once the other eleven variables were entered. Therefore, the function was employed without that variable. The results show a potential gain in efficiency of nearly 42 percent, over the entire period 1969-early 1975, with some tendency for the gains to diminish in the subperiods near the end of the full period under review. The results suggest that the MISF, along with the MISR, merit further attention as alternative approaches to the identification of banks that can be considered vulnerable in the event of economic strains or uncertainties.

CONCLUDING COMMENTS

To sum up, the results of the analysis thus far suggest that it is possible to identify vulnerable banks in advance of a significant deterioration in their financial condition by several alternative procedures. This early identification could yield significant efficiencies through allocation of supervisory resources to those sectors of the banking industry where there is evidence of significant vulnerability to economic difficulties. Effective use of the approaches described here would, of course, depend on there being a significant measure of confidence in the accuracy of the separation between resistant and vulnerable banks obtained through the procedures described in this article. Although more work is needed in this area, we believe the analysis presented here can help to improve the efficiency with which supervisory resources are deployed.