

Failure Prediction Model: A Cash-Flow Based Approach

RYUSUKE TANABE*

I. Introduction

With the improving arrangement of computer program packages for statistical analysis, it has been becoming more and more possible for the users to apply multivariate techniques to corporate valuation or financial statement analysis. The failure prediction model to be presented in this paper is an application of multivariate discriminant analysis, the computer code for which is now one of the most common application programs.

Discriminant analysis is a statistical technique that classifies objects on the basis of information. Stated in terms of failure prediction, the classification of firms as either failed or non-failed on the basis of financial ratios is performed by means of a linear discriminant function:

$$z = l_1x_1 + l_2x_2 + \cdots + l_px_p, \quad (1.1)$$

where

x_i = the i -th explanation variable (ratio),

l_i = the coefficient value (parameter) of x_i ,

z = the discriminant score.

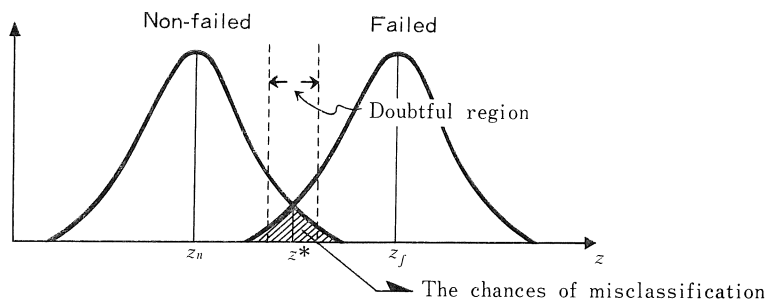
The discriminant function thus transforms the values of the individual variables x_i into a single discriminant score z which is then used to classify the firms into a failed or non-failed group. Once the

* I thank Dr. Masatoshi Hirata for his useful comments and his permission with which I was able to use Seinan Gakuin Univ. Computer Center for data analysis. Responsibility for any errors remains with the author.

parameters l_1, l_2, \dots, l_p are known, we can assess the failure potential of a firm by comparing its z -score with a pre-determined critical score, say z^* .¹⁾ If the score is lower than z^* then the firm is classified as non-failed and vice versa.²⁾

Since Altman (1968) first introduced discriminant analysis into his prediction model, it has become the dominant technique in this field; different authors have tried to identify an optimal combination of explanation variables that could give the most accurate prediction. Edmister (1972), for instance, adopts in his model time-series changes of the ratios and some data peculiar to the industry to which each firm belongs.

1) Of course the classification is not free from error. It is conceivable that now and then a firm with a low z -score will fail and that a firm with a high z -score will not fail. Therefore, in carrying the analysis, we must always take into account the chances of misclassification which can be statistically obtained using the estimated coefficients. If the chances of misclassification are considered too large, then we can set a certain doubtful region as that shown in the figure. Firms with z -scores between the limits of the doubtful region will be reserved for further scrutiny.



2) Strictly speaking, the relationship among the firm's z -score, the critical z^* and a group into which the firm should be classified depends on the signs of coefficients in the discriminant function. In the empirical test for the derived model later, we will find that all the signs of the estimated coefficients are negative, so that if the z -score of a firm is lower than z^* then the firm will be classified as non-failed.

Although, thanks to the available computer codes, we have no difficulty in estimating the parameters, a crucial problem facing us is how to choose the appropriate explanation variables. The purpose of this paper is to develop from financial theory a workable failure prediction model which differs completely from the previous ones in that ours has a theoretically consistent structure based on cash-flow concept.

The cash-flow model is developed in Section II. In Section III an empirical test for the derived model is implemented. Eighteen corporations which went bankrupt over the period 1974-1980 are included in the sample. Concluding remarks are presented in Section IV.

II. The Cash-Flow Discriminant Model

2.1. Ratio-Selecting Procedures in the Previous Studies

A great number of meaningful ratios could be made out of almost all the pairs of accounts on the financial statements. It becomes very troublesome to test all the sets of explanation variables, i.e., financial ratios, in terms of their prediction performance in order to find an optimal combination. Therefore, in the previous studies many authors did the preliminary selection of ratios according to certain criteria. Among the authors is Beaver (1966) who employed the following three criteria:

- 1) popularity—frequent appearance in the literature,
- 2) good performance in one of the previous studies,
- 3) relationship with cash-flow concept.

Then Beaver classifies each of the pre-selected 30 ratios, in accordance with the characteristic of its numerator, into one of six “common element” categories such as cash-flow ratios and net-income ratios. Next, on the basis of the outcome of repeated predictions, the best ratio is chosen from each of the six groups.³⁾ Although Beaver referred

3) After having selected the six ratios, however, Beaver proceeds to develop a univariate prediction model of corporate failure rather than a

to a “theory of ratio analysis” and introduced cash-flow concept as a selecting criterion, he did not devise a consistent cash-flow-based system to derive explicitly an optimal combination of ratios: that is, as criteria 1) and 2) indicate, there does not exist a theoretical base among the selected six ratios.

2.2 Donaldson Model for Evaluating Corporate Debt Capacity

In order to overcome Beaver and others' shortcoming and construct a financial theory of corporate failure, Van Frederikslust (1978) fully adopts a cash-flow model that Donaldson (1961) developed to predict the failure of firms. I also follow the same cash-flow approach throughout this paper. Now let us briefly review Donaldson's cash-flow model insofar as it is needed for our model building.

The very superiority of his approach lies in the fact that with no regard to the causes of firms' bankruptcy we can describe the phenomenon as the interruption of cash flows: that is, a firm goes bankrupt at any moment the total of its available cash inflows falls short of the mandatory payments to be due. Among the obligatory cash outflows are interest payment and principal repayment on which Donaldson focuses. Using common accounting terms, he describes the event of corporate failure, i.e., cash insolvency, on the basis of cash-flow components rather than changes in liquidity-related financial ratios. The cash balance of a firm at the end of period t could be defined as follows⁴⁾:

multivariate model. That is, he plots the mean values of these ratios of both groups, respectively, to identify clear differences in the trend curve between them.

4) However Donaldson's simple definition of the ending cash balance will show actual cash flows, at best, very approximately. This is because, as we see from such mutations as $(AR_t - AR_{t-1})$, computing cash flows requires us to know exactly about paying or receiving practices of the firms. Since a credit term of a full year is considered to be too long for most firms, we shall compute cash flows on a half-yearly basis in the later empirical test.

$$CB_t = CB_{t-1} + S_t - (AR_t - AR_{t-1}) + OI_t + (AP_t - AP_{t-1}) - GA_t - (BI_t - BI_{t-1}) + (SD_t - SD_{t-1}) + ALD_t + AEQ_t, \quad (2.1)$$

where

CB_t = cash balance at the end of period t ,

S_t = sales in period t ,

AR_t = accounts receivable in period t ,

AP_t = accounts payable in period t ,

GA_t = general, administrative (including interest) and sales expenses in period t ,

OI_t = other incomes (including liquidation of assets) in period t ,

BI_t = inventories at the end of period t ,

SD_t = short term debt at the end of period t ,

ALD_t = additional long term debt obtained in period t ,

AEQ_t = additional equity obtained in period t .

Needless to say, a firm will fail at a certain moment t when its cash balance becomes smaller than zero. Thus we define the event of failure as $CB_t < 0$. With this definition Donaldson then proceeds to the evaluation of corporate debt capacity.

2.3 Derivation of the Explanation Variables

In order to derive the relevant variables we shall decompose the aggregate CB_t into some variables which are explicable in financial theory. For an extension of equation (2.1) above let us introduce a new variable:

$$ER_t = S_t - (AR_t - AR_{t-1}) + OI_t + (AP_t - AP_{t-1}) - GA_t - (BI_t - BI_{t-1}), \quad (2.2)$$

which denotes the earned resources from normal business activities in the period between moments $t-1$ and t . Substituting (2.2) into (2.1), we can write for the cash balance as follows:

$$CB_t = CB_{t-1} + ER_t + SD_t - SD_{t-1} + ALD_t + AEQ_t. \quad (2.3)$$

As was defined earlier, a firm goes bankrupt when $CB_t < 0$ or,

$$CB_{t-1} + ER_t + SD_t - SD_{t-1} + ALD_t + AEQ_t < 0. \quad (2.4)$$

We can then transform this inequality as follows:

$$\frac{CB_{t-1} + ER_t}{SD_{t-1}} + \frac{SD_t + ALD_t + AEQ_t}{SD_{t-1}} < 1. \quad (2.5)$$

The first term in inequality (2.5) denotes, after all, the *internal coverage* of short term debt, SD_{t-1} : firms' capacity to repay the existing short term debt with the internal cash resources. Hereafter the ratio is abbreviated to IC_t . The second term is, likewise, the *external coverage* of short term debt, EC_t , for it indicates the cash resources externally obtained by the renewal of debt and the additional introduction of debt and equity to repay, if necessary, the existing short term debt. Thus, by extending Donaldson's cash-flow model, we have seen that the event of corporate failure at moment t can be completely determined by the values of IC_t and EC_t .

However we cannot use immediately these two indicators as explanation variables in our model. This is because when we predict failure at future moment t , IC_{t-k} and EC_{t-k} , where k is a positive integer, must be utilized instead of IC_t and EC_t . It is no use unless the event of failure is predicted enough time before to prepare for it. Therefore, the question arises here whether IC_{t-k} and EC_{t-k} are good indicators for the values of IC_t and EC_t , respectively.

Internal coverage ratio

The numerator of this ratio, i. e., internally generated resources from firms' operating activities, is determined by such structural factors as market share, costs, business policies and management. These factors are not likely to fluctuate rapidly in a short time span. Therefore if k is not too large, the values of IC at successive moments of time will show a stable changing trend so that we could consider IC_{t-k} as a sufficient proxy for IC_t . We shall adopt the ratio as an explanation variable in the discriminant function. It can be referred to as *liquidity variable* which indicates firms' fundamental cash solvency.

External coverage ratio

For external coverage a similar argument as that given above will not serve because this ratio may not show a smooth changing trend. Since the cash resources included in the numerator of EC are provided by the outside capital suppliers, i.e., shareholders and debt holders, the values of the ratio depend to a large extent on their investing or lending decision. Even when a firm foresees a crucial discontinuity in its cash flows in a near future, it could temporarily recover or keep high its EC value by means of urgent loans if the banks are willing to lend them. Needless to say, however, this might lead to a wrong prediction. Thus an actual value EC_{t-k} of the external coverage will not be a very satisfactory proxy for its future value EC_t .

The reason why EC is not stable over time is that it is based on an undaily business activity: external financing. However let us assume that firms do such activities as borrowing additional debt and issuing new equity every period. Then if their EC values show a worsening trend due to the contraction of the numerator, this means that the firms' capacity for external financing is also decreasing. Since outsiders' willingness to supply capital to a firm reflects their evaluation of the firm, we could regard the essence of EC ratio as corporate valuation. If the firm is evaluated by the outside capital suppliers in terms of its fundamental structure of profitability and risk, then any valuation variable they will use is supposed to be satisfactorily stable over time so that we can use it to predict at moment t a certain event of $t-k$. Therefore our next work is to find a valuation indicator which can replace EC ratio.

The cost of equity

The modern theory of corporate valuation states that the total value of a firm, i.e., the added values of debt and equity claims, is the appropriately discounted expectations of cash flows to these claims. In order to derive simply a sufficient proxy for EC ratio from the theory of finance, we shall follow the argument by Modigliani and Miller

(1958, 1963) on cost of capital, corporate valuation, and capital structure⁵⁾.

To clarify the above proposition let us look at the following *pro forma* cash flow statement⁶⁾:

R	Revenues
$-VC$	Variable costs of operations
$-F$	Fixed costs (i.e., administrative costs and depreciation)
NOI	Net operating income
$-rD$	Interest on debt (interest rate, r , times principal, D)
EBI	Earnings before taxes
$-T$	Taxes = $\tau_c (EBI)$, where τ_c is the corporate income tax rate
NI	Net income

MM uses the expectations of *net operating cash flows before interest and taxes*, $NOCB$, as a basic component in their valuation formula. It goes without saying, however, that NOI is not equivalent to $NOCB$. It is extremely important to distinguish between cash flows and the accounting definition of income. In order to convert NOI into cash flows let us partition fixed costs into two parts: let F^* be the cash-

5) MM's theory of corporate valuation is constructed on the basis of the following assumptions:

- Capital markets are frictionless.
- Individuals can borrow and lend at the risk-free rate.
- There are no costs to bankruptcy.
- Firms issue only two types of claims: risk-free debt and (risky) equity.
- Corporate taxes are the only form of government levy (i.e., there are no wealth taxes on corporations and no personal taxes).
- All cash flow streams are perpetuities (i.e., no growth).

Some of them are just simplifications and some others are more crucial. However we must note that their theory can be derived from a broader general equilibrium framework of the *Capital Asset Pricing Model*, CAPM, which is still being extended to prove its validity under more relaxing assumptions.

6) The theoretical development hereafter will follow that provided by Copeland and Weston (1979). See Chapter 11 of their text. As for the very close relationship between cash-flow concept and the theory of finance, the description by Boudreaux and Long (1977) is extremely useful.

fixed costs and “*dep*” be the noncash-fixed costs, therefore $F = F^* + dep$. Of course *dep* must be added back when we calculate cash flows.

Now we turn to after-tax cash flows from operations. Net operating income less taxes is

$$NOI - \tau_c(NOI). \quad (2.6)$$

To convert this after-tax operating income into cash flows, we must add depreciation and other noncash expenses. Then we have

$$(R - VC - F^* - dep)(1 - \tau_c) + dep,$$

which can be simplified to

$$(R - VC - F^*)(1 - \tau_c) + \tau_c dep. \quad (2.7)$$

This expression denotes *net operating cash flows after taxes*. However, the derivations which follow are considerably simpler if we ignore the tax shield ($\tau_c dep$) provided by depreciation and other noncash expenses. Therefore it should be kept in mind that hereafter when we write *NOI*, we always mean that it is defined in terms of the appropriate cash flows. It is not the same as accounting profit.

If a firm issues no debt, its interest costs are zero so that the shareholders receive $NOI(1 - \tau_c) = NI$. Then the value of such a firm, i.e., an unlevered firm, will be

$$V^U = \frac{NOI(1 - \tau_c)}{\rho}, \quad (2.8)$$

where

V^U = the present value of an unlevered firm,

ρ = the appropriate risk-adjusted rate for an all equity firm.

Next let us assume that the firm issues debt. The after-tax cash flows must be split up between debt holders and shareholders. The latter receives *NI*, net cash flows after interest and taxes, while the former receives interest on debt, rD , which is equivalent to

$$\begin{aligned} NI + rD &= (NOI - rD)(1 - \tau_c) + rD \\ &= NOI(1 - \tau_c) + rD\tau_c. \end{aligned} \quad (2.9)$$

The first term of (2.9) is exactly the same as the numerator of (2.8) so that as we assume that it is a perpetual stream, we can discount it at the rate for unlevered firms, ρ . The second term, $rD\tau_c$, is assumed to be risk free so that we discount it at the cost of risk-free debt, k_d . Note that k_d is the current market-required rate of return for the risk-free stream. Therefore the value of the levered firm is derived as follows:

$$V^L = \frac{NOI(1-\tau_c)}{\rho} + \frac{rD\tau_c}{k_d} = S + \tau_c B, \quad (2.10)$$

where $S = V^U$ denotes the value of equity and B the value of debt. That is, the total value of the levered firm is equal to the value of an unlevered firm, S , plus the tax shield provided by debt, $\tau_c B$. This is MM's corrected first theorem.

For further extension let us transform equation (2.9) to

$$NI + rD - \tau_c rD = (1 - \tau_c) NOI, \quad (2.11)$$

and substitute this into (2.10). Then we have

$$V^L = \frac{NI + rD - \tau_c rD}{\rho} + \tau_c B. \quad (2.12)$$

Subtracting B from both sides of (2.12), we obtain a valuation formula only for equity:

$$S = \frac{NI + (1 - \tau_c)rD + \rho\tau_c B - \rho B}{\rho}. \quad (2.13)$$

Next multiplying both sides of (2.13) by ρ gives

$$\rho S = NI - (1 - \tau_c)(\rho - k_d)B \quad (\because rD = k_d B),$$

and then

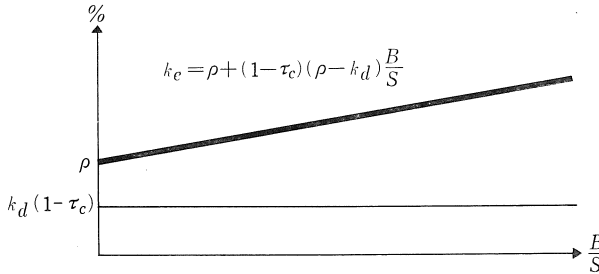
$$NI = \rho S + (1 - \tau_c)(\rho - k_d)B. \quad (2.14)$$

By dividing both sides of (2.14) by S , we finally have the rate of return required by shareholders, or the cost of equity:

$$k_e = \frac{NI}{S} = \rho + (1 - \tau_c)(\rho - k_d) \frac{B}{S}, \quad (2.15)$$

where B/S is usually referred to as debt-to-equity ratio. Equation (2.15) shows MM's corrected second theorem. Figure 2.1 displays the relationship between k_e and B/S in (2.15).

Fig. 2.1 The cost of capital as a function of the ratio debt to equity



Thus we have derived from the MM theory of corporate valuation a very useful proxy for EC ratio in that it can be easily obtained from the published financial data of corporations. Besides, while IC ratio shows the liquidity of a firm, we can let the cost of equity, k_e , denote *profitability* of the firm. Using IC and k_e as the fundamental components in the discriminant function, the theoretical consistency of the model based on cash-flow concept is sufficiently maintained.

Now let us proceed to the final stage of the model building. In order to strengthen the discriminant power of our model, we shall add some supplementary variables to the function: the changing rates of IC and k_e values per period. We suppose that a firm going towards a certain crisis will show in its financial data abnormally rapid changes with regard to liquidity and profitability. With these additional variables our cash-flow discriminant model will have the following structure:

$$z = l_1 IC_t + l_2 k_{et} + l_3 \beta_{ict} + l_4 \beta_{ket} \quad (2.16)$$

where

l_{1-4} = the coefficients of the explanation variables,

β_{ict} = the changing rate of IC in period t ,

β_{ket} = the changing rate of k_e in period t .

III. Empirical Test

3.1 Sample Design and Data

Now that a meaningful discriminant model has been developed in the previous section, we shall turn to the empirical test for the model using a sample of eighteen corporations which went bankrupt over the period 1974-1980.⁷⁾ These firms, all in manufacturing industries except a trading company, were listed on the 1st Section or the 2nd Section of the Stock Exchange in either Tokyo or Osaka, or both. From a statistical point of view, the number of the firms in the sample is far from desirable. However, the sources of financial data were so limited that I could not but perform the test with such a small sample. Despite this problem the cash-flow model will be tested with regard to how accurate, and how long before, it could have predicted the failure of these corporations.

Pairing procedure

First we discuss a procedure followed in sample design. The most important thing to be noted in carrying the data analysis is that only the direct relationship between the explanation variables and the failed or non-failed group must be identified; other possible factors, such as size, industry, and general economic conditions, which can influence the failure of a firm must be controlled. If this is not to be done, then observed differences in the discriminant score, z , between the failed and non-failed groups may be attributed to the differences of size, industry, economic situation and so forth. In order to satisfy this requisite we shall follow pairing procedure, which is commonly used in the empirical tests for failure prediction models. After the eighteen firms were listed as the components of the sample, for each of them a non-failed firm was selected as the pairing partner in such a way that it is com-

7) Financial data of the sample firms were analysed with *HITAC M-160 II* and an application program for discriminant analysis written for the machine.

parable with the failed counterpart as to industry and size. As a measure for firm size, we use the value of total assets because assets size seems to be appropriate when the status of a firm is evaluated in the capital market. However, perfect matching with regard to industry and size was of course impossible. Because not a few large corporations are diversified across different industries, in some cases I attached more importance to the composition of the firms' product lines than to the industrial categories into which the firms are officially classified.

Sample data

After all the number of the sample firms has doubled to 36. For each of these firms three to six financial statements, depending on their publication, for the years prior to failure were collected. Since the corporations quoted on the Stock Exchanges are to report their financial data every six months, the failure predictability of a failed firm whose data were collected for full six periods will be assessed half-yearly over the period from three years before to, if nearest to the failure moment, a month before it. The latest reporting month prior to failure is designated as $t=-1$, the second latest reporting month as $t=-2$, and so forth. Since firms are free to choose any couple of the reporting months, the latest month, $t=-1$, means different actual moments prior to failure. The average time span between the latest financial reports prior to failure and the failure moment was 4.9 months, with the shortest span being a month and the longest span 8 months. The pairing list of the sample firms is presented in Table 3.1.

3.2 Results

The prediction equation for the latest reporting month before failure

The results of parameter estimation for the latest-month prediction equation is as follows:

$$t=-1: \quad z = -0.02998IC - 0.07387k_e - 0.16395\beta_{ic} - 0.09031\beta_{ke},$$

$$\text{Mahalanobis } D^2 = 11.40550, \quad (3.1)$$

Table 3-1 The pairing list of the sample firms

No.	Failed firms ⁸⁾	Non-failed firms
1	Nihon Netsugaku Kogyo (May 1974)	Takasago Thermal Engineering
2	Yamato Woolen Mills (Oct. 1974)	The Nankai Worsted Spinning
3	Tokyo Tokei Seizo (Nov. 1974)	Ricoh Watch
4	Sansei Manufacturing (Dec. 1974)	Takisawa Machine Tool
5	Kohjin (Aug. 1975)	Daiwa House Industry
6	Asahi Seiko (Nov. 1975)	Osaka Bearing
7	Yoshida Machine Tool (Nov. 1975)	Okamoto Machine Tool Works
8	Murayama (Feb. 1976)	Tachikawa
9	Kaijima Coal Mining (Mar. 1976)	Matsushima Kosan
10	Nippon Ferrite Industrial (Mar. 1977)	Tokyo Cosmos Electric
11	Osaka Yogyo (Aug. 1977)	Osaka Yogyo Firebrick
12	Seto Koatsu Kogyo (Sept. 1977)	Chuo Spring
13	Hashihama Shipbuilding (Dec. 1977)	Naikai Shipbuilding & Engineering
14	Eidai (Feb. 1978)	Daiken Tread & Industry
15	Tanaka Machinery Manufacturing (Sept. 1978)	Showa Crane Manufacturing
16	Hayashi Spinning (Feb. 1979)	Toa Wool Spinning
17	Suzue Agricultural Machinery (Feb. 1979)	Noda Industrial
18	Rin Kagaku Kogyo (Aug. 1980)	Taki Chemical

8) The months and years in parenthesis say when the firms failed.

where larger D^2 shows better discriminant efficiency for the two groups.

First of all let us do significance test, using F -statistic, for the estimated equation. F -statistic, which can be used to reject the null hypothesis H_0 stating that the means of the explanation variables of both groups are the same, is calculated as follows:

$$F(m, n+n-1-m) = \frac{n_1 n_2 (n_1 + n_2 - m - 1)}{m(n_1 + n_2)(n_1 + n_2 - 2)} \cdot D^2, \quad (3.2)$$

where

m = the number of the parameters,

n_1, n_2 = the numbers of the failed and non-failed firms,

$n_1 + n_2 - 1 - m$ = the degree of freedom.

Then F -ratio for the estimated equation is

$$F(4, 31) = 23.39803, \quad (3.3)$$

which indicates fairly successful discrimination between the two groups because it is much greater than $F_{.995}(4, 30) = 4.6233$: that is, the null hypothesis is rejected at a significant level, α^* , smaller than .005. Therefore, the estimated chances of misclassification will be very small for this prediction equation. The chances of misclassification are given by using Mahalanobis D^2 :

$$u = \frac{\sqrt{D^2}}{2} = \frac{3.377}{2} = 1.69, \quad (3.4)$$

and then from the normal distribution,

$$P_r(u > 1.69) = .0455. \quad (3.5)$$

The theoretical chances of misclassification were thus very small 4.55% for $t = -1$, on the average, 4.9 months before failure. Actually, however, there was no misclassification in this case.

Finally we compute the critical discriminant score, z^* , from the mean z values of the two groups, \bar{z}_f and \bar{z}_n :

$$z^* = -\frac{1}{2}(\bar{z}_f + \bar{z}_n) = -\frac{1}{2}(0.1992 - 0.1363) = 0.03145. \quad (3.6)$$

If the z -score of a target firm turns out to be higher than 0.03145, then the firm can be regarded as having a large failure potential; if the firm is to fail half year later from the prediction moment, then discriminant function (3.1) will have all but perfect success. However, the problem is, of course, that we never know exactly when the firm will fail. If that firm survives until, say, two years later, we need a prediction equation for $t=-4$ and then we can assess its failure potential at that moment. Now let us see the results for the earlier reporting months from $t=-2$ to $t=-5$.⁹⁾

The prediction equations for earlier reporting months before failure

The results of parameter estimation for the other prediction equations are summarized in Table 3.2.

Table 3-2 Results for earlier reporting months before failure

Prediction moment (t)	l_1	l_2	l_3	l_4
- 2	-0.01225	-0.00740	-0.08652	-0.03014
- 3	-0.01238	-0.05032	-0.00793	-0.01281
- 4	-0.00727	-0.00512	-0.03387	-0.02893
- 5	-0.02190	-0.00691	-0.04569	-0.05776
Prediction moment (t)	Mahalanobis D^2	F -ratio	Chances of misclass.	z^* -score
- 2	3.72040	7.63228 ^a	0.1685	-0.00248
- 3	1.25948	2.42549 ^b	0.2877	-0.00414
- 4	1.22812	2.05600 ^b	0.2912	-0.00197
- 5	3.50299	5.42289 ^a	0.1736	-0.00445

a : $\alpha^* < .005$ b : $.05 < \alpha^* < .10$

The values of D^2 , and F -ratio and the chances of misclassification in Table 3.2 all show a rapid decreasing trend of the discriminat power after the projection span spreads over a year. Especially for $t=-3$ and -4 , the values of F -ratio were no good, though these are barely

9) Although for most of the sample firms financial data were collected for six periods, we ended up with five prediction moments as a result of using the changing rates per period of the explanation variables.

below the critical values at significant level $\alpha^* < .05$. As a result the chances of misclassification amount to nearly 30%. Still, by setting a doubtful region, we can take advantage of the estimated chances of *correct* classification, 70%, for efficient decision procedures. As to the performance for $t = -5$, how can we explain the sudden recovery of the values? A possible explanation is that once firms foresee their failure potential as a real threat in a near future, say, two years or a year and half later, they begin to rush into the window dressing of their financial data. Consequently, for prediction moment $t = -3$ or -4 , the discriminant power may decrease very rapidly. On the other hand if most of them even never dream the possible crisis some three years before it, then their financial statements will still show *clean* figures, therefore leading to better discrimination.

As a conclusion of the empirical test in this section, we could say that by means of the cash-flow discriminant model the failure of a firm is predicted with the probability of, at least, 70% even three years prior to it.

IV. Concluding Remarks

Since the comparison of prediction performance between our model and other authors' on the basis of the same data is not given in this paper, we cannot insist here that the cash-flow based theoretical approach for failure prediction is particularly useful for practical forecasting. Generally speaking, the performance of a discriminant model is likely to improve as the number of explanation variables included in it increases. For this reason our four-variable model has plenty of room for improvement if a few more relevant variables are added to it. This, in turn, will require a further theoretical elaboration.

Still, there are some possible pitfalls concerning the model. First, the valuation theory which we employed in Section II is derived from a set of assumptions as to the behavior of an individual or a firm and the characteristics of the capital market. Therefore, the discriminant power of a resulting model will depend to a large extent on the real-

world validity of the theory, which is still, with some controversial aspects, in the process of refinement. Second, the explanation variables provided by the theory, IC and k_e , are much more complicated in structure than the existing financial ratios, so that more bias is liable to slip into the values when we elaborate IC and k_e from the published financial data.

Despite these disadvantages, however, we are still convinced that the cash-flow based approach stated in this paper has provided failure prediction as an application of discriminant analysis with a new analytical point of view. It is not until we apply the viewpoint that we can follow a very useful methodology to refine failure prediction: that is, the well-known process in any scientific research where a relevant model is derived from a theory of corporate failure, the model is tested empirically and then, if the results are not desirable, the frameworks of the initial theory are reviewed to produce a better failure prediction model.

References

1. Altman, E. I., "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *The Journal of Finance*, Vol. 23, No. 4 (Sept. 1968).
2. Beaver, W. H., "Financial Ratios as Predictors of Failure," *Empirical Research in Accounting: Selected Studies, 1966, Supplement to Journal of Accounting Research* (1966).
3. Boudreaux, K. J. and H. W. Long, *The Basic Theory of Corporate Finance*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 1977.
4. Copeland, T. E. and J. F. Weston, *Financial Theory and Corporate Policy*, Addison-Wesley Publishing Company 1979.
5. Donaldson, G., *Corporate Debt Capacity*, Boston Division of Research, Harvard Business School 1961.
6. Edmister, R. O., "An Empirical Test of Financial Ratio Analysis for Small Business Failure Prediction," *Journal of Financial and Quantitative Analysis* (March 1972).
7. Modigliani, F. and M. H. Miller, "The Cost of Capital, Corporate Finance, and the Theory of Investment," *American Economic Review* (June 1958).
8. —, "Corporate Income Taxes and the Cost of Capital," *American Economic Review* (June 1963).
9. Van Frederikslust, R. A. I., *Predictability of Corporate Failure*, Martinus Nijhoff Social Sciences Division, Leiden/Boston 1978.