Credit Analysis: An O.R. Approach

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CREDIT ANALYSIS:
AN O.R. APPROACH

Mass consumer credit calls for quantitative credit control techniques that can reduce the need for employee judgment and thus cut administrative costs. This article describes one such technique.

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IN THIS ERA of the charge account, you — or the members of your family — can probably walk into a department store; choose a television set, suit, or electric razor; tell the sales clerk to "charge it please"; and walk out loaded down with bundles.

All this will have been accomplished without any exchange of money — at least until the bill arrives the following month.

This privilege has been conferred upon you only as the result of a rigorous screening which has established your presumed reliability in meeting that payment. You are what is known as a "convenience customer" — it is merely more convenient for you to use a charge account than pay cash for many of the items you buy. Typically, your accounts will be held with the large and lavish metropolitan stores—the Marshall Fields, the Altmans, the Woodward and Lothrops.

However an entirely different form of credit has undergone spec-tacular growth in the past two decades. This form of credit is characterized by the presumed inability of the debtor to meet the obligation at the moment the debt is incurred; one spends money that literally isn't there.

The historic prototype of this type of credit is the home mortgage. (One can speculate as to the growth of home ownership in this nation if it had been limited to individuals who could pay cash.) Not long ago the home mortgage stood virtually alone on the "time payment" credit scene.

In 1945 consumer credit, excluding home mortgages, stood at $5½ billion. In these days of "E-Z Terms" that figure has exploded to $85 billion; its dominant element has been the financing of automobile purchases.

As the amount of money involved in the time payment loan has shrunk from the many thousands of dollars involved in the home mortgage to the smaller amounts involved in the small loan or merchandise credit, the profit potential inherent in each loan has dwindled. This has created a need for a means of credit control that is less costly than the procedures used in mortgage financing — but still effective.

To solve this problem we have adapted some of the basic techniques of operations research. This article describes the application of these techniques to mass consumer credit operations, particularly to the screening of credit applications.

The "mass consumer credit" operations which we will speak of here will be loans in the $10-1,000 range; in the specific case of auto loans, the upper figure may be several thousands. These are referred to here as "mass" operations inasmuch as they depend upon the servicing of a large volume of smaller credit contracts.

The companies with which we have dealt represent a broad spectrum of industries, having in common a heavy involvement in credit and collection activity. The five

principal industries which have provided this specialized operations research service are mail order houses, finance companies (small loan, auto, and sales financing), utility companies, credit card operations, and retailers (chain and local department stores, specialty stores, etc.).

Consumer credit problems

Management has by now become somewhat accustomed to the use in business decision making of various mathematical, statistical, and other scientific techniques (generally described as operations research). Principal areas of application include production and inventory control, marketing research, and distribution systems.

It is somewhat more difficult to see how such a mathematical approach might be effectively utilized in the consumer credit area. In the "mass consumer credit" operations considered here, we are dealing with a large number of people and are interested in the performance of aggregate groups. The essential problem is to determine the "riskiness" or "risk level" of any single individual; for this purpose, individuals may be assigned to "risk pools," a concept similar to that used by the insurance industry. With this in mind it becomes possible to talk about a certain percentage incidence of collection problems, or the residual portion of good, paying accounts.

Problem categories

Credit problem areas may, for the purposes of discussion, be broken down into three categories. Although these are interconnected within the context of a credit operation, it will be useful to consider them separately. These are, in reverse chronological order:

1. The collection of delinquent accounts
2. The control of individual account purchase activity, i.e., the setting of loan maximums or credit limits
3. The risk appraisal of new

credit applications, and the decision to grant or deny credit.

Under any credit granting system it may be reasonably anticipated that there will be some customers who will not pay their bills on time. For these customers it becomes important to determine the best and most economic manner of securing payment.

First, one must determine the proper sequence of approaches to use in "breaking" a customer; the techniques one might use would include reminders, soft letters, hard letters, phone calls, telegrams, field visits, attorneys' letters, collection agencies, etc. The proper sequencing and "tone" of these collection techniques might be likened to a series of moves in a chess game.

Second, and equally important, one must decide when to quit the game. The above activities all have expenses connected with their use; there comes a point in the pursuit when the expected return from continuing the game is less than the expected cost of continuing.

This problem is amenable to a mathematical approach. Inasmuch as it has been considered at length elsewhere,[1] we will not focus attention on this problem in this article.

Credit limits

While some customers are obviously justified in being granted high credit limits, many customers have to be carefully contained in order that they do not overextend themselves and become collection problems. From the viewpoint of sales, it is of paramount importance that the good risk be allowed to purchase goods (or borrow) in a relatively unrestricted fashion. A balance between sales promotion and credit costs and losses must be struck.

In addition to the problem of initially assigning credit limits, one must also be concerned with the subsequent changes in these limits

in relation to the account's purchasing activity and to its payment patterns.

The determination of initial limits is largely dictated by the risk level of the individual. The subsequent dynamic alteration of this limit is a somewhat complex problem and will not be treated in this article.

Appraisal of applications

The obvious fundamental question in the appraisal of a credit application is whether the individual concerned will meet his payments. This is the "risk" inherent in granting credit.

Typically, in the past, credit managers have used a completely subjective approach to this problem. The key elements in this area have been "experience" and "judgment."

This "human" approach has a number of weaknesses. First, human beings are, of course, subject to their own "biases and prejudices," which are not always substantiated by the facts. Secondly, subjective decision making has certain deficiencies with regard to management control and record-keeping. Thirdly, judgment and experience must be slowly developed in new personnel in an environment where the results of a decision are quite slow in becoming apparent — and quite often are never even communicated back to the original decision maker. Finally, in a situation of great expansion in credit volume, the few truly talented people find themselves greatly overburdened; this situation is aggravated when some form of decentralization is present.

In the past decade or so some

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[1] Dr. T. E. Caywood, "The Use of Mathematical Techniques to Improve Credit Operations," *Management Controls,* September, 1964.

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companies, wholly or increasingly involved in the consumer finance area, have recognized these problems and have attempted to turn their operations toward a more quantitative and measurable basis. It is the fundamental quantitative assessment of risk with which this article is primarily concerned.

Numeric scoring system

The quantitative technique by which we have measured risk is commonly called a "pointing plan" or "pointing scheme" or "pointing system." The use of this technique is to provide a numeric measure of the risk of an individual. Pointing schemes provide a set of number scores which may be applied to an individual applicant so as to place him in a distinct risk classification. They may be thought of as "score cards," for an individual is credited with a certain number of points for each of his personal characteristics; the point total places the applicant into a risk category with other applicants achieving the same total. The actual numeric value of the point total is a direct indication of the risk to be associated with that value.

The use of pointing schemes is simple and highly efficient; it is much like grading a multiple-

ployed by relatively untrained personnel. For example, assume we have a 36-year-old married truck driver. He may receive 4 points for his age, 3 points for being married, and 2 points for being a truck driver, achieving a total of 9 points. The actual points awarded are integers of low value for ease of calculation; they may easily be added in one's head. The maximum total may range from 15-60 points; choice of scale is largely a matter of convenience. The number of factors actually considered by a working plan may vary from about seven to fifteen. Such a scheme is called a "linearly additive scheme," for each category is considered separately and merely added to a total.

The actual point score total places the individual in a risk classification; individuals then become associated with this classification. One will then speak of a "19-pointer" or a "26-pointer" rather than a "marginal" risk or a "fairly good" risk; the numeric designation is a more precise way of communicating, bringing into mind a category with very definite risk characteristics.

Such pointing schemes can separate applicants into highly differentiated categories when constructed properly. On one end of the point-

ing scale one may find applicants with only 1 chance in 1,000 of becoming charge-offs; at the other end the chance may be 1 in 3.

Pointing plan construction

The operational simplicity of a pointing scheme belies the complex statistics required in its creation.

For the technically minded, the technique is that of the discriminatory analysis model where the hypothesis is not of full rank. The model is a subset of analysis of variance theory, which is in turn part of the broad topic of linear regression theory.

The actual system is based upon the "correlation" between the historical loss experience of the client's credit operation and the personal characteristics of individual applicants. In the first stages of implementation of such a system a moderately large sample of applications is collected, perhaps several thousand each of (1) accounts which have performed well, (2) accounts which have been written off as losses, and (3) applications which have been rejected.

The information about each individual account will minimally contain the information that has been historically required on the credit application. In addition, one may add a number of economic measures, e.g., contract type and terms; account performance information; collection activity; interest paid, accrued, or returned; terminal account balance; life of loan; losses incurred; etc. One may also add a digest of information obtained from a credit bureau on the applicant, where such information has been recorded.

The problem then narrows down to determining which factors are useful in distinguishing good risks from bad risks. As in most large-scale statistical and mathematical calculation today, computing machinery is required.

The end result of this "number juggling" is the creation of a set of pointing scores which are "best" in separating the good accounts from the poor ones. A number of tech-

EXHIBIT I

LIST OF CREDIT FACTORS IN RELATIVE ORDER OF IMPORTANCE	
1. Type of Neighborhood	15. Finance Company Reference
2. Time at Address	16. Time at Previous Job
3. Occupation	17. Number of Rooms
4. Time at Job	18. Jeweler Reference
5. Telephone	19. Type of Merchandise
6. Bank Account	20. Total Indebtedness
7. Marital Status	21. Down Payment
8. Number of Dependents	22. Type of Store
9. Amount of Income	23. Time at Previous Address
10. Living Status	24. Length of Terms
11. Source of Additional Income	25. Furniture Store Reference
12. Department Store Reference	26. Automobile
13. Company Region	27. Total Number of References
14. Amount of Additional Income	28. Other Business References

tion for the biases introduced by rejecting some applicants, factor classifications, interval determination, structural weaknesses in the mathematical model, etc., will not be discussed in this introductory article.

Effort is then expended in creating a simple and workable scheme for actual use in the field. Many applications contain literally dozens of factors, and one must choose only the most important in order to keep the final system as simple as possible. It is therefore necessary to determine the relative importance of the factors.

Everything one knows about an applicant, which may include credit bureau information, neighborhood assessment, etc., may be thought of as a "box" of information. All we really want out of the box is that portion which will enable us to measure the risk of the individual; the remainder might serve other purposes for the company, e.g., the collection process. By considering the factors in combination it is possible to determine what is "new and unique" about each factor in contributing to our knowledge; we wish to omit all redundancies. Typically, out of a list of thirty factors, for instance, the top eight to twelve will statistically represent virtually all the information contributed by the "boxful" we started with. Exhibit 1 on page 54 shows a typical list of factors in their relative order of importance.

Exhibit 2 on this page illustrates how accounts might perform within four highly indicative factors. Note that this exhibit is drawn from a study that included economic information. It is immediately obvious that certain application characteristics suggest a very poor payment history, while others point to a very good history.

The use of pointing schemes

We have, to some extent, discussed how one would actually use a pointing scheme. Their use requires little or no subjective judg-

ACCOUNT PERFORMANCE INFORMATION
BY CATEGORY WITHIN FACTOR

Factor and Category	Average Collection Cost	Number Charge-off Rate	Average Profit
Type of Neighborhood			
Best	$ 3.76	4.8%	$18.03
Good	5.76	8.1	10.42
Fair	9.07	17.3	3.01
Poor	11.46	21.7	—1.02
Military Base	8.46	16.4	3.47
Time at Address			
0-6 Months	9.26	17.3	2.46
7 Months to 1 Year	8.76	14.6	3.91
1 Year to 2 Years	7.42	12.1	5.86
2 Years to 3 Years	6.91	9.8	8.92
3 Years to 5 Years	5.89	8.1	10.50
5 Years to 7 Years	5.53	6.5	12.79
7 Years and Over	4.24	5.9	15.96
Telephone			
Yes	5.37	6.8	12.79
Nearby or Neighbor	9.18	16.9	3.17
None	8.69	14.2	4.02
Bank Account			
None	8.62	13.7	4.00
Name Only	6.81	9.7	8.82
Checking	5.81	7.3	11.02
Savings	6.63	8.2	8.67
Checking and Savings	5.42	6.8	13.01

EXHIBIT 2

ment. Two of the factors in Exhibit 2 — type of neighborhood and occupation—might be subject to some judgment. Zoning maps or directories of occupational listings can be used to minimize this effect. The calculation of a point total for an applicant is a relatively simple matter; the technique is designed for use by clerical personnel.

In Exhibit 3 on page 56 a typical —but fictitious—pointing plan is presented. This plan consists of nine factors, with the possible total point score ranging from 0 to 41. The majority of the applications will fall between 15 and 30 points. In this scheme high scores correspond to good credit risks and low scores to poor credit risks; one can easily define it the other way. The reader might enjoy "pointing up" himself.

Exhibit 4 on page 57 provides a pertinent summary of the operation of a typical (fictitious) pointing scheme. What is given is the actual average account performance at

each point level (or risk pool). In addition, the number of applications normally experienced at each point level is given, commonly called the "risk distribution." The information consists of average total purchases, service charges, and collection costs. In addition, the total dollars written off in that category (or risk pool) has been averaged across all members in that category and is designated as "Amount Charged Off"; the percentage of accounts in the point value category that may be expected to be charged off is indicated as "Percentage Accounts Charge-off." From these figures it is possible to derive the average profit to be associated with any particular point value. The profit figure also includes a merchandise (or net finance) margin and the usual credit department revenues and costs (including account acquisition costs and cost of capital).

In this exhibit, one can readily

NINE-FACTOR POINTING PLAN

Type of Neighborhood
7	Best
5	Good
3	Fair, Military Base
0	Poor

Time at Address
0	0-6 Months
1	7 Months to 1 Year
2	1 Year to 2 Years
4	2 Years to 5 Years
6	5 Years or More

Occupation
0	Unemployed, Relief
5	Pension, Retired
4	Professional, Managerial, Clerical
2	Salesman
3	Non-Seasonal Skilled
2	Non-Seasonal Semi-Skilled and Unskilled
2	Seasonal Skilled
1	Seasonal Semi-Skilled and Unskilled

Time at Job
0	0 Year-1 Year
1	1 Year-2 Years
2	2 Years-5 Years
3	5 Years-8 Years
4	8 Years or More

Telephone
0	None or Nearby
4	Yes

Bank Accunt
0	None
3	Name Only
4	Checking or Savings
3	Checking and Savings

Marital Status
1	Single Male
3	Singe Female
4	Married
0	Divorced or Separated
2	Widow

Number of Dependents
1	0
2	1
3	2
1	3
0	4 or More

Amount of Income Per Week
0	$0-$50
1	$51-$70
2	$71-$90
3	$91-$110
4	$111-$130
3	$131-Over

EXHIBIT 3

observe that 23 points or above represents an extremely desirable application. A point score of 17 or less is clearly undesirable. The mid-range category, 18-22, may be considered as marginal in value. For this middle 39 per cent of the applications, more extensive investigation seems warranted as well as the judgment of the more expert credit personnel.

The value of pointing systems

Such schemes, developed through elaborate mathematical and statistical procedures, do not provide a panacea. At best, the scheme is designed to process a large proportion of the volume at a low error rate. Such schemes provide for the rather routine disposal of from 60 to 85 per cent of all applications.

The actual employment of a pointing system by any given company may serve manifold purposes.

1. A first purpose might be to minimize the amount of investigation activity required by disposing of a large portion of the applications rather routinely, as indicated above; in addition, such schemes provide a method for standardization.

2. A second typical purpose is to contain and reduce actual losses in order to improve the profitability of the overall operation. It has been our experience that, with the assistance of such a system, charge-off losses may be reduced by from 10 to 35 per cent without a material decrease in credit volume. When a slight reduction in volume is desired or warranted, the reduction will be greater—in some cases, 60 per cent loss reductions have been effected. The amount of improvement will, of course, depend upon the efficiency of the operation prior to the introduction of these techniques. While we would

not rank these schemes on a par with a very seasoned and expert credit man, such schemes do work about as well as a good credit man. For the booming company having difficulty in maintaining high standards of excellence in staffing its credit department, such schemes may prove to be extremely useful.

There are other substantial benefits that accrue from the use of these schemes, including:

3. The focusing of problem applications upon experienced personnel: Recall that these schemes will generate a "marginal risk" in the mid-range; it is here that the system operates as a lens to focus the expertise of the better credit people upon the tougher "problem applications."

4. The training of new personnel: These schemes essentially summarize the history of the company's loss experience in simple form.

5. They provide for the constant monitoring and control over the risk grade of incoming accounts, a feature not possible under a subjective system. For a multi-location user, these schemes allow one to measure the "average risk level" and "risk distribution" of the credit offerings at each location. Differences in the risk quality of offerings are immediately apparent.

6. These schemes provide for effective management control over the general risk level at which the firm will operate. It is much more precise to issue instructions in terms of "Raise the minimum score from 17 to 18" rather than "Tighten up a bit." The former procedure allows one to calculate in advance the impact of this directive upon volume and losses.

7. Such schemes provide for the identification of weak elements in the overall credit operation. No longer can the branch rely upon excuses of "poor offerings," etc. Each location has a measurable risk situation with which it must cope; those who fare badly are immediately recognizable.

8. The sample taken for purposes of credit evaluation provides a marketing panel as well; these samples provide a "profile" of the

SUMMARY OF AVERAGE ACCOUNT PERFORMANCE BY POINT VALUE

Point Value	Frequency	Total Purchases	Service Charges	Collection Cost	Amount Charged Off	% Accounts Charge-off	Profit
36	2	240.37	36.90	3.15	.00	.0	50.26
35	18	236.42	34.07	4.17	.00	.0	47.26
34	27	227.96	35.26	5.16	.00	.0	47.19
33	38	237.43	33.27	4.92	.00	.0	42.47
32	61	218.76	31.49	4.07	.00	.0	38.42
31	93	221.43	32.91	5.97	.46	.3	41.06
30	127	219.81	30.19	5.06	1.01	.7	37.19
29	186	201.47	30.21	4.98	.97	.9	38.47
28	201	207.96	29.47	6.01	1.43	1.2	41.27
27	248	193.87	28.87	6.91	1.20	2.1	32.58
26	308	179.08	26.49	7.01	2.01	2.9	30.96
25	369	181.18	28.51	7.23	2.86	4.6	28.76
24	401	176.91	25.37	6.98	4.01	7.6	30.91
23	437	163.87	23.90	7.43	3.91	9.8	20.96
22	517	171.43	22.47	6.03	6.21	12.0	12.46
21	486	141.26	19.38	8.91	8.17	15.1	8.26
20	400	163.91	21.43	10.17	10.02	17.1	5.47
19	307	138.87	19.71	11.17	12.19	20.9	3.26
18	226	127.42	17.03	13.32	15.01	23.2	1.07
17	173	121.98	16.70	11.46	16.15	27.6	−1.42
16	143	100.41	15.91	12.59	17.18	30.1	−6.41
15	108	112.96	13.83	13.98	18.42	38.7	−8.01
14	76	97.16	14.96	14.32	21.03	40.6	−12.43
13	22	81.43	13.71	15.26	23.71	53.2	−15.27
12	14	69.40	10.93	17.01	26.90	70.1	−20.19
11	8	73.90	12.14	18.96	38.70	100.0	−30.91
10	4	62.14	10.40	19.47	41.90	100.0	−41.06

EXHIBIT 4

characteristics of the credit consumer.

While the most obvious benefits of these systems are in the measurable reduction in dollar losses (and perhaps investigation costs), oftimes the more indirect benefits of placing the credit operation of the company on a sound, quantitative basis—and much more amenable to management's control —may be equally important.

It might be added that there is some temptation to use a scheme created for a competitor or another industry. Every scheme we have created has been done on an entirely individual basis; there is no "package program." While the next man's scheme may provide some improvement for your own situation, it will generally provide only a fairly efficient system for your own operation. All the advantages of having the scheme "sharply tuned" to your own operation will be lost. As a management tool, the ancillary information provided in

the study report is additionally required if intelligent use is to be made of the system. For an operation of even small to moderate size, the difference in efficiency between the "borrowed" plan and the custom plan is easily great enough to pay the costs (and learning experiences) of developing your own.

Other applications

The use of this discrimination modeling approach may well grow beyond its current use in credit and marketing. Such techniques are already being used to predict whether a prisoner will "jump bail" when released. Research is under way on using such systems in the granting of auto insurance. For industries with high training costs and turnover such a technique might well be used to separate out the "short-termers."

In merchandising and retailing one might construct pointing systems to predict who might be the

hardware buyer, or camp equipment buyer, at whom special promotions should be directed. Retailers under pointing systems are pressing these developments, inasmuch as the detailed information collected on each account provides a very natural lead-in to promotional and marketing activities.

Automated credit bureaus, recently discussed in this magazine, are under development. The techniques discussed here may very well allow the bureaus to supply prediction indicators as well as raw data from their files.

To summarize, credit activities have provided businesses with a profitable venture as well as a tremendous selling tool. When issuing credit on a mass basis, it is necessary to find a fast, efficient, objective, and controllable method of screening applications. It is our belief that the system described here meets these requirements and provides the most effective means for taking the guesswork out of credit.

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