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Credit-Rating Formulae

IN THE last chapter we presented a series of individual analyses, each of which treated the relation of an isolated credit factor to bad-loan experience. We shall now attempt to bring these isolated findings together and to consider the problem of credit analysis as a whole. One common way of meeting this problem is to select a number of the more important factors, to determine the relative importance—or weight—of each factor, and to combine these factors and weights to obtain a credit-rating score, which may then be used as a basis for accepting or rejecting applications for loans. For example, one bank officer has advanced a rating scheme based on five groups of items: he allots 20 percent of the total rating to the applicant's employment record and 25 percent to the income statement, 10 percent to the financial statement (including data on assets, liabilities, income, expense, and similar items appearing on a borrower's application), 20 percent to the type of security, and 25 percent to the past payment record; a score of 70 or better is necessary to indicate a satisfactory risk.[1] A sales finance officer has a substantially similar scheme; on the whole he treats the same fundamental concepts, but he treats them in more detail, and he gives more weight to occupation.[2] A "credit quotient" scheme for evaluating automobile transactions also has been devised.[3]

[1] H. L. Dunham, "A Simple Credit Rating for Small Loans," *Bankers Monthly*, vol. 55, no. 6 (June 1938) pp. 332, 333, 361.
[2] Joseph M. Greenberg, "A Formula for Judging Risks Accurately," *The Credit World*, vol. 28, no. 9 (June 1940) pp. 20-22.
[3] Owen L. Coon, *An Analysis of Automobile Repossessions and the Credit Quotient Method of Credit Analysis*, American Finance Conference, Special

Finally, a very systematic procedure for evaluating mortgage risks has been worked out by the Federal Housing Administration and described in their *Underwriting Manual.*

A credit formula is ordinarily regarded as a supplement to, rather than a substitute for, judgment and experience. It may enable a loan officer to appraise an ordinary applicant fairly quickly and easily; and in large-scale operations, it may be of service in standardizing procedure, thus enabling most of the routine work of investigation to be handled by rather inexperienced and relatively low-salaried personnel. A credit formula may not be satisfactory, however, in the investigation of extraordinary cases.

The credit-rating schemes or formulae in common use are generally, if not always, derived from a combination of experience and intuition. To devise a satisfactory formula, a credit officer usually draws first on his own experience, which he then supplements with the experience of others; he next employs his imagination to incorporate this information into a mechanical rating scheme; and finally he puts the scheme into practice, finds flaws in it, and modifies it accordingly.

In this study we have experimented with deriving purely objective credit formulae by statistical methods. Three of the formulae thus derived are presented in this chapter to show how the individual findings of the previous chapter can be combined into a single result. Unfortunately, these formulae are subject to a number of limitations that seriously restrict their usefulness in practical risk selection. First, since the samples on which the analysis was based are composed entirely of loans that were made only after the applicants had been carefully investigated and the poorest risks culled out, the resulting formulae will be suitable only as a supple-

Bulletin no. 27 (February 7, 1938) pp. 21 ff. A brief description will be found also in National Bureau of Economic Research (Financial Research Program), *Sales Finance Companies and Their Credit Practices*, by Wilbur C. Plummer and Ralph A. Young (1940) p. 138.

mentary means of risk control; after the original selection has been made, the formulae may be used for a further weeding out of undesirables. Second, our formulae are seriously handicapped by the non-inclusion of important factors like past payment record and moral character, on which no data were available. Finally, the statistical methods by which the formulae are derived—which are similar to the methods used in multiple correlation analysis—are not readily understood by any but trained statisticians or mathematicians; therefore, all details of the procedure and all discussion of its theoretical aspects are omitted here, and only a brief summary of the results is given.

SPECIFIC FORMULAE

For the commercial bank sample, two sets of formulae were determined. The first of these, which includes nine factors, provides a means of computing a credit-rating score for any applicant as follows:

Age: Give a credit of .01 for each year of age over 20, with a maximum of .30 for 50 years or more.
Sex: Credit of .40 if applicant is a woman.
Stability of Residence: Credit of .042 for each year at present residence, with a maximum of .42 for 10 years or more.
Occupation: Credit of .55 for either of two good-risk occupations of Table 13 (1a and 2a); nothing for either of two bad-risk occupations (2c and all of 6); credit of .16 for all others.
Industry: Credit of .21 for those employed in utility industries, government service, and banking or brokerage business.
Stability of Employment: Credit of .059 for each year at present employment, with a maximum of .59 for 10 years or more.
Three Asset Items: Credit of .45 for bank account, .35 for real estate, .19 for life insurance.

A score of 0 is the minimum that any borrower could receive, and a score of 3.46 is the maximum.

After the formula had been worked out, each loan included in the commercial bank sample was given a credit-rating score. The distribution of loans by this formula rating appears in the top section of Table 18; a marked divergence between good and bad loans is apparent. The good-loan scores on the whole are distinctly higher than those for bad loans; the dividing line between better-than-average loans and worse-than-average is about 1.25. The efficiency index for this credit-rating formula is 31, which is higher than that for any one of the component factors; bank account, for example, which is the highest single component, has an efficiency index of 23.

A second credit formula was determined by another method, which has the advantage of taking account of interrelationships between factors. If, for example, longer employment records are more characteristic of the older borrowers than the younger—as is actually the case—the second method automatically takes account of the relation. This advantage is probably not great in cash-loan experience, where relationships between factors are not pronounced; but it may be great in sales finance, where the relationships are closer. The method has the disadvantage of being laborious and complex. In the actual application of the method, two factors considered in the first formula, age and industry, were discarded, and the calculation was limited to a subsample of 191 good loans and 190 bad loans.

By the second formula the credit rating of an applicant may be determined as follows:

Sex: Give a credit of 2.63 if applicant is a woman.
Stability of Residence: Deduct .025 for each year applicant has lived at present address, with a maximum deduction of .25 for 10 years or more. (The negative weight for this factor, which implies that stable residence signifies poor risk, probably is faulty; it is at least partly due to the size of the subsample from which the

TABLE 18

PERCENTAGE DISTRIBUTION OF GOOD-LOAN AND BAD-LOAN SAMPLES, BY TWO CREDIT-RATING FORMULAE

Source and Composition of Data	*Rating According to Formula*[a]										*Number of Cases*		*Efficiency Index*
	.00–.49	.50–.74	.75–.99	1.00–1.24	1.25–1.49	1.50–1.74	1.75–1.99	2.00–2.24	2.25–2.49	2.50 and Over	Reporting	Not Reporting	
First credit-rating formula													
20 Commercial banks[b]													
Good loans	3.3	7.2	8.9	11.6	16.6	13.2	13.4	10.3	8.6	6.9	1,020	210[c]	
Bad loans	13.2	16.7	17.0	15.3	13.8	11.1	6.5	3.6	1.4	1.4	961	238[c]	
Bad-loan relative	4.0	2.3	1.9	1.3	.8	.8	.5	.3	.2	.2			31.2
			Less than 0	0–1	1–2	2–3	3–4	4–5	5–7	7 and Over			
Second credit-rating formula													
21 Commercial banks													
Good loans			4.2	9.7	12.9	12.5	14.3	13.8	20.0	12.6	1,157	137	
Bad loans			12.1	23.7	23.3	11.8	10.1	9.0	7.9	2.1	1,110	184	
Bad-loan relative			2.9	2.4	1.8	.9	.7	.7	.4	.2			32.3
9 Industrial banking companies[d]													
Good loans			2.9	12.2	15.9	11.8	14.4	15.1	17.7	10.0	271	151	
Bad loans			11.8	26.2	22.9	11.8	8.6	7.9	8.3	2.5	279	143	
Bad-loan relative			4.1	2.1	1.4	1.0	.6	.5	.5	.3			29.9

[a] Each class according to the second credit-rating formula includes the lower and excludes the upper limit.
[b] One sample containing 109 good and 106 bad loans was eliminated from this tabulation because the reported information was inadequate. For this tabulation the weights used to obtain the average differ slightly from those used in all the other commercial bank tabulations.
[c] Actual number of cases not reporting. In the other commercial bank tabulations, the number given is fictitious, as explained in footnote 13, p. 37.
[d] One sample containing 241 good and 237 bad loans was eliminated from this tabulation because the reported information was inadequate.

formula was determined.[4] The fact that it is faulty apparently does not seriously affect the results. The limitation of the maximum deduction to .25 was made arbitrarily.)

Occupation: For either of two good-risk occupations (items 1a and 2a) of Table 13 give a credit of 1.19; for either of two bad-risk occupations (2c and all of 6) deduct 1.19; for all others make no adjustment.

Stability of Employment: Credit of .077 for each year applicant has been at present employment.

Three Asset Items: Credit of 1.87 for real estate, 2.72 for bank account, 1.19 for life insurance.

A score of minus 1.44 is the absolute minimum that any applicant could receive. Although there is no absolute maximum, a score of more than plus 10 would be extremely high, and one of more than plus 14 would be virtually impossible.

By use of this second formula, scores were computed for all the commercial bank loans reporting sufficient information. The distribution of these scores is shown in the lower section of Table 18. The ratings obtained by this formula, like those secured by the first, are substantially higher for the good loans than for the bad. The efficiency indices are virtually the same—32 for the second formula and 31 for the first; the difference is altogether too small to be significant in a sample of this size. Thus, in spite of the fact that it contains seven factors instead of nine, and a negative weight for stability of residence, the second formula appears to be quite as good a risk indicator as the first.

The second formula was also applied to the industrial banking sample, with two minor variations: stability of residence was eliminated altogether because of the unreliability of the evidence, and all professional persons (both 1a and 1b in Table 13) were given the highest occupational rating. These changes tend to make the scores obtainable by

[4] See Appendix B, pp. 130-31 in the technical edition (cf. pp. x, xi, above).

the formula slightly higher: the absolute minimum is —1.19 instead of —1.44. The distribution of the scores is also shown in Table 18. The efficiency index of 30 is again substantially higher than that for any of the components; the highest component index is 21 for stability of occupation. Here it is interesting to note that a formula derived from commercial bank experience may also be applied to industrial banking companies.

A third formula, determined for the sample of used cars, was based on only four factors—price, down payment, length of contract, and purchaser's income, as follows:

	down payment (in dollars)	
less	.174	x cash price (in dollars)
plus	.124	x monthly income (in dollars)
less	6.45	x length of contract (in months)

This formula was never actually used to determine ratings for the various cases. An estimate of the efficiency index, based on theoretical considerations, was 25. This index was such a slight improvement over 23, the efficiency index for the down payment component, that it seemed hardly worth while to compute and tabulate all the scores.

This formula was derived by the second method mentioned above, which takes account of the interrelationships between factors; as a result, the formula does not conform with the individual analyses of cash purchase price and duration of contract described in Chapter 3. The analysis of cash price showed that high-priced used cars are less frequently repossessed than the low-priced cars; yet the negative weight for price in the formula implies the opposite. The reason for this discrepancy may be found in the relation between price and down payment. When a high price is accompanied by a high down payment—as it usually is—it connotes a good risk; but when a high price is accompanied by a low down payment—which is the exception—it connotes a poor risk.

The individual analyses showed no relation between repossession experience and contract length, but the negative weight in the formula implies that short contracts are better risks. Here the reason for the discrepancy is that low-priced used cars are apt to be financed with short-term contracts. In any particular price level, the short-term contracts are the good risks; but when all price levels are combined, the short-term contracts are no longer noticeably good because they tend to be associated with low-price deals, which are poor.

EVALUATION OF FORMULAE

There is probably no such thing as a unique, ideal credit formula, for different formulae are probably appropriate for different phases of business cycles, for different types of consumer financing agencies, and perhaps even for different firms in the same type of financing. Yet when we consider that the first and second credit formulae above were, despite their differences, about equally effective as risk indicators, we are likely to conclude that the form of a credit formula can be chosen with some latitude. Perhaps a formula designed for depressions will be nearly as useful during prosperity as another especially designed for prosperity; a formula derived for California may work fairly well in New York; and a formula determined by an industrial banking company may even serve for a personal finance company. These questions, however, cannot be answered without recourse to more data than have been available for this study.

The formulae have been presented here only for the purpose of illustrating how individual factors may be combined to obtain credit-rating scores for borrowers; it is not suggested that lenders use these formulae to select risks. Each formula has the not-so-surprising quality of being a better indicator than any of its component factors. But even so, the combination is not substantially better than its com-

ponents. For example, as pointed out above, the first formula has an efficiency index of 31 as against 23 for bank account, its highest component. Although this difference represents an appreciable increase, we do not believe it sufficient to make the first formula a revolutionary discovery. The practical credit executive is primarily interested in a formula that will promise a substantial reduction in credit losses and a substantial increase in profits. Such a formula might have an efficiency index of 62 instead of 31, as we shall show in the next chapter.