Models for Management of Banks' Credit Risk

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WHY USE CREDIT MODELS?

Taking risks is an integral element of banking operations. Sound banking operations are characterised partly by having an overview of the risks which the bank’s operations entail, and partly by the bank's earnings being in reasonable proportion to those risks. Granting of credit is central to ordinary banking operations, and quite naturally this is the principal source of the risks to which banks are exposed. In its simplest form, the risk on credit granting (credit risk) is that the borrower fails to meet its payment obligations to the bank.

Traditionally, banks' management of credit risk has been related to the credit assessment of individual customers. The basis for credit assessment is the customer's financial situation, which gives a picture of the customer's creditworthiness. A key issue for the bank is whether the customer has both the will and the ability to fulfil its obligations to the bank, i.e. to service the debt.

It is also important for the bank to spread its lending on different segments, in order to avoid excessive concentration of risk. This is because different sectors develop differently. Some are cyclically dependent, while others are less sensitive to business cycles. When a bank diversifies its exposures on several sectors, problems in individual sectors will have less impact on the bank's financial stability.

Technological progress in particular, including improved possibilities for complex computation of large amounts of data, has given the banks greater scope to apply credit models to their management of credit risk. Another catalyst in this process is recent years' international consideration of the implementation of new capital-adequacy rules. In the draft proposal for a new Capital Accord the Basle Committee has discussed the possibility of allowing financial institutions at some time in the fu-
ture to use credit models to compile capital requirements, in contrast to the present uniform capital requirements.  

Credit models are not a new approach to credit assessment, however, since the models apply the traditional credit-risk assessment methods. The primary difference is greater systematisation of the existing credit-management methods. In addition, the models make it possible to quantify the risks. In contrast to the present day, where in general terms customers are subject to a qualitative ranking, the use of credit models will make it possible to determine the relative value of a credit exposure.

To a greater degree the use of credit models will enable the banks to undertake portfolio management which takes due account of the varying impact of business cycles on lending. Moreover, the models will make it possible to assess risk and earnings, thereby for each loan ensuring an appropriate trade-off between yield and the risk assumed by the bank, not only for the individual loans, but also in relation to the rest of the loan portfolio.

It is important to note, however, that the banks’ concrete decisions to grant credit will continue to depend on an assessment of the actual risk that an exposure entails.

This article is divided into two sections. The first presents a review of the basic elements of a credit model, while the second focuses on the application of credit models by the banks. Emphasis is on issues concerning the technical deficiencies of the models, as well as the potential implications for financial stability of using the models.

**BASIC ELEMENTS OF CREDIT MODELS**

As in traditional credit assessment, the basis for a credit model is to determine the risk and earnings on each credit exposure. However, in a credit model it is not sufficient to estimate earnings and risk on the basis of qualitative groupings. On the contrary, exact measures must be set for each individual exposure.

Assessment of risk and earnings must include information on co-variations between individual credit exposures. Data is hereby implemented to indicate the extent to which the risk on one credit exposure is affected by a change in the risk on another loan. This is also an element of today’s credit granting, since based on their previous experience the banks take into account that the risk on lending to certain sectors shows equivalent development, while for other sectors the risk

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development courses diverge. For example, a sub-supplier will quite naturally depend on the sales opportunities of the producer of the finished product. On the other hand, the risk development courses of two companies producing substitutes, e.g. beef and pork, in certain situations will diverge, i.e. show a negative correlation.

As in the case of the risk assessment of each credit exposure, the use of a credit model implies that the correlation can be quantified in terms of exact correlation data. It is thus not enough merely to have a general overview of the correlations between the various types of loan. Instead, there must be an exact statistical measure of the links to all other types of loan in the credit portfolio.

For both an individual loan and a credit portfolio the credit risk is quantified by evaluating two central parameters – the expected loss and the unexpected loss. The expected loss (EL) indicates the expected level of the credit loss on the loan/credit portfolio. In principle, EL is not a part of the risk, but can be perceived as a cost. The actual risk, on the other hand, comprises the unexpected loss (UL). UL thus expresses the scale of the loss in more extreme circumstances, i.e. in situations where the development is not as expected. It must be possible to cover such losses from the bank’s own funds.

**Expected and unexpected loss on an individual loan**

The expected credit loss on each borrower can be determined as a product of three factors. The first element is the probability that the borrower defaults. The basis for this might be the ratings of well-reputed international credit rating agencies such as Standard & Poor’s, Moody’s and KMV. Alternatively, internal ratings, which are the banks’ own assessments, can be used.

The second factor is the size of the loan at the time of default. However, it is not certain that the bank will lose the total outstanding. Therefore, a third factor is included, which is the loss given default ratio. This will depend primarily on the seniority and security of the granted loan. All other things being equal, the lower the mortgage seniority and security, the higher the loss ratio.

The fact that a bank cannot be certain of the size of the three factors means that the credit loss, which is the bank’s risk – the unexpected loss – is subject to uncertainty. An individual loan can thus be seen as a stochastic variable. The loan will with great certainty be repaid on the agreed terms, but there is a risk that the borrower either cannot or will

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1 Basle Committee on Banking Supervision (1999) and J.P. Morgan (1997) elaborate on the methods of calculating expected and unexpected loss.
not repay the loan. Therefore, the bank must take into account a small probability that the loan will not be repaid on the agreed terms.

The probability of repayment of the loan will typically depend on the economic development, since experience shows that it is more difficult for a borrower to repay a loan when the business conditions are less favourable. The bank thus cannot in advance only rely on an average probability that the borrower will repay the loan, since this probability will be subject to great fluctuation. It is thus necessary for a bank besides the average values of the aforementioned factors (EL) also to consider the scale of variation (UL).

**Expected and unexpected loss on the credit portfolio**
Quantification of a portfolio's credit risk in principle constitutes the combined risks on the individual loans in the portfolio. However, this cannot be added up in the ordinary way since, as previously stated, account must be taken of the interdependence/correlation of the individual credit exposures. Via concentration and diversification effects these have a great influence on the overall risk of the portfolio.
The expected loss on the total credit portfolio can, however, be determined without taking into account the trade-off between the loans, since it is found by simply adding up the expected losses on individual borrowers/credit exposures.

In principle, the expected loss should be perceived as a cost in line with staff and IT costs, etc. The banks must cover this cost by requiring an appropriate interest premium which is added to the funding and administration costs, etc.

The unexpected loss, UL, or the risk entailed by the credit portfolio, on the other hand, is the probability that the credit loss will be greater than expected. UL will depend on the volatility of the portfolio's credit loss, which again depends partly on the uncertainty concerning the losses on individual credits, and partly on the interdependence of the individual credits. UL is thus to a high degree determined by the extent to which the bank's lending is subject to geographical and sectoral distribution, etc., or in other words, the scale of the portfolio's diversification.

A simple example of perfect diversification is a bank with a portfolio of two loans of equal size. The bank is assumed to know with full certainty that one of the two borrowers will default within the near future, but also that the two loans will not be defaulted at the same time. In this situation the bank will not be exposed to any risk on the portfolio, since a loss which is known in advance will occur with certainty. The example represents a hypothetical situation with a perfect negative correlation in the portfolio. In practice, it will not be possible to achieve such high diversification gains, since the development in lending will
normally show a certain co-variation. In general, however, the greater the diversification of a bank’s credit portfolio, the smaller the probability of losses on all loans at the same time. Therefore the risk is reduced.

The relation between the various concepts of credit loss is illustrated in Chart 1 which applies a distribution function to credit losses on a credit portfolio. The distribution is characterised by a long tail, which is explained by a relatively high probability of small losses and a small probability of very high losses.

EL is given as the average of all the credit losses on the portfolio. UL is determined by a percentile of the distribution function over the credit losses. This measure indicates the bank’s risk as the maximum credit loss which will occur with a given probability. UL can e.g. be set as the 99th percentile, in which case there is a maximum 1 per cent probability of a loss that exceeds UL. This builds, of course, on the assumption that the probability distribution can be determined with sufficient accuracy. A separate problem in this connection is that the distribution changes across the business cycle.

USE IN PORTFOLIO AND CAPITAL MANAGEMENT

The banks can make many different uses of credit models both in connection with their risk management and on their assessment of the trade-off between risk and yield. The models therefore expand possibilities for exact quantification of the credit risk. A bank can therefore establish a credit portfolio with a suitable trade-off between risk and
yield. A bank will also be able to use a credit model to manage and monitor the own funds which must be resilient towards unexpected losses and is a vital buffer against credit losses.

**Portfolio management**

One of the primary areas of application of credit models is management of the banks' credit portfolio. The models can thus be used to assess the present trade-off between the risk and earnings of a credit portfolio. The model can then be used to select or replace credits so as to ensure suitable diversification of the portfolio. In this case models can contribute to eliminating disproportionately high risk concentrations, measured by a marginal risk contribution, from the portfolio.

This is illustrated by Chart 2, which shows an initial portfolio in a yield-risk diagram. The yield and risk of the portfolio are combined from the individual credit exposures included in the initial portfolio. In the example, the credit portfolio can be improved. It is thus possible to obtain a higher yield with the same risk, or to achieve the same yield with a lower risk.

The optimum trade-off between risk and yield is achieved at the efficient frontier. This is the point where it is not possible to gain a higher yield on the portfolio without at the same time increasing the risk. To move the initial portfolio out towards the efficient frontier, an active portfolio analysis is required, whereby the marginal contributions to risk

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1 Saunders (1999) elaborates on the application of the portfolio theory to credit portfolios.
and yields on the potential credit exposures shown in Chart 2 are assessed in relation to the initial portfolio. The assessment can lead to a restructuring of the credit portfolio, whereby certain types of loan are replaced with other types.

Management of own funds

Credit models can also be a valuable instrument in a bank’s management of its own funds, i.e. determining the capital requirement to cover the risk on lending. The purpose of the own funds of a bank is e.g. to have a buffer to absorb the credit losses which are not expected, and which exceeds the bank’s current operating revenues.

In accordance with the methodology underlying the credit models a bank should reserve capital to absorb the unexpected credit loss with a chosen probability. This reservation is normally called the bank’s economic capital (EC) set off to cover credit risks. EC is the bank’s own quantification of the capital required. The bank’s own quantification can vary substantially from the regulatory capital requirements. According to current rules these are standardised.

However, EC is not the entire own funds, since there must also be room for the bank to counter "stress loss", which is losses exceeding the upper limit for unexpected losses. This is shown in Chart 1 as the outermost section of the tail, i.e. the credit loss beyond UL. It must be possible to absorb the extremely high credit losses using the bank’s buffer capital. Overall, the economic capital and the buffer capital are the bank’s total own funds.

The economic capital has become a key element of the banks' presentation of accounts, and several banks perform risk adjusted return on capital (RAROC) calculations for individual business lines. This measure is used by financial institutions to ensure effective capital utilisation. Applying credit models will not only make it possible to perform RAROC calculations for business lines, but in principle it will also be possible to calculate this ratio for individual credit exposures.

In an overall perspective, credit models, when used correctly, can be a useful instrument in the banks' management of their own funds. However, it is important to note that the application of credit models to calculate the capital requirement should be linked to an objective for the bank’s creditworthiness, and with due consideration of the prevailing business cycles. For example, high credit losses can make it necessary to reduce lending if the bank is to maintain an acceptable rating. It is up

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2 Baldvinson et al. (2000).
to each bank to determine the confidence range, and thereby the size of economic capital, the bank is to hold. Application of credit models to management of own funds thus cannot be done automatically without being subject to assessments by the bank's board and management.

PROBLEMS WITH USING CREDIT MODELS

So far, the authorities have been reluctant to allow the banks to apply credit models in the calculation of their regulatory capital requirements. Like all other models, credit models give only an overall description of the reality they seek to describe. So naturally it is vital that the models are robust and can produce safe and stable capital-adequacy requirements which moreover are comparable among individual banks. In this respect there have been problems concerning uniqueness, as well as the data basis and model checking.

Uniqueness

Although the concept of loan default is a central element of the credit models, it has no clear definition. In reality, the banks' definition of a loan default will often be based on varying concepts (e.g. doubtful loan, overdue payments, suspension of payments, liquidation, etc.). If the banks do not use the same definition, the model input will naturally vary in terms of both the probability that a borrower will default, and the size of the loan default, as well as the loss given default ratio.

There is no common understanding of how credit losses are distributed, including how borrowers' creditworthiness and default probability are correlated. Applying confidence ranges in the "tail" of the distribution function (e.g. the 99th percentile) may therefore show great variations among the various models.

Furthermore, different time frames can be applied to calculation of EL and UL. Either a uniform time frame is used across all credit exposures, or a time frame based on each exposure's remaining maturity is used. Typically, a common 1-year time frame is chosen, since (a) this reflects the time range on which data on borrowers' default probability, etc. is based (the majority of the credit rating agencies' data has a 1-year time frame); (b) internal budgeting and accounting procedures are typically based on one year; (c) loans are typically re-assessed once a year. The disadvantage of this time frame is, however, that the credit risk on the loans running for several years can be miscalculated. The argument for using a

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1 IIF & ISDA (2000) contains a comparison and an assessment of published credit models.
2 Basle Committee on Banking Supervision (1999).
hold-to-maturity time frame is that most exposures are kept until maturity and are often illiquid.

**Data problems and model validation**

A fundamental problem is a lack of historical data on loans that have defaulted that covers several business cycles. Historical data from external credit rating agencies will, moreover, be dominated by data for American companies and will therefore not necessarily match regional conditions.

Due to data problems it is not easy to determine whether a model is "good" (back-testing). Moreover, a BIS survey shows that in their application of credit models banks currently only to a limited degree carry out stress testing (e.g. scenarios with downgrades, increased credit spreads, changes in default probabilities) and sensitivity analyses (e.g. of central model parameters or model assumptions). If the credit models are to be accepted in a regulatory context, the authorities will have to require that the models can be checked and evaluated.

**CREDIT MODELS IN RELATION TO FINANCIAL STABILITY**

The use of credit models to manage a credit portfolio may have several implications if the models become customary in the financial sector. This especially concerns the regulatory aspects of the application of models, including the safeguarding of financial stability, but also the impact on the competitive environment in the financial sector.

The Basle Committee has put forward a proposed revision of the current capital-adequacy rules. The purpose is to increase the incentive for the banks to strengthen their credit-risk management and to increase the diversification of their lending. The proposal describes the possibility of the banks at some time in the future applying credit models to determine the regulatory capital requirements. This will present many new challenges to the supervisory authorities in their monitoring of the models.

For the financial sector, the use of credit models will be a good tool in both day-to-day risk management and more general strategic credit decisions. Combined with traditional credit assessment the credit models will improve the banks' decision-making when granting credit. However, several parties find the models, as yet, too fragile to calculate the buffer capital (e.g. various models have proved to yield different results). Moreover, one of the reasons for not permitting credit models at the

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1 Basle Committee on Banking Supervision (2000).
2 Cf. also Hyldahl (2001).
present time is that due to a lack of data the banks have not yet had the opportunity to test the techniques in an actual economic recession.

Widespread use of credit models will affect the credit markets. So far, the banks' fixing of interest rates has to a high degree been driven by the amount of capital tied to the loan, rather than the level of credit risk. Today's price structure thus shows an only marginally rising trade-off between risk and yield, cf. Chart 3. Capital requirements calculated in credit models will induce the banks to require each borrower to pay an interest rate in reasonable proportion to the risk (and thereby the requirement of capital). All other things being equal, this will improve the efficiency of the credit markets. At the same time, financial stability will improve, since higher risk will be set off by higher earnings.

The application of credit models should also be viewed in the light of bank shareholders' demands for higher yields on invested capital, i.e. greater shareholder value. The debate on shareholder value has e.g. meant that financial institutions have reduced the proportion of the own funds which exceeds the regulatory capital requirement. The grounds given include the considerable variation between the regulatory capital requirement and the economic capital, which is the bank's own quantification of the optimum capital. Besides contributing to the bank's assessment of its own risks, credit models can be seen as a tool for adjustment of the own funds, i.e. make it easier to calculate and utilise diversification gains.

In the immediate future the use of credit models will probably become most common among the major banks. This is first and foremost due to the costs related to introducing the models, including the requirements
of computation capacity and know-how. However, this does not mean that small banks which do not use credit models will lose competitiveness. Good local market experience is still a key parameter of competition and can help to maintain the competitiveness of small banks.

CONCLUDING REMARKS

The application of credit models by the banks will be a tool in the management of credit risk. Moreover, the models will make it possible to determine prices on a more appropriate basis, so that to a higher degree the interest rates for various exposures reflect variations in risk. This is because the use of credit models allows the credit risk to be quantified.

Moreover, active application of credit models can limit the extent of unintended risk concentrations and contribute to increasing yields in relation to risk via the selection of credits which overall constitute a well-diversified credit portfolio yielding the required return.

Another factor, and perhaps the most important implication of using credit models, will be the possibility to improve the basis for decision-making regarding capital structure and assessment of the capital adequacy. The calculated credit risk in the models, together with a bank's creditworthiness objectives, are the key elements in determining a bank's economic capital allocated to cover credit risk.

So far, the authorities have not permitted the use of credit models in connection with the compilation of the regulatory capital requirement. This is because there is still not full clarity concerning the consequences of using the models for each bank and to financial stability.

However, interest from the banks can be expected to increase in the near future, and especially if there are great variations between, on the one hand, the regulatory capital requirements, and on the other, the banks' own quantification of the optimum own funds, calculated with the help of credit models. In connection with the implementation of new capital-adequacy rules a good degree of accordance will be desirable and this will be an incentive for the sector to use credit models.
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