The Bundesbank's method of assessing the creditworthiness of business enterprises

Prior to the launch of European monetary union, the Bundesbank's monetary policy instruments included discount policy. In line with section 19 of the Bundesbank Act, the Bundesbank purchased "fine trade bills" from credit institutions at its discount rate up to a ceiling (rediscount quota) set individually for each institution. The Bundesbank ensured that the bills submitted to it were sound by examining the solvency and financial standing of the parties to the bill.

The Bundesbank discontinued its rediscount lending operations with the start of monetary union on January 1, 1999. However, it will continue to accept bills – and in future loan claims as well – from credit institutions as forms of lending to trade and industry as part of the refinancing operations of the European System of Central Banks (ESCB). They have a wide range of potential applications: they can be used as collateral for all central bank loans.[1]

However, "eligible" non-bank enterprises domiciled in Germany will now have to meet the ESCB's more stringent credit standing requirements which are geared to the quality standard of the union-wide tier-1 list of collateral.

1 See Allgemeine Regelungen für die geldpolitischen Instrumente und Verfahren des Europäischen Systems der Zentralbanken, Deutsche Bundesbank, Informationsbrief zur Europäischen Wirtschafts- und Währungsunion No. 15, October 1998.

The Bundesbank's system of assessing creditworthiness

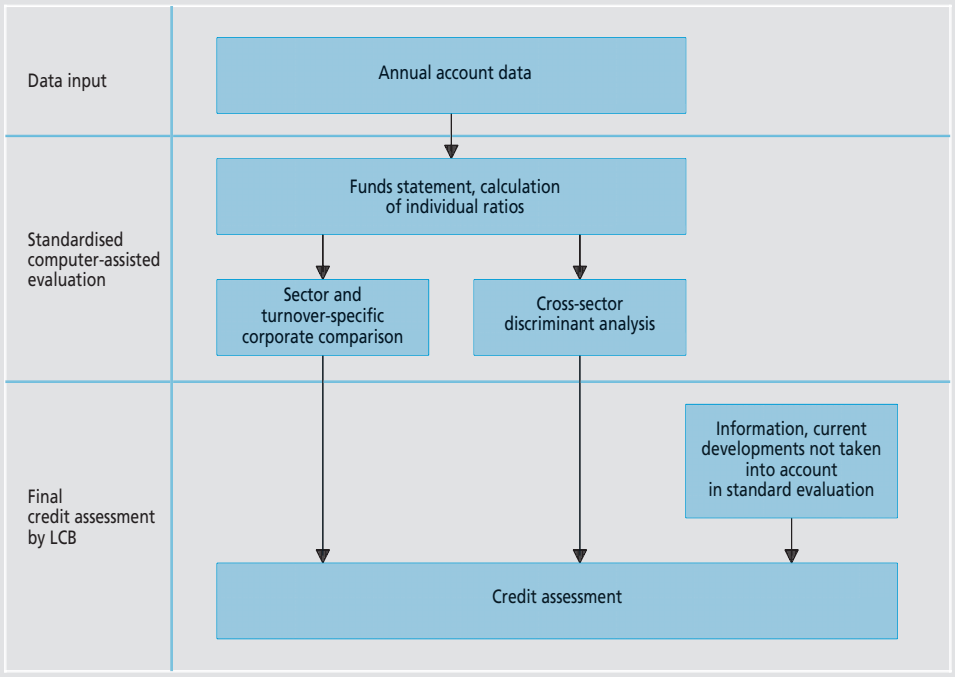
ESCB places higher demands on credit-worthiness

In order to meet the higher demands on creditworthiness, the Bundesbank introduced a new credit assessment procedure for "its" tier-2 collateral in the form of bills and loan claims starting from July 1, 1998. It is based on the old credit assessment procedure and likewise requires non-bank enterprises which post collateral for loans to present detailed annual accounts – as was the case under the old bill rediscounting system. However, the new credit assessment procedure takes account not only of quantitative annual account data but also of qualitative data. They are evaluated using modern analytical techniques in the form of sector-specific discriminant analyses and an expert system which are described below. Additional technical details are described in the Annex to this article.

The old procedure and ...

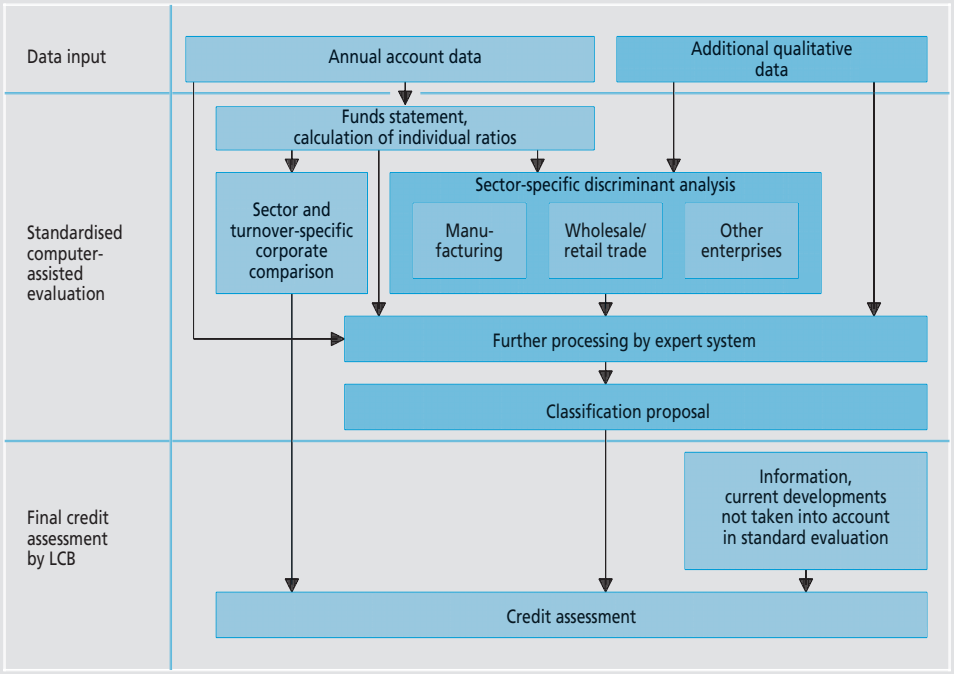
Under the old procedure a standardised method of treatment was applied solely to annual account data in the form of the funds statement, individual economic ratios, discriminant analysis and what was known as a corporate comparison. The managers of the appropriate branch of the Bundesbank made a direct credit assessment on the basis of these data. Other information on the enterprise in question, including qualitative information, was occasionally used in making the assessment; but these additional data were not subjected to any systematic treatment or processing (see chart "Credit assessment procedure – old system").

Credit assessment procedure (old system)



Deutsche Bundesbank

Credit assessment procedure (new system)



Deutsche Bundesbank

... the new procedure

By contrast, the Bundesbank's new procedure prepares the credit assessment in a much more complex manner. Both the quantitative annual account data and qualitative information about an enterprise are subjected to a differentiated discriminant analysis and are subsequently further processed by an expert system. This standardised data processing procedure thus produces an automated credit assessment which is objectively substantiated to a high degree. But the credit assessment generated in this way still has to be confirmed and, if necessary, revised by the managers of the appropriate Bundesbank branch in the light of additional information and insights (see chart "Credit assessment procedure – new system").

First step: recording the data

Recording of at least two sets of annual accounts

The process of analysis and evaluation begins with the recording and processing of annual account data and, now in addition, of qualitative corporate data. As before, this is carried out by the Bundesbank branches on the basis of at least two consecutive sets of annual accounts. The data are entered on to a recording sheet which also includes details of the enterprise's accounting practice as well as additional qualitative details about the enterprise.

Accounting practice

By including the enterprise's accounting practice as an additional factor, the Bundesbank takes into consideration the fact that German accounting law offers firms various valuation options which can change the way in which

annual account figures are interpreted. Indications of an enterprise's accounting practice and its use of accounting options are contained principally in the notes to the annual accounts pursuant to section 284 of the German Commercial Code. However, the Bundesbank also obtains supplementary information on a firm's accounting policy from other sources such as discussions with the firm's management. This information may concern the following items: the amount of provisions, the scale of capitalised production costs, the type and amount of depreciation, the valuation of stocks, the implied interest rate used for pension provisions, extraordinary factors affecting earnings, and the liquidity position on the balance sheet date.

Each enterprise is examined to see whether its use of the available accounting options differs significantly from that of the majority of firms with which the Bundesbank has business dealings. If there is a deviation from the norm in one direction or another, the enterprise's accounting practice is categorised as conservative or progressive. It is an empirically confirmed rule that high-performing enterprises tend to use a conservative accounting policy and hence to "underrate" their earnings performance by applying accounting options which depress the disclosed profit result, whereas low-performing enterprises tend to use a progressive accounting policy, i.e. they "overrate" their earnings performance by applying accounting options which boost their disclosed profit result. In this way information which is important for the credit analysis – in addition to the balance sheet data – is obtained in an objective form.

Other information

Other information that is gathered includes, for example, the age of the enterprise, its size and its legal form.

Second step: standardised evaluation of the data

Funds statement and the calculation of ratios

On the basis of the annual account data, processed according to a given system, a funds statement is generated in the course of the evaluation and economically informative ratios are calculated for the firm's financing structure and profitability.

The funds statement drawn up by the Bundesbank for each enterprise is more than a simple statement of the sources and uses of funds. Derived from the balance sheet and profit and loss account figures, an enterprise's payment flows are treated as a closed system, broken down by turnover, asset formation and financing, and the resulting financial surplus or deficit is then determined. This gives the Bundesbank an insight into the firm's investment and financing policies and allows it to assess the enterprise's ability to generate financial resources. These are two key indicators of a firm's underlying soundness and hence for assessing its overall creditworthiness.

Corporate comparison

The same goes for what is known as the corporate comparison, which ranks individual ratios of enterprises into quartiles broken down by sector and turnover size. For the sectoral breakdown the Bundesbank makes use of the industrial classification system of the Federal Statistical Office by which each

enterprise is allocated to the sector in which its main field of activity lies. To improve comparability, each sector is subdivided into a maximum of three turnover size categories. The standardised procedure is based – wherever data material is available – on the evaluations of at least the last two and, if possible, the last three years, thus enabling the enterprise's development to be assessed in comparison with other competitors over time.

Evaluation steps

The ratios obtained from the funds statement and the annual accounts form the raw material for the actual evaluation. The latter is made up of two components: (1) the discriminant analysis, a mathematical-statistical process which permits an initial classification of the enterprise's soundness, and (2) the expert system by means of which the results of the discriminant analysis are fine-tuned by means of a rule-based processing of additional information with the aim of achieving a more precise classification of the enterprise.

Classification into credit groups through discriminant analysis

By means of the discriminant analysis an overall ratio is calculated for each enterprise from the sum of weighted individual ratios. On the basis of this overall ratio the enterprise is then placed in one of three categories of creditworthiness: "good credit standing" (A group), "indifferent credit standing" (B group) and "endangered credit standing" (C group).

Sector-specific discriminant functions with accounting practice

Whereas in the past the Bundesbank used only one discriminant function for all enterprises, it now computes three different discriminant functions in order to obtain a somewhat better classification, for (a) the manufacturing sector, (b) the wholesale and retail trade, and (c) "other enterprises". A further innovation is the inclusion in these sector-specific discriminant functions of the qualitative feature "accounting practice" as an individual ratio (see table above).

Further processing of the discriminant analysis

The result of the discriminant analysis is still not sufficiently precise, however. The overall ratio – whether sector-specific or not – remains a variable which merely facilitates the "presorting" of a set of data and which allows only a fairly rough classification of enterprises into the three aforementioned categories of creditworthiness A, B and C. Firms in the B group, in particular, need to be further processed because their classification is not sufficiently unambiguous. Hitherto this task of further processing was the job of the

Individual ratios for calculating discriminant functions

Sector	Ratios in the discriminant function
Manufacturing	Equity/pension provision ratio [1] Return on total capital employed [2] Return on equity [3] Capital recovery rate [4] Net interest rate [5] Accounting practice
Wholesale/ retail trade	Equity ratio [6] Return on equity Capital recovery rate Accounting practice
Other enterprises	Equity ratio Return on equity Capital recovery rate Accounting practice

1 Adjusted equity capital and pension provisions as % of total capital employed. — **2** Profit/loss before taxes on income and before interest paid as % of total capital employed. — **3** Profit/loss before taxes on income as % of adjusted equity capital. — **4** Net receipts/net expenditure as % of capital invested. — **5** Net interest result as % of turnover/total output. — **6** Adjusted equity capital as % of total capital employed.

Deutsche Bundesbank

credit officer. In future, this task will be performed largely in a standardised form.

Standardised further processing by the expert system

To this end, use is made of what is known as an expert system. This modern technique – which represents the second step in the data evaluation process – simulates the activity of a human expert in the decision-making process. It uses rules to perform the task of classification and can therefore indicate the logical conclusions on which a decision is based. In contrast to other classification techniques, such as neural networks, expert systems meet the essential condition in credit assessment that the reasons for the standardised decisions they make can be verified by the credit officer.

Task of the expert system

The enterprises, which have already been presorted through the discriminant functions, are further processed by the rule-based expert system with three concrete aims in mind: (1) reduction of the number of B enterprises by attempting to allocate as many of this group of enterprises as possible either to the A group or to the C group; (2) standardised processing of additional information that has so far not been considered in the evaluation process in order to obtain as comprehensive a picture as possible of the degree of soundness of the enterprise that is being evaluated; (3) assistance to the managers of the Bundesbank's branches in making the final credit assessment.

The expert system is "fed" with the overall ratio from the discriminant analysis as well as additional annual account data and qualitative information. This includes such information as the firm's legal form, its size and age, the way it finances its fixed assets, and the annual rates of change of various ratios.

This additional information is processed by the expert system on the basis of economically derived and statistically significant rules. Each of these rules changes the firm's overall ratio if it meets certain conditions: if the rules are defined as a condition of sound enterprises, the overall ratio rises, otherwise it falls. However, the expert system is supposed to adjust the overall ratio only moderately; therefore it is designed in such a way that it does not reclassify A enterprises into the C group or vice versa. Of the large number of rules available in the expert system, it activates all those that are applicable to the specific case of the enterprise to be evaluated. In most cases these include rules that both raise and lower the overall ratio. As part of the overall assessment, therefore, the expert system weighs up the competing rules against one another.

Resulting classification proposal

In the upshot the system makes a clear classification proposal for the bulk of the enterprises processed. Whereas more than 17 % of enterprises remain in the indifferent B group after the discriminant analysis, the expert system improves the precision of the classification appreciably: only around 6 % of the enterprises still have no clear allocation.

Third step: credit assessment

Despite all endeavours to automate and standardise decision-making within a credit

No automated credit assessment

assessment procedure, the final assessment of an enterprise's creditworthiness cannot be made solely by employing state-of-the-art computer-assisted systems. Although such techniques can help human operatives in making their decisions and can relieve them of routine work, they cannot entirely replace human experience and knowledge. For this reason the final credit assessment – i.e. whether the enterprise's liabilities are eligible as collateral for central bank loans or not – will continue to be made by the managers of the Bundesbank's branches.

Examination of the classification proposal

Before making their final assessment, the managers will ask themselves at least two questions after this automated procedure has been concluded: (1) Are there any other data on the enterprise's current development that were not taken into account in the standardised process? (2) Does the standardised evaluation of the balance sheet present a plausible picture or has it failed to take account of specific circumstances which might make a different credit assessment appear more appropriate? Depending on how these questions are answered in each individual instance, the credit assessment may or must differ from the classification proposal generated by the standardised credit assessment procedure.

Credit assessment procedure: standardised but flexible ...

The Bundesbank's new credit assessment procedure for assessing the creditworthiness of enterprises is characterised by two key features. Firstly, the extensive standardisation of the process permits efficient and transparent processing of a large number of annual accounts. Secondly, the measure of individual decision-making that is necessary in credit business is retained.

... although it cannot be transferred to the credit business of commercial banks

The credit assessment resulting from the Bundesbank's examination of an enterprise's creditworthiness is reported both to the assessed enterprise and to the credit institution that is seeking to use its loan to the enterprise in question as collateral for refinancing from the central bank. It is important to bear in mind, however, that the Bundesbank's credit assessment is not to be applied to the credit business of the commercial banks. A credit assessment of "not eligible for refinancing at the central bank" may under no circumstances be interpreted as meaning "not creditworthy" in banking business, as the strict ESCB standard, which is geared *inter alia* to a high credit rating, cannot be transferred to banks' lending activities.

The Annex to this article appears on the following pages.

Annex

Explanation of the classification procedure

Discriminant analysis

Discriminant analysis – a mathematical-statistical procedure

Discriminant analysis is a mathematical-statistical procedure in which observable features are used to allocate objects precisely to one of at least two non-overlapping subsets. For the purposes of credit assessment, the objects are the enterprises which are to be classified and the observed features are the corporate data such as economic ratios. The non-overlapping subsets are defined from a sample containing both insolvent enterprises and enterprises which are definitely solvent. The discriminant analysis performed by the Bundesbank is carried out in the following four steps:

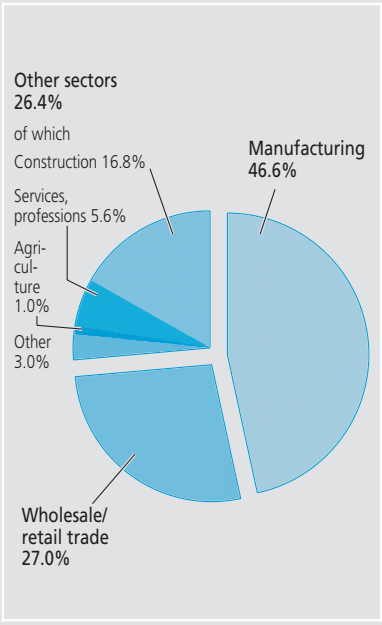
First step: calculation of economic ratios

In order to obtain as comprehensive a picture as possible of an enterprise's soundness, the Bundesbank analyses key ratios on the enterprise's assets and liabilities, profit or loss and financial position. These quantitative ratios can be used without any further processing to determine the discriminant function. By contrast, qualitative ratios[2], such as the enterprise's accounting practice, have to be scaled prior to processing, i.e. the verbal information has to be "translated" into numbers to facilitate mathematical processing.

Second step: definition of a sample

By means of a representative sample of the enterprises to be assessed in the Bundesbank's business dealings, the discriminant functions are determined and their effectiveness is assessed. The sample is composed of both solvent and insolvent[3] enterprises. As they are less numerous, the available insolvent enterprises determine the size of the sample because it is beneficial for statistical reasons to have the same number of solvent and insolvent enterprises in the sample. The sample for the Bundesbank's current discriminant analysis includes the last available annual accounts for the years 1995, 1996 or 1997 of enterprises which have in the meantime become insolvent. These annual accounts are contrasted with the same number of comparable[4] annual accounts of solvent enterprises. The breakdown of the sample by sector is shown in the chart above.

Insolvent enterprises by economic sector



Deutsche Bundesbank

Third step: determination of the discriminant function

In the applied case of the linear discriminant function, the enterprises are classified according to the

2 Qualitative ratios are variables which are not available on a continuous basis and which frequently exist only in verbal form.
3 An enterprise is regarded as insolvent if an application has been made for the instigation of bankruptcy or composition proceedings against it.
4 Comparability is ensured by matching each insolvent enterprise with a solvent enterprise in the same sector and the same accounting year.

following rule. The discriminant value Z (overall ratio) is determined as $Z = a_1 \cdot x_1 + ... + a_n \cdot x_n$, where x_1, x_2, ..., x_n are the input ratios and a_1, a_2, ..., a_n are their respective weights. If Z is greater than the cut-off point Z_{co}, the enterprise under examination is allocated to the group of sound enterprises; if not, it is allocated to the group of unsound enterprises.

On the basis of the sample data, the discriminant analysis provides optimal parameters a_1, a_2, ..., a_n and Z_{co} for a given combination of ratios x_1, x_2, ..., x_n in the sense that the classification error[5] is minimised for this discriminant function.

Fourth step: assessment of effectiveness by means of ...

To assess the effectiveness, statistical significance tests[6], the expected classification error and the definiteness of separation of the model are additionally considered. The last two variables are determined from the sample.

... classification error and ...

For this purpose the sample should be divided ideally into an analytical sample and a test sample; the analytical sample is used to calculate the weights of the discriminant function, and the effectiveness of their classification is then estimated on the test sample. To this end, the Bundesbank uses the classification errors described in footnote 5. However, this method presupposes a minimum size of the sample, which is determined by the accuracy of error to be achieved. For example, in a sample consisting of 100 enterprises, even one outlier can distort the error by 1 percentage point. Owing to the sector-specific breakdown of the enterprises included in the discriminant analysis, the Bundesbank cannot meet this strict requirement despite the large size of the available dataset. For this reason the discriminant functions are determined on part of the sample and the classification errors on the sample as a whole.

... definiteness of separation

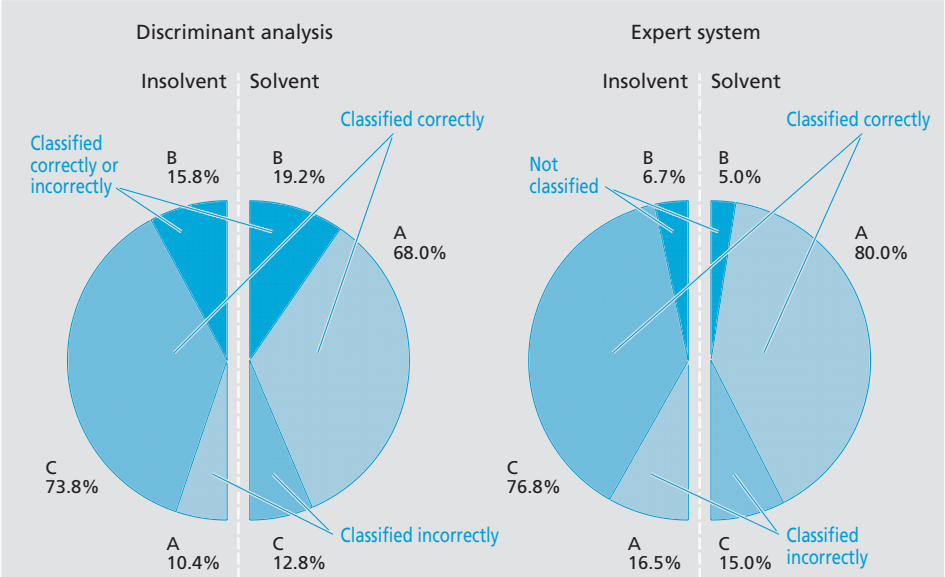
The definiteness of separation denotes the degree of certainty with which enterprises are allocated to the two groups. The degree of probability that an enterprise belongs to a given group is considered to increase in line with the distance of its overall ratio Z from the cut-off point. The Bundesbank's classification of enterprises into the different credit groups is also based on this: the B group is characterised by overall ratios in an interval around the cut-off point, while the A group and the C group are characterised by overall ratios which lie above or below the B group, respectively.

Consequently, insolvent enterprises with overall ratios from the A group and solvent enterprises with overall ratios from the C group are always incorrectly classified; insolvent or solvent enterprises in the B group are incorrectly classified only if their overall ratio lies above or below the cut-off-point. The chart on page 60 shows the effectiveness of the Bundesbank's discriminant functions across all sectors. At around 19 %, the overall classification error, which includes the incorrectly classified enterprises in the B group, is acceptable, but the definiteness of separation of the procedure, at over 17 % in the enterprises classified in the indifferent B group, is unsatisfactory.

As more ratios are available than are required for a discriminant function, steps 2 and 3 are repeated with different combinations of ratios until an optimal result is obtained. In the end it is those ratios which have proved empirically to be the most

5 The possible classification error is made up of two components: the α error, indicating the share of insolvent enterprises classified as solvent in all insolvent enterprises, and the β error, indicating the share of solvent enterprises classified as insolvent in all solvent enterprises.
6 A significance test answers the question of whether the outcome of a statistical process may be due to chance.

Classification results of the sample after the discriminant analysis and the expert system



A: Group with good credit standing. — **B**: Indifferent group. — **C**: Endangered group.

Deutsche Bundesbank

meaningful for separating the two groups that are included in the optimal discriminant function.

Classification of unknown enterprises

After the discriminant analysis has been successfully completed in the four steps described above, the discriminant functions obtained make it possible – as the sample mirrors the circumstances in the totality of enterprises – to classify unknown enterprises, too, into those which predominantly have the features of solvent enterprises and those which predominantly have the features of insolvent enterprises. They are classified on the basis of the ratios contained in the discriminant function together with their corresponding weights.

Expert system

Expert systems are techniques of artificial intelligence by which the decision-making process of human experts – hence the name – is simulated by computer systems. Using such systems, along with discriminant analysis, problems of classification can be resolved. At the Bundesbank the classification problem consists in allocating an overall ratio of either the A group or the C group to the enterprises under assessment in order to arrive at a clear-cut classification proposal.

Expert systems – a technique of artificial intelligence

In contrast to discriminant analysis, in which – as described above – the classification rule is derived empirically, expert systems require prior knowledge in the form of universally valid rules. On the other hand, an expert system can cope quite well with incomplete data: in making its decision it uses only those rules for which the preconditions are met. By contrast, the overall ratio can be calculated using a discriminant function only if all the individual ratios included in its calculation are known. On account

Expert systems versus discriminant analysis

of these different methods of processing, the two techniques complement each other rather well.

Rules of the expert system

The rules of the expert system can be derived either theoretically or from statistically observed facts and must comply with the following logical structure:

If property 1 and if property 2 and ... and if property N apply, then increase (or reduce) the overall ratio.

Verbally formulated rules

The properties in the If-part of the rule are quantifiable and are initially formulated as imprecise[7] verbal features (high, medium, low or declining, unchanged, increasing and so on). Examples of such properties are: "If the turnover is lower than in the previous year" or "If the turnover is unchanged against the previous year". This "fuzzy" formulation and processing of the rules is geared to human patterns of thinking and enhances the system's acceptability and effectiveness.

Preconditions for rule checked first

The processing technique within the expert system checks each rule to see whether its preconditions are met for the enterprise in question. This means that the system tests, first of all, whether the properties 1 to N of a concrete rule apply. Reverting to the previous example, the system needs to check whether a change in turnover indicated by the annual account data is to be categorised as "declining" or "unchanged".

Translation into numbers

In order for them to be processed in the system, the fuzzy features naturally have to be "translated" into concrete figures; in other words, the properties "declining", "unchanged" and so on have to be quantified. This translation is performed for each property in the rule preconditions by means of a special inclusion function. Such a function determines on a continuous scale from 0 to 1 to what extent this particular property is fulfilled. The higher the degree of inclusion the more the property is fulfilled; if the degree is zero, the property is not fulfilled; if it is 1, it is completely fulfilled. The inclusion functions can overlap, so that, for example, a change in turnover indicated by the balance sheet data can have a degree of inclusion both to "declining" and to "roughly unchanged".

The chart on page 62 illustrates this concept for a given feature with the properties "declining", "unchanged" and "increasing". The inclusion functions give rise to five different subsets for a feature:

- three subsets of clear-cut inclusion in which the feature – with a varying degree of inclusion – is exclusively "declining", "unchanged" or "increasing", and

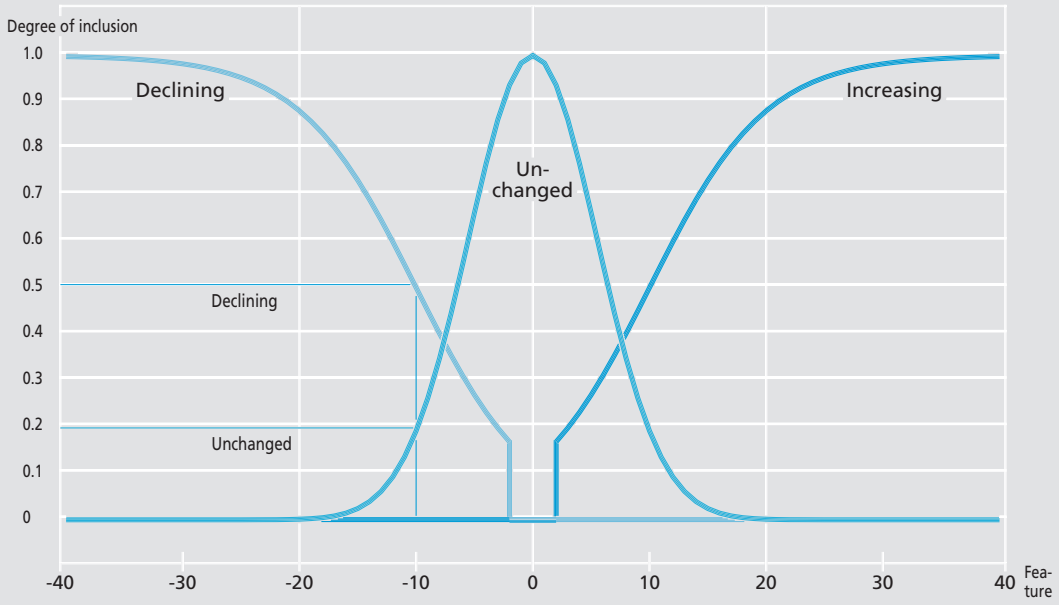
- two areas of overlap in which a fluid transition occurs between the clear-cut subsets because in them the feature is both "unchanged" and "declining" or both "unchanged" and "increasing".

Adjustment of the overall ratio

If it is assumed that the expert system works with M different rules, a variable e_i can be calculated as the degree of fulfilment of the i-th rule (i = 1, ..., M) for each of these rules using the inclusion functions. This is done using the formula $e_i = \gamma_i \cdot p_i^1 \cdot p_i^2 \cdot \ldots \cdot p_i^N$ where γ_i is the absolute rule weight and $p_i^1, \ldots, p_i^N$ is the degree of fulfilment of the N properties stipulated in the If-part of the i-th rule. After adding another variable

7 A system that processes features in this form is also known as a fuzzy system.

Inclusion functions * for the properties "declining", "unchanged" and "increasing" of a given feature



* The inclusion functions translate verbal properties into numbers. For example, a value of –10 has a degree of inclusion of 0 to "increasing", 0.19 to "unchanged", and 0.5 to "declining".

Deutsche Bundesbank

$$\Delta Z_i = \begin{cases} Z^+ > 0, & \text{if the overall ratio is to be increased} \\ Z^- < 0, & \text{if the overall ratio is to be reduced} \end{cases}$$

a new overall ratio is calculated, adjusted by the expert system, by means of

$$Z^{new} = Z + \frac{\sum_{i=1}^{M} e_i \cdot \Delta Z_i}{\sum_{i=1}^{M} e_i}$$

This expression can be interpreted graphically such that the rules with the various Then-parts are weighed against one another and the result of this weighing process is normed in such a way that the overall ratio Z from the discriminant analysis is not increased by more than Z^+ or decreased by more than Z^- for any enterprise. Which rules had what influence in this weighing process can be gauged from the specified expression for Z^{new} by comparing the degrees of fulfilment. As a result, the decision generated by the system is rendered transparent.

Optimisation of the expert system

The formula for the adjusted overall ratio Z^{new} still contains some parameters that are initially unknown: the rule weights γ_i, the maximum increases and decreases in the overall ratio Z^+ and Z^-, respectively, and variables that may affect the position of the various inclusion functions. These are optimised – analogously to the weights of the ratios in the discriminant function – by stipulating the requirement for enterprises in a sample that as many solvent enterprises as possible display an adjusted overall ratio in the A group and as many insolvent enterprises as possible display an adjusted overall ratio in the C group.

Effectiveness of classification improved by the expert system

Naturally, in this case – as in any statistical procedure – the optimisation is not perfect. This means that even after the assessment has been generated by the expert system, there are still incorrectly classified or ambiguously classified enterprises. The chart on page 60, which compares the classification results from the discriminant analysis with those from the expert system on the basis of the sample, shows that the expert system substantially improves the performance of the discriminant analysis. For one thing, there is a considerable increase in the definiteness of separation from more than 17 % to less than 6 % being non-classified enterprises. For another thing, the mis-classification rate falls significantly from 19 % incorrectly classified enterprises (including those in the B group) after the discriminant analysis to 16 % of enterprises incorrectly classified by the expert system.