REXS : A financial risk

diagnostic expert system

W Richter

and

P S Kruger

Department of Industrial and Systems Engineering
University of Pretoria
South Africa

Abstract

Artificial intelligence techniques are rapidly emerging as important contributors to more effective management. One of the greatest growth areas probably lies in the use of Expert System methodology for supporting managerial decision processes.

Existing Decision Support Systems often attempt to apply analytical techniques in combination with traditional data access and retrieval functions. One of the problems usually encountered while developing such decision support systems is the need to transform an unstructured problem environment into a structured analytical model. Using an expert system approach to strategic decision making in such unstructured problem environments may provide significant advantages.

The financial Risk diagnostic EXpert System (REXS) concentrates on Financial Risk Analysis. Based on a Forecasting Model the system will, with the support of several expert system knowledge bases, attempt to evaluate the financial risk of a business and provide guidelines for improvement.

Opsomming

Tegnieke gebaseer op Kunsmatige Intelligensie toon tans die belofte om belangrike bydraes te maak tot meer effektiewe bestuur. Een van die toepassingsgebiede met waarskynlik die grootste potensiaal is die gebruik van Ekspertstelselmetodologie vir die ondersteuning van bestuursbesluitprosesse.

Bestaande Besluitsteunstelsels poog dikwels om analitiese tegnieke en tradisionele datatoegang- en onttrekkingsfunksies te kombineer. Een van die probleme wat gewoonlik ondervind word gedurende die ontwikkeling van 'n besluitsteunstelsel bestaan uit die behoefte om 'n ongestruktueerde probleemomgewing te transformeer na 'n gestruktueerde analitiese model. 'n Ekspertstelselbenadering tot strategiese besluitneming in 'n ongestruktureerde probleemomgewing mag betekenisvolle voordele inhou.

Die "financial Risk diagnostic EXpert System (REXS)" konsentreer op finansiële risiko-analise. Uitgaande vanaf 'n Vooruitskattingsmodel, en deur gebruik te maak van verskeie ekspertstelselkennisbasisse, poog die stelsel om die finansiële risiko van 'n onderneming te evalueer en riglyne vir moontlike verbetering voor te stel.

1. INTRODUCTION

The financial failure of industrial businesses has become one of the most important aspects of any economy. A business is a legal failure if the assets of the business are not sufficient to meet the legally enforceable claims of creditors. It is a proven fact that the underlying cause of most failures can best be summarized by the term "management incompetence". The usual "causes" given for financial failure, e.g.,lack of capital, faulty accounting, poor planning, etc., are often not causes but rather rationalizations or excuses for poor management performance.

The two most important factors concerning financial failure are the economic and financial risk of the business. Economic risk is associated mainly with the industry to which the business belongs, and with the general conditions of the particular economy. Financial risk, on the other hand, is subject almost completely to the discretionary control of management.

To help management in detecting, or even forecasting possible financial failure, a research project, consisting of the development of a Forecasting Model, was carried out at the Bureau of Financial Analysis at the University of Pretoria [9]. The model measures the risk of financial failure by means of calculating a risk factor through the combination of ratios determined from items in financial statements. This risk factor is a reflection of the probability that a large business may fail financially. The lower the value of the calculated risk factor, the greater the risk that the business may fail financially.

A financial Risk diagnostic EXpert System (REXS), was developed to further improve the significance and usefulness of the forecasting model, by adding five diagnostic modules to this risk analyses module. The system will enable the user not only to analyse the business, but also to diagnose the problems indicated by the analysis, therefore providing a closed-loop integrated system.

The system consists of several components as follows :

a)Data Management : All the data needed by the system is maintained in three different data resources.

Financial Statement Data Base : The information needed to calculate the risk factors, e.g.,item values, ratio values, etc. are maintained in this data base.

Diagnostic Data Base : The information needed in the Diagnostic Analysis modules, e.g., user ratings, user priorities, industry ratio value, etc., is maintained in this data base.

User : The user is a very important data resource not always successfully used. The expert system environment makes user interfacing relatively easy.

b)Risk Value Analysis : The business being analysed is classified into a risk class according to a rating determined through time series analysis.

c)Ratio Value Analysis : The ratios that constitute the Financial Forecasting Model are analysed and priorities are allocated according to the importance for financial improvement.

d)**Diagnostic Simulation** : Improvements on the risk factor and ratio values are proposed based on a comparison between the calculated values and corresponding values from the industry and the company goal set by management. A simulation, based on the improvements proposed by both the system and the user, is carried out.

e)**Review of Diagnostic Simulation** : All values are displayed on different graphs to indicate the results of the diagnostic simulation.

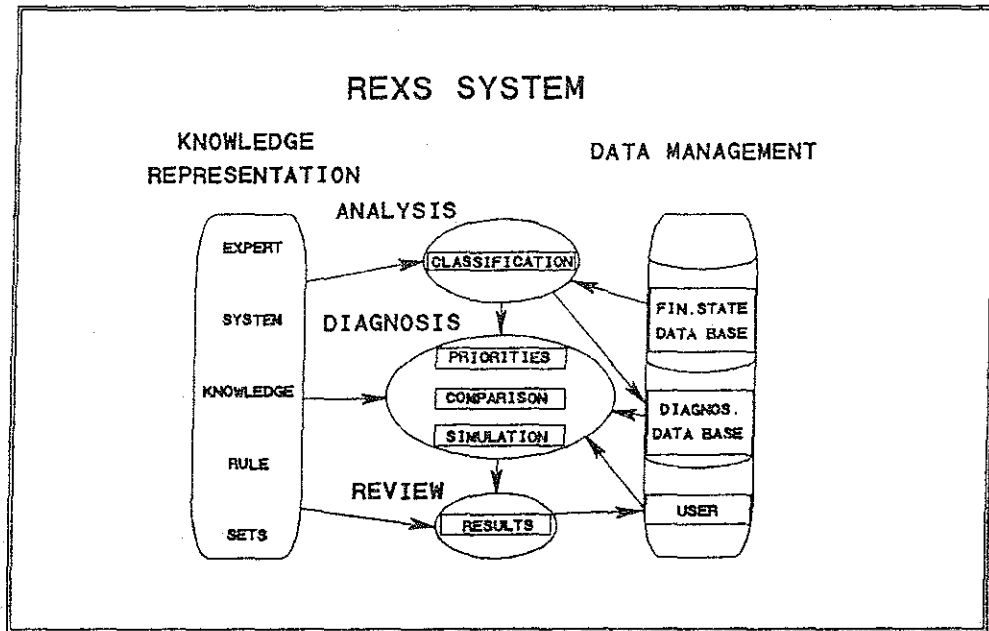A conceptual view of the system is presented in Figure 1.

Figure 1. Conceptual view of the system.

2. DESIGN STRATEGIES AND OBJECTIVES

The system is based on the **expert system development environment GURU** [19,20], which supports a broad range of integrated knowledge processing capabilities.

The system consists of seven individual, yet integrated, components, each accessed from the main menu. The first component of the system is a **data base** to control, organize, store, retrieve and update all information needed by the system. The remaining six components of the system use **expert system** facilities to assist a financial analyst to diagnose the financial risk of a business. The logical procedure may be described as follows :

a) **Capturing data** from financial statements,
b) **Classification** of a business, using user experience,
c) **Allocating priorities,**
d) **Comparing results** with industry trends,
e) **Simulating improvements** recommended by the user, and
f) **Reviewing** the general financial implications.

As previously noted the diagnostic components of the system are based on an expert system environment. Conversely, the system itself consults various knowledge bases in the course of its execution and allows the user to directly interact with the system. When a user

presents a particular problem, the system uses the available stored expertise to infer advice which is presented to assist the user when asked for further information.

The specific objectives of the system are as follows :

a) Analysis and interpretation of Financial Statements,
b) Leading the user through the decision making process,
c) Setting certain directives based on user experience, and
d) Providing a total review of the financial environment.

3. SYSTEM OVERVIEW

3.1 Financial statement data base

In the financial statement data base all the components, e.g.,items, ratios, etc., needed to calculate the risk factor of the Forecasting Model are maintained and stored. The detail table chart of this data base is shown in Figure 2.
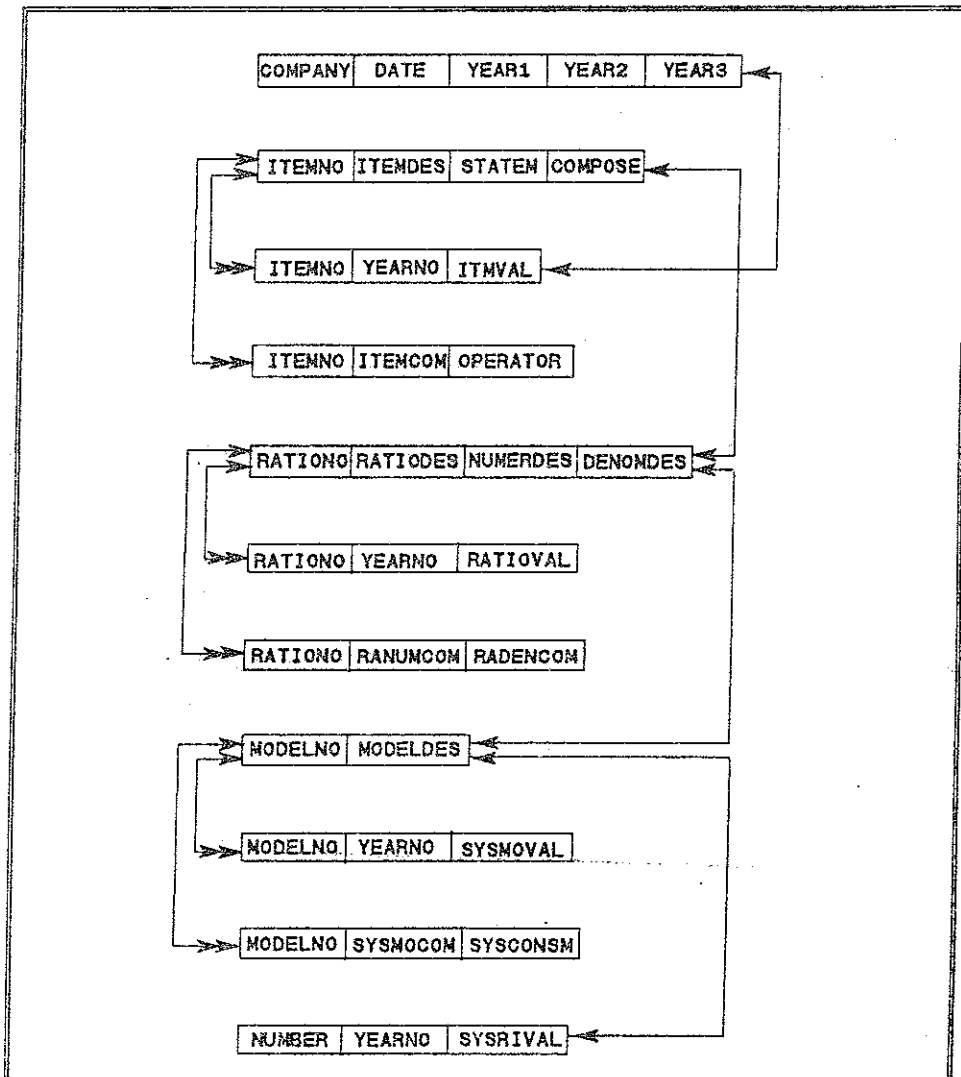

Figure 2. Detail table chart for the financial statement database.

3.2 Diagnostic data base

In the diagnostic data base information, e.g. user ratings, user priorities, industry ratio values, etc., used in the diagnostic modules of the system are maintained and stored. The detail table chart of this data base is shown in Figure 3.

USERNAME	RADATE	CLASS1A	CLASS1B	CLASS1C	CLASS1D
	CLASS2A	CLASS2B	CLASS2C	CLASS2D	CLASS3A
	CLASS3B	CLASS3C	CLASS3D	USCLASS	USRATING

USERNAME	PRIDATE	FIN	PROBEF	CURASS	PROAFT
				CASHFL	INVEN

USERNAME	DIADATE	RFUSIM	FIUSIM	PROBUSIM	CURUSIM
		PROAUSIM	CASUSIM	INVUSIM	RFSIMUL

INDATE	FIN	PROBEF	CURASS	PROAFT	CASHFL
				INVEN	RIVAL

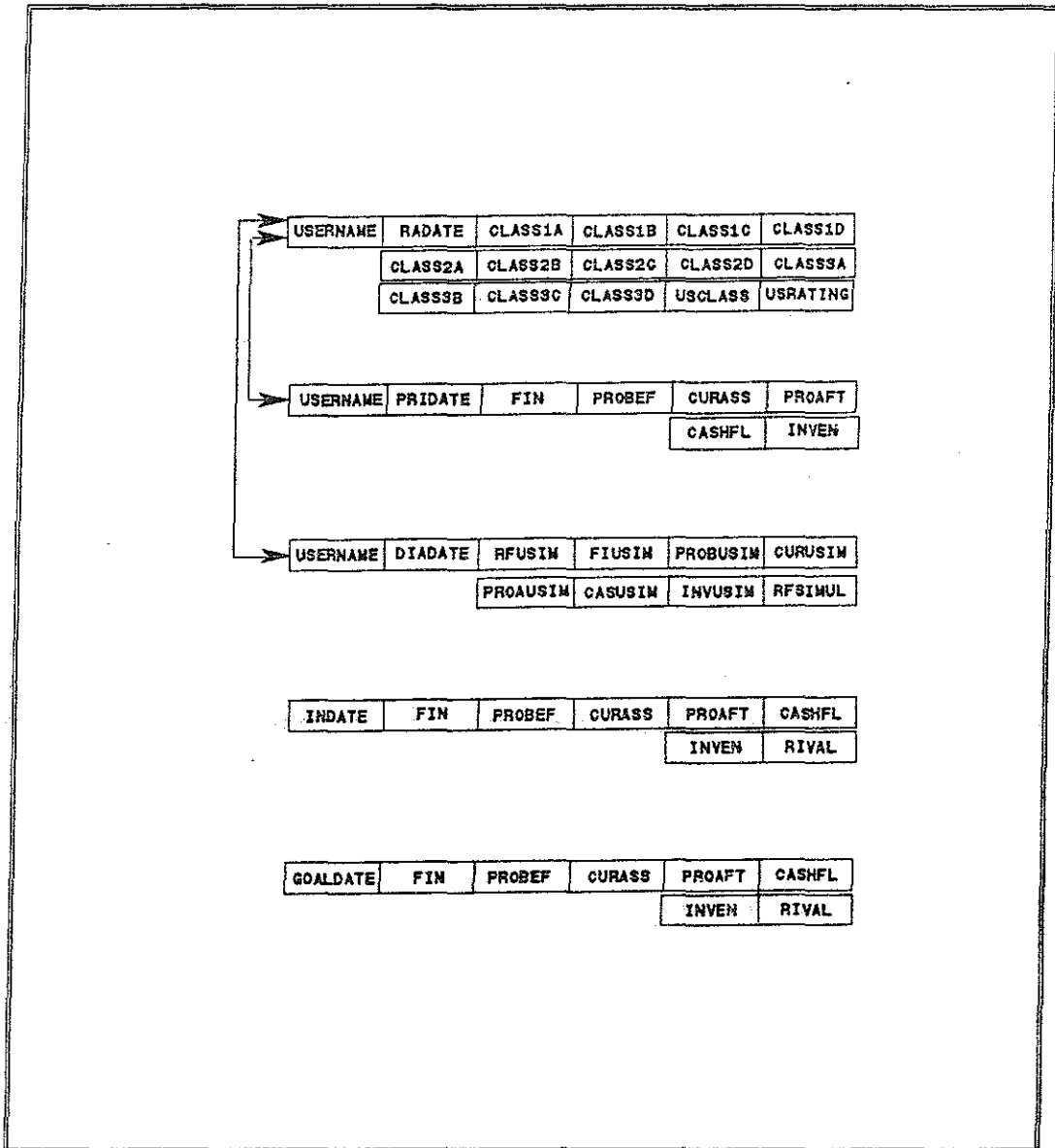| GOALDATE	FIN	PROBEF	CURASS	PROAFT	CASHFL
				INVEN	RIVAL

Figure 3. Detail table chart for the diagnostic data base.

3.3 Diagnostic analysis

The diagnostic analysis involves several expert knowledge bases. An expert system is a computer based consultant that has access to stored expertise about some problem domain. When a user presents a particular problem to the expert system, it uses the available expertise to infer

some advice which is presented to the user. An expert system has three major parts :

a) **Stored expertise** : Expertise about a problem domain may be represented as a rule set, which is a collection of rules. Each rule has a premise and a conclusion. Whenever the inference engine can establish that a premise is true, then the conclusion of the rule is also valid.

b) **Inference engine** : An expert system's inference engine is the software that carries out the reasoning needed to solve a problem. This software draws upon the stored expertise in order to reach its conclusions.

c) **User interface** : When consulting an expert system, the user states a problem or goal and interacts with the system.

One may think of an expert system as containing knowledge about how to obtain information, rather than as a procedure which processes some information algorithmically.

3.3.1 KNOWLEDGE REPRESENTATION

Domain knowledge is stored in the form of rule sets. The system contains 26 different rule sets, which may be divided into four groups :

a) Classification rule sets,
b) Rating allocation rule sets,
c) Priority allocation rule sets and
d) Improvement rule sets

The ratio value improvement rule sets are used for demonstration purposes. This rule set determines the possible improvement needed on a specific ratio value after comparing the ratio value of the three years analysed, with the ratio values of the industry and the company goal. Figure 4 describes the components of these rule set.

```
GOAL
IMUSVL - Improvement proposed by user.
INITIALIZATION
Data obtained from tables :
   Ratio value of first year,
   Ratio value of second year,
   Ratio value of third year,
   Ratio value of industry,
   Ratio value of company goal.
CONSULTATION
Uses comparative values from the industry and the company
goal to compare calculated ratio values, and to propose
improvements according to information in the system, and
user expertise.
COMPLETION
Results of consultation :
   Improvements proposed by the system, and the user are
   displayed on the screen or printed.
```
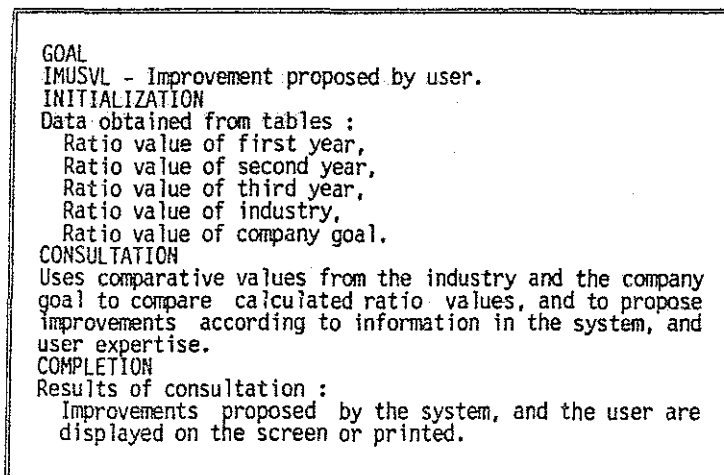
Figure 4. Representation of ratio value improvement rule sets.

3.3.2 USER INTERFACE

The information needed by the different rule sets, are obtained from the three data resources. The inference engine will first use the information stored in the two data bases to reach a conclusion, and then use this advice to lead the user through a series of procedures.

4. PERFORMANCE OF THE SYSTEM

The performance of the system is demonstrated by means of a practical example.

4.1 Financial statement data management

Information in the financial statement data base should be valid and up to date before attempting to execute any of the other functions provided in the system.

A report listing all the item values may be generated. A sample item value is shown in Figure 5.

```
                          REXS
                    ITEM VALUE REPORT
             COMPANY : FARMCHEM LIMITED

CIPS                                        DATE : 26/12/1988

                  ITEM NUMBER :   10
             ITEM DESCRIPTION :   LAND AND BUILDINGS
          FINANCIAL STATEMENT :   BALANCE SHEET

          YEAR NUMBER                  VALUE FOR YEAR

               1986                        34411.00
               1987                        34412.00
               1988                        11276.00

         The average value for the period is : R   26699.67
```

Figure 5. Sample item value report.

4.2 Classification according to risk factor

First the Risk Factor for every year is calculated and reported. Secondly the classification analysis according to these values as well as ratings supplied by the user is performed as follows :

4.2.1   CALCULATION OF RISK FACTOR VALUES

This option will calculate the risk factor values for a three
year period. A report will list all the risk factor values over
the period analysed. A sample output of this report is shown in
Figure 6.

```
                                    REXS
                            RISK VALUE REPORT
                        COMPANY : FARMCHEM LIMITED

            CIPS                            DATE : 26/12/1988

    ----------------------------------------------------------------

            Value to measure the risk of financial failure.

    ----------------------------------------------------------------

                    YEAR NUMBER              VALUE FOR YEAR
                    -----------              -------------
                        1986                    10.3604
                        1987                    18.9362
                        1988                    14.8919

    ----------------------------------------------------------------

            CIPS :  Centre for Computer Integrated Production Systems
```

Figure 6. Sample report of risk factor values.

4.2.2   CLASSIFICATION ANALYSIS

An expert system rule set containing certain classification
knowledge will classify the business being analysed into one of
three classes, i.e.:
                a financially SOUND,
                a financially BORDER CASE, or
                a financially FAILING business.
    A sample screen is shown in Figure 7.

```
    ┌─────────────────────────────────────────────────────┐
    │  ┌─────────────────────────────────────────────────┐ │
    │  │              BUSINESS CLASSIFICATION            │ │
    │  │  Company: FARMCHEM LIMITED                      │ │
    │  │                            Date: 26/12/1988     │ │
    │  ├─────────────────────────────────────────────────┤ │
    │  │ According to the information in the Financial Data Base │
    │  │    the business is classified as a Financially  │ │
    │  │                                                 │ │
    │  │                   SOUND                         │ │
    │  │                                                 │ │
    │  │  business analysed according to its financial risk. │
    │  ├─────────────────────────────────────────────────┤ │
    │  │           FINANCIAL RISK FACTOR                 │ │
    │  │                                                 │ │
    │  │  The financial risk for 1988 is :     14.89190  │ │
    │  └─────────────────────────────────────────────────┘ │
    │                                                     │
    │  ┌─────────────────────────────────────────────────┐ │
    │  │  Centre for Computer Integrated Production Systems │
    │  └─────────────────────────────────────────────────┘ │
    └─────────────────────────────────────────────────────┘
```

Figure 7. Sample business classification screen.

4.2.3 USER CLASSIFICATION RATING

The risk factors are further analysed over time by setting ratings for 12 different classes. Ratings are allocated to 12 different classes by an expert system rule set containing classification criteria, and also by the user. These ratings are set beforehand as a standard to measure the performance of the business over the time period.

This rating is a percentage value. The higher the rating the better the financial growth of the business over the time period analysed.

4.2.4 CLASSIFICATION BASED ON RATING

This option will again classify the business, this time using all the information obtained from the previous operation. An expert system is consulted, and a classification report generated, summarizing all the classification information pertaining to the business.

4.3 Allocating procedure

The system will consult the corresponding priority allocation knowledge base for each ratio, determining a priority according to the stored information in the rule set. This priority will be shown to the user to assist the user in the decision making process of allocating a priority according to his own judgement.

This decision making process is well structured by using priorities to determine the degree of importance of every ratio. The greater the importance of a ratio for improvement the higher should be the priority allocated to this specific ratio.

4.4 Revision

This option is used to revise all the priorities allocated to the different ratios. Two graphs are used to display firstly, the ratio values and secondly the allocated priorities.

4.5 Comparitive industry and company goal values

Comparative ratio values must be set as evaluation criteria, before any further evaluation may be performed. The following three different evaluation criteria are used in this system :

HISTORICAL DATA FROM WITHIN THE BUSINESS : The ratio values of the last three years are calculated. These criteria are used throughout the system.

DATA'FROM OUTSIDE THE BUSINESS : Corresponding data from the industry, in which the business being analysed is operating, is used for calculation purposes. The weighted average of the different ratio values serve as an excellent normative guideline for the ratio values of the business.

A sample output report is shown in Figure 8.

```
                              REXS
                     INDUSTRY RATIO VALUE REPORT
                     COMPANY : FARMCHEM LIMITED

         CIPS                               DATE : 26/12/1988

    --------------------------------------------------------
             INDUSTRY RATIO VALUE ON : 31/11/1988

             PROFIT BEFORE INTEREST & TAX :  20.60
             CURRENT ASSETS & LIABILITIES : 175.80
                CASH FLOW PROFIT AFTER TAX :  17.24
                          PROFIT AFTER TAX :  13.10
                               INVENTORIES :  12.02
                                 FINANCING :  42.00

    --------------------------------------------------------
         CIPS :  Centre for Computer Integrated Production Systems
```

Figure 8. Sample industry ratio value report.

COMPANY GOALS : By its very nature financial decision making involves purposeful behaviour, which implies the existence of a company goal, or what is much more likely, some combination of goals. Corresponding company goal values for the different ratios, are set by the management of the company. The output report for these values is similar to the report for the industry values.

4.6 Diagnostic simulation

In the preceding modules different classification schemes were used to classify the different financial criteria, in order to prepare the groundwork for improvement application. If this analysis of risk and classification schemes is to be meaningful for the business, a method must be found to translate this analysis and classification schemes into operational decision rules for improvement of the financial risk.

4.6.1   IMPROVEMENT RECOMMENDATIONS

The risk analysis and various classification schemes mentioned, are all mutually inclusive and are all used in the diagnostic simulation to recommend improvements and simulate a new financial environment.

A knowledge base containing certain decision criteria based on the risk factor analysis and classification schemes from the preceding modules will determine an improvement value. This improvement value is a value proposed by the system, to be added to the present risk factor value in order to find a better financial risk value.

This consultation will be followed by a graphical presentation of the different risk values. This graphical presentation will give the user an idea of the improvement needed by comparing the industry and company goal values with the present risk factor value. The user will be asked to propose an improvement value, using the improvement recommended by the system as a measure.

After entering an improvement value a summary of the implication of these improvements proposed by the system and the user will be displayed on the screen. A sample of this screen is shown in Figure 9.

```
┌─────────────────────────────────────────────────┐
│ ┌─────────────────────────────────────────────┐ │
│ │      PROPOSED IMPROVEMENT ON RISK FACTOR     │ │
│ │   Company: FARMCHEM LIMITED                  │ │
│ │                        Date: 26/12/1988      │ │
│ └─────────────────────────────────────────────┘ │
│                  RISK FACTOR                      │
│                                                   │
│     According to the Diagnostic Expert System :  │
│     1) The improvement proposed by system  :   1.4532 │
│     2) The improvement proposed by the user:   2.7500 │
│                                                   │
│ ┌─────────────────────────────────────────────┐ │
│ │              IMPROVED RISK FACTOR            │ │
│ │  Improved Risk Factor according to user  :    17.54190 │
│ │  Improved Risk Factor according to system:    15.89190 │
│ │      General warning : SERIOUS DECREASING GROWTH │ │
│ └─────────────────────────────────────────────┘ │
│ ┌─────────────────────────────────────────────┐ │
│ │  Centre for Computer Integrated Production Systems │ │
│ └─────────────────────────────────────────────┘ │
└─────────────────────────────────────────────────┘
```

Figure 9. Sample risk factor improvement screen.

Each ratio value will be handled individually. The procedure for the ratio values is precisely the same as for the risk factor.

4.6.2   SIMULATION OF A NEW FINANCIAL ENVIRONMENT

A new financial environment is simulated. This includes the calculation of the improved ratio values, and the calculation of the new improved risk factor value. A sample form of the improved values is shown in Figure 10.

```
┌─────────────────────────────────────────────────┐
│ ┌─────────────────────────────────────────────┐ │
│ │              SIMULATED RISK FACTOR           │ │
│ │   Company: FARMCHEM LIMITED                  │ │
│ │                        Date: 26/12/1988      │ │
│ └─────────────────────────────────────────────┘ │
│            SIMULATED FINANCIAL RISK FACTOR        │
│                                                   │
│       The Industry Financial Risk on 12/12/1988  │
│                                                   │
│                is :    14.90038.                  │
│ ┌─────────────────────────────────────────────┐ │
│ │  Centre for Computer Integrated Production Systems │ │
│ └─────────────────────────────────────────────┘ │
└─────────────────────────────────────────────────┘
```

Figure 10. Sample simulated value form

The user may compare the new simulated risk factor value, determined from the improved ratio values, with the improved risk factor and the present business risk factor value. If the user is not satisfied with the improvement in the risk factor value he can revise the proposed improvements on the different ratio values.

This sensitivity analysis may be repeated until the simulated value compares favourably with the improved risk factor value proposed by the user.

4.7 Review diagnostic analysis

This module is used to review the results emanating from the REXS system. A review of all the improved values determined by the system, and improvements proposed by the user are presented in the form of graphs.

The different graphs are used to display the results obtained from the diagnostic analysis and to compare the improved values with the present values. A sample review graph is shown in Figure 11.
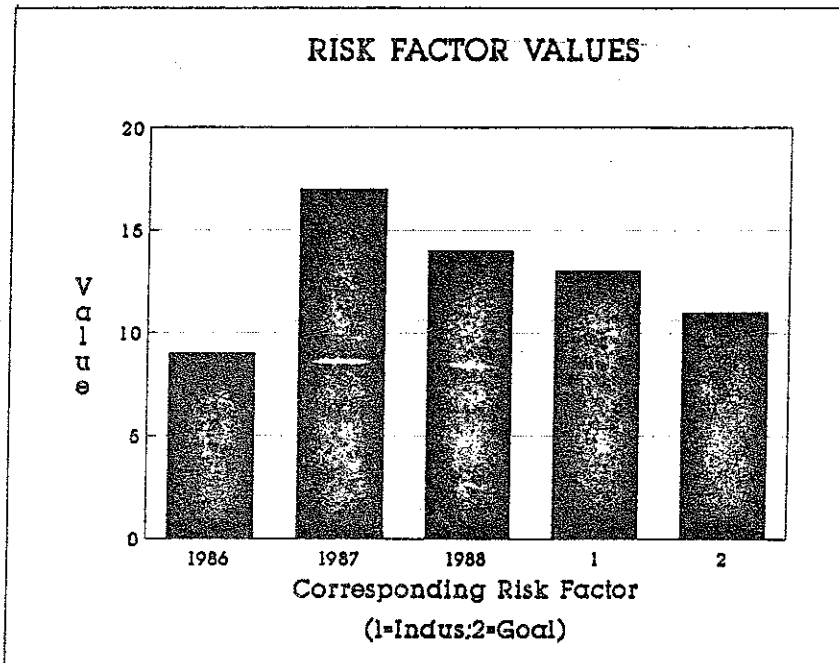
Figure 11. Sample reviewing graph.

A summary screen form containing the different values i.e., values of the last three years, comparative industry and company goal values and improved values emanating from the system, will be displayed on the screen. A sample of this screen form is shown in Figure 12.

Figure 12. Sample summary screen form.

5. CONCLUSIONS AND POSSIBLE APPLICATIONS

5.1 Conclusions

Planning is the key to the financial manager's success. Financial plans may take many forms, but any good plan must be related to the firm's existing strengths and weaknesses. This indicates that all financial plans must begin with the type of financial analysis presented in the REXS system. If this analysis is to be meaningful for a business, a method must be found to translate this analysis into operational decisions. A diagnostic environment has been developed that allows the user to recommend certain improvements according to personal judgement, and simulate a financial environment based on these improvements. These improvements may be revised for an unlimited number of times, in order to try and find the best alternative as a basis for future financial planning.

5.2 Training

The system has the potential of becoming an excellent training tool for business school students and managers. The objectives of such a training program will generally include :

a) Better understanding of Financial Risk,
b) Better insight into Ratio Analyses,
c) Better insight into Comparative Analyses,
d) Better insight into managing by objectives,
e) Testing of personal judgement, and
f) Development of diagnostic skills.

The system contains a diagnostic simulation module, providing the facility to run different sensitivity analyses, testing the trainee's skills in financial risk diagnostics and improvement.

5.3 General

The REXS system concentrates on Financial Risk Analysis. Based on a Forecasting Model the system will calculate a financial risk factor reflecting the probability that a business will fail financially. By breaking the risk factor down into the components constituting the risk factor, causes for financial failure are determined through classification, comparison and evaluation. These mutually inclusive analyses are focussed on the improvement of the financial risk factor. A diagnostic simulator is used to simulate a new financial environment, setting guidelines for management to improve the financial risk of the business.

The application possibilities of the system are :

a) Ratio analysis over time,
b) Classification of businesses into risk classes,
c) Specific problem identification,
d) Comparison of business growth with industry trends, and
e) Setting guidelines for future financial improvement.

The system in general provides the facilities to do a number of sensitivity analyses, to improve the financial risk of the business being analysed.

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