Development of Creditworthiness Expert System

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Abstract. *Expert systems are widespread in the field of economics. There are many systems that have been developed and implemented decades ago, especially in the field of accounting and finance. Some of these systems and research in a given area are briefly presented in the paper. Particular emphasis is on the results of research we conducted on the process of estimation of creditworthiness, which led us to conclusion that expert systems are much needed in this process. Furthermore, the article illustrates the main steps of development process of creditworthiness expert system with highlight on the problems that have emerged.*

Keywords. *Expert system, Creditworthiness, Exsys Corvid*

1 Introduction

Expert systems (ESs) are computer programs that solves complex problems with high degree of competence. They rely on the expertise and experience of human-expert(s), on the knowledge and technology, information, heuristics and procedures that human-experts use for solving different problems and as such they simulate their reasoning and behavior in a particular problem domain. Usually an expert in a specific problem domain provides "rules of thumb" about the way he/she evaluates a problem, either explicitly with the help of experienced system developers, or implicitly, extracting the rules from relevant data sets.

Knowledge implemented in an ES is situated in the knowledge base that is separated from the program that uses knowledge to solve problems - so called inference engine. Thanks to the knowledge base, the inference engine, and the interface that connects the inference engine with the system user, expert or knowledge engineer, other computers or computer programs, and external databases, ESs exhibit characteristics that are related to the notion of intelligence in humans, which is the characteristic that distinguishes them from other types of programs.

ESs are often used in business, especially in finance for credit process, portfolio management, tax planning, financial planning and banking diagnosis [10]. Assessment of creditworthiness is a very complex process, and requires an extensive analysis of various financial indicators and various aspects of business, like structure of revenues and expenditures, business cost-effectiveness, financial position of companies, to name only a few. This is why ESs support is very much welcomed in this area. In this article we described the development process of one such system. The steps undertaken after the knowledge acquisition in the development of the creditworthiness ES are presented in the sequel of the paper. They include structuring the acquired knowledge, its placement into the knowledge base and different ways of connecting and relating the analyzed individual aspects of creditworthiness, the main expert system comprises of. Special emphasis is on incorporation of peculiarities and limitations of a software tool in which the system was developed - expert systems shell Exsys Corvid, within the system design.

2 Expert systems in economy

Expert systems are widely used in the domain of economics. According to [6], more than 60% of all implemented expert systems are business-oriented, developed for companies and their managers, while others are developed for certain production, field of medicine or education. The reason for economics being an extremely important area for the development of ESs is that procedures, rules and techniques used to solve problems in this area are very appropriate for structuring rules. ESs are increasingly developed for business management and accounting, while the field of finance has been recognized as an ideal field for their use long time ago, particularly in credit process, portfolio management, tax planning, financial planning and banking diagnosis.

The authors in [10] presented the results of the application of ESs in accounting, with special emphasis on their application in the following areas: auditing, taxation, financial accounting, personal financial planning, and management accounting. ESs are able to help accountants improve the quality of their service in the areas of audit planning, internal control evaluation and identification of audit risk. Authors identified the field of taxation as a key subfield in which ESs are currently in common use. Tax treatment on stocks, investments and dividends are part of the domain of these systems. Also in [10] is stated that "Guidance for corporate tax accrual and the planning process, value-added tax, tax preparation systems, and corporate tax planning for oil and gas industry are provided by expert systems created to assist those involved in tax. In internal taxation there are expert systems available for international tax planning and optimization of international corporation tax position". Furthermore, these authors identified linkages of the suite of personal-financial management programs and its expert-like features. This relationship is reflected in the portfolio advice, financial projections, portfolio accounting, online help, form chooser in tax preparation, tax advise, to mention just a few. In financial accounting ESs are available for cash flow evaluation, analysis of mergers, acquisitions and other investment decisions. Determination of financial status by ratios, leases, and analysis of financial reports are other areas in financial accounting where ESs exists.

Diversified expert systems are developed and deployed in the domain of finance. In the field of financial analysis, according to [7], ES FINEVA (FINancial EVAluation) is the best example. This is a multicriteria knowledge-based decision support system for the assessment of corporate performance and viability. The output that FINEVA produces is a specific ranking of the firms considered, according to a class of risk. The assessment of corporate performance and viability is achieved through the combination of the evaluation of financial status and the qualitative evaluation of the firm.

In [3] another ES is described: Port-Man is a banking advisory expert system designed to assist bank officers to give advice on personal investment in a bank. It helps to speed up the consultation process and standardize the experience of the bank's financial consultants. The task of the system is to select a range of bank products that will satisfy the criteria for investment. The selected products are ranked according to the rates of return on-investment and risk levels.

The problem of measuring credit risk is a particularly interesting field. Financial institutions, banks, credit institutions, clients, suppliers and others have to predict the failure of companies with which they are interested to make any kind of cooperation. As stated in [5], methods commonly used for this purpose are the econometric analysis that estimate the probability of clients' insolvency, but do not distinguish creditworthy and non-creditworthy clients at a satisfactory level. The authors conducted research in order to overcome the limitations of econometric models and they developed a fuzzy expert system for bank creditworthiness. The ES results were compared to the results obtained through econometric analysis conducted over the same data. They came to the conclusion that the fuzzy system offered better solutions to this problem and also a better measurement of the discriminant power of the model.

Motivated by these studies, we developed an expert system that supports creditworthiness evaluation of business entities. The system evaluates separately the relevant viewpoints of business performance of an organization: the financial standing, leverage, structure of income and expenses, profitability and cost-effectiveness. We selected expert system's shell Exsys Corvid for the development of this system.

3 Exsys Corvid – the utilized expert system's shell

Exsys Corvid is an extremely powerful environment for developing knowledge automation systems. It enables efficient emulation of the logical rules and procedural steps used by experts in business operations into the system that is easy to understand, easy to interpret and maintain. Corvid provides an intuitive development environment that allows domain experts to easily describe the steps in the decision making process in a logical manner.

Corvid offers two different views of the system logic: tree diagram form that allows the user to access the entire structure of the system, and the full text of individual rules. The open architecture and a wide range of functionality allow integration of Corvid systems with corporate databases, external programs, CRM tools, systems for monitoring processes, Web sites and other IT infrastructures.

The basic elements to work with in Corvid tool are:

- Variables. Variables in the Corvid are very similar to variables in other programming languages. There are several different types: static list, dynamic list, numeric, string, date, collection and confidence.
- Logical block. A group of rules that are defined in the form of tree diagram, or are shown as a separate rule.
- Action block. Represents an extremely simple way of building a system that uses a procedural approach of solving problems by asking a series of questions.
- Command Blocks. Contain procedural commands that tell an inference engine how to apply the defined rules. Each system must have at least one Command Block.

The main difference between action and logic blocks are reflected in their structure, thus the functioning. The rules in a logic blocks have a form of a tree diagram, and can be chained by backward or forward chaining. They may have multiple IF conditions that are associated with logical operator AND. On the other hand, structuring rules in action blocks implies that there is only one IF condition which is connected to one or more THEN actions. Only forward chaining can be applied on such rules.

4 The creditworthiness expert system – an overview

Creditworthiness of a company can be understood as the estimation of likelihood of company's insolvency in the future. Broader perception refers to liquidity and assessment of credit capabilities. In the broadest sense, creditworthiness is an overall estimation based on the analysis of balance sheet and the standing of an enterprise. Assessment of creditworthiness of a company is an extremely complex process. It requires analysis of a number of different economic and financial indicators that can be divided into the following groups:

1. Indicators of the structure of income and expenditure,
2. Indicators of business efficiency,
3. Indicators of business profitability,
4. Solvency indicators,
5. Indicators of leverage.

Indicators of the structure of income and expenditure estimate the relations between different types of incomes and different types of expenditures. Indicators within the second group evaluate the business efficiency by comparing different types of income and expenditure to global price parity. Some of the indicators for the assessment of business profitability are profit margins, return on assets, return on equity, contribution margin, etc. Indicators within the fourth group are used for deriving conclusions on the business solvency, by means of analyzing relations among the capital and liabilities, the acid test, the cash flow and more.

Each of the analyzed indicators requires extensive mathematical calculations and a complex inference process for deriving a cumulative evaluation of each indicator group. Comprehensiveness of an overall evaluation process and the number of indicators required to determine the creditworthiness confirm the complexity of the issue. Considering the breadth of possible applications of the system and the frequency of performing these evaluations, led us to the conclusion that both a comprehensive system for assessing creditworthiness of

enterprises, as well as small scale expert systems for assessing separate aspects of creditworthiness are highly desirable and their development justified.

Within the expert system´s inference process, the data from the current business year for all individual indicators are compared to data from the previous year, and to the average values of indicators for the industry sector the company belongs to. The goal is to derive a unique evaluation of each group of indicators. Table 1 and Table 2 present the interpretation of values each group can be evaluated with, while Fig 1 presents the logic block with all the rules needed to determine the final standing of enterprise's structure of revenues and expenditures.

Table 1. The interpretation of values of indicators belonging to the first 3 groups

Interpretation of results	Group of indicators		
	Structure of income and expenditure	Business efficiency	Business profitability
Very favorable	>=7	>7	>12
Favorable	>0 & <7	>1 & <=7	<=12 & >0
Neutral		<=1 & > -1	
Unfavorable	<=0 & > -7	<=-1 & >-6	<=0 & >-12
Extremely unfavorable	<= -7	<= -6	<= -12

Table 2. The interpretation of values of indicators belonging to the last 2 groups

Interpretation of results	Group of indicators	
	Solvency	Leverage
Good	>7	-
Acceptable	>-4 & <=7	-
Bad	<= -4	-
Large	-	>7
Acceptable	-	>-4 & <=7
Small	-	<= -4

The key problem we faced during the development of the expert system for creditworthiness evaluation was how to determine the intervals for the classification of indicators into groups of neutral, favorable, acceptable, bad etc. Determining these intervals solely on indicators of current and previous year was not appropriate. The problem laid not only in the arbitrariness of the evaluation (for e.g. whether the threshold for considering some indicator very unfavorable should be set to 7 or 8), but in the fact that in many cases it was difficult to provide a valid assessment. Thresholds depend not only on the country and industry, but also on the seasonality and the economic cycle. Therefore we concluded that the only valid way to assess individual indicators should be to compare them with industry averages as well. Then it was possible to create a ranking or positioning of companies in the same industry. In that case, the neutral value could be regarded as fixed/theoretical, while the boundaries for favorable, very favorable, unfavorable or very unfavorable assessments could fluctuate depending on country, sector and economic cycles.

Each of the above listed groups includes a variety of economic and financial indicators that are evaluated in order to form a final estimation of a given group of indicators. The final numeric estimation and the related assessment are presented in Table 1 for the first three indicator groups and Table 2 for the last two groups.

Figure 1. Evaluation of a structure of income and expenditure

For exemplification purpose, Table 3 briefly presents a set of analyzed indicators belonging to the group ´leverage´. Comprehensive assessment of financial standing of an enterprise is based on the assessment of presented individual groups of indicators. However it should be noted that each of these groups of indicators has varying degrees of importance for creditworthiness. When running the system, at the very beginning the user is offered the opportunity to agree with the presented and predefined level of importance for

different groups of indicators or to set their own values. Thus, we predefined that on a scale from 1 to 10, a group of indicators named `business efficiency`, profitability and leverage have the same degree of importance which is 8, while the solvency of a company has the highest impact factor so its weight is 10. The setting of these values, whether the user chooses the predefined ones or set his own values, directly influence the derivation of confidence values, since it is determined by a specially made calculation that implies that the degrees of importance given to certain groups of indicators are multiplied by the values associated with the results obtained for each group (for example, very favorable = 30, favorable = 20 etc.).

Table 3. Illustration of the analyzed indicators in the group `business efficiency`

<table>
<tr><td>Indicator</td><td colspan="2">Explanation and calculation</td></tr>
<tr><td rowspan="2">Basic indicators of the business efficiency</td><td>Total revenues/Total expenditures</td><td rowspan="2">The higher the indicator the better the business efficiency</td></tr>
<tr><td>Operating revenues/Operating expenditures</td></tr>
<tr><td>Global price parity</td><td colspan="2">Sales revenue / (Expenditure[1]* (Operating expenditures + Decrease in inventory – Increase in inventory)/(Operating expenditures– Expenditures of goods))

The higher this indicator, the better credit rating. Threshold is 1. If the indicator is less than 1, then the company has a very bad situation because his purchase prices are greater than sales prices.</td></tr>
</table>

In the expert system development process we had two possibilities: to declare all raw data, some of which are shown in Table 3, as dynamic type of variables, or to declare them as variables of numeric value type. Declaration of variables as dynamic means that all values are read during inference process from an external source, such as an MS Access file, SQL Server database, or Excel spreadsheet. The target users of an expert system that is structured like this would be banks or other financial institutions that have their own databases of financial statements of clients, from which the system could retrieve the data and calculate the required values. Since our objective was to make the creditworthiness expert system as widely available as possible, the integration of the system with a database or an external data file, were left to future research. With the declaration of variables as numeric value type, we allowed any potential user to use the system, whether he has or has not his own database. Therefore, users of the system have to provide the required information, prior to the calculations, comparisons and necessary inferences performed by the system.

Given the fact that the expert system is developed in the version of Corvid that is not intended for building complex systems, we were forced to break a complex system to several modules. Thus, for each group of indicators separate expert systems which enables users to evaluate on one hand the individual aspects that determine creditworthiness, and on the other hand the creditworthiness of an organization as a whole, were developed. Therefore, the estimation of all five groups of indicators: efficiency, productivity, solvency, leverage and structure of revenues and expenses, is conducted by the system at the same time. However, we encountered some problems while integrating separate systems into a functional unit, explained in the sequel of the paper.

Since Exsys Corvid tool is Java based, it provides various options for running a system. It is reasonable that the developed expert system should be run either as a desktop application or as an applet. Regardless the way it is run, the expert system should function the same way and produce the same results. However, differences occur when connecting separate entities i.e. expert systems.

If the system runs as an applet, connection of individual expert systems is significantly facilitated. We introduced one static list variable that allows the user to select the business aspect which he would like to evaluate. This is displayed in Fig 2.

[1] The expenditure includes both expenditure of goods and materials.

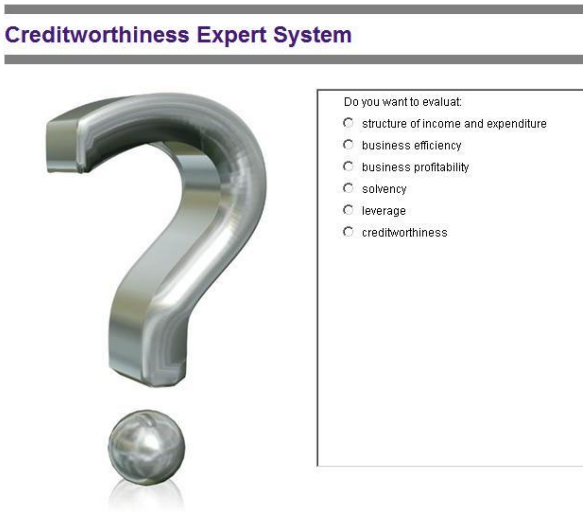

Figure 2. Selection of the desired aspect to be analyzed

In the Command Block shown in Fig 3 each selected aspect is associated with the appropriate expert system. Since Corvid systems are run in the browser, it is sufficient to link an adequate .html page to the combination of DISPLAY_HTML command and the path to the .html page.

Figure 3. Illustration of a Command block

In addition, upon completion of assessment of one aspect, users are able to carry out an independent assessment of some other aspect, as shown in Fig 4. On the last screen, which gives an overview of the results derived by the system, links to other expert systems are offered. At this point, we emphasize that this linkage of expert systems offers only estimation of the selected business aspect at the time. The problem we encountered refers to a case when a user wanted to assess the overall creditworthiness, which means that each aspect must be analyzed and the output of one expert system must be an input to the other. At this point, we can grasp the full complexity of this task.

Connecting expert systems in such a way is certainly possible, but extremely complicated in Exsys Corvid, so the recommendation of the provider is to run the system as an application whenever it is possible to read/write data to the local file system. It is possible to achieve this goal from an applet, but that would require a server-side program to read/write the data on the same server. This is due to Java security restrictions.

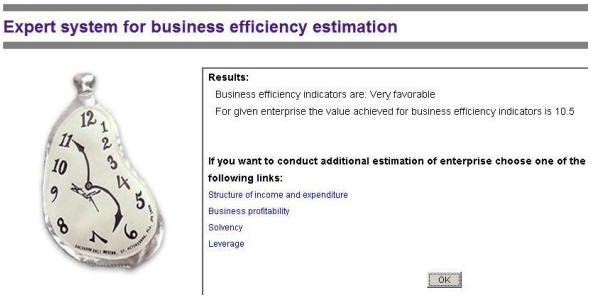

Figure 4. Expert system for business efficiency estimation - the illustration of the results screen

When the system is run as an application, the output value of an expert system can be saved in a text file, Excel spreadsheet or a database. Such saved values can then be used at appropriate places. This would mean that each expert system must have one dynamic list variable whose values would be populated from file or database. This would be a justified solution if expert systems should not be run one after the other. However, running the system as an application has an advantage of writing the results to a file, but at the same time it has a limitation of not providing a clear ability for linking individual expert systems. One can optionally use the available EXTERN command that will execute a desired program. This command requires information on the program that should be run and the parameters to pass to the program. This way, when one expert system reaches the end, Corvid will run the next one, but unfortunately it will not run the executable file, and therefore the end user can access the source code and the knowledge base, which is not preferable. For this reason, a user should have to run each system by

him/herself. This is the main drawback of the presented method for connecting expert systems into a functional unit.

Although other possibilities of saving and using the stored data are available, for example, the implementation of SAVE button, we decided that further research and efforts should be directed to resolving the problem that is imposed by setting up the system to be run as an applet and connecting separate expert systems in such a constellation.

5 Conclusion

The field of economics has long ago been recognized as one of the most interesting and most suitable for the development of expert systems. Having in mind the complexity of economic analysis and the frequency of conducting different analysis, expert systems emerged as a natural solution to problems in this field. One of them is the task of creditworthiness evaluation.

Although minor problems occurred in the development of creditworthiness expert system, which were solely connected to the restrictive version of the tool in which the system was developed, we believe that we have come to useful progress and results. The test of individual expert systems showed that the degree of estimation accuracy is high, and the assessment process was significantly speeded up. As already stated, additional changes to the system will be implemented, and further work in Corvid tool will surely result in even better system.

6 Acknowledgements

This paper is the result of a research on the project titled: "Comparative Advantages of Intelligent Data Analysis Methods in Strengthening the Sector of Small and Medium Sized Enterprises", No. 114-451-01092/2008-01, funded by the Ministry of Sciences and Technology Development of Province of Vojvodina, Republic of Serbia.

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