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A Web-Based Expert System Application for Working Capital Management

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ABSTRACT

The aim of this study is to develop an expert system application called SME Emergency for working capital management (WCM) in Small and Medium-Sized Enterprises (SMEs). SME Emergency performs financial analyses for WCM and thus evaluates the WCM performance of the enterprise. There is no independent audit obligation for SMEs operating in Turkey. Therefore, the data of 283 enterprises listed in the BIST All Shares between 2012 and 2020 were used in the development of this application since they do not differ in terms of working capital characteristics, and the data of publicly traded enterprises are subject to independent auditing. The SME Emergency presents the general performance of the enterprise about WCM. In addition, it evaluates the success of the enterprise according to the industry within the framework of WCM determinants and presents its position compared with enterprises in the industry. In this context, the enterprise's financial performance in terms of WCM can be interpreted, and suggestions can be made in the case of unsuccess.

Keywords: Working Capital Management, SME Emergency, Artificial Intelligence, Expert System.

JEL Classification Codes: C67, C88, G31, G32

Referencing Style: APA 7

INTRODUCTION

Working capital is explained as the source of finance necessary to support the short-term operations of enterprises. Similarly, working capital is expressed as an investment in current assets (Karadağ, 2015). Working Capital Management (WCM) includes current investment and financial decisions. In other words, it includes planning and controlling short-term investments and debts. In this context, effective WCM contributes to establishing the balance between risk and profit, thus minimizing the risk of non-fulfillment of short-term liabilities (Akın & Eser, 2014).

Although WCM is related to all enterprises, it is more important for SMEs than for large-scale enterprises. Because the profits and cash flows of SMEs are more volatile, their liquidity is low, and these enterprises need more short-term financing due to the financial constraints they face (Boschker, 2011). Therefore, for small and growing enterprises, effective WCM is crucial to be success and survival; in other words, it is important in terms of both profitability and liquidity (Padachi, 2006).

Due to the competition in the changing business environment as a result of technological advancements and digital transformation, data and information management becomes important in enterprises to predict changes in technology, industry tendencies, customer needs, and other factors. However, the development of the information technologies network and user/server structures of the enterprises is necessary for the use of shared knowledge in decision-support environments. Therefore, enterprise managers need more information analysis instruments to assist their decisions in a complex and changing business network (Arias-Aranda et al., 2010).

Expert systems in enterprises are developed for the use of different decision-making groups, such as managers, accountants, financial analysts, strategic planners, and marketers. Likewise, expert systems help minimize the constraints faced by managers in the decision-making process, such as time, financial resources, and expert advisors (Tan et al., 2016). In this direction, it can be said that expert systems will contribute to enterprises by

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This study is derived from the doctoral dissertation titled "KOBİ'lerde Çalışma Sermayesi Yönetimine Yönelik Bir Uzman Sistem Geliştirilmesi", which was completed in 2021 by Yusuf GÜNEYSU at Karadeniz Technical University, Institute of Social Sciences, Department of Business Administration, supervised by Prof. Dr. Bünyamin ER

facilitating the decision-making process and increasing the accuracy and reliability of decisions.

In the national and international literature, although there are expert systems developed for SMEs, these applications provide information about expert systems (e.g., Zopounidis et al., 1997; Kaynar, 1999; Nedovic & Devedzic, 2002), financial analysis, and performance evaluation (e.g., Matsatsinis et al., 1997; Moynihan et al., 2006; Shiue et al., 2008; Filippidis et al., 2013; Kara et al., 2016; Giraldo et al., 2018). In contrast to the literature, this study considers the factors of WCM and all possible variables that may have an effect on WCM and visualizes the data of these variables. On the other hand, it indicates the success of the enterprise in comparison with the industry average and other enterprises in the industry. In addition, according to the best of the researchers' knowledge, no study has been found on the expert system applications for the WCM of SMEs.

In this study, a web-based expert system application (SME Emergency) was developed, which aims to contribute to SMEs in WCM. In this direction, the study aims to analyze the WCM of SMEs, make comments and suggestions according to the results of this analysis, and thus assist enterprise owners or managers. In the development of the SME Emergency application, the data of 283 enterprises listed in the BIST All Shares between 2012 and 2020 were used. The SME Emergency presents the success of the enterprise in WCM, its position according to previous periods, and other enterprises in the same industry using visuals.

This study consists of four sections. First, the literature review, including studies on expert systems in the field of finance and their applications for SMEs, is offered. Then, the development process and structure of the expert system application are revealed. Finally, the conclusions and recommendations are presented.

LITERATURE REVIEW

This section of the study examines the applications of expert systems in enterprises, especially in the field of finance, and the studies on their applications in SMEs.

Expert systems, one of the important application areas of artificial intelligence, were adopted in the 1970s and became the focus of research in the 1980s. In this direction, expert systems are applied in many areas to support the decision-making process of enterprises. There are many expert systems to support managers in decision-making processes such as accounting, finance, production, and marketing (Wong & Monaco, 1995; Jayaraman & Srivastava, 1996; Metaxiotis & Psarras, 2003; Wagner, 2017; Kütük, 2020). In this context, examples of expert systems related to these fields are given below.

In the field of marketing, there are expert system applications such as EXMAR (aims to assist the marketing planning process), ADCAD (developed to support advertisers in determining targets, copy strategy, and communication approaches), ADDUCE (provides an assessment of consumer response to advertising by researching past advertising experiences), and SHANEX (designed to reveal possible causes of changes in a product's market share rather than estimates of changes in market share) (Metaxiotis & Psarras, 2003).

In the field of production, there are expert system applications such as XCON (product design), LOGIX (developed to adjust order entry, rescheduling, and reordering to improve inventory efficiency), DEC (designed to assist in order management, transportation, warehousing, and sourcing), and capacity planning system called Performance Expert Prototype (PEP) (Jayaraman & Srivastava, 1996).

In the field of accounting, there are expert system applications such as RISK ADVISOR, The Internal Control Model (TICOM), AGGREGATE, Financial Statement Analyzer (FSA), and the Integrated Consulting System (ICS). Accordingly, RISK ADVISOR has been developed to assess audit risks and the economic performance of the customer. TICOM assists auditors in modeling the internal control system and provides queries about this model. AGGREGATE was developed to support decision-makers in designing accounting information systems and financial statements. FSA is designed to perform tasks such as examining entries in financial statements, checking documents submitted, and ratio analysis. ICS has been developed to provide strategic planning and management support in industries with high product diversity (Kütük & Zor, 2020).

Artificial intelligence techniques such as fuzzy logic, machine learning, artificial neural networks, and expert systems are widely used in finance. The scope of expert systems in finance generally includes financial planning and forecasting, portfolio management, and credit evaluation (Matsatsinis et al., 1997; Nedovic & Devedzic 2002; Moynihan et al., 2006; Shiue et al., 2008; Bahrammirzaee, 2010; Yunusoglu & Selim 2013; Milana & Ashta, 2021).

When the expert systems developed in finance were examined, it was seen that Matsatsinis et al. (1997)

aimed to reveal a methodology for the development of expert systems in financial analysis. They applied that methodology in the Financial Evaluation (FINEVA) to evaluate institutional performance and financial capacity. Moynihan et al. (2006) developed an expert system for ratio analysis. Thus, by calculating the ratio and establishing a relationship between the ratios, they were able to present a report on the position of the enterprise and make suggestions in this direction.

Shiue et al. (2008) proposed a knowledge-based system to aid the decision-making process of experts in evaluating the financial positions of enterprises. In this system, 13 basic financial ratios (profitability, liquidity, utility, and long-term solvency) were calculated, and these ratios were categorized according to 5 qualitative criteria (very bad, bad, fair, good, very good). Then the general financial position of the enterprise was determined.

Filippidis et al. (2013) proposed a web-based tool called Statement Analysis (STAN), which allows enterprises to perform financial statement analysis. The STAN application allows the calculated financial ratios to be presented in plain text based on a decision tree analysis. In this context, various financial ratios were calculated by using the yearly data of an enterprise for the period 2007-2011. Information about the financial position of the enterprise was presented by comparing these ratios with the criteria values determined.

Nedovic and Devedzic (2002) aimed to provide information about the approaches and techniques used by expert systems, which are well-known in finance. In addition, they briefly explained an expert system called DEVEX. To explain the expert system approaches and techniques mentioned here, quantitative, and qualitative variables were used in the FINEVA system, which was modeled according to a 5-point Likert scale (not satisfactory, medium, satisfactory, very satisfactory, perfect). In the FINEVA system, the strengths and weaknesses of the enterprises are defined according to this scale through created rules. Likewise, Portfolio Management in Banks (PORT-MAN) selects a variety of products and classifies these products by return on investment and level of risk. It then offers the investment instrument that meets the investor's criteria. On the other hand, in Investment Management (INVEX), investments are divided into 5 groups (very bad, bad, medium, good, very good) according to the criteria determined for some indicator (net present value, return on investment, payback period, etc.) values. Thus, investments from the very good group are accepted, while investments from the very bad group are rejected. The expert system called Financial Marketing (FAME) helps prepare comprehensive recommendations about the financial decision-making processes used in marketing products and services (Nedovic & Devedzic, 2002).

In terms of the applicability of expert systems in SMEs, Torkzadeh & Rao (1988) provided information on expert systems and their benefits for small enterprises. They also examined the role and integration experts and decision support systems (DSSs) for small enterprises. Likewise, McMahon (1990) explained expert systems and DSSs. In addition, he gave information about the issues that expert systems can be applied in the field of finance and expressed the importance of expert systems for small enterprises.

Seth et al. (2015) reviewed the studies done in this field to develop expert systems for SMEs worldwide. In this direction, they concluded that SMEs operating in India had a high potential for the implementation of expert systems. However, Khitilova (2017) reviewed whether it was suitable to use expert systems for supplier evaluation in SMEs in the Czech Republic. In this context, SME conditions in the Czech Republic and the appropriate tool requirements for the supplier-customer relationship were defined, and expert systems were explained in line with the current trends for the evaluation of supplier-customer relationships. In another study, Giraldo et al. (2018) proposed a rule-based prototype system based on fuzzy logic to analyze the financial position of Micro, Small, and Medium Enterprises (MSMEs) and offered alternative solutions related to problem fields. In this framework, they first determined the possible diseases related to the financial field of MSMEs by using the literature and gathered these diseases under three main headings (liquidity shortage, high level of indebtedness, and insufficient capital). Afterward, they created various rules for determining an enterprise's financial position and presenting solution proposals related to diseases detected.

Gupta and Celtek (2001) developed a fuzzy logic expert system to analyse the loan applications of small enterprises. The main criteria (repayment capacity, credit history, owner investment, and management capability) and sub-criteria (amount of equity, experience, debt/equity ratio, etc.) in the system were evaluated for membership functions (very low, low, medium, high, very high), and a decision was made whether or not to lend.

St-Pierre and Delisle (2006) aimed to show that comparing helps enhance the operational performance

of SMEs. Accordingly, they presented an expert system (PDG-performance, development, growth) that evaluated the performance of SMEs on a comparing basis. The data required for the PDG system were obtained from the SMEs with a questionnaire. Then relevant data and the reference group characteristics of the SMEs were reported together with colored diagrams through the PDG system.

Pavaloaia (2009) aimed to explain a method for computerizing the field of finance and economics of SMEs in Romania. For this purpose, he combined web technologies with expert systems and spreadsheets. He also used financial ratios in his economic and financial diagnosis process. Thus, he developed a computer-based model accessed through a webpage and obtained the values of the variables from the spreadsheet field.

Iqbal et al. (2014) designed a business intelligence prototype which is suitable for the SMEs' characteristics by analyzing existing studies on the behavioral patterns of SMEs in Indonesia towards information and communication technologies. In this direction, they have developed a knowledge-based expert system prototype using data mining to accommodate decision-making for SMEs.

Hernandez et al. (2015) developed an expert system based on three main criteria (labor, financial, and fiscal) to identify risks for SMEs in Mexico. In this direction, they evaluated the indicators of each criterion according to their priority levels (risk-free, low, medium, high, very high), and the expert system made suggestions to avoid risks. Finally, Singh et al. (2016) proposed a fuzzy expert system to evaluate the sustainable manufacturing of SMEs in Malaysia. In this context, they have created various rules by evaluating the linguistic variables (poor, fair, and good)) in terms of economic, environmental, and social performance criteria, and thus they made performance evaluations of manufacturing SMEs.

When examining the applications of expert systems for SMEs in Turkey, the study of Kaynar (1999) takes attention first. In his study, the researcher aimed to provide information on expert systems used in the world and presented the applications of expert systems used by large-scale enterprises for SMEs. Tütüncü (2002) designed an expert system using the GURU shell, which will aid SMEs and small-scale investors in turning their savings into investments and making suggestions for them about the most suitable investment instrument. In this direction, by comparing the features of the investors with the features of the investment instruments, he made suggestions to the investors about which investment instrument was suitable.

Kara et al. (2016) aimed to develop an expert system with MATLAB software based on the artificial neural network algorithm in technology audit activities. In this direction, they compared the average values of technology management capabilities of 72 SMEs operating in four different industries with expert opinions. Accordingly, they concluded that enterprises using expert opinion performed better.

When previous studies are viewed, it is seen that although there are expert systems developed for SMEs, these applications provide information about expert systems, financial analysis, and performance evaluation. However, when the studies in Turkey are evaluated, few studies are found on expert systems for SMEs. Also, these studies are on performance evaluation and the introduction of expert systems. In addition, to the best of the researchers' knowledge, there have been no studies on the WCM of SMEs.

DEVELOPMENT OF THE EXPERT SYSTEM

In this study, a web-based expert system application (SME Emergency) was designed and developed using expert systems to analyze and evaluate the WCM in SMEs.

Data

In the development of the SME Emergency application, the 2012-2020 period data of 283[1] enterprises listed in the BIST All Shares[2] in Turkey were used. The financial data of the enterprises were obtained from the Public Disclosure Platform (PDP), and the data regarding the categorical variables were obtained from the annual reports of the enterprises. According to the data obtained, the values related to the WCM variables of the enterprises, and the industry averages related to these values were calculated and recorded in the SME Emergency system database.

[1] Financial leasing and factoring companies, venture capital investment trusts, football clubs, banks and private financial institutions, and insurance companies were not included in the application.

[2] SME data were needed in the development of the SME Emergency expert system application, but there were some restrictions on obtaining the relevant data. For this reason, the data of the enterprises listed in the BIST All Shares were used to develop the SME Emergency application. The input and output variables for the SME Emergency expert system do not differ for SMEs or large-scale enterprises. This situation is also seen in the literature (e.g., Wang, 2002; Deloof, 2003; Kieschnick et al., 2006; Nazir & Afza, 2009; Gill, 2011; Doğan & Elitaş, 2014) on working capital management in large-scale enterprises. In addition, enterprise scale (firm size) is considered as a variable in the input layer determined for the expert system. Therefore, large-scale enterprise data were used to create a better rule base for the system. Besides, the rule base can be updated according to SME data.

Table 1. WCM Variables and Description

Variable	Description
Sales Growth	Change in sales to the previous year
Firm Size	Natural logarithm of assets
Board Size	Number of board members or directors
Executive Age	Year of financial data minus executive's date of birth
Firm Scale	Micro, small, medium, and large scale
Relationships with Financial Institutions	Short-term bank debt to total debt
Z Score	[(0.104 ∗ Working capital + 1.010 ∗ Retained earnings + 0.106 ∗ Operating profit + 0.169 ∗ Sales) / Total assets] + 0.003 ∗ (Book value of equity / debt)
Financial Leverage	Total debt to assets
Debt Maturity Structure	Long-term debt to total debt
Cash Flows	Net profit and depreciation to total assets
Liquidity	Difference between working capital and liquid assets to assets
Firm Age	Year of financial data minus the date of incorporation.
Return on Assets (ROA)	EBIT to assets
Gross Profit Margin	Gross profit to sales
Operating Profit Margin	Operating profit to sales
Opportunity Cost of Keeping Cash	Difference between ROA and treasury bills rate
Investment Policy	Current assets to assets
Financing Policy	Current liabilities to assets
Export	Yes or no
Cost of External Finance	[(Interest paid) / (Non-current liabilities + Current liabilities – Creditors) / 2] * 100
Asset Tangibility	Fixed assets to assets
Operating Cash Flow	Net profit and depreciation to net assets
Cash Holdings	Liquid assets to net assets
Assets Turnover	Sales to assets
Current Assets Turnover	Sales to current assets
Fixed Assets Turnover	Sales to fixed assets
Operating Expenses	Operating costs to sales
Financial Expenses	Financial expenses to sales
Current Ratio	Current assets to current liabilities
Quick Assets Ratio	Difference between current assets and inventories to current liabilities
Industry	It is classified as main and sub-sector
Industry Power of Enterprise	Enterprise's sales to industry's total sales
Competitiveness (Price – Cost Margin)	EBIT and depreciation to sales
Inventory Holding Period (INV)	(Inventories / Cost of sales) * 365
Accounts Receivable Period (AR)	(Receivables / Sales) * 365
Accounts Payable Period (AP)	(Payables / Sales) * 365
Cash Conversion Cycle (CCC)	INV + AR – AP
Net Working Capital (NWC)	[(Receivables + Inventories – Payables) / Sales] * 100

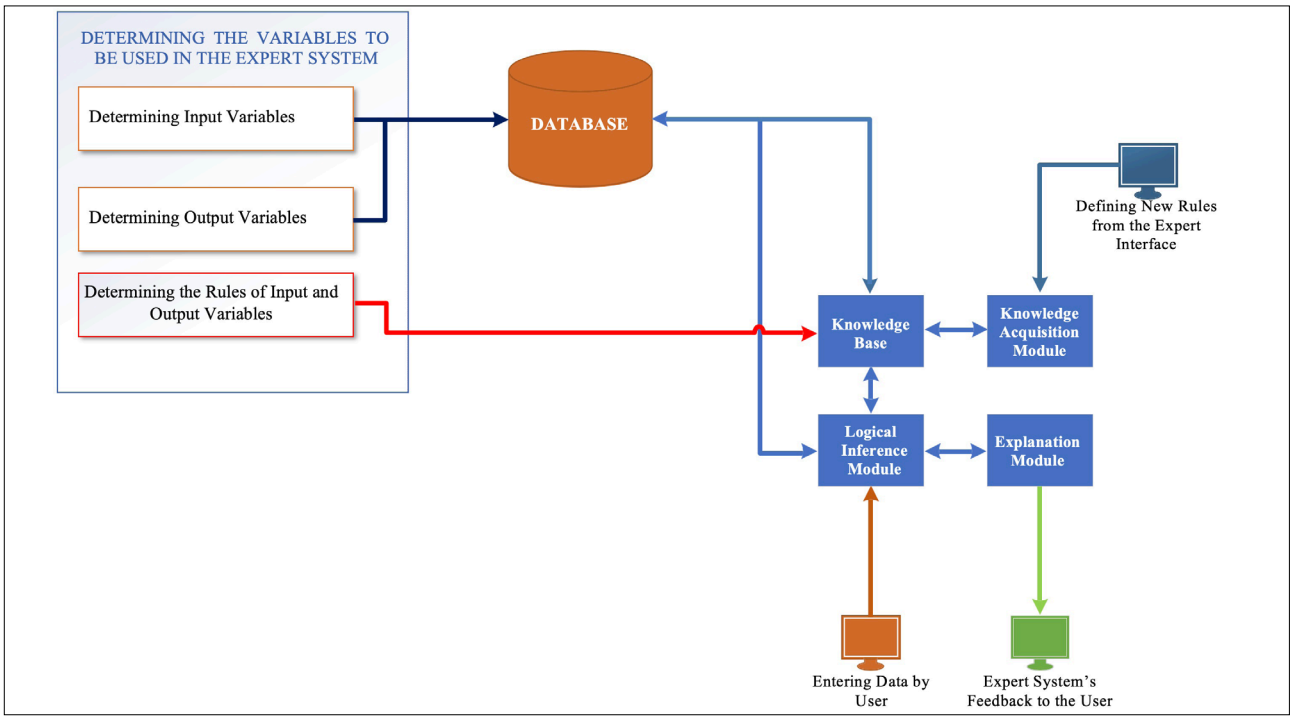

Figure 1. General Structure of the SME Emergency Application

The variables used for WCM and the necessary formulas for calculating these variables are presented in Table 1. While determining the components of WCM and the factors affecting WCM, studies for SMEs were used (e.g., Padachi, 2006; Banos-Caballero et al., 2010; Afeef, 2011; Boschker, 2011; Karadağlı, 2012; Afrifa, 2016). In addition, while determining the factors affecting WCM, studies (e.g., Wang, 2002; Deloof, 2003; Kieschnick et al., 2006; Nazir & Afza, 2009; Gill, 2011; Doğan & Elitaş, 2014) on large-scale enterprises and SMEs were examined. Accordingly, in the study, the WCM performance of enterprises was evaluated in terms of 5 different performance outputs (Inventory Holding Period-INV, Accounts Receivable Period-AR, Accounts Payable Period-AP, Cash Conversion Cycle-CCC, and Net Working Capital-NWC) using a total of 38 different variables.

Development Process of Expert System

The general structure and basic components of the SME Emergency expert system application developed in the study are presented in Figure 1. These components are briefly described below.

The user is defined as the person who provides facts or other information to the expert system and receives expertise or expert advice (Giarratano & Riley, 1998). In the SME Emergency application, users can be owners, managers, accountants, or personnel from the finance department.

The user interface is explained as the unit that provides information exchange and communication between the expert system and the user (Yıldız, 2009). In the user interface module, there is an interface where the enterprises that will use the system can make membership and data entry transactions. Enterprises can update their user profiles whenever they want to access the expert system created through this interface.

The knowledge base is explained as the unit where the information needed by the expert system to solve the problem is stored and allows the production of new information from existing information. The information in the knowledge base generally includes facts and rules (Yıldız, 2009; Nabiyev, 2016). The knowledge base consists of two components: a database and a rule base.

The database is expressed as storage where facts describing the present status of the problem and attribute-value pairs obtained until a certain moment are stored (Allahverdi, 2002). In the study, the MySQL server was used to create the database, and the phpMyAdmin application was used for database management. The database of the developed application includes the values of WCM variables calculated based on the 2012-2020 period data of 283 enterprises and the industry averages of these values. In addition, the information entered by users via the business information entry form and the values for the WCM variables calculated within the framework of this information are transferred to the database. A visual sample from the database is presented in Figure 2.

firm_data_id	year	firm_name	main_sector	sub_sector	output	sales_growth	firm_size
4925	2019	AVOD	Manufacturing	Food, Beverage, and Tobacco	Partially Successful	0.271249	5.602252
4926	2019	ACSEL	Manufacturing	Chemicals, Petroleum Rubber and Plastic Products	Partially Successful	0.343005	3.900923
4927	2019	ADANA	Manufacturing	Non-Metallic Mineral Products	Unsuccessful	-0.126309	7.040673
4928	2019	ADBGR	Manufacturing	Non-Metallic Mineral Products	Unsuccessful	-0.126309	7.040673
4929	2019	ADNAC	Manufacturing	Non-Metallic Mineral Products	Unsuccessful	-0.126309	7.040673
4930	2019	ADEL	Manufacturing	Other Manufacturing Industry	Unsuccessful	-0.098674	5.964918
4932	2019	AFYON	Manufacturing	Non-Metallic Mineral Products	Partially Successful	-0.067735	6.474383
4933	2019	AKENR	Electricity Gas and Water	Electricity Gas and Steam	Partially Successful	-0.177292	8.835512
4938	2019	ATEKS	Manufacturing	Textile, Wearing Apparel and Leather	Successful	0.159573	6.596076

Figure 2. A Sample Visual of Defining Data to The Database

Table 2. A Sample View from the Rule Base

Rule No	C1*	C2*	C3*	C4*	Average	**Output**
1	1	1	1	1**	1	Very unsuccessful
2	1	1	1	2**	1.25	Very unsuccessful
3	1	1	1	3**	1.5	Unsuccessful
4	1	1	2	1	1.25	Very unsuccessful
5	1	1	2	2	1.5	Unsuccessful
6	1	1	2	3	1.75	"
7	1	1	3	1	1.5	"
8	1	1	3	2	1.75	"
9	1	1	3	3	2	Partially successful
10	1	2	1	1	1.25	Very unsuccessful
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.

*Represents the conditions in Figure 3 **1=low; 2=normal; 3=high

The rule base is called the storage that the expert system has to store a set of rules that work in certain circumstances and are in the form of "If-Then" or otherwise (Allahverdi, 2002). The "IF…THEN…ELSE" structure was used to create the rule base for the SME Emergency expert system application.

Table 2 presents the rule base on how the success or unsuccess of enterprises is determined. Accordingly, the section shown on the left side of the table presents the rule base prepared numerically. On the right side of the table, there are rules created on the basis of the letters. While determining the number of rules, the positions (low, equal, and high) between the variable values used to obtain the conditions and the number of conditions were used. In other words, the number of rules was obtained as 3^4=81. In determining the outputs, the value (2/5= 0.4) obtained by dividing the

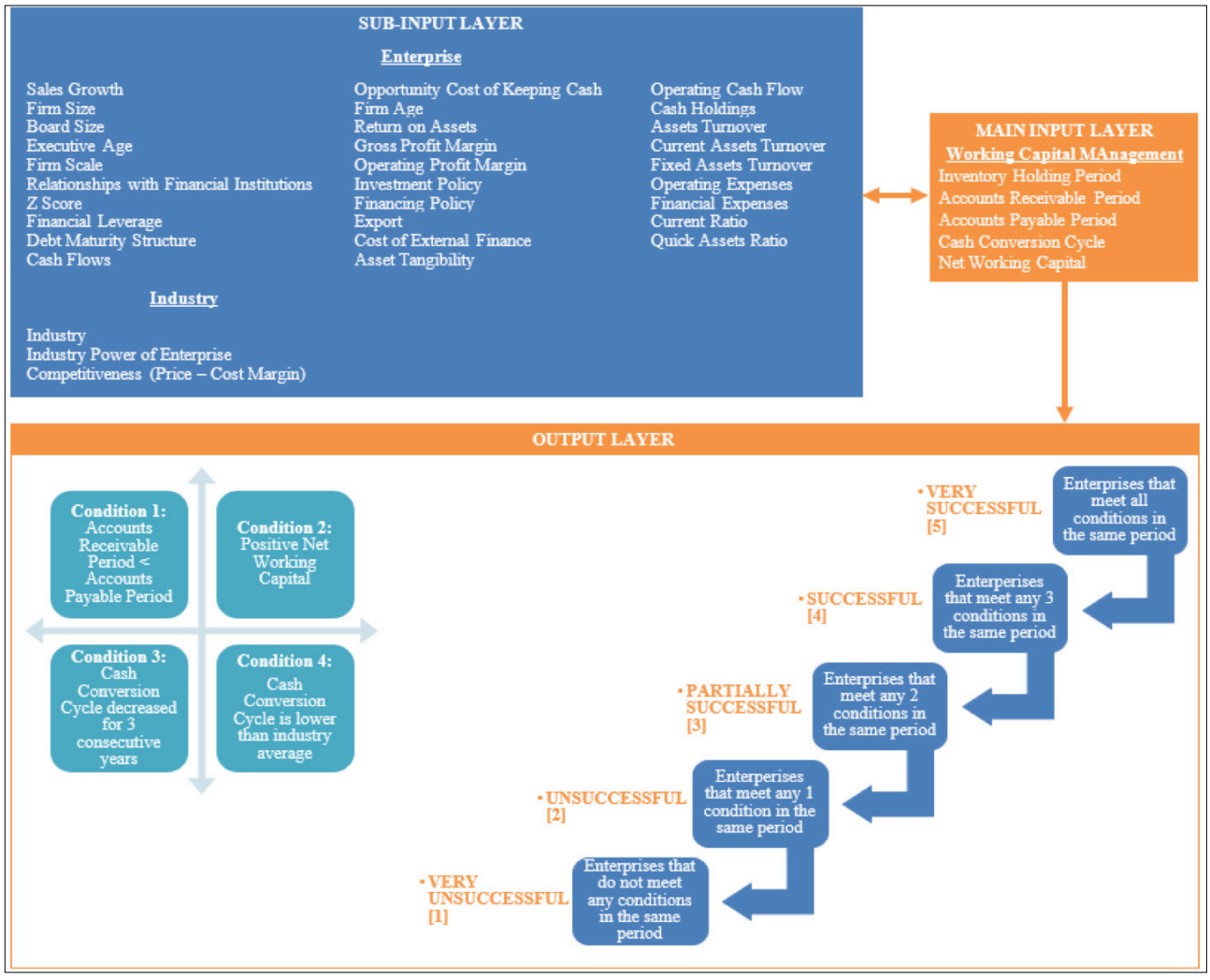

Figure 3. Input and Output Layer of WCM

interval values (there are two intervals between 1-2-3 values) by the number of outputs (very unsuccessful, unsuccessful, partially successful, successful, and very successful) was used. Accordingly, outputs (e.g., very unsuccessful if the average value is between 1 and 1.4) were determined according to every 0.4 increase from 1 to 3.

The data recorded in the database were transferred to the logical inference module together with the rules in the knowledge base. In addition, new rules can be added and updated using the ***knowledge acquisition module***.

The inference engine is described as a unit that searches, filters, interprets, and generates solutions in the knowledge base and has two types of inference methods, forward and backward chaining (Öztemel, 2016).

The explanation unit refers to the section where the results are reported by the expert system to be presented to the users (Şahin et al., 2011). Through this unit, the user is given feedback on the WCM of the enterprise. Various graphics and visuals were used in the presentation of the data. In addition, the user can save these visuals as reports or printouts.

The input variables used in the developed SME Emergency system, the success conditions, and the relevant criteria are given in Figure 3. Accordingly, enterprise and industry variables constitute sub-input variables. On the other hand, WCM determinants constitute the main input variables. The output layer, which is created depending on the main input variables, shows whether the enterprises are successful or unsuccessful in terms of WCM efficiency, and a classification is made according to the extent to which they meet the conditions. After determining the WCM performance of an enterprise, if it is unsuccessful, it can be determined in which file there is a problem, and suggestions can be made in this direction.

STRUCTURE OF THE EXPERT SYSTEM

In this section of the study, the webpage designed for the SME Emergency application and the evaluations on the result screen of the application are presented. SME Emergency application is a web-based expert system. In this context, the general structure of the SME Emergency application is presented in Figure 4. This page contains information about the SME Emergency application and accesses the system registration and login screen through this page.

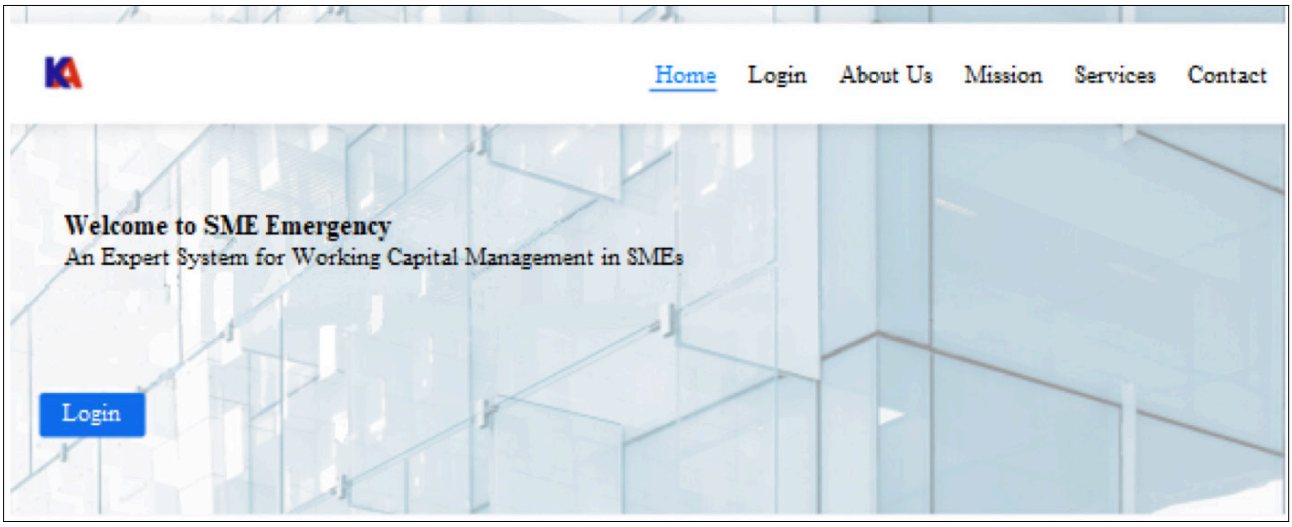

Figure 4. Structure of SME Emergency Expert System

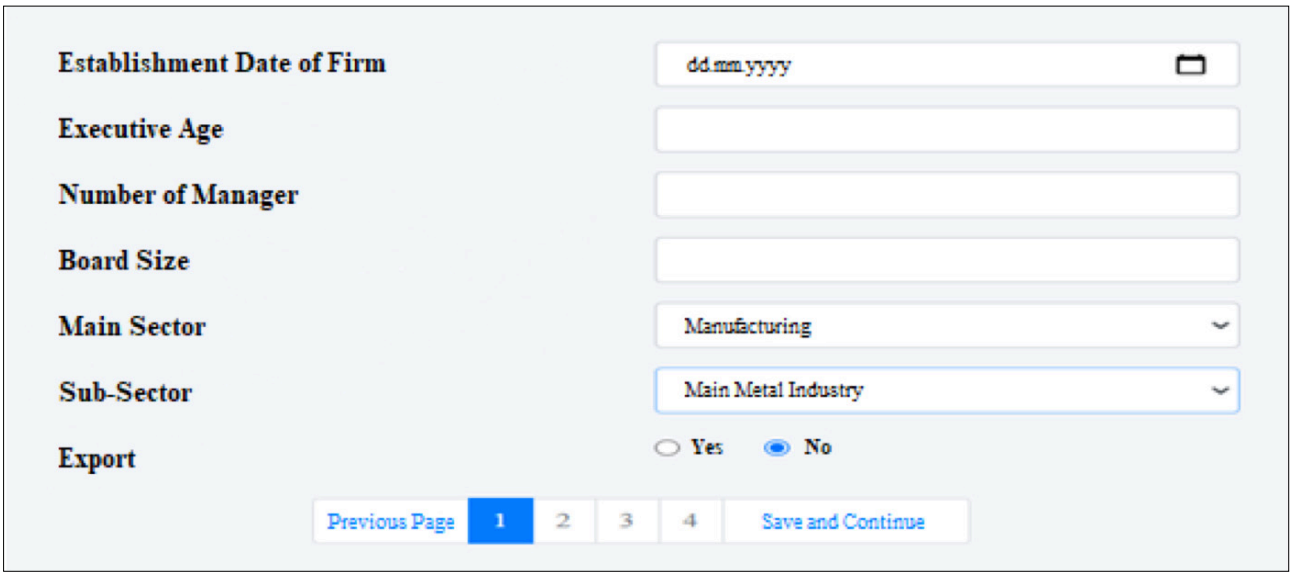

Figure 5. SME Emergency Data Entry Screen

You must be a registered user to log into the application. Registration on behalf of the enterprise or enterprise owner/manager can be created via the registration and login screen of the SME Emergency application. The main screen of the SME Emergency application can be accessed through the created user profiles. The data entry screen required for evaluating the WCM of the enterprise and the frequently asked questions section can be accessed through the main screen of the SME Emergency application.

In the SME Emergency application, the data entry screen of the enterprise is presented in Figure 5. This page consists of four sections and continues by defining the data for the items in each section. After defining the data for each item on this page, the values for the WCM determinants are automatically calculated by the system, and the result screen is accessed.

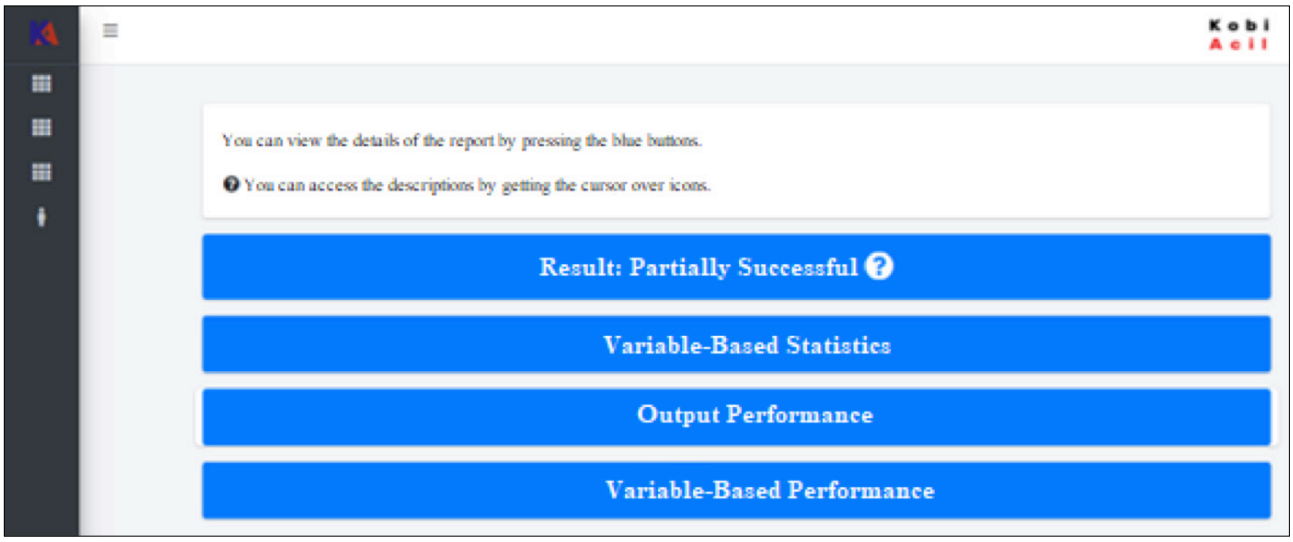

Figure 6. SME Emergency Result Screen

Table 3. A Sample View of Evaluation of Variables by Industry Average

Input Items (Variable)	Industry Average	AVOD	Percent Low/High Compared to Industry Average
Sales Growth	0.2306	0.2695	16.8849%
Firm Size	6.1592	2.4330	-60.4989%
Return on Assets	0.0752	0.0590	-21.5236%
Competitiveness	0.0530	0.2011	279.2643%
Inventory Holding Period	88.6718	207.5818	134.1014%
Accounts Receivable Period	94.3021	53.8479	-42.8985%
Accounts Payable Period	48.6130	81.5642	67.7826%
Cash Conversion Cycle	32.3260	179.8655	456.4109%
Net Working Capital	5.9969	0.3879	-93.5311%

Figure 6 presents the evaluation results screen related to the WCM of the enterprise. On this screen, there is also the interface including the homepage, user guide, system information notes, and logout tabs. In the user guide section, there is information on how to use the system. The system information note section provides information about the aim of the system, the definition and calculation of the variables used, and the performance evaluation process.

On the result screen, details are viewed by clicking on the tabs shown in blue, and related explanations are accessed by using the question mark icons. On this page, first of all, the general success of the enterprise in terms of WCM is presented. With this result screen, the user can access various evaluations related to WCM variables and convert these evaluations to pdf format with the "Receive Report" tab.

In the result screen for WCM, the values of the WCM variables belonging to the enterprise (e.g., A.V.O.D. Kurutulmuş Gıda ve Tarım Ürünleri Sanayi Ticaret A.Ş. – AVOD) are presented in comparison with the industry average, as shown in Table 3. In this direction, the WCM performance of the enterprise according to the industry is presented. If the success is higher according to the industry, it is shown in green; if it is lower, it is shown in red. Here, the industry average for the relevant variable and the average of successful enterprises are used as reference values in order to make the evaluation more sensitive, rather than the values of some variables (investment policy, financing policy, current ratio, and quick ratio) being lower or higher than the industry average. The fact that any variable is indicated in red in this table means that the success of the enterprise is lower in terms of the relevant variable, and suggestions can be made accordingly.

In the result screen, the position of the enterprise in terms of WCM is shown. As presented in Figure 7, the position of the enterprise in terms of WCM according to the main sector and sub-sector in which it operates and the average success status of the enterprises in

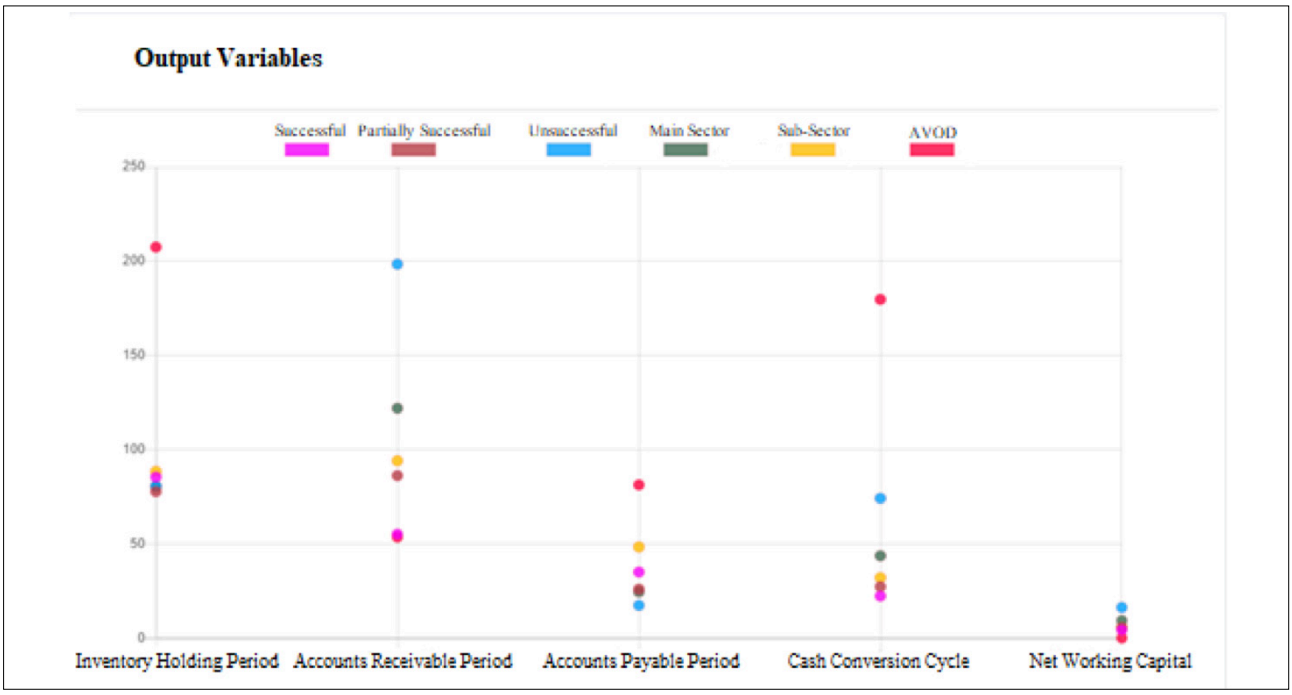

Figure 7. Position of the Enterprise for the WCM Determinants

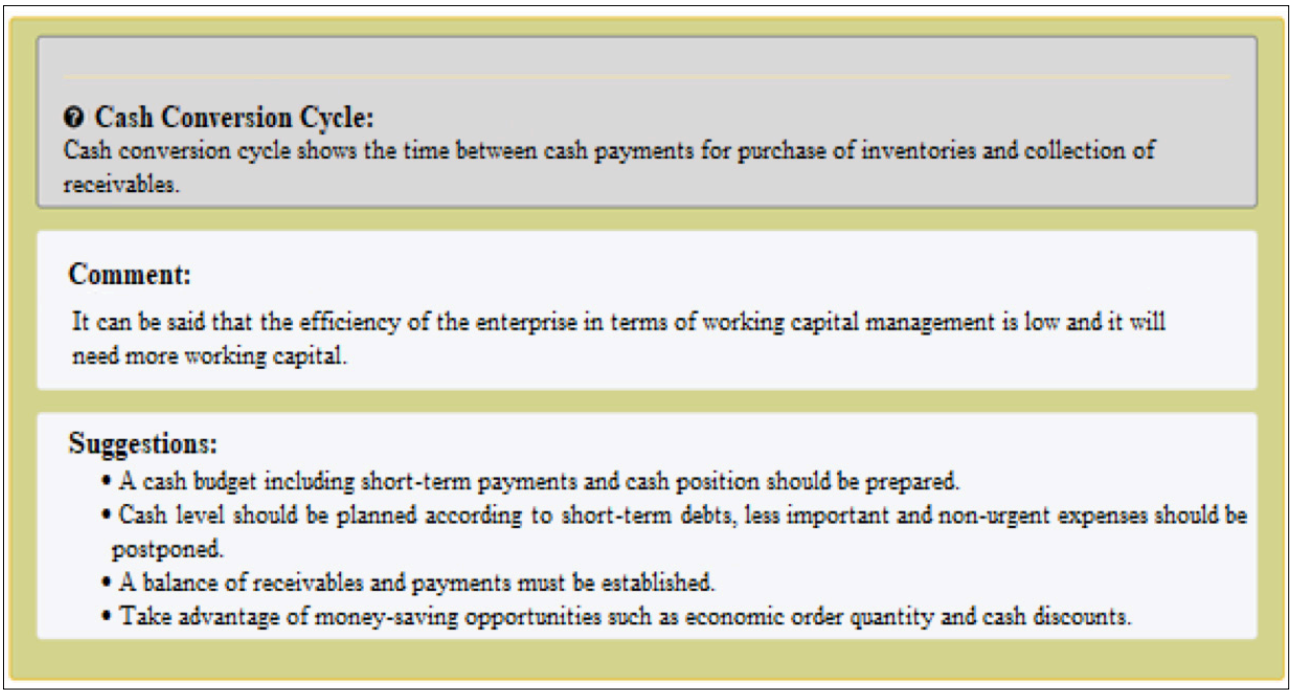

Figure 8. Indicator-Based Interpretation (CCC)

the industry is shown. Accordingly, the enterprise can compare itself with the industry average and its competitors in the industry in terms of WCM efficiency. In other words, it enables the enterprise to see that the efficiency of inventories, receivables and payables management is lower (higher) than the industry average and competitors in the industry.

In this framework, the results screen contains comments and suggestions regarding the determinants of WCM. Accordingly, first of all, the general financial performance of the enterprise regarding WCM is interpreted. However, according to the evaluations obtained from Table 3, comments on each WCM variable are included. If it has lower success than the industry (indicated in red), additional suggestions are presented. In this respect, an example of the evaluation regarding the CCC of the enterprise is given in Figure 8.

On this screen, comments, and suggestions regarding the CCC are presented. The evaluation regarding the CCC of the enterprise is obtained by the following rule.

IF "CCC of the enterprise <= Average CCC of the sub-sector AND CCC of the enterprise < Previous period CCC of the enterprise AND previous period CCC of the enterprise < CCC of the enterprise 2 periods ago" THEN

PRINT "Comment"

ELSE

PRINT "Comment"

FOREACH "Suggestion IN Suggestions"

PRINT "Suggestion"

In the process of developing the SME Emergency application, an expert system method based on artificial intelligence techniques was used. The developed SME Emergency application consists of three main modules. Accordingly, *the user interface* module contains the interface where the enterprises that will use the system can make membership and data entry transactions, the structure of the expert system application is developed in *the expert system module*, and the performance of the enterprise on WCM is presented to the user in *the evaluation module*.

The performance of enterprises with WCM is evaluated

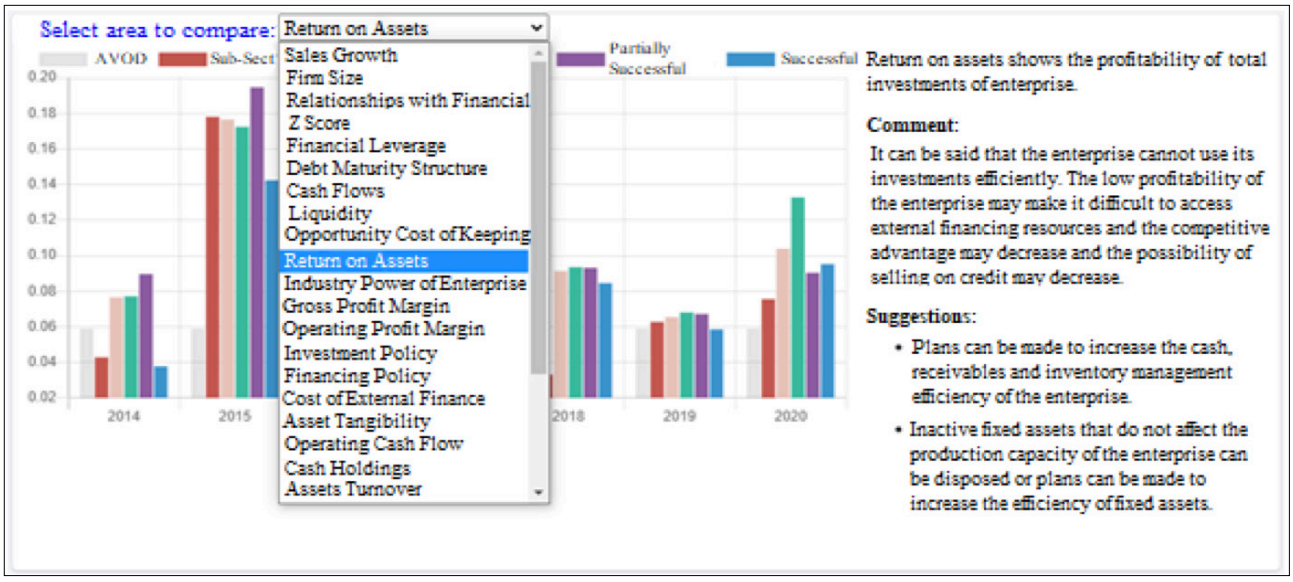

Figure 9. Evaluations of Sub-Input Variables

The results screen for WCM also includes comments and suggestions about the variables that may influence WCM. A sample display of this evaluation is presented in Figure 9. Accordingly, by selecting any variable on the chart, the financial position of the enterprise can be compared to previous years, the industry average, and competitors in the industry. Comments and suggestions regarding these variables can be accessed.

CONCLUSION

This study aims to provide expert support to increase the efficiency of SMEs in WCM. In this direction, an expert system application (SME Emergency) was developed to analyze the WCM of SMEs and offer comments and suggestions based on these analyses. The SME Emergency application was developed using the 9-year data (2012-2020 period) of 283 enterprises listed in the BIST All Shares.

in terms of 5 different performance outputs (AR, INV, AP, CCC, and NWC) using 38 different variables. The output layer shows whether the enterprises are successful or unsuccessful in terms of working capital efficiency through the created rule base. A classification (very unsuccessful, unsuccessful, partially successful, successful, and very successful) is made according to the extent to which they meet the relevant conditions. After determining the WCM performance of the enterprise, if there is an unsuccessful, it can be determined on the basis of the variable in which field the problem is, and suggestions can be offered in this direction.

SME Emergency application was developed as a web-based expert system. The SME Emergency web page contains information about the application and a login section for accessing the system. You can become an individual or corporate member of the system through the SME Emergency registration and login screen and access the data entry screen required for WCM with the

created user profiles. The values required for the WCM variables can be defined separately through the data entry screen. Then the values for the variables used for the WCM are automatically calculated by the system.

After calculating the values related to the WCM variables, the result screen of the SME Emergency application is accessed. In the result screen, first of all, the performance status of the enterprise in terms of WCM is presented. The general position of the enterprise in terms of WCM performance is interpreted. Then, the screen regarding the evaluation of the WCM variables according to the industry average in which the enterprise operates is accessed. The position of the enterprise according to the industry is shown through this screen. In the evaluation table in this section, stating the line related to the variable in red color enables the suggestions to be presented because the lower level of success helps to find out which variable is problematic.

In addition, on the result screen, the position of the enterprise in terms of WCM performance according to the industry in which it operates and the enterprises with a different financial position in the industry are presented graphically. In addition, this section includes comments and suggestions for each variable according to the determinants of WCM.

Finally, in the SME Emergency application result screen, there are evaluations of other variables that may be related to WCM. According to these variables, the success of the enterprise and the averages of the enterprises with different success situations in the industry in which the enterprise operates, and the industry average are shown comparatively over the years through graphs. In addition, suggestions are presented based on the result obtained from the evaluation table for each variable.

As a result, SME Emergency allows SMEs to see the performance of WCM compared with previous years and their competitors in the industry in which they operate. In this context, it is thought that the SME Emergency application will contribute to SMEs in terms of WCM compared to large-scale enterprises because SMEs cannot receive external consultancy services on financial management, which requires expertise due to the high cost. Likewise, this expert system application can be used by large-scale enterprises.

In this study, there are limitations, such as not being able to provide SME data and manually defining the comments and suggestions in the developed system in advance. Therefore, a more comprehensive and intelligent learning system can be developed by accessing a large number of SME (especially micro-scale) data. In addition to this, an expert system application can be designed for the evaluation of all operational performance of enterprises for enterprises of all sizes. In addition, artificial neural networks, machine learning, and fuzzy logic techniques can be used to develop a self-learning expert system and make more sensitive evaluations.

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