ESTABLISHING THE MOST INFLUENCING CAUSES OF COMPANIES' FINANCIAL HEALTH AND PERFORMANCE – A GREY FUZZY APPROACH

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Abstract: : The core of our paperwork consists in construction of a model for determining a hierarchy of qualitative and quantitative causes that are influencing service companies' financial health. While the quantitative causes are objectively measurable, the qualitative causes are mainly subjectively measurable, quantified based on some experts' opinion. In order to reduce the degree of subjectivity, we took advantage of methods offered by fuzzy systems, mainly in construction of the expertons. Expertons are in fact intervals built using the □-fuzzy sub-set and the opinion of several experts over a certain problem. Furthermore, after constructing the expertons, we use the methods offered by grey systems theory and fuzzy sub-sets arithmetic to determine the degree of influence of each qualitative and quantitative cause on company's performance. By classifying the causes and acting on the most important of them, the activity of the analyst can be really improved and the company's performance will rise.

JEL classification: C02, D22

Key words: service companies; fuzzy sets; grey systems theory; fuzzy sub-sets arithmetic; financial health;

1. INTRODUCTION

In the context of the new economy, an economy in which the intangible capital is at least as important as the tangible capital, and in which an important part of the value of tangible capital is in fact based on intangible inputs, the importance of companies in any economic activity is vital.

As it is known, the term of “new economy” refers basically to a set of quantitative and qualitative changes, which appeared over the past few years and which succeeded in modifying the structure, the functions and the rules that guided the economy.

Stockholders, creditors, auditors and senior management all have a mighty interest in utilizing and developing a methodology that will allow them to monitor and to regulate the financial performance of a firm. By identifying different elements that influence their financial health and performance, firms can increase positive effects, thus facilitating the achievement of the firm’s goals.

Prediction of firm’s financial health is a relatively new field in the economic and financial analysis.

This paper contains the way we can establish which of the qualitative or quantitative variables that influence the firm’s financial health and performance are the most important. Knowing these variables, managers can act on them, in the benefit of their service firm. Because the analyzed variables, the qualitative and the quantitative ones, are influencing the firm’s output, we will refer them as “causes”.

The causes of the firm’s financial health and performance are objectively and subjectively measurable. Their occurrence allows certain methods to be used for establishing which one of them have the higher impact on firm’s financial health. That is what makes this field suitable for tools taken from fuzzy and grey systems theory. This relatively new approach using the mentioned theories allows us to properly model the variables taken into consideration.

2. BRIEF HISTORY OF MODELS AND METHODS USED TO DETERMINE THE FINANCIAL HEALTH OF FIRMS

The desire to early understand the precursor signals of a disaster and to take action that would try to improve the financial situation of a firm, even avoid its bankruptcy constitutes the starting point in making a prediction on the firm’s evolution.

The main assumption on which such predictions leans on was that certain preliminary aspects regarding the insolvency of a firm can be seen by studying the dynamics of growth rates for a set of indicators derived from the financial accounting.

Fitz Patrick [9] has published first papers on this filed. In his analysis he considered two sets of 19 bankrupt firms and 19 non-bankrupt firms, and he succeed to demonstrate that three years before bankruptcy, the financial ratios were significantly changed. Another important study is the one made by Winakor and Smith [21], who conducted research for a period of ten years before the bankruptcy establish, noticing that the financial ratios deteriorate as firms were directed towards bankruptcy. Mervin [13] reached similar conclusions.

However, the scientific concerns in this area began in 1967 with the research made by Beaver [4]. His research is intended to be a benchmark for future research in purpose of finding alternatives for bankruptcy prediction using the financial ratios of a company. Beaver developed a uni-variable analysis model that is now part of the classical models of bankruptcy prediction. Over the time, the uni-variable analysis gained his position in the class of statistical methods used in prediction of financial health of a firm mostly because it’s competitive advantage over simple calculation, its low-cost, easy explanations and “not bad” performance. [5]

The birth’s year of the risk index models is considered to be 1966. In these models, to each analyzed firm it is assigned a number of points between 0 and 100, according to the rates involved in the model, so that the higher sum given by these points indicate a better financial situation. Points are allocated so that the most important rates to get a higher weight into the model. However, the allocation of weights is subjective [3]. These models were introduced by Tamari [20] and later extended by Moses and Liao [14].

In 1968 multi-variate discriminant analysis was introduced by Altman [1], called "multiple discriminant analysis", which used in estimation the Z-score model. This model was used to discriminate between abnormal and healthy firms, using a statistical function. The main difference between the uni-variate analysis and the multi-variate analysis was that the last one tries to fix the gaps of the first one, basically on the field of the variables taken into account. As it is known, the uni-variate analysis didn't consider the contradictions or the possible interactions among the analysed variables.

After 1968, there have been an enormous number of studies based on Altman's Z-score model, many of them being focused on assessment of the results obtained by the above mentioned model (Halderman, Narayanan [2], Deakin [6], Edminster [8], and Taffler [19]).

In 1970 Myer and Pifer [15] introduced the linear probability model, followed in 1980 and 1984 by the stochastic models such as logit [16] and probit [23]. Some weak points of these models were the need to transform the original variables and the complicated computations involved.

Fuzzy logic (Zadeh in 1965 [22]) was also widely used in firms' bankruptcy prediction. Thus, Siegel, Korvin and Omer [17] argue that quantitative models based on fuzzy systems theory can solve this problem. It goes to a new approach to problem that may occur at firm's level, both from the view point of quantitative variables, but especially in the qualitative variables, related to the subjectivity of decisions taken therein.

From 1990, a lot of studies have applied artificial intelligence (AI) to the problems regarding the financial health of the firm. The main research directions included: decision trees, support vector machine, rough sets theory, fuzzy sets theory, genetic algorithms, neural networks (BPNN=back propagation neural networks, PNN=probabilistic neural networks, SOM=self organizing map, Cascor=cascade correlation neural network) and CBR (case-based reasoning).

Professor Deng Ju-Long has published in 1982 the paperwork "Problems of Grey Control Systems", in which proposed a new theory: the grey systems theory which managed to develop and mature rapidly, and even to impose. In practice, grey systems theory has been widely applied in analysis, modelling, prediction, control, decision making, in almost all areas: social, economic, mechanical and technical science, agriculture, industry, transport, petrology, meteorological, ecological, hydrological, geological, financial, medical, military, and others [18]. Its main characteristic is that it manages to achieve good performance in analysis conducted on a small range of data and on a large number of variables.

3. COMPANIES' FINANCIAL HEALTH AND PERFORMANCE

3.1 Establishing the Causes

In the context of economy, we consider that each firm is different from another in such a manner that it is difficult to establish some general causes that affect financial health of a group of firms. Our purpose is to succeed in ordinate them decreasingly, accordingly to each service company specific. This will help managers to better operate on causes in such a manner that will improve the financial health and performance of their firms.

For a firm, most of the quantitative causes, represented mainly by financial causes, are the same with the ones that we meet in financial diagnosis and prediction models (e.g. rising in sales' volume, in current assets, floating of the employment costs etc.). In the area of quantitative causes, we are also including some structural causes, related to the number of employees, type of company, shares of the company, etc, and some macroeconomic causes, referring to real GDP growth, real effective exchange rate, etc.

On the other hand, the qualitative causes cannot be identified using the company's financial statements or changes in the macroeconomic indicators. The main difference between qualitative and quantitative causes that are affecting firm's performance and financial health is that the first ones cannot be objectively measurable.

Qualitative causes are being seen as value judgments made by an expert or a group of experts over a specific problem. That is the reason why they are considered as being subjective.

As we discussed in the previous section, qualitative causes are multiple and most of them have already being identified in the literature of service science.

Some of the most important qualitative causes that can affect the financial health of a company or contribute to its performance, as they result from previous research ([5], [7],[11], [12] and not only), are listed here:

- The intensity of organizational innovation;
- Level of customer interaction and customization;
- The measure of customer involvement;
- Customers' perception on services;
- The type and intensity of leadership;
- The degree of knowledge-based resources;
- The degree of competitiveness of internal resources;
- The predominance of information transformations in all service types;
- The level of service company's flexibility on the changing environment;
- The level of collective learning and cooperative learning;
- The degree of social relationships;
- The professionalism of employees, their capacity of learning;
- Managerial capacity;
- The ability of identifying, developing, deploying and preserving particular resources that distinguish it from rivals;
- The degree of absorptive capability;
- The capacity of firm to create competitive advantage;
- The capacity of firm to take advantage of social relationships;
- The architecture of IT infrastructures;
- The structure of information and navigation design found on service company's websites, etc.

Depending on each company, only a part of these qualitative causes may appear, and it is the role of specialists to determine which of them are the most important, in such a manner that can be selected for the following steps of the research.

3.2 Measuring the Qualitative Causes with Fuzzy Sub-Set Theory

One of problem that has raised the most controversy regarding the techniques used for the treatment of subjectivity in economic problems was related to the assignment of values to membership functions. Although the human way of thinking and evaluating problems is related to a high degree of subjectivity, over the past years, researches have tried to eliminate as much as possible this subjectivity.

Fuzzy logic, developed by L. Zadeh [22], offers the suitable methods for the treatment of subjectivity and uncertainty. Almost four decades ago, when the concept of linguistic variables was introduced by fuzzy logic, it was criticized by the researches. Now, the concept of linguistic variables plays an important role in scientific theories.

The main characteristic of fuzzy sub-sets is that the function characteristic of membership is taking its values from [0; 1] instead of {0; 1}. For a better representation of reality, we will consider that those values are intervals and not numbers, situated in [0; 1], called "*ϕ-fuzzy sub-set*". This concept of "*ϕ-fuzzy sub-set*" came from medical field and was developed by Sambuc, which extended the theory of fuzzy sub-sets, in such a manner that allows to the experts to have a less subjective perception about a phenomenon.

Once with the idea of *ϕ-fuzzy* sub-set, the idea that the opinion of a single expert is being insufficient emerges. That is the reason why it is preferred to gather several experts' opinion and even to construct an "experton". (We recommend [10] for further reading on the way an experton can be designed).

We will use the fuzzy intervals to establish the degree of intensity of qualitative causes on firms' performance. For that reason, we will need the following definition regarding the operational rules among intervals of confidence [10]:

Definition:

Let $[\underline{s},\overline{s}]$, $[\underline{s}_1,\overline{s}_1]$ and $[\underline{s}_2,\overline{s}_2]$ be intervals. The basic arithmetic of intervals is defined as follows:

1. Addition:

   $[\underline{s}_1,\overline{s}_1] + [\underline{s}_2,\overline{s}_2] = [\underline{s}_1+\underline{s}_2, \overline{s}_1+\overline{s}_2]$
2. Subtraction:

   $[\underline{s}_1,\overline{s}_1] - [\underline{s}_2,\overline{s}_2] = [\underline{s}_1-\overline{s}_2, \overline{s}_1-\underline{s}_2]$
3. Reciprocal:

   If $0 \notin [\underline{s},\overline{s}]$ then $[\underline{s},\overline{s}]^{-1} = [1/\overline{s}, 1/\underline{s}]$

   If $0 \in [\underline{s},\overline{s}]$ then $[\underline{s},\overline{s}]^{-1}$ is undefined
4. Multiplication:

   $[\underline{s}_1,\overline{s}_1] \cdot [\underline{s}_2,\overline{s}_2] = [\underline{p},\overline{p}]$

   where: $\underline{p} = \min\{\underline{s}_1\underline{s}_2, \underline{s}_1\overline{s}_2, \overline{s}_1\underline{s}_2, \overline{s}_1\overline{s}_2\}$ and $\overline{p} = \max\{\underline{s}_1\underline{s}_2, \underline{s}_1\overline{s}_2, \overline{s}_1\underline{s}_2, \overline{s}_1\overline{s}_2\}$
5. Division:

   $[\underline{s}_1,\overline{s}_1]/[\underline{s}_2,\overline{s}_2] = [\underline{s}_1,\overline{s}_1] \cdot [\underline{s}_2,\overline{s}_2]^{-1}$ provided that $0 \notin [\underline{s}_2,\overline{s}_2]$
6. Absolute value:

   $[\underline{s},\overline{s}] = \max\{|\underline{s}|, |\overline{s}|\}$

Thus, the absolute value of a singleton s=[s, s], is its usual absolute value $|[s,s]| = |s|$ for all $s \in R$

7. Midpoint (Mean)

$$m\{[\underline{s},\overline{s}]\}=\frac{1}{2}\cdot(\underline{s}+\overline{s})$$

Those operations on intervals will be necessary in calculating the degree of some causes' incidence on the performance of a company, by inserting experts' evaluation over the qualitative causes (expressed by intervals) into the formulas given by grey systems' theory.

3.3 Grey Systems Theory

Unlike other interdisciplinary theories, grey systems theory has found and has managed to retain a place within them, especially because its success in real systems applications. This theory exceeds the drawbacks encountered in the use of probability theory and statistical methods (the need of reasonable size samples and determination of certain distributions to make inferences) and those of fuzzy mathematics (which deals with the study of problems with cognitive uncertainty phenomena, using so-called "membership functions", based on experience).

Most of the models used in establishing the financial health of a company are based on a set of quantitative data collected from firm in a given period of time.

To have an overview of how the cause are evolving, until the moment they actually get to determine the performance of a firm, we propose a 3 years analysis and we use a matrix of personalised causes expressed for each firm taken into analysis. The partially missing data can be computed using the methods offered by the grey systems' theory [12], [18].

Our goal is to determine which one of the considered causes manifest the biggest influence in each firm and to establish a hierarchy of them, in order to help managers to improve the financial health and performance of service companies.

We note the set of causes S_j, with j = 1, 2, n. The correlation matrix between the level of each cause of a firm and the corresponding year, for an interval of time equal to 3 years, is noted as follows:

$$X=\begin{pmatrix} x_{11} & x_{12} & \ldots & x_{1n} \\ .. & \ldots & \ldots & \ldots \\ x_{31} & x_{32} & \ldots & x_{3n} \end{pmatrix}$$

To reach our purpose, we compute the absolute degree of grey incidence, the relative degree of grey incidence and, by their combination, the synthetic degree of grey incidence, which will help us in taking the decision regarding the causes.

I. *Absolute Degree of Grey Incidence*

We calculate the next sequence [19]:

$X_j^0=(x_{1j}-x_{1j},x_{2j}-x_{1j},x_{3j}-x_{1j})$, with $j=1,\ldots,n.$

For the first set of causes, we have the following sequence:

$$X_1^0=(x_{11}-x_{11},x_{21}-x_{11},x_{31}-x_{11})=(x_{11}^0,x_{21}^0,x_{31}^0)$$

Then, we apply the formula of the absolute degree of grey incidence of the first year's causes over the performance:

$$\varepsilon_{0j}=\frac{1+|s_0|+|s_j|}{1+|s_0|+|s_j|+|s_0-s_j|},$$

where $|s_1|,|s_2|,|s_3|,|s_4|,\ldots,|s_n|$ are computed as follows:

$$|s_j| = \left|x^0{}_{2j} + (1/2)\cdot x^0_{3j}\right|$$

In this way, we obtain the absolute degrees of grey incidence: $\varepsilon_{12},\varepsilon_{13},\varepsilon_{14},\ldots,\varepsilon_{1n}$.

II. *Relative Degree of Grey Incidence*

The relative degree of grey incidence is obtained using the following relations:

$$r_{0j} = \frac{1+|s_0^{'}|+|s^{'}{}_j|}{1+|s_0^{'}|+|s_j^{'}|+|s^{'}{}_0 - s_j^{'}|}$$

$$|s^{'}{}_j| = \left|x^{0^{'}}{}_{2j} + (1/2)\cdot x^{0^{'}}_{3j}\right|$$

We compute the initial values of X_j as being:

$X_j^{'} = (\frac{x_{1j}}{x_{1j}},\frac{x_{2j}}{x_{1j}},\frac{x_{3j}}{x_{1j}},) = (x_{1j}^{'},x_{2j}^{'},x_{3j}^{'})$, and the images of zero-start points:

$$X_j^{0'} = (x^{'}{}_{1j} - x^{'}{}_{1j}\ ,x^{'}{}_{2j} - x^{'}{}_{1j},x^{'}{}_{3j} - x^{'}{}_{1j}) = (x_{11}^{'0},x_{21}^{'0},x_{31}^{'0})$$

III. *Synthetic Degree of Grey Incidence*

The synthetic degree of grey incidence is based on the absolute and relative degrees of grey incidence obtained earlier:

$\rho_{0j} = \theta\varepsilon_{1j} + (1-\theta)r_{1j}$, with j = 2, ..., n, $\theta \in [0,1]$ and $0 < \rho_{0j} \le 1$.

The sizes of synthetic degree of grey incidence obtained, $\rho_{01},\rho_{02},\ldots,\rho_{0n}$ determine the degree in which each cause influence the firm. As the synthetic degree of grey incidence is higher, its corresponding cause is more important. We classify these causes depending on the calculated degree of grey incidence.

By identifying the most important causes that conducted to the achievement of performance or to the improvement of financial health, managers can act on them in their company's benefit.

3.4 Steps to classify causes

First of all, we must say that we consider necessary that in some of the research's stages to make use of some specialists' experience, so that, for the evaluation of the qualitative causes, the degree of subjectivity to be as low as possible.

So, first of all, we choose the specialists that will help us in research. On the next step, based on the specialists' experience and company's characteristics, we will identify the ratios that will help us in establishing the firm's performance and the qualitative and quantitative causes that conducted to it.

We shall mention that in some cases, in which the analysed company doesn't have a good performance, we will talk about its financial health, and the qualitative and quantitative causes that conducted to it, will be accordingly chosen.

For the quantitative causes and performance, the figures will be calculated using firm's financial statement. As for the qualitative causes, the specialists will give their opinion for each of the selected cause, as a number or as an interval between 0 and 1. For example, when an expert is sure about the level of a qualitative variable he will put the corresponding number and when he couldn't establish a cause's level, he will record in table an interval. When he doesn't know anything about the cause intensity level, he will simply record [0; 1]. All the opinions will be gathered in some tables, the number of tables been equal to the number of years taken into account for the analysis. From each table, using the fuzzy sub-sets theory we will construct an “experton”.

In the next part of our research, we will use the measures obtained for the firm’s performance and for the qualitative and quantitative causes to establish the most influencing causes. For that, we will apply the methods offered by grey systems’ theory. In the case of qualitative causes, where we deal with expertons, which are in fact expressed by intervals, we will make use of some fuzzy basic arithmetic on intervals.

Using the synthetic degree of grey incidence, calculated for, we will classify the causes, in order to decide which of them are the most influencing on company’s performance.

In the last step, knowing the classification, managers will choose the best ways to act on the causes in such a manner that will improve the company’s performance or its financial health.

Figure no. 1 summarise the steps presented above an illustrative numeric example can be found in the next section.

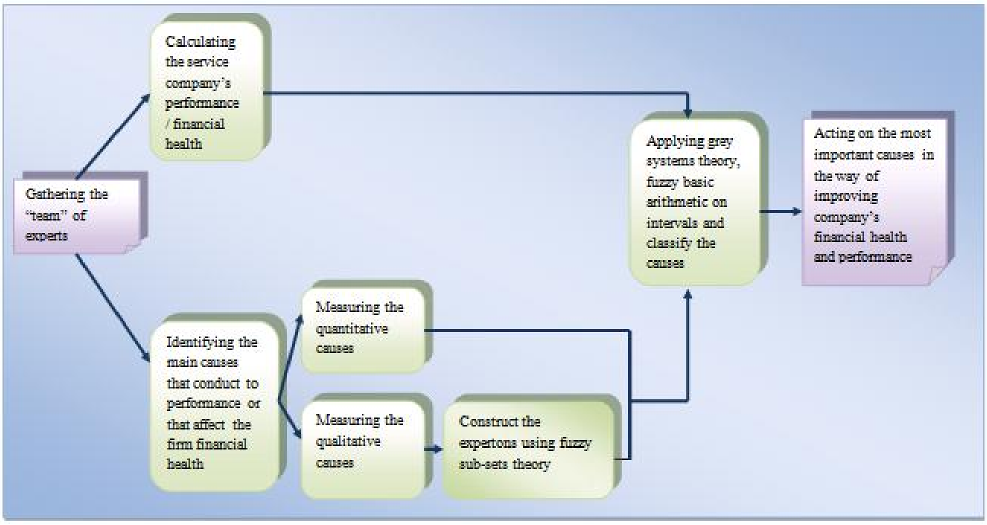

Figure no. 1 Steps to classify causes

4. AN ILLUSTRATIVE NUMERICAL EXAMPLE

We won’t discuss in this paragraph about the way we establish the set of causes that we use, because in many cases those causes are being identified by a group of experts.

In order to better understand the proposed model, we develop a numerical example below. We analyze a set of 8 causes (denoted X_1, X_2, ..., X_8), four of them quantitative causes and the other four qualitative causes as follows:

X_1: Labour force expressed through the number of employees
X_2: Sales volume
X_3: Fixed costs
X_4: Investments

X_5: Predominance of information transformations in all type of activities
X_6: Customers' influence on products
X_7: Efforts in improvement and innovation
X_8: Professionalism of the employees

As a performance indicator we used service revenue, noted X_0. For evaluating the qualitative causes, the number of experts was established at 7. The period of analysis was considered equal with 3 years.

For building-up the "expertons" we will use the opinions over the qualitative variable given by the experts. Those values are presented in Appendix 1.

The values obtained for each of the three expertons are listed below (Table no.1):

$$E_1 = ([0.2277;0.7702],[0.4135;0.5425],[0.4281;0.5425],[0.4707;0.5996])$$

$$E_2 = ([0.3993;0.5139],[0.5854;0.6282],[0.5571;0.5996],[0.571;0.6428])$$

$$E_3 = ([0.671;0.8424],[0.6712;0.757],[0.6856;0.7566],[0.6571;0.6854])$$

Table no. 1 Values of expertons

Experton 1	X5	X6	X7	X8
Inferior limit	0.2277	0.4135	0.4281	0.4707
Superior limit	0.7702	0.5713	0.5425	0.5996

Experton 2	X5	X6	X7	X8
Inferior limit	0.3993	0.5854	0.5571	0.571
Superior limit	0.5139	0.6282	0.5996	0.6428

Experton 3	X5	X6	X7	X8
Inferior limit	0.671	0.6712	0.6856	0.6571
Superior limit	0.8424	0.757	0.7566	0.6854

These values will be introduced in the equations described at 3.C.1, 3.C.2 and 3.C.3 in order to calculate the synthetic degree of incidence of each qualitative cause on firm's performance.

In the qualitative causes' case, we will use the values of expertons, which are intervals, and because of that, some fuzzy arithmetic related to those intervals is required (see [20]).

The values of quantitative and qualitative causes, together with the performance indicator are presented in Table no. 2.

Table no. 2 The values of quantitative and qualitative causes and performance indicator

Firm	X0	X1	X2	X3	X4	X5	X6	X7	X8
Year 1	17569	14	4311	7114	14795	[0.2277; 0.7702]	[0.4135; 0.5713]	[0.4281; 0.5425]	[0.4707; 0.5996]
Year 2	21493	9	5562	2027	2212	[0.3993; 0.5139]	[0.5854; 0.6282]	[0.5571; 0.5996]	[0.571; 0.6428]
Year 3	32711	11	7423	3719	10138	[0.671; 0.8424]	[0.6712; 0.757]	[0.6856; 0.7566]	[0.6571; 0.6854]

After computing, the results were listed in Table no. 3.

Table no. 3 The values of synthetic degree of incidence for each cause

ε0j	ε01	ε02	ε03	ε04	ε05	ε06	ε07	ε08
	0.500022	0.622113	0.500014	0.500009	0.500047	0.500038	0.500036	0.500034
r0j	r01	r02	r03	r04	r05	r06	r07	r08
	0.654458	0.998634	0.618598	0.615626	0.600717	0.630147	0.634713	0.640985
ρ0j	ρ01	ρ02	ρ03	ρ04	ρ05	ρ06	ρ07	ρ08
	0.57724	0.810374	0.559306	0.557818	0.550382	0.565093	0.567375	0.570511

From: $\rho_{02} > \rho_{01} > \rho_{08} > \rho_{07} > \rho_{06} > \rho_{03} > \rho_{04} > \rho_{05}$, it can be seen that: $X_2 \succ X_1 \succ X_8 \succ X_7 \succ X_6 \succ X_3 \succ X_4 \succ X_5$.

The most influencing factor is X_2, followed by X_1, X_8, ... , X_4, and the factor with the less influence on the financial performance of the analysed firm is X_5. This is equivalent to say that sales volume have the greatest effect on firm's performance, labour force (number of employees) have the second greatest effect, and the predominance of information transformations in all type of activities the smallest effect on the firm's performance.

As it can be seen, the quantitative and qualitative causes are been interposed. Among the qualitative causes, the professionalism of the employees, the efforts in improvement and innovation, and customers' influence on product seem to be the most influencing causes.

On the purpose of increasing the performance of the analysed firm, managers can try to find ways to act upon the most "important" causes.

5. REMARKS AND FUTURE WORK

Numerous scientific papers deal lately with the new approached problem of company's performance and financial health. Many theories have been developed since the research begun in this economic analysis field and their purposes are convergent: to find a way to establish the main causes that are affecting service firm's performance.

In classifying the firms' causes, a peculiar attention must be shown to the qualitative causes manifested by the firms under analysis and their quantification.

As we have seen in this article, the classification of causes is based on facilities offered by the grey systems theory, being designed to find a way of determining the rank to which individual cause affects the final status of a firm.

As for the qualitative causes, we combined the fuzzy sub-sets arithmetic with grey systems theory. Also, some "expertons" are being used, to the purpose of quantify them better.

The research can be extended to include facilities offered by other theories. Also, a soft procedure can be created for aggregate easier the qualitative causes and for the construction of expertons. Using some new methods, like case based reasoning, to this procedure we can attribute the ability to learn from past experiences.

In order to bring future improvements to the proposed model, we intend to consider into analysis several issues, such as: the way of choosing the ratios, the weight of every ratio, and the absence of some figures for a specific period of time; all of them deserving further investigations and explorations.

ACKNOWLEDGEMENTS

This paper is a part of our results obtained within the research grant : (1) PNII – IDEI 810/2008 -"The Development of Theoretical Fundaments of Knowledge Ecosystems and Their Applications on Economy and Healthcare", funded by CNCSIS-UEFISCSU and (2) project POSDRU/6/1.5/S/11, "Doctoral Program and PhD Students in the educational research and innovation triangle", funded by European Structural Founds, coordinated by The Bucharest University of Economics.

Appendix 1:

Expert 1	X5	X6	X7	X8
Year 1	[0.2; 0,3]	0.5	[0.3; 0.6]	0.6
Year 2	0.4	0.6	0.6	[0.6; 0.7]
Year 3	[0.6; 0.8]	[0.6; 0.7]	0.6	0.7

Expert 2	X5	X6	X7	X8
Year 1	[0; 1]	[0.4; 0.5]	0.6	0.6
Year 2	[0.2; 0.4]	0.5	[0.6; 0.7]	[0.5; 0.6]
Year 3	[0.7; 0.9]	0.7	[0.7; 0.8]	0.6

Expert 3	X5	X6	X7	X8
Year 1	0.2	[0.2; 0.6]	0.4	[0.2; 0.8]
Year 2	[0.3;0.5]	0.6	[0.5; 0.6]	[0.4; 0.6]
Year 3	0.8	[0.7; 0.8]	0.7	0.7

Expert 4	X5	X6	X7	X8
Year 1	0.4	[0.3; 0.7]	[0.3; 0.7]	0.6
Year 2	[0.4; 0.5]	[0.5; 0.7]	0.6	0.7
Year 3	[0.5; 1]	0.7	[0.6; 0.8]	0.7

Expert 5	X5	X6	X7	X8
Year 1	0.5	[0.4; 0.6]	0.5	0.5
Year 2	0.5	0.6	[0.5; 0.6]	0.6
Year 3	0.7	[0.6;0.8]	0.8	[0.6; 0.7]

Expert 6	X5	X6	X7	X8
Year 1	[0.3; 0.6]	0.6	0.4	0.6
Year 2	0.6	[0.6; 0.7]	0.5	[0.5; 0.6]
Year 3	0.9	0.7	[0.6; 0.8]	0.6

Expert 7	X5	X6	X7	X8
Year 1	[0; 1]	0.5	[0.5;0.6]	0.5
Year 2	[0.4; 0.7]	0.7	0.6	0.7
Year 3	[0.5; 0.8]	[0.7; 0.9]	0.8	[0.7; 0.8]

REFERENCES

1. Altman, E. I. — Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy, The Journal of Finance 23 (4), 589-609, 1968.
2. Altman, E. I. Halderman, R.G., Narayanan, P. — ZETA Analysis: A New Model to Identify Bankruptcy Risk of Corporations, Journal of Banking and Finance 1(1), 29-51, 1977.
3. Balcaen, S. Ooghe, H. — 35 Years of Studies on Business Failure: An Overview of the Classic Statistical Methodologies and their Related Problems, The British Accounting Review 38, 63-93, 2006.
4. Beaver, W. H. — Financial Ratios Predictors of Failure. Empirical Research in Accounting: Selected Studies 1966, Journal of Accounting Research 4 (Suppl.), 71–111, 1967.

5. Chen, H.J. Huang, S.Y. Lin, C.S — Alternative Diagnosis of Corporate Bankruptcy: A Neuro Fuzzy Approach, Expert Systems with Applications, no 36, Elsevier, 7710-7720, 2009.
6. Deakin, E. — A Discriminant Analysis of Predictions of Business Failure, Journal of Accounting Research 10 (1), 167-179, 1972.
7. Delcea, C. Scarlat E. — The Diagnosis of Firm's "Diseases" Using the Grey Systems Theory Methods, IEEE GSIS, pp. 755-762, Nanjing, China, 2009.
8. Edminster, R. — An Empirical Test of Financial Ratio Analysis for Small Business Failure Prediction, Journal of Financial and Quantitative analysis, 1477-1493, 1972.
9. Fitz Patrick, P.J. — A Comparison of Ratios of Successful Industrial Enterprises with Those of Failed Firms, Certified Public Accountant, October/November/December, pp. 598-605, 656-62 and 727-31, 1932.
10. Gil-Lafuente, A.M. — Fuzzy Logic in Financial Analysi, Springer-Verlang Berlin Heidelberg, 2005.
11. Lica, L. — Mobile and Social: Ten Best Practices for Designing Mobile Applications, Informatica Economica Journal 14, no. 3/2010, pp. 60-74, 2010.
12. Mărăcine, V. Delcea, C. — How We Can Diagnose the Firm's Diseases Using Grey Systems Theory, Economic Computation and Economic Cybernetics Studies and Research, no 3, 2009.
13. Mervin, C.L. — Financing Small Corporations in Five Manufacturing Industries, 1926-1936, National Bureau of Economic Research, 1942.
14. Moses, D. Liao, S.S. — On Developing Models for Failure Prediction, Journal of Commercial Bank Lending 69, 27-38, 1987.
15. Myer, P.A. Pifer, H.W. — Prediction of Bank Failure, Journal of Finance, 4, 853–868, 1970.
16. Ohlson, J.A. — Financial Ratios and the Probabilistic Prediction of Bankruptcy, Journal of Accounting Research, 18(1), 109–131, 1980.
17. Siegel, P.H. Korvin, A.D. Omer, K. — Application of Fuzzy Sets and the Theory of Evidence to Accounting, Jai Press Inc, 1995.
18. Sifeng, L. Lin, Y. — Grey Information. Theory and Practical Applications, Springer-Verlag London Ltd., London, 2005.
19. Taffler, R.J. — Forecasting Company Failure in the UK Using Discriminant Analysis and Financial Ratio Data, Journal of the Royal Statistical Society 145, 342-358 (part 3), 1982.
20. Tamari, M. — Financial Ratios as a Means of Forecasting Bankruptcy, Management International Review 4, 15-21, 1966.
21. Winakor, A., Smith, R.F. — Changes in Financial Structure of Unsuccessful Industrial Companies", Bureau of Business Research, Bulletin No 51, 1935.
22. Zadeh, L.A. — Fuzzy Sets, Information and Control, 9, 338-353, 1965.
23. Zmijewski, M.E. — Methodological Iissues Related to the Estimation of Financial Distress Prediction Models, Journal of Accounting Research, 22, 59-80, 1984.