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Simulation of Causal Relations of Stakeholder Management System by Using Fuzzy Cognitive Map Approach – a Comparison of Hungarian and Lithuanian Attitudes

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Abstract

Stakeholder Relationship Management Systems (SRMS) describe the general behavior of stakeholder relations at organizations. Knowing the interactions between the drivers of the SRMS helps to improve the efficiency of the whole system. This paper investigates the applicability of Fuzzy Cognitive Maps (FCM) to simulate the system dynamics and the causal connections within it. Previous investigations showed that FCM is a proper tool to analyze these relations and with the help of that the business management process and decision making in projects can be supported. The aim of this paper is to present the results of current simulations made with the help of FCM at Lithuanian and Hungarian organizations and to explain the causes of the identified differences. Beside that the paper investigates the influences of the modification of the threshold function’s parameter on the final factor states.

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Keywords: Stakeholder Relationship Management System; Fuzzy Cognitive Maps, Corporate Social Responsibility, threshold function

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1. Introduction

Stakeholders are actors who influence the operation of various economic actors in various ways. Not only organizations have their own stakeholders but also projects, programs or different activities are affected. Stakeholders are interested in the operation, the decisions and general attitude of the actor. Stakeholders are interested parties of an organization whether intern or extern. Different categories of stakeholders can be identified such as e.g. professional associations, other companies, shareholders, authorities and customers, of course. In this paper authors are investigating the applicability of Fuzzy Cognitive Maps to simulate the causal interconnections within the SRMS.

In the first part of the paper information’s are given about the research hypothesis and the commonly used techniques of the stakeholder analysis. After introduction into the theory of FCM’s the applied methodology of the research is highlighted. The results of the simulation is analyzed in the similarities and differences of the two analyzed countries. The paper is closed with the analysis of the parameter dependence of the values on the threshold function and with the list of future research topics.

2. Research hypothesis

The interests and the attitudes of stakeholders can differ from each other significantly. In that way stakeholders can play determinative role in the success of the organization. Every organizations has to set up a positive and effective relationship with the interested parties. This can be supported by Stakeholder Relationship Management System. SRMS can contribute that way to the successful operation of an organization or to an effective completion of a project. The first and essential step of the management of stakeholder related issues is to identify the stakeholders and group of them by definite parameters. Company success and long-term sustainability of an organization can be supported by a well-founded SRMS. Fig. 1. shows a simplified operating scheme of the relations among organization and stakeholders. The connection between stakeholders and organization is bi-directional. At first, stakeholders require information about the operation. In the interest of this they are communicating and cooperating with each other. The other hand they generate influence on the operation of the organization. They can also form the circumstances of the operation. Deeper knowledge of the relations and their causes contribute to the establishment of an effective SRMS. To get a brighter picture there is a need of deeper assessing the stakeholder structure of an organization. Beside the identification of the stakeholders the priority ranking of them is also essential. Choosing and managing the most significant ones improves the operational efficiency the management issues.

2.1. Corporate Social Responsibility and SRMS

During recent years, corporate social responsibility (CSR) has gained increasing attention and critical consideration for businesses and academics alike and many companies consider CSR as an important corporate strategy for achieving a competitive advantage. The number of articles in academic and business journals increases where it is agreed that if companies cause (are a source of) problems to different stakeholders and environment, they must contribute to solving or offsetting them.

In response to numerous demands for corporations to play a more active role in the overall welfare of society,
many businesses have paid considerable attention to the social impact of their economic activities in recent years\textsuperscript{12,13}. Sustainability and corporate social responsibility (CSR) can be treated as a commitment on the part of companies to deal with the wider social impacts of their activities which means that business take into account different stakeholder interests in managing organizations. Therefore, stakeholder politics and their relationship management become very important in dealing with the issues and there is a need to measure relevant processes in an organization as to manage them.

At the top level there is a need to concentrate at the key indicators and to relate them to the evidences of stakeholder satisfaction in creating the value for all stakeholders. Usually the organization’s goal should be threefold: economic, legal and societal.

Thus a company should not only concentrate on economic goal (create value for shareholders) but include other stakeholders in value creation for them as value creation for shareholders focuses on profitability, pushing responsibility to other stakeholders in the background also of lower status. But organization is not an instrument for owners it has responsibilities for other stakeholders as well. Emphasizing not only profitability, but also the responsibility we expand the role of an organization therefore the creation of value for other stakeholders becomes important. Here emerges the view that the organization must serve various stakeholders or their groups.

2.2. Commonly used analyzing-techniques of SRMS

Inquiry techniques, checklist-surveys, brainstorming workshops are the most common methods to get accurate level of information about the stakeholders and about the organizational issues regarding management processes in the organization. These techniques are mostly suitable for outlining the stakeholder structure only in a static way. With the help of them company-experts are not able to analyse the system dynamics and the interconnections between the main system drivers.

Current research aims to develop a novel methodology where the dynamic modelling of the stakeholder system can be achieved. With the help of a methodology, which gives information’s about the causal interconnections between the driver elements and weights of these connections the SRMS can be better understood.

In this paper the applicability of the Fuzzy Cognitive Map approach was studied for this simulation purpose. Authors used data obtained from experts on identifying factors of the SRMS for the research.

3. Short introduction to Fuzzy Cognitive Maps

FCMs were first introduced by Kosko\textsuperscript{14} in 1986, but this field is still intensively researched\textsuperscript{15}. The method is able to analyze or simulate the behavior of complex systems\textsuperscript{16,17}. FCM can be considered as an artificial neural network represented by a signed fuzzy graphs.
The nodes of the graph represent the identified, important components of a particular system. These components are often referred to as factors or concepts. The edges are responsible to represent the strengths and directions of connections between concepts, as you can see it in Fig. 2. The concepts will be denoted by \( C_i \), while the weights of connections between them by \( w_{ij} \), where \( i, j \) \( \in \) \( 1 ... N \), and \( N \) is the number of concepts. \( w = 1.0 \) denotes the strongest (causal) connection in a supportive sense while \( w = -1.0 \) the same for opposing connections, and \( w = 0 \) means that no connection exists between the affected concepts. With other words, the weights (or membership values) have to be in the \([-1; 1]\) interval. The connections may be represented also numerically using a connection matrix. The elements of the main diagonal have to be zeros because by definition the factors do not affect themselves (self-effect would lead to instability of the FCM because of excitation; in some other applications self-loops are necessary, however. See e.g. \( 1^8 \)). If the static connection matrix and the initial states of concepts are given, the operation of the investigated system can be simulated using the appropriate equations. The intensity of concepts are also represented by a membership degree. The value of concept states are always in the \([0; 1]\) interval. The subsequent states (discrete time steps) of concepts can be calculated from the previous states of the factors with the connection matrix using equation (1).

\[
V_{k+1} = f(N \cdot V_k)
\]  

(1)

In (1) concept states in step \( k \) are denoted by \( V_k \), the connection matrix is \( N \) and \( f \) is the so called threshold or transition function. One of the most frequently used threshold functions (and the one used by the authors in this paper) is the following (2):

\[
f(x) = \frac{1}{1 + e^{-\lambda x}}
\]  

(2)

The threshold function keeps concept values inside the allowed interval. The value of \( \lambda \) have to be greater than zero. The \( \lambda \) value defines the gradient of the function (see Fig. 3), thus it heavily affects the final values of the concepts, but not their respective order.
4. Methodology used for the investigation

The two main steps of the stakeholder analysis are: (a) to identify the stakeholders; (b) to analyze the relationship with them. For the first step mainly different management techniques (e.g.: brainstorming of the experts) are used. The second step is the more important for this investigation. Decision makers use commonly different matrix approaches for identify the relations between the stakeholders. Two different dimensions, namely the degree of involvement of the stakeholder (from low to high) or their type of influence (opposing or supporting) are analyzed in this stage.

The before mentioned analysis gives a static picture about the stakeholder environment of an organization and enables the definition of suitable management strategies. There is a lack of knowledge about the dynamic changes of the actors’ attitudes because this analysis gives a picture only for a definite time moment. To establish well-founded and adequate strategies the dynamic interconnections of the system are also required. The commonly used methods hide these casual correspondences and its cross cutting connections.

The classic representation of stakeholder groups with different attitudes is showed in Fig. 4. There are four main categories clearly separated. The separation of different categories eases the development of management strategies. Letters from A to J are representing hypothetic stakeholders of an organization.

The main goal of the stakeholder management is to manage the actors in such a way that the stakeholders with great influence should be cooperative (upper right section of Fig. 4.).

The causal relations between the stakeholders and the characteristics of this connection matrix are not in the focus of the currently used methods.

To understand the logic of a stakeholder system better decision makers have to identify the main driving elements of such a system and to deal with the interactive connections between these main driving elements and also with the whole system dynamics. For that purpose a novel analysing method is needed.

The aim of the research presented in this paper is to investigate the applicability of fuzzy logic approach and especially the FCM as a novel approach to model the interconnections between the main criteria of the. In the course of this the priority of the elements will be also analyzed and stated to support management decisions. The FCM is an ideal tool for modelling multi-discipline systems, especially in that case when they incorporate ‘soft’ parameters as human factors, environmental characteristics or social relations. FCM method can help to investigate the causal relationships and the weights of these relations between the defined factors (in this case: the criterion defined regarding the SRMS). Another important issue is to identify the stable position of the system which describes the ideal combination of the weights of the driving factors.

The research was realized in the following steps: (1) at first the main driving forces of a SRMS were defined. These drivers have the most determinative influence on the efficiency of a SRMS and so they are subject of the management investigations; (2) as a second step the possible causality and the weights of the connections were identified; (3) thirdly the simulations were realized and the stable point of the system was defined.

The driving forces (in the FCM so called “concepts”) compose the baseline for the model. The drivers compose nodes. The interconnections of the drivers and their causality will be measured and modelled at these nodes by FCM. The appropriate definition of these nodes is elementary for the proper working.
The above mentioned indicators were chosen according to existing attitudes in academic literature and accordingly these attitudes/indicators were grouped into concepts identified by the authors. The monitoring of adapted criteria and indicators allows diagnosing and undertaking corrective actions in organizational operations and constitutes prerequisites for value creation to stakeholders in the organization’s management.

The second step of the research dealt with identifying the possible causal relations between the nodes and beside that the weights of these connections. Input information for this step was gathered by interviewing company and scientific experts in Hungary and in Lithuania. The interviewed experts were representatives of the private sector (e.g.: machine manufacturing, service sector and governmental sector) and researchers of this field. Authors chose this information collecting method because practitioners have the greatest knowledge about the dynamic of a stakeholder management system. The interviews were realized by a definite method, which was worked out in advance. Information categories were defined as follows (X; Y and Z defines one of the above mentioned main categories):

- how significant is a node in the SRMS;
- which effects can change the present (stable) situation and which are their main driving factors;

Authors of this paper defined 10 main categories which have outstanding influence on the SRMS. These 10 categories are:

1. **C1: Importance of the stakeholder management**: describes how important it is to deal with stakeholder issues in the organization.
2. **C2: Allocation of resources**: the resources which are available to deal with stakeholder issues.
3. **C3: Involvement of employees**: the involvement of employees into the main decisions and the readiness to keep relationship with employees.
4. **C4: Organization culture**: the general culture within the organization to understand and satisfy the needs of persons.
5. **C5: Internal regulations**: the availability of internal regulatory instruments to standardize the management of stakeholder issues.
6. **C6: Organizational strategy, policy**: the integration of stakeholder needs into the main company strategy.
7. **C7: Internal expectations**: expectations of internal parties to deal effectively with stakeholder issues.
8. **C8: External expectations**: expectations of external parties to deal effectively with stakeholder issues.
9. **C9: External regulatory instruments**: official regulations which specify the expected actions.
10. **C10: Activity of internal stakeholder parties**: which describes the weight and activeness of the internal stakeholders.

These main driving factors were identified by using opinions of company practitioners and by thorough analysis of academic literature concepts. They will generate the premises for satisfaction of stakeholder needs and can precondition the validity and reliability of assessment of organizational processes and activity in the aspect of stakeholder satisfaction and reveal strengths and weaknesses of these processes.
• how big is the size and way of the effect which concept X has on concept Y;
• which processes and changes are affecting X;
• identification of the direction and nature of changes by X when Y changes; the effect of this changes on Z;
• correspondence between the changes of X and Y;
• causal relationship between the categories and the nature of the connection;

The strengths of the causal connections was indicated a value between -10 and + 10. According to the research theory and practice, representativeness, reliability and validity of the measuring instrument should be checked. Representativeness was revealed by research sample from which the aggregate was discussed. Additionally for checking reliability the relationship of identified concepts, the pilot concept was examined because this concept is of general nature and correlates with the rest ones.

The results of the investigation were summarized in a matrix which describes the main connections of the analyzed SRMS. Data from the matrix was used as one input data for the FCM-model. Hungarian and Lithuanian results of the investigation differ from each other significantly. This difference influences the later simulation results made by using FCM also.

All of the Hungarian and Lithuanian results were averaged and can be seen in Table 1 and Table 2 (values are varying between [-10; 10]). The FCM model of the SRMS was set up for the 10 main factors by using this information.

5. Results of the FCM-simulation

Authors used for the first model a fix connection matrix which was mentioned above (see Table 1 and Table 2). Initial weighting of the factors among each other was an other input for the model (see in the second column of Table 1 and Table 2).

Authors defined two planned outcomes of the simulation: (1) identifying the causal relationship of the concepts over time; (2) identifying the stable state of the model. Both outcomes are essential important for the goodness of the model. Identification of the stable state is very determinative because it represents the priority ranking of the main driving factors of the SRMS and the priority list of the drivers outlines the main strategy elements of the management actions. Authors identified on the basis of FCM simulation the driving factors which can influence mostly the efficiency of the SRMS. A priority list for Hungarian and Lithuanian circumstances was defined. Table 3 shows the order of the concepts (with \( \lambda = 1 \); starting with the most determinative one and ending with the least important one) for the Hungarian circumstances and Table 4 for the Lithuanian ones.

Results for Hungarian and for Lithuanian simulation values differ significantly from each other. While the three most important factors for Hungarian situation are the ‘Allocation of resources’ (C2); the ‘Involvement of employee’ (C3) and the ‘Internal regulations’ (C5), the Lithuanian Top3 are as follows: ‘Organizational strategy, policy’ (C6); the ‘Organizational culture’ (C4) and the ‘Involvement of employee’ (C3). Only one identical element can be seen in the list of the first three concepts, which is the ‘Involvement of employees’.

By using the results of the simulation (the ranking of the factors) a comprehensive strategy for SRMS can be synthesized and also a logical framework of such a system can be highlighted. Further investigations of the topic can lead to better understanding of operational logic of SRMS.

5.1. Understanding difference between Hungarian and Lithuanian results

In order to get a broader understanding of our obtained results we analyse them comparing to survey conducted by TNS Political & Social in 2013 at the request of the European Commission and to earlier surveys.

The overall tendency found by the TNS survey was that just over half of European citizens believe that companies have a positive influence on society, while more than 4 out of 10 believe companies have a negative influence. Europeans are more sceptical about the influence of companies than citizens from other major economies. The survey illustrated that most Europeans do not feel informed about what companies are doing to behave in a responsible way towards society and the proportion who feel informed varies dramatically across EU countries. Denmark is at the top where the respondents are the most likely to say they feel informed in this area (67%), and the countries with the lowest ranking were Spain 23%, Latvia and France 29%20. Regarding our research and
comparison of Lithuanian and Hungarian companies, in this survey authors find some differences in treating CSR issues that could affect the obtained results.

Within the EU, respondents living Lithuania (50%) are more likely than the EU average to think that companies now pay more attention to their influence on society compared to 10 years ago. In a sharp contrast only 15% of Slovenian, 23% of Hungarian and 29% of Czech respondents think this way. In fact an absolute majority of respondents in Slovenia (64%), Hungary (57%), Croatia (56%) and Romania (51%) think that companies pay less attention to their influence on society compared to 10 years ago.

Respondents living in Finland (83%), Portugal (82%), Ireland and Austria (both 81%) are the most likely to say that small and medium sized companies make efforts to behave responsibly towards society. At the other end of the scale Slovakian and Hungarian respondents are the least likely to say this (both 56%) - although in both cases small and medium companies are thought more likely than large companies to behave this way.

At least one quarter of Finnish (28%) and Hungarian (26%) respondents say that their company has taken measures to behave responsibly towards society but they do not think the measures are effective. By comparison, 12% of German and 13% of Austrian respondents say the same. Across the EU respondents, in Slovenia, Latvia, Poland and Lithuania are the most likely to say that their company hasn't taken any measures to behave in a responsible way towards society (all 16%), compared to 3% of UK and 5% of Swedish respondents.

In order to get a wider understanding and tendencies in understanding the importance of CSR practices in Lithuania and Hungary, we analysed survey "What Does Business Think about Corporate Social Responsibility?" (2005) supported by European commission. Here are some findings:

- 50 percent of Lithuanian respondents think that companies pay more attention to their influence on society whereas 57 percent of respondents in Hungary think that this attention decreased compared to ten years ago.
- 56 percent of Hungarian respondents are least likely to say that small and medium companies make efforts to behave responsibly, beside that 26 percent of Hungarian respondents say that the measures of social responsibility taken by their company are not effective.
- 16 percent of Lithuanian respondents say that their companies haven’t taken any measures at all to behave responsibly.
- In Lithuania social responsibility activities are linked to complying with ethical conduct, and transparency in operations whereas in Hungary - with existing regulations.
- In Lithuania approximately one third of respondents believe addressing stakeholders’ concerns are socially responsible activities. In Hungary this segment is bigger and reaches fifty percent.
- Lithuanian companies believe that the most important role of a company in society is paying taxes whereas for Hungarian companies it is making profit.
- Minority of respondents (respectively 9 and 3 percent) think that there are no internal benefits to be derived from the adoption of CSR practices.
- Respondents of both countries list the greatest external benefit deriving from CSR practices is improved image and reputation. The vast majority of both countries believe that sharing information, discussing, collaborating and negotiating with different stakeholders would make their CSR practices more relevant.

### Table 3. Ranking of the concepts on the basis of model results (Hungarian values)

<table>
<thead>
<tr>
<th>Ranking Hungarian values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>0.9956</td>
</tr>
<tr>
<td>C3</td>
<td>0.9944</td>
</tr>
<tr>
<td>C5</td>
<td>0.9937</td>
</tr>
<tr>
<td>C1</td>
<td>0.9893</td>
</tr>
<tr>
<td>C4</td>
<td>0.9870</td>
</tr>
<tr>
<td>C6</td>
<td>0.9794</td>
</tr>
<tr>
<td>C10</td>
<td>0.9777</td>
</tr>
<tr>
<td>C7</td>
<td>0.9585</td>
</tr>
<tr>
<td>C8</td>
<td>0.9162</td>
</tr>
<tr>
<td>C9</td>
<td>0.6784</td>
</tr>
</tbody>
</table>

### Table 4. Ranking of the concepts on the basis of model results (Lithuanian values)

<table>
<thead>
<tr>
<th>Ranking Lithuanian values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C6</td>
<td>0.9983</td>
</tr>
<tr>
<td>C4</td>
<td>0.9972</td>
</tr>
<tr>
<td>C3</td>
<td>0.9981</td>
</tr>
<tr>
<td>C5</td>
<td>0.9981</td>
</tr>
<tr>
<td>C7</td>
<td>0.9977</td>
</tr>
<tr>
<td>C1</td>
<td>0.9993</td>
</tr>
<tr>
<td>C9</td>
<td>0.9673</td>
</tr>
<tr>
<td>C8</td>
<td>0.9907</td>
</tr>
<tr>
<td>C2</td>
<td>0.9937</td>
</tr>
<tr>
<td>C10</td>
<td>0.9953</td>
</tr>
</tbody>
</table>
Linking this survey with our research we can state that Lithuanian respondents are more optimistic about companies’ social responsibility practices and its effectiveness. In Lithuania the respondents link social responsibility activities more with soft and voluntary measures such as ethical conduct, whereas in Hungary it is related with existing regulations where voluntarism is low. Addressing stakeholder concerns is considered as social responsible activities by respondents in both countries; only the percentage in Hungary is higher (50 percent I Hungary, 30 percent in Lithuania). Respondents of both countries believe that the most important role of a company in a society is economical responsibility (Lithuania-paying taxes, Hungary – making profit) and that companies get internal benefits from social responsible activities. Improved image and reputation was listed as the greatest external benefit deriving from CSR practices in both countries. This benefit should be treated with some carefulness as it can mean that the involvement in CSR practices by the companies is more of declarative character.

This survey results reveal certain correlation points with our research. Lithuanian respondents believe in more soft measures (strategy, culture, involvement of employees) whereas Hungarian ones - in hard measures such as allocation of resources and internal regulations. Our research also reveals the same trend with the survey conducted by TNS concerning stakeholder management, i.e. in conducted surveys importance of stakeholder management issues are higher by Hungarian respondents than by Lithuanian one (respectively ranking 4 and 6). In our research external benefit can be treated as internal expectations and there the results are quite different as compared to TNS survey. Our research showed that internal expectations are not ranked very high (Lithuania ranking 5, Hungary -8) and we can assume from our research that there are other important issues than improved image and reputation for companies. This can be explained due to limitations of our research. More simulations with more datasets should be performed for getting more accurate results.

Another limitation of this research is the inconsistency in methodology and research design in the studies that are compared when analysing the results of two countries. A third limitation concerns the interpretation of information provided by respondents. When the measure is used to measure the perception of employees within one organization, special care should be taken in interpreting the results. Future research could expand the present analysis in several directions and provide additional evidence by increasing the number of reports and the quality of information in order to expand the sample size and enrich the dataset.

6. Studying the dependence of final concept values on the parameter of the threshold function
The early simulation results of SRMS were in several cases hardly interpretable, because the values of concepts in the last simulation step were almost the same. Several empirical attempts were made earlier to find an appropriate value for $\lambda$, but the more thorough definition and analysis of this parameter was lacking until now. Because the same method was applied for Hungarian and Lithuanian data, only the details of Lithuanian results are presented here as illustration. Concept values can be easier differentiated if the spread of them is as wide as possible. The authors borrowed the standard deviation function from statistics in order to quantify the spread of concept values. Fig. 5 shows that using different $\lambda$ values different final concept values can be achieved. The standard deviation of concepts calculated with different $\lambda$ values is depicted in Fig. 6. The maximum of the standard deviation is 0.044 at $\lambda = 0.359$. This is still a very low value, but it is 4.8 times higher than in the previous one achieved by using $\lambda = 1$, and it makes the interpretation of results much easier. This result was calculated numerically using the Golden Section Search algorithm. This is a well-known and rather simple member of the family of line search methods. The concept values calculated with the optimal $\lambda$ parameter are listed in Table 5. The presented method makes possible to achieve the most easily interpretable simulation results at the cost of executing a computationally inexpensive local search algorithm.

7. Topics of future research

The results presented in this paper show the applicability of FCM to simulate the behaviour of SRMS. The presented analysing approach gives a novel opportunity to understand the internal logic and causal interconnections of the stakeholder management. Further research is planned in the following fields:

- more detailed analysis of the differences between Hungarian and Lithuanian results;
- extension of expert based input data for the simulation, using questionnaire;
- refining the model with identifying sub-categories for each main driving factor;
- analyzing the changes of causal connections in time.

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