FUZZY EXPERT SYSTEM FOR EVALUATING THE FLEXIBILITY OF AN ORGANISATION – THEORETICAL FOUNDATIONS AND FIELD STUDY RESEARCH

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ABSTRACT

In an unpredictable environment, flexibility can represent the core competence of an organisation. While it provides the conditions which guarantee a successful performance and long-term existence on the market, it also requires more resources and increases the level of risk. It is therefore of fundamental importance for an organisation to evaluate its own level of flexibility as a basis for formulating its business policy. Since an evaluation of this kind typically involves a high level of uncertainty, grading subjectivity and a poor structure of individual indicators, the fuzzy expert system is proposed and developed. In the first part of this paper some reasons for development of the expert system are explained, mostly from strategic management perspective. Further, a conception of the flexibility is discussed and then the fuzzy expert system is presented. At the end of the paper the system is evaluated in the field study research.

Keywords: flexibility, strategic management, expert systems, fuzzy logic

INTRODUCTION

In order to keep pace with technological changes, global competition and the development of the "knowledge economy", organisations ought to abandon traditional and rigid structures, which were designed to meet the needs of routine transactions and activities. The typical companies of the post-industrial society or the society of knowledge, conduct their affairs in specific environments, where they are exposed to constant changes which can alter business rules drastically. These environments are characterised by frequent innovations concerning products and technologies, a relatively steep curve of experience, an unstable market structure and unpredictable changes. In 1938, the economist Shackle (1) defined these changes as "kaleidoscopic": seemingly small, insignificant alterations can dramatically change the whole context of a certain industry or some of its fields. These are subject to Schumpeter's criterion of creative destruction: at its core, each favourable marketing structure (eg. a monopoly) carries a seed of its own destruction in terms of encouraging economic entities to attack the current order of things and establish new rules of the game (3).

The process of dynamic changes influences the level of uncertainty in the environment. Unstable surroundings limits the ability of an organisation for long-term and mid-term planning. Hence management cannot focus on just one of the possible varieties of future development to optimise the functioning of the organisation. Subsequently, the inability to foresee the future renders the notion of organisational flexibility critical for understanding the idea of core competences or core capabilities. The organisation's management question passes from "What do we need to do

in the future?" to "How should we develop and organise the resources and capabilities of our organisation in order to respond successfully to unexpected situations?" (13).

This article features a fuzzy expert system, which is intended as a tool of support for the management to evaluate and analyse the existing flexibility in an organisation, as well as to assess the potential impact of adopted measures to change it. Our expert system is based on the supposition that the real system of the organisation and its environment is so complex that it aggravates the generalisation and identification of the laws of organisational functioning. Therefore, an organisation needs to be simplified and turned into a system, which comprises only carefully selected components of the organisation (with regard to the studied aspect), including the relations among these components.

The second part of the article provides various definitions of organisational flexibility and describes the main characteristics of the model, which in turn serves as theoretical foundation for establishing the knowledge base of our fuzzy expert system. Then we proceed to a short description of the basic characteristics of the developed expert system. At the end we touch upon a practical example of system evaluation in two different Slovene companies, and summarise some principal findings regarding the advantages and weaknesses of the system.

ORGANISATIONAL FLEXIBILITY

The concept of organisational flexibility has no unitary definition. That is why various definitions by different authors are presented before we move on to describe the actual system for evaluating the flexibility of an organisation.

Volberda and Rutges (13) define organisational flexibility as a multitude of all the present and potential capabilities of its management and the level of speed by which these capabilities can be activated to improve control and influence over the organisation. Efficient use of these capabilities depends on general conditions in an organisation which include the technology, structure and organisational culture.

An even broader definition is introduced by Bahrami (1). He discusses organisational flexibility from two aspects: "offensive" and "defensive." The first one is about *agility*, ie. the ability of an organisation to change the direction of its own development quickly in order to make use of an emerging opportunity or to avoid a new threat. This ability is critical for success in time-based competition. Further, this aspect comprises the notion of *versatility*, ie. the competence to carry out different things and trigger different sources and capabilities, depending on the demands of a particular situation. The defensive aspect, however, is concerned with *the ability of an organisation to survive* despite an unexpected and unfavourable change in its (internal or external) environment. This quality is related to the concepts of "toughness" and "suppleness." The first of the two denotes the capability of an organisation to absorb a punch and to stand up against the disturbance (eg. by using extra finances). The latter stands for the ability of an organisation to survive an outside disturbance without suffering negative long-term consequences. Bahrami (1) also sees the strategic flexibility as an ability to do things in a different way or to do different things when the developments in the outside environment of the organisation require so.

A more global and simplified definition comes from Aaker in Mascarenhas (10). In their view, the strategic flexibility is an organisation's ability to adjust to considerable, unexpected, fast changes in its environment that have an important influence on its success. For the needs of this research, a new definition has been formulated in order to meaningfully interlink all the definitions described above: »*Organisational flexibility is the organisation's ability of producing a suitable and timely response to unexpected inside and outside changes which represent either an opportunity or a threat.*«

Since a higher level of organisational flexibility usually means more expenses, a burning question emerges: In which specific area (culture, structure, systems, manufacturing, marketing, R&D etc.) should the organisation increase its level of flexibility (11)? Certain authors, such as Wheelen and Hunger (14), label this phenomenon as a paradox of strategic management. On the one hand, a successful organisation requires effectiveness and internal stability (however, such an organisation might become passive and unprepared for radical changes in its environment). On the other hand, the organisation must stay flexible enough to introduce changes rapidly when faced with new challenges or threats from its environment (when this does not allow for a certain degree of effectiveness, the very survival of the organisation could be threatened). It is therefore a fact that there are constant internal tensions between striving for control and the aspiration for autonomy within every organisation.

Possibilities for increasing the flexibility of an organisation are numerous. But before a decision about introducing certain measures is made, it is only rational to evaluate how flexible the organisation is in its present state. Unfortunately, not many managers have the necessary knowledge and skill to do so. A well-developed expert system hence offers suitable domain knowledge which can results in more efficient and successful work.

For this purpose we need suitable criteria and indicators that would embrace different subsystems of an organisation. Consequently, we have developed an integral model, which takes into account three time dimensions (long-term, mid-term and short-term) and three main aspects of management: orderliness, programmes and assets.
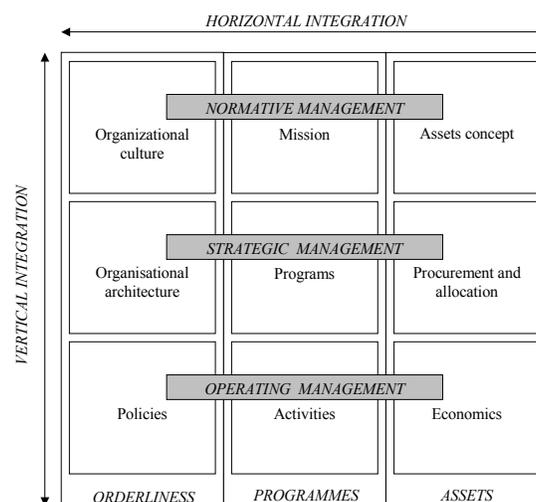

Figure 1: Integral management model

FUZZY EXPERT SYSTEM FOR EVALUATING FLEXIBILITY OF AN ORGANISATION

Fuzzy logic and flexibility evaluation

Managers perceive the flexibility assessment process as involving a high degree of uncertainty and ambiguity. Also, different researchers point out that this kind of process is subject to fuzziness, imprecise measures and uncertainty about which factors affect the flexibility of an organization. But we know from different articles and textbooks that one principal factor leading to managerial dissatisfaction with computer supported expert systems is the inability of these systems to deal with uncertainty. The problem now is how to overcome these weaknesses. Fuzzy logic is a technique designed to cope with this kind of problems or, to be more exact, to cope with imprecise linguistic concepts or fuzzy terms (15). Fuzzy logic allows users to provide inputs in imprecise terms and receive either fuzzy or precise outputs.

In our case, we decided to use fuzzy logic because the choice of impartial indicators for this kind of assessment is very limited. Numerous evaluations are extremely subjective and their intensity for individual indicators can in most cases only be expressed verbally. Furthermore, the connections among individual indicators and dimensions are anything but certain.

Presentation of the fuzzy expert system

The inputs to the expert system consists of the replies in a form of semantic differential that have been submitted by the participants regarding certain aspects of organisation's flexibility. The graphic user interface, enables the participants to provide an answer by moving the horizontal scroll bar between the two statements at each pole. The conventional methods deal with the indicators in a "crisp" or "clear-cut" way; for example, there is an abrupt change from "I agree" to "I'm indifferent". The use of fuzzy logic gives us the possibility of gradual change with certain confidence within one dimension when the value of flexibility criteria increases or decreases. The user "crisp" replies are fuzzified in the system by conversion into membership functions with five fuzzy terms (I strongly agree with the left/right answer; I agree with the left/right answer; I'm indifferent), as shown in Figure 2. To simplify the calculation for the inferential logic, trapezoidal membership functions are used.
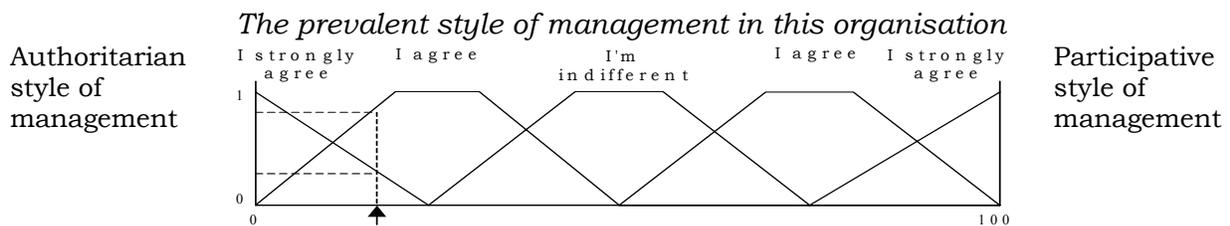

Figure 2: Example of fuzzy semantic differential

All the rules whose conditions match perfectly or partially will contribute to the final diagnosis on some dimension, aspect or time frame. The final outcome may be more than one of the three terms (low, medium, high) with the different degrees of support.

Since the flexibility of the organisation is assessed by each group member separately, these assessments need to be aggregated at the group level. For this purpose, we use Kosko's equation for knowledge combination $k = Min(m, 1 - m + l)$, where k stands for the value of knowledge combination and $X_i(v)$ for the assessment of an individual, $m = Max\, X_i(v)$ and $l = Min\, X_i(v)$ (5).

Evaluation of the fuzzy expert system

Evaluation is the process of assessing a system's or a model's overall value (8). It is also defined as the process of examining a systems' ability to solve real world problems in a particular problem domain (2). In our context, this means that the validation question is: Does the fuzzy expert system make the process of organization flexibility assessment more effective?

McIntyre (6) argues that the ideal subjects for assessing a system or a model would be those who are expected actual field users. For this reason we decided on a two-stage process of validation which included forty managers from two Slovene companies and two different cases for each stage. For the first stage, we asked half the managers to make their assessment without expert system, in accordance with our integral model, and the other half to make their assessment with the use of the expert system. In the second stage, the first half of the managers made their assessment with the use of the expert system, and the second half without it. At the end they assessed it's effectiveness with the use of a questionnaire. The questionnaire was structured in terms of robustness of system, performance of decision activity (4), decision confidence (12), level of consensus (12), and helping of strategic thinking (7).

The responses on the questionnaire are summarised in Table 1. It can be seen from the Table that the use of the expert systems contributed above all in decision confidence and strategic thinking.

Measurement	First group (averaged score)	Second group (averaged score)	Averaged score for both groups
Robustness of system (not at all 1 2 3 4 5 completely)	3, 45	3, 83	3, 64
Improving on the performance of the decision activity (no improvement 1 2 3 4 5 significant improvement)	3, 96	3, 28	3, 62
Improving the level of decision confidence (no improvement 1 2 3 4 5 significant improvement)	4, 23	3, 86	4, 05
Improving the level of group consensus (no improvement 1 2 3 4 5 significant improvement)	2, 96	3, 39	3, 18
Helping strategic thinking (no help 1 2 3 4 5 extremely helpful)	4, 11	4, 29	4, 2

Table 1: Findings of the evaluation

We can suppose that these results are the upshot of complex flexibility assessment process, where is "almost impossible" to take in mind all different aspects of the organisation and

appropriate flexibility dimensions without an information system support. Where we were a little bit negatively surprised was the inferior result (in relation with our expectations) in the support of the system to group consensus achievement. In this regard we think that we can improve the result if we complement the system with some group decision support features.

CONCLUSION

A growing co-dependence of individual components within a system makes it increasingly difficult to estimate the level of flexibility of the organisation. According to Prahalad and Krishnan (9), managing an organisation that consists of subsystems with highly dissimilar degrees of flexibility, resembles driving a car with each wheel spinning at different revolutions. In order to evaluate how flexible an organisation is, it is therefore simpler to divide it into subsystems. The dimensions and indicators required for flexibility diagnosis are then described and analysed for each of the subsystems separately. This is one of the advantages of this model, because it offers a complete evaluation of specific subsystems within the organisation. Furthermore, it provides explicit graphics, which are much more surveyable than the results presented in a tabular form. Expert system enables an assessment of the present state of affairs as well as a diagnosis of future conditions (taking into account the planned measures) on the basis of "what-if" analysis.

The system described is supposed to serve as a starting point for the development of a broader system, which would help us assess the flexibility of an organisation as well as the changeability of the environment. By applying that system it would be possible to estimate how much flexibility a certain organisation actually needs. Hopefully, the system will later on be equipped with a much more extensive knowledge base, which would allow the system to give its users advice on what is required and what changes should be introduced in the organisation to reach the appropriate degree of flexibility.

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