Fuzzy approach to risk assessment in the crisis management systems.

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Extended abstract:

Nowadays the companies to support the continuity of their operations in rapidly changing business environment have to prepare for manufacturing system's failures before they appear. To look forward to crisis is essential for good operations management but the high number of failures of manufacturing systems appearing in business environment suggests that action to do it are not being undertaken. The higher level of stability and safety of production activities can be achieved by introduction of crisis management system in the organisation. It is impossible to prepare for every kind of disastrous event but there is a set of crisis types written in manufacturing activities in each industrial sector.

The paper presents the theoretical background for the design of a risk assessment tool that might be successfully implemented into the crisis management system of manufacturing organisation.

The aim of the paper is to propose the potential and real application of the fuzzy sets theory in the design of risk assessment tool that breaks down the complex problems associated with crisis management into discrete units that supplies aid in the process of understanding and assessing the level of risk. Units included in the designed tool are developed using fuzzy sets theory. The risk assessment tool is designed for management of risk from man -induce disasters. The emphasis is placed on the pre-impact crisis phases like mitigation and preparation, which are bounded with high costs but also benefits when being successful.

Throughout the world there are many professionals and academics who work in disaster related field, however most of the papers concentrate mainly on natural disasters. In our research we tried to find a relevant theoretical framework that might be successfully applied for management of man-induce crisis in the manufacturing organisation. The concepts evaluated by authors are briefly presented below.

There are different definitions of failure; one we applied is Laplat, (1984) who define it as a consequence of disfunctionning in the system, which does work as a planned.

Cisin and Clark (1962) define disaster as an event of a series of events, which seriously disrupts the normal activities.

For purpose of the paper we combine elements of both definition to achieve a straightforward and relatively all-embracing description of crisis in manufacturing organisation. In the following we will not distinguish between failure and disaster because the differences between them are not relevant when discussing the applicability of crisis management systems.

Crisis in this paper would be define as a disfunctionning in the manufacturing system being caused by an event of a series of events which seriously disrupts the normal activities and effects in loss.

To successfully manage the crisis there is a need to define what type of crisis can happen, which action should be taken, what are the costs, benefits and risk involve, what influence would have the action taken on the future scenarios. Risk assessment is a crucial element for efficient application of crisis management systems.

The introduction of any action taken in the field of planning and mitigation and resource allocation in order to keep the manufacturing operations being continued should be preceded by risk analysis.

Risk has a different meaning and is applied differently in various disciplines such as economics, environmental and engineering. The crisis management is a interdisciplinary in its origin so a combined definition of risk is required, which will be based on the quantification of various uncertainties occurring in the evaluation of physical processes related to company every day activities and their implication on the business environment.

The uncertainty might be divided into two forms (Simonovic, 2002):

- Uncertainty caused by inherent stochastic variables
- Uncertainty due fundamental lack of knowledge

The three major sources of variability are temporal, spatial individual heterogeneity.
Fundamental lack of knowledge appears when that particular values cannot be presented with expected confidence because lack of understanding or limitation of knowledge. The lack of knowledge deals with:

- model and structural uncertainties when oversimplification arise, or important parameter are being excluded from investigation
- parameter uncertainty , the source of it are mainly the systematic and random errors in measurements
- decision uncertainty witch deals with selection of index to measure risk, transforming risk measures into comparable quantities and quantification of social values (company is a technical-social-economics system)

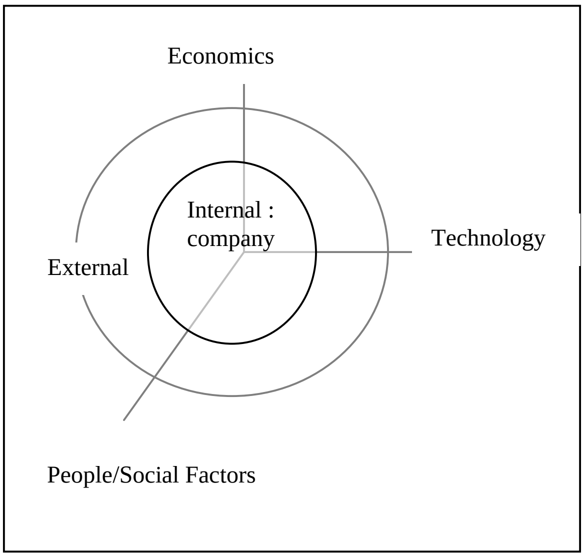
In man-induce crisis domain the uncertainty associated with lack of knowledge has a great importance. Taking in consideration the scale of negative economic consequences or the social devastation following the crisis the proper a priori risk quantification is a must.

Risk assessment can be divided into three stages, which are described by following questions (Kaplan, Garick 1981):

- What can go wrong?- the identification of the risk factors
- What is the likelihood that it will go wrong ?- risk measurements and quantification
- what are the consequences?- the evaluation of scenarios

The answer for these questions should be given in the framework of the manufacturing system. The manufacturing system is treated as a complex entity combining technological-social- economics subsystems and being influenced by business environment. So crisis might be cause be any of the social, technology factors economics conditions of internal or external origin. (Figure 1)

Figure 1: Factors inducing crisis in manufacturing organisation



Source: modified from Mitroff (1992)

The complexity of the system causes difficulty in the managing crises. The decision makers cannot rely on intuition and experience due the fact that there very often is a lack of experience in dealing with extreme events which differ significantly for every day operations management.

The difficulties pointed above determine that ad hoc approach in dealing with crisis might not be effective, a mitigation and crisis planning policy is required.

The risk assessment is applied in identification and evaluation of all aspects of system management, from the identification of loads to the planning of emergency scenarios for the case of operational failure, and of recovery for the case of structural failure.

There are different suggested methodologies of risk assessment and management available in the literature. When the sufficient data is available the stochastic approach may be implemented. In many crisis situation the uncertainty is inherent in crisis data, values of parameters, boundary conditions of variables used in mathematical modelling may not be easily quantifiable. In that case the fuzzy set approach is appropriate (Zadeh, 1965). A fuzzy membership function acknowledges that stakeholders are not completely sure about the values and statistical precision can be independent in classification of events. Fuzzy sets membership function within intervals (0,1) presents the degree of confidence for value of fuzzy number. The fuzzy sets theory provides an intuitive and flexible framework for interactively exploring a problems that are ill-structured or has limited available data.

There is a number of successful application of fuzzy set theory into the risk assessment of natural disasters like extreme weather, floods, droughts etc.(Simonovic,1999,2000).

In our research we transpose some of the solution applied for natural disaster management into the field of man-induce crisis management.

Tools that might be applied to risk assessment in manufacturing organisation are Fuzzy Optimalization and Fuzzy Multi Objective Analysis. The fuzzy optimalization is based on the Zimmerman (Zimmermann 1976) concept, that soften the usual linear programming problem into the fuzzy version:

$cx \leq z$

$Ax \leq b$

$x \geq 0$

What means that objective function cx should be essential smaller or equal to an aspiration of level z of the decision-makers constrains Ax should be essential smaller than or equal to b. The Fuzzy Multi-Objective Analysis concept include imprecise or fuzzy understanding of the parameters in the problem formulation.

Simulation models show how a system works and help to evaluate changes in the system from action taken.

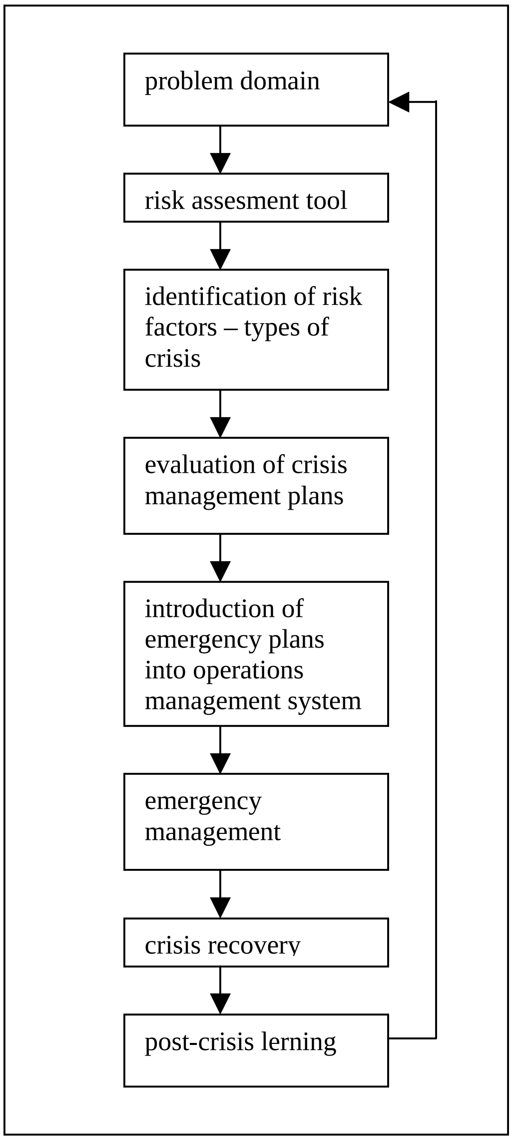
The simulation model consist of:

- input
- physical relations
- non-physical relationships
- operational rules
- outputs

The identification of the simulation model components in framework of manufacturing organisation is in progress and detailed solution will be presented in the final version of the paper.

The theoretical frameworks presented in the paper will allow creating a risk assessment tool that might be assistance in the process of application the crisis management system in the manufacturing conditions. Figure 2 presents the perspective application of the tool.

Figure2: Perspective application of the risk assessment tool.



The tool might be successfully combine with decision support system. Activities taken in framework of crisis management system especially these dealing with crisis planning and emergency response required reliable and adequate data and information in a real-time. Information needed by decision-makers is often inadequate or impossible to obtain on the other hand people involved in crisis management may be information overloaded and be receiving stream of overlapping or contradictory messages.

Decision Support System allows decision-makers to combine personal judgement with computer output, in a user-machine interface, to produce meaningful information for support in a decision-making process. Such systems are capable of assisting in solution of structured, semi-structured, and unstructured problems using all information available on request with usage of quantitative models and database elements. Stakeholders involved in crisis have different needs and responsibilities during each crisis phase, the design of DSS should fulfilled needs of all of them. There are levels of functional support that can be provided within the framework of DSS design like information support including technical drawings, plots, animations, video, spatial data etc. and technical support. Technical support includes access to databases and modelling tools which allows for all users responsible for crisis management in manufacturing site for analysis, processing and technical forecasting, modelling, simulation and optimisation analyses.

The role of crisis management decision support systems includes guiding through the decision-making process during crisis phases, collecting of information that supports problem description, helping in evaluation of alternatives using multiple and often conflicting objectives; and evaluation of the prospective outcomes of the implemented decisions. The goals cannot be achieved without appropriate risk assessment.

The implementation of crisis management system allows companies to protect themselves from crisis and also reduce the negative effects when crisis appears. Risk assessment as mentioned is a crucial element in crisis management system. Our work on the development of the appropriate tool for risk assessment is in progress. Literature review has been completed and theoretical framework for design proposed. The next step is creation of the tool that will be built on the theory presented in this paper.

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