RESEARCH ON USING FMEA AS A RISK ASSESSMENT METHOD IN ORDER TO REDUCE RISK HANDLING COSTS

Ruxandra Maria Mateescu (Bejinariu)[1], Vasile Dinu[2] and Mihaela Maftei[3]
[1) 2) 3)] *The Bucharest University of Economic Studies, Romania*
E-mail: ruxandra.bejinariu@gmail.com; E-mail: dinu_cbz@yahoo.com
E-mail: mihaela.maftei@ase.ro

Abstract
This article proposes the extension of the Failure Mode and Effects Analysis (FMEA) model as more reliable and efficient way of assessing risks. The control mechanisms that quantify and analyze the consequences of risk materialization and its probability of appearance are usually considered by managers using subjective data. How can we measure if the probability of appearance of one risk is high or medium?
The objective of this paper is finding new ways of introducing FMEA's detection as a third parameter in the risk assessment matrix and establishing weather the evaluation is more efficient or not. The methodology includes interviews with managers and specialists that handle risk management processes in their organizations and that share an opinion on extending the risk matrix and improving the whole risk assessment process in order to cut risk handling costs.

Keywords: Risk assessment, risk management, FMEA, control mechanisms, process efficiency

JEL Classification: G31

Introduction

Using the Failure modes and effects analysis (FMEA) model can be a methods to increase the effectiveness of any risk assessment process in organizations by ensuring the accuracy of the controlling processes and systems. Introducing detection as a third attribute in the risk assessment matrix can decrease the materialization of risks and therefore, reduce costs with risk handling. While consequence and probability of appearance are mostly assessed using subjective data, evaluating the control mechanisms that determine these parameters should lead to a more pragmatic risk assessment process.

Carbone T. and Tippett D. (2015) mention that by adding the detection value to the risk quantification process, another measure beyond the typical risk score is made available to the project team. The benefits of the new method include an increased focus on the most imminent risks, prioritizing risk contingency planning, improved team participation in the risk management process, and development of improved risk controls.

The main research questions are:

- What is the role of detection in the risk assessment process?
- Is detection applicable to any risk matrix?
- Which are the main control mechanisms that should be evaluated during the risk management process?
- How can risk handling costs be reduced as a result of the risk matrix extension?

The objective of the paper is to illustrate and evaluate a risk matrix model applicable to any organizational process or area of activity using three attributes: probability of appearance, consequence and FMEA's detection. The main advantages and conclusions related to the new model are the result of qualitative research during interviews with specialists from 23 different companies and four different areas of business: FMCG, construction, pharmaceuticals and agriculture.

Theoretical Aspects

Risk management should be part of any decision making process and has a key role in achieving the organizational objectives (Mateescu (Bejinariu) et al., 2015). Based on today's uncertain market conditions, demands of globalization and increasing external threats, Jereb, Ivanuša and Rosi, (2013) concluded that in order to assure continuity of operations in any organization certain measures have to be taken. The role of risk management is to detect uncertainties and their nature - the uncertainties of not achieving or not accomplishing something, uncertainties about the enhancement of opportunities, about achieving and exceeding targets and performance, etc. and to determine how they can be handled. According to Grigore and Drăgan (2015), in an innovation-oriented or knowledge-based economy, the function of opportunity recognition and taking the risk of realizing it becomes more prominent. Risk management is also a key process in development and operationalization of a model of innovation management system as a part of an integrated quality-environment-safety system (Maier, et al., 2017).

Risk analysis can be either qualitative or quantitative or a combination of both. The qualitative risk evaluation methods use the judgment and opinions of knowledgeable experts to categorize the risks, while quantitative tools are based on probabilistic and/or statistical models that calculate risk over time (Dinmohammadi et al., 2016). Quantitative risk assessment methods are more reliable and robust than the qualitative ones, however, quantitative risk evaluation requires more indexed data, which makes it difficult to apply. Qualitative data relies on subjective evaluation and control mechanisms, creating a gap in the risk assessment process.

One of the methods that involves the evaluation of these control mechanisms is FMEA (U. S. Dep. of Def., 1949). According to Chang K., Chang Y. and Lai P. (2014), FMEA has been used to identify the critical risk events and predict a system failure to avoid or reduce the potential failure modes and their effect on operations. The risk of failure is evaluated using the risk priority number (RPN) that is the mathematical product of three parameters: severity
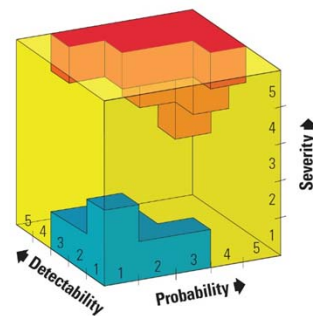

Figure no 1: Tridimensional risk chart with high-risk zone in red and low-risk zone in blue
Source: Youssef N. F., Hyman W. A., 2010, Risk Analysis: Beyond Probability and Severity, Medical Device and Diagnostic Industry

(SS), occurrence (OO), and detection (DD) (see Figure no. 1). Traditionally, FMEA is used in the engineering and medical fields, being defined as a reliability analysis based on historical failure data and focuses on problems that have occurred (Schneider H., 2012). According to ArunKumar and Dillibabu (2016), FMEA is one of the first systematic techniques for failure analysis. An FMEA is often the first step of a system reliability study. It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. Indexing past errors and negative events leads to creating a registry of the main risks that have materialized and therefore, identifying the main causes for these negative events. Managers use risk handling plans (see Table no. 1) in order to determine which actions are to be taken for each of the analyzed risks. Preventing these negative events can be managed by listing all historical causes, therefore minimizing the chances of risk materialization and related effects (see Figure no. 2).

Figure no. 2: From cause to effect – Example

While all the risk management processes are in place and the risk handling actions have been taken, managers and specialists have to determine what went wrong: Why couldn't these risks be prevented? Were they identified too late or were they just skipped? Is the risk assessment process flawed? How can they control the risk evaluation process?

The Extended Risk Assessment Process
Before introducing the probability of detecting risks as a third attribute in the risk evaluation process, a standard risk matrix will determine risk levels (see Table no. 1) using probability of occurrence and consequence on a 0 to 25 scale using the NASA matrix (NASA 2011).

Table no. 1: Risk levels and risk handling plan

Risk levels	Risk type	Risk handling actions	Responsible
1-2	No risk	-	-
3-9	Acceptable risk	Can be indirectly influenced by actions taken in order to minimize tolerable or unacceptable risks	Process specialist
10-12	Tolerable risk	If it cannot be influenced, control mechanisms will be set up in order to not transform into an unacceptable risk.	Process specialist
13-20	Unacceptable risk	If it cannot be influenced, control mechanisms have to be set up.	Process manager
20-25	Maximum risk	All process activities have to be stopped until the associated risk becomes acceptable.	Process manager

The probability of detecting risks using the default attributes varies depending on the control mechanisms that determine the values for each attribute. How do one know if the probability of occurrence for one risk is high or medium? Who and what determines the gravity of the consequences? By evaluating the control mechanisms, detection rates the likelihood that the problem will be identified before the risk materializes. Introducing detection recalibrates the risk matrix scale using the already identified risk levels (1-25) and probability of detection on a 1 to 5 scale (see Figure no. 3).

Maximum	25	RISK LEVEL	25	50	75	100	125
Unacceptable	20		20	40	60	80	100
Tolerable	12		12	24	24	48	60
Acceptable	9		9	18	18	36	45
No risk	2		2	4	4	8	10
	0		**PROBABILITY OF DETECTION**				
			1	**2**	**3**	**4**	**5**
			Very high	High	Moderate (medium)	Low	Very low

Figure no. 3: Risk matrix using 3 attributes

Methodology and results

In order to determine the advantages and disadvantages of the extended risk assessment matrix for all industries, 8 interviews were conducted and 93 questionnaires were sent by email between November 2016 and March 2017. The analyzed data is based on the answers of 74 specialists and department managers from 23 companies. Given the fact FMEA is mainly used in Engineering and Medicine, the versatility of the extended risk matrix was researched by discussing the topic with employees from companies that handled FMCG, constructions, pharmaceuticals and agriculture. The questionnaire included seven questions related to the risk assessment process within each of the interviewees' organizations in order to test the following hypotheses:

1. *Detection as a third attribute in the risk evaluation matrix can be used in any area of business;*
2. *Using a historical risks registry and determining the main causes for the most common and dangerous risks, companies can reduce the probability of these risks to reoccur by either eliminating the causes or increasing the probability of detection;*
3. *By increasing the probability of detecting risks, there will be less risks to be introduced in the risk handling plan - therefore costs will be reduced.*

Question no. 1 *Have you ever consider using FMEA or detection within the risk evaluation process?*
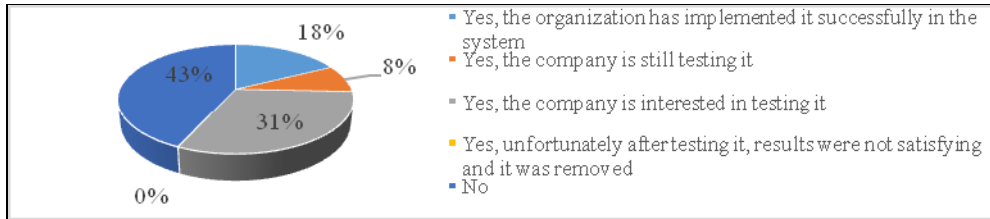
Figure no. 4: Results for Question no. 1

Results: The first question intended to determine the level of awareness about FMEA and more precise detection. 43% of the organizations are using FMEA in order to increase the efficiency of the risk matrix. Almost 40% of the companies are interested in the extended risk assessment process or are already testing it.

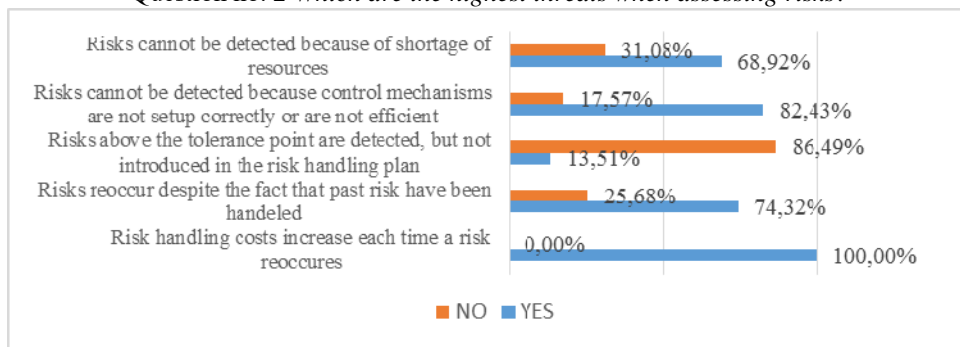Question no. 2 *Which are the highest threats when assessing risks?*

Figure no. 5: Results for Question no. 2

Results: Almost 70% of the respondents say that there is no separate budget for the risk evaluation process and the limited resources can lead to risks not being detected on time or at all. Another cause for risks not being detected is the inefficiency of the control mechanisms according to almost 83% of the managers and specialists. Almost 90% of the employees answer that risks are usually registered in the risk handling plan, while almost 75% respond that risks do reoccur despite the fact that actions were taken in order to prevent them in the past. All the managers and specialists agree that the reoccurrence of risk is an important threat for the organizations and implies big costs with risk handling.

Question no. 3 *Do you think the extended risk matrix should be used in your area of business?*
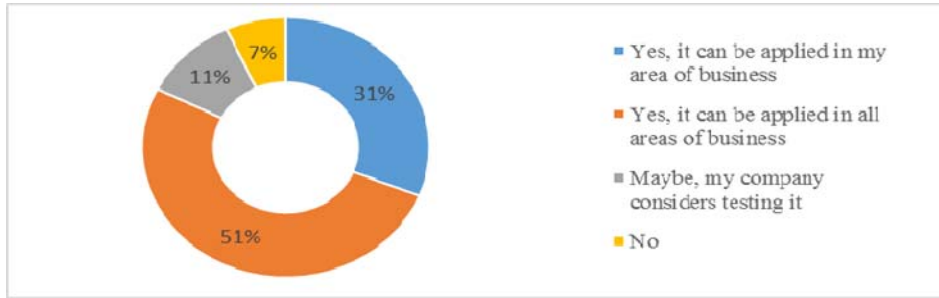
Figure no. 6: Results for Question no. 3

Results: More than half of the respondents consider that the extended risk assessment process can be applied to all domains and areas of business. 31% of the managers and specialists consider that the change can be made for their organization, but cannot have a saying considering all other companies.

Question no. 4 *Which are the main advantages of using detection as a third attribute in the risk evaluation process?*
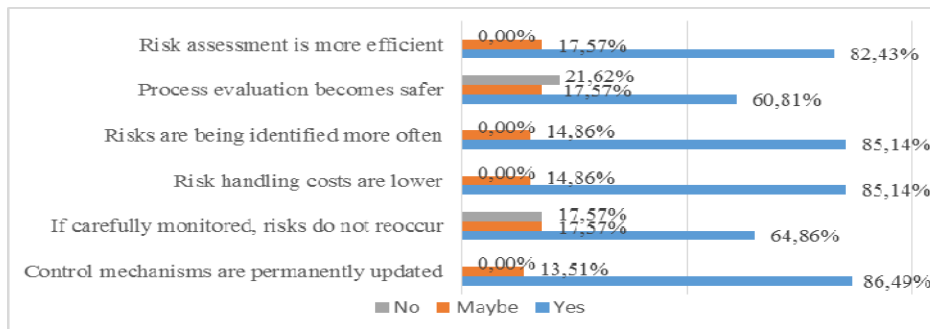

Figure no. 7: Results for Question no. 4

Results: Almost 83% of the managers and specialists agree that introducing detection transforms the risk evaluation process into a more efficient one. Also, it is safer to evaluate processes according to almost 61% of the respondents. 85,14% of the interviewees agree that risks are being identified more often and that risk handling costs are lower. Almost 65% of the employees say that careful monitoring usually prevents the reoccurrence of risks and almost 87% consider updated control mechanisms as a real advantage for their company.

Processes are part of the infrastructure of every company and are an essential component in the analysis of corporate performance when it comes to business sustainability (Mateescu (Bejinariu), Buchmüller and Just, 2016). Approximately 60% of the respondents considered that there is a tight bond between a correct and efficient risk assessment process and process evaluation.

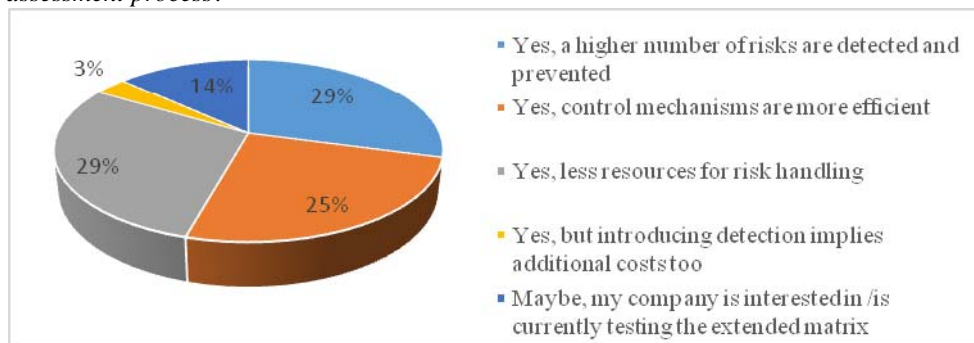Question no. 5 *Are risk handling costs reduced by introducing detection in the risk assessment process?*

Legend:
- Yes, a higher number of risks are detected and prevented
- Yes, control mechanisms are more efficient
- Yes, less resources for risk handling
- Yes, but introducing detection implies additional costs too
- Maybe, my company is interested in /is currently testing the extended matrix

Figure no. 8: Results for Question no. 5

Results: Almost 30% of the respondents answer that more risks are prevented and a lower number of risks need to be handled. Also, control mechanisms are more efficient according to 25% of the managers and specialists. Only 3% of the interviewees mention that introducing detection implies additional costs as well.

Question no. 6 *How does your department handle preventing the reoccurrence of risks that have materialized in the past?*
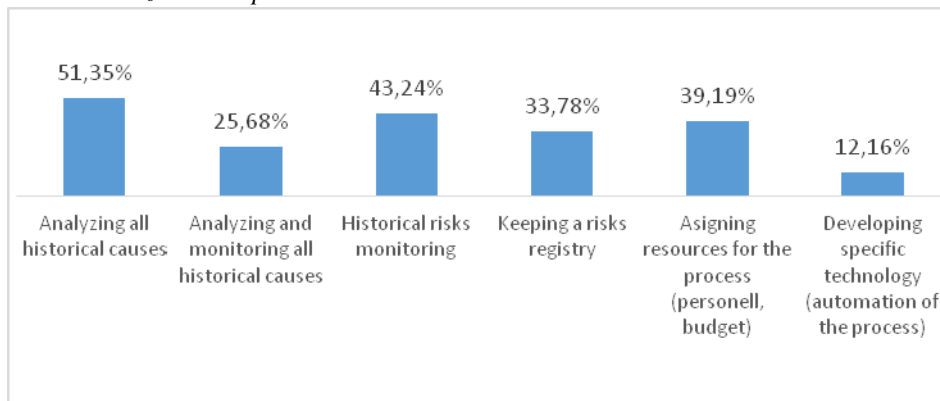

Figure no. 9: Results for Question no. 6

Results: More than half of the managers and specialists answer that their organization prevents risks from reoccurring by analyzing historical causes, but only 25,68% also monitor the identified causes. Almost 45% of the respondents monitor historical risks, while only 33,78% keep these risks in a risks registry. Only 39,19% of the companies have assigned special resources for the process and 12,16% are investing in new automation technology.

Conclusions
The FMEA-based risk matrix has not been used in all industries because the method mainly relates to technological errors and bases its premises on historical malfunctions. These

errors can be considered the effects of risks that have materialized in the past, that have not been detected on time or at all and that have an unknown cause. Analyzing the effect determines the risk and the cause, therefore the reoccurrence of these negative events can be prevented by analyzing and monitoring the initial cause. Another method of minimizing the materialization of risks is to evaluate the probability of detection by checking on the mechanisms that determine or estimate the probability of occurrence and consequence of the presumed negative event.

Almost half of the companies have already started using the extended risk assessment process and agree that it adds value for the organization. Other companies are still testing it or are interested in extending their risk management process by using FMEA-based elements. More than half of the respondents consider that this method can be used in all areas of business and another 31% say that it can be applied to their industry.

One of the barriers in implementing the new model is budget – most of the organizations have not allocated a budget for the process and have not assigned roles for this process only. When it comes to control mechanisms or risk detection resources, these are not evaluated or monitored in most of the companies, therefore there is a risk in not being able to detect risks correctly and/or on time. Another risk that related to the risk management process is the reoccurrence of risks that have been identified in the past. Despite the pact that managers and specialists agree that risk handling costs increase significantly if risk reoccur and/or even materialize, less than half of the companies monitor historical risks and only a quarter monitor the historical causes for these risks.

Most of the specialists agree that the identification of risks is easier and safer by introducing detection as a third attribute in the risk matrix, leading to a higher number of risks that can be prevented and less negative events to be handled. Another advantage of the extended model is that control mechanisms are being constantly updated, therefore there is no risk that over time these mechanisms do not detect new or more complex risks.

The extended risk matrix is considered as more efficient, applicable to most of the areas of business and saves considerable costs with risk handling costs. The advantages of evaluating the mechanisms that analyze risks are indisputable given the fact that most of the risk identification processes are based on qualitative data rather than quantitative. The proposed extension of the risk assessment process aims to improve the risk management process regarding quality, control and overall profitability of the organization. This paper may bring a contribution to further research on risk management and control mechanisms efficiency.

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