# Anatomy of Risk with The Cost Impact Valuation

Olga Dobrovolschi*

*CTU in Prague, Faculty of Mechanical Engineering, Department of Management and Economics,*
*Karlovo náměstí 13, 121 35 Prague 2, Czech Republic*
*Supervisor: doc. Ing. Theodor Beran, Ph.D.*

## Abstract

Project risk management aim is to provide insight into the risk profile of a project as to support decision makers to reduce the impact of risks on project objectives such as budget and time. Risk analysis of the overall project also poses the danger of developing inappropriate responses. Despite every risk is by nature subjective, at the time of risk management progress many analytical models have been developed. The aim of this article is to propose a quantitative approach to risk management in a project of engineering company. As a tool for risk analysis is used Failure Mode and Effect Analysis (FMEA) technique adapted to risk management. For risk evaluation are used statistical approaches, that define risk impact to the whole project. The main idea behind working on this project is to provide a fertile ground for project managers of an engineering company on dealing with risks and reach the project success with the reduced costs.

*Key words:* project risk management; risk analysis; risk matrix; RFMEA; cost impact; time impact

## 1. Introduction

Lately, in automotive engineering has been increased attention to the integrated risk management. Companies, by this time, do not take up each risk factor individually, but as an interconnected system. There is a strong relationship between the application of project risk analysis and the success of any project. Taking in consideration, that in today's highly competitive and globalized market, engineering enterprises are placing an emphasis on efficiency and cost effectiveness the main scope is to meet with success project. The high chance of project success, increase efficiency and reduce project's costs can be reached by systematic risk monitoring. At the time of risk management progress many analytical models have been developed, and are available to analyze almost all categories of risks. Unnumbered models have also been created to evaluate risk in the New Product Development process. But still there is a gap for improvement with these models and tools. [1]

This study is an attempt to start composing an effective method for a manage project risks that will be for the project team easy to understand, use and apply. Basic goals are to show a sample risk management tool, improve it and realize how we can develop it in future.

## 2. Risk Terminology

Before proceeding further, here are defined some of the key terms.

- A *risk* is an event, which is uncertain and has a negative impact on some attempt.
- *Risk analysis* is the process of assessing risks. This involves an estimation of both the uncertainty of the risk and of its impact.
- *Risk management* is the practice of using risk analysis to devise management strategies to reduce risk.

The risk analysis process is generally split into two sub-stages: a qualitative analysis, that focuses on identification and subjective assessment of risks and a quantitative analysis, that focuses on an objective assessment of the risks. A quantitative analysis involves more sophisticated techniques and requires measurement of uncertainty in cost and time estimates, or probabilistic combination of individual uncertainties.

## 3. Risk Management Framework

Most project managers agree that risk management is urgent to the success of any projects, especially Research and Development Projects (R&D). However, the various risk management methodologies were adopted in different organizations, there are still companies that do not provide risk assessment on the needed level.

The ability to prevent company from big losses and the project to be successful is close connected with the ability to conduct risk analysis. Effective risk management strategy allows to identify project's strengths, weaknesses, opportunities and threats. Most of the respective organizations would benefit from a new and more structured risk management methodology. As the process should be improved and periodic reviewed from time to time risk management is cyclic and is shown on Fig. 1.

### 3.1. Establishing the context

To understand and analyze risk we should define the objectives of the activity being considered. The main goal of risk management in R&D projects of an engineering company is to finish project on estimated time with the reduced costs.

*Corresponding author: Olga.Dobrovolschi@fs.cvut.cz

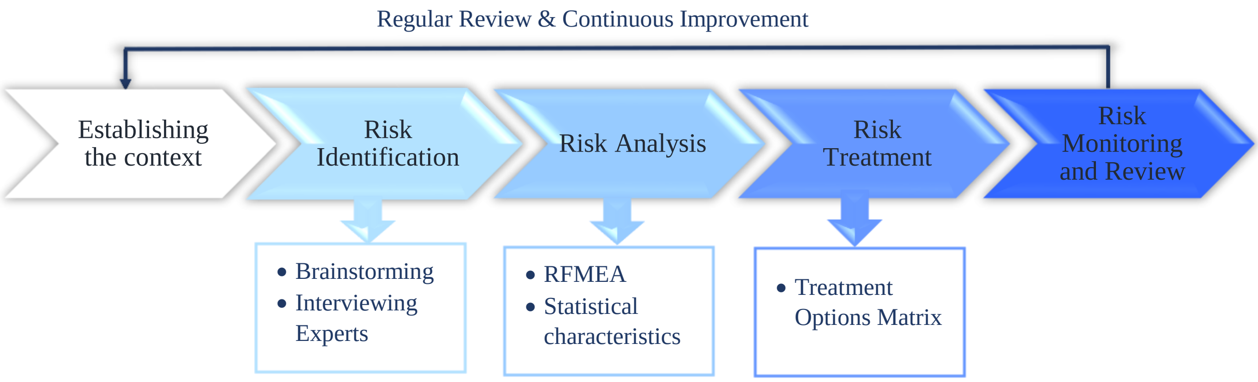


***Fig. 1.*** *Risk Management Process Framework.*

### 3.2. Identification of risk factors

As next step, and key one of risk management is identification, that involves creating a list of the potential events that can affect project and company in future. Risk identification allows an organization to take steps to create plans of managing and controlling risks before they appear. This is typically more cost effective than waiting to react to adverse events when they occur. Some of the methods and tools for risk identification are: brainstorming, interviewing experts, assumption analysis, diagramming techniques, checklists, forms and templates.

In this article risks were identified with one the best and most popular ways – brainstorming. Combining it results with the experts interviews a risk register for a R&D project is created and shown in Table 1.

***Table 1.*** *Risk register.*

| Item | Risk Factor | Risk Category |
|---|---|---|
| 1F | Customer credit risk | Financial |
| 2F | Currency risk | |
| 3F | Cost forecasts are not exact | |
| 4F | Increasing of production costs | |
| 1T | Changing customer needs | Technical |
| 2T | Technical difficulties | |
| 3T | The desired product parameters are not technically achievable | |
| 4T | Unverified or new product material | |
| 1P | Changing project requirements | Project |
| 2P | Supply Chain Delays | |
| 3P | Short time defined for the finish | |
| 4P | Insufficient resources to complete project on time | |
| 1D | Poor software quality | Design |
| 2D | Wrong selection of materials | |
| 3D | Lack of information coming from customer | |
| 4D | The necessity of new equipment for required design | |

Firstly, were established the four risks groups (financial, technical, project, design) by sources of risk and the area of the project affected. Categorizing risks improve the effectiveness and quality of the identification, analysis processes as well. For each category four risk factors were identified using experts experience in conducting R&D project. Just as were classified all possible risk factors we can proceed to risk analysis.

### 3.3. Risk Analysis

#### *3.3.1. Risk Failure Mode & Effect Analysis*

The implementation of technological innovation though R&D projects is not without its challenges. These projects are overflowing with risks and uncertainties occur at every stage of the project lifecycle. [3]

To improve the success rates of the projects, project managers apply specific methods and techniques. This allows to identify and manage the uncertainties as effectively as possible. [4]

A useful tool that helps to find possible flaws in a system or process is Failure Modes and Effects Analysis (FMEA). [5] Recently has acknowledged the extended version of FMEA, named Project Risk FMEA, known as RFMEA. The FMEA method is a natural addition to the project risk management process due to its ease of use, familiar format and comprehensive structure.

This simple RFMEA method of classifying and prioritizing risks helps the organization mature its risk management process. Compared to other existing methods in arranging major risks, the RFMEA model can help identify effective possible plans to reduce high-priority risks in R&D projects. [6] While FMEA is used to score down the risks associated with the technical aspects of the design and planning processes of product development, RFMEA is used to quantify and analyze risks, specifically in the project environment. [7]

The difference between the two techniques is in the definition of the detection technique. For FMEA, the detection attribute is assigned a high value if a company has no method of detecting that a product fault will occur and a low value if they do have the ability to detect a fault. For RFMEA, the detection factor is a measure of the ability to foresee a risk event with sufficient time to plan for it. [3]

Concerning the use of RFMEA process, every risk is assessed by its severity value, probability value, and detection method value. Determining those values is based on the secondary data and interviews with the experts. Various rating scales are being used, such as a scale of 1–5, 1–10, or 1–100%. The chosen scale for this risk assessment is of 1-10 for all ratings.

The severity (S) measures the effect on the project should it occur, mostly defined by time and cost impact. Table 2 shows how severity ratings can be defined.

***Table 2.*** *Severity value ratings.*

| Score | Description |
|---|---|
| 9 or 10 | *Time*:> 15 % impact to critical path |
| | *Cost*: Total project cost increase> 15 % |
| 7 or 8 | *Time*: 12 %- 15 % impact to critical path |
| | *Cost*: Total project cost increase of 12 % - 15 % |
| 5 or 6 | *Time*: Impact of 7 % - 12 % of critical path |
| | *Cost*: Total project cost increase of 7 % - 12 % |
| 3 or 4 | *Time*: Impact of <7 % impact to critical path |
| | *Cost*: Total project cost increase <7 % |
| 1 or 2 | *Time*: Insignificant impact |
| | *Cost*: Project cost increase insignificant |

The probability (P) is the measure of the likelihood that this risk factor will occur. Determination is made of the probable occurrence of a cause, not of the failure mode - the probability that the cause will lead to a failure. Table 3 describes probability ratings.

***Table 3.*** *Probability value ratings.*

| Score | Description |
|---|---|
| 9 or 10 | Very likely to occur |
| 7 or 8 | Will probably occur |
| 5 or 6 | Equal chance of occurring or not |
| 3 or 4 | Probably will not occur |
| 1 or 2 | Very unlikely |

The third factor detection method (D) for each risk in the risk register reflects the project team's ability to foresee that a risk will occur and plan for it. Table 4 describes detection method ratings.

***Table 4.*** *Detection method value ratings.*

| Score | Description |
|---|---|
| 9 or 10 | There is no detection method available or known that will provide an alert with enough time to plan for a contingency. |
| 7 or 8 | Detection method is unproven or unreliable; or effectiveness of detection method is unknown to detect in time. |
| 5 or 6 | Detection method has medium effectiveness. |
| 3 or 4 | Detection method has moderately high effectiveness. |
| 1 or 2 | Detection method is highly effective and it is almost certain that the risk will be detected with adequate time. |

After determining the probability of occurrence, severity and detection method values of risk, the Risk Priority Number (RPN) and Risk Score Value (RSV) can be calculated by using equations (1) and (2), respectively.

$$RSV = S * P, \qquad (1)$$

The RPN merely ranks the failure in the system, giving an idea of the "risk" of the failure happening.

$$RPN = S * P * D, \qquad (2)$$

In the Table 5 are shown the results of defined and calculated characteristics for each factor.

***Table 5.*** *RSV and RPN calculation.*

| Item | S | P | D | RSV | RPN |
|---|---|---|---|---|---|
| *1F* | 6 | 3 | 4 | 18 | 72 |
| *2F* | 4 | 3 | 5 | 12 | 60 |
| *3F* | 7 | 4 | 3 | 28 | 84 |
| *4F* | 7 | 3 | 9 | 21 | 189 |
| *1T* | 4 | 1 | 7 | 4 | 28 |
| *2T* | 6 | 5 | 7 | 30 | 210 |
| *3T* | 7 | 4 | 6 | 28 | 168 |
| *4T* | 8 | 3 | 7 | 24 | 168 |
| *1P* | 8 | 4 | 5 | 32 | 160 |
| *2P* | 5 | 6 | 5 | 30 | 150 |
| *3P* | 5 | 2 | 4 | 10 | 40 |
| *4P* | 7 | 3 | 7 | 21 | 147 |
| *1D* | 8 | 2 | 2 | 16 | 32 |
| *2D* | 5 | 3 | 5 | 15 | 75 |
| *3D* | 6 | 6 | 2 | 36 | 72 |
| *4D* | 9 | 3 | 4 | 27 | 108 |

Firstly, a critical RPN value is necessary to identify the critical project risks. For the typical FMEA, a standard RPN threshold value across all projects is also not used or recommended in the RFMEA. A certain RPN value on one project may be deemed moderate, whereas on another project it may be an essential risk to manage. As each project is unique, so are the risks and the corresponding RPN values. [8]

Critical values provide guidance for prioritizing risk and plan responses for it. For the selection of the critical values there is no specific rule. In some projects, the choice is obvious, and in other ones making decision is more difficult. Often, a critical step to determine the value to use further is the analysis of the Pareto. Constructed Pareto charts are shown in Fig. 2-3.

By analyzing the RSV numbers, we make a decision that risk factor identified 3D and 1P have the biggest risk score value. To be sure, if they are the risk to that manager must pay attention the most we compare it to the RPN Pareto chart. According to the numbers of the priority another factor has the highest score –2T.

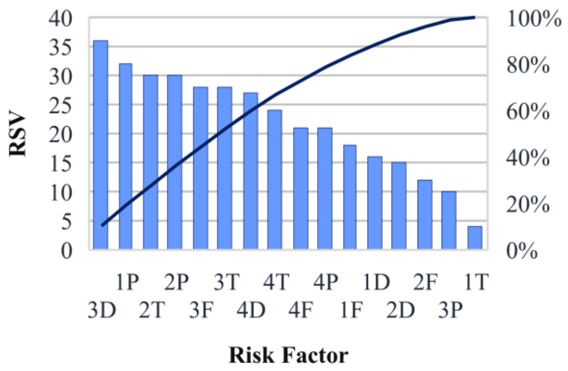


***Fig. 2.*** *Risk Score Value's Pareto chart.*

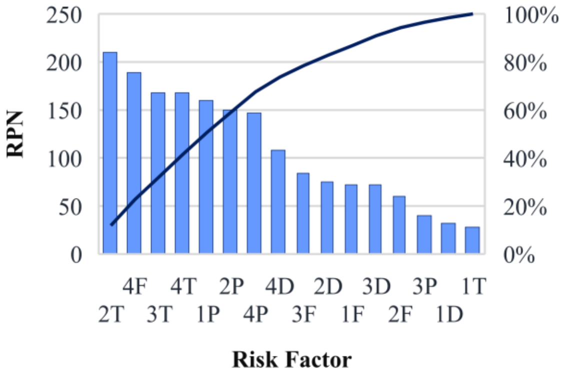


***Fig. 3.*** *Risk Priority Number's Pareto chart.*

Now this is the time to determine critical values. In this project risk assessment, we determine critical values from the average RSV and RPN scores. Referring to our rating scale, the average of RSV is 25, and the average of RPN is 125. Considering this data, the critical Risk Score Value was chosen as 25 and the risk priority number critical value was 125.

The next step is to construct a scatter diagram that has the RSV value plotted along the x-axis and the RPN value plotted along the y-axis. Now the major project risks can be visually recognized as those that have both an RSV and an RPN above the respective critical value. The critical values for the RSV and RPN are highlighted on the Fig. 4 by the red dotted vertical and horizontal lines.

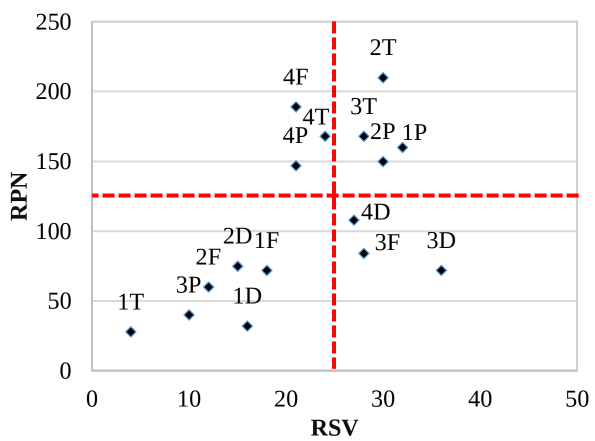


***Fig. 4.*** *Scatter Diagram.*

Basing on the RFMEA method all risks that have RSV and RPN values greater than these critical values (those that reside in the top right-hand quadrant of the scatter diagram) are thus categorized as the highest priority risks. For the more accurately determination of risk significance we use all the quadrants of the diagram.

As the severity of each risk factor measures the time and cost impact of the project, the critical value of the RSV shows that the factors with the value greater than 25 will affect mostly project schedule. Adding risk priority, we define that risk factors with the RPN value more than 125 will have more influence on the project cost. Since some factors have low score value but high priority, as for example risk named 4F, we cannot just skip it. The same situation is with the factors with low priority and high score value, as for example risk factor named 3D. Therefore, we describe and title on Fig. 5 each quarter of the scatter diagram, conformably time and cost influence on the project.

Risk factors that belong to quadrant 1 are considered as low risks and are named “clouds”. The impact of the risks on the project and company is insignificant and factors can be accepted, but monitored. Quadrant 2 and 4 are for medium risks, called “windstorms” and “downpours”, that require control of all contributing sources. A handling plan or risk milestones can be developed for risks of quadrant 2. Considering these risks time reserves in the project schedule must be done. For risks in quadrant 4 must be added addition control on budget plan. These shall be reviewed more often to ensure that they are not turning into high risks.

Quadrant 3 has the most vulnerable factors with significant impact, they are called critical and named as “tsunami”. The project managers of an engineering company must take in consideration time and cost impact of each “tsunami” factor to the whole project. A detailed plan of risk treatment and systematic review are needed. Referring to the risk matrix in Fig. 5 and Scatter Diagram on Fig. 4 the critical and catastrophic risks for our risk project assessment are: 2T, 3T, 2P and 1P and are considered for further study.

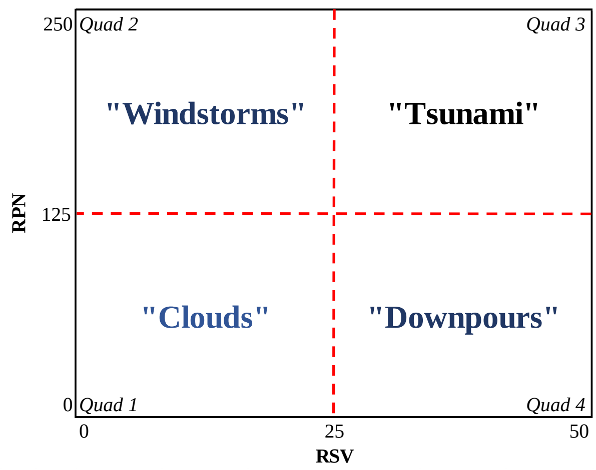


***Fig. 5.*** *Risk Matrix.*

### *3.3.2. Overall Impact on Project*

For estimation of total time and cost impact of the risks to the project success statistical methods can be used. For a general and not detailed idea of the overruns we will examine risk factors with the highest priority. The severity of the concrete risk factors is stated by time and cost overruns in Table 6. Further statistical characteristics are used to analyze risk impact.

Let $X$ be a random variable. The $r^{th}$ moment of $X$ about zero is defined by

$$\mu`_r = E(X^r) = \sum_x X^r p(x) \ , \qquad (3)$$

if $X$ is discrete.

The first moment about zero is the mean or expected value of the random variable and is denoted by $\mu$; thus $\mu`_1 = \mu = E(X)$. Again, the $r^{th}$ central moment of X or the $r^{th}$ moment about the mean of X is defined by

$$\mu_r = E(X-\mu)^r = \sum_x (X-\mu)^r p(x) \ , \qquad (4)$$

if $X$ is discrete.

The second central moment,

$$\mu_2 = E(X-\mu)^2, \qquad (5)$$

is known as the variance of the random variable. [9]

***Table 6.*** *Expected Value of critical factors.*

| Risk Factor | Severity Overrun Time (CW) | Severity Overrun Cost (K€) | P | Expected Value of Severity Overrun Time (CW) | Expected Value of Severity Overrun Cost (K€) |
|---|---|---|---|---|---|
| 2T | 5 | 2 | 0,26 | 1,32 | 0,53 |
| 3T | 5 | 3 | 0,21 | 1,05 | 0,63 |
| 1P | 7 | 4 | 0,21 | 1,47 | 0,84 |
| 2P | 3 | 2 | 0,32 | 0,95 | 0,63 |
| | | | | 4,8 | 2,63 |

The analysis, using equation (3) revealed that the project is expected to have experienced with 4,8 calendar weeks delay and 2,63 thousand Euro costs overrun, considering the critical “tsunami” risks. The results can be used in further to derive the expected time and cost overrun along with the respective standard deviations, using formulas (4) and (5), in the risk assessment of all risk factors.

### 3.4. Risk Treatment

Risk treatment is the process of selecting and implementing measures to modify the risk. Risk treatment includes as its major element, risk control, but extends further to, for example, risk avoidance, risk transfer, risk financing. Any system of risk treatment should provide as a minimum: effective and efficient operation of the organization, effective internal controls and compliance with laws and regulations. [10]

Having identified and evaluated the risks in the previous steps of our risk assessment, the next step involves the identification of alternative appropriate actions for managing these risks, the evaluation and assessment of their results or impact and the specification and implementation of treatment plans. In general, the cost of managing a risk needs to be compared with the benefits obtained or expected. Treatment plan can be done for each crucial factor generally for a category, or for a quadrant. Risk treatment options are shown in Fig. 6. Management or treatment options for risks expected to have positive outcome include. The future work of the paper includes development of treatment options for each critical factor.

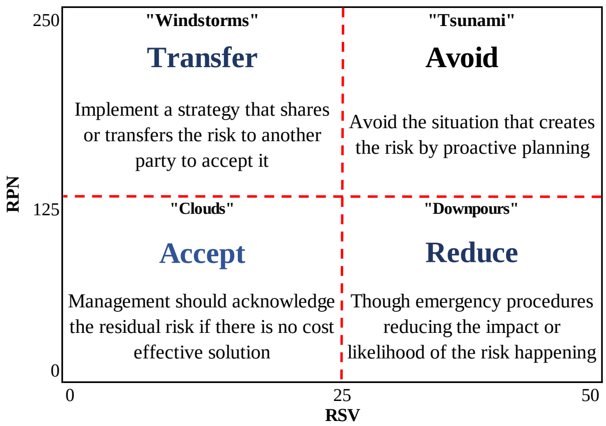


***Fig. 6.*** *Risk Treatment Options.*

### 3.5. Risk Monitoring and Review

Effective risk management requires a reporting and review structure to ensure that risks are effectively identified and assessed and that appropriate controls and responses are in place. The risk monitoring process should provide assurance that there are appropriate controls in place for the organization’s activities and that the procedures are understood and followed. [10]

Monitoring and review are two distinct processes intended to detect change and determine the ongoing validity of assumptions. Both are necessary to ensure that a company maintains a current and correct understanding of its risks, and that those risks remain within its risk criteria.

This stage in risk management requires a systematic approach, integrated into an organization’s management systems, that reflects the speed at which change occurs within the internal and external environment. Tools and techniques for risk monitoring and control are for example: risk audit, variance and trend analysis, technical performance measurement. It could take some time to find which ones suit a business or a project. Risk monitoring is intended to be a systematic, on-going process across the entire project lifecycle.

## 4. Conclusion

The risk management knowledge area is vital to the project management process, and organizations must make an effort to ensure the tools they are using are providing with the required level of insight and value. This study suggests a project management model with the application of risk management principles.

The main effort is to investigate the effectiveness of the advanced risk tool RFMEA method, is based on the FMEA technique, modified for project risk management. Traditional risk assessment tools adopt only a two-dimensional risk-rating matrix to calculate the risk score for project risk factors. Suggested quantitative approach includes one more variable detection factor. The main idea of this study is exact determination risk severity related to the time and cost impact.

The risk assessment begun with the identification of risk factors, that have been divided into 4 categories. Each factor was described by three variables: severity, occurrence and detection. Evaluating both the risk score and risk priority value critical risks were found. For qualitative analysis a risk matrix was designed considering diverse levels of risk’s time and cost impact to the project and organization. It gives an efficient and comprehensive overview of risk factors in R&D project. By determining for each critical risk factor called “tsunami” its time and cost overrun, was defined expected increase in project duration and the expected cost overrun of the project.

To prevent company`s big losses quantitative and qualitative analysis requires immediate risk response planning. A matrix of risk treatment options for every category is suggested. But because each factor is specific and has different variables risk treatment plan requests a project management model. To help the management in project making objective decisions this approach should be exact and analyze detailly effect on various activities and responses. This is an opportunity for further research in this area.

The future work on the project includes detailed risk treatment responses that refers to the most prioritized risk factors. The responses will be chosen by the least impact of the project to the engineering companies. Both the time and cost impact, that define severity of a risk, will be converted as exact as it is possible to the expected money value. Once we will have chosen treatment suggestions with the least expected money value, the right risk treatment system will be composed.

Current contribution of this paper and proposed risk management methodology is that engineering manager can use this tool and format as a simplex way to keep one’s eye on project and arrange risks. The provided information and risk assessment can be used to improve project success by focusing on key risks. The main reason of project is interrelated with the idea that risk management process in an organization must become part of the culture.

## Acknowledgment

This work was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS17/178/OHK2/3T/12 - Modern cost management instruments.

## List of symbols

| | |
|---|---|
| D | detection value |
| P | probability value |
| RPN | risk priority number |
| RSV | risk score value |
| S | severity value |
| $p(x)$ | probability |
| $X$ | random variable |
| $\mu_r$ | the $r^{th}$ moment about the mean of $X$ |
| $\mu_2$ | second central moment |
| $\mu`_r$ | the $r^{th}$ moment of $X$ |

## References


[1] Claypool EG, Norman BA, Needy KL (2015) *Design for Supply Chain: An Analysis of Key Risk Factors*. Ind Eng Manage 4:156. doi:10.4172/2169-0316.1000156

[2] Galway, Lionel A., *Quantitative Risk Analysis for Project Management: A Critical Review*, Santa Monica, Calif.: RAND Corporation, WR-112-RC, 2004.

[3] Gassmann, O., & Han, Z. (2004). *Motivations and barriers of foreign R&D activities in China.* R&D Management.

[4] Luppino, Ricky & Hosseini, M. Reza & Rameezdeen, Raufdeen. (2014). *Risk management in research and development (R&D) projects: The case of South Australia. Asian Academy of Management Journal*. 19. 67-85.5

[5] Garcia, A., and E. Gilabert. *Mapping FMEA into Bayesian Networks*. International Journal of Performability Engineering, 2011.

[6] Carbone, T. A., & Tippett, D. D. (2004). *Project risk management using the project risk FMEA*. Engineering Management Journal,

[7] Mastroianni, S. A. (2011). *Risk management among research and development projects.* Unpublished Master’s thesis, Lehigh University.

[8] Bongiorno, Jim, *Use FMEAs to Improve Your Product Development Process,”*PM Network, 15:5 (May 2001).

[9] Canavos, G.C. *Applied Probability and Statistical Methods*, Little, Brown and Company, 1984.

[10] Institute of Risk Management/National Forum for Risk Management in the Public Sector/Association of Insurance and Risk Managers (2002) *A Risk Management Standard.*

[11] Dobrovolschi, O.: *Hodnocení rizika při přípravě podnikatelského projektu.* In: Konference Studentské Tvůrci Činnosti. Praha: ČVUT v Praze, Fakulta strojní, 2017, ISBN 978-80-01-06143-5.