

Quantitative Method of Ex-Ante Project Risk Assessment Based on Checklist Method

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Abstract

Risk is an issue of interdisciplinary character and accompanies all actions undertaken in companies, e.g. projects. Identification and assessment of risk is an important issue, but at the same time it is particularly difficult in actions of unique character such as projects. This article identifies exogenous and endogenous risk factors that affect successful project implementation. Six risk-generating areas were defined to identify and assess ex-ante risks in the project: project environment, client and contract, suppliers, organization maturity and a project team. Each one of them was assigned analytical criteria and a method for their assessment. Empirical verification was made based on an example of a manufacturing process. The proposed method is a support for project managers in a process of decision-making and for actions undertaken by managers aimed at reduction of risk in a project, especially at a stage of its preparation.

Keywords

Project management, Production planning and control, Procedures for process planning, Production activity control, Process supervision, Risk assessment.

Introduction

Risk is associated with various actions taken by people over the centuries. Many risk-generating factors influence the assessment of these actions and their results. Generally, one may differentiate between routine actions, i.e. to a certain degree repeatable, standardized actions versus non-routine, unrepeatable actions, such as projects (Kozień, 2018c; Kozień & Kozień, 2018d; Kozień & Stanuch, 2024). Contemporarily, projects as complex actions are particularly connected with high existential risk of the technical, organizational, financial character as well as a question of prestige (Trocki et al., 2013). In reference to project management the risk constitutes the integral part of understanding the essence of a notion of a “project” and managing it. For a project management the risk means a possibility of occurrence of uncertain incidents, which may have impact not only on the management process efficiency, but also on decisions of undertaking or abandonment

of the project implementation. In particular, the identification and ex-ante assessment of risk is a key element of risk management in a project in the initial phase of its implementation. Impact of risk on project implementation may concern not only negative but also positive aspects of actions. Risk assessment performed in various moments of project implementation and in varied scope makes it possible to foresee incidents in the future which may but do not have to occur. When deciding to proceed with the project, the project manager should use the methods supporting the process of identifying and ex-ante risk assessment in the project, in order to determine the acceptable risk, and to take measures to limit its impact in the context of the project’s success.

Each human action, including actions performed in a form of a project, is accompanied by risk. Project in professional literature is commonly interpreted as a goal-oriented enterprise, unique, complex and temporary (PMBOK Guide, 2021; Turner, 1993; DeMarko, 1998; Verzuh, 2012; Craig, 2012; Jakoby, 2015). Risk in a project is particularly connected with the characteristics of uniqueness. The more unique the project, the higher the risk, as well as the needs of its identification and assessment. Risk in a project is also generated both by exogenous as well as endogenic factors. An issue of risk assessment in a project is a difficult and

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complex problem. The undertaken research problem connected with ex-ante risk assessment in a project requires the context-based approach. Risk identification in a context-based approach refers to key elements referring to the examined project milieu, maturity of an organization as well as of the project itself. Generally, it can be stated that the risk is connected with the occurrence of uncertain incident or incidents, which have impact on achievement of a goal (Verzuh, 2012; Jakoby, 2015; PMBOK Guide, 2021; Tahir et al., 2008; Franke et al., 1998; Burke, 1999; Khan et al., 2021), as well as a formation of basic parameters of a project. The risk in a scope of the project goal may be connected with certain deviations and mean its partial achievement or may put its achievement at risk (Romeike, 2018; Romeike et al., 2020; Haller, 1978; Krieg, 1978; Beyeler, 1994). However, the occurrence of uncertain events in a scope of parameters of the so-called project triangle in practice means the exceeding of a deadline and/or the budget. In this context the consequences of the risk occurring in the project are considered. This situation refers to unfavourable impact on implementation or a result of a project as a consequence of occurrence of uncertain incidents, and even the abandonment of its implementation. The incident may occur or may not appear, but if it does, it impacts the effective implementation of a result of the project. This impact, in a context of negative concept, may have only negative dimension, identifying the risk solely with a threat, damage, loss (Wilson, 2005), while in the neutral concept, risk is neither a negative nor a positive phenomenon (Jajuga, 2007), its occurrence may cause the obtained result of an action to be different than expected (Kaczmarek, 2002). Another result of action, compliant with the positive concept, also means the chances of obtaining a positive result (Hopkin, 2013).

Risk assessment in a project should begin with indication of risk-generating areas. In a scope of inter-action of external and internal factors one could identify the areas of mutual relations among the project environment, project stakeholders, maturity of the organizations implementing the projects as well as a project itself. In a context of discussed problems also the sustainable development concept may be helpful in risk assessment, as well as a principle of sustainable development derived therefrom (Kozień & Kozień, 2018b; Kozień & Kozień, 2019; Kozień, 2021). Identification and ex-ante risk assessment in an initial phase of a project in indicated areas is of a vertical and horizontal character. Identifications of the risk may begin at mutual interaction of the project environment and the project. Project environment according to the DIN project are the conditions, “in which the project is created and is being implemented, which impact

the project and are subject to its impact” (DIN, 2000). Adopting a criterion of mutual relationships of a project and its environment one may differentiate between the external and internal project environment. However, taking into account the intensity of relations in the scope of external project environment one may differentiate the distal external project environment with indirect impact (political, legal, economic, social, technological, natural) also defined as global environment (Schreyögg, 1993), as well as the proximal external project environment which is formed by regulators (international and national institutions), suppliers, recipients, with direct impact on the project. However, in the scope of the internal project environment one may differentiate between intra-organizational and intra-project environment. The internal relations of project environment and the project may generate risk. Firstly, the risk may arise from the dynamics of changes of external changes. Secondly, the best interests of interested external and internal stakeholders may be breached in the scope of impact on a process of preparation, a course of the project and its results. Thirdly, a risk-generating factor may be a result of a lack of institutional support in the national as well as international dimension (Kozień et al., 2018a).

Progressing to the legal dimension of an analysis of the client and contract relations one may state that implementation of projects is connected with appropriate legal regulations at the level of the international, European Union, national and local law. Moreover, it requires the existence of a defined legal relationship between the entity obliging other entity to implement a given project. The entities implementing projects or obliging other entities to implement projects may be both the public law entities as well as the private law entities. Depending on the above, the relationship joining these entities may be of public and legal or private and legal character, or this relationship may have a form of sui generis hybrid by regulations connected with the so-called public and private partnership (Sharma et al., 2014; Heinz, 1999; Samii et al., 2002; Tang et al., 2010). Regardless of the above considerations, it should be pointed out that generally between two entities a legal relation of obligatory character is formed, at the source of which there is a contract between two entities. Contracts are the most frequent source of forming obligatory relations (Wolter et al., 2001). Not delving into details of the contract forming methods, its period of validity and a possibility of an amendment, termination and expiration of a contract, one should indicate that the unanimous statements of will of the entities will be of key character for each contract (Wolter et al., 2001). In case of private legal contracts concerning the imple-

mentation of projects usually will have a character of mutual contracts, assuming the equivalency of benefits (Radwański et al., 2016). Also, the freedom of contracts and its scope will be of key importance in this respect, which is restricted by statutory regulations, principles of social interaction as well as the very nature of a given obligatory relation (Radwański et al., 2016). Contracts in a scope of project implementation, also in a scope of public and private partnership, may bear the risk (Nisar, 2007). Firstly, this risk may refer to the very process of concluding contracts, so therefore the honesty of both potential parties, which from a legal perspective may transform into the so-called culpa in contrahendo (Radwański et al., 2016). Secondly, the risk may be connected with the performance of the obligatory relation pursuant to the agreement, so therefore an issue of performance and the undue performance of a contract, which may be under the influence of factors of endogenic or exogenous character. Thirdly, the risk is connected with improper construction and preparation of a contract both with a formal as well as the material (contents-related) aspect in mind and may not meet the criteria of an obligatory character. Fourthly, the risk may be connected with excessively rigid or overregulated character of a contract, which does not allow for adjustment to dynamic variables during the project implementation, but on the other side the risk may be connected with too general a character of the contract, which may cause the failure of project implementation in compliance to the intention of the entity obliging to perform the project. It should be emphasized, too, that the risk connected with the conclusion of contracts for project implementation may appear on the sides of all parties to the contract, so therefore an entity obliging to perform the contract as well as contractors implementing a given project. As a consequence, one may notice that the risk connected with a contract concerning the project implementation may appear at every stage of conclusion of a contract or in a period of validity of an obligatory relationship and may depend on the parties or to be completely independent from the will of the parties, and also may take a form of a risk connected both with formal and material aspects of the contract.

Another factor which has impact on reduction of risk in a project is the project maturity defined in a scope of an organization as sensitivity whereas in a scope of a process it is perceived as a capacity of an organization to implement processes connected with project management (Kerzner, 2004; Ibbs et al., 2004) using professional tools. In practice, the lack of project maturity of an organization may generate risk arising from: a lack of differentiation of operational activity and specifics of a project, as well as a failure to develop a cohesive

methodology of project management, where improvisation and chaos in action dominate, therefore the success is unpredictable. This is why the measurement of project maturity is so important in a scope of human resources, project environment, method of project management and project knowledge management (Spalek, 2013). Modeling and assessment of project maturity of an organization reduces the project risk.

A project itself as an enterprise of a unique character as well as a process of managing the project generates threat, which have impact on its effective implementation. In an aspect of project planning the sufficient significance is attached to a definition of a goal and its basic parameters. A proper cost-estimate related to a project is an element which is important from the point of view of its commencement, and exceeding of a certain budget may increase the risk of failure of its implementation. Problem with estimating the project budget may be a result of underestimating or disregarding the costs of operational risk management in the project budget, which is estimated on the basis of performance of specific project works (Frame, 2001; Szyjewski, 2015). Assessment of costs in a project depends on its specificity and a level of innovativeness, uncertainty connected with budget planning requires the definition of appropriate operational reserve earmarked for risk management. Imprecise or/and unambiguous definition of project requirements may lead to improper interpretation of tasks and in effect to the risk of occurrence of conflict between the assigning party and the contractor. Moreover, the project implementation is conditioned by resources availability which are limited. Especially, in a situation of simultaneous implementation of many projects managers must take into consideration the restricted resources of organizations, therefore there is a necessity of establishment of task implementation priority in particular projects (Kozarkiewicz, 2012). Problems with allocation of resources may significantly contribute to a delay and/or exceeding the costs and/or deviation from the planned quality. The significant issue in a scope of human resources is a selection of project team members at a project planning stage (Kozarkiewicz, 2012). Reaching a specific project result is possible owing to suitable knowledge, experience and skill of cooperation between the team members. An issue of forming a project team and selecting its members is widely described in professional literature in the dimension of creating project culture (trust), a tendency to exchange and acquire new knowledge as well as a risk appearance of conflicts with various backgrounds. The risk may be identified on the plane of exchange of knowledge what has impact on any difficulties in the enterprise implementation. Improperly selected project

team as well as lack of integration may threaten the implementation of specific tasks of a specialist character (Twardochleb, 2014), for reason of a lack of appropriate skills of team members. A project team has impact on effective implementation and finishing of the project (Scott-Young, 2008; Troanca, 2011). Another threat to the analyzed area is a lack of effective communication both among the project team members and project stakeholders, what impacts on formation of tensions and conflicts arising from a problem of access to information and leads to the decrease in efficiency of a team. Another significant factor threatening the project implementation within the deadline includes too high employee rotation in which new members of a team may be mismatched to the existing project team. Each employee possesses an individual scope of characteristics, skills or experience, for whom the allocation of appropriate tasks and actions should be a conscious choice by a team manager.

In the literature on risk analysis, it is possible to find many approaches to their identification and qualitative or quantitative assessment. However, these methods are usually dedicated to a specific type of project, especially related to a specific industry. Therefore, they are dedicated methods. For example Krechowicz et.al. (2022) describes the risk evaluation results of the FMEA and a Pareto–Lorenz analysis for 14 external risk factors in horizontal directional drilling technology. Borecki (2022) focuses on the analysis of selected risks as part of investments in the power engineering at the initial stage of the life cycle of the project. Both of these sample approaches are very accurate, but dedicated to specific types of projects.

The research objective of the paper is the emphasis of the significance of identification and ex-ante risk assessment in the project in the initial phase of its preparation as a significant aspect of efficient project management. In the article the following thesis was formulated: ex-ante risk assessment contributes to efficient achievement of a goal and results. It is proposed to use the described universal quantitative method in this case.

Materials & Methods

Risk assessment

An issue of the risk assessment in a project is an important but at the same time a current problem for research, which a subject of an academic discourse among researchers. The dynamics of the environment has impact on efficient project implementation, a project being a unique risk-bearing action. In this context, an issue of risk assessment in a project gains particular significance.

Research methodology of the ex-ante risk assessment in a project includes the following stages:

1. Stage 1 – Defining the goal and subject of an assessment.

The formulated general research methodology of ex-ante risk assessment in a project, refers to the specification of a goal and subject of research. The research goal is ex-ante risk assessment in a project, however the subject of assessment are the projects which are in an initial phase of their preparation.

2. Stage 2 – Identification of risk-generating areas and criteria in a project.

The identified areas and criteria in the project are the result of the diagnosis of exogenous and endogenous factors that may threaten the effective implementation of the project. On the other hand, the identification of areas, as well as the compilation of detailed analytical criteria within the identified areas, is intended to facilitate the ex-ante risk assessment of the project.

3. Stage 3 – Development of general and detailed assumptions of a method and defining a method of ex-ante risk assessment in a project.

Methods developed and specified include: identification of risk generating areas together with differentiated analytical criteria as well as definition of a qualitative and quantitative approach, as well as an attempt to ex-ante risk assessment in a project.

4. Stage 4 – Ex-ante partial and complete risk assessment in a project.

Result of the ex-ante partial and complete risk assessment in a project aims at definition of actions restricting the impact of risk on efficient implementation and success of a project. Ex-ante risk assessment at an initial stage of project means effective use of active approach to risk management in a project.

Uncertain incidents have impact in a defined period of time or they arise from a specific challenge (Adams, 1995) such as projects. Therefore, the risk assessment in a project may be performed in various moments of its implementation. Adopting a cycle of project implementation, simplified down to three phases, the following moments of risk assessment in a project may be distinguished (see Fig. 1):

- ex-ante risk assessment which should be performed in an initial phase of project preparation,
- on-line risk assessment, which is proper for its phase of implementation,
- ex-post risk assessment performed after the project implementation.

Taking into account the entire picture, an issue of the risk assessment in a project is important in each phase of its implementation. However, one should emphasize

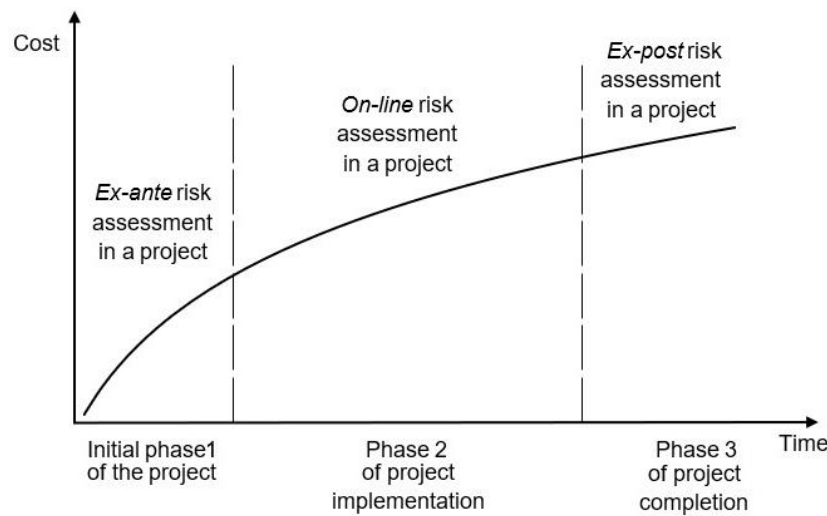


Fig. 1. Risk assessment in a project in reference to the phases of its implementation

that the identification and assessment of uncertain incidents is of key importance already in an initial phase of its preparation, in a context of a managerial decision concerning the undertaking or abandonment of project implementation. Ex-ante risk assessment in an initial phase of the project makes it possible to apply an active approach, i.e. preemptive, so therefore in effect reducing its negative impact on the project implementation in its subsequent phases in a context of its success, whereas in a phase of project implementation the on-line risk assessment means undertaking actions restricting the impact of risks identified in an initial phase, and also monitoring and identification of new kinds of risks in relation to which the reactive actions are undertaken. Ex-post risk assessment in a project makes it possible to evaluate the actions and applied strategies in relations to the identified risks in a context of closing the project, as well as implementation of subsequent projects in the future.

Project implementation should bring positive benefits to each of the parties, not only in an aspect of an ordering party or project contractor, but also individual users who will be using the end solutions. External stakeholders of a company (focusing mainly on suppliers) also have a vast impact in project implementation. Risk related to this area refers to the timely performance of the entrusted tasks and the quality of workmanship of a given subproduct or service. Usually, companies expect professional solutions and works of suppliers, whose reliability has vast impact on the end effect of the project. The lack of appropriate cooperation with the supplier may translate to the implementation of incomplete product and prolong its implementation deadline. Therefore, while assessing

project risk assessment it is important to take into consideration certain aspects arising from cooperation with suppliers. One should analyze current suppliers, check whether the timely delivery of services is realistic, check their willingness to cooperate regarding a specific issue and to verify the references of particular suppliers. The important element in relation to cooperation with suppliers is an aspect connected with a list of reliable suppliers, allowing a company to specify the conditions of cooperation and appropriate relationship with suppliers in a scope of a project being implemented.

Ex-ante risk assessment in a project with a checklist method

Assessment means value or estimate, valuation of something and is of a valuing character referring to norms, adopted and effective standards, as well as benchmark system of assessments (Dictionary, 1979). Such generally formed definition of a notion “assessment” regarding a project requires making its scope, duration and specification of a tool more precise. Here, it should be emphasized that in practice one cannot eliminate the risk, but based on its assessment, the actions restricting or securing its negative influence on the effective project implementation. Moreover, based on the conducted project risk assessment, a decision may be undertaken concerning its implementation or abandonment. Making a decision by a decision-maker on project implementation on a basis of ex-ante risk assessment in an initial phase of its preparation makes it possible to identify the incidents which may have real impact on reaching the goal, timeliness, quality as well as the adopted project implementation budget

(Aven, 2015). However, a decision on project abandonment does not mean that no actions had been undertaken, what is not equivalent with not undertaking them in the future. Project abandonment means withholding actions. It should be clarified that withholding any actions may be also analyzed on the legal basis and concern a moment before or after contract conclusion. Progressing to implementation of the formulated research objective, as a result of critical analysis of professional literature in a scope of project risk assessment methods, the Bradley method (Bradley, 2003) was expanded and specified. Author's elements of the method which have been modified, concern making the moment of risk assessment in a project. It was assumed that identification and risk assessment in a project is important at every moment of its implementation, but it is of key importance in an initial phase of its preparation (ex-ante risk assessment in a project). A list of analytical criteria helpful in ex-ante risk assessment in a project was expanded. Bearing in mind the significance of both exogenous as well as endogenic factors, a new area of ex-ante risk assessment concerning project environment was proposed. Moreover, apart from comprehensive ex-ante risk assessment in a project – a partial ex-ante risk assessment for particular six distinguished areas was proposed, in order to precise specification of risk-generating area/areas.

The prepared checklist method serves for ex-ante risk assessment in a project and is based on the following eleven assumptions:

1. Uncertain incidents always accompany project implementation, therefore there is a need to identify and assess them.
2. Risk assessment in a project is performed in an initial phase connected with its preparation, therefore it is defined as ex-ante risk assessment in a project.
3. The method is of quantitative character.
4. Ex-ante risk assessment in the project is multi-criteria.
5. Analytical criteria of ex-ante risk assessment in the project are grouped in a scope of six distinguished areas: project environment, client and contract, suppliers, project maturity of an organization, project characteristics, a team participating in the project (Bradley, 2003).
6. A number of analytical criteria according to which the ex-ante risk assessment in a project is made, amounts to 50 and is shaped in the following way for the distinguished six areas:
 - project environment – 7 criteria ($N_1 = 7$);
 - client and contract – 8 criteria ($N_2 = 8$);
 - suppliers – 6 criteria ($N_3 = 6$);
 - project maturity of an organization – 4 criteria ($N_4 = 4$);
 - project characteristics – 17 criteria ($N_5 = 17$);
 - project team – 8 criteria ($N_6 = 8$).
7. Ex-ante risk assessment in a project includes: a comprehensive assessment defined for a project and a partial assessment calculated for the distinguished six areas.
8. A basis for the comprehensive ex-ante risk assessment in project which is performed by the calculation of the value of the total project risk coefficients (R_B) is answering to 50 analytical criteria ($s = 1, 2, \dots, 50$) assessed by giving a value of ex-ante risk assessment for a single criterion p_s in a scale from one to five in a discrete way, referring to natural numbers. Analytical criteria are connected with six areas: project environment, client and contract, suppliers, project maturity of an organization, project characteristics, a team participating in a project. Bradley recommends the adoption of an appropriate weight for each of the criteria w_s , simultaneously proposing the scope of variability of values of these weights. In such a formula the value of comprehensive project risk coefficients R_B is calculated according to the formula (1) (Bradley, 2003).

$$R_B = \frac{\sum_{s=1}^{50} p_s w_s}{\sum_{s=1}^{50} w_s} \quad (1)$$
9. The formulated method of ex-ante risk assessment in a project will not make it possible to identify the risk in particular areas, and the value of each of the criteria is weighed only comprehensively, although the number of criteria in each area proposed by Bradley varies. In order to avoid these problems the generalization of Bradley's method was proposed, by introduction of partial coefficients of risks for the distinguished six areas of the project R_j ($j = 1, \dots, 6$) (2) and values of comprehensive project risk coefficient R calculated as arithmetic average from partial risk coefficients for distinguished areas (3). Such a definition of the comprehensive project risk coefficient better reflects the contribution of individual areas when a number of criteria within the distinguished areas clearly differ from each other. In the proposed approach the values of appropriate weights w_{ij} are adopted for i -th criterion from j -th area, ($i = 1, \dots, N_j$), which may adopt any values from the range [1,5] (Likert, 1932; Geoff, 2010) where N_j means an approved

number of criteria for j -th area and the values of risk assessment are defined for a single criterion r_{ij} . With this process a condition (3) is fulfilled.

$$R_j = \frac{\sum_{i=1}^{N_j} r_{ij} w_{ij}}{\sum_{i=1}^{N_j} w_{ij}} \quad (2)$$

$$\sum_{j=1}^6 N_j = 50 \quad (3)$$

$$R = \frac{1}{6} \sum_{j=1}^6 R_j \quad (4)$$

Defining the comprehensive project risk R parameter as the average of partial risk coefficients R_j , which in computational practice is the average of the average of suitable values, can lead to slightly biased results, especially when the number of criteria in each area varies significantly between areas. Therefore for parallel estimation and verification of the value of comprehensive risk R , the new parameter of the total project risk R_T can be defined in the form of the formula (5). The definition of the total risk parameter does not take into account the groups of risks.

$$R_T = \frac{\sum_{j=1}^6 \sum_{i=1}^{N_j} r_{ij} w_{ij}}{\sum_{j=1}^6 \sum_{i=1}^{N_j} w_{ij}} \quad (5)$$

10. Partial ex-ante risk assessment in a project is calculated as the value of partial coefficient of R_j risks for the distinguished six areas and is a basis for classification of the risk implementation policy in particular areas as proposed by Bradley (Bradley, 2003):

- low risk – for the resulting value of coefficient below 2.0
- moderate risk – for the resulting value of coefficient from the range [2.0, 2.2]
- high risk – for the resulting value of coefficient from the range (2.2, 2.6]
- very high risk – for the resulting value of coefficient above 2.6

This approach can be identified as fuzzy assessment.

11. Comprehensive ex-ante risk assessment in a project is calculated as the value of comprehensive coefficient of the risk in a project R and is a basis for classification of a project as proposed by Bradley (Bradley, 2003) and given above in point 10 for partial assessment.

In the method developed by Bradley (Bradley, 2003) the Likert scale was applied (Likert, 1932), hence the value “two” was adopted as the neutral value of risk. The bottom borderline value for low risk is “one”, and the upper value of high risk is “five”. The value “two” means the risk “within the norm”, called the moderate risk. The expanded checklist method included fifty risk factors, formed descriptively and referring to various areas, which impact the efficient project implementation. Risk assessment for each coefficient is calculated subjectively by quotation of values of parameters of the descriptive risk analysis r_{ij} (or p_s), $i = 1, \dots, N_j$; $j = 1, \dots, 6$, $s = 1, \dots, 50$; which adopt the values from one to five pursuant to the above comment. The considered factors have various kinds of impact on project implementation. Therefore, the weight coefficients are introduced for factors w_{ij} (or w_s), by determination of subjective values of significance of a factor for a given project among the range of values referred to in the checklist method. The best results are obtained when the checklist is modified to include the business, culture and type of project (Bradley, 2003).

The determined resulting value of project risk coefficient R is a basis for classification of a project pursuant to the risk assessment in the project presented above according to Bradley (Bradley, 2003).

Results

The proposed checklist method was applied for the ex-ante risk assessment in a manufacturing project. The project is connected with modernization, which concerns the subprocess of food product packaging. A scope of a project refers to a change, food product packaging process, which involves a change of manual packaging with an automated process. The ex-ante risk assessment in the analyzed project was conducted in an initial phase of preparation of a process modernizing a product packaging process, which is to be prepared and implemented in a company. Performing a risk assessment is crucial from the perspective of minimizing its impact on the success of implementation (Bradley, 2003).

In Tab. 1 the ex-ante risk assessment was done according to the criteria gathered in six areas taken into consideration in the checklist method.

Table 1
Criteria of risk assessment, their weights and values for analysed manufacturing process

s	i	Low risk descriptive assessment ($r_{ij} = 1$)	High risk descriptive assessment ($r_{ij} = 5$)	r_{ij}	Scope [0-10]	w_{ij}
PROJECT ENVIRONMENT ($j = 1$)						
1	1	Predictable changes occurring in the distal external project environment or macro-environment (political, legal, economic, social, technological, natural)	Unpredictable significant changes occurring in the distal external project environment or macro-environment (political, legal, economic, social, technological, natural)	3	2–7	4
2	2	Predictable changes occurring in the proximal external project environment (regulators [international and national institutions], suppliers, recipients)	Unpredictable significant changes occurring in the proximal external project environment (regulators [international and national institutions], suppliers, recipients)	4	5–9	8
3	3	Predictable changes occurring in the intra-organizational project environment	Unpredictable significant changes occurring in the intra-organizational project environment	3	3–7	6
4	4	Predictable changes occurring in the intra-organizational environment	Unpredictable significant changes occurring in the intra-organizational environment	2	2–6	4
5	5	Involvement and positive impact of external stakeholders	No involvement of external stakeholders	4	6–9	8
6	6	Involvement and positive impact of intra-organizational stakeholders	No involvement of intra-organizational stakeholders	2	3–7	7
7	7	Involvement and positive impact of intra-project stakeholders	No involvement of intra-project stakeholders	1	3–7	7
CLIENT AND CONTRACT ($j = 2$)						
8	1	Institutional support of international organizations	No institutional support of international organizations	3	3–7	7
9	2	Financial support of international organizations	No financial support of international organizations	4	6–9	9
10	3	Institutional support of state/ local administration bodies	No support of state/ local administration bodies	2	4–8	4
11	4	Financial support of state/ local administration bodies	No financial support of state/ local administration bodies	3	5–8	6
12	5	Client as the ordering party shows full understanding of the requirements of the project and their effect	Client as the ordering party shows weak understanding of the requirements of the project and their effects	3	6–9	8
13	6	No changes in current solutions at the client's will be necessary	Changes in current solutions at the client's will be necessary	2	4–9	5
14	7	Formally the conditions are agreed in a contract	No formal contract was concluded	1	5–8	8
15	8	Contracts are concluded with a client in the past were successful	In the past there were problems with the client and former contracts	2	2–5	2
SUPPLIERS ($j = 3$)						
16	1	Suppliers are known and approved and they have good references	New, unverified suppliers who not much is known about	4	6–9	7
17	2	A company has a list of credible suppliers	A company does not have a list of credible suppliers	4	6–9	6

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s	i	Low risk descriptive assessment ($r_{ij} = 1$)	High risk descriptive assessment ($r_{ij} = 5$)	r_{ij}	Scope [0-10]	w_{ij}
18	3	Supplier has a project management system based on a selected general or specialist methodology	System of management of supplier's project is organized on as needed basis and indeterminate	4	6-10	9
19	4	A contract with a supplier was concluded	Only informal arrangement was concluded	2	5-7	7
20	5	Supplier possesses a system of guaranteeing appropriate quality	Supplier has not implemented the quality guaranteeing system	2	3-6	4
21	6	Supplier's professional work is expected	It is not possible to evaluate the supplier's future work on account of the lack of information	3	4-7	5
PROJECT MATURITY OF AN ORGANIZATION ($j = 4$)						
22	1	There is a managerial and organizational system supporting project management	There is no managerial and organizational system supporting project management	3	7-10	8
23	2	Management practices the commonly applied human resources management standards	No defined standards of human resources management	1	3-7	5
24	3	Project team introduces project management standards (methods and methodologies, time, quality, cost, risk management, agile management)	Project team does not introduce any project management standards	3	6-10	9
25	4	A system of knowledge management (knowledge base) exists	There is no knowledge management system	2	4-8	7
PROJECT CHARACTERISTICS ($j = 5$)						
26	1	The requirements are or will be well-defined and documented by a client	The requirements are indeterminate and undocumented	3	5-9	7
27	2	Project scope is fully agreed upon	Project scope changes	3	4-8	6
28	3	Planned quality is defined by project requirements	Planned quality has not been determined by project requirements	3	4-7	7
29	4	Typical project with a single life-cycle	Many interdependent life-cycles of a project	4	5-7	5
30	5	Final product of a project without or with a small number of novelty functions	Pioneer solutions are tested in a project	4	5-8	8
31	6	Equipment installed within a project is well-known and tested	Equipment is not tested, its use uncertain	4	5-8	6
32	7	Current, main operations will be subject to changes arising from a project to a small degree	Significant impact of a project on the current and main operations	3	4-7	5
33	8	There will be no need of significant changes in the existing technical standards	Large changes in existing technical standards will be necessary	3	4-7	7
34	9	Concurrently there is a small number of developmental works are conducted	Paralelly with a project there are other developmental works being conducted	2	3-7	4
35	10	Low dependency on developmental equipment being beyond control of project team	High dependency on developmental tools being beyond control of project team	3	4-7	6

Table continued at the next page

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s	i	Low risk descriptive assessment ($r_{ij} = 1$)	High risk descriptive assessment ($r_{ij} = 5$)	r_{ij}	Scope [0-10]	w_{ij}
36	11	Little or no limitation on project completion dates	The client has specified the binding project completion date	4	6-9	8
37	12	Plans and estimates are or will be based on accurate data coming from similar projects	Plans and estimates are or will be based on inaccurate data	3	4-7	6
38	12	Estimates were prepared according to verified documented standards	Estimates were prepared according to unverified standards	3	4-7	5
39	14	This is the first or subsequent approach to project – no earlier failures	There have been already several attempts to develop this project – there is a history of failures	2	3-5	4
40	15	Only several departments of a client's organization will experience end results of a project	Many departments of a client's organization will experience end results of a project	3	4-7	4
41	16	Project implementation will have only a small impact on a client's everyday activity	Project implementation will have large impact on a client's everyday activity	2	3-7	5
42	17	Developed and understandable project management standards are available to a project team	Few project management standards are available to project team members	3	5-8	7
PROJECT TEAM ($j = 6$)						
43	1	Anticipated readiness of project team and client for cooperation	Anticipated low involvement of project team and client in the project	2	6-9	8
44	2	High quality of project team, knowledge, experience and competences are compliant with project requirements	Inexperienced project team without appropriate competences defined by project scope	3	7-10	9
45	3	Project team performs tasks connected solely with a project	Project team performs tasks connected not only with the project	2	3-6	4
46	4	Low turnover of project team members, experts' participation	Frequent changes among project team members arising from their incompetence	1	3-6	5
47	5	Building project culture based on trust	No need to create project culture	2	5-7	7
48	6	Tendency to exchange information and knowledge among project stakeholders	No tendencies to share information and knowledge among project stakeholders	3	6-9	8
49	7	Efficient communication system	Low efficiency of communication system	2	7-10	9
50	8	Creative character of conflicts	Destructive character of conflicts preventing project implementation	3	4-7	6

Discussion

Based on assumed values of weights w_{ij} and obtained values of risk assessment r_{ij} the values of partial ex-ante risk assessment and comprehensive ex-ante risk assessment in a manufacturing process were obtained and is shown in Tab. 2.

In the analyzed case, the total ex-ante risk of project implementation is very high. Analyzing partial risks, it should be noted that in the scope of areas with very high risk, there are two whose measures exceeded the value of three (suppliers, characteristics of a project), and two slightly exceeded the limit value of the ex-ante high risk assessment (project environment, client and contract). For areas project team and maturity

Table 2

Comprehensive and partial results of ex-ante risk assessment in a manufacturing process using a checklist method

Risk areas and risk parameters	Value	Risk description
Project environment (R_1)	2.80	very high risk
Client and contract (R_2)	2.66	very high risk
Suppliers (R_3)	3.29	very high risk
Maturity of an organization (R_4)	2.41	high risk
Characteristics of a project (R_5)	3.14	very high risk
Project team (R_6)	2.32	high risk
Comprehensive risk (R_T)	2.77	very high risk
Total risk (R)	2.82	very high risk

of an organization the ex-ante risk assessment is high. This means that the project manager must apply an active approach to risk management at the time of the decision to start the project. In the event of significant threats, the project should be stopped.

The checklist method is of universal character, what means that a number of areas in risk assessment in a project may be expanded similarly like a list of analytical criteria included in their scope. The specified analytical criteria of ex-ante risk assessment in a project may change on account of the project specification. Risk assessment is best if the proposed checklist and, in particular, the values of the weights reflect the specificity of project. A benefit of this method is a possibility to perform ex-ante risk assessment in a project at a stage of its preparation and also it may serve for on-line assessment of risk in a project, however after current supplementation of new possible risks appearing in a project. Another benefit refers to supplementing of a comprehensive ex-ante risk assessment in a project with a partial ex-ante risk assessment in a project for particular areas and it makes it possible to undertake appropriate actions and decisions which aim at effectiveness of project implementation and effectiveness in reaching goals and possible benefits. Project manager, based on comprehensive and partial ex-ante risk assessment in a project may define a strategy of proceeding towards the identified risk in a project, i.e. to take up a decision on its approval, avoidance, security, transfer or reduction. Also, a benefit of the ex-ante risk assessment in a project is a possibility to make adjustments of basic parameters of a project in an initial phase and its implementation what is difficult but possible, however in a phase of project closing becomes unfeasible.

Conclusions

Diagnosing of uncertain risks in a project is of key importance in praxeological dimension, i.e. the assessment of effective project implementation as well as reaching the goal (goals) of a project. Therefore, a special importance is attached, pursuant to concepts of risk formed in professional literature, to ex-ante risk assessment in a project in a context of its success. It should be emphasized that ex-ante risk assessment in a project is a difficult and at the same time important issue, especially in reference to projects which as unique and complex actions are challenges requiring professionalization of management. Identification and ex-ante risk assessment is both a key as well as critical element of project management, on one hand making it possible to undertake appropriate remedial measures and provision of lasting benefits arising from project implementation contributes to its success, however on the other hand by abandonment of these actions and the lack of expected benefits it is a failure. The ex-ante risk assessment in a project allows for using an active approach, i.e. preceding the appearance of various kinds of risk in a project, but not reactive approach, being only a reaction to the existing risks.

The proposed methodology which serves for ex-ante risk assessment in a project is an expansion of a method of risk analysis in a project according to Bradley (Bradley, 2003). The methodology is of universal character and may be developed in the future by the:

- inclusion of additional areas
- change of a number of analytical criteria in particular areas,
- change of values of weights for criteria in the areas,
- adoption of other borderline values for interpretation of a type of risk.

Moreover, the development of a method which serves for ex-ante risk assessment in a project may be a basis to develop software assisting the ex-ante risk assessment in the project.

The novelty of the method is the quantitative ex-ante risk assessment in specific project areas, which makes possible efficient active and reactive risk management in the project. The methods known in the literature so far only concerned the total assessment of project risk and are dedicated to a specific type of project.

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