

THE KNOWLEDGE MAP AS A TOOL FOR INVESTMENT RISK ASSESSMENT IN CONSTRUCTION COMPANIES

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Abstract:

The article deals with issues concerning prequalification of investment risk factors in small and medium-sized construction companies. The previously developed Computer Program KNOWLEDGE MAP for process management in a construction company will be enriched with tools for the identification, pre-selection and analysis of risk factors emerging in the course of implemented processes or planned and executed investments. In the article there are presented the Author's preliminary studies on perception of a potential risk in a building company, which constitute a basis to design a model of risk assessment.

Keywords:

risk factors in a construction company, risk management, surveys on risks in a construction industry

INTRODUCTION

In most cases the specificity of construction output is characterized by the uniqueness of activities in the sphere of preparation, design and implementation of investments. Furthermore, a compromise between the expectations of an investor, a designer and a contractor must be taken into account. It often appears difficult to reconcile conflicting interests of the above-mentioned participants of an investment process. The primary objectives assumed by project organizers, a designer and a contractor, are to respect the envisaged (by an investor) date of the works execution, not to exceed the planned budget and to optimally use available tangible assets and intangible resources. Preparing and performing a project in accordance with the formal and legal

procedures, which are in force in Poland and are repeatedly changed, also significantly affect the course of investments.

Therefore, the proposed model of construction company management according to the Program Knowledge Map developed by the team from the Wrocław University of Technology under the direction of Dr. Eng. Bożena Hoła, Professor at the WUT, allows for analyzing the possibility of making errors.

Due to the specific nature and complexity of an investment process, construction projects are susceptible to errors, thus the analysis of the risk of errors is of great importance for participants of any investment processes. The team from the Wrocław University of Technology under the direction of Dr. Eng. Bożena Hoła, Professor at the WUT, developed the Program Knowledge Map for managing a small or medium-sized company, and in the designed model they included risk factors occurring in the subsequent implementation stages, but they did not specify detailed elements associated with the record and risk assessment.

1. RISK ANALYSIS FOR CONSTRUCTION INVESTMENTS

The concept of risk in the technical literature is defined by determining the level of probability (frequency of occurrence) of certain events evoked by risk factors, and specifying their consequences. In the course of an investment process in the construction industry the use of a model taking a risk into account and determining the consequences of the occurrence of adverse events can meet the demands of a contracting entity.

Running an investment process in the construction industry requires knowledge not only in the domain of construction, but also that related to fields such as law, finance, management and others. A construction investment refers to the area where it is realized rather than to the seat of an executing company, but is also associated with the environment understood as a group of subcontractors, suppliers and construction institutions.

Construction companies seeking to improve the quality of management implement the ISO requirements concerning the issue of quality management in terms of process, which is contained in the standard PN-ISO 10006: 2005 *Quality management systems. Guidelines for quality management in projects*. According to that standard, the procedure involves the following processes: risk identification, risk assessment, determination of procedures related to dealing with risk and controlling it. When adopting the proposed procedure it is not only necessary to identify risks in the following processes, but also regard an appropriate model for assessment of the likelihood of a given factor emergence and its impact on the entire investment process. A model constructed in such a way, implemented by a company, can allow to stay ahead of dangers of risky events, to a greater extent will meet the deadline for an investment implementation and not exceeding its costs. A model of a construction project process due to its multi-dimensional nature is difficult to be qualified as a model of the serial, parallel or hybrid structure.

Legal aspects of risk in an investment process result from the large number of legislative provisions in the form of acts of law (including the construction law, the geological law, the public procurement law, etc.) and regulations appearing in the subsequent stages of an investment. What is more, the administrative procedures accompanying the further steps of the proceedings (applications, permits, approvals and administrative decisions) are time-consuming and oftentimes imprecise, which affects the course of an investment. On the other hand, ignorance and non-compliance with arrangements provided for in the law regulations is reflected in the quality and correctness of claims for relevant administrative decisions and may affect the extension or refusal to issue a given necessary decision. The Authors of the Program KNOWLEDGE MAP noticed that the elements of risk associated with incorrectly prepared documents can be minimized by collecting properly stored documentation templates in the database of the Program, assigned to processes and modified on the basis of current experience.

The aspects of construction project preparation often include other areas, such as protection of monuments and nature or the impact on the environment, which is enshrined in relevant law regulations. An important element is the identification, analysis and presentation of appropriate solutions related to the effect of a given investment on the environment, in particular in the fields of gas emissions and noise levels, sewage disposal systems, producing and managing waste, soil contamination or the level of consumption of natural energy resources. Dealing with risk in this aspect at the investment preparation, design and implementation stages should consist in determining any potentially possible threats, attempting to eliminate them, preventing or taking corrective actions.

The investment process is the result of proper project preparation in formal and legal terms, and also depends on the choice of a suitable experienced contractor, with adequate resource of measures necessary for investment execution. Therefore, it can be assumed that risk factors at the implementation stage are partly linked to risk factors arising at the investment preparation stage. The implementation process generates itself additional risk factors depending on design solutions and technology adopted, an organization method used, as well as appropriate analysis of execution costs.

An important element in a realization process in the construction industry is the qualitative aspect concerning the project documentation and execution of works analyzed in terms of efficiency of technological processes carried out at the building site in relation to resources of a contractor: human resources or assets. After identification of risk factors in that area, the next step should be to apply appropriate management strategies, e.g. by raising qualifications of the personnel, introducing additional training courses, modifying the work remuneration system into more motivating, transferring processes with a high level of risk on suppliers and subcontractors, or using more efficient equipment.

Implementation of construction works belongs to the economic sectors of a high risk of accidents at work, thus, when determining the efficient and safe investment execution it is of significant importance to analyze risk factors associated with work safety and particularly with the loss of health or life. The process of risk treatment in this field

is the same as described above. Having safety hazards specified, preventive actions can be undertaken through the use of appropriate protective measures, training of employees, control over machines operating permissions or application of other technological and organizational solutions at the building site.

The sphere of finance is a very important element while assessing investment efficiency and it is analyzed at every stage of a project, from its preparation including planning in the form of budgets and cost estimations or other financial documents, through the implementation in respect to the settlement between an employer and a contractor, to the final procedural step of accounts for the entire task. As Górecki [1] showed in his publication, elements of risks associated with cost-related subsequent stages of construction investment affect its participants. At the beginning the beneficiary of financial risk is an investor / an employer, after the investment has been prepared and project documentation has been developed, a share of the risk is taken over by a designer, then during the implementation stage the risk also encompasses a contractor, subcontractors and suppliers. Previously made analyses of the financial capacity allow the determination of reserves or shortages that may occur at different phases of a project construction. Such actions may boil down to the transfer of the financial risk onto others (e.g. subcontractors, suppliers), or force to secure the financial liquidity of an investment through lending.

Currently the process approach is used to manage a construction company, with an analysis of risk management processes, which is used in the KNOWLEDGE MAP. The standard PN-ISO 10006: 2005 concerning a project management (p.7.7.1) defines the following processes relating to risk:

- risk identification;
- risk assessment;
- coping with risk;
- risk control.

The overall risk of an investment project can be expressed as the function of the five risk areas:

$$R_C = f(R_P \times m_p, R_J \times m_j, R_\xi \times m_\xi, R_B \times m_b, R_F \times m_f) \quad (1)$$

where:

- R_C – overall risk;
- R_P – legal risk;
- R_J – quality risk;
- R_ξ – environmental risk;
- R_B – occupational safety and health risk;
- R_F – financial risk;
- m_i – weighting of the i^{th} risk area.

Depending on the structure (serial, parallel or mixed) of an investment process the model represented by the formula (1) must be calculated before the final assessment of the overall risk; however it is not the subject of the present work.

Small and medium-sized construction companies employing a little number of technical staff are not interested in the risk identification and valuation of risks, but they need a simple tool to take an appropriate decision while predicting and minimizing risk-related business losses. The proposed tool to deal with the risk being the collection of experiences of many companies provided in the Program Knowledge Map will support the management of a construction company.

The typical procedure related to coping with risk is to select one of the following solutions: taking risks, resignation (risk avoidance), prevention or transferring (risk transfer).

Taking risk by a participant of an investment process largely depends on the location in the process, and whether the entity is an investor, a designer or a contractor. In relation to a given investment, depending on the level of design and implementation difficulty, while taking a risk we can secure ourselves by e.g. insuring a project, setting aside resources, taking predictable and unpredictable events into account, or entrusting more complicated tasks to subcontractors. This requires the use of own experience with providers of services, after due analysis of the realization of research and implementation undertakings, using own experiences and adequately prepared analytical studies.

Resignation, or risk avoidance, should take place in such cases, when taking a given action may generate high losses and at the same time there is room for opting out of the action. This is not always possible when the company independently realizes an investment, then a good solution can be to transfer a given scope of work to a specialized realization unit. Other options that allow for the resignation of risk are structural, technological and organizational changes in a process with a high degree of risk.

Prevention is of similar character, that is the protection (tangible or intangible) of the subject of the contract from the possible occurrence of risk. Most often this is done by appropriate clauses in agreements, concerning for example the accounting for works, conditions of warranty / guarantee, having previously assessed the paying credibility of an entity or introducing technological and organizational activities with less risk level than originally adopted.

Another possibility in the risk management is **the risk transfer to others / transferring**, through e.g. making the appropriate contractual provisions between participants of an investment process, dislocation tasks with a higher risk level to others, so that the risk had a wider circle of recipients.

2. PRACTICE OF CONSTRUCTION COMPANIES AND RISK MANAGEMENT

The experiences gained from the cooperation with a group of small and medium-sized construction companies shows that they do not apply accurate methods allowing to identify, assess and prevent risks. The reason for this is the difficulty in collecting and processing information necessary to do so, due to high labor costs in Poland and the



inability of hiring an additional employee dealing with a given issue in a company. Having collected a lot of information, the Authors of KM (which supports construction company management) attempted to upgrade the Program with elements enabling risk management in a construction company. The Program contains a block referring to risk, but currently it does not allow for a complete analysis of risk and its influence on processes executed in a company, projects and a company itself.

In order to improve the functionality of the block and the whole program it was necessary to develop a questionnaire broadening the Authors' knowledge on risk, and direct it to the companies surveyed in order to obtain the necessary information.

The construction company operating strategy should be directed towards the elimination of 'highest risk factors' in the realm of time - cost - quality. Moreover, construction investments are characterized by a long implementation period (even up to several years), high execution costs, uniqueness of objects made and works performed, or different location. Therefore, it is a difficult task to assess the impact of risk on the course of an entire investment. The research procedure was proposed based on the appropriately prepared questionnaire addressed to a selected group of construction companies carrying out certain projects, which will allow for the construction of a suitable model of risk assessment in accordance with the Program KM.

3. STAGING OF RISK AT INDIVIDUAL PHASES OF INVESTMENT EXECUTION ACCORDING TO GÓRECKI [1]

Procedures for conducting a construction project, which are expounded in the construction law and implementing rules, include phases: preparation, design, implementation and commissioning of an investment. The level of risk involved in the investment task depends on: the size of an investment site, the complexity of architectural, construction and installation solutions, the manner of implementation or the location of a building site.

In his publication Górecki J. [1] summarizes changes of addressees of investment risk during the successive phases of preparation, implementation and commissioning of an investment. The data presented in the publication shows that with the increasing number of entities in the next stages of the investment, the number of new risk factors distributed among a wider group of beneficiaries grows. This process can be defined as a dislocation of investment risk.

According to Górecki [1] a contractor's risk set out in the subsequent stages has a nature of:

- offer risk – when developing, bidding and selecting an offer;
- risk of dividing tasks – when selecting subcontractors;
- task and cost risk of the structure of contractors – formed during a project preparation;
- risk of changes in prices (rates) of labor, materials and equipment – includes implementation risk of a contractor, subcontractors and suppliers;
- risk of responsibility for the effect – during a phase closing an investment.

Due to the large number and diversity of processes carried out by construction companies (approximately 260 processes pre-separated), examining all the risk factors in individual processes requires the pre-selection of processes and risk factors according to the adopted evaluation criteria. The number of processes in a group was narrowed to 80, in conjunction with the risk factors occurring in them. In the next step the severity levels of the impact of a given element of risk on the course of the entire investment in analyzed areas of company management should be determined.

4. PREQUALIFICATION OF RISK FACTORS AFFECTING THE COURSE OF AN INVESTMENT

In literature the term *prequalification* is understood in different ways. E. Plebankiewicz and A. Dziadosz [2] in their publication define *prequalification* as selecting a group of the most suitable contractors to apply for a given specific investment or as a grouping of suitable suppliers for a certain task. Prequalification of risk factors occurring at particular realization stages of a construction project can be defined similarly, that is as the selecting / choosing factors with the highest level of significance affecting the entire project or implemented as a grouping of risk factors in relation to a particular task.

The variety of construction projects is not conducive to finding strict rules for them regarding the course of prequalification activities of risk factors. However, an attempt can be made to build lists of templates, based on preliminary input assumptions such as: strategic goals of a company, depending on the way of project implementation, factors determining the achievement of the assumed financial objective, with taking into account the optimal use of available resources. The specificity (financial reasons) of medium-sized and small construction companies employing up to 49 people does not allow for additional employment of administration and technical staff analyzing risk factors for a company. Thus, the issue concerning risk in this type of business entities should be properly arranged and entered in simple procedures easily accessible to the management personnel, which should contribute to better management of the company.

Procedures applied in risk prequalification proposed by E. Plebankiewicz and A. Dziadosz [2] can be transposed to the Program KM through:

- a) definition of risks emerging at every stage of an investment process;
- b) enrichment of processes described in the KM with procedures for recording risk factors;
- c) creation of models of construction processes runs for different types and ways of realization of an investment;
- d) correlation of risk factors affecting individual elements of processes, the project cycle and investment company activity of temporal, economic or organizational aspects;
- e) after the survey and the analysis of answers received, setting weights of individual risk elements in terms of their impact on elements / an overall investment process.

5. SURVEYS AS A METHOD OF ACQUIRING INFORMATION ABOUT RISK ELEMENTS IN A BUILDING COMPANY

According to the Author of the publication, an important component of the program knowledge map development when analyzing risk elements is appropriate prequalification of factors based on surveys targeted at construction companies as entities having the greatest practical experience. In literature one can find plenty of information on surveys relating to risk assessment in an investment process (P. Jaśkowski, S. Biruk [3], D. Skorupka [4], M. Połowski, K. Pruszyński [5], A. Koper [6], A. Dziadosz [7]). Literature studies and own preliminary research proved that the clear adoption of a rating scale and weight of individual risk factors assessed is difficult. The Authors propose various approaches to this subject. The methodology used in the risk assessment for surveyed construction companies should be characterized by the simplicity of a model and its intelligibility for a potential user. On the other hand, the simplification of the risk assessment method by adopting a progressive scale requires the preliminary establishment of criteria for the adopted assessments scale, universal for various factors, which is not an easy task. Risk assessment criteria may be defined after the questionnaire development and surveying construction companies. Processing of the information obtained requires time, but enables receiving results from a variety of actual realizations of construction projects. Looking at investments through executive and design companies, subcontractors or suppliers allows for obtaining objective research results from different perspectives of observation. At the pre-selection stage - prequalification risk factors - it was established to gather initial information through questionnaires carried out in a number of construction companies. The results obtained would be used to verify the contents of the questionnaire before publishing it at the stage of final research carried out on a wide group of respondents. The methodology based on the following steps shown in Figure 1 was adopted when developing the survey [8].

Owing to the results obtained from the research surveys (the so-called original version) directed to several companies, the layout and contents of the questionnaire were possible to be verified. Taking suggestions into account the final version of the questionnaire was developed and assigned for the task execution. Essential benefits from prequalification of risk factors can be defined as [8]:

- shortening the time and lowering costs of the risk analysis for new projects;
- accelerating the pace of analyses performed by the Computer Program KM due to less data prepared for processing;
- classification of processes and risk factors associated according to different classes of validity to obtain information which areas of business activity attention should be paid to, and which are less crucial;
- predicting importance of risk at subsequent stages of implementation and strengthening weak points of a process investment (for implementation factors of a high level of risk) affects the compliance with the conditions established in the agreement regarding: a completion date, an investment budget, a certain quality of works, as well as it allows for the optimal use of compa-

ny's resources (equipment and personnel) or enhancing the positive image of a company on the market.

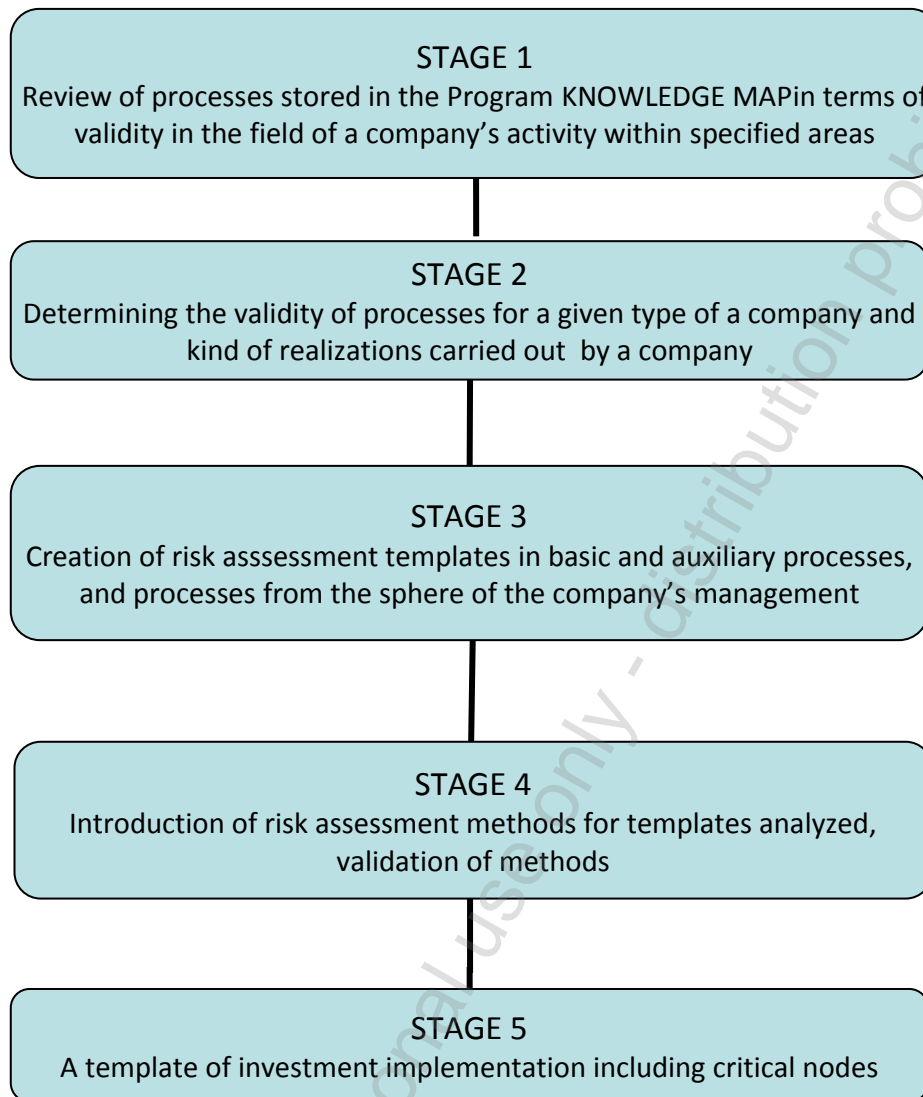


Fig.1. Methodology used in prequalification of risk factors in construction companies

Source: Own study [9]

6. THE STRUCTURE OF THE SURVEY DIRECTED TO CONSTRUCTION COMPANIES

The primary strategic objective during the construction of the survey was to obtain maximum information from the greatest possible number of respondents, which was a difficult task, requiring much professional experience regarding building construction and related areas. When developing the questionnaire, the range of questions asked should have been formulated in such a way to make them synthetic, with simple explanations and understandable to respondents, without causing effects of fatigue and discouragement when completing the survey. On the other hand, the quality of the information obtained and its quantity required longer questions in the questionnaire.

The structure of the proposed survey was based on six blocks, collecting information [9]:

Block 1: Information identifying a company: the scope of its activity, employment, owned resources (tangible, intangible), the environment in which the company operates, its realizations (completed, in progress and planned ones), objectives of the company and tools used in the sphere of management.

After analyzing the data from the questionnaires basic profiles of small and medium-sized construction companies (such constitute 98% of all construction companies in Poland) will be established in connection with with typical realizations carried out by them.

Block 2. Prequalification of the highest-rank processes carried out by a company influencing the company's activity. In this block, respondents rate the importance of various processes in relation to the nature of their companies. The basis for prequalification is a group of 80 processes stored in the Program KNOWLEDGE MAPas well as preliminary surveys. The task of respondents was to rank the validity of the processes due to the nature of the business activity, its size, the specificity of investments performed, the experience related to the presence of the company on the construction market. There was adopted a simple scale from 1 to 5, where 1 means the lowest negative level, and 5 - the highest rank.

Data obtained in this part of the survey allowed the initial statistical analysis for determining the correlation of the parameters received in the Block 1 with the characteristics in the Block 2, both in relation to a given company or an investment executed, but also in relation to the global profiles of business types and undertakings.

Block 3: Verification of understanding of the concepts: risk in a company, defining the fields / areas of risk in a company. Respondents in this Block defined the concept of risk in their own words, identified areas of risk in relation to their own experiences. The results will enable the creation of definitions of risk in a construction company by actual implementers of construction projects.

Block 4: Risk assessment methods used in a company. In this part, the respondents refer to the proposed risk assessment models, but they may submit their own proposals for methods of risk assessment (in a process, a group of processes or the whole investment implementation). Collected information will make it possible to compare the method presented by the Author of the survey with methods used in companies, and construct a model that meets the expectations of both the Author and the respondents.

Block 5: Block of selecting critical processes. The task of respondents is to select 10 processes out of the areas: 1. Preparation and design of an investment, 2. Implementation of an investment and 3. Commissioning to use, which in their opinion contain risk elements of major importance for the course of investments. The group of critical processes with risk elements defined for them will allow the development of the classification of processes in terms of the level of risk appearing in them.

Block 6: The block defining the respondents' expectations collects information from respondents about their expectations with regard to the model of investment realization taking into account the overall risk. The proposed risk elements presented in the questionnaire were verified by respondents as a function of the factors: time, cost, quality with specifying the functionality of the other Blocks of the Program KM for risk assessment.

CONCLUSION

After verifying the initial survey of a selected group of several construction companies and improving its content, the research was conducted. Respondents filled out questionnaires in paper form, mostly via the Internet. Due to the involvement of construction companies in projects carried out, it was difficult to collect information during the construction season, until the end of 2015, when the interest in the survey considerably increased. The acquired surveys confirmed that the direction of research and correctness of the proceedings had been properly adopted. The findings of the survey will be presented in subsequent publications.

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BIOGRAPHICAL NOTE

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