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Project portfolio risk categorisation – factor analysis results

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Abstract:
The subject of this article is project portfolio risk categorisation. Research conducted indicated categories containing the most probable and significant risks. The research described in this paper was carried out in two stages. In the first stage, the relevant literature was reviewed and the Delphi method was used to identify 36 risks specific to a project portfolio. In the second stage, the respondents (project portfolio managers) assessed the probability of each risk occurring and the impact of that risk on the objectives of the project portfolio. The empirical data obtained in this way made it possible to conduct an exploratory factor analysis and to identify the risk categories of the project portfolio. The presented results may also contribute to a broader discussion concerning the validity of identifying project portfolio risks and how to categorise them. The results may be useful for further discussion on the empirical confirmation of three categories of portfolio risks proposed by the Project Management Institute.

Keywords:
project portfolio risk; portfolio risk categorization; factor analysis results.

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1. Introduction

Aspects concerning the management of project risks, focusing predominantly on tooling [1, 2] and interpersonal [3] issues, have been described in detail in the literature. Managing project portfolio risks, however, is a relatively new area of interest. Based on Markowitz's studies [4], a portfolio can be defined as a collection of projects, the value of which can be maximised at acceptable risk levels when they are managed together [5] (p. 97). An analysis of the literature shows that managing project portfolio risks is much more complex than managing project risks [6]. Studies emphasise the importance of limiting the implementation of traditional risk management, which is oriented towards single projects in a multi-project environment [7]. A traditional approach does not take into account the risk that arises from the collection structure or the risk resulting from potential relationships between the projects found within the collection [8, 9] (p. 85). Identifying risks for projects implemented as part of a portfolio can be done at once. This improves the efficiency with which project portfolio risks can be managed [10]. In discussing this issue, it is important to point out the significant outlays, which are made with respect to managing risks, and correlate them with expected results [11]. Therefore, one can state that the proper management of project portfolio risks leads to a potentially lower likelihood of errors and failures, which in turn leads to a higher likelihood of project portfolio success [12, 13]. From a managerial point of view, it needs to be said that managing risks requires a comprehensive overview of the whole portfolio. Should the manager lack such an approach, they may have a problem with monitoring risks on the portfolio level [7]. Managing risks thus demands unique competences from the part of the manager, which will shape the desired behaviours of the organisation members [14–16]. An analysis of the literature produced four interesting research questions:

- RQ_1 – what are the risk categories obtained from exploratory factor analysis based on the following variables: the likelihood of risk occurrence and the risk's impact on portfolio objectives?
- RQ_2 – which of the categories identified will include the risk with the highest likelihood of occurrence?
- RQ_3 – which of the categories identified will include the risk with the greatest impact on portfolio objectives?
- RQ_4 – is the empirically obtained categorisation of project portfolio risks coincident with the categorisation most frequently appearing in the literature, i.e. structure, component and overall risks?

Answering the above questions would allow for the identification and naming of project portfolio risks. It would also facilitate the identification of the category of risk within a project portfolio that has the highest likelihood of occurrence, as well as of the risk that has the greatest negative impact on the project portfolio's objectives.

The article is structured as follows. The first part presents the theoretical aspects of project portfolio risk management. The second presents the method to identify project portfolio risks and its results. The third part contains the findings of research on project portfolio risk categorisation (i.e. the characteristics of the research sample and research results). The article closes with a presentation of the conclusions from the conducted research and a discussion on their importance for the management of a project portfolio.

2. Portfolio risk management – theoretical background

The management of project portfolio risks has gained increasingly more attention from researchers [10, 13, 18, 19, 20]. As already mentioned, the origins of portfolio management can be traced to the works of Markowitz, which were rooted in the context of equity investments. Portfolio management later found its way into the development of new products [21] and into the field of project management [6, 22]. Applied to project portfolio management, portfolio theory concerns the constant allocation of resource choices, taking into account the interdependencies between projects. Guidelines for managing project portfolios have been included in special studies [9, 23]. Companies adapt those guidelines, written into standards, to the organisational solutions implemented in their structure. A project portfolio is a collection of single projects and programmes that are carried out under a single sponsorship and typically compete for scarce resources [24]. Focus is on the alignment of the projects and programmes with the organisation's strategy and the balancing of the project portfolio regarding risks and benefits [9, 17]. The task of project portfolio management involves the management of resources and other constraints, the coordination of the group of projects, and the management of the interfaces between projects [8, 25].

Risk is defined as an uncertain event or condition that, if it occurs, has a significant positive or negative effect on at least one strategic portfolio objective [9] (p. 85). In discussing risk management, it is necessary to consider two important aspects. The first is understanding and defining the notions of uncertainty and risk. Knight and Frank make a distinction between measurable uncertainty (which can be considered risk) and immeasurable uncertainty [26]. One can assume that risks relate to events which are either perceived or perceptible, and the likelihood of which can be estimated. The ongoing discussion in this field of study is crucial for the perception of risk either as a consequence of uncertainty or as a separate notion in its entirety, which defines a wholly independent phenomenon [27]. It seems appropriate to consider risk as a situation in which the result of the actions undertaken is not known. This way of defining risk allows us to distinguish between two basic notions of risk: negative (unilateral) risk and neutral (bilateral) risk. A negative perception of risk involves associating this notion with a negative event: danger, damage or loss. A neutral approach to risk means that it is perceived as neither negative nor positive [28]. The Project Management Institute describes three categories of portfolio risk (i.e., structure, component and overall risks). Structural risks are those associated with the composition of the group of projects and the potential interdependencies among components. Component risks are risks that the project manager needs to escalate to the portfolio level for information or action. Overall risks consider the interdependencies between projects and are, therefore, more than just the sum of individual project risks [9] (pp. 85–86). This approach to categorising project portfolio risks has been preliminarily adopted in this research.

The issue of project risk management has been covered both in terms of methodology and tooling [1, 2, 29]. Apart from that, there are studies which bring a methodological approach to project risk management in SMEs [30]. The management of risks at the portfolio level may enhance the effectiveness of risk management compared to the independent consideration of risks at project level [5, 8]. Considering the relationships between individual projects in managing risks at the portfolio level makes it possible to find solutions which will significantly contribute to lowering the likelihood of negative impact on the entire portfolio. At the same time, such solutions would not be viable when applied to single projects. Furthermore, it can transpire that while the manager of a single project assesses a given situation to be wholly negative considering its negative impact on the scope, time and cost of the project, its effects on the portfolio as a whole may be positive, and the losses made in one project compensated by gains in another. A comprehensive overview of project portfolio risks produces new opportunities for preventive actions, which would minimise the likelihood of the risk materialising, as well as actions which would diminish the effects of a negative event on the project portfolio. An analysis of the available studies on portfolio risk management shows that this issue is discussed both from a theoretical and an empirical perspective. Pellegrinelli was the first to address this issue. He differentiated between risk management on project level and risk management on programme level, pointing out that programme risk management is a much broader problem and requires a different approach [6]. Olson mentioned differences between risk management on project level and risk management on portfolio level [8]. Sanchez, in turn, made a theoretical model for risk management on the level of project portfolios [5]. As mentioned before, certain studies address the management of project portfolio risks from an empirical point of view. In his studies, Teller presents a broad empirical account of the impact of formalisation and risk management quality on the success of a portfolio [10, 18]. More recent studies take a theoretical and empirical approach to selecting portfolios and establishing their structure in the context of portfolio success [31, 32]. Further, a separate strand of research on portfolio risk management studies the specific nature of managing project portfolios in engineering [33, 34] and IT projects [35, 36]. Finally, Guan and his team suggested an interesting way to reduce risk in project portfolios based on the Bayesian network structure learning algorithm and the set theory [37].

3. Project portfolio risk identification

Recent studies have facilitated the selection and identification of risks specific to a project portfolio [5, 7, 8, 12, 13, 14, 15, 16, 17, 19, 25, 31, 32, 33, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50]. All identified risks were classified into three categories, as suggested in the literature (component, structural and general risk) [9]. They were, then, evaluated by experts in accordance with the Delphi method [51, 52]. Four experts in the field of project management were invited to participate. The expert evaluation of the list of risks developed by the study was conducted in the first half of 2014 and involved six evaluation rounds. Each assessment round lasted for two weeks and was moderated by a designated member of the research team [53]. The criteria for selecting the experts ensured competent assessment, as well as a critical view of the conceptual value of the list of risks (i.e. correctness of the proposed names and descriptions, proper classification of risks and the level of completeness of the list).

Table 1. List of project portfolio risks [53]

Component risks	Structural risks	Overall risks
1.1 Significant changes in the project or programme environment	2.1 Too large a portfolio from the point of view of the portfolio executors' capacity	3.1 Lack of transfer of information and knowledge among the portfolio elements
1.2 Change in an approach of key project or programme stakeholders	2.2 Significant portfolio fragmentation	3.2 Improper control over life cycles of projects and programmes
1.3 Significant change in the basic parameters of particular portfolio elements	2.3 Overly complicated hierarchical structure of portfolio management	3.3 Unavailability of resources necessary to execute works within the portfolio
1.4 Improperly defined priorities for particular portfolio elements	2.4 Significant portfolio homogeneity	3.4 Lack of coordination of the involvement of key resources in the execution of the portfolio
1.5 Disturbances in information flow and communication within the portfolio elements	2.5 Portfolio diversity range too wide from the point of view of portfolio executors' applied capacity	3.5 Relationships among products created by the portfolio elements
1.6 Ignoring risks by portfolio element managers	2.6 Mismatch between the portfolio structure and the parent organisation's strategy	3.6 Problems with access to the portfolio financing capital
1.7 Lack of developed methodical standards within the scope of portfolio element management	2.7 Improper portfolio balance	3.7 Possibility of the lack of financial liquidity within the portfolio
1.8 Improperly operating steering committees of projects, project groups and programmes		3.8 Portfolio financing collapse
1.9 Conflicts between project and programme managers within the portfolio		3.9 Non-compliance of a key element strategy with the portfolio's strategy
1.10 Conflicts between portfolio element managers and the parent organisation's decision-makers		3.10 Conflicts among objectives of projects and programmes executed within the portfolio
1.11 Improper competencies of project and programme managers		3.11 Conflicts between portfolio managers and portfolio element managers
1.12 Risks arising from the application of innovative technical and material solutions in the portfolio elements		3.12 Lack of involvement of top-level and middle-level managers in portfolio execution
		3.13 Lack of appropriate competencies of the portfolio manager and of the portfolio support structures
		3.14 Risks arising from the unknowns at the cost estimation of the execution of selected portfolio elements

Component risks	Structural risks	Overall risks
		3.15 Risks related to the personnel stability of the portfolio managing team and the possibility of losing key portfolio element managers
		3.16 Lack of developed methodical standards within the scope of portfolio management
		3.17 Formulation of fixed-price contracts for the portfolio elements

The research methodology adopted by the team assumed a compromise between providing the experts with adequate freedom to modify (or submit new proposals for) the names and descriptions of risks, add risks and move risks within categories as required, and acquiring information on how to adjust the available statistical tools to suit expert consensus. Upon reaching consensus, the experts recommended 36 risks specific to the project portfolio: 12 in the component risk category, 7 in the structural risk category, and 17 in the general risk category (see Table 1).

4. Project portfolio risk categorisation

4.1 Sample description and research method

Under the next research phase, the likelihood and impact of each identified risk on the project portfolio was assessed. This assessment was made by respondents with professional experience in programme and portfolio management. The request to complete the questionnaire was sent to managers with an international certificate confirming their competence in project management. Contact details were obtained from local branches of international organisations associating professionals with project management. A request for participation in the assessment of the above variables for each identified risk of the project portfolio was addressed to a group of 400 managers. The scope of the research covered the territory of Poland. 73 respondents (that is to say, 18% of all respondents) assessed portfolio risk. Within the group of respondents who made the assessment, women constituted 16% of the professionals examined. 8% of respondents had 16–25 years of professional experience in the management of multiple projects, 15% had 11–15 years of experience, 47% had 5–10 years of experience, while 30% had less than four years of experience. Within the assessing group, 64% of the experts worked for service companies, 21% worked for manufacturing companies, while 11% worked for mixed-profile companies. 62% of all respondents were employed in large enterprises (over 250 people), 18% in medium enterprises (employing 50–249 people), and 21% in small enterprises (employing less than 50 people). In the group of respondents, 21% managed IT project portfolios. The research was carried out in 2015.

Based on the characteristics of the survey participants, it may be argued that the sample included individuals with experience in the management of various project portfolios, both in terms of type, size and industry. It may also be argued that the results obtained may describe both the materiality level and also illustrate the relationships between risks for the full scope of the project portfolios. As mentioned above, experts in managing multiple projects assessed 36 risks, which were identified in the previous step by the Delphi method (see Table 1). According to the approach suggested in the literature, the operationalisation of each assessed risk included two variables: (1) risk likelihood, and (2) impact of the risk on portfolio goals [1 (pp. 143–145), 29 (pp. 91–93), 54 (pp. 242–252), 55 (p. 47)]. The variables studied were defined on an ordinal scale, with 1 denoting very low risk likelihood, 2 – low, 3 – average, 4 – high and 5 – very high risk likelihood. A variable – risk impact – was assessed on a scale, where 1 denoted very low impact of the risk on portfolio goals, 2 – low impact, 3 – average impact, 4 – high impact and 5 – very high impact. The Computer Aided Self-Evaluation Interviews (CASI) method was applied. The respondents assessed individual risks in a special questionnaire, which was posted on the website. It contained all the risks from the list, along with their names and description. Risks from the list were distributed in the questionnaire at random, in order to avoid suggesting the relevant categorisation referred to in the literature (structure, component and overall risks) to respondents [9]. In order to answer the research questions posed at the beginning, an exploratory factor analysis was applied. The calculations performed took into account the likelihood of occurrence of a given risk in executing the project portfolio as a variable. The statistical procedure adopted for the research involved scree plots and varimax rotation [56].

4.2 Research results

The implementation of the statistical procedure resulted in determining main factors. Implementing the Kaiser criterion [57] meant that the analysis was to be conducted for 11 factors (see Fig. 1).

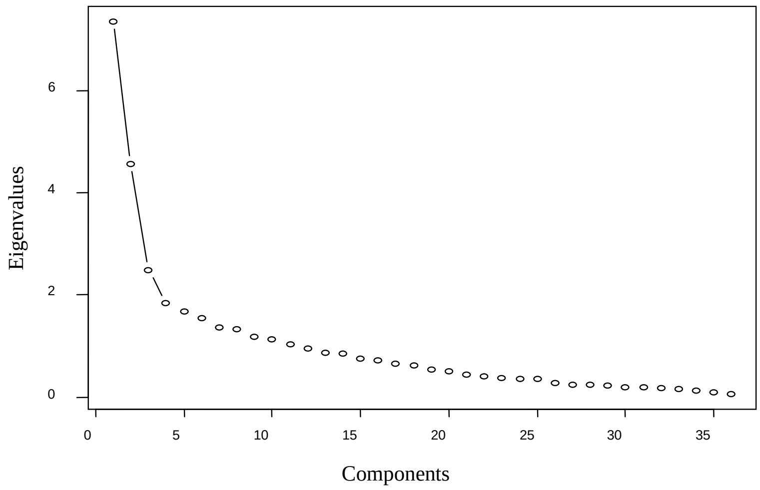

Fig. 1. Scree structure for the variable - likelihood of project portfolio risk occurrence

Appendix A contains the eigenvalues and rotated component matrix for all distinguished main factors. The statistical analysis allowed for classifying the 36 assessed risks to 11 factors (see Table 2). Total explained variance for the 11 factors was 59%. The analysis was conducted using the method of maximum reliability with varimax rotation. The reliability of respondents' evaluations was reviewed with Cronbach's α. In accordance with the interpretation provided in the literature, the value of this coefficient ranges from 0 to 1. The studies available state that Cronbach's α values above 0.6 mean satisfactory reliability, above 0.7 – good reliability and above 0.9 – perfect reliability [58].

Table 2. Likelihood of risk occurrence – main factors

Factor	Portfolio risks	Cronbach's α
Factor 1 – Risks which may cause problems with controlling the project portfolio environment	1.2 Changes in an approach of key project or programme stakeholders 1.3 Changes in the basic parameters of particular portfolio elements 1.5 Disturbances of information flow and communication within the portfolio elements 1. 6 Ignoring risks by portfolio element managers 1.11 Improper competencies of project and programme managers 1.12 Risks arising from the application of innovative technical and material solutions in the portfolio elements 3.1 Lack of transfer of information and knowledge among portfolio elements 3.12 Lack of involvement of top-level and middle-level managers in portfolio execution	0.825

Factor	Portfolio risks	Cronbach's α
Factor 2 – Risks which cause problems with the proper structure of the portfolio	2.3 Overly complicated hierarchical structure of portfolio management 2.4 Significant portfolio homogeneity 2.5 Portfolio diversity range too wide from the point of view of portfolio executors' applied capacity 2.6 Mismatch between the portfolio structure and the parent organisation's strategy 3.2 Improper control over life cycles of projects and programmes 3.13 Lack of appropriate competencies of the portfolio manager and of the portfolio support structures 3.15 Risks related to the personnel stability of the portfolio managing team and the possibility of losing key portfolio element managers	0.761
Factor 3 – Risks which cause anomalies among the project portfolio components	1.1 Significant changes in the project or programme environment 1.4 Improperly defined priorities for particular portfolio elements 1.7 Lack of developed methodical standards within the scope of portfolio element management 1.10 Conflicts between portfolio element managers and the parent organisation's decision-makers 2.7 Improper portfolio balance 3.14 Risks arising from the unknowns at the cost estimation of the execution of selected portfolio elements	0.719
Factor 4 – Risks which cause anomalies in the strategic management of portfolio financing	3.8 Portfolio financing collapse 3.9 Non-compliance of a key element strategy with the portfolio's strategy	0.743
Factor 5 – Risks which cause anomalies in the management of material and financial resources	3.4 Lack of coordination in the involvement of key resources for the execution of the portfolio 3.5 Relationships among products created by the portfolio elements 3.6 Problems with access to the portfolio financing capital	0.574
Factor 6 – Risks which result in interpersonal conflicts within the portfolio	1.9 Conflicts between project and programme managers within the portfolio 3.11 Conflicts between portfolio managers and portfolio element managers	0.789
Factor 7 – Risks which result in the limited accessibility of material and financial resources within the portfolio	3.3 Unavailability of resources necessary to execute works within the portfolio 3.7 Possibility of the lack of financial liquidity within the portfolio	0.665
Factor 8 – Risks which cause problems with the consistency of objectives within the project portfolio	2.1 Too large portfolio from the point of view of the portfolio executors' capacity 3.10 Conflicts among objectives of projects and programmes executed within the portfolio	0.334
Factor 9 – Risks which cause portfolio fragmentation	2.2 Significant portfolio fragmentation	–
Factor 10 – Risks associated with fixed-price contracts for the portfolio elements	3.17 Formulation of fixed-price contracts for portfolio elements	–
Factor 11 – Risks which cause methodological irregularities within the portfolio	3.16 Lack of developed methodical standards within the scope of portfolio management 1.8 Improperly operating steering committees of projects, project groups and programmes	0.428

In regard to the variable of the likelihood of risk occurrence, Cronbach’s α for factors 8 and 11 was below the satisfactory level. Analysis of the eigenvalues for these factors and the total explained variance showed that these factors should be excluded from further analysis. As such, factors 8 and 11 were excluded from further stages of the analysis (see Table 3).

Table 3. Explained variance and Cronbach’s α value for the likelihood of risk occurrence – main factors

Factor	Eigenvalues	Explained variance	Cronbach’s α
Factor 1	7.344941	11.8%	0.825
Factor 6	1.551096	4.1%	0.789
Factor 2	4.564699	8.5%	0.761
Factor 4	1.845396	5.2%	0.743
Factor 3	2.490466	7.8%	0.719
Factor 7	1.371455	4.1%	0.665
Factor 5	1.677928	4.6%	0.574
Factor 11	1.038219	2.7%	0.428
Factor 8	1.332244	3.5%	0.334
Factor 9	1.177720	3.5%	–
Factor 10	1.136058	3.2%	–

In regard to the variable of the impact of risk on portfolio objectives, the implementation of the Kaiser criterion [57] meant that the analysis had to be conducted for ten factors (see Fig. 2). Appendix A contains the eigenvalues and rotated component matrix for all distinguished main factors.

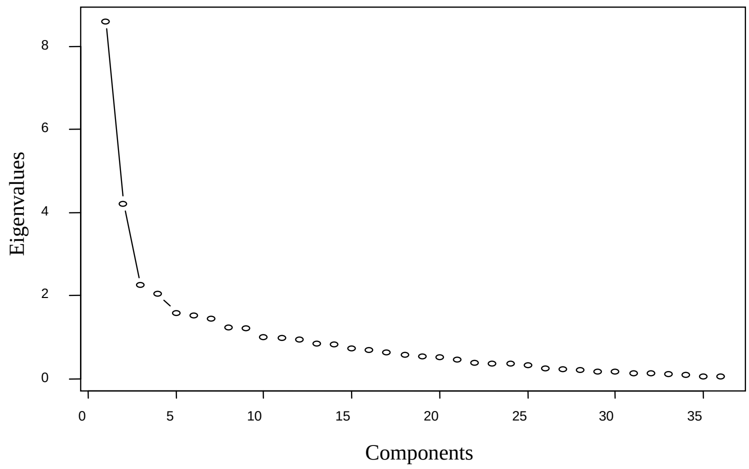

Fig. 2. Scree structure for the variable - impact of risk on portfolio objectives

Using the impact of risk on portfolio objectives as a variable, the statistical analysis allowed for the classification of the 36 assessed risks to 10 factors (see Table 4). The total explained variance for the impact of risk on portfolio objectives is 58.8%. As in the previous case, the analysis was conducted using the method of maximum reliability with varimax rotation.

Table 4. Impact of risk on portfolio objectives – main factors

Factor	Portfolio risks	Cronbach's α
Factor 1 – Risks related to anomalies in project portfolio planning	1.4 Improperly defined priorities for particular portfolio elements 1.6 Ignoring risks by portfolio element managers 1.7 Lack of developed methodical standards within the scope of portfolio element management 1.8 Improperly operating steering committees of projects, project groups and programmes 1.10 Conflicts between portfolio element managers and the parent organisation's decision-makers 2.7 Improper portfolio balance 3.3 Unavailability of resources necessary to execute works within the portfolio 3.9 Non-compliance of a key element strategy with the portfolio's strategy 3.14 Risks arising from the unknowns at the cost estimation of the execution of selected portfolio elements	0.701
Factor 2 – Risks resulting from improper project portfolio structure	2.2 Significant portfolio fragmentation 2.4 Significant portfolio homogeneity 3.4 Lack of coordination of the involvement of key resources in the execution of the portfolio 3.5 Relationships among products created by the portfolio elements 3.6 Problems with access to the portfolio financing capital	0.643
Factor 3 – Risks resulting from anomalies in project portfolio management	1.12 Risks arising from the application of innovative technical and material solutions in the portfolio elements 3.2 Improper control over life cycles of projects and programmes 3.10 Conflicts among objectives of projects and programmes executed within the portfolio	0.327
Factor 4 – Risks resulting from anomalies in the transfer of information and knowledge within the project portfolio	1.5 Disturbances of information flow and communication within the portfolio elements 1.11 Improper competencies of project and programme managers 3.1 Lack of transfer of information and knowledge among portfolio elements 3.17 Formulation of fixed-price contracts for the portfolio elements	0.639
Factor 5 – Risks resulting from changes in the project portfolio structure	1.3 Significant changes in the basic parameters of particular portfolio elements 2.1 Too large a portfolio from the point of view of the portfolio executors' capacity 2.5 Portfolio diversity range too wide from the point of view of portfolio executors' applied capacity 2.6 Mismatch between the portfolio structure and the parent organisation's strategy 3.12 Lack of involvement of top-level and middle-level managers in portfolio execution	0.581
Factor 6 – Risks resulting from anomalies in managing project portfolio financing	3.7 Lack of financial liquidity within the portfolio 3.8 Portfolio financing collapse	0.749
Factor 7 – Risks resulting from changes in the approach of project portfolio stakeholders	1.2 Changes in an approach of key project or program stakeholders 3.15 Risks related to the personnel stability of the portfolio managing team and the possibility of losing key portfolio element managers	0.550

Factor	Portfolio risks	Cronbach's α
Factor 8 – Risks which result in interpersonal conflicts within the project portfolio	1.9 Conflicts between project and programme managers within the portfolio 3.11 Conflicts between portfolio managers and portfolio element managers	0.789
Factor 9 – Risks resulting from methodological irregularities of portfolio management	1.1 Significant changes which can occur in the project or programme environment 2.3 Overly complicated hierarchical structure of portfolio management 3.16 Lack of developed methodical standards within the scope of portfolio management	0.393
Factor 10 – Risks resulting from the lack of appropriate competencies of the portfolio managers	3.13 Lack of appropriate competencies of the portfolio manager and portfolio support structures	–

In regard to the variable of the impact on portfolio objectives, Cronbach's α for factors 3 and 9 was below the satisfactory level (see Table 5). These factors are, therefore, excluded from further analysis. Factors 5 and 7, however, which were just below the satisfactory level will still be accounted for.

Table 5. Explained variance and Cronbach's α value for the impact of risk on portfolio objectives – main factors

Factor	Eigenvalues	Explained variance	Cronbach's α
Factor 8	1.240838	4.4%	0.789
Factor 6	1.522739	5.1%	0.749
Factor 1	8.593424	10.3%	0.701
Factor 2	4.209597	7.7%	0.643
Factor 4	2.049452	6.0%	0.639
Factor 5	1.588498	5.9%	0.581
Factor 7	1.440268	4.9%	0.550
Factor 9	1.217886	5.1%	0.393
Factor 3	2.254325	6.7%	0.327
Factor 10	1.005667	3.7%	–

4.3 Findings

The factor analysis answered the first research question (RQ1), which assumed the possibility of differentiating several categories (factors) that covered risks with respect to two variables: (1) the likelihood of risk occurrence, and (2) the impact of risk on portfolio objectives. The investigation distinguished categories grouping 36 specific project portfolio risks in terms of those two variables (analyses were conducted separately for each variable). In order to answer the second research question (RQ2), it was necessary to use descriptive statistics for each factor. An analysis of those values made it possible to indicate the category (factor), which covered the project portfolio risk that was deemed most likely to occur by the respondents (see Table 6).

Table 6. Descriptive statistics for the main factors distinguished, with the variable likelihood of risk occurrence (scale 1–5)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11
Average	3.15	2.56	3.19	3.73	2.68	2.73	3.71	2.69	2.64	3.32	2.92
SD	0.75	0.80	0.79	0.93	0.85	0.84	0.89	0.76	0.81	1.03	0.90
Min	2	1	1	1	1	1	1.5	1	1	1	1
Q25	2.5	2	3	3	2	2	3	2	2	3	2.5
Median	3	2	3	4	3	3	3.5	2.5	3	3	3
Q75	4	3	3.5	4.5	3	3.5	4.5	3	3	4	3.5
Max	5	5	5	5	5	4.5	5	4.5	5	5	5

The data in the table above show that respondents think the risks assigned to the fourth category are the most likely to occur, with the average evaluation level at 3.73 and the median at 4 (on a scale 1–5). This factor covers the risk which results in anomalies in the strategic management of portfolio financing. It included the following risks: 3.8 and 3.9. The respondents deemed the risk included in the seventh factor (covering risks resulting in limited access to material and financial resources within the portfolio – risks 3.3 and 3.7) as slightly less likely to occur (average 3.71, median 3.5). This finding answered the second research question (RQ2), which postulated the possibility of indicating the categories of group project portfolio risks that were most likely to occur.

As was the case with the second question, for RQ3 it was necessary to use descriptive statistics for each factor. An analysis of those statistical values allowed for the determination of which category (factor) covered the risks that would have the greatest impact on project portfolio objectives according to the respondents (see Table 7).

Table 7. Descriptive statistics for the main factors distinguished, with the variable impact of risk on portfolio objectives

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10
Average	2.95	3.21	3.19	3.51	3.52	2.45	3.49	3.05	2.86	3.37
SD	0.83	0.87	0.95	0.77	0.82	0.95	0.91	0.87	0.82	0.95
Min	2	1	1	1.5	2	1	1.5	1	1	1
Q25	2	3	3	3	3	2	3	2.5	2	3
Median	3	3	3	3.5	4	2.5	3.5	3	3	3
Q75	4	4	4	4	4	3	4	3.5	3	4
Max	5	5	5	5	5	5	5	5	5	5

The data included in Table 7 show that respondents think that the risks assigned to the fifth factor have the greatest impact on portfolio objectives, with an average evaluation level of 3.52 and a median of 4. This factor covers the risks resulting from changes in project portfolio structure. It includes the following risks: 1.3, 2.1, 2.5, 2.6 and 3.12. This finding answered the third research question (RQ3), which postulated the possibility of indicating the categories of risks that would have the greatest impact on portfolio objectives. The fourth research question (RQ4) regarding the correspondence between the empirically obtained categorisation of project portfolio risks and the categorisation most frequently appearing in the literature (i.e. structure, component and overall risks) received a negative response. This research has shown from the outset (Table 1) that the risks had a characteristic designation for each group prefix, i.e. component risks were assigned the prefix “1.”, structural risks “2.”, and overall risks “3.”. Analysing the composition of individual factors in Tables 2–4, it may be seen that for almost all there are risks in at least two groups from component risks, structural risks and overall risks. Therefore, grouping factors into larger collections does not lead to a reproduction of the division from the literature, because the mixing of risks occurs at the level of individual factors. Therefore, even a factor analysis with a predetermined number of factors equal to three did not produce results as derived from the literature. Also, the k-means algorithm with any given three clusters did not reproduce the theoretical categorisation.

5. Conclusion

The research conducted with the use of exploratory factor analysis produced answers to the research questions posed at the beginning of this study. The answer to the first question (RQ_1) allowed for the identification of 11 categories (factors) grouping project portfolio risks according to the variable of likelihood of risk occurrence, and 10 categories (factors) covering the risks according to the variable of the impact on portfolio objectives. The answers obtained allow us to look at the classification proposed by PMI, assuming the division of risk in three categories, i.e. component, structure and overall risks, in a different light [9]. The research carried out indicates that respondents perceive portfolio risks in a more analytical way, by distinguishing a greater number of categories, including the risk of those who endanger it. The answer to the second question (RQ_2) highlighted the category which covered the risks deemed by the respondents to be the most likely to occur (i.e. risks within categories 4 and 7). These categories capture the risks resulting from irregularities in the strategic financial management of the project portfolio (Factor 4) and the risk resulting from problems with the availability of material and financial resources within the portfolio (Factor 7). The answer to the third research question (RQ_3) indicated the category which grouped the risks with the greatest impact on portfolio objectives (i.e. the risks within category 5). In this case, the category captures the risk resulting from changes in the structure of the project portfolio. The negative answer to the fourth research question (RQ_4) reveals the need for a more detailed study on the appropriateness of the division into component, structure, and overall risks adopted in the literature, or the verification of the categorisation made by experts using the Delphi method. The reason for the negative answer to the last research question may also lie in cultural and macroeconomic differences. Repeating the research in other countries may provide an explanation for many of these issues.

The results obtained allowed us to categorise the risks of project portfolios and, what is more, to indicate the categories that capture the risk with the highest probability of occurrence and the one which has the greatest impact on the goals of the portfolio. The presented results may also make a contribution towards a broader discussion concerning the validity of identifying project portfolio risks and how to categorise them. The results may be useful for further discussion on whether the empirical confirmation of the three categories of portfolio risks (i.e. structure, component and overall risks) proposed by the Project Management Institute [9] (pp. 85–86) is possible.

Conversely, the knowledge gained concerning the categories that capture the most probable risk and the categories that capture the risk that has the greatest potential impact on the portfolio's goals may be helpful in developing rules for managing such risks [59]. Such knowledge could be useful for design managers and the subsequent implementation of preventive actions by project portfolio managers, which would minimise the likelihood of risk occurrence, as well as the negative effects that such risks would have on project portfolios.

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Appendix A

Table. 1 Rotated component matrix for the likelihood of risk occurrence (Factor 1)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
1.2	0.39367	0.283301	-0.05942	0.103809	0.143165	0.15229	-0.05622	0.324695	0.093393	0.066118	0.099662
1.3	0.702794	0.17951	-0.0946	0.083693	-0.09692	-0.01845	-0.023044	-0.02287	-0.017672	-0.138364	-0.158089
1.5	0.657743	0.027049	-0.02866	-0.1338	0.120447	0.110338	0.026974	-0.00087	0.135453	0.034516	-0.0304
1.6	0.702418	0.006002	-0.01295	0.023254	-0.09525	0.041877	-0.146	0.238879	-0.09835	0.01964	0.14496
1.11	0.558796	0.2106	-0.21424	-0.11217	-0.14316	0.077496	-0.02662	0.069437	-0.23815	0.094819	-0.1916
1.12	0.416929	0.007031	0.287289	-0.0619	0.107168	0.179725	-0.00365	-0.04901	0.177891	0.047376	0.11335
3.1	0.767683	0.108555	0.27384	-0.01949	0.13352	-0.00226	-0.22686	-0.01103	0.099394	-0.06583	-0.075306
3.12	0.601676	-0.06975	-0.12003	-0.03695	0.092839	0.177333	0.118708	0.249324	-0.09563	0.042064	-0.21048

Table. 2 Rotated component matrix for the likelihood of risk occurrence (Factor 2)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
2.3	0.12738	0.700134	0.183936	-0.06263	0.061626	0.08837	0.044068	0.15803	-0.03171	0.033286	0.073909
2.4	-0.00968	0.520325	0.128014	-0.07576	0.072839	0.047351	0.018662	-0.06066	0.106054	-0.00425	0.109762
2.5	0.122795	0.52434	0.080293	0.148226	0.273573	-0.06697	0.192543	0.085933	0.048627	-0.15974	-0.15386
2.6	0.314956	0.528261	-0.05946	0.305407	-0.13071	0.086182	-0.13025	0.002238	0.158966	0.07101	-0.10117
3.2	0.359665	0.3617	-0.11065	-0.05487	0.270898	0.025496	-0.03247	-0.045	-0.10186	0.226079	0.049013
3.13	0.435101	0.52139	0.229909	-0.20637	-0.12232	0.195621	0.007235	0.198898	-0.02681	0.108537	0.184919
3.15	-0.0797	0.481828	0.090009	0.006832	0.285148	0.189545	-0.01157	0.116894	0.264126	0.15951	0,113875

Table. 3 Rotated component matrix for the likelihood of risk occurrence (Factor 3)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
1.1	-0.12302	-0.00043	0.472111	0.144504	-0.05286	0.015583	0.060479	0.104657	0.061938	0.087956	-0.12159
1.4	0.089249	-0.09778	0.483099	0.456178	0.092763	-0.05392	0.182774	0.237488	0.269433	-0.13381	0.13007
1.7	0.026201	0.227241	0.74728	0.057103	0.084453	0.071983	0.128365	-0.26283	-0.07214	0.060226	0.092666
1.10	-0.0896	0.245458	0.551719	0.177685	0.073108	0.05537	0.19539	-0.02394	0.110001	0.005603	-0.03214
2.7	0.227317	-0.04817	0.378525	0.055512	-0.12061	0.087114	0.107952	0.168371	0.086994	-0.0265	0.028449
3.14	-0.07742	0.112066	0.471749	-0.00335	0.081584	0.138562	-0.02537	0.095229	0.038641	0.111694	0.071101

Table. 4 Rotated component matrix for the likelihood of risk occurrence (Factor 4)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
3.8	-0.11129	-0.18497	0.193493	0.602249	0.01278	0.017089	0.378323	-0.00704	0.04882	0.041002	0.027769
3.9	-0.09999	0.099722	0.186884	0.896934	0.045919	0.042716	0.04576	0.040095	-0.0029	0.022895	0.021318

Table. 5 Rotated component matrix for the likelihood of risk occurrence (Factor 5)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
3.4	0.23409	0.335306	0.085064	0.035199	0.432908	0.289447	-0.21145	0.116544	0.006453	-0.20255	-0.06519
3.5	-0.0254	0.124871	0.103557	0.092452	0.863767	0.139378	0.044806	0.015069	0.120679	0.103552	0.052985
3.6	0.204103	0.182522	-0.05859	-0.1283	0.321761	0.042823	0.190599	0.173142	0.154301	0.254904	-0.01077

Table. 6 Rotated component matrix for the likelihood of risk occurrence (Factor 6)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
1.9	0.424225	0.210658	0.063105	0.000597	0.249344	0.588946	-0.01318	0.030894	0.074181	-0.06133	0.049855
3.11	0.168672	0.180353	0.348245	0.059105	0.102027	0.793619	-0.05347	0.184083	0.183322	-0.03085	0.045329

Table. 7 Rotated component matrix for the likelihood of risk occurrence (Factor 7)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
3.3	-0.11553	0.31682	0.271998	0.095712	0.044424	-0.14826	0.511568	0.262516	-0.00544	0.00905	-0.19236
3.7	-0.12274	-0.00314	0.363848	0.33504	0.00548	0.00032	0.826374	-0.19629	-0.04614	-0.0605	0.089735

Table. 8 Rotated component matrix for the likelihood of risk occurrence (Factor 8)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
2.1	0.340887	0.093297	-0.0799	-0.03239	0.218877	-0.08696	-0.08146	0.368775	-0.12433	0.055332	0.078864
3.10	0.185891	0.139054	0.209629	0.072002	0.004545	0.183713	0.007915	0.616852	0.04572	0.003663	0.057602

Table. 9 Rotated component matrix for the likelihood of risk occurrence (Factor 9 & 10)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
2.2	0.044872	0.312535	0.198712	0.083277	0.157095	0.196361	-0.03052	0.006376	0.885364	-0.02503	-0.01354
3.17	0.31428	0.067543	0.345774	0.06628	0.127046	-0.09748	-0.05078	0.035308	-0.04105	0.857121	0.043662

Table. 10 Rotated component matrix for the likelihood of risk occurrence (Factor 11)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
1.8	0.194807	0.085422	0.343148	0.23106	0.058521	-0.09569	0.065067	0.051012	-0.09439	-0.16354	0.343504
3.16	0.189631	0.532568	-0.00409	0.041778	0.062269	0.252866	-0.06365	0.260475	0.083857	0.223526	0.69061

Table. 11 Rotated component matrix for the impact of risk on portfolio objectives (Factor 1)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.4	0.643952	0.182861	-0.03045	-0.07813	0.155842	0.018008	-0.15913	-0.07383	-0.00331	-0.1043
1.6	0.343291	-0.00998	0.198983	0.33562	0.146156	0.073138	0.012245	0.102637	0.298432	0.237303
1.7	0.635833	-0.11435	0.250083	0.118953	-0.08225	0.130683	0.069572	0.109114	0.012782	0.125342
1.8	0.824196	-0.08897	-0.00753	-0.05373	0.03017	-0.01774	-0.06547	-0.16218	0.172146	0.152014
1.10	0.69448	-0.14774	0.14372	0.006982	-0.0575	0.349339	0.170634	0.131567	-0.01999	0.035191
2.7	0.48497	0.241393	-0.12938	0.024819	0.124786	-0.07939	-0.39278	-0.14953	-0.10355	0.073736
3.3	0.444726	0.049384	0.095084	-0.18561	0.099332	0.195839	-0.24675	-0.03472	-0.08461	-0.13299
3.9	0.552911	-0.10407	0.103009	0.149953	0.002486	0.290639	0.033808	0.142324	0.098864	0.092015
3.14	0.569661	0.077848	0.008045	0.157823	-0.04892	0.069455	0.141375	0.12092	0.06343	-0.18976

Table. 12 Rotated component matrix for the impact of risk on portfolio objectives (Factor 2)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
2.2	0.105799	0.54457	0.149154	0.068258	0.176667	0.068656	-0.13068	0.244125	0.112852	0.104525
2.4	-0.12578	0.554736	0.22012	0.087923	-0.07127	0.053421	0.084429	-0.03719	0.19744	0.077377
3.4	0.195905	0.430636	0.114849	-0.21565	0.152207	-0.03407	0.112914	0.362214	0.244819	-0.02198
3.5	-0.04938	0.66158	0.14909	0.033858	0.068419	-0.01604	0.203717	0.107417	0.135418	-0.06685
3.6	-0.01766	0.50657	0.185114	0.119989	0.125087	0.0024	0.081607	0.11155	-0.15583	0.194205

Table. 13 Rotated component matrix for the impact of risk on portfolio objectives (Factor 3)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.12	-0.01858	0.217735	0.597024	0.073002	0.137629	0.067242	0.022667	-0.02583	0.022175	0.186209
3.2	0.2347	0.136307	0.717565	0.1343	0.113832	0.111074	0.181501	0.080676	0.159876	0.096218
3.10	0.105291	0.229468	0.549901	0.179403	0.077183	-0.0897	0.004001	0.145769	0.116526	-0.03819

Table. 14 Rotated component matrix for the impact of risk on portfolio objectives (Factor 4)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.5	0.188998	0.142846	0.088302	0.44751	0.111867	0.246892	0.24738	0.14599	0.193287	0.139127
1.11	-0.13561	-0.00755	0.238571	0.454455	0.220718	0.138931	0.37611	0.072482	0.170122	0.22396
3.1	0.001999	-0.07323	0.079504	0.482407	0.342585	0.035916	-0.01212	0.112633	0.047104	0.128445
3.17	0.081376	0.276467	0.193154	0.927494	0.049032	0.005954	0.099085	-0.01433	-0.02581	-0.03553

Table. 15 Rotated component matrix for the impact of risk on portfolio objectives (Factor 5)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.3	0.049305	-0.03916	0.152526	0.170586	0.658465	-0.32648	-0.02608	0.196211	-0.10857	-0.04447
2.1	0.111845	0.189644	0.390672	-0.03171	0.464179	0.019714	0.190441	0.261472	0.026849	-0.14089

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
2.5	0.054374	0.336648	0.43577	0.112919	0.597545	0.198252	0.103448	0.079682	0.024831	0.136101
2.6	0.254994	0.207879	0.012243	0.088545	0.400992	-0.20735	-0.02626	0.124618	0.093807	0.156595
3.12	-0.10621	0.043928	0.031689	0.098033	0.506188	0.167112	0.159991	-0.15342	0.083956	0.047157

Table. 16 Rotated component matrix for the impact of risk on portfolio objectives (Factor 6)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
3.7	0.27764	0.011797	-0.07261	0.053156	-0.07971	0.662359	0.00997	0.080934	0.045587	0.136838
3.8	0.258635	0.090354	0.146739	0.104539	0.091494	0.796995	0.016294	-0.06449	0.109693	-0.12081

Table. 17 Rotated component matrix for the impact of risk on portfolio objectives (Factor 7)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.2	0.12528	0.150948	0.388017	0.0891	0.125534	-0.12415	0.518658	0.005324	0.14022	0.112653
3.15	-0.07519	0.419198	0.040475	0.188407	0.22416	0.129901	0.824222	0.162344	0.014852	0.058759

Table. 18 Rotated component matrix for the impact of risk on portfolio objectives (Factor 8)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.9	-0.01698	0.237516	0.267165	0.254769	0.264276	0.005308	0.206601	0.43052	0.102311	0.020936
3.11	-0.00388	0.392585	0.103634	0.174771	0.070634	0.036501	0.104601	0.827792	0.221753	0.218895

Table. 19 Rotated component matrix for the impact of risk on portfolio objectives (Factor 9)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
1.1	0.239701	0.242561	-0.00334	0.042952	-0.02042	0.177999	0.109561	0.212696	0.317555	-0.01886
2.3	0.045715	0.277462	0.360191	0.115173	0.045028	0.092638	0.156446	0.223293	0.819093	0.130652
3.16	0.15951	0.282245	0.110136	0.212583	0.362675	0.251229	0.002411	0.046889	0.397279	0.272185

Table. 20 Rotated component matrix for the impact of risk on portfolio objectives (Factor 10)

Risk	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
3.13	0.018934	0.27114	0.27354	0.202709	0.111531	0.028657	0.159276	0.157236	0.159186	0.846475

Biographical notes

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