Prioritizing project risks by a transdisciplinary approach using the grey ordinal priority approach: A case study of an electricity distribution company

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Abstract: *This paper addresses important concerns unique to network privacy in energy distribution systems by presenting a transdisciplinary framework that integrates transdisciplinary tools and transdisciplinary knowledge concepts from risk management, project management, electrical engineering and financial management. The study advances solutions that take into consideration both organizational and technical issues. This is achieved by combining effective decision-making approaches with real-world applications in electrical networks through the use of the Grey Ordinal Priority Approach (GOPA). Electricity distribution projects can immediately benefit from the comprehensive framework proposed by this study, which merges technical expertise with strategic risk management and offers useful insights that can be applied to a variety of domains. By emphasizing the importance of linking disciplines to effectively address complex, high-stakes project challenges, this transdisciplinary viewpoint enhances both the academic and practical dialogue. Results show that changes in project prioritization and announcement of new plans, pressure for early project delivery, improper selection of contractor and consultant, and lack of close supervision of project progress and scheduling are among the significant risks in the project. Electricity distribution companies can improve management of the complexity of their real-world projects by focusing on eliminating or reducing the severity of the aforementioned risks effects.*

Keywords: transdisciplinary, risk management, project management, grey ordinal priority approach, electricity industry

1 Introduction

The potential rise in energy demand due to global warming holds significant importance, particularly evident in densely populated urban areas where the combined impacts of global warming and urban heat islands can exacerbate temperature increases, raising concerns about heightened energy consumption. Global warming may induce an upsurge in cooling requirements and a decline in heating requirements, consequently elevating the demand for electricity (Takane, Nakajima, Yamaguchi, & Kikegawa, 2023).

Enhancing energy efficiency, reducing greenhouse gas emissions, and reducing energy expenses can be achieved through energy management and standardization. Energy management not only diminishes costs, carbon emissions, and risks but also fosters efficient energy utilization through various activities, processes, and techniques. With the ongoing global population growth and advancements in energy technologies over the past few decades, the need for solutions to regulate the escalating energy consumption, notably in electricity, has become increasingly apparent. In Iran, the easy availability of relatively inexpensive electricity has dampened the drive to conserve electricity and optimize energy usage (Masoomi, Panahi, & Samadi, 2022). Despite playing a pivotal role in economic development, the electric power industry now faces challenges such as the persistent growth in electricity consumption and emerging issues like environmental pollution and fossil fuel depletion (Masoomi et al., 2022). The evolution of electricity technology has heightened the exposure to electrical hazards for workers engaged in electricity generation, transmission, distribution, as well as for consumers, including domestic and industrial users (Masoomi et al., 2022). In power generation, transmission, and distribution sectors, employees are exposed to severe occupational hazards and safety risks posed by electric currents during their shifts (Sadeghi-Yarandi et al., 2023). The distribution segment of the electricity industry witnesses numerous incidents and accidents annually, resulting in significant human and financial losses. Electrical shock stands out as one of the most common industrial injuries, with 67% of all electrocutions found to be work-related according to epidemiological studies. Understanding potential risk factors for electrical injuries and providing actionable recommendations to implement effective safety programs for reducing the risk of electrocution is imperative (Sadeghi-Yarandi et al., 2023).

Moreover, due to the nature of the risk assessment process and incidents in the power distribution industry, there is ambiguity in determining the components of probability and severity of these events. The escalating electricity demand necessitates each country's energy ministry to define and execute multiple projects in electricity production, transmission, and distribution. However, uncertainties, numerous decision-making challenges, and the intricate layers in the electricity industry have engendered numerous obstacles and risks in achieving project objectives. Various methods exist for identifying and prioritizing risks, necessitating the selection of appropriate prioritization and risk assessment methods tailored to industry conditions and work activities to effectively prevent accidents. Novel tools and techniques have been deployed in the power industry for risk identification and prioritization. Implementing risk management and evaluation based on working conditions is vital for reducing accidents and occupational hazards in the electricity distribution sector. Identifying, prioritizing, and evaluating potential risks followed by the implementation of suitable control measures form the initial stages of risk management.

While acknowledging the importance of risk management, it is essential to identify and prioritize specific risks in each project type using the latest multi-criteria decision-making (MCDM) methods to undertake appropriate actions. The absence of a robust risk management process in electricity distribution companies poses significant challenges to project success. Hence, this study aims to identify and prioritize pertinent risks to overcome barriers in network privacy projects, frequently implemented in the North Kerman Electricity Distribution Company in Iran.

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This research is distinctively transdisciplinary as described in Section 3 and depicted in Figure 1. In addition, the results of this research are actionable. They are in line with solving real-world issues by emphasizing the importance of linking active disciplines to address complex and high-stakes project challenges.

To pursue this aim, the manuscript commences by reviewing project risk management literature, subsequently outlining the steps and methodologies for identifying and prioritizing project risks. Following this, it introduces the risks associated with the case study project and prioritizes their mitigation using MCDM methods. Finally, it offers suggestions and conclusions.

2 Theoretical Backgrounds

Project risk is defined by the probability and impact of an event that can influence positively or negatively the achievement of project success at an organization level (Croitoru, Oprisan, & Ofelia Robescu, 2021). Numerous research endeavors have delved into project risk management strategies. For instance, Zhou, Zhao, Shen, Yang, and Cai (2020) introduced a novel method and system that integrates the risk management system with the quality management system to manage hazards during construction. Esmaeili, Ravandi, and Zare (2023) scrutinized safety performance indicators (SPI) concerning the health, safety, and environment (HSE) management system in the electricity sector during the COVID-19 pandemic. Seyedhossein and Moeini-Aghtaie (2022) proposed a risk management framework for Peer-to-Peer (P2P) electricity markets, categorizing ten risks into three main groups and suggesting potential responses to mitigate risks. Kolahan, Rezayinik, Hassani Doughabadi, Ramezanpour, and Tajadod (2015) explored risk management in transmission and sub-transmission projects of the Khorasan Regional Electricity Company based on the "Project Management Body of Knowledge (PMBOK)." They identified and prioritized various risks in the mentioned area, assessing them based on probability of occurrence, identifiability, manageability, and impact on project objectives.

In another domain, Parviainen, Goerlandt, Helle, Haapasaari, and Kuikka (2021) investigated Bayesian risk models within the ISO 31000:2018 context, focusing on integrating diverse sources of oil spill risk knowledge. Their study highlighted the utility of Bayesian Networks (BNs) in analyzing oil spill occurrence, response strategies, and variable impacts, emphasizing the need for further research. Furthermore, Lim and Foo (2021) assessed the impact of a catastrophic flood in 2014 on organic, inorganic, and microbial contaminants in floodwater, quantifying health and microbial risks through various risk assessment methodologies. Celik and Gul (2021) introduced innovative dam safety approaches employing the "Best-Worst Method (BWM)" and "Measurement Alternatives and Ranking according to Compromise Solution (MARCOS)" with interval type 2 fuzzy sets (IT2FSs). Khalilzadeh, Shakeri, and Zohrehvandi (2021) scrutinized risks in oil and gas projects under potential sanctions using PMBOK guidelines, identifying and mitigating threats through expert judgment and risk interrelationship analysis. Iqbal, Isaac, Al Rajawy, Khuthbuddin, and Ameen (2021) delved into risk evaluation in the oil industry by analyzing potential risk scenarios during drilling, focusing on control measures to ensure a safe work environment. Selvakumar and Ruvankumar (2020) assessed risks in the truck industry assembly process using Hazard Identification Risk Assessment (HIRA) to implement appropriate risk controls. Ghasemi (2017) examined risk strategies for Tehran Electricity Distribution Company operations by employing SWOT analysis and prioritizing risks with the Analytical Network Process (ANP). Szymański (2017) analyzed construction project risks across different project phases, employing diverse risk management strategies. Muriana and Vizzini (2017) proposed a methodology combining traditional critical path techniques and multi-criteria decision-making to evaluate project risks and implement preventive measures. Unver and Ergenc (2021) identified and prioritized safety risks associated with deforestation activities using AHP, ensuring consistency in expert decision-making.

Thus, despite the extensive research on project risk management, a comprehensive study focusing on identifying and prioritizing project risks in the electricity distribution sector is warranted. This study aims to identify and prioritize project risks to effectively manage and mitigate their impacts.

3 Transdisciplinary Framework of the Study

In this paper, we used a transdisciplinary approach to tackle the problem defined in Section 1. According to Ertas (2010), the transdisciplinary approach entails a cooperative process in which participants from diverse disciplines work together to develop a co-created conceptual framework to address a common problem. Originally, the transdisciplinary process was mostly used in limited contexts, such as urban and environmental development. However, the application of this process has been extended in recent years into fields such as business, management, engineering (Scholz et al., 2024), energy, and risk management (Hernandez-Aguilar et al., 2020; Menoni, 2006; Ozsoy & Mengüç, 2024; Spreng, 2014). Transdisciplinary research (TDR) is able to provide research with a comprehensive approach for addressing complex issues by integrating different disciplinary perspectives to create practical and actionable results.

The transdisciplinary research process produces three essential types of knowledge through the problem-solving process, including systems knowledge, orientation (or target) knowledge, and transformation knowledge (Lawrence, Williams, Nanz, & Renn, 2022). Systems knowledge assesses the current state of a situation or system, orientation knowledge focuses on envisioning the desired future or target status, and transformation knowledge develops strategies to transition from current state to the target status (Hadorn et al., 2008). These types of knowledge support a comprehensive, goal-oriented approach, moving from understanding the present to building pathways toward an improved future.

The complexity of the problem under investigation is known as a principle of TDR process (Hadorn et al., 2008). The complexity of the problem in the context of electricity distribution projects risks arises from the need to address interconnected technical, organizational, and strategic risks. In such projects, factors like technical, financial, and social changes, uncertainties, natural or man-made disruptive events, prioritizing projects, time pressures, contractor competencies, and network privacy create high-stakes challenges that demand a robust and adaptable framework. In this regard, the transdisciplinary approach combines expertise from risk management, project management, electrical and network engineering, financial management, and general management allowing for a framework that can effectively manage the uncertainty and multi-faceted nature of these risks. This holistic and adaptable approach enables a more dynamic and resilient response to real-world challenges and threats.

The proposed transdisciplinary framework is illustrated in Figure 1 with the following description for each section of the figure:

3.1 Transdisciplinary Tools Integration

This section shows the integration of the Ordinal Priority Approach (OPA) as a method of the Group Multi-Criteria Decision-Making (MCDM) domain and Grey System Theory as a mathematical modeling tool for handling uncertainties in the decision-making process. The combination of these methods forms the Grey Ordinal Priority Approach (GOPA), which has been employed as a comprehensive method within our proposed framework. GOPA is suitable for addressing uncertain aspects of the complex decision-making process in network privacy in energy distribution systems.

3.1.1 Project Risk Management Process

The project risk management (RM) process is an intersection of the project management and risk management disciplines and consists of several essential steps, including risk identification, risk analysis, risk evaluation, risk treatment, and risk monitoring (Ahmed, Kayis, & Amornsawadwatana, 2007). As a structured method, RM is applied to address risks in a complex project. Using GOPA within the RM process, we are able to accomplish a holistic assessment of risks and prioritize those that have significant impacts on the electricity distribution project performance.

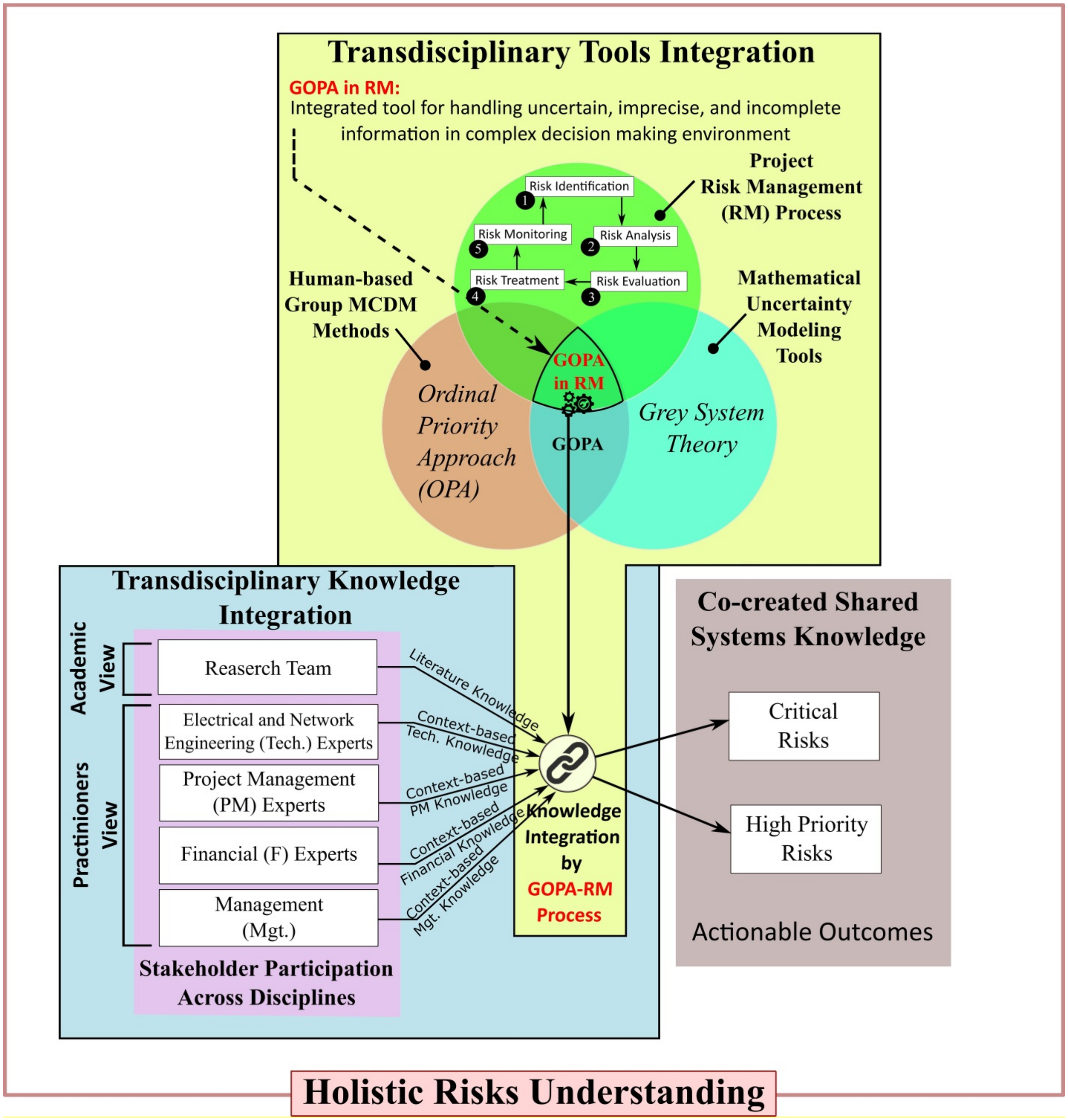

Figure 1: Proposed Transdisciplinary Framework

3.1.2 Human-Based Group MCDM Methods

Group MCDM is a transdisciplinary systemic tool (Hernandez et al., 2024) and can bring together expert opinions to evaluate complex and real-world issues efficiently (Ahmad, Khan, & Ahmad, 2023). In the study, experienced experts from diverse fields active in electrical network projects (i.e., electrical and network engineers, project managers, financial experts, and general managers) have collaborated by supporting the GOPA to generate valuable system knowledge and holistic insights for the risks in the complex projects under study.

3.1.3 Mathematical Uncertainty Modeling Tools

Uncertainty is known as an attribute of TD problems (Scholz et al., 2024). Mathematical tools for uncertainty modeling, specifically Grey System Theory (GST), could help manage uncertainties and complexities in multifaceted problems (Javanmardi, Liu, & Xie, 2020). So, this capacity of Grey System Theory to handle uncertainty and complexity aligns well with the characteristics of electricity distribution projects, where certain data on different aspects of the project may not always be available. GST allows the researchers to model imprecise data in order to identify and rank risk factors, enhancing RM process.

3.2 Transdisciplinary Knowledge Integration

Transdisciplinary knowledge integration is a core principle of TDR (Scholz et al., 2024) and is crucial for developing a holistic understanding of complex project risks. It involves synthesizing diverse forms of knowledge from multiple disciplines to shape a comprehensive understanding of a complex issue. In this section of the study, the GOPA method synthesizes stakeholders' perspectives of electricity distribution network projects from a variety of disciplines, as depicted in Figure 1 to create a shared understanding of risks, reflecting the transdisciplinary nature of the study.

3.3 Co-Created Shared Systems Knowledge

Co-creation of knowledge is another crucial element of TDR, emphasizing the collaborative development of solutions where knowledge is shared inclusively (Rigolot, 2022). In this study, the integration process results in a co-created shared systems knowledge (as described earlier), representing both academic and practitioner viewpoints. This shared knowledge is essential for aligning stakeholders on risk priorities and actionable insights, ultimately leading to make better decisions by the projects owners and project managers. The GOPA output, specifically the high-priority risks, is shaped by this combined knowledge.

3.4 Actionable Outcomes: Critical Risks and High-Priority Risks

TDR also emphasizes the real-world impact of research results and has a focus on outcomes that are actionable and beneficial to society (Wada, Grigorovich, Kontos, Fang, & Sixsmith, 2021). This practical orientation ensures that research efforts make solutions or shape insights that stakeholders can use to address real-world challenges. The actionable outcomes, categorized as critical risks and high-priority risks in this research, allow for targeted interventions and desired provisions in electricity distribution projects. By identifying and ranking these critical risk factors, organizations can allocate resources effectively as well as design and execute proper response-to-risk (R2R) plans to enhance project success rates.

3-5 Stakeholder participation across disciplines

Collaboration across disciplines is also essential in the TDR process, as it brings together experts from multiple fields to create a holistic understanding of complex problems (Slade et al., 2023). This involves integrating knowledge not only from various academic fields but also from practitioners and stakeholders (i.e., diversity of participants), ensuring a comprehensive and multifaceted approach (Steelman et al., 2021).

3.6 Holistic Risks Understanding

At the foundation, the goal of the TDR approach in this study is to achieve a holistic understanding of the risks of electricity distribution projects that leads to actionable insights. By combining the technical, human, and uncertainty-focused components and methods, the framework captures a comprehensive and multifaceted view of the risks that transcend traditional disciplinary boundaries, delivering results that can be immediately applied to improve risk management strategies in electricity distribution projects.

4 Methodology

The present study was conducted in the North Kerman Electricity Distribution Company in Iran to prioritize project risks. Based on the steps of risk management, which include identifying, assessing, and prioritizing risks, risk response, and monitoring and controlling risks (ASKARI, SADEGHI, & SEIFLOU, 2016), the methodology steps of this study are as follows.

- Introducing the organizational projects
- Identifying project risks
- Prioritizing project risks

4.1 Introducing the organizational projects

Figure 2 illustrates the life cycle of the completed projects, which is obtained by reviewing the project documentation in the studied organization and is as follows.

- Planning
- Designing
- Selecting the contractors and concluding the contract
- Execution, control, and supervision
- Operation

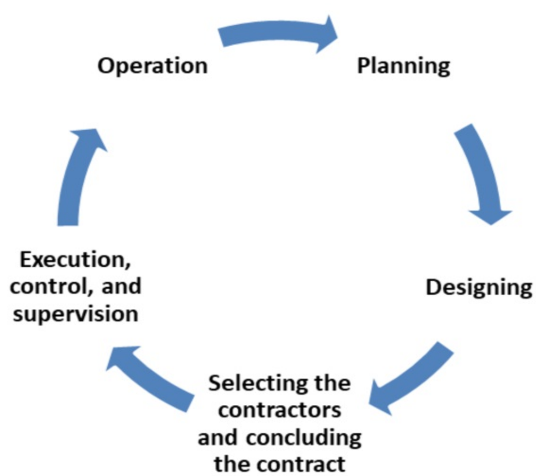

Figure 2: The Life cycle of projects in the company under review

In order to evaluate the risks of the organization's projects, the project of removing privacy barriers was proposed and examined by the electricity distribution company. Privacy is the permitted distance of new buildings located in the path of electricity distribution networks according to the established rules and regulations, and electricity distribution networks include all existing facilities and equipment at different voltage levels. Removing privacy is also freeing privacy. After selecting the sample project, interviews were conducted with experts who include the employees of the electricity distribution company and the risks of different phases of the project were identified. The number and specifications of specialists are given in Table 1.

Table 1: Experts' profile

Row	Degree of education	Work experience	Job
1	Master of Electrical Engineering	14 years	Expert of design and supervision unit
2	Master of Management	21 years	Head of the planning group
3	Bachelor of Computer Engineering	17 years	Expert in charge of statistics and planning
4	Bachelor of Electrical Electronics	17 years	Head of Office
5	Bachelor of Accounting	10 years	Finance expert
6	Bachelor of Electrical Engineering	20 years	Project control office manager
7	Bachelor of Power Electrical	20 years	Project control office expert

4.2 Identifying project risks

Identifying and categorizing risks in projects is regarded as the second step in the risk management process. According to some experts, risk identification is considered the most important step in the risk management process. Identifying and classifying documents related to the implemented projects to determine the factors affecting non-achievement of project objectives, modeling, and other similar projects are regarded as the most important output of the step above (Kolahan et al., 2015).

4.3 Prioritizing project risks

To prioritize the identified risks, the GOPA was selected among the MCDM methods in the definite, fuzzy, and grey cases. Ataei, Mahmoudi, Feylizadeh, and Li (2020) introduced the Ordinal Priority Approach (OPA) in Multi-Criteria Decision Making (MADM), which can be applied in individual or Group Decision-Making (GDM), and its notable differences with other methods are as follows.

- OPA does not use two-way comparison matrices, decision matrices (without the need for numerical input), normalization methods, intermediate methods for collecting expert opinions (in GDM), and linguistic variables.
- Experts comment only on features and alternatives they have sufficient knowledge and experience.

The validity of the ordinal priority approach method has been evaluated using several group and individual samples. The results showed that the ordinal priority approach compared to other methods such as AHP, BWM, TOPSIS, VIKOR, PROMETHEE and QUALIFLEX based on comparing weights and ranks using Spearman and Pearson correlation coefficients to calculate the correlation between two distance or relative variables and the existing correlation (Ataei et al., 2020).

4.3.1. Ordinal Priority Approach

Ordinal Priority Approach (OPA), as one of the MCDM methods, can be applied in groups and individually, in which the experts and their priorities are determined (Ataei et al., 2020). In OPA, each expert ranks the alternatives based on each criterion, and the criteria are divided into sub-criteria when there is any. Finally, the weight of criteria, alternatives, experts, and sub-criteria are obtained simultaneously (Figure 3). One of the important advance of OPA is GOPA that can work without any data based on paired comparison and has a high ability against uncertainty (Islam, 2021).

Decision-making is regarded as one of the most widely used techniques in management, engineering, and the like. In most cases, the input data are considered incomplete or unknown. In such cases, GOPA methods are used, while the fuzzy method is utilized in cases of uncertainty. Table 2 represents the parameters and variables applied in GOPA (Ataei et al., 2020).

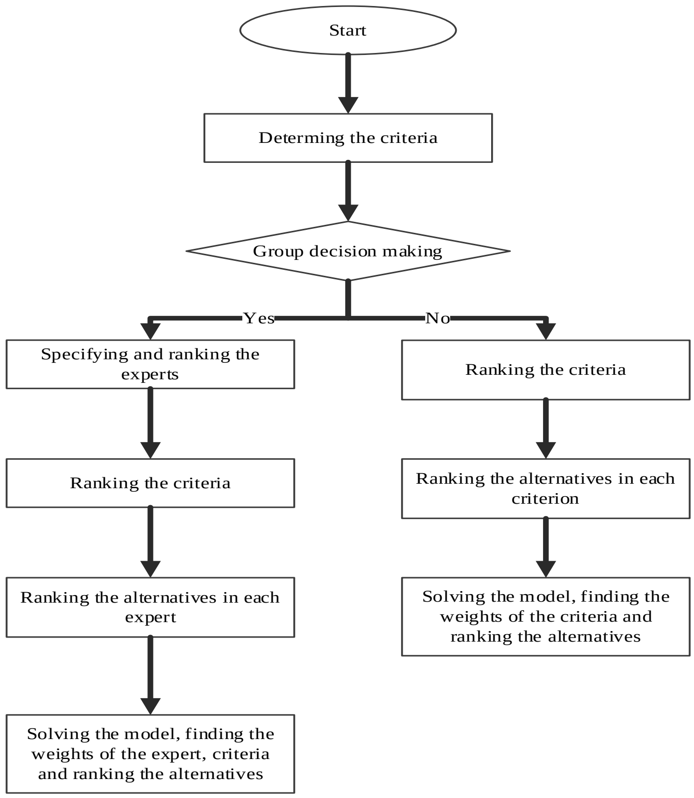

Figure 3: Flowchart of OPA steps

Table 2: Sets, parameters, and variables of GOPA

Sets	
Set of experts	I
Set of criteria	J
Set of alternatives	K
Indexes	
Index of experts	i
Index of preference of the criteria	j
Index of the alternatives	k
Variables	
Grey objective function	$\otimes Z$
Grey weight of k^{th} alternative based on j^{th} criteria by ith expert at r^{th} rank	
Parameters	
Grey rank of expert i	$\otimes i$
Grey rank of criterion j	$\otimes j$

Grey rank of alternative k	$\otimes k$

The steps of GOPA are as follows (Ataei et al., 2020).

1. Determining the criteria: The basic and sub-criteria should be determined by the decision-maker.
2. Identifying and ranking experts in the case of GDM: The issue becomes GDM when there is more than one expert. The experts and their priorities are determined at this step.
3. Ranking the criteria: The priority of the requirements is determined by experts at this step.
4. Ranking the alternative in each criterion: The experts determine the priorities of the alternatives in each measure at this step.
5. Solving the GOPA model, finding the criteria weight, and ranking the alternatives: Based on the data in steps 1-4, a linear model is formulated to determine the criteria weight and rank the choices as Eq. (1).

$$\begin{aligned}
&Max \ \otimes Z \\
&s.t: \\
&\otimes Z \leq \otimes i\left(\otimes j\left(\otimes r\left(\otimes w_{ijk}^{r} - \otimes w_{ijk}^{r+1}\right)\right)\right),\ i,\ j, k \ and\ r \\
&\otimes Z \leq \otimes i \otimes j \otimes m \otimes w_{ijk}^{m} \\
&\sum_{i=1}^{p}\sum_{j=1}^{n}\sum_{k=1}^{m} \otimes w_{ijk} = [0.8, 1.2] \\
&\otimes w_{ijk} \geq 0,\ i,\ j, and\ k
\end{aligned} \tag{1}$$

The grey weight of the experts, criteria and other alternatives are obtained from the following equations after solving the grey model as Eq. (1). The grey weight of the alternatives is determined as Eq. (2).

$$\otimes w_{k} = \sum_{i=1}^{p}\sum_{j=1}^{n} \otimes w_{ijk} \quad for\ each\ i,\ j \tag{2}$$

The grey weights of the criteria are calculated by applying Eq. (3).

$$\otimes w_{j} = \sum_{i=1}^{p}\sum_{k=1}^{m} \otimes w_{ijk} \quad for\ each\ i, k \tag{3}$$

The grey weights of experts are identified using Eq. (4).

$$\otimes w_{i} = \sum_{i=1}^{p}\sum_{k=1}^{m} \otimes w_{ijk} \quad for\ each\ j, k \tag{4}$$

6. Finally, the experts, criteria, and alternatives are ranked after calculating their weight in step 5.

5 Results and Discussions

The risks related to eliminating the barriers of privacy, which seek to free the confidentiality of the network of low air pressure due to the property in its adjacent were identified and prioritized by preparing questionnaires and interviewing the experts. In addition, the risks associated with each step of the project life cycle were identified by examining other projects

To prioritize the identified risks, some questionnaires were reviewed and completed by the project team based on the probability of occurrence, the extent of the impact on the project, and probability of identifying and detecting the risks (Tables 3, 4, and 5).

Table 3: Probability of risk occurrence

Probability of occurrence	Definition for the probability of occurrence	The Risk or opportunity number
High	Risk occurs almost frequently and continuously at the organizational level.	3
Medium	Risk has a relatively high probability of occurrence in the organization.	2
Low	Risk infrequently occurs in the organization with a low probability.	1

Table 4: The extent of risk impact

Consequence or severity	Definition for the extent of risk impact	The Risk or opportunity number
High	Severe impact risk can expose the company to significant challenges in the relevant areas and create significant damage.	3
Medium	The risk with severe impact: Loss of resources, damage which can be compensated by reprocessing.	2
Low	The risk with low wasted resources: The relatively severe impact of the damage which can be offset in the short term.	1

Table 5: Probability of risk detection

Detectability	Definition of detectability	Risk or opportunity number
Low	The risk is unlikely to be detected and revealed by existing controls.	1
Medium	The ability to detect risk is considered moderate, and the potential risk or opportunity can be seen and revealed by existing controls in half of the cases.	2
High	The ability to detect risk is regarded as high, and the potential risk or opportunity can be seen and revealed by existing controls with a relatively high probability.	3

5.1 GOPA in the project life cycle

5.1.1 Design process

The identified risks were ranked by interviewing and completing the questionnaire by experts while designing the projects.

The risks and alternatives in each risk were ranked by completing the questionnaire by the experts in project planning. The risks are weighted by an expert because there is an expert in the project team during planning. Based on the results obtained from the GOPA in LINGO 17.0 software and placement in Eqs. (2)-(4), the weight of alternatives, risks, and experts can be obtained, respectively. Tables 6 and 7 show the weights obtained from GOPA.

Table 6: Weight of alternatives and experts during designing

Weight of alternatives		
Probability of occurrence	The extent of the impact on the project	Probability of risk detection
0.3	0.9	0.35
	Weight of expert/experts	
1	Expert	0.97~1

Table 7: Weighing and ranking the risks in GOPA

Row	Risk index	Risk title	Criterion weight	Rank
1	A_d	Changes in project scope /features	0.l2	3
2	B_d	Incorrect estimation of project time and cost volume	0.058	5
3	C_d	Misunderstanding the demands and needs of project Stakeholders	0.043	6
4	D_d	Change in the prioritization of projects to announce new plans	0.39	1
5	E_d	Lack of sufficient competence in-network and project design	0.061	4
6	F_d	Lack of accurate design of development plans	0.037	7
7	G_d	Lack of feasibility and accurate estimation of the project scope	0.18	2
8	H_d	Lack of definition of technical and qualitative features related to the project	0.033	8
9	I_d	Existence of errors in the documents	0.061	4
10	J_d	Climate change	0.029	9

As shown in Table 8, the risks identified during designing are ranked by the weights obtained. Figure 4 shows the ranking of risk criteria identified in the process above by one expert.

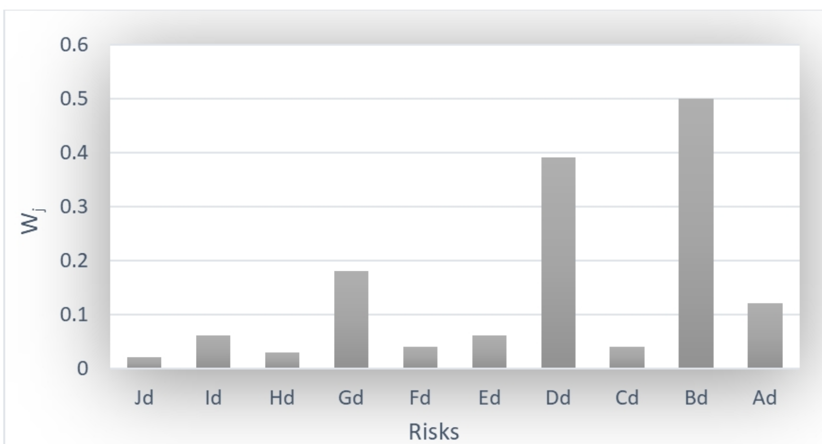

Figure 4: Ranking the risks by one expert during designing

The significant risks are as follows due to the weight and ranking of criteria using GOPA during designing.

- Change in the prioritization of projects in order to announce new plans
- Lack of feasibility and correct estimation of the project scope
- Changes in the scope/features of the project

5.1.2 Planning process

The risks of the planning process were prioritized by interviewing and completing a questionnaire by two experts. Each risk was ranked by experts based on the probability of its occurrence, extent of impact, and probability of detection. Table 8 represents the weight and ranking of risks using GOPA.

Table 8: Ranking the risks by group GOPA during planning

Row	Risk index	Risk/opportunity	Weigh	Rank
1	A_P	Limited financial resources	0.092	5
2	B_p	Changing project implementation priorities in order to announce new plans	0.15	2
3	C_p	Incorrect estimation of project time and cost	0.07	7
4	D_p	Price fluctuations and inflation	0.09	6
5	E_p	Pressure for early project delivery	0.28	1
6	F_p	Increasing workload and overshadowing priorities	0.01	8
7	G_p	Lack of proper budget estimation	0.13	4
8	H_P	Failure to allocate funds in accordance with the budget	0.14	3

Table 9 presents the weights of the experts and alternatives obtained in group GOPA, and Figure 5 demonstrates the ranking of the criteria identified during planning. In addition, the weight of the risks was obtained separately for each expert by GOPA to compare the obtained results individually with those taken from group GOPA to evaluate their compatibility. Table 10 indicates the weight of risks in GOPA for each expert.

Table 9: Weight of alternatives and experts during planning

Weight of alternatives		
Probability of occurrence	The extent of impact on the project	Probability of risk detection
0.37	0.34	0.27
	Weight of expert/experts	
1	Expert one	0.73
2	Expert two	0.25

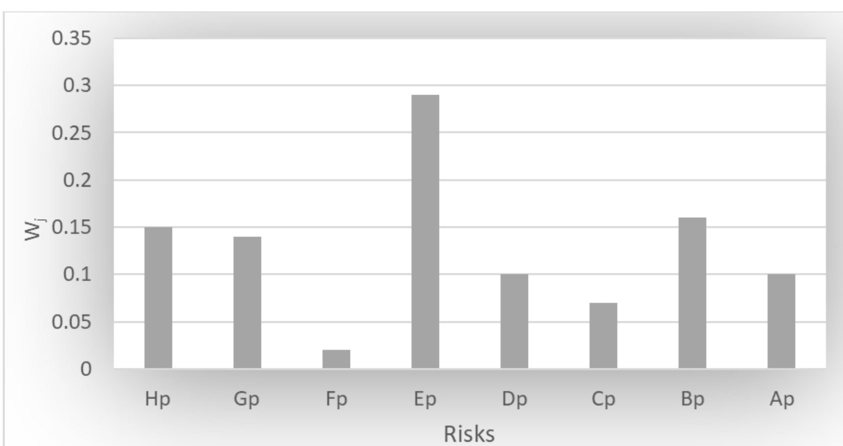

Figure 5: Ranking of risks during planning in group GOPA

Table 10: Weight and rank of risks during planning in individual GOPA

Row	Risk title	Expert one		Expert two	
		Weight	Rank	Weight	Rank
1	Pressure for early project delivery	0.38	1	0.08	5
2	Lack of proper budget estimation	0.17	2	0.07	6
3	Changing project implementation priorities in order to announce new plans	0.17	2	0.09	4
4	Incorrect estimation of project time and cost	0.08	3	0.05	7
5	Failure to allocate funds in accordance with the budget	0.06	4	0.29	1
6	Price fluctuations and inflation	0.08	3	0.14	3
7	Limited financial resources	0.05	5	0.25	2
8	Increasing workload and overshadowing priorities	0.03	6	0.04	8

A compatibility relationship is observed between the results based on the weight of the criteria obtained in group and individual GOPA. In addition, the Pearson correlation coefficient was utilized to examine the relationship between the weights obtained from expert one and group GOPA. The correlation coefficient between -1 and 1 means the correlation between the two variables. The correlation coefficient is obtained from Eq. (5).

$$R_{x,y} = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left(n\sum x^2 - \left(\sum x\right)^2\right)\left(n\sum y^2 - \left(\sum y\right)^2\right)}} \quad (5)$$

Pearson correlation coefficients of 0.9 and 0.089 are obtained for expert one and two GOPA with group GOPA, respectively, by solving Eq. (5). In addition, a direct relationship and correlation are reported between individual and group GOPA since the coefficients are between -1 and 1. In Figure 6, the weight of risks in the planning process is given in the GOPA method for specialist one and two and in groups.

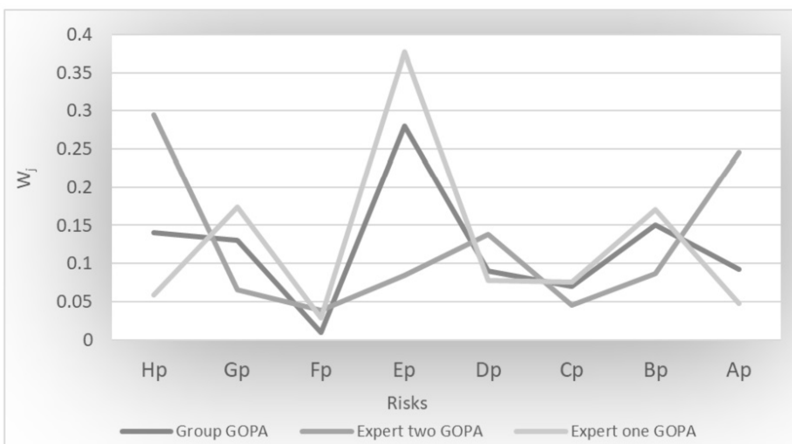

Figure 6: Weight of expert one, two, and group risks in GOPA during the planning

The important risks which cause the plans to fail and create irreparable damage during planning are as follows.

- Pressure for early project delivery
- Changing project implementation priorities to announce new plans
- Failure to allocate funds following the budget

5.1.3 Selecting the contractor and concluding the contract

The risks for selecting the contractor and concluding the contract were prioritized after interviewing and completing the questionnaire by the experts. Each risk was prioritized by each expert according to its probability of occurrence, extent of impact, and detection percentage. Tables 11 and 12 show the weights obtained from GOPA for the alternatives and experts. Figure 7 displays the obtained weights of criteria in group GOPA during selecting the contractor and concluding the contract.

Table 11: Weight of alternatives and experts during selecting the contractor and concluding the contract

Weight of alternatives		
Probability of occurrence	The extent of impact on the project	Probability of risk detection
0.30	0.5	0.2
	Weight of experts	
1	Expert one	0.7
2	Expert two	0.3

Table 12: Weight and rank of criteria in GOPA during selecting the contractor and concluding the contract

Row	Risk index	Risk/opportunity	Weigh of risks	Priority of risks
1	Ac	Ambiguity in the contract	0.11	4
2	Bc	Improper selection of contractor and consultant	0.41	1
3	Cc	Inadequate type of contracts such as EPC and the like	0.06	5
4	Dc	Lack of transparency in the needs of the employer and contractor	0.06	5
5	Ec	The slowness of the contracting processT	0.16	3
6	Fc	Inadequate steps of the project payment	0.03	7
7	Gc	Delays in project payments	0.04	6
8	Hc	The tendency of some agents to prolong the project	0.02	8
9	Ic	Limitations on the contractors' capacity	0.2	2
10	Jc	Lack of attractiveness of projects for contractors	0.03	7

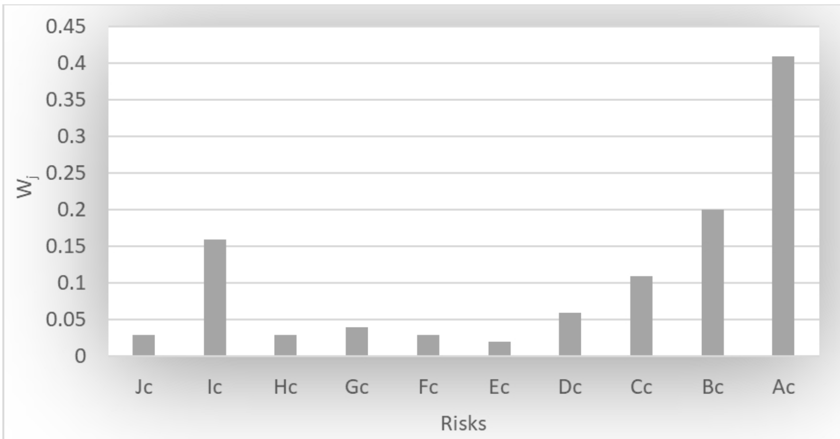

Figure 7: Weighing and ranking the criteria in group GOPA during selecting the contractor and concluding the contract

In addition, the weight of the risks was obtained separately for each expert during selecting the contractor and concluding the contract by GOPA to compare the obtained results individually with those taken from group GOPA to evaluate their compatibility. Table 13 represents the weight of risks in GOPA for each expert.

Table 13: Weight and rank of risks during selecting the contractor and concluding the contract in individual GOPA

Row	Risk title	Expert one		Expert two	
		Weight	Rank	Weight	Rank
1	Improper selection of contractor and consultant	0.14	1	0.37	1
2	Limitations on the contractors' capacity	0.21	2	0.18	2
3	Ambiguity in the contract	0.09	3	0.15	3
4	Lack of transparency in the needs of the employer and contractor	0.07	4	0.06	4
5	The tendency of some agents to prolong the project	0.05	5	0.07	4
6	Inadequate type of contracts such as EPC and the like	0.04	6	0.09	3
7	Delays in project payments	0.04	6	0.06	5
8	Lack of attractiveness of projects for contractors	0.03	7	0.02	8
9	The slowness of the contracting process	0.03	7	0.04	6
10	Inadequate steps of the project payment	0.03	7	0.03	7

Figure 8 shows the weight of risks during selecting the contractor and concluding the contract for experts one and two, as well as group GOPA. A compatibility relationship is observed between the results based on the weight of the criteria obtained in group and individual GOPA. Pearson correlation coefficients of 0.93 and 0.91 are obtained for expert one and two GOPA with group GOPA, respectively, by solving Eq. (5). In addition, a direct relationship and correlation are reported between individual and group GOPA because the coefficients are between -1 and 1.

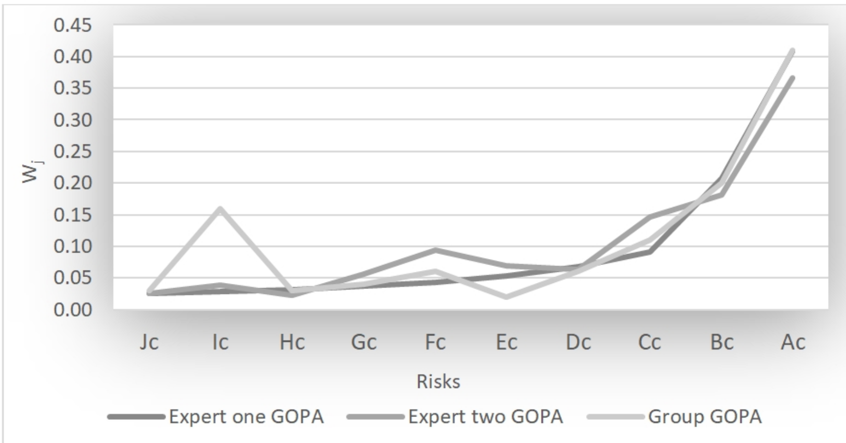

Figure 8: Weight of risks for expert one, two, and group GOPA during selecting the contractor and concluding the contract

The important risks which create delays in the implementation of projects during selecting the contractor and concluding the contract are as follows.

- Improper selection of contractor and consultant
- Limitations on the contractors' capacity
- Delays in project payments

5.1.4 Supervision and execution

Supervision and execution are among the most important processes in the organization to implement the projects correctly and on time. To this aim, two experts in the field of supervision and execution were interviewed, and a questionnaire was completed.

The identified risks were prioritized and ranked by interviewing and completing a questionnaire by two experts in the supervision and execution of the company projects based on the probability of occurrence, extent of impact, and probability of their detection in the project. Table 15 indicates the risk ranking during supervision and execution by group GOPA, which is conducted by obtaining their weight.

Table 14 presents the weight of alternatives and experts in group GOPA during supervision and execution.

Table 15 indicates the risk ranking during supervision and execution by group GOPA, which is conducted by obtaining their weight.

Table 14: Weight of alternatives and experts during supervision and execution

Weight of alternatives		
Probability of occurrence	The extent of impact on the project	Probability of risk detection
0.2	0.34	0.46
	Weight of expert/experts	
1	Expert one	0.58
2	Expert two	0.42

Table 15: Weighting and ranking the criteria in group GOPA during supervision and execution

Row	Risk index	Risk/opportunity	Weigh of criteria	prioritization
1	7	Error in predicted activities	0.038	6
2	5	Consultant delays	0.35	7
3	6	Employer delays	0.19	13
4	13	Lack of accurate estimation in scheduling	0.22	18
5	14	Failure to comply with the prerequisites of the activities	0.17	14
6	1	Lack of accurate supervision for project progress and schedule	0.202	1
7	8	Lack of budget management by the contractor	0.027	11
8	17	Lack of access to the project	0.013	17
9	9	Technical and quality problems of equipment	0.034	8
10	2	Lack of timely supply of equipment	0.101	2
11	16	Lack of timely access to documentation during the project	0.016	15
12	21	Prolonged review and approvals such as status reports	0.03	9
13	3	Lack or absence of specialized human resources	0.02	12
14	11	Lack of precise and efficient coordination and information system	0.08	4
15	22	Change in project stakeholders	0.011	19
16	10	changes in the inflation rate	0.029	10
17	18	Restrictions on the import of equipment and knowledge	0.083	3
18	20	Changes in currency prices	0.012	18
19	4	Lack of proper insurance in projects	0.057	5
20	15	Changes in rules and requirements	0.014	16
21	12	Accidents at work for project agents	0.016	15
22	19	Natural and unforeseen disasters such as flood and the like	0.012	18

Therefore, Figure 9 illustrates the obtained risk weights in group GOPA during supervision and execution.

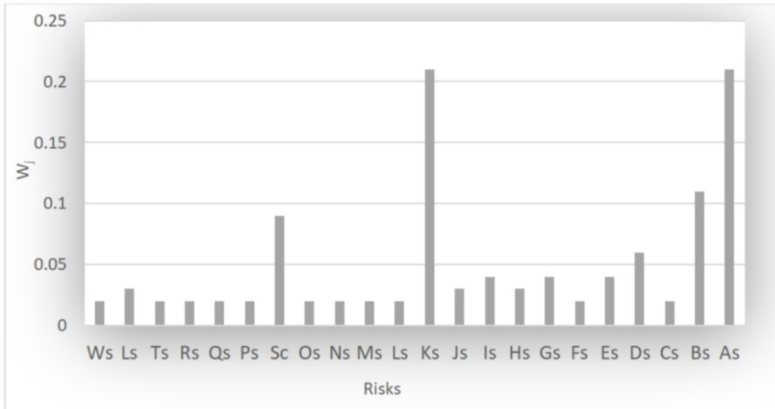

Figure 9: Weighting and ranking the criteria in group GOPA during supervision and execution

In addition, the weight of the risks was obtained separately for each expert by GOPA to compare the obtained results individually with those taken from group GOPA to evaluate their compatibility. Table 16 shows the weight of risks in GOPA for each expert.

Table 16: Weight and rank of risks related to supervision and execution in individual GOPA

Row	Risk title	Expert one		Expert two	
		Weight	Rank	Weight	Rank
1	Lack of accurate supervision for project progress and schedule	0.33	1	0.34	6
2	Lack of timely supply of equipment	0.18	2	0.13	2
3	Lack or absence of specialized human resources	0.08	4	0.02	9
4	Lack of proper insurance in projects	0.06	5	0.31	8
5	Consultant delays	0.05	6	0	13
6	Employer delays	0.04	7	0.018	10
7	Error in predicted activities	0.37	8	0.05	4
8	Lack of budget management by the contractor	0.31	9	0.02	9
9	Technical and quality problems of equipment	0.23	10	0.06	4
10	Changes in inflation rate	0.21	11	0.05	5
11	Lack of precise and efficient coordination and information system	0.015	13	0.09	3
12	Accidents at work for project agents	0.018	12	0.01	12
13	Lack of accurate estimation in scheduling	0.017	14	0.02	9
14	Failure to comply with the prerequisites of the activities	0.015	13	0.02	9
15	Changes in rules and requirements	0.013	15	0.01	12
16	Lack of timely access to documentation during the project	0.013	15	0.37	1
17	Lack of access to the project	0.012	16	0.012	11
18	Restrictions on the import of equipment and knowledge	0.09	3	0.03	7
19	Natural and unforeseen disasters such as flood and the like	0.011	17	0.012	11
20	Changes in currency prices	0.012	16	0.012	11
21	Prolonged review and approvals such as status reports	0.013	15	0.13	2
22	Change in project stakeholders	0.009	18	0	13

Figure 10 demonstrates the weight of risks during selecting the contractor and concluding the contract for experts one and two, as well as group GOPA. A compatibility relationship is observed between the results based on the weight of the criteria obtained in group and individual GOPA. Pearson correlation coefficients of 0.71 and 0.61 are obtained for expert one and two GOPA with group GOPA, respectively, by solving Eq. (5). In addition, a direct relationship and correlation are reported between individual and group GOPA because the coefficients are between -1 and 1.

The most important risks identified and prioritized during supervision and execution process are as follows.

- Lack of accurate supervision for project progress and schedule
- Restrictions on the import of equipment and knowledge
- Lack of timely supply of equipment

Occurrence of the criteria above leads to delays in projects and the non-fulfillment of plans.

6 Conclusion

In this research, 50 risks were identified for the project of removing network privacy barriers in the North Electricity Distribution Company of Kerman province based on the life cycle processes of the projects in this company and were prioritized by the normal group priority approach method in gray mode. Important criteria in the processes include the following:

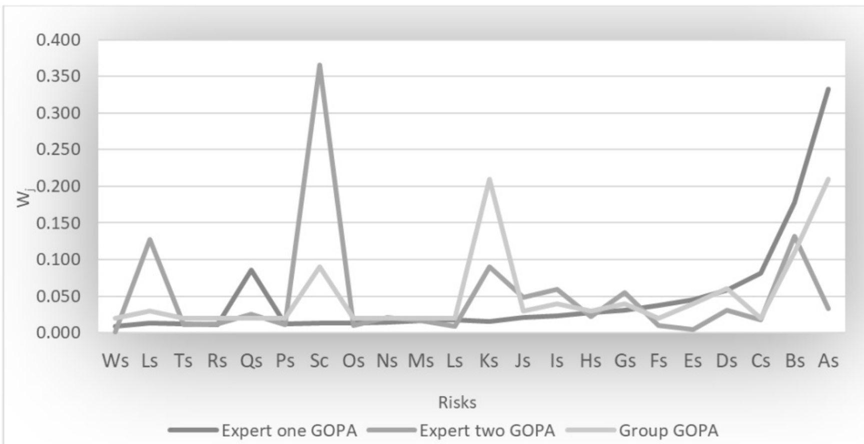

Figure 10: Weight of risks for expert one, two, and group GOPA during supervision and execution

1. Design process:
    - Change in project prioritization and notification of new plans
    - Lack of feasibility and correct estimation of project scope
    - Changes to project scope/specifications
2. Planning process
    - Pressure for early delivery of the project
    - Changing the priorities of implementing projects and announcing new plans
    - Failure to allocate credit according to the budget
3. The process of selecting a contractor and signing a contract
    - Inappropriate choice of contractor and advice
    - Limitations of contractors' capacity to perform work
    - Delay in project payments
4. Monitoring and implementation process
    - Lack of careful monitoring of project progress and schedule

- Restrictions on the import of equipment and knowledge
- Failure to provide equipment on time

Considering the risks and prioritizing can be a basic guide for risk planning in managing projects in the North Kerman Electricity Distribution Company. Many of the risks identified in the selected project are regarded as probable in other projects in the North Kerman Electricity Distribution Company. Thus, an accurate and practical database of all of the possible risks on the projects can be created by continuously identifying and assessing the risks of the projects, one of the main applications of which is applying them in the processes and steps of projects and indicating them in contracts as documents attached to the contract. In addition, more accurate and comprehensive values for the current status of the risks above can be determined by continuously implementing the risk management process. Accurate estimation of project schedule and costs requires the calculation and application of actual project coefficients, which are obtained based on the results of identifying and evaluating the project risks.

The appropriate responses and solutions can be identified and selected in future studies in the form of an appropriate model after collecting and prioritizing risks in the continuation of risk management steps. In addition, other methods such as AHP, BWM, and the like can be used for comparing the above-mentioned method with MDCM one. The present study should review OPA method in the fuzzy state. Further, an instrument should be utilized to ensure the results, although Javed, Mahmoudi, and Liu (2020) compared the theory of GOPA model with a number of well-known MCDM methods with acceptable answers, concluding that the experts can only comment on the features and options for which they have sufficient knowledge and experience, and a large number of aspects appear superior to the classical MCDM theories. Furthermore, other risks should be applied in addition to those presented in this study, such as risks related to COVID 19 diseases and power outages. Finally, the method above should be used for various issues in other projects, making its limitations and weaknesses understandable due to its novelty.

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