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Risk factors in international rail-system projects

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Abstract:
Construction projects carry many risks due to their long-term, changeable, and dynamic structures. When these risks are transferred to the international environment, they may give rise to new risks and increase the effects of existing risks. International railway-system projects, involve many project-specific risks due to their long duration and high volume of technological manufacturing. Opening completed rail lines for use requires the anticipation of risks that may arise during the warranty period. This study conducted a survey with construction-sector employees working on rail-system projects in Turkey, Italy, and India regarding the risks they face within the scope of the project. Based on the exploratory factor analysis, the risks encountered in international rail-system projects were grouped under three factors: "management-related risks," "time- and cost-related risks," and "product quality-related risks." The results showed that time and cost risks differed by country.

Keywords:
construction sector; international railway system projects; risk factors

1 Introduction

In construction projects, work must be completed with the optimum level of safety, as specified in the contract, in terms of quality, time, and cost. Construction projects carry many risks owing to their unique structure, long-term duration, and numerous interactive activities and teams, as well as criteria such as the economic structure of the company and country [1]. Additionally, the risks in small-scale projects lead to different and more significant risks when transferred to international platforms. Country-specific risks and uncertainties are prevalent in international construction projects, making them more dangerous for companies. Meta-analysis studies on the risk factors encountered in international construction projects [2, 3] reveal country-specific risks, such as the political situation, inflation, laws and regulations, exchange rates, expropriation, bribery and corruption in the host country, language barriers, tax procedures, social conflicts, gross domestic product, entry restrictions, relations with neighbouring countries, and bureaucracy. The probability of basic risks emerging or having significant effects in developing countries has also increased [4]. Companies inevitably face risks such as access to qualified labour, the level of advanced technology used in equipment and machinery, and a fluctuating economy.

This study focuses on two main points. The first is to examine the risks encountered in international construction projects in both developed and developing countries. Three categories of countries were selected based on the Human Development Index (HDI), which was included in the Human Development Report published by the United Nations Development Program (UNDP) in 2016 [5]. Italy, Turkey, and India, representing the categories of countries with very high, high, and medium human development, respectively, were included in the study. According to the United Nations Conference on Trade and Development classification, Italy has a developed economy, whereas Turkey and India have developing economies [6]. The aim of selecting three different countries is to examine the impact of political and economic development on the countries in which the projects are carried out, problems encountered in borrowing from local banks, inflation, local tax regulations and laws, the supply process of equipment and materials, human resources, permits obtained from local authorities, the local people's approach to the project, and different geographical and climatic conditions. The second focus of the study is international rail-system projects, which have long construction periods, routes, and construction sites, and use advanced technology. Special conditions such as continued responsibility and risk-sharing during the guarantee periods and the opening of the completed route make the situation more critical for companies in road-construction projects [7].

2 Developing countries and international construction projects

Construction projects carry many risks owing to their long durations and unique structures, and working in different countries allows many new uncertainties [8, 9]. Studies have suggested that the likelihood of risk is higher in developing countries [10].

Political and/or economic fluctuations in developing countries can affect the uninterrupted progress of a project [11], especially in uncertain political environments where unexpected customer behaviour [8], interruptions, suspensions, and critical risks such as route changes can occur. In addition, inflation and exchange-rate fluctuations pose significant cost risks to companies [12]. Payment delays can occur, even if the employer is in the public sector. Land-permit delays and high taxes are also risky for companies.

In construction projects in developing countries, the preference for local labour may be perceived as advantageous owing to cheaper labour costs; however, insufficient occupational-safety culture, strikes, foreign languages, and communication problems are inevitable risks [2]. Transferring the contractor's key personnel to the country in which the project is conducted can also cause socio-psychological adaptation problems. Employees do not prefer to live in the country in which a project is being conducted for a long time [11].

If a project requires advanced technology, important issues such as access to qualified labour, advanced technological equipment, machinery, and spare parts, as well as quality assurance

deficiencies [4, 11, 13] need to be considered. Considering these risks, the economic, technical, cost, and legal feasibility of a new market must be improved. Moreover, options such as reflecting risks in the contract period and bid price or insurance must be considered.
International rail-system projects require meticulous planning, the use of construction and operational schemes, and the prioritisation of safety and reliability because they will be used by a large number of passengers. The requirement for advanced engineering applications in international rail-system projects leads to the preference for expert firms for the project and its applications, which increases the likelihood of international firms being preferred [11].
As with all transportation projects, the difficulties arising from the land properties and climatic conditions of the project location should be identified at the feasibility stage of international rail-system projects.
High-speed rail projects contain more new and technological systems than traditional rail-system projects and carry risks that can cause deviations in time and cost-control during construction [14, 15]. Changes in technology, location, and route may arise during a project's lifetime, creating additional risks. Changes in the route may involve not only the central government of the country where the work is being done, but also the local administration. This situation adds social and political risks to technological and cost risks [16].
In particular, in rail-system projects that are planned to be put into use at certain stages, responsibility distribution should be performed well during the guarantee period. The long duration of rail-system projects causes many cost risks; thus, contracts must include the necessary compensation [11]. In addition, different teams performing technological work may occasionally damage electronic manufacturing equipment because of erroneous applications. The maintenance and repair expenses of opened lines should also be addressed separately in the contract. Thus, the importance of contract management has increased. Contract implementation should be adjusted in a timely manner according to changes that occur during the project lifecycle [17]. Contract management should be dynamic and require constant effort and supervision [18]. Yebin [17] emphasised that many parties are involved in rail-system projects and, because of their variable dynamic structure, firms lack an effective contract-management system. Firms have difficulty controlling risks because they are unaware of contract-management dynamics. Yebin [17] also drew attention to the lack of trained and knowledgeable human resources for contract management.

3 Materials and methods

3.1 Materials

A study was conducted to identify the risk factors affecting the success of international rail-system projects, and it was applied to rail-system project employees in three countries. Different countries were chosen to investigate the presence of country-specific risks in construction projects. The countries were selected according to the HDI published within the scope of the UNDP [5] from among the countries that the researcher could reach because of the firm and work area in which the rail-system projects were carried out. Italy, Turkey, and India, representing the categories of very high, high, and medium human development, were included in the study.
To determine the risk factors affecting the success of international rail-system projects, a literature review was conducted, and risk factors were identified [11, 19-28]. Using the institutional experiences of the researcher, a survey comprising two main sections was created. The first section of the survey inquired about information related to the company, and the second section asked participants to rate 73 risk factors using a seven-point Likert scale (1 = not at all important to 7 = extremely important).
The surveys were prepared in Turkish, English, and Italian and were made available online through the Survey Monkey survey-software website [29]. Surveys were conducted between January 2018 and April 2018 and 93 employees provided complete responses. The sample size was limited owing to the international nature of the study and the specific topic of rail-system projects.

3.2 Method

The Cronbach Alpha coefficient was calculated to determine the reliability of the surveys. The frequency and percentage distributions of the data based on the country in which the project was located, employer profile, and quality system applied to the project were calculated.
Exploratory factor analysis (EFA) was applied to the 73 risk factors that formed the basis of this study to determine factor structures. The suitability of the dataset for factor analysis was evaluated using Bartlett's test and Kaiser–Meyer–Olkin (KMO) values. The significance level of Bartlett's test was 0,000 and the KMO value was 0,909. A KMO value of 0,90 or higher was interpreted as a "marvellous" fit [30]. Principal component analysis (PCA) and varimax rotation were used in the EFA. Items with communality values below 0,50 [31] were excluded from the analysis. Factor loading values of 0,32 or higher were considered significant; however, items with a cross-loading rate of 0,10 [32] were also removed from the analysis.
Additionally, the relative importance index (*RII*) values of the risk elements for each factor were calculated using Formula 1 [33]. The Kruskal-Wallis test was used to test the hypotheses created to determine whether the risk factors of rail-system projects differ according to the country, sector, and quality system used. Hypotheses with a significance level of less than 0.05 were rejected. The results are discussed in relation to findings in the literature. Microsoft Office Excel 2010 and SPSS 18 software packages were used for the analyses.

$$RII = \frac{\sum W}{(A \cdot N)}, \qquad RII \in [0,1] \tag{1}$$

Where the symbol *W* denotes weight assigned to each factor by the respondents (ranging from 1 to 7); *A* the highest weight (7); and *N* denotes overall number of respondents (93).

4 Findings

To identify the risk factors in international rail-system projects, the reliability of the survey was measured by calculating Cronbach's alpha coefficient, which was 0,980; indicating a "high degree of reliability" [34].
The distribution of the results from the study conducted in the three specified countries is provided in Table 1.

Table 1. Distribution of survey responses by country

Country	*N*	%
Turkey	32	34,41
Italy	30	32,26
India	31	33,33
Total	**93**	**100,00**

Table 2 presents the employer profile of the project studied, categorised by sector. The majority of the projects were carried out in the public sector.

Table 2. Employer profile

Employer's sector	*N*	%
Private	8	8,60
Public	56	60,22
Private and public	29	31,18
Total	**93**	**100,00**

Employees were asked about the quality systems applied in the project; the results are presented in Table 3. The majority of the projects implemented quality systems and preferred ISO 9000 and Total Quality Management.

Table 3. Quality systems applied in the project

Quality systems applied in the project	*N*	%
No quality system was applied	2	2,15
Total quality management	24	25,81
ISO 9000	33	35,48
Quality control	13	13,98
Quality assurance	8	8,60
Others (ISO 14001, OHSAS 18001, ISO 9001, EN 50126, EN 50128, EN50129)	3	3,23
Unknown	10	10,75
Total	**93**	**100,00**

To identify the risk factors affecting project success in international rail-system projects, a 73-item questionnaire was used and analysed with PCA to conduct EFA. In the first stage of the analysis, 36 questions (1-8, 10, 12-14, 16-20, 22, 30, 32, 36, 39, 46, 54, 56-59, 61, 63-65, 67, 68, 70, 71) were eliminated from the analysis because their common variance values were less than 0,50 [34]. Varimax rotation was applied to the remaining 37 questions. Fourteen of the 37 questions (21, 24-26, 33, 35, 45, 47, 48, 52, 62, 66, 72, 73) were removed from the analysis because of high loading values for the same factor (overlapping) [35]. Twenty-three items related to the risk factors were grouped into three factors. The results of the EFA of the risk factors in rail-system projects are presented in Table 4. Factor loadings ranged from 0,787 to 0,599; 0,845 to 0,612, and 0,828 to 0,655 for the first, second, and third factors, respectively. The contributions of the factors to the total variance were 30,421 %, 23,342 %, and 13,512 % for the first, second, and third factors, respectively. The total contribution of these three factors to the variance was 67,275 %. According to the results of the EFA, the first factor in the rail-system project risk questionnaire consisted of risks arising from indirect expenses being higher than planned, inadequacies in occupational health and safety (OHS) measures, lack of calibration of equipment, deficiencies in contract and site management, deficiencies in reporting and document management, risks arising from supplier selection, and unequal opportunities provided to employees and its reflection on employee performance. These risks arise from malfunctions, errors, and delays in planning, organisation, coordination, command, and control functions and are called "management-related risks." The second factor comprises risks related to cost difficulties, delays and problems in credit usage and payments, penalties, and difficulties in obtaining permits for employees, which may cause delays in the project timeline or involve cost risks; these are named "time and cost-related risks." The third factor consists of risks related to complete damage to the product by the employer, vandalism and theft, design deficiencies, and poor workmanship that directly affect the product itself. Because the third factor consists of risks related to the direct product, it is called "risks affecting product quality."

Table 4. Rail-system project risk factors

Questions	Risk-factor survey factor structure		
	Management-related risks	Time and cost risks	Product quality-related risks
53	0,787	0,218	0,211
50	0,780	0,325	0,232
28	0,740	0,360	0,052

29	0,739	0,362	0,181
69	0,734	0,201	0,278
27	0,721	0,403	0,177
60	0,709	0,397	0,132
34	0,691	0,380	0,253
49	0,673	0,185	0,381
23	0,667	0,327	0,133
51	0,599	0,241	0,426
40	0,193	0,845	0,219
55	0,313	0,765	-0,084
41	0,332	0,762	0,199
38	0,292	0,731	0,271
42	0,287	0,728	0,269
37	0,503	0,663	0,112
43	0,532	0,633	0,116
44	0,502	0,612	-0,038
11	0,074	0,091	0,828
31	0,311	0,112	0,729
9	0,156	0,031	0,725
15	0,223	0,265	0,655
KMO = 0,909 Bartlett's test sig. = 0,000			

Table 5 provides the results of the RII analysis for the risk factors. Among management-related risks, issues such as disruption in reporting and exchange of information between departments, lack of interest and experience in contract management, site management, and supervision are not being addressed properly, and problems are caused by supplier selection. In terms of time and cost risks, the major issues include delays in payment schedules by the employer, difficulties in obtaining permits from all the institutions required for the work (municipality, electricity, gas, military, etc.), reflections of the financial failures occurring at the company centre on the project, and difficulties in obtaining work permits for international employees. Risks affecting product quality, design deficiencies, poor workmanship, vandalism, and theft, and damage to activities caused by employers are the most prominent.

Table 5. Risk-factor *RII* results

Risk-Factor Survey		*RII*
Management-related risks		
51	Disruption in reporting and exchange of information between departments	0,816
49	Lack of interest and experience in contract management	0,805
50	Site management and supervision not being conducted properly	0,790
60	Problems caused by supplier selection	0,786
29	Deficiencies in OHS	0,748
53	Problems in document management (reporting, distribution, archiving)	0,748
69	Loss of performance due to unfair opportunities for all employees (social rights, insurance, transportation, communication, meals, accommodation, etc.)	0,734
28	No periodic health checks of employees	0,730
34	Failure of timely maintenance and calibration of equipment and test devices	0,727
27	Inadequate level of supply, usage, and audit for personal protective equipment	0,727

23	Indirect costs such as meals, accommodation, and transportation; expenses are more than planned	0,651
Time and cost risks		
37	Delays in payment schedule by the employer	0,763
43	Difficulties in obtaining permits from all the institutions required for the work (municipality, electricity, gas, military, etc.)	0,750
38	Reflections of the financial failures occurring at the company centre on the project	0,743
44	Difficulties in obtaining work permits for international employees	0,707
55	Application of penalties for delays calculated and applied with high and unusual rates	0,704
40	Delays in submitting the guarantee letter (performance bond)	0,702
41	Problems in the use of credit	0,682
42	Problems during the advance payment by the client	0,677
Product quality-related risks		
11	Design deficiencies	0,817
15	Bad workmanship	0,816
31	Vandalism and theft	0,762
9	Damages to activities caused by employer	0,757

The hypotheses that were created to determine whether the risk factors affecting project success in rail-system projects vary according to the country, industry, or quality system used were tested using the Kruskal–Wallis test, and the results are presented in Table 6. According to the tested hypotheses, no differences were observed in the risk factors according to the quality system applied or industry. When the three countries were evaluated, no difference was observed in the management and direct product quality affecting risks; however, a significant difference was observed between countries in terms of time and cost risks.

Table 7 presents the average results of the risk factors in rail-system projects according to three factors. An examination of the general results shows that the risks that affect product quality are significantly important in international rail-system projects, while management-related risks and time and cost risks are also significant. An examination of the time and cost risk factors, in which differences were observed among countries, showed that Italy was the riskiest country, followed by India and then Turkey, with the least risk.

In Table 8, the average results of the factors that make up the time and cost risks in rail-system projects are provided separately for each country. For Italy, the riskiest factor is "application of penalties for delay calculated and applied with high and unusual rates," whereas for Turkey and India, it is "delays in payment schedule by the employer." The least risky situations are "problems during the advance payment by the client" for Italy and India and "delays in submitting the guarantee letter (performance bond)" for Turkey.

In general, "delays in payment schedule by the employer" is considered the riskiest situation. The least risky situation is determined as "problems during the advance payment by the client.

Table 6. Evaluation of risk factors by country, sector, and quality system

H_0 Hypotheses		Sig.	Description
H_{01}	Management-related risks do not differ between countries.	0,274	
H_{02}	Time and cost-related risks do not differ between countries.	0,012	Rejected
H_{03}	Product quality-related risks do not differ between countries.	0,171	
H_{04}	Management-related risks do not differ between sectors.	0,917	
H_{05}	Time and cost risks do not differ between sectors.	0,215	
H_{06}	Product quality-related risks do not differ between sectors.	0,751	

H_{07}	Management-related risks do not differ according to the applied quality system.	0,446	
H_{08}	Time and cost risks do not differ according to the applied quality system.	0,563	
H_{09}	Product quality-related risks do not differ according to the applied quality system.	0,713	

Table 7. Average results of risk factors in rail-system projects

Risk Factors	*N*	Turkey		Italy		India		General	
		$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Management-related risks	93	5,05	1,45	5,45	1,05	5,28	0,70	5,26	1,11
Time and cost-related risks		4,51	1,35	5,40	1,14	5,15	0,95	5,01	1,21
Product quality-related risks		5,55	1,45	5,63	1,12	5,36	0,82	5,52	1,05

Table 8. Items related to time and cost risks

Time and cost-related risks		Turkey		Italy		India		General	
		$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
37	Delays in payment schedule by the employer	4,91	1,91	5,47	1,66	5,68	0,79	5,34	1,55
38	Reflections of the financial failures occurring at the company centre on the project	4,88	1,52	5,50	1,41	5,26	1,12	5,20	1,37
40	Delays in submitting the guarantee letter (performance bond)	4,13	1,43	5,57	1,17	5,27	0,98	4,97	1,35
41	Problems in the use of credit	4,41	1,50	5,27	1,64	5,00	1,22	4,88	1,50
42	Problems during the advance payment by the client	4,25	1,67	5,03	1,27	4,97	1,54	4,74	1,53
43	Difficulties in obtaining permits from all the institutions required for the work (municipality, electricity, gas, military, etc.)	4,84	1,61	5,50	1,11	5,42	1,12	5,25	1,32
44	Difficulties in obtaining work permits for international employees	4,53	1,78	5,23	1,41	5,27	1,11	5,00	1,49
55	Application of penalties for delays calculated and applied with high and unusual rates	4,16	1,72	5,63	1,40	5,20	1,03	4,98	1,54

5 Discussion

To identify the risk factors encountered in international rail-system projects, EFA was applied to the data obtained from survey studies conducted in Italy, Turkey, and India, and the risks were grouped under three factors. These factors were identified as management-related risks, time and cost-related risks, and risks affecting product quality. Similar studies examining the factor structure of international rail-system projects have also highlighted cost risks [14, 36], management-related risks [37], and engineering risks that affect product quality [14], similar to this study. Figure 1 presents the results of the risk factors for rail-system projects according to the three factors. The overall results show that risks affecting product quality are the most risky factors in international railway projects, owing to the predominance of technological manufacturing, which requires expertise and coordination between teams.

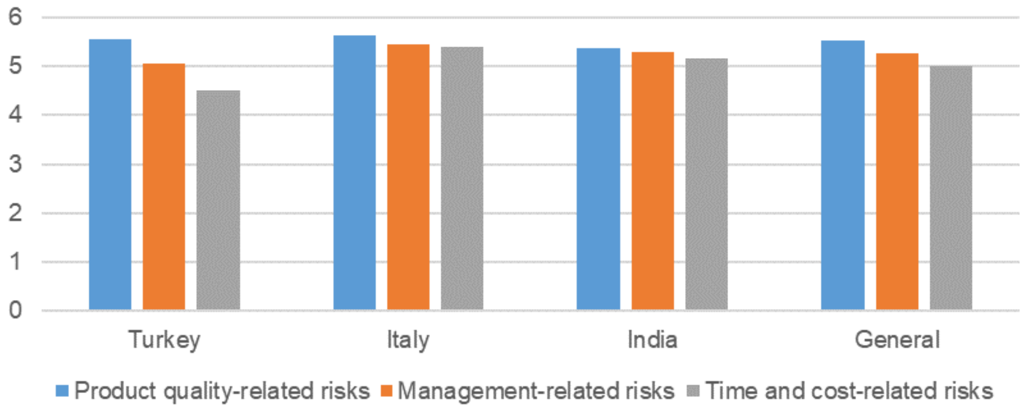

Figure 1. Risk factors in rail-system projects

5.1 Product quality-related risks

When examining the overall factor averages, the highest risk was attributed to the factor that affected product quality. The main subject of the contract is the project itself. At the end of the contract, a product that will affect the lives of many people, such as transportation infrastructure, is produced. The quality of manufacturing should enable safe use of the product for many years. Because the product is a technological structure (signalling, electrification, and telecommunication), all teams must prioritise quality to achieve holistic quality. Figure 2 presents the product quality-related risks in rail-system projects.

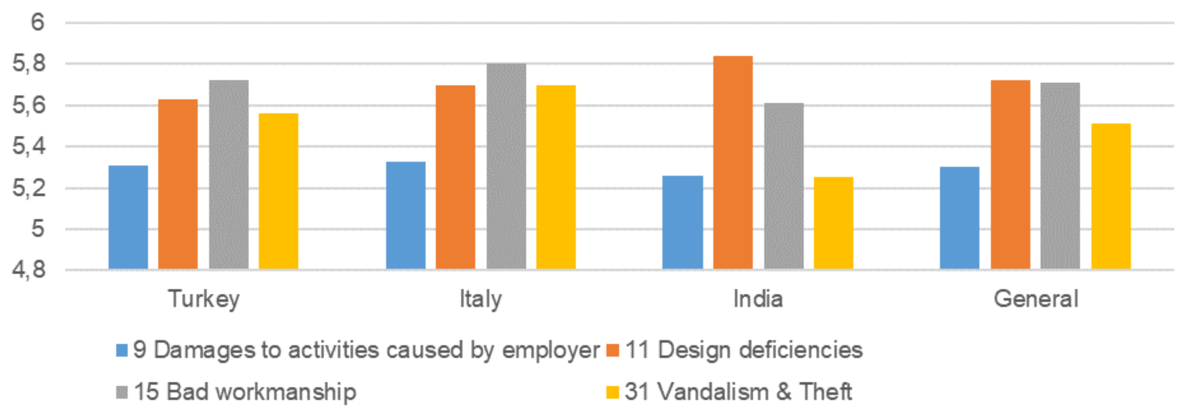

Figure 2. Product quality-related risk factors in rail-system projects

In the scope of the study, the most important risk affecting product quality was design deficiencies [4, 38]. Rail-system contractors who own the technology generally employ their design offices in the country in which their headquarters are located. In international projects, technical personnel in the design team may need to travel to the country in which the project is being conducted either during the approval stage of the design, when the design changes are decided on during the construction process [39], or during the preparation of final drawings. This situation leads to time and material losses. Rail-system contractors operating overseas should employ a full-time site-design team consisting of at least one engineer, technician, technical draughtsman, and topographer with foreign-language skills and the competency to work collaboratively with the central-office design unit. Preparing projects comprehensively at the contract stage and having the designs reviewed by a consulting firm separately would be beneficial.

Another significant risk factor affecting product quality is poor workmanship. Especially in developing countries, poor workmanship and lack of experienced technical personnel pose risks to projects and cause difficulties for companies [4, 12, 13]. Eybpoosh et al. [40] indicated that inadequate quality management resulting from management-skill deficiency is the reason why the quality requirements of international construction projects are not met. Losses caused by poor workmanship are the responsibility of contractors. In international rail-system projects, contractors generally prefer to use local personnel for assembly work and provide short on-the-job training to attempt to reduce costs. Supervision is crucial in this practice. The contractor must periodically ensure the quality control of the manufacturing carried out by assembly teams composed of local employees, which must be performed by a control team consisting of trained personnel and/or those with similar project experience. Another issue that companies must prioritise is poor workmanship and material quality. Technical specifications must be prepared without any deficiencies and samples must be requested from companies during the offer stage to ensure that the desired quality is achieved in the materials used. These materials must be inspected and tested after delivery. Definitions and sanctions for poor workmanship and faulty production should be clearly stated in the contract and technical specifications. Guarantees should be requested from the local companies that manufacture the products. In addition, attention should be paid to the appropriate storage of materials at construction sites.

Other risks that affect product quality are vandalism and theft. The areas of responsibility of the police or gendarmerie may vary depending on the political and geological structure of the country in which the international rail-system project is conducted. Therefore, the contractor should request cooperation from the employer regarding this issue considering long routes and difficult terrain conditions. At the beginning of the project, local people should be introduced to the project, and the benefits should be emphasised to create a positive project and company image. Professional security services can be obtained from private companies to ensure manufacturing security. Before submitting a proposal for a project in a different geography, an international rail-system contractor must conduct preliminary research on the project route and request a report and analysis from security experts. Because ensuring security on problematic routes can lead to unforeseen high costs, the expenses for this operation should also be considered when submitting a proposal. Drone technology can be utilised for land research on challenging railway routes and to ensure security in the project's advanced stages. Additionally, risks can be transferred through insurance.

Another risk affecting product quality is the damage caused by employers to complete installations. Making the completed stages of railway-system projects available for use is a standard practice in general operations. Employers can accept completed routes temporarily. In railway-system projects, where logistics and/or passenger transportation continues along the route where the project is being carried out, damage to completed installations due to employer teams and/or equipment is a very common problem. If the relevant section of the route has not yet been accepted, the responsibility for repairing the damage falls to the contractor. These damages, which cause material and temporal losses, must be recorded in a damage assessment report that includes participation from employers, consultants, and contractor officials. The project manager of the contractor company should demand financial and temporal compensation for the damage reports that have been recorded until the acceptance of the damaged section. Another important issue is that if a spare-parts contract has not been made with the employer, the materials used to repair the damages must be supplied from materials that have been provided for the project needs. In this case, the project manager should consider international procurement and customs clearance times and inform the supply-chain manager as soon as possible.

To continuously improve the construction quality in railway projects, risk-management systems and quality-management and control systems should be coordinated using risk-control measures regarding design deficiencies, application errors, problems arising from management deficiencies, undefined departmental tasks and responsibility distributions, and the protection of completed installations.

5.2 Management-related risks

After product quality-affecting risks, management-related risks have been identified as the riskiest factors in international railway-system projects [3, 18]. Figure 3 presents the management-related risks in rail-system projects. When management-related risks are examined, these risks can be reduced by taking necessary precautions. These are risks that the company can intervene in more easily and situations that can be brought under control. To prevent or reduce the effects of management-related risks, the following issues should be considered. Management-related risks include disruptions in reporting and information exchange between departments, lack of interest and experience in contract management, and problems in document management (reporting, distribution, and archiving) [3, 4]. These risks are interconnected, and any problem experienced with one can cause other risks. Because international railway-system projects are generally large-scale projects, establishing a contract-management unit determined according to the size of the project is useful. The entire operation should be monitored by the contract manager, and any deficiencies should be corrected immediately. Reporting and document management between departments should be conducted in accordance with the document-management plans prepared within the company's quality-management system. This operation should be conducted under the supervision of the quality-control department and project manager. The documentation plan approved by the employer should be monitored regularly and thoroughly. Archives of all documents and papers should be maintained. A software package developed for the company should be used, and training in the use of this software should be provided to all employees.

Continuous workforce changes in international construction firms weaken the company because of the process of every new employee's adaptation and the perception of the project and company. Therefore, every international construction firm should employ key personnel. These key personnel should be selected from among individuals with international project experience, who work well in foreign languages and have a good level of expertise.

Management-related risks include those related to occupational health and safety. The results show that deficiencies in occupational health and safety measures; failure to conduct periodic health check-ups of employees; and inadequate provision, use, and inspection of personal protective equipment (PPE) have emerged as the most prominent risks [41]. Despite being overlooked, employee safety is one of the most important risks that can cause significant delays in companies. Occupational health and safety training should be fully and comprehensively implemented for all primary contractors and subcontractor personnel. General and on-the-job training on occupational health and safety should be conducted in the native language of each employee. PPE selection should be made in accordance with the project's needs, and their use should be regularly inspected. To ensure continuity, punishment and/or reward policies should be implemented fairly based on the general attitude of the company.

Another management-related risk is inadequate site management and supervision. Because railway-system projects are generally conducted over long distances, site management should be structured by dividing the distance into subunits under the central site office and employing the necessary number of technical personnel.

Another risk for companies arises from supplier selection. We recommend obtaining preliminary information from companies that have previously worked in the same country during the selection of the supplier firm. Company references should be examined and a qualification certificate should be requested. Additionally, scientific methods such as the analytic hierarchy process should be used to select supplier or subcontractor firms [42]. Notably, the logic of "the cheapest offer is always the best" contradicts the project quality target.

Among management-related risks, the issue of performance losses due to the unfair provision of opportunities (social rights, insurance, transportation, communication, food, and beverages) to all employees is present. Project performance undoubtedly depends on well-organised and executed contract management; however, individual performance has a cumulative effect on overall performance, including implementation. Imbalances in interdepartmental and intradepartmental wages reflect employee performance. Ensuring high job satisfaction for all employees positively affects their motivation [43], which also reflects their performance and organizational commitment. Applying fair remuneration, rewards, and promotion policies to ensure the continuity of employee satisfaction will contribute to the long-term success of an organisation. The human resources (HR) department should manage this process carefully throughout the project. A hierarchical wage policy should be determined, and should not be deviated from. Facilities such as salary increases, bonuses, overtime pay, accommodation and transportation, private health insurance, and social aid should be provided to employees.

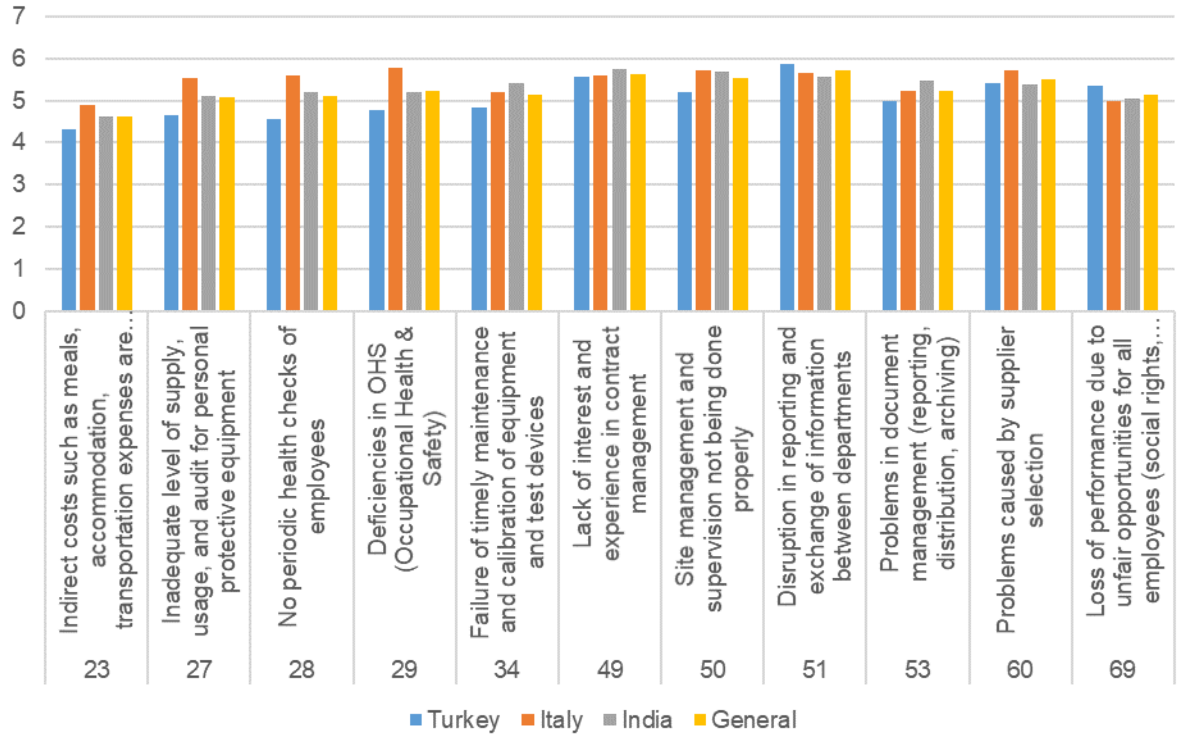

Figure 3. Management-related risk factors in rail system projects

Another management-related risk is the failure to perform maintenance and calibration of equipment and testing devices in a timely manner. To prevent this, an independent organisation with international accreditation certification should be contracted to carry out periodic calibration and maintenance of all equipment and devices and to monitor this process. A separate work schedule must be prepared to monitor this process.

Another management-related risk is the possibility of indirect expenses, such as accommodation, meal costs, and transportation costs exceeding the planned budget. A detailed analysis of the indirect expenses should be conducted during the proposed phase and reflected in the offer. The financial conditions of companies should be considered, and cost optimisation, resource allocation, and balance should be conducted in accordance with the work program [44]. Gradually increasing the number of personnel in departments to align with the work program will reduce employment expenses during a project lifecycle. An appropriate selection should be made according to the construction site, especially for accommodation, transportation, and meal options, to prevent financial and time losses.

5.3 Time- and cost-related risks

The risks under the time- and cost-related risk factors consist of situations that are difficult for a company to intervene in directly. Therefore, an identified risk factor for unforeseeable circumstances that may affect time and cost in the bidding stage should be reflected in the bid,

and the effects of risks should be controlled through additional contract clauses. Figure 4 shows the time- and cost-related risks of rail-system projects.
Time- and cost-related risks include difficulties in payments by the employer and problems with advance payments by the customer (employer). Occasionally, owing to financial difficulties in the employer's country, sufficient funds may not be allocated from the budget for payment of the project entitlements. Although not preferred, in the case of prolonged and recurring delays in payments, official requests for rights should be created using contracts and legal rights. If risk anticipation is made before the contract, the contract can be made in a currency (euro or dollar) stronger than the local currency. To offset the possible value losses of unit prices in the contract against inflation due to unforeseeable reasons, resulting in time extensions, a clause related to price differences should be added to the contract.

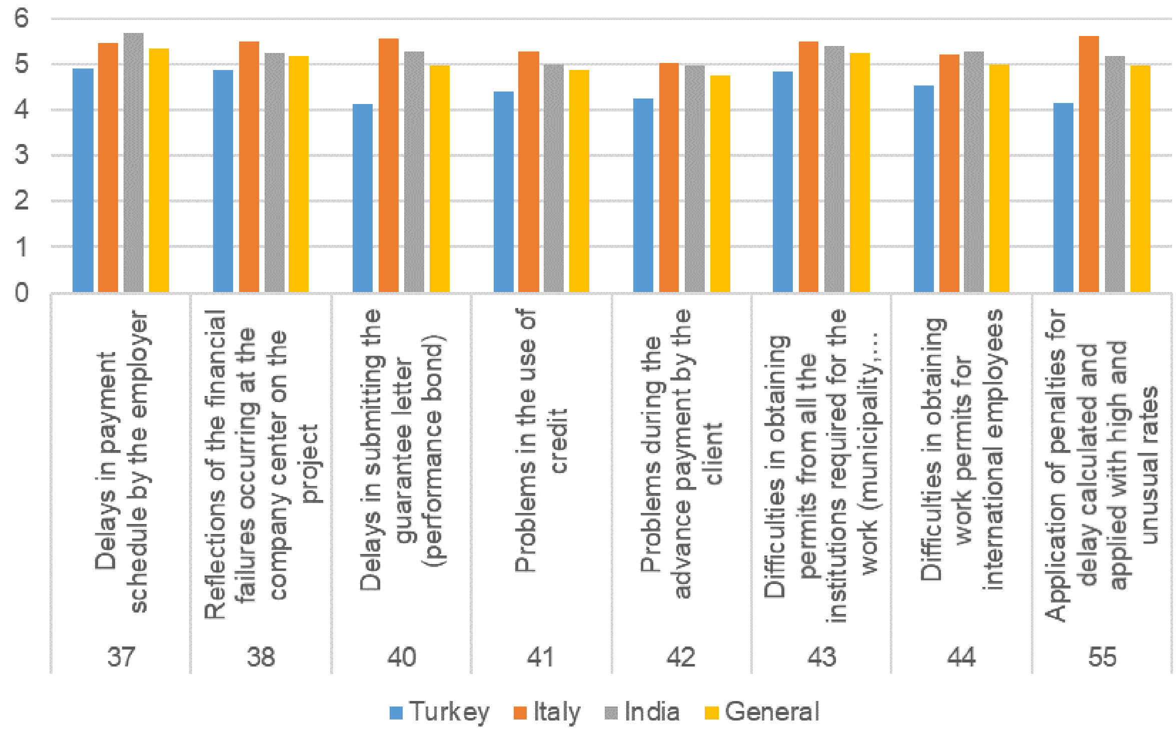

Figure 4. Time- and cost-related risk factors in rail system projects

One of the time- and cost-related risks is the difficulty encountered in obtaining permits from all necessary institutions (e.g., municipalities, electricity, gas, military). To work on railway-infrastructure projects, especially in routes where railway-infrastructure works are carried out or in rail-system lines where high voltage (electrification) and train traffic are active, the necessary permits must be obtained from relevant institutions and organisations. These institutions can be listed as rail-system operator organisations, municipalities, military units, water, sewage, natural gas, electricity, and Internet providers. To avoid this risk, the project-management team should work with the OHS unit to determine the permit procedures in advance and continuously follow up with relevant institutions to ensure that the permit processes do not cause temporal delays.
Among the time- and cost-related risks are the impact of financial difficulties at the company's headquarters on the project, delays in the submission of the guarantee letter, and difficulties in obtaining credit. Financial difficulties at the contractor headquarters can also affect international projects under construction. To ensure the minimum impact of this situation on the project, the advance payment, incentives, credit, and other facilities provided for the project should only be used to finance the same project. If the employer finances the entire project or a part of it with credit, then the conditions required by the lending institution must be fully met.

This stage is the employer's responsibility. To avoid credit termination, the creditor firm should monitor the physical progress and entitlement payments of the project. If a delay occurs outside the tolerance limits, disruptions and delays in financial resources may occur. During this process, both the employer and contractor should share responsibilities.

To prevent the financial sources provided by the creditor institution from being terminated, both parties must meticulously fulfil all requirements and not evade their responsibilities at any stage of the project to complete the work. Both sides should act according to the 'win-win' principle. Moreover, the use of international organisations is recommended for guarantee and credit transactions.

The difficulties encountered in obtaining work permits for foreign workers also fall under time- and cost-related risk factors. In international railway-system projects, foreign personnel are typically required to hold special job positions that cannot be employed locally. The visa, residence, and work permits for these personnel must be obtained, and the process must be tracked using professional HR management. For example, the timely presence of foreign supervisors required by a construction group for assembly work in the field depends on this process. Otherwise, delays may occur during the work program.

High and unusual penalty rates also fall under time- and cost-related risk factors that affect companies. Penalty clauses defined in the contract are generally included to create sanctions for contractors when they do not fulfil their responsibilities. If the contractor continues to violate the contract terms despite the employer's written and verbal warnings, the employer should apply these penalties. Measures should be taken to prevent penalty clauses from being questioned, and financial and prestige losses should not be allowed. In this case, the project-management team, on behalf of the contractor, is primarily responsible for taking the necessary precautions. Establishing an emergency plan to address unforeseen delays would be useful.

The hypothesis tests showed a difference between countries only in terms of time- and cost-related risk factors. Italy's risk score was higher than those of India and Turkey for this factor, and Turkey had the lowest risk score. Among the results for Italy, the factor with the highest risk score was the high and unusual penalty rates. This is believed to be the main factor that makes Italy riskier in terms of time- and cost-related risks. In addition, in developing countries, governments attract foreign investor firms by providing incentives for investment projects such as tax exemptions, market priorities, and infrastructure services, and they even provide monopoly rights [45]. This situation is believed to have created the perception that time- and cost-related risks in railway-system projects are lower when evaluated from the perspectives of Turkey and India. Furthermore, developing countries have a lower professional approach to risk-management practices [46], and this reflects in risk awareness.

Time- and cost-related risks vary on a national basis, and companies' risk-management departments should identify the difficulties they face in each project and maintain records to develop the company's memory. Companies should create variable and important risk-factor scales for countries that benefit from their experience. Additionally, the risk departments of international construction companies should benchmark and share risk analyses of countries that they previously worked on and adopt mutually beneficial strategies. Each company should identify its own strengths and weaknesses and develop a personalised feedback-based risk-assessment model through regular strengths, weaknesses, opportunities and threats analyses [47].

6 Conclusions

The risk factors in international railway-system projects were identified in a study conducted in Italy, Turkey, and India. The risks affecting product quality were the riskiest group, followed by management-related risks, and time- and cost-related risks. Railway operations vary according to the level of development of countries, and have not yet been standardised under a single worldwide structure. This situation suggests that in a country where the contractor has not previously operated, the rail-system technology, which will be applied for the first time, may fail to meet some of the employer's demands during commissioning, resulting in temporal and financial losses for the contractor. In technology-driven projects, such as international railway systems, risks that affect product quality also generate time- and cost-related risks.

Signalisation-system technologies, which may be applied for the first time to the railway route of a country in which the international railway-system project will be realised, may vary according to the operating policies of the end-user organisation. In terms of railway-system operations, each country, region, and end-user organisation has different operating procedures and parameters. For example, the speed limits at switch crossings, minimum speed limits at station entrances and exits, parameters of the train braking system, and the maximum and average speed values desired in operations may differ in the metro systems of different countries. Therefore, the European Train Control System, which is to be applied to the railway route of the international railway-system project, must fully meet these needs, and the appropriate technology must be selected. If the train-control system is designed while ignoring the country's technological infrastructure and sufficiency, and its incompatibility is noticed in the advanced stages of the project, such as testing and commissioning, it may cause temporal and financial losses that endanger the project's success. In projects conducted in different countries, a feasibility study that includes political, economic, technological, financial, and legal details becomes even more crucial for the company. Time- and cost-related risks should be shared and transferred or their impacts should be reduced through regulatory clauses in the contract.

The other prominent risk factors highlighted in this study were management-related risks. Management-related risks are thought to be the easiest risks for a company to intervene in and can be reduced with precautions taken during the contract phase. The wide scope of railway-system projects makes controlling them difficult. At this point, good relationships should be established with the local community, and the future benefits of the project should be emphasised.

In future studies, contracts made according to the countries in which international railway-system projects are carried out should be examined in detail, and studies involving project managers should be conducted.

References

[1] Genç, O. Identifying principal risk factors in Turkish construction sector according to their probability of occurrences: a relative importance index (RII) and exploratory factor analysis (EFA) approach. *International Journal of Construction Management*, 2023, 23 (6), pp. 979-987. https://doi.org/10.1080/15623599.2021.1946901

[2] Aydoğan, G.; Köksal, A. Host-Country Related Risk Factors in International Construction: Meta-Analysis. *Megaron*, 2014, 9 (3), 190-200. https://doi.org/10.5505/MEGARON.2014.17894

[3] Jaber, Z. et al. Identification and Analysis of the Approaches and the Risk Factors Affecting the Performance of the Construction Work. In: *Proceedings from the 24th International Congress on Project Management and Engineering*. 7-9 July 2020, Alcoi, Spain, Asociación Española de Dirección e Ingeniería de Proyectos (AIEPRO); 2020, pp. 2034-2047.

[4] Bahamid, R. A.; Doh, S. I.; Al-Sharaf, M. A. Risk Factors Affecting the Construction Projects in Developing Countries. *IOP Conference Series: Earth and Environmental Science*, 2019, 244, 012040. https://doi.org/10.1088/1755-1315/244/1/012040

[5] UNDP Türkiye. İnsani Gelişme Raporu 2016. Accessed: 30 November 2017. Available at: https://www.undp.org/tr/turkiye/publications/insani-gelisme-raporu-2016

[6] Arslan, A. *Trade Between Developing Countries: The Case of Turkey – India*. [master thesis], Uludag University, Social Science Institution, Bursa, Turkey, 2020.

[7] Telmaç, A. *Determination of Risk Factors in International Rail System Projects*. [master thesis], Cukurova University, Institute of Natural and Applied Sciences, Adana, Turkey, 2020.

[8] Baloi, D.; Price, A. D. F. Modelling global risk factors affecting construction cost performance. *International Journal of Project Management*, 2003, 21 (4), pp. 261-269. https://doi.org/10.1016/S0263-7863(02)00017-0

[9] Sharma, S.; Gupta, A. K. Risk Identification and Management in Construction Projects: Literature Review. *International Journal of Humanities, Arts and Social Sciences*, 2019, 5 (6), pp. 224-231. https://dx.doi.org/10.20469/ijhss.5.20002-6

[10] Ofori, G. Research on construction industry development at the crossroads. *Construction Management and Economics*, 1993, 11 (3), pp. 175-185. https://doi.org/10.1080/01446199300000017

[11] Ling, F. Y. Y.; Hoi, L. Risks faced by Singapore Firms when undertaking construction projects in India. *International Journal of Project Management*, 2006, 24 (3), pp. 261-270. https://doi.org/10.1016/j.ijproman.2005.11.003

[12] Nyoni, M.; Sukamani, D.; Mavengwa, T. N. Factors Affecting Risk Management in Developing Countries. *North American Academic Research*, 2019, 2 (10), pp. 23-42. https://doi.org/10.5281/zenodo.3489804

[13] Viswanathan, S. K.; Jha, K. N. Critical Risk Factors in International Construction Projects: An Indian perspective. *Engineering, Construction and Architectural Management*, 2020, 27 (5), pp. 1169-1190. https://doi.org/10.1108/ECAM-04-2019-0220

[14] Suh, D. S. Risk Management in a large-scale new railway transport system Project - Evaluation of Korean High-Speed Railway Experience. *IATSS Research*, 2000, 24 (2), pp. 53-63. https://doi.org/10.1016/S0386-1112(14)60029-7

[15] Sarkar, D.; Singh, M. Risk analysis by integrated fuzzy expected value method and fuzzy failure mode and effect analysis for an elevated metro rail project of Ahmedabad, India. *International Journal of Construction Management*, 2022, 22 (10), pp. 1818-1829. https://doi.org/10.1080/15623599.2020.1742634

[16] Yuan, T.; Xiang, P.; Li, H.; Zhang, L. Identification of the main risks for international rail construction projects based on the effects of cost-estimating risks. *Journal of Cleaner Production*, 2020, 274, 122904. https://doi.org/10.1016/j.jclepro.2020.122904

[17] Yebin, Q. Research on the System Construction of the Railway Enterprise Project Contract Management. *International Journal of Management Science and Engineering Research*, 2015, 2 (2), pp. 38-42.

[18] Yang, S. Research on the Risk and Opportunities of International Railway Projects based on FIDIC-EPC Contract. *PM World Journal*, 2018, VII (VI), pp. 1-13.

[19] National Economic Development Office (NEDO). *Before you Build, What the Client needs to know about the Construction Industry*. London, UK: Her Majesty's Stationery Office (HMSO), 1974.

[20] Touran, A.; Bolster, P. J.; Thayer, S. W. Risk Assessment in Fixed Guideway Transit System Construction. Northeastern University, Boston, USA, Accessed: 25 July 2024. Available at: https://rosap.ntl.bts.gov/view/dot/600

[21] Dikmen, I.; Talat Birgonul, M. An analytic hierarchy process based model for risk and opportunity assessment of international construction projects. *Canadian Journal of Civil Engineering*, 2006, 33 (1), pp. 58-68. https://doi.org/10.1139/l05-087

[22] Uğur, L. O. Risks and Risk Management in the Construction Industry (İnşaat Sektöründe Riskler Ve Risk Yönetimi), Turkish Contractors Association, 2006.

[23] Dikmen, I.; Talat Birgonul, M.; Han, S. Using fuzzy risk assessment to rate cost overrun risk in international construction projects. *International Journal of Project Management*, 2007, 25 (5), pp. 494-505. https://doi.org/10.1016/j.ijproman.2006.12.002

[24] Aven, T. *Risk Analysis: Assessing Uncertainties Beyond Expected Values and Probabilities*. England: Wiley, 2008.

[25] Ersoy, M. S. Project Management Basic Concepts and Tools (Proje Yönetimi Temel Kavramlar ve Araçlar). Imaj Publication, 2010, Ankara, Turkey.

[26] Greene, J.; Stellman, A. *Head First PMP*. 3rd Edition, USA: O'Reilly Media, Inc., 2013.

[27] Tekir, G.; Şakar, S. *Project Manager's Handbook (Hayatımız Proje – Proje Yöneticisinin El Kitabı)*. Istanbul, Turkey: Collective, 2016.

[28] Süllüoğlu, D. E. *The Assessment of Project Risk Management Maturity in the Construction Industry of Turkey*. [master thesis], Istanbul Technical University, İstanbul, Türkiye, 2019.

[29] SurveyMonkey. Accessed: 15 April 2018. Available at: http://www.surveymonkey.com

[30] Schreiber, J. B. Issues and recommendations for exploratory factor analysis and principal component analysis. *Research in Social and Administrative Pharmacy*, 2021, 17 (5), pp. 1004-1011. https://doi.org/10.1016/j.sapharm.2020.07.027

[31] Hair, J. F.; Black, W. C.; Babin, B. J.; Anderson, R. E. *Multivariate Data Analysis*.7th Edition, USA: Pearson, 2009.

[32] Tabachnick, B. G.; Fidell, L. S. *Using Multivariate Statistics*. 7th Edition, USA: Pearson, 2021.

[33] Akadiri, O. P. *Development of a Multi-Criteria Approach for the Selection of Sustainable Materials for Building Projects*. [doctoral thesis], University of Wolverhampton, Wolverhampton, UK, 2011.

[34] Kalaycı, Ş. *SPSS Applied Multivariate Statistics Techniques (SPSS Uygulamalı Çok Değişkenli İstatistik Teknikleri)*. Ankara, Turkey: Asil Publication, 2008.

[35] Çelik, G. *Relationship Between Personality Traits, Organizational Commitment and Job Satisfaction of Turkish Construction Industry Professionals*. [doctoral thesis], Cukurova University, Institute of Natural and Applied Sciences, Adana, Turkey, 2013.

[36] Junhu, T.; Yajie, W. Risk management methods of high-speed railway construction. In: *2013 6th International Conference on Information Management, Innovation Management and Industrial Engineering.* 23-24 November 2013, Xi'an, China, Institute of Electrical and Electronics Engineers IEEE; 2014, https://doi.org/10.1109/ICIII.2013.6703128

[37] Hamzaoui, F. et al. Evolutive Risk Breakdown Structure for managing construction project risks: application to a railway project in Algeria. *European journal of environmental and civil engineering*, 2015, 19 (2), pp. 238-262. https://doi.org/10.1080/19648189.2014.939416

[38] Vishwakarma, A.; Thakur, A.; Singh, S.; Salunkhe, A. Risk assessment in construction of highway project. *International Journal of Engineering Research & Technology*, 2016, 5 (02), pp. 637-640.

[39] Jayasudha, K.; Vidivelli, B. Analysis of major risks in construction projects. *ARPN Journal of Engineering and Applied Sciences*, 2016, 11 (11), pp. 6943-6950.

[40] Eybpoosh, M.; Dikmen, I.; Talat Birgonul, M. Identification of risk paths in international construction projects using structural equation modeling. *Journal of Construction Engineering and Management*, 2011, 137 (12), pp. 1164-1175. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000382

[41] Iqbal S. et al. Risk Management in construction projects. *Technological and Economic Development of Economy*, 2015, 21 (1), pp. 65-78. https://doi.org/10.3846/20294913.2014.994582

[42] Eshtehardian, E.; Ghodousi, P.; Bejanpour, A. Using ANP and AHP for the supplier selection in the construction and civil engineering companies; Case study of Iranian company. *KSCE Journal of Civil Engineering*, 2013, 17, pp. 262-270. https://doi.org/10.1007/s12205-013-1141-z

[43] Aydınlı, S.; Oral, M.; Oral, E. Wage Determinants and Wage Inequalities – Case of Construction Engineers in Turkey. *Teknik Dergi Technical Journal*, 2019, 30 (2), pp. 8961-8985. https://doi.org/10.18400/tekderg.378955

[44] Hariga, M.; El-Sayegh, S. M. Cost Optimization Model for the Multi resource Leveling Problem with Allowed Activity Splitting. *Journal of Construction Engineering and Management*, 2011, 137 (1), pp. 56-64. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000251

[45] Erdoğan, E.; Ataklı, R. Investment Incentives and FDI in Turkey: The Incentives Package after the 2008 Global Crisis. *Procedia - Social and Behavioral Sciences*, 2012, 58, pp. 1183-1192. https://doi.org/10.1016/j.sbspro.2012.09.1100

[46] Şener B. *Perception of the Risk for Construction Companies and the Risk Reducing Precautions*. [master thesis], Istanbul Cultur University, Turkey, 2012.

[47] Abdul-Rahman, H.; Wang, C.; Mohamad, F. S. Implementation of risk management in Malaysian construction industry: case studies. *Journal of Construction Engineering*, 2015, 2015 (1), 192742. https://doi.org/10.1155/2015/192742