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Identifying Principal Risk Factors of Turkish Construction Sector According to Their Probability of Occurrences: A Relative Importance Index (RII) and Exploratory Factor Analysis (EFA) Approach

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Abstract

A construction project has many phases, all of which involve various risks. The first step in risk management is risk identification. The literature lacks to address identifying key risk factors affecting construction projects concerning the variables' likelihood of occurrences. The goal of this paper is therefore to investigate key risk factors affecting Turkish construction sector based on their probability of occurrence by using the Relative Importance Index (RII) and the Exploratory Factor Analysis (EFA). 201 valid responses to a questionnaire detailing 33 risk variables are analyzed using RII and EFA. The results emphasize that disaster and force majeure, project management, technical management, external, and design-estimation are the main risk factors in the construction projects. It is also found that using unqualified subcontractors/workers/staff during the process, delays in payments, economic matters such as inflation, speculations on prices, late change-order requests of project stakeholders and, failure to complete the work within expected budget limits are the top five most-likely risks while flood, boycott, landslide, attack, hurricane, tornado risks are rare. Through the findings, practitioners that consider defined risk factors when evaluating the potential risk management approaches may increase the accuracy of their risk response method and related cost estimates.
Keywords: *Construction sector, Exploratory factor analysis (EFA), Relative importance index (RII), Risk factors, Risk management*

1. Introduction

There are several stages in the development of a construction project, all of which involve danger, uncertainty, and risk. The danger is a condition that poses a threat to issues like health, property, environment, and individual integrity. In the construction project environment, danger may be anything that may obstruct the progress of the project operations or the project as a whole. Uncertainty and risk are two terms that are generally thought to be the same but in fact, they are distinct and have different interpretations. Uncertainty is the outcome of something that is known little or none, while risk, although may contain some uncertainties (Duncan, 2005), is the result of an event that can usually be predicted on a statistical probability basis. Uncertainty arises when there is more than one possible situation, while risk arises due to an incorrect decision made from many possible situations (Perminova et al., 2008). Risk has several definitions such as *any factor, event, or impact that threatens the successful completion of a project in the planned time, cost, and quality* (Keil et al., 1998)*; a situation with no information about its outcome* (Roehl and Fesenmaier, 1992)*; high probability of failure* (Altarejos-García et al., 2012)*; results from lack of estimates in planning and decision making* (Yeo, 1990)*; the chance of situations that can affect the goals* (Genç et al., 2018). Even though it has several definitions, the risk is characterized by two main factors; (1) the exposure to the chance of occurrence of a particular danger (Al-Bahar and Crandall, 1990), and (2) the effects and consequences of that danger (Blum et al., 2014). Thus, the first step in risk assessment is to identify the dangers that may pose a possible risk threat.

The construction sector is an extremely competitive, price-controlled market, and to maintain competitiveness, construction firms must continually seek to reduce their project costs while providing their customers with quality products and services at the same time (Chan, 2012a). Major parts of a construction project cost come from the trade work which is usually subleased to subcontractors by general ones to minimize their operation cost and risk, and from project overheads that are linked to matters explicitly provided by the general contractor and thus any related risk is non-transferable (Chan, 2006). Hence, both the main and sub-contractors must have a risk management approach.

Risk management can be defined as taking the necessary precautions by considering the potential dangers of the risk in order not to be harmed by the negative effects of possible risks while moving towards the goals of an organization (Akçakanat, 2016). It is a systematic management model in which risks are defined, classified, and analyzed with various methods to identify their possible effects in case of occurring, and finally, the reactions to be given are determined (Kuşan et al., 2016). Risk identification is the first step of risk management and it is of great significance since the processes of risk analysis/evaluation and risk response management, which are the other steps of risk management, may only be carried out on identified possible risks (Al-Bahar and Crandall, 1990). There are two main approaches to risk management; (1) avoiding or minimizing the risk and possible nature of damages arising, and (2) making allowance for the recovery of damages that may exist (Khan and Burnes, 2007). Risks that will cause insignificant damages are expected in almost every organization and are covered by business resources without causing significant problems. Before occurring, some measures can also be taken to prevent those risks, but they are not preferred by companies due to their uneconomical nature. Also, small losses do not cause business activities to cease unless they are repeated frequently. Thus, these risks are usually directed thru the first risk management approach. The second risk management approach consists of the costliest variables, e.g, insurance. It can be costly to use this approach for a high impact but unlikely risk. Therefore, before risk response management, it is important not only to identify the risks that may occur but also to identify their probability of occurrence.

Depending on the size of the construction project, the environment in which it is carried out and the characteristics and quantity of the resources used, the effects of the risks on the project can be identified by systematically evaluating the existing risk factors that differ for each project. In this way, possible disputes between the parties can be obstructed by determining the appropriate contract terms (Birgönül and Dikmen, 1996; Mhetre et al., 2016). There are various studies concerning risk factors for the construction sector. Chan (2012b) highlighted those eight crucial factors affect construction projects: contractor design specifications, regional economic trends, financial and insurance costs, project size, procurement processes, site layout, and stakeholder involvement. Jadidoleslami et al. (2018) suggested five categories of macro factors that affect constructability in construction projects: contractual, environmental, project management, technical, and organizational. Soewin and Chinda (2018) concluded that there are ten key factors affecting construction performance; 1) Time, 2) Cost, 3) Quality, 4) Safety & Health, 5) Internal Stakeholder, 6) External Stakeholder, 7) Client Satisfaction, 8) Financial Performance, 9) Environment, and 10) Information, Technology & Innovation. Dixit et al. (2019) surveyed 201 the primary stakeholders of the Indian construction industry including consultants, architects, civil contractors, developers, PMC, and academic people on the significant factors that affect construction productivity. They indicated that the most significant factors affecting construction productivity are the availability of resources, contractual disputes, scope clarity of the project, design capability, and frequent design changes.

The above research studies provide an insight into construction projects' performance evaluation against the factors affecting them. However, most of these studies focus primarily on identifying casual factors affecting the projects, while the studies on the probability of occurrence of those factors are still sparse. This paper, therefore, aims at examining key risk factors affecting the Turkish construction sector according to their probability of occurrence by utilizing the Relative Importance Index (RII) and Exploratory Factor Analysis (EFA) method.

The remainder of this paper is organized as follows. Section 2 presents the methodology used in this study. Section 3 provides the results of RII and EFA. Section 4 discusses the findings, and finally, Section 5 provides conclusions, limitations, and future work.

2. Methodology

This section presents the methodology of the study. Firstly, the objectives are addressed. This is followed by the method.

2.1. Objectives

To minimize the risks that may occur during construction processes, it is crucial to analyze the prominent risk types and their causes with numerical data and then determine the measures that must be taken. Empirical studies concerning of occurrence of the risks are very scarce despite their importance to the overall risk investigation in the construction sector. Hence, the primary objective of this study is to identify the key factors affecting the construction sector and to understand the implicit properties of them. With a deeper understanding of the crucial factors affecting the construction industry, relevant risk management approaches can be developed.

2.2. Method

This section presents the method of the study. Firstly, the data collection is addressed. This is followed by the identification of variables, design of questions, and data analysis method, respectively.

2.2.1. Data collection

Primary data on the importance of the variables affecting construction processes have to be collected in order to fulfill the goals of this study. Among the different methods of data collection, the questionnaire survey is the most common and cost-effective way of gathering information on behaviors, beliefs, and attitudes (Gravetter and Forzano, 2012), and it is commonly used by scholars in the area of construction management (Chan, 2012). The questionnaire survey is therefore found to be an appropriate instrument for this study.

2.2.2. Identification of variables

The data analyzed in this study is derived from larger studies (Genc, Olcay; Erdis, Ercan; Oral, 2016; Genç et al., 2018). Given the lack of empirical researches on the subject, both currently limited literature and the views of practitioners are taken into account when creating a list of variables affecting construction processes. In the study, potential risks and uncertainties encountered in the quality/cost/time axis of construction works, the attitudes of the construction firms towards these risks, and the effects of these risks on the construction project success were investigated. To this end, the variables considering the literature (Demirci et al., 2004; Mhetre et al., 2016; Uğur, 2006) and opinions of construction company managers were collected.

2.2.3. Design of questions

In the study that the data were taken, a questionnaire was prepared and delivered to the civil engineers, who work for the public and private sector of Turkey, via the chamber of civil engineers. The questionnaire consists of three parts containing 5-point Likert scale questions (1- extremely low to 5-extremely high); (1) according to the likelihood of occurrence, the risks that may occur in the construction sector (Table 1), (2) the impact level of the risks that may affect construction projects' success (3) demographic questions. The first and second parts of the study include the same variables shown in Table 1. However, the participants were asked to score the variables' probability of occurrence in the first part, while they were asked to score the impact level of the variables on the construction project's success in the second one. In this study, the first part of the questionnaire is used for analysis.

Table 1. Potential risks in the construction sector

No	Code	Variable	Reference
1	VAR1	Carrying out the design phase without including all stakeholders (architects, engineers, clients, etc.)	Genç et al., 2016
2	VAR2	Design / calculation errors and deficiencies	Mhetre et al., 2016
3	VAR3	Choosing inexpensive and inadequate solutions that can become more costly over time	Genç et al., 2018
4	VAR4	Late change-order requests of project stakeholders	Mhetre et al., 2016
5	VAR5	Misunderstanding of customer requests	Genç et al., 2018
6	VAR6	Acceptance of wrong / incomplete contracts and specifications	Mhetre et al., 2016
7	VAR7	Work planning errors	Mhetre et al., 2016
8	VAR8	Not having a certain management approach	Genç et al., 2018
9	VAR9	Using unqualified subcontractors/workers/staff during the process	Mhetre et al., 2016
10	VAR10	Using poor quality and non-standard materials	Mhetre et al., 2016
11	VAR11	Time and cost increment due to the use of inappropriate old technology/advanced technology/equipment	Genç et al., 2018
12	VAR12	Failure to complete the work within expected budget limits	Uğur, 2006
13	VAR13	Failure to keep up with the work schedule during the construction process	Uğur, 2006
14	VAR14	Failure to fulfill the requirements of the contract and specifications	Uğur, 2006
15	VAR15	Inadequate precautions for occupational health and safety/work accidents	Mhetre et al., 2016
16	VAR16	Strike, lockout, stopping the work by inspecting firm	Genç et al., 2016
17	VAR17	Conflicts between workers in the project	Mhetre et al., 2016
18	VAR18	Economic matters such as inflation, speculations on prices	Genç et al., 2018
19	VAR19	Delays in payments	Genç et al., 2016
20	VAR20	Unexpected changes in laws and standards	Uğur, 2006
21	VAR21	Inclusion of new stakeholders in the project and their change-order requests	Genç et al., 2018
22	VAR22	Change in ground conditions	Uğur, 2006
23	VAR23	Bad weather conditions	Demirci et al., 2004, Uğur, 2006
24	VAR24	Terrorism (Attacks that do not directly target the construction site, but occur very close to the construction site and cause work to stop)	Genç et al., 2018
25	VAR25	Attack (Attacks directly targeting the construction site)	Genç et al., 2018
26	VAR26	Boycott (Actions to boycott construction, contractor, business owner)	Genç et al., 2016
27	VAR27	Earthquake	Demirci et al., 2004, Uğur, 2006
28	VAR28	Flood	Demirci et al., 2004, Uğur, 2006
29	VAR29	Landslide	Mhetre et al., 2016
30	VAR30	Hurricane	Mhetre et al., 2016
31	VAR31	Tornado	Mhetre et al., 2016
32	VAR32	Fire	Demirci et al., 2004
33	VAR33	Explosion / industrial accidents	Mhetre et al., 2016

2.2.4. Data analysis method

The reliability of the questionnaire data is evaluated by calculating the Cronbach's alpha coefficient. The Cronbach's alpha value is calculated as 0.922 which indicates high internal consistency (Mazlina Zaira and Hadikusumo, 2017). This study investigates the risk factors of the construction sector with respect to their possibility of occurrence by means of Relative Importance Index (RII) and Exploratory Factor Analysis (EFA) of the data adopted from literature using IBM SPSS version 26.

The evaluation methods for analyzing the risk factors of the construction sector are addressed in the following subsections. Section 2.2.4.1 captures an explanation of the RII method, followed by Section 2.2.4.2 that similarly describes the method of EFA used in this study.

2.2.4.1. Relative Importance Index (RII)

To analyze the order of significance of the variables, the relative value of each variable as perceived by the participants is expressed by the Relative Importance Index (RII) (Chan, 2012a). This method is one of the most commonly used and has a highly accurate value when rating variables using a questionnaire (Dixit et al., 2019). The RII for variable k is calculated as shown by Equation 1.

$$\mathrm{RII} = \frac{\sum s_k}{S \times N} \tag{1}$$

Where s_k is the score assigned to variable k by participants (1 to 5), S is the highest score (5) and N is the total number of participants (201). The higher the value of the RII, the greater its influence on the dependent variable. Note that, in this study, the RII can get a value between 0,2-1 (0,2: less important - 1: most important). The RII scores are evaluated using the evaluation criteria presented in Table 2 (Çelik and Oral, 2016; GENÇ et al., 2017).

Table 2. The evaluation criteria of Likert scale (5-point) questions

Likert Score Interval (Mean)	RII Score	Evaluation Criteria
1,00 – 1,79	0,200-0,358	Very low level
1,80 – 2,59	0,359-0,518	Low level
2,60 – 3,39	0,519-0,678	Medium level
3,40 – 4,19	0,679-0,838	High level
4,20 – 5,00	0,839-1,000	Very high level

2.2.4.2. Exploratory Factor Analysis (EFA)

EFA is a statistical technique used to aggregate a number of interrelated variables to form more general, fundamental ones namely "factors" (Gunduz and Abdi, 2020). The key goal of this methodology is to reduce the number of variables measured to smaller parameters in order to enhance interpretability and to identify secret data structures (jadidoleslami et al., 2018).
Two fundamental principles of factor analysis (FA), namely multivariate normality and sampling adequacy, should be checked prior to the extraction of the factors (Chan, 2012a). In order to measure the multivariate normality of the variables, Bartlett's test of sphericity is used while Kaiser-Meyer-Olkin (KMO) test is used to measure whether the distribution of values is adequate for conducting FA (George and Mallery, 2007). Bartlett sphericity test result of the data shows statistical significance ($p<0,05$) and KMO value (0,888) indicates the eligibility (>0,5) of the data for FA (George and Mallery, 2007).

In order to carry out EFA, principal component analysis is used as the extraction method and Oblimin is used as rotation method. To understand the significance of a factor, the main variables for each factor are defined and used as explanatory indicators. These key variables are chosen according to four parameters; (1) eigenvalue ≥ 1, (2) loading values of variables should be minimum 0,4, (3) one variable should only be loaded on one factor, and (4) a factor should comprise minimum two variables (Gorsuch, 1988).

2.3. Responses

The sample size of the study is 201 civil engineers (%94 private sector, %4 public sectors). While %34 of the participants works as director, %15 work as project manager, %15 work as site chief, %10 work as a contractor, and %26 work as office/site engineer. %46 of the participants has a minimum of 20 years of work experience while %23 have 10-19 years, %15 have 1-4 years, %12 have 5-9 years, and %4 have less than 1 year of work experience.

3. Results

This section presents the results of the data analysis. Firstly, the Relative Importance Index (RII) results are presented. This is followed by the Exploratory Factor Analysis (EFA) results.

3.1. RII Results

The RII scores of all variables are presented in Table 3 and expressed in Figure 1. As seen in the table, the RII scores for most of the variables are above 0,519 indicating that the participants typically agree on the probability of occurrence of these risk variables on the construction projects, but with differing degrees of agreement (min. medium level) only. Out of the 33 variables, 5 of them are perceived as highly significant (0,679≤RII≤0,838). These variables include (1) *using unqualified subcontractors/workers/staff during the process*; (2) *delays in payments*; (3) *economic matters such as inflation, speculations on prices*; (4) *late change-order requests of project stakeholders*, and (5) *failure to complete the work within expected budget limits*. While 15 variables are rated as moderate significant (*carrying out the design phase without including the all stakeholders (architects, engineers, clients, etc.); choosing inexpensive and inadequate solutions that can become more costly over time; inadequate precautions for occupational health and safety/work accidents; not having a certain management approach; acceptance of wrong / incomplete contracts and specifications; failure to keep up with the work schedule during the construction process; work planning errors; design / calculation errors and deficiencies; time and cost increment due to the use of inappropriate old technology/advanced technology/equipment; failure to fulfill the requirements of the contract and specifications; using poor quality and non-standard materials; conflicts between workers in the project; bad weather conditions; earthquake; misunderstanding of customer requests*), 10 variables are rated as low significant (*inclusion of new stakeholders in the project and their change-order requests; fire; unexpected changes in laws and standards; change in ground conditions; strike, lockout, stopping the work by inspecting firm; terrorism (attacks that do not directly target the construction site, but occur very close to the construction site and cause work to stop); explosion / industrial accidents; flood; boycott (actions to boycott construction, contractor, business owner); landslide*). Out of the 33 variables, only 3 of them are perceived as very low significant (0,200≤RII≤0,358). These variables include (1) *tornado*; (2) *hurricane*, and (3) *attack (attacks directly targeting the construction site)*.

Table 3. Relative Importance Index (RII) scores of variables

No	Variable Code	Variable	RII
1	VAR9	Using unqualified subcontractors/workers/staff during the process	0,699
2	VAR19	Delays in payments	0,699
3	VAR18	Economic matters such as inflation, speculations on prices	0,694
4	VAR4	Late change-order requests of project stakeholders	0,692
5	VAR12	Failure to complete the work within expected budget limits	0,682
6	VAR1	Carrying out the design phase without including all stakeholders (architects, engineers, clients, etc.)	0,670
7	VAR3	Choosing inexpensive and inadequate solutions that can become more costly over time	0,669
8	VAR15	Inadequate precautions for occupational health and safety/work accidents	0,664
9	VAR8	Not having a certain management approach	0,660
10	VAR6	Acceptance of wrong / incomplete contracts and specifications	0,659
11	VAR13	Failure to keep up with the work schedule during the construction process	0,657
12	VAR7	Work planning errors	0,655
13	VAR2	Design / calculation errors and deficiencies	0,645
14	VAR11	Time and cost increment due to the use of inappropriate old technology/advanced technology/equipment	0,608
15	VAR14	Failure to fulfill the requirements of the contract and specifications	0,597
16	VAR10	Using poor quality and non-standard materials	0,580
17	VAR17	Conflicts between workers in the project	0,551
18	VAR23	Bad weather conditions	0,546
19	VAR27	Earthquake	0,541
20	VAR5	Misunderstanding of customer requests	0,531
21	VAR21	Inclusion of new stakeholders in the project and their change-order requests	0,518
22	VAR32	Fire	0,510
23	VAR20	Unexpected changes in laws and standards	0,509
24	VAR22	Change in ground conditions	0,474
25	VAR16	Strike, lockout, stopping the work by inspecting firm	0,423
26	VAR24	Terrorism (Attacks that do not directly target the construction site, but occur very close to the construction site and cause work to stop)	0,420
27	VAR33	Explosion / industrial accidents	0,414
28	VAR28	Flood	0,408
29	VAR26	Boycott (Actions to boycott construction, contractor, business owner)	0,396
30	VAR29	Landslide	0,387
31	VAR25	Attack (Attacks directly targeting the construction site)	0,353
32	VAR30	Hurricane	0,336
33	VAR31	Tornado	0,296

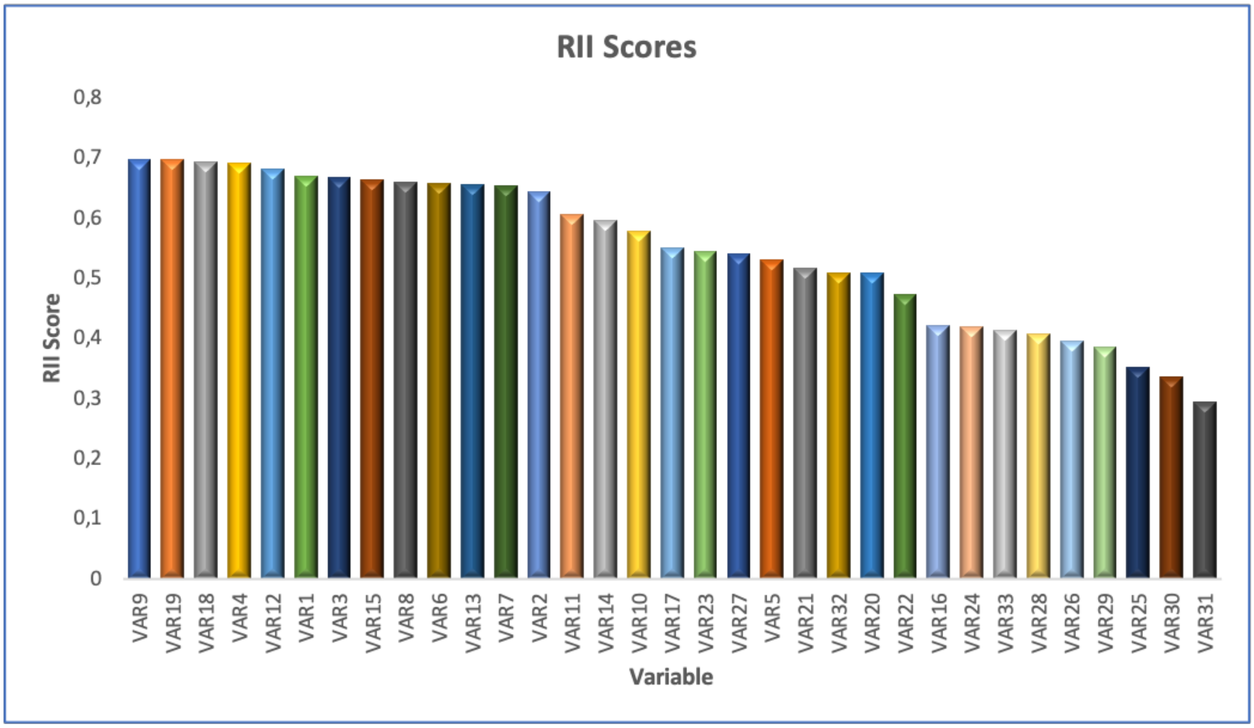

Figure 1. The graphical representation of variables' RII scores

3.2. EFA Results

As a result of EFA, five factors that explain 60,933% variance are extracted. Table 4 presents these factors and their representative variances. Table 5 shows the factor structure and loadings of the principal factor extraction. It is evident that the loadings of the main variables listed for each extracted factor, except for two variables, are greater than 0,5, representing the significant contribution of each variable to the extracted factor. The variables that have less than 0.4 loading scores are excluded from the analysis (VAR5, VAR6, VAR11, VAR14, VAR16, VAR17, VAR19, VAR21, VAR23, VAR27).

Table 4. Factors and total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	7.298	31.729	31.729	7.298	31.729	31.729	6.155
2	3.139	13.648	45.377	3.139	13.648	45.377	3.590
3	1.304	5.668	51.045	1.304	5.668	51.045	3.915
4	1.230	5.346	56.391	1.230	5.346	56.391	2.565
5	1.045	4.542	60.933	1.045	4.542	60.933	2.070

Table 5. Factor structure and loadings of the principal factor extraction

	Component				
	1	2	3	4	5
VAR30	**.876**	,289	,061	,118	,231
VAR31	**.858**	,328	,228	,038	,290
VAR28	**.798**	,291	,012	,353	,141
VAR33	**.748**	,115	,144	,175	,098
VAR25	**.712**	,261	,124	,226	,332
VAR29	**.688**	,343	,253	,352	,087
VAR26	**.672**	,366	,361	,239	-,055
VAR32	**.664**	,054	,105	,138	,271
VAR24	**.653**	,229	,166	-,061	,399
VAR22	**.493**	,219	,342	,021	,246
VAR7	,088	**.788**	,112	,328	,097
VAR12	,331	**.686**	,104	,242	,022
VAR13	,199	**.652**	,112	,035	,066
VAR4	,165	**.638**	,192	,064	,094
VAR3	,048	**.476**	,336	,077	,265
VAR10	-,076	,276	**.827**	,052	,358
VAR9	,158	,083	**.745**	,018	,039
VAR15	,326	,152	**.679**	,338	,216
VAR8	,002	,099	**.519**	,334	,203
VAR18	,097	,347	,128	**.783**	,048
VAR20	-,157	,037	,171	**.777**	,228
VAR1	,318	,091	,040	,358	**.801**
VAR2	,371	,354	,328	,094	**.545**

Every extracted factor is given a suitable aggregate name to represent the association of all variables within it. The extracted risk factors and their related variables are shown in Table 6. The averages of the factors are presented in Figure 2. Depending on the proportion of variance, this is the order of the relevant factors; (1) disaster and force majeure, (2) project management, (3) technical management, (4) external, and (5) design-estimation.

Table 6. Extracted risk factors and their related variables

Factor	Variables
Disaster and force majeure	Hurricane
	Tornado
	Flood
	Explosion / industrial accidents
	Attack (Attacks directly targeting the construction site)
	Landslide
	Boycott (Actions to boycott construction, contractor, business owner)
	Fire
	Terrorism (Attacks that do not directly target the construction site, but occur very close to the construction site and cause work to stop)
	Change in ground conditions
Project management	Work planning errors
	Failure to complete the work within expected budget limits
	Failure to keep up with the work schedule during the construction process
	Late change-order requests of project stakeholders
	Choosing inexpensive and inadequate solutions that can become more costly over time
Technical management	Using poor quality and non-standard materials
	Using unqualified subcontractors/workers/staff during the process
	Inadequate precautions for occupational health and safety/work accidents
	Not having a certain management approach
External	Economic matters such as inflation, speculations on prices
	Unexpected changes in laws and standards
Design-Estimation	Carrying out the design phase without including all stakeholders (architects, engineers, clients, etc.)
	Design / calculation errors and deficiencies

The first factor "disaster and force majeure" reflects the largest total variance (%31,729). It consists of ten variables; *hurricane*, *tornado*, *flood*, *explosion/industrial accidents*, *attack*, *landslide*, *boycott*, *fire*, *terrorism*, and *change in ground conditions*. The second factor "project management" represents %13,648 of the total variance and consist of five variables; *work planning errors*, *failure to complete the work within expected budget limits*, *failure to keep up with the work schedule during the construction process*, *late change-order requests of project stakeholders*, and *choosing inexpensive and inadequate solutions that can become more costly over time*. The third factor "technical management" explains the %5,668 variances. This factor includes four variables; *using poor quality and non-standard materials*, *using unqualified subcontractors/workers/staff during the process*, *inadequate precautions for occupational health and safety/work accidents*, and *not having a certain management approach*. The fourth factor "external" reflects %5,346 of the total variance and consists of two variables; *economic matters such as inflation, speculations on prices*, and *unexpected changes in laws and standards*. The fifth and last factor "design-estimation" represents the smallest total variance (%4,542). This factor also has two variables; *carrying out the design phase without including all stakeholders (architects, engineers, clients, etc.)*, and *design/calculation errors and deficiencies*.

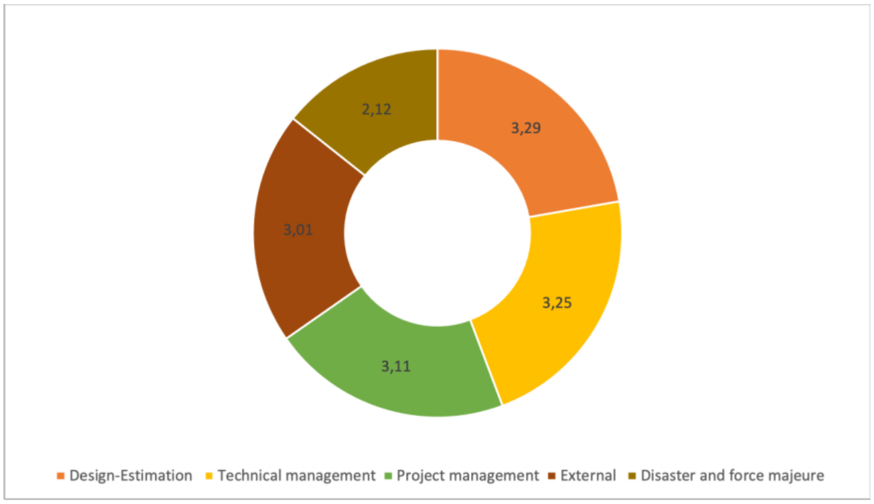

Figure 2. Factor averages

4. Discussion

The factor "disaster and force majeure" encompasses the most variables. However, it is considered the less important factor by civil engineers (Figure 2). The RII results show that most of those variables have low RII scores indicating a low probability of occurrence on construction projects. The reason for that may be that some weather events, e.g., hurricanes and tornados, are regarded as extremely rare and exceptional in Turkey (Kahraman and Markowski, 2014). Although the other disaster and force majeure variables such as an attack, terrorism, boycott, and explosion may have extremely negative effects on construction projects if they occur, these are also considered as low probability risks by participants again maybe because of been uncommon in the country.

One of the most important risks affecting construction projects is the risks arising from managerial factors (Hillson et al., 2006; Szymański, 2017) that typically emerge from internal organizational powers, specific constraints, challenges, strategies, and deciding results (jadidoleslami et al., 2018). All of the project management factor variables have high RII scores and two of them a place in the top five (late change-order requests of project stakeholders, and failure to complete the work within expected budget limits). Getting numerous requests for change at various phases of a construction project is known to be one of the factors in the failure of the project (Genç et al., 2020). Carrying out meetings with stakeholders at every stage of a construction project may help with this matter. One component of constructing project management that demands commitment is expenditure management in a way that is kept within the budget of clients (Adafin et al., 2020). Proper budget preparation practices should ensure that accurate construction project estimates are made, and resulting cost management efforts should avoid the negative effects of cost overruns, conflicts, and project abandonment (Skitmore and Picken, 2000). According to the EFA results, work planning errors are the most significant variable of the project management risk factor. This is in line with the study of Sambasivan and Soon (2007) which indicates that improper planning is the most important cause of delay in construction projects. Failure to keep up with the project schedule fails the expected timetable and is also known to be a major issue in construction projects (Assaf and Al-Hejji, 2006). The time of the contract also occurs as a matter of interest if there is too much time or too little time provided in the agreement (Jiang, 2009). The negative consequences of time constraints are primarily due to carrying out patterns, creating work errors, cutting corners, and lacking the desire to work (Nepal et al., 2006). The decision on materials and methods to be used in a construction project has major natural, economic, financial impacts that may be thoroughly tackled through a variety of techniques, e.g., multi-objective modeling, ranking methods, index-based methods, and cost-benefit analysis (Marzouk et al., 2012). Addressing managerial limitations and implementing the best construction practices may help mitigate project management risks (Yap et al., 2020). Consequently, the effect of project management assistance for laborers and stakeholders as well as project sustainability is of critical importance (Zhao et al., 2018).

The technical management factor is considered the second important factor by civil engineers (Figure 2). EFA results show that "using poor quality and non-standard materials" is the most significant variable of the factor. Enshassi et al. (2009) state that owners, consultants, and contractors, which are the three main actors of a project, agree that the low quality of the equipment and raw materials available is one of the six most critical factors impacting project efficiency. In construction projects, substantial proportions of construction operations are carried out by subcontractors; thus, the progress of the project relies solely on the output of the chosen subcontractors (Bingol and Polat, 2017). Lack of coordination between contractors and other stakeholders typically influences performance metrics in a secret or explicit manner. According to RII results, the variable of the technical management factor "*using unqualified subcontractors/workers/staff during the process"* has the highest score indicating a very high probability of occurrence on construction projects. In the construction sector, the recruitment of subcontractor firms is typically based on two standard approaches; (1) selecting the lowest bid, and (2) selecting known subcontractors (Hartmann et al., 2009; Tserng and Lin, 2002). However, choosing subcontractors based on the bid may result in working with unskilled subcontractors and their inexperienced team (workers, staff, etc.) (Bingol and Polat, 2017) while choosing known subcontractors may lead to issues such as cost-control challenges, the use of new technical capabilities in the project, and the reduction of negotiating processes (Arslan et al., 2008). Thus, to prevent these risks to occur, subcontractors' performances should be evaluated based on the most commonly used indicators before selection. Health and safety threats are also some of the most serious risks in construction projects, as the construction sector is marked by a comparatively high accident and mortality rate compared to other sectors (Aminbakhsh et al., 2013). Inadequate precautions for occupational health and safety/work accidents, which is one of the variables of technical management factor, has a high RII score indicating a high probability of occurrence in construction projects by participants. This risk has an important place compared to other risks because it is not only related to project success but also related to human health and safety. Thus, more cautious effort is required to prevent this risk to occur. To this end, before the project start, the safety risk assessment step should be initiated and carried out during the project in defining possible threats and determining dangers associated with those threats. To handle all technical management risks efficiently, a systematic risk control approach should be applied during the construction processes, in particular in the pre-contracting and post-contracting phases (Zhi, 1995).

Inflation risk falls within the macro-level risk category for construction projects (Bing et al., 2005). The inflationary and speculative rise in the price of building materials is one of the big bans on production and a cause leading to regular overruns and, consequently, to the abandonment of projects (Oghenekevwe et al., 2014). Exploratory results of this study show that economic matters such as inflation and speculations on prices have a high probability of occurrence in construction projects (ranked 3rd place by participants). Except for the global crisis, inflation rate volatility varies by country. Low inflation rate volatility is seen in more developed countries (Berganza and Broto, 2012). The lower the inflation rate the lower the probability of this risk to occur on construction projects. However, this situation is related to the internal dynamics of the country, and construction companies cannot be expected to have a direct impact on inflation. Hence, to prevent this risk from occurring, planning should be made according to the economic situation of the country and the world, and articles should be included in the contract for unforeseen economy-related risks. Law and standard changes occur when governments are inconsistent with the application of new legislation and regulations (Karim, 2011). RII results show that the risk arising from changes in law and standards has a low probability of occurrence on construction projects (ranked 23rd). The reason for that may be that this situation is not seen often and when some changes are made in law and standards, usually, new laws and standards do not include the ongoing projects except for having vital importance.

The actions made at the outset of the life cycle of the construction projects have a direct effect on the construction costs (Erdis et al., 2015) and the operating costs of the structure in the following periods (Çoşkun et al., 2016). The sole authority to make certain decisions is the owner-client, but they must make use of the experience of the experts (Genç et al., 2017; Hendrickson and Au, 1989). The design-estimation factor is considered the most important factor by civil engineers (Figure 2). The first variable of the factor, carrying out the design phase without including all stakeholders, also has a high RII score (6th out of 33 variables) again indicating a high probability of occurrence in construction projects. The risks that may arise from this variable can be minimized by employing concurrent engineering, which is a systematic approach in which products, processes, and support services are carried out simultaneously to fulfill requirements such as quality, cost, time, and user needs (de la Garza et al., 1994; Shouke et al., 2010). This method may also minimize the risks arising from design/calculation errors and deficiencies.

5. Conclusions

In this paper, a comprehensive investigation of the main risk factors in Turkish construction sector is presented. From the questionnaire survey conducted with 201 civil engineers in Turkey, risk factors affecting the construction sector are identified by relative importance index (RII) and exploratory factor analysis (EFA). Interpreting the results from the RII and EFA together provides such a new type of insight allowing one to analyze the main risk factors of the construction sector concerning the likelihood of occurrence. The RII component substantially improves insights into the significance of the variables. The results of the RII shows that the top five risk variables that have a high probability of occurrence in the construction sector are; (1) using unqualified subcontractors/workers/staff during the process, (2) delays in payments, (3) economic matters such as inflation, speculations on prices, (4) late change-order requests of project stakeholders and, (5) failure to complete the work within expected budget limits. The component of EFA improves insights into the aggregation of several interrelated variables to form a more general concept. The study shows that the results of the exploratory EFA identify five key factors namely; (1) disaster and force majeure, (2) project management, (3) technical management, (4) external and, (5) design-estimation. According to their average results, the participants classified the factors in order of importance as follows: design – estimation > technical management > project management > external > disaster and force majeure.

The theoretical contribution of this study is in the form of a questionnaire survey study to the risk management knowledge base in which the study illustrates how the key risk factors and related variables of the construction sector are identified, hence supporting selecting appropriate risk response method. The methodological contribution is the integration of RII and EFA that provide new insights by enabling a combined interpretation of the results from both methods to assess the risks of the construction sector. These contributions provide practitioners and policy-makers with a tool for decision-making in risk management with respect to the identification and selection of risk response methods to maximize the economic gain and sustainability of the construction projects.

The process of collecting data for the questionnaire was carried out in Turkey, and thus it is necessary to endure inter-cultural verification of the tool in order to enhance the generalization of objects. Also, the present analysis does not examine the causal relationship between the risk variables affecting the construction sector. Hence, it is also important to carry out a confirmatory factor analysis (CFA) to assess the adequacy of the measuring tool. Future studies may replicate the methodology to investigate and compare the risk factors affecting construction projects in other locations by addressing the limitations.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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