Cost and time risk factors in construction projects in the Dominican Republic

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The building sector is very dynamic and complex, so construction works are surrounded by uncertainties. The deficiencies of this sector are mainly related to poor project planning and management, resulting in losses because of missed deadlines, cost overruns, reworks, and unsatisfied clients. For a project to be successful, all the parties involved should work together to effectively manage the risks that could emerge in the project life cycle. This research defines and establishes a classification of the factors causing cost and time deviations in construction projects in the Dominican Republic. For this purpose, the most common factors are compiled, and their risk levels are determined by using the data obtained in a survey in which professionals from the building sector participated. The indexes marked by the participants show that the serious risk factors are design variations and the variations made by clients, a tight project schedule and the preparation of bid offers, deficiencies in the work planning and schedule, the lack of skilled labour, and work performance errors.

KEYWORDS

construction, cost, developing country, risk assessment, time

1 Introduction

The building sector, like many other sectors, is surrounded by uncertainty because of both long performance periods and the involvement of various participants, thus implying more negative risks. The success or failure of any project could be measured through the fulfilment of its goals, the impact on the interested parties and users' satisfaction, among other dimensions. However, success is defined by delivering a quality project within the budget and schedule established.

Cost and time deviations in construction projects constitute a worldwide problem for the building sector. Many works are not finished as planned. Flyvbjerg et al. (2002) showed this aspect in their study on cost underestimation in 20 countries in 5 continents. Cost overruns take place in 9 out of every 10 major construction projects. In this regard, Cantarelli et al. (2012) stated that cost overruns are a global phenomenon, but the size varies according to the location. KPMG (2015) reported that only 31% of the projects analysed finished with deviations lower than 10% of the initial budget. The remaining 69% presented excesses between 10% and 50%, whereas only 25% of projects fulfilled the schedule established. Al-Nahhas et al. (2024) indicate that certain construction projects in highly developed countries reach cost overruns between 16% and 95%. In the case of infrastructure projects, the author states that in certain developing countries the cost overruns are between 70% and 200%. This causes taxpayers to have to pay higher expenses for services associated

with these projects. For the author, it is essential to thoroughly assess and analyse risks, as well as implement risk management plans. For Chen et al. (2023), the risks that come from the complexity of infrastructure projects have caused budget overruns around the world, having a substantial impact on economies. Ammar et al. (2023) study project cost overruns and indicate that contingency reserves are usually implemented to address such risks and uncertainties, with risk management in this context being one of the most important jobs of planners. The problem also exists with respect to the compliance with temporary deadlines in projects, the problem also exists. Gurgun et al. (2024) indicates that completing projects on time is widely considered one of the greatest indicators of project success. In this regard, they argue that despite technological advances in the current era of digitalisation, in the construction sector there is still a poor result in compliance with schedules. For the authors, the reasons for this circumstance require investigation.

According to the Project Management Institute (2017), risk is any uncertain event that, if it happens, affects at least one project objective. Several factors could affect the fulfilment of goals, varying because of the sector, the geographic environment, and the project's characteristics. Consequently, risks should be assessed in all works to guarantee success. In their study on risks in power plant projects, Islam, Nepal and Skitmore (2023) refer to the importance of studying the specific risks of a specific country or geographic environment. Risk management is the process of identifying, analysing, responding planning, response implementation, and monitoring project risks (Project Management Institute, 2017). Risk management is crucial to be considered as a discipline within project management to achieve success. It is aimed at both improving performance and contributing to the fulfilment of goals by reducing threats and by increasing opportunities.

Risk management has been required since ancient times, but the first research studies in the building sector emerged in the mid of the 20th century (Taroun, 2014). According to Flanagan and Norman (1993), risks have been managed in the building sector since the last two decades. Baloi and Price (2003) indicated that the risk management techniques based on statistical models are seldom used in practice by contractors. De Camprieu et al. (2007) also showed the lack of applying this type of models. Moreover, Taroun (2014) reviewed the techniques used to manage risks in recent decades and stated that there is a significant gap between the theory and the use in practice of these techniques. Thus, risk management is a useful tool that provides benefits and avoids problems; however, it should be more studied.

In this research, risks are events that can affect the cost and time objectives of the project. Within the risk management process, this research is aimed at developing the risk identification stage in construction projects in the Dominican Republic. According to the Banco Mundial (2020), the Dominican Republic's economy is among the Latin America's higher growth economies, with an annual average of 6.3% between 2014 and 2018. In 2019, the gross domestic product (GDP) increased by 5.1%, the highest in Latin America, corresponding 12% of the GDP to the building sector. Moreover, this sector has played a crucial role in the growth of the service sector in the country. This research is also aimed at determining the importance level of risk factors in relation to both the cost and time goal and its relationship with the interested parties,

thus providing project managers with useful information to tackle with them.

To identify these risks, both the existing literature has been exhaustively reviewed and influential factors have been listed. The literature review was carried out using Scopus, Web of Science, and Google Scholar as main search engines. These risks have been assessed by various professionals of the sector through a survey based on two attributes: occurrence probability and impact. The data obtained were used to classify the serious risk factors, thus determining their influence on the following aspects: (i) cost and time goals, (ii) the stage in which risk factors take place, and (iii) the agents responsible for these risk factors.

2 Literature review

Cost and time deviations, together with their causes in projects, have been widely studied in various areas of the building sector, particularly since the 1980s. These studies are mainly based on questionnaire surveys targeting professionals of the sector.

In addition, there is a worldwide distribution of the territorial contexts where these studies were conducted. The territorial scale is sometimes very large. Flyvbjerg et al. (2002) studied the cost overruns of 258 projects in 5 continents, mainly focusing on Asia and Africa. On the other hand, there are more reduced scopes, such as that in Ahmed et al. (2003), which identified the main delay causes in the building sector when building constructions in Florida. Moreover Enshassi et al. (2009) studied the delay and cost overrun causes in the construction projects in the Gaza Strip.

There are many risk factors which vary according to both the characteristics of the project and the geographic scope analysed. However, there are also general risks, as Zou et al. (2007) showed by comparing factors between Australia and China. Table 1 includes the most stressed risk factors in literature and summarises the studies identifying them. These factors are also understood as sources of risk, that is, uncertain events that, if they occur, can affect the objectives of the projects.

Cost and time risk factors are usually identified and analysed in large projects (high budget and complexity) belonging to both the public and civil engineering sector. Some of these studies only considered the risk on the cost goal (Akinci and Fischer, 1998) or on the time goal ((Ogunlana et al., 1996; Al-Momani, 2000)). Others, such as Kaming et al. (1997), Frimpong et al. (2003), Le-Hoai et al. (2008) and Al-Hazim et al. (2017)), studied the risks affecting both goals, prevailing the studies on cost factors. There were also other criteria according to the nature of the risk, its source or origin, or the project stage where the risk takes place.

Most research studies are qualitative and are based on the professionals' experience and judgement. Surveys, questionnaires, and interviews are used as tools for data acquisition. In addition, various methods are used to analyse the consequences of the risk factors: (i) Assaf and Al-Hejji (2006) and Le-Hoai et al. (2008) used the frequency index, the severity index, and the importance index; (ii) Chan and Kumaraswamy (1997) and Frimpong et al. (2003) used the relative importance index (RII); (iii) Bubshait & AL-Juwairah (2002) used the severity index; and (iv) Zou et al. (2007) used the significance index.

TABLE 1 Main risk factors influencing construction projects.

Factors	Authors
Design variations or changes	Arditi et al. (1985), Mansfield et al. (1994), Kaming et al. (1997), Acharya et al. (2006), Assaf and Al-Hejji (2006), Omoregie and Radford (2006), Zou et al. (2007), Abd El-Razek et al. (2008), Le-Hoai et al. (2008), Enshassi et al. (2009), Memon et al. (2010), Ameh et al. (2010), Olawale and Sun (2010), Aziz (2013), Al Hosani et al. (2020), Johnson and Babu (2020), Sharma et al. (2020), Arantes and Ferreira (2021)
Cost estimate-imprecise duration	Okpala and Aniekwu (1988), Akinci and Fischer (1998), Acharya et al. (2006), Assaf and Al-Hejji (2006), Omoregie and Radford (2006), Sambasivan and Soon (2007), Zou et al. (2007), Olawale and Sun (2010), Aziz, 2013; Tahir et al. (2019), Kavuma et al. (2019), Al Hosani et al. (2020), Johnson and Babu (2020), Omotayo et al. (2020)
Financing problems	Arditi et al. (1985), Morris (1990), Mansfield et al. (1994), Assaf et al. (1995), Al-Momani (2000), Koushki et al. (2005), Alaghbari et al. (2007), Zou et al. (2007), Abd El-Razek et al. (2008), Le-Hoai et al. (2008), Ameh et al. (2010), Memon et al. (2010), Abdul Rahman et al. (2013), Aziz (2013), Choudhry et al. (2014), Larsen et al. (2016), Larsen et al. (2016), Murali and Kumar (2019), Johnson and Babu (2020), Sharma et al. (2020), Sohu et al. (2020), Yap et al. (2021)
Deficient planning	Morris, 1990, Elinwa and Buba, 1993, Mansfield et al., 1994, Odeyinka and Yusif, 1997, Bubshait and AL-Juwairah, 2002, Assaf and Al-Hejji, 2006, Zou et al., 2007, Enshassi et al., 2009, Memon et al., 2010, Omotayo et al., 2020, Rivera et al., 2020, Sohu et al., 2020, Arantes and Ferreira, 2021, Obi et al., 2021, Yap et al., 2021)
Variations by the client	Morris (1990), Chan and Kumaraswamy (1997), Akinci and Fischer (1998), Al-Momani (2000), Ahmed et al. (2003), Moura et al. (2007), Zou et al. (2007), Memon et al. (2010), Tahir et al. (2019), Kavuma et al. (2019), Al Hosani et al. (2020), Johnson and Babu (2020), Yap et al. (2021)
Deficient work management	Arditi et al. (1985), Mansfield et al. (1994), Ogunlana et al. (1996), Chan and Kumaraswamy (1997), Frimpong et al. (2003), Moura et al. (2007), Zou et al. (2007), Abd El-Razek et al. (2008), Azhar et al. (2008), Le-Hoai et al. (2008), Memon et al. (2010), Doloi et al. (2012), Gunduz and Tehemar (2020), Rivera et al. (2020), Sohu et al. (2020), Widowati and Rachmawati (2020), Arantes and Ferreira (2021), Obi et al. (2021)
Shortage of materials	Arditi et al. (1985), Elinwa and Buba (1993), Mansfield et al. (1994), Kaming et al. (1997), Frimpong et al. (2003), Koushki et al. (2005), Omoregie and Radford (2006), Alaghbari et al. (2007), Sambasivan and Soon (2007), Enshassi et al. (2009), Abdul Rahman et al. (2013), Tahir et al. (2019)
Lack of skilled labour	Kaming et al. (1997), Assaf and Al-Hejji (2006), Zou et al. (2007), Abd El-Razek et al. (2008), Memon et al. (2010), Abdul Rahman et al. (2013), Aziz, 2013; Tahir et al. (2019), Murali and Kumar (2019)
Inflation	Kaming et al. (1997), Frimpong et al. (2003), Zou et al. (2007), Enshassi et al. (2009), Ameh et al., 2010; Aziz (2013), Khanal and Ojha (2020), Sharma et al. (2020)
Climate conditions	Akinci and Fischer (1998), Al-Momani (2000), Iyer and Jha (2005), Koushki et al. (2005), Assaf and Al-Hejji (2006), Zou et al. (2007), Widowati and Rachmawati (2020)

Nevertheless, there are few studies focused on the risk management in Latin America, particularly on the factors of cost and time deviations in the construction projects of one of the economies with the best indexes in recent years: the Dominican Republic. Senior and Rodríguez (2012) analysed the barriers to improve productivity (the study was based on surveys targeting 134 professionals of the construction sector), and Martínez et al. (2016) conducted a work for the Technological Institute of Santo Domingo on the key factors required for the building construction of that city to be successful.

Knowing the factors that cause cost overruns increases the effectiveness of cost control, so continuous researching and the diversification of studies on this issue throughout time and in various geographic context are crucial. The reduction of cost and time increases is also among the main challenges to be overcome by the interested parties of a project.

In this work, a central research question is proposed: What are the specific risks that can negatively impact the cost and time of construction projects in the Dominican Republic? To answer it, we propose the objective of developing the stage of identification of those events that may affect the cost and deadline of construction projects in this geographical area. The project risk management process is usually made up of the stages of identification, analysis, monitoring, and control. In this way, it is intended to contribute, using these techniques, to

improving project management. The methodology followed in the research is described below.

3 Methodology

3.1 Obtaining the preliminary list of risk factors

After analysing the references, a total of 135 risk factors affecting the time and cost goals in construction projects were initially obtained. As explained below, this set of factors was subjected to a first refinement process and subsequently to a pilot survey. After this process, the final list of factors was obtained, which was the subject of expert surveys.

Risk factors related to this research were taken from all references throughout the review process. Each time a factor was found that was considered to refer to the same concept or was even named in the same way, a point was added to the count. Some of these factors were similar, which is something usual when using various references; however, the goal in this first stage was based on identifying as many risk factors as possible. The risk factors with the highest points in the count were as follows: (i) project financing problems/lack of resources/method of financing/owner incapable of facing the economic load of the project, with 23 points; (ii) design

TABLE 2 Equivalence of experts' assessments scale with numerical scale of probability and impact.

Assessment scale	Equivalent numeric scale	
Probability/Impact	Probability	Impact
Almost null (0.5)	0.05	0.025
Very low (1)	0.10	0.05
Low (2)	0.30	0.10
Moderate (3)	0.50	0.20
High (4)	0.70	0.40
Very high (5)	0.90	0.80

variations, with 22 points; (iii) environmental/climate conditions, with 21 points; (iv) variations by the client/requests for changing project requirements or definitions, with 20 points; and (v) incomplete, imprecise or inappropriate cost estimate/incorrect estimate method, with 19 points. On the other hand, various factors obtained just one point in the count: (i) executive bureaucracy in owner organizations, (ii) slow exchange of documentation among participants, (iii) worker's nationality, and (iv) schedule restriction to carry out activities.

The next stage consisted in improving the initial list with the 135 risk factors, which were analysed considering several aspects. Thus, certain factors related to similar concepts or those mentioned an unclear, ambiguous, or contradictory way were removed. In addition, those considered insignificant as they obtained just one point in the repetition count were also removed. After this second stage, the initial list went from 135 to 71 risk factors. In a third stage, a pilot survey was conducted, thus reducing again the list to 56 risk factors, which were then assessed by a panel of experts.

After analysing and improving the list, the risk factors were classified and organised in homogeneous groups. Several ways of classification were considered, such as that presented by Zou et al. (2007) related to the interested parties of the project. On the other hand, Assaf and Al-Hejji (2006) combined the interested parties with other

risk sources, including design, external factors, materials or equipment. Finally, the criterion by Garcia Casares (2015) was adopted as it deals with the factor origin. Thus, a set of 71 units were previously established and again improved after a pilot survey. The factors were eventually grouped in several blocks: (i) design equipment, (ii) client, (iii) contractor, (iv) subcontractors and suppliers, (v) government, (vi) materials and equipment, (vii) contract, (viii) project administration or management, (ix) project's own factors, and (x) external factors.

3.2 Risk modelling

The process of obtaining the final level of a risk, that is, risk modelling, is usually considered as a combination of the probability of its occurrence and its consequences (ISO, 2018). Taroun (2014) stated that the combination of probability with impact as the result of both prevails in research studies to model the risk.

For the experts' assessments of the probability of the risk and its impact on the time and cost goals of the various factors, a scale similar to the Likert scale but with 6 levels was provided. The scale includes 6 values: 0.50 = almost null; 1 = very loo; 2 = low; 3 = moderate; 4 = high; and 5 = very high. Two questions were included in one section, independently of the assessments: one question was based on the factor that should be removed from the list, and another on the convenience of including any other factor that could imply delays and increase costs in a project. These two questions were open-ended questions. Another section included two questions aimed at knowing the state of the risk management process in the Dominican Republic. In this case, the information required was the frequency of using risk management in the projects in which the expert has participated, as well as the tools they knew or had used for the task.

To analyse the values obtained, the response options of the scale used were associated with numeric values. For this, the scale indicated by the Project Management Institute (Project Management Institute, 2017) was used as a starting point, where the probability value adopts a range between 0.10 and 0.90 and the impact range between 0.05 and 0.80. The ranges used in our research include the probability values of 0.05 and the impact value of 0.025,
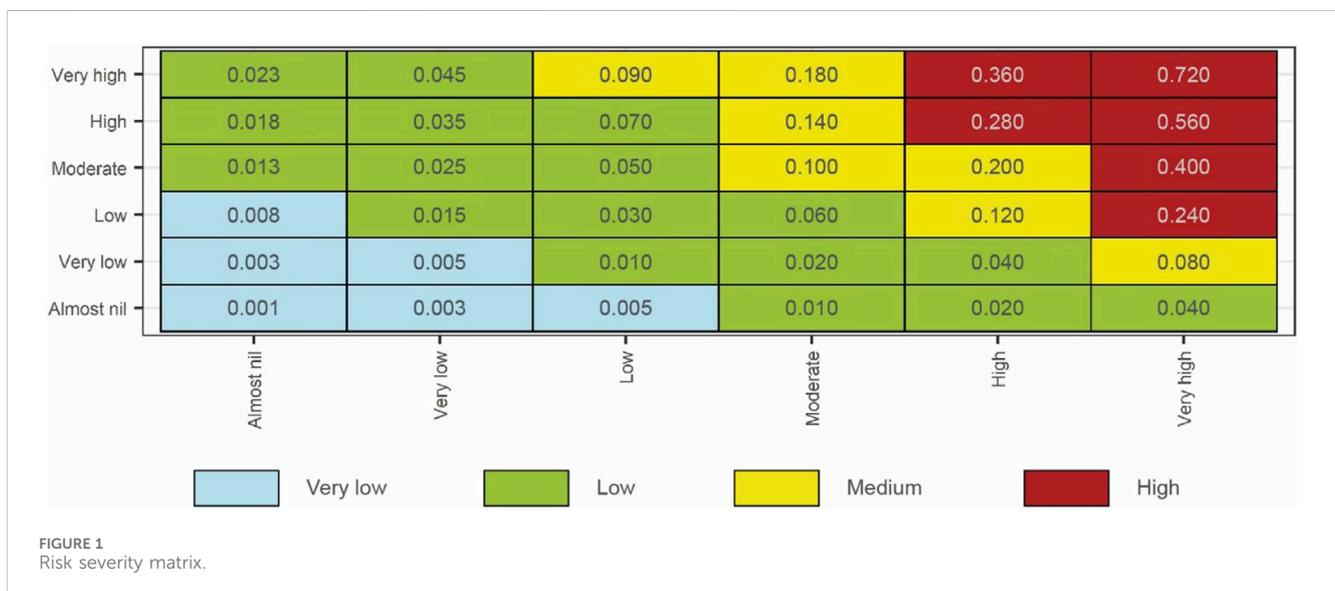

FIGURE 1
Risk severity matrix.

TABLE 3 Structure of the survey.

Risk factors in construction projects in the Dominican Republic		
		Questions
Block 1 Respondents' professional profile data	Section 1	Age range
		Occupation
		Work area
		Years of experience
		Types of project
		Industry
Block 2 Risk factor assessment	Section 2	Block description
	Section 3	Factors related to the design equipment (A)
	Section 4	Factors related to the client or owner (B)
	Section 5	Factors related to the contractor (C)
	Section 6	Factors related to subcontractors/suppliers (D)
	Section 7	Factors related to government (E)
	Section 8	Factors related to materials and equipment (F)
	Section 9	Factors related to the contract (G)
	Section 10	Factors related to the project administration (H)
	Section 11	Factors related to project nature (I)
	Section 12	External factors (J)
Block 3 Other questions	Section 13	Do you think that any factor should be removed from the list?
		Which other factors could imply delays and cost overruns in a construction project?
Block 4 Risk management	Section 14	How often risk management has taken place in the projects in which you have been involved?
		Which tools or techniques do you know to manage risks?

corresponding to the almost null value (0.5) of the assessment scale. Table 2 includes the values adopted.

After obtaining the probability and impact values, these values were combined to obtain the significance score of each risk (S_{ij}) assessed by each respondent:

$$S_{ij} = P_{ij} * I_{ij} \qquad (1)$$

Where P_{ij} is the occurrence probability of risk i assessed by respondent j; and I_{ij} is the impact degree of risk i assessed by respondent j.

The next calculation was to obtain the average score for each risk (Eq. 2). This average score was called in Zou et al. (2007) as "risk significance index score". It was used to classify all risks, both for the cost and time goal.

$$IS_i = \frac{\sum_{j=1}^{n} S_{ij}}{n} \qquad (2)$$

Where IS_i is the significance index of risk i; S_{ij} is the significance score of risk i assessed by respondent j; i is the ordinal number of risk i (in this case, from 1 to 56); j is the ordinal number of respondent for risk i (in this case, from 1 to 41); and n is the total number of valid respondents (in this case, 41).

To obtain severity levels of the risks expressed at a qualitative level based on the risk significance indexes calculated, the matrix

from Figure 1 was used. This matrix is based on that indicated by the Project Management Institute (2017), being adapted to the 6 possible probability and impact values. The matrix was divided into 4 zones according to their significance index for the cost and time goals of the project. Values could achieve four risk levels: "Very low," "Low," "Medium," and "High."

3.3 Pilot survey and improvement of the list of risk factors

Surveys were addressed to a panel of experts. A pilot test was previously conducted to include in the activity the adjustments required before sending it to the participants. The survey was expedited using on Google Forms and was divided into 4 blocks and 14 sections, as Table 3 shows. The survey was configured to a response by each respondent through a compulsory login but remaining anonymous. All questions were defined in the questionnaire as compulsory to remove the error of no answer.

Block 1 is composed of 6 questions aimed at obtaining information on the respondent's professional profile. These questions are closed questions, with several response options. Block 2 shows the list containing the 71 risk factors previously

TABLE 4 Significance index for time and cost goals.

Code	Factor	Code	Factor
A	**Factors related to the design equipment**	**E**	**Factors related to government**
A1	Design variations	E1	Excessive procedures of permit approvals or government bureaucracy
A2	Incomplete or inappropriate information of the site	E2	Standard changes
A3	Incomplete or inappropriate cost estimate	**F**	**Factors related to materials and equipment**
A4	Incomplete and low-quality maps, with no specifications	F1	Lack of machinery in the market
A5	Design errors	F2	Machinery failures or equipment damages
A6	Lack of experience of the design team	F3	Lack or shortage of materials
A7	Slowness when preparing design proposals and maps	F4	Dependence of imported materials
B	**Factors related to the client or owner**	F5	Construction material price fluctuations
B1	Tight project chronogram or schedule	**G**	**Factors related to contract**
B2	Project financing problems	G1	Non-realistic contracting budget
B3	Slow payments by the ownership	G2	Deficient contracts with errors and discrepancies
B4	Variations by the client	G3	Contract complaints (on the part of any participant)
B5	Owner's lack of experience	**H**	**Factors related to the project administration**
B6	Lack of definition or incomplete definition of the scope	H1	Lack of communication and coordination among the participants
B7	Slow decision-making on the part of the client	H2	Corruption, bribery, and fraudulent acts
B8	Limited time to prepare tender offers	**I**	**Factors related to project nature**
C	**Factors related to the contractor**	I1	Difficult project location
C1	Contractors' poor management ability	I2	Large size or importance
C2	Deficiencies in work planning or programming	I3	Design complexity and its construction
C3	Contractor's financing difficulty	I4	Change or unexpected condition of the site
C4	Lack of skilled labour	**J**	**External factors**
C5	Negligent or deficient supervision	J1	Inflation
C6	Lack of deadline control	J2	Exchange rates/currency fluctuations
C7	Deficient control of costs and resources	J3	Unfavourable climate or environmental conditions
C8	Work performance errors	J4	Unstable political and social situation
C9	Low labour efficiency and productivity	J5	Unstable economic situation
C10	Staff accidents or wounds when working	J6	Disputes with the residents' association (neighbours, district society)
C11	Lack of experience of the project professional team	J7	Market competitiveness
C12	Lack of experience of the construction company/contractor		
C13	Non-compliance of documentation, building permit and environmental standards		
C14	Internal strikes in works		
C15	Obsolete/inappropriate tools and technology		
D	**Factors related to subcontractors/suppliers**		
D1	Subcontractors' incompetency		
D2	Delay of materials in works because of the supplier		
D3	Materials arriving under defective conditions, low quality or with incorrect specifications		

TABLE 5 Respondents' professional profile.

University degree	%
Architect	90.2
Engineer	9.8
Type of work	**%**
Project technicians (planning and budgets)	36.6
Construction supervisor	22.0
Project manager	14.6
Contractor/Construction company	12.2
Designer	4.9
Others (security, maintenance, geotechnics, supply)	9.7
Experience	**%**
5–7	53.6
7–10	29.3
10–15	7.3
>15	9.8
Area of work	**%**
Private	65.8
Public	12.2
Public-Private	22.0
Types of projects	**%**
Housing	22.0
Hotels	22.0
Shops or offices	17.1
All the previous	14.6
Road infrastructures	7.3
Hydraulic structures	7.3
Others (parks, club-houses, telecommunication towers, reinforcement and watertightness, mining)	7.3

identified in both the literature review and the first improved stage. Factors were grouped in 10 classification categories, each focused on a section. For each risk factor, the experts assessed 3 variables: (i) occurrence probability of the factor; (ii) impact on the cost goal of the project if the factor takes place; and (iii) impact on the time goal of the project if the factor takes place.

A total of 10 professionals were selected for the pilot surveys, but 7 of them took part in it. The university degree is engineering for 6 of the participants and one architect. The professional profile of engineers is that of project manager, construction supervisor, and contractor, and on the part of the architect that of designer. Each respondent was individually discussed with their general opinion on the survey and on the risk factors that seemed confusing and difficult to understand. Participants in this pilot test were surveyed on the refined list of 71 risk factors with the value scales and methodology described

above. After having the data from the assessment in the pilot test, the factors were organised according to the values obtained in the significance index for the time and cost goals. Semi-structured interviews are then held with the participants in the pilot survey. The objective of these interviews was to obtain complementary information useful for the final design of the survey. Thus, added difficulties when developing the activity or factors which were confused or difficult to understand were detected. Data cleaning was also carried out, the factors with the lowest score were analysed to determine if they should be removed from the list and the reasons, so the factors with the lowest score were removed, as well as those considered doubled because of their similarity with others. After these adjustments, the list was reduced to the 56 factors indicated in Table 4, which were included in the definite survey.

3.4 Surveys for the panel of experts

In this stage of the research, surveys are carried out with the group of experts. To identify the panel of participants, intentional sampling was carried out. The panel of experts was formed through professional colleagues from the research group in the Dominican Republic. These colleagues, in turn, provided other new professionals who met the established requirements to be part of the group of respondents. One of the requirements was to have a qualified professional profile related to the construction sector, engineers and/or architects, or other related subjects. The second requirement was to have a minimum of 5 years of work experience in the public or private construction sector in the Dominican Republic. In total, 86 professionals were identified to whom the survey was sent electronically. The survey is created and distributed using Google Forms. 47 responses were received to the form, of which 6 were eliminated because they presented the same answer to all the questions. The remaining 41 surveys represent a response rate of 47%, which is considered acceptable according to Zou et al. (2007). The professional profile of the respondents, obtained from the first block of the survey, is shown in Table 5.

4 Results and interpretation

4.1 Risk level of the factors

Data from surveys were collected and analysed. The aim was to identify the serious factors for both goals and to determine tendencies, similarities, and variations in the results. In the second block of the survey, the participants assessed the probability and occurrence, as well as the impact on the 56 factors. These factors were classified in the 10 groups previously mentioned. After obtaining the values, probability and impact were combined. The significance of each risk was obtained by applying Eq. 1, and the significance index that indicates the severity level of each risk was obtained with Eq. 2. Figure 2 shows the value distribution of the significance index for each factor, both for the cost and time goal.
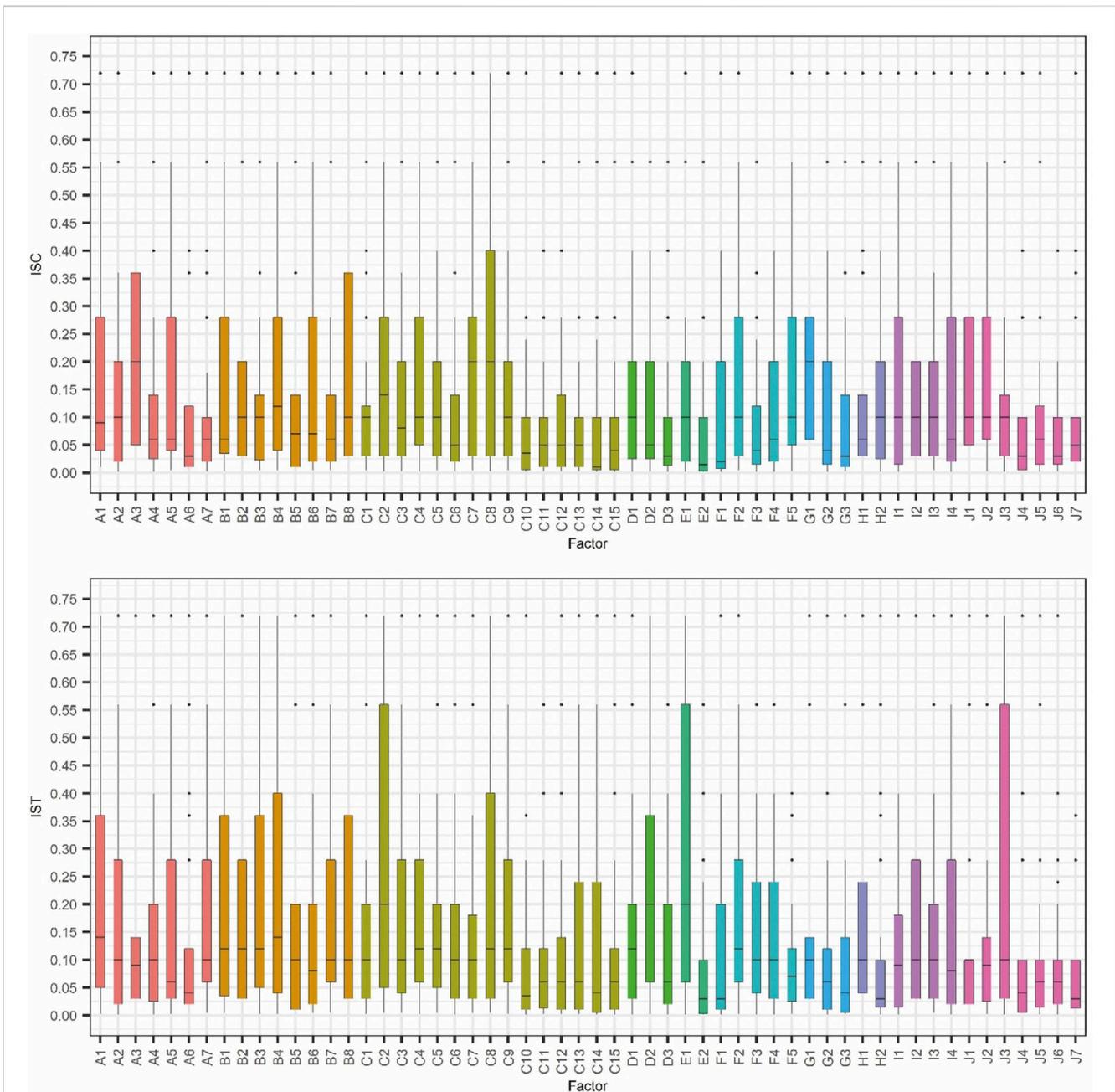
FIGURE 2
Box plots with the values of the significance indexes for the cost (ISC) and time goal (IST).

Figure 2 shows the factors with the greatest significance index. In general, the indexes with the greatest values (between 0.20 and 0.30) and repeated in both goals constituted the serious risk factors: (i) A1-Design variations; (ii) B4-Variations by the client; (iii) B1-Tight project chronogram or schedule; (iv) B8-Limited time to prepare tender offers; (v) C2-Deficiencies in work planning or programming; (vi) C4-Lack of skilled labour; and (vii) C8-Work performance errors.

Afterwards, the severity matrix of the risk (Figure 1) was used as it turned the numerical significance index values into a scale of severity level of the risk qualitatively expressed. Thus, most serious factors reached a "High" risk level, i.e., numerical significance index values between 0.20 and 0.30 were reached. In this regard, Table 6 shows the risk levels achieved by the 56 factors.

The results showed more factors with a "High" level for the time goal. The risk perceived was therefore greater for the time goal than for the cost goal. Figure 3 shows this aspect, including a radar graph for each group of risk factors. The graphs represent the significance indexes in relation to the cost (ISC) and time (IST) of the various factors, constituting a greater graphic surface of risks for the time goal. In addition, serious factors, i.e., those achieving significance index values between 0.20 and 0.30, were repeated both for the time and goal (A1, B1, B4, B8, C2, C4, and C8). On the other hand, there was no factor at the "Very low" risk level in any of

TABLE 6 Risk level of the factors.

Level	Cost goal		Time goal	
	Number of factors	%	Number of factors	%
High	8	14.3	14	25.0
Medium	46	82.1	41	73.2
Low	2	3.6	1	1.8
Very low	-	-	-	-

the goals. Thus, all the risks included in the list should be consider in the construction projects. Figure 3 also shows that the risk sources concentrating more serious risks were group C (contractor) and B (client), with greater graphic surfaces of risks than the other groups.

4.2 Relationship among the factors and assessment by respondents

The Pearson correlation coefficient was used to measure the relationship level among the risk factors, independently of the group to which they belonged. In addition, Seaborn, a statistical tool, was used to calculate the coefficients among the factors for both goals. The results are graphically shown in Figure 4, 5 with matrix heatmaps. The most intense red colours represent the most correlated factors, with values close to 1. The less correlated factors, with values close to 0, are represented with darker blue colours.

The factors with a stronger correlation for both time (J1-J2 and A6-C8) and cost goals (B1-C1, B7-E2, and J5-J6) are shown in Table 7, reaching correlation values between 0.81 and 0.88. To see Figure 4, 5 clearly, the number indicating the correlation values is represented with a decimal as in these Figures there are more factors with a coefficient of 0.8 than those indicated in Table 7.

The similarities among the respondents' opinions were also analysed with the Pearson correlation coefficient. For the cost goal, the greatest similarities took place between the group of contractors/subcontractors and supervisors, with a strong correlation (0.64). The group project managers and supervisors showed a moderate relationship (0.42). The remaining relationships among groups was weak: designers and supervisors (0.35), contractors/subcontractors and designers (0.32), contractors/subcontractors and project managers (0.29), and project managers and designers (0.27). For the time goal, there was a strong correlation between contractors/subcontractors and supervisors (0.648), as well as a weak correlation between contractors/subcontractors and designers (0.3775). The remaining relationships among groups was moderate: project managers and supervisors (0.45), designers and supervisors (0.42), contractors/subcontractors and project managers (0.41), and project managers and designers (0.40).

4.3 Risk sources and life cycle of the project

This stage analysed the relationships between the risk sources (10 groups of factors, Table 4) and the life cycle of

the project in which the risk is materialised. Three life cycles were established, containing most risks: a conceptual and study phase related to the project viability, a design phase, and a construction phase. For the analysis, the factors were classified in tables with double entry: risk source and life cycle phase. Table 8 corresponds to the cost goal, and Table 9 to the time goal. The severest risk factors, i.e., the factors with the greatest significance indexes (values between 0.20 and 0.30), were considered. These factors were 13 for the cost goal, and 14 for the time goal. Both tables show in bold the 7 serious risk factors previously identified, which are the severest taking place in both goals. For each risk source, the various factors were classified in each of the three life cycle phases in which they took place. For the cost goal, the construction phase included 54% of the factors, the design phase included 38%, and the viability phase included 8%. For the time goal, 64% of the risks were in the construction phase, 22% in the design phase, and 14% in the viability phase. For both goals, 57% of the serious factors took place in the construction phase, and the remaining 43% in the design phase. Therefore, the stage with the greatest risk was the construction phase, which included the severest and most serious factors, with the contractor and the client being the most responsible for them.

4.4 Factors that could be removed and possible new factors

In the third block, information was obtained about the possibility of not considering certain risk factors included in the list. A total of 79.5% of the respondents considered that no risk factor should be removed. The remaining 19.5% (8 participants) considered the following risk factors to be removed: (i) those related to the client (1 participant), (ii) Difficult project location (2 participants); (iii) environmental factors (1 participant); (iv) corruption, bribery, and fraudulent acts (1 participant); (v) market competitiveness (2 participants), and (vi) great size of the project (1 participant).

In this block, participants were also asked about the other possible factors which could be included in the analysis. There were 15 positive responses; however, some corresponded to general concepts such as allocation, internal works in the place or the lack of task delegation. Others corresponded to factors already considered in the list, such as climate or deficiencies in the planning. Finally, 3 possible new factors were indicated: (i) participants' wage conditions, (ii) health factors, such as the COVID-19 pandemic, and (iii) government changes.

4.5 Application of risk management in the Dominican Republic

This issue was developed in the fourth block of the survey through two questions. The first question was: "How often risk management has taken place in the projects in which you have been involved?." The results showed that 17.1% "never" used it, 36.6% "hardly," 26.8% "sometimes," and 19.5% "almost always." To verify
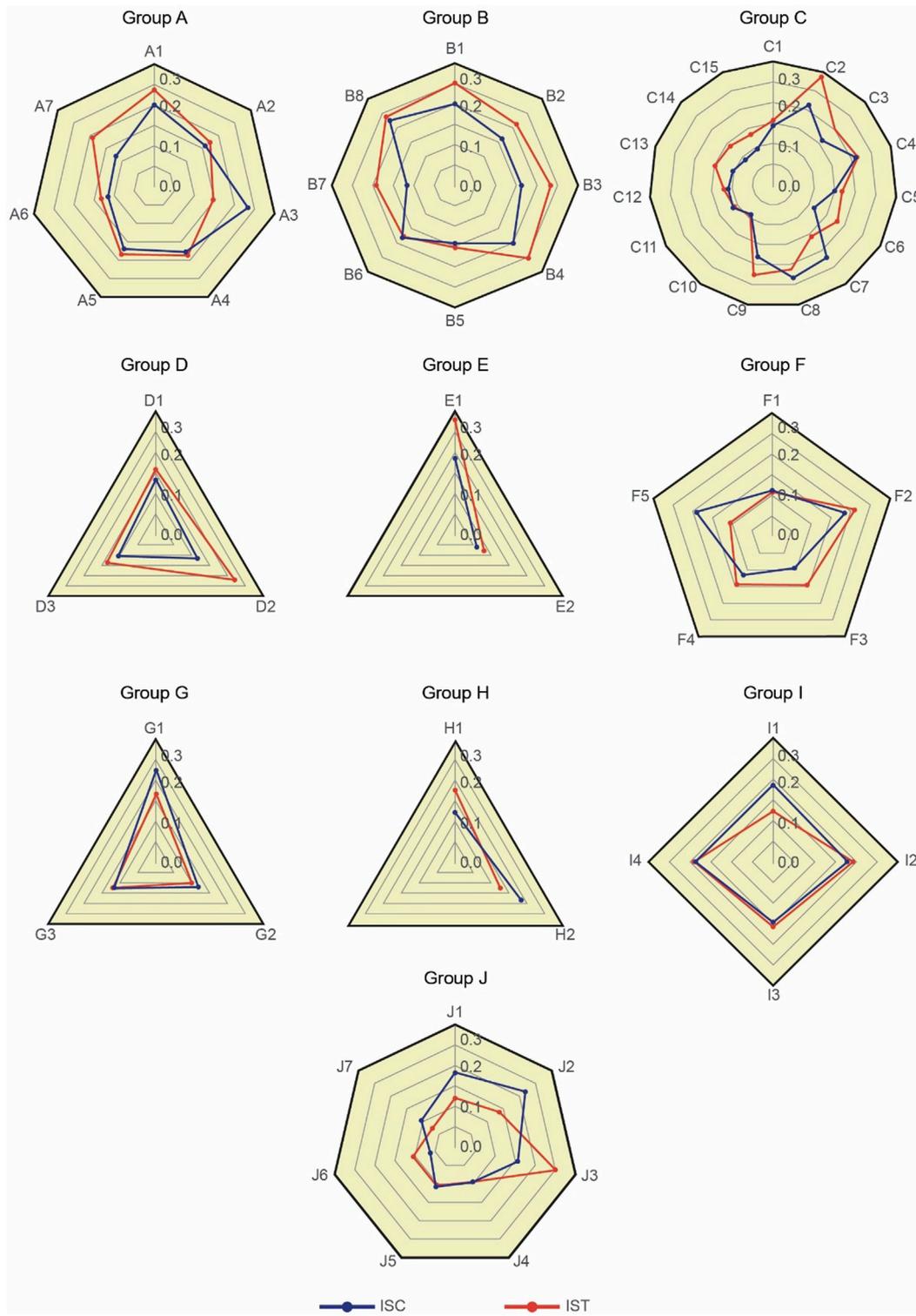
FIGURE 3
Comparison of the risk significance indexes according to the risk factors groups indicated in Table 4.

this information, the tools or techniques known or used to manage risks were also asked. From the respondents who answered "sometimes," 36% did not know any tool, whereas 64% knew

some tool. From the respondents who answered "almost always," 25% did not know any tool, whereas 75% knew some tool. The tools and techniques mentioned by the participants and related to this

FIGURE 4
Correlation matrix among the risk factors according to the cost significance index.
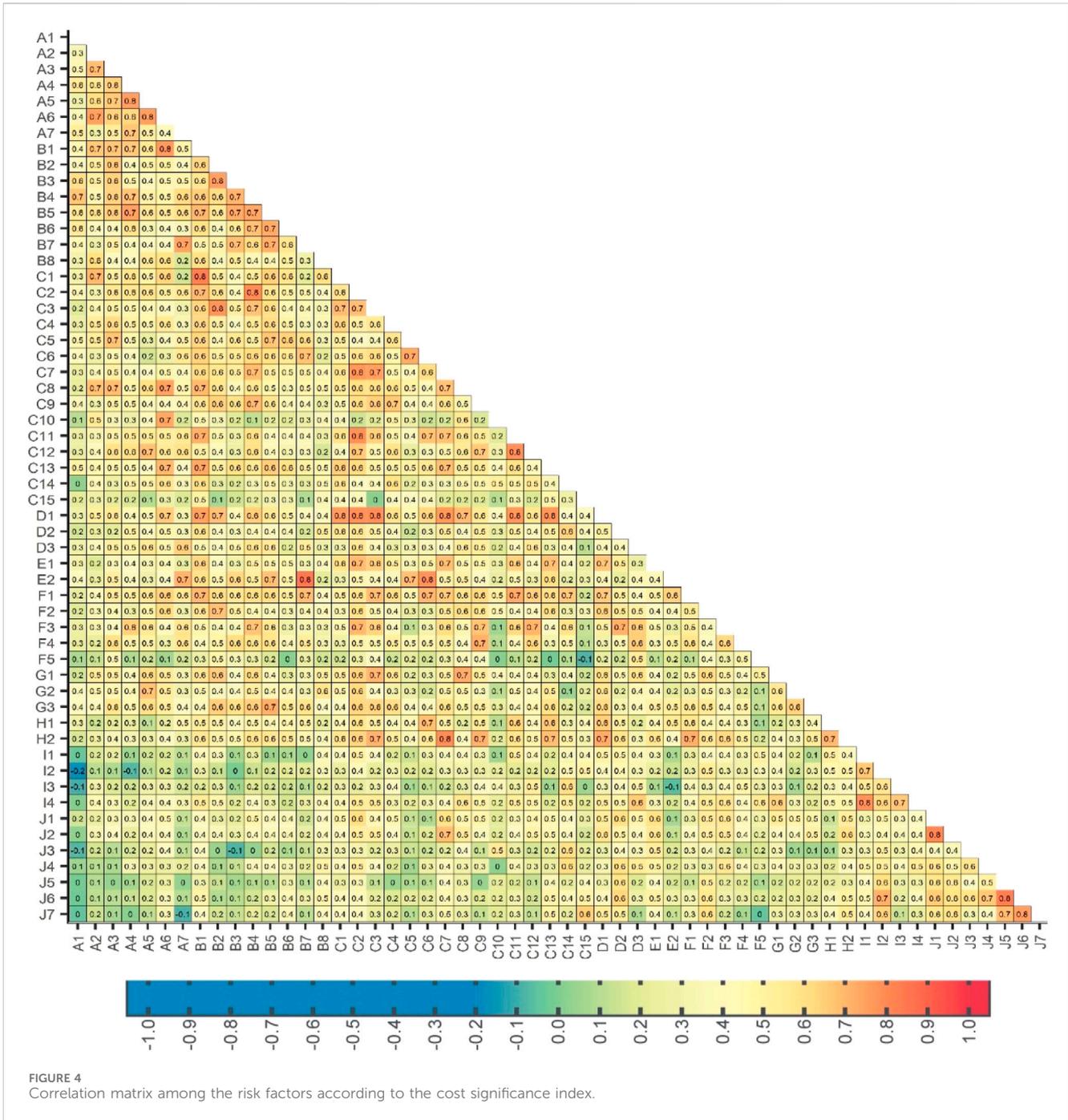
research were as follows: (i) risk matrix, (ii) risk indicators, (iii) the ISO 31000 standard, (iv) the model analysis of failures and effects, (v) @Risk, (vi) Montecarlo, (vii) past experience analysis, (viii) Moday.com, and (ix) flow graph of processes and questionnaires.

Ferreira (2015) analysed the frequency of using the risk record in the public projects in the Dominican Republic. In their survey, 50% of participants answered that they had "never" used this tool, 20% "sometimes," 3% "almost always", and anyone answered "always." By comparing these results with the results obtained in our survey, it is seen that the use of risk management in the country has increased. However, risk assessment should be more studied, focusing on security, labour, and quality management risks.

5 Conclusion

This research is focused on cost and time deviations in projects, which are among the main problems of the building sector. Given their importance, risks should be assessed in all projects, and risk management is a key tool. These techniques are very beneficial; however, the results confirmed that they are scarcely used in the Dominican Republic: only 19.5% of the respondents usually use risk management tools and methodologies. Unfortunately, culture on identifying and assessing risks in the country is poor. On the other hand, the collected information indicate that most risks managed are financing risks or those related to labour security.
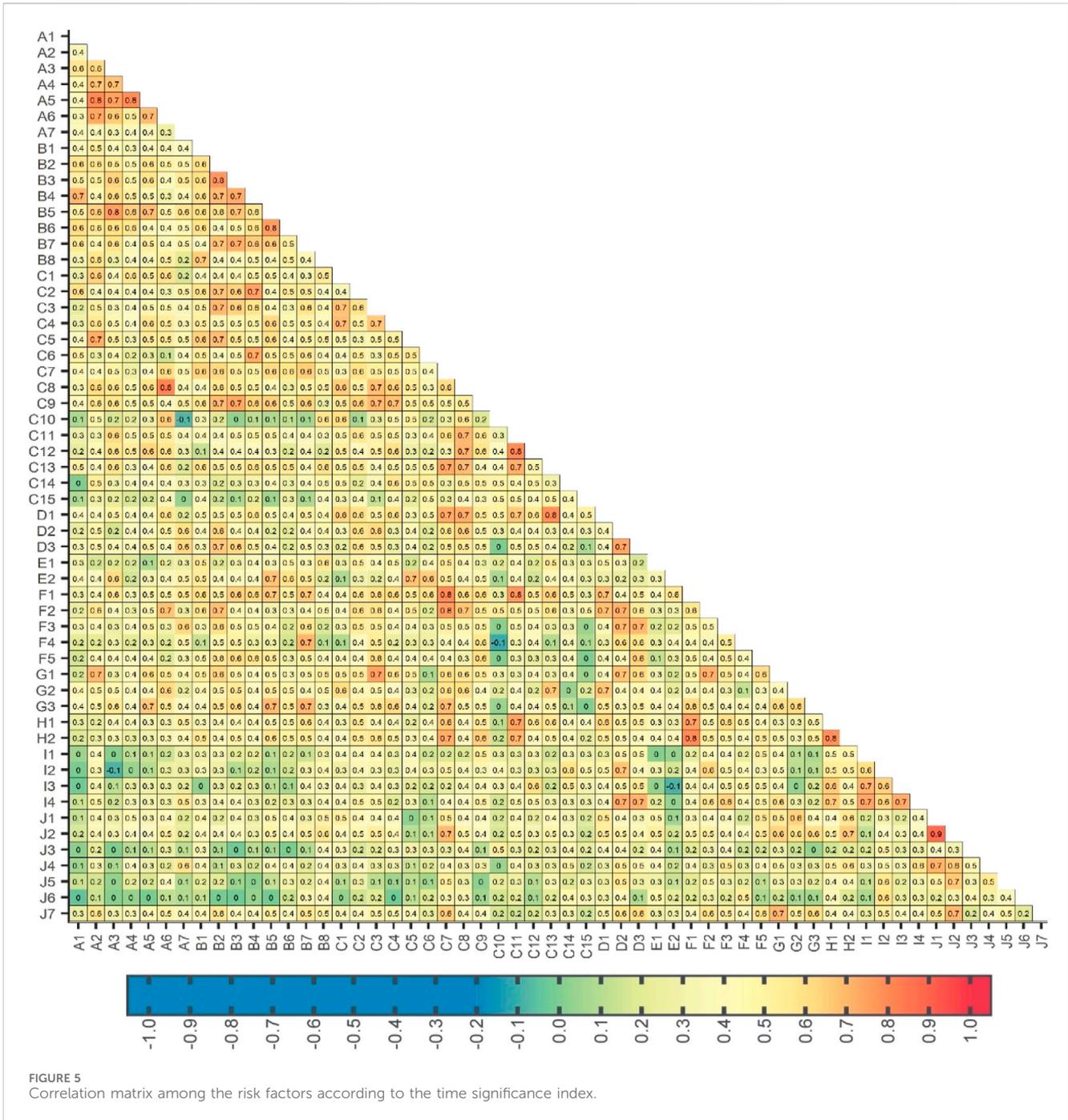
FIGURE 5
Correlation matrix among the risk factors according to the time significance index.

TABLE 7 Risk factors with a stronger correlation.

Cost goal	Correlation coefficient
B1: Tight schedule - C1: Contractors' poor management ability	0.83
B7: Slow decision-making on the part of the client - E2: Standard changes	0.85
J5: Unstable economic situation - J6: Disputes with the residents' association	0.83
Time goal	
J1: Inflation- J2: Exchange rates	0.88
A6: Lack of experience of the design team - C8: Work performance errors	0.81

TABLE 8 The severest risk factors (cost goal) according to both the project phases and the interested parties.

	Viability	Design	Construction
Designers		**A1**, A3	
Clients		**B1**, **B8**	**B4**
Contractors			**C2**, **C4**, C7, **C8**
Subcontractors/Suppliers			
Government			
Materials and equipment			F5
Contract	G1		
Administration			
Project nature			I4
External		J2	

TABLE 9 The severest risk factors (time goal) according to both the project phases and the interested parties.

	Viability	Design	Construction
Designers		**A1**	
Clients	B2	**B1**, **B8**	B3, **B4**
Contractors			**C2**, **C4**, **C8**, C9
Subcontractors/Suppliers			D2
Government	E1		
jMaterials and equipment			F2
Contract			
Administration			
Project nature			
External			J3

The indexes marked by the participants show the serious risk factors: the factors related to the design variations and the variations by the client, tight project schedule and offer preparation, the deficiencies in the performance of construction works and their programming, and the lack of skilled labour. These results are similar to the key factors mentioned by various studies. The study by Zou et al. (2007) was conducted in China and also added financing problems. Regardless of the similarities in the serious factors, all factors included in the list present a significant interest. Most of them reach high and moderate severity levels, according to the participants. For the cost goal, 14.3% represents the high level, and 82.1% the moderate level, whereas for the time goal, the percentages are 25% and 73.3%, respectively. In addition, there is a greater perception of the risk for the time goal than for the cost goal. In addition, the factors with a low level did not achieve 4% in any of the two cases. Identifying all these risk factors contributes to creating links with the improvement of results in construction projects in the Dominican Republic. Evaluations of experts participating in the research coexist with the problems of construction projects in the country, as this is their field of work. Therefore, this compilation of lessons learnt must contribute

especially to the development of one of the processes in project management: the management of the knowledge generated during the development of the project. Specifically, for the collection, recording, and dissemination of these lessons learnt. They are expected to be put into practice in the construction sector in the country.

The Pearson correlation coefficient determined a strong-moderate correlation for both goals in around 52% of the factors. The factors with a strong correlation are as follows: (i) slow decision-making on the part of the client - standard changes, (ii) tight project schedule - contractors' poor management ability, (iii) unstable economic situation - disputes with the residents' association, and (iv) inflation - exchange rates.

Regarding the risk sources, around 70% of the serious factors are caused by the contractor, the client, and designers in both goals. These results could be expected, as they are the stakeholders that have the greatest capacity to intervene in the development of the project. However, despite what is expected, it is necessary to confirm these assumptions scientifically for the geographical context analysed, the Dominican Republic. Not in vain, this country has been one of the economies in Latin America where the greatest growth has been experienced recently. We must take into account that each geographical context has its specific risks and these are the ones that have been identified in the research. In the same sense, the results of the work show that, for the cost objective, the contractor is the greatest source of risk with 30.8% of the most critical factors and for the time objective the client with 35.7%. On the other hand, the most susceptible phase to the risks in the life cycle of the project is the construction phase. Most of the risks identified take place in this phase, as well as most of those considered serious.

The assessments of the professional profiles are assessed, and it is determined that the respondents disagree on the risk level of the various factors. The reason could be the diversity of work area in which participants are involved. Osipova and Eriksson (2013) points out that the use of expert assessments within this risk management process implies different perceptions, since each group of actors may have their own vision of the importance of the risks. The Pearson correlation coefficient is also used for this analysis. The results indicate the greatest consensus on the severity of the risk factors in both goals, between contractors/subcontractors and supervisors, whose correlation is strong. The greatest disagreement, in this case for the cost goal, is between project managers and designers. Thus, it can be deduced that those working in a construction work have a similar perception of the risk, differing from those working in offices.

Finally, we must indicate that this work has been based on the evaluations of a selection of professionals with experience and knowledge of the construction sector in the Dominican Republic. However, these conclusions must be reported with some caution due to the possibility that the assessments of these experts may not represent the general opinions of the country. Regardless of this issue, this research shows that methodologies and plans should be established to identify and assess risks, so that the interested parties of the project could know the risks and face them appropriately to achieve their goals. It also aims to foster their use and to remove the gap between the theory and the practice of risk management in the building sector. This work continues the research line on the identification and analysis of risk factors in various territorial

contexts. Further studies could be focused on other territories, particularly in the Dominican Republic, to verify the expected increase in using risk management techniques in construction projects.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

PF-V: Writing–review and editing, Writing–original draft, Methodology, Investigation, Formal Analysis, Conceptualization. CU-E: Writing–review and editing, Methodology, Investigation, Formal Analysis, Data curation, Conceptualization. JM: Writing–review and editing, Validation. DB-H: Writing–review and editing, Validation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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