Risk Analysis in Private Building Projects: A Pilot Study in Chile

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Abstract A proper identification, assessment, and allocation of risks are essential for reducing the likelihood of time and cost overruns. Aiming for lowering the overall cost of claims and disputes, this study aims for the identification, assessment, and allocation of the risks in private building projects in Chile. Based on a thorough examination of the literature, reveals 104 risks that are organized into four categories and eleven subcategories. The allocation, probability, and impact of these risk variables were estimated by experts consulted through questionnaires. Results show that delays in approval/permits, delays in decision-making, poor design, equipment problems, planning deficiencies, poorly trained skilled labor, unclear contract clauses and conditions, late design changes, competition, resource availability, and unrealistic baseline scheduling are the top-ranked risk factors. The study's respondents' recommendations regarding the risk allocation were compared with the contractual risk allocation in the projects analyzed unraveling that over 50% of the most critical risks had disparities between contractual allocation and respondents' recommendations. The study's findings are useful for assisting practitioners in allocating risks to those stakeholders who are better equipped to evaluate, manage, and control those risks. The risks can be prioritized for response planning using the generated risk priority.

Keywords Risk identification · Risk assessment · Risk allocation · Project success factors · From global to local

1 Introduction

The development of architectural and engineering projects generates significant contributions to the economic growth of all the countries around the world. However,

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the complexity of these projects and their increasingly uncertain environments may jeopardize their quality, budget, and time performance [1]. Moreover, the poor performance and recurrent conflict between the contractor and client in these projects frequently are linked to flaws in the risk assessment and allocation [2].

Numerous risks and conflicting relationships exist between contractors and owners throughout construction projects, which typically result in disputes initiated by either party. These conflicts frequently are disruptive, expensive, and time-consuming particularly when they are not solved quickly and escalate to official resolution by a tribunal or a court [3–6].

The construction sector is constantly looking for more effective and efficient dispute resolution mechanisms, such as alternative dispute resolution techniques like adjudication, mediation, conciliation, and other hybrid procedures that are popular and well-liked in the building sector [7]. However, these methods are expensive and, frequently, ineffective in resolving disagreements [8]. Furthermore, the majority of alternative dispute resolution techniques for avoiding litigation and arbitration are not legally binding on the parties until the dispute is finally settled by the end of the project [3].

The allocation of risks involves their transfer via contractual provisions from one party to another [9]. Fair risk allocation is a practical method for preventing expensive disagreements [2, 10]. In effect, unclear risk allocation in building contracts is one of the main causes of disputes [11, 12]. Proper risk management and allocation in building projects require a careful development of contractual governance mechanisms reflected in risk allocation and control [13–16]. For this reason, the identification and understanding of risks should be prioritized in the early phases of the project to limit potential negative consequences of them [17].

Project Management researchers have developed countless papers focused on risk allocation of public work projects [16, 18–25]. Their preference for these projects is due to the availability of public databases with the information required. However, there is a remaining gap in non-public projects because of the lack of transparency on this information, as reported in the literature [26, 27]. Moreover, the construction sector has been the subject of risk assessment research by a number of academics in regions around the world, such as North America, East Asia, and Europe rather than medium size developing countries located in some other regions. To address the aforementioned gap, this study aims for analyzing the risk factors in the Chilean private building construction sector.

2 Background

2.1 Risk Quantification

The Project Management Body of Knowledge (PMBoK) establishes that risks are chance events that may negatively or positively affect the objectives of the project

[28]. Risk is inevitable considering the inherent uncertainty associated with every human action [29]. Considering the frequency and influence of risks on project objectives, decision-makers should conduct risk quantification.

One of the first quantification models proposed was developed by Daniel Bernoulli almost 300 years ago and was focused on the calculation of the utility of weighted averages for the potential outcomes based on an uncertain scenario [1]. This model became the standard reference for two hundred years until the mid-1900s when Neumann and Morgenstern proposed the probability-weighted average of a single utility of combined outcomes but of the utilities of all outcomes [30].

Nowadays, the Expected Utility Theory has become the most widely accepted model to quantify risks. Under this theory, the PI model establishes the estimation of a risk event as the multiplication of its impact (I) and the probability of occurrence (P).

2.2 Risk Assessment and Identification

The implementation of risk management is impeded by insufficient resources, insufficient experienced staff, and scarce time for implementation [8]. Cost overruns and time delays are the main reasons for disputes [31, 32]. Moreover, the biggest influence on construction time and cost is financial risk, which is typically correlated with a lack of financial resources, cash flow issues, and claims due to payment delays [33–37]. Construction time and cost also demonstrated being susceptible to specific features such as delayed modular component deliveries, disruptions in the supply chain, capital cost increases, management complexity, environmental sustainability, and stakeholder fragmentation [38–42].

From the perspective of the contractor, construction risk factors include decreased productivity, uncertain ground conditions, ambiguous specifications, and varying construction standards [43, 44]. Additionally, contract-based analyses have identified key risk factors: change in design, design error, unclear clauses and conditions, inflation, Currency exchange rate fluctuations, corruption, and public opposition to projects [8, 45]. However, it is required to complement risk identification with quantification to offer value for project managers and improve risk management.

3 Methodology

3.1 Risk Identification

The methodological process started by identifying the construction projects' risk factors. This identification process was focused not only on a list of potential risks

Table 1 Procurement Risks

Category	Subcategory	Risk
Procurement	*Management*	*Planning deficiencies*
		Site acquisition
	Environmental	*Environmental Impacts*
	Contracting	*Tender delay*
		Approvals delay
	Financial	*Funding*
	Institutional	*Environmental approvals*
	Project Site	*Access and rights*
		Unforeseen Underground Structures
		Connections to the site
		Ground conditions
		Easements

but also on a taxonomy to classify them into specific risk categories, as recommended in risk literature [46–48].

Based on a literature review process, 137 risks were identified initially. Risks unrelated to lump-sum contracts were discarded. After this filtering process, a list of 104 risks was reached as shown in Tables 1, 2, 3 and 4, which is consistent with previous risk identification [8, 49].

The risk taxonomy considered three hierarchies. The first is the category that is closely related to the project phase, namely: procurement, design, construction,

Table 2 Design Risks

Category	Subcategory	Risk
Design	*Management*	*Corruption*
		Delays in the approval of suppliers
	Institutional	*Delay in approval/permits*
		Change in law
	Liaison	*Construction Standards*
		Measure Standards
		Information Accessibility
		Client's expectations
	Relational	*Design coordination*
	Technical	*Poor design*
		Changes
		Complexity
		Design delivery delay
		Unexperienced designer

Table 3 Construction Risks (*Short version*)

Category	Subcategory	Risk
Construction	*Management*	*Resources availability*
		Improper risk monitoring
		Delays in decision-making
		Owner's management issues
		Subcontractor
		Suspension of works
		Construction monitoring issues
		Construction initiation delay
		Fast-track costs
	Environmental	*Weather conditions*
		Pollution due to construction works
	Contracting	*Unclear contract clauses*
		Supervision delays
		Unrealistic baseline scheduling
		Contract omissions
		Lack of experience
		Subcontractors issues
		*Competition*ara>
		Opportunistic behavior
		Litigation
		Unclear contract clauses and conditions

Table 4 Transfer Risks

Category	Subcategory	Risk
Transfer	*Management*	*Conformity inspections delay*

and transfer. Then, the subcategory focused on the risk type such as environmental, management, institutional, liaison, relational, technical, and contracting.

In summary, procurement risks entail six subcategories and twelve risks (Table 1), design risks are made of five subcategories and fourteen risks (Table 2), construction risk is disaggregated into thirteen subcategories and 76 risks (Table 3), and transfer risk related to one single risk and subcategory (Table 4).

3.2 Projects' Data Collection

For this pilot study, Chilean projects were selected. In general, all the projects are lump sum contracts for high-rise residential buildings, 83% of the projects are Design-Bid-Build, and 17% Design-Build.

3.3 Risk Quantification

For this pilot study, an exploratory analysis was conducted based on questionnaires with various experts. The questionnaire's respondents included representatives from the owner (37%) and the contractor (63%). The respondents were filtered to exclude practitioners with less than three years of working experience and avoid the least experienced and qualified practitioners.

The questionnaire started by asking for respondents' general information. Then, the severity (impact) and probability of occurrence of each of the risk factors were requested using a Likert scale, where five (5) and one (1) mean very high and very low, respectively. Finally, the allocation of each risk factor was asked, giving the options of the contractor, owner, or shared, as recommended by risk literature [8].

The risk factor was computed based on the associated risk impact and risk probability as follows:

$$\text{Risk Factor} = \text{Risk Impact} * \text{Risk Probability} \tag{1}$$

Consequently, for a respondent that assesses a low (=2) probability and high (=4) impact of a certain risk, the Risk Factor is eight (8).

3.4 Risk Allocation

The contractual documents of each project were analyzed through a content analysis for identifying the risk allocation. This analysis technique allows for replicability in the inferences through the coding and interpretation of text [46, 50–53].

A risk allocation rubric was developed for the analysis of the contractual documents, as recommended in risk allocation studies [54]. Then, the risk allocation was filled in the form based on the content analysis of the contractual documents.

The respondents were also asked for their recommendations regarding the risk allocation for each of the risks. This allows for contrasting the real risk allocation with the experts' perspectives.

3.5 Validation

To evaluate the consistency and reliability of the questionnaire, Cronbach's Alpha Coefficient was calculated as follows:

$$\alpha = \frac{K}{K-1} \times \left(1 - \frac{\sum Vi}{Vi}\right) \quad (2)$$

where α is Cronbach's Alpha Coefficient, *K* is the number of risk factors in the questionnaire, *Vi* is the variance of risk *i*, and *Vt* is the total variance. According to the extant literature, when this coefficient exceeds 70%, the questionnaire may be considered reliable [8].

4 Findings and Discussion

The reliability and consistency of the questionnaires were confirmed based on Cronbach's Alpha values over 0.95. Based on the data gathered in the questionnaires, the Risk Impact was calculated. The most critical risks according to the Risk Impact (>20) are shown in Table 5.

Although design risks only represent around 10% of the risks analyzed in this study, 20% of the most critical risks were related to design issues. The first and third risks are within the design category, namely: "delay in approval/permits and "poor design." In effect, a significant proportion of the risks may not necessarily affect the critical path of the project and, consequently, will not affect the project duration; "delay in approval/permits" undoubtedly affect the critical path of the project and, consequently, the project duration. Additionally, previous literature has

Table 5 Most critical risks

Rank	Risk	Category	Subcategory
1	*Delay in approval/permits*	*Design*	*Institutional*
2	*Delays in decision-making*	*Construction*	*Management*
3	*Poor design*	*Design*	*Technical*
4	*Equipment problems*	*Construction*	*Execution*
5	*Planning deficiencies*	*Procurement*	*Management*
6	*Poorly trained skilled labor*	*Construction*	*Execution*
7	*Unclear contract clauses and conditions*	*Construction*	*Contracting*
8	*Late design changes*	*Construction*	*Technical*
9	*Competition*	*Construction*	*Contracting*
10	*Resources availability*	*Construction*	*Management*
11	*Unrealistic baseline scheduling*	*Construction*	*Contracting*

emphasized the common practice of owners to impose tight schedules for the delivery of the drawing and design that could be in some cases unrealistic [8]. Moreover, "poor design" may also have significant detrimental effects on the quality, cost, and time performance of the project. Additionally, there is one single critical risk within the procurement category, namely, "planning deficiencies." In effect, project management literature has emphasized the relevance of planning processes in order to establish a proper scope and accurate budget and schedule [55].

Conversely, eight out of the eleven critical risks within the construction category, namely: "delays in decision-making", "equipment problems", "poorly trained skilled labor", "unclear contract clauses and conditions", "late design changes", "competition", "resources availability", and "unrealistic baseline scheduling." Overall, the insufficient time and untimely efforts devoted by the owner in the planning along with organizational issues may result in delays triggered by the owner affecting the time for key decisions, lack of clarity in the contract clauses, late design changes (and their consequent cost and time overruns), and unrealistic schedule.

4.1 Risk Allocation

An essential aspect of risk management is risk allocation, which is the practice of allocating risks to the most appropriate contracting party. The importance of assigning risk to the party that can manage it the best is that a suboptimal risk allocation is likely to result in controversies, drive up costs, and significant delays.

The allocation of the risks was analyzed in both the contractual documents and according to the experts' criteria. For the analysis of questionnaires, this study adopted the literature's recommendation to assign each risk to the party when there is more than 50% of respondents agree to allocate that risk to it [8, 56]. Conversely, risks that have a threshold of less than 50% are classified as "non-decided."

The allocation recommended for each critical risk in this study is shown in Table 6. There are only four risk factors listed that should ideally be allocated to the owner: "Delays in decision-making"; "Poor design"; "Unclear contract clauses and conditions"; and "Late design changes". Most of these risks (60%) belong to the construction category and the remaining 40% to the design. Evidently, these risks entail untimely decisions of the owner that will impact the project outcomes so as poor contractual documents and design (for DBB projects).

Conversely, Table 6 shows that five risk factors are assigned to contractors. These risks are "Equipment Problems", "Planning deficiencies", "Poorly trained skilled labor", "Competition", and "Resources availability". Most of these risks (80%) belong to the construction category and the remaining 20% to the procurement category. This pattern is closely related to general practice for allocating construction risks to the contractor.

The remaining two critical risks ("Delay in approval/permits" and "Unrealistic baseline schedule") were recommended to be shared.

Table 6 Experts' recommendation for risk allocation for the most critical risks

Rank	Risk	Contractor (%)	Owner (%)	Shared (%)	Allocation
1	*Delay in approval/permits*	*0*	*50*	*50*	*Shared*
2	*Delays in decision-making*	*12.5*	*50*	*37.5*	*Owner*
3	*Poor design*	*0*	*87.5*	*12.5*	*Owner*
4	*Equipment problems*	*62.5*	*12.5*	*25*	*Contractor*
5	*Planning deficiencies*	*62.5*	*12.5*	*25*	*Contractor*
6	*Poorly trained skilled labor*	*100*	*0*	*0*	*Contractor*
7	*Unclear contract clauses and conditions*	*12.5*	*87.5*	*0*	*Owner*
8	*Late design changes*	*12.5*	*87.5*	*0*	*Owner*
9	*Competition*	*62.5*	*25*	*12.5*	*Contractor*
10	*Resources availability*	*75*	*12.5*	*12.5*	*Contractor*
11	*Unrealistic baseline scheduling*	*25*	*25*	*50*	*Shared*

A comparison between the contractual risk allocation in the Chilean contracts analyzed and the recommendations made by experts is shown in Table 7. Interestingly, almost 50% of the most critical risks presented discrepancies between contractual allocation and what respondents have recommended, as seen in the table. These differences and ambiguities in risk allocation could lead to recurrent claims and conflicts.

Table 7 Risk allocation in the contractual documents vs. experts' recommendation

Rank	Risk	Contractual Allocation	Allocation Suggested
1	*Delay in approval/permits*	*Contractor*	*Shared*
2	*Delays in decision-making*	*Owner*	*Owner*
3	*Poor design*	*Shared*	*Owner*
4	*Equipment problems*	*Contractor*	*Contractor*
5	*Planning deficiencies*	*Contractor*	*Contractor*
6	*Poorly trained skilled labor*	*Contractor*	*Contractor*
7	*Unclear contract clauses and conditions*	*Contractor*	*Owner*
8	*Late design changes*	*Shared*	*Owner*
9	*Competition*	*Contractor*	*Contractor*
10	*Resources availability*	*Contractor*	*Contractor*
11	*Unrealistic baseline scheduling*	*Contractor*	*Shared*

5 Conclusions

The findings show that the assessed risks' impact and probability on the project's goal were moderate on average. In effect, only 11% (11 out of the 104) risks analyzed were critical and 17% of the risks were significant. Conversely, 36% of the risks were moderated, and 30% minor.

Although only around 10% of the risks examined in this study were design risks, 20% of the most critical risks included design-related difficulties. In practice, design risks undoubtedly affect the critical path of the project and, as a result, the project duration. Within the procurement category, there is only one single major risk, which indicates the need for planning procedures in order to establish an appropriate scope, precise budget, and reliable timetable.

Contrarily, eight out of the eleven significant risks in the construction category fall into the category of critical risks, It illustrates how organizational problems, combined with the owner's inadequate planning efforts and timing, can lead to mistakes in the scope, budget, and schedule definition.

Both the contractual papers and the recommendations established by the experts were used to examine how the risks were allocated. There are only four significant risks that pertain to the construction and design categories and should ideally be assigned to the owner.

Contrarily, five critical risks are allocated to contractors in the construction category, while the remaining are allocated to the procurement category, This is very similar to the custom of transferring construction risk to the contractor. It was suggested that only two critical risks be disclosed.

It was found that over 50% of the most critical risks had disparities between contractual allocation and what respondents suggested. These discrepancies and ambiguities in risk allocation may give rise to repeated disputes and claims.

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