Power System Protection and Control
ISSN:1674-3415

RISK MANAGEMENT IN RESIDENTIAL CONSTRUCTION PROJECTS: A COMPARATIVE DYNAMIC ASSESSMENT

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Received:15 February 2025 **Revised**:18 March 2025 **Accepted**: 8 April 2025

***ABSTRACT*:**

Residential building project risks are intrinsic in nature and have the potential to affect project finance, schedules, quality, and stakeholder satisfaction substantially. On the basis of a systematic questionnaire-based survey, this study investigates and categorizes risk variables affecting residential building in India. Statistical methods like exploratory factor analysis (EFA), reliability analysis, and non-parametric comparison analysis (Kruskal-Wallis test) were applied to assess opinions across different stakeholder groups. Sixteen heterogeneous risk factors were identified, which collectively explained over 74% of the variance. The findings indicate considerable variations in stakeholder perceptions, which underscore the necessity for risk reduction strategies for individual stakeholders. Besides providing a data-driven solution for enhancing residential building project outcomes in emerging countries, this research enhances the comprehension of dynamic risk classification. The questionnaire has been validated by three civil experts.

Keywords: *Residential Construction, Risk Management, Factor Analysis, Kruskal-Wallis, SPSS, India, Stakeholder Perception*

1. INTRODUCTION

Given the rapidly urbanizing population within India, residential construction plays a vital role in meeting housing demands. Residential construction is a complex process with many uncertainties since it is exposed to irregular market forces, regulatory schemes, weather, and various stakeholder interests. Residential project risk management is necessary because small errors or outside intervention can lead to delays, ballooning budgets, and compromise on quality. Residential projects have fewer budget jumps and project schedule cushions than commercial or industrial construction. Lack of skilled labor, changing weather conditions, and shifting government regulations also contribute to these uncertainties, particularly in growing economies like India **[14][9][20]**.

The Indian residential building industry is dominated by a large number of small and medium-sized developers and contractors who may not have formal risk management processes. In such a scenario, risks such as material delivery delays, regulatory updates, cost overruns, and stakeholder miscommunication are not only prevalent but also highly critical. Identification, estimation, and planned mitigation of risks in the early stages become critical for effective project delivery. Further, construction risk is not evenly experienced; different stakeholders such as engineers, contractors, and project managers perceive and prioritize risks differently depending on their role, responsibility, and exposure to operational concerns. Even as these issues are pressing, there is a significant gap in localized, data-driven research on residential construction risk in India. Although international risk management models like ISO 31000 provide generic guidelines **[13]**, they are not customized to the Indian context and barely take into account the nuanced views of various stakeholders. This study attempts to fill this gap by using strong statistical tools such as Exploratory Factor Analysis (EFA) and the Kruskal-Wallis test to identify, group, and contrast risk factors perceived across stakeholder groups. In the course of doing so, it attempts not only to improve the understanding of risk behaviors in residential construction but also to offer actionable insights to policymakers, engineers, and project managers to create customized, stakeholder-centric risk mitigation strategies **[19]**.

DOI: 10.46121/pspc.53.2.15

Power System Protection and Control
ISSN:1674-3415

2. AIM, OBJECTIVES, AND SCOPE

Aim:
To apply statistical examination and empirical information to research, classify, and compare major risk factors of Gujarat residential building projects.

Objectives:
• In order to categorize and ascertain the major hazards affecting residential building.
• To evaluate the validity of measurement instruments for risk perception.
• To apply exploratory factor analysis in determining underlying risk factors.
• To compare how stakeholders view risks with the Kruskal-Wallis test.
• To offer tailored risk-reduction methods for each stakeholder group.

Scope:
Residential development projects in the Indian context are being researched. The research discusses some of the risk factors such as labor problems, financial, regulatory, material, scheduling, technology, and environmental risks. Some of the respondents include project managers, engineers, and contractors.

3. LITERATURE REVIEW

Construction projects have for long been associated with a high degree of uncertainty due to their complexity and especially their dependence on both internal organizational factors and external environmental variables. It has been put in the literature that construction risks can be classically divided into two main categories, namely internal risks such as design flaws, labor shortages, procurement issues, and so forth, and external risks like change of policy, natural disasters, and socioeconomic disturbances **[20]**. These aforementioned risks, if not managed proactively, would cause a chain reaction of adverse incidences on the cost, quality, and time of construction projects. While several risk management frameworks have been developed internationally, the ISO 31000 is considered the main reference for risk identification, evaluation, and mitigation **[13]**.

Research studies have maintained the view that comprehensive risk assessment and stakeholder engagement are paramount to the success of project management. For example, Choudhry and Iqbal **[5]** and Chileshe and Kikwasi **[6]** have argued about the need for risk management systems to be incorporated in all stages of project planning and execution. In these studies, it is reported that risk management frameworks do exist but are seldom applied in practice, particularly within developing countries because of resource constraints, lack of awareness, and institutional inertia. Other studies have shown that different stakeholders define risk according to their respective roles. In other words, to a contractor, logistics and financial issues may be paramount, while an engineer may be more concerned with technical and safety issues **[12]**.

However, the literature undeniably shows a lack of comparative statistical approaches genuinely addressing stakeholder-specific perceptions of risk. Majority of the aforementioned publications have been based on qualitative evaluations or generalized surveys that tended to overlook the heterogeneity in their views. According to Zou et al. **[20]**, this sort of generalization can misalign or render futile risk mitigation strategies. Amongst recent calls being made are the need to adopt analytical approaches, notably Exploratory Factor Analysis (EFA), and non-parametric tests like the Kruskal-Wallis H test, which succinctly capture the complexity and diversity of stakeholder views **[10] [18]**. This methodological vacuum therefore provides an avenue for significant contribution for this study. By applying these methods to primary data collected in the major residential construction stakeholders of Gujarat, the current study develops the understanding of the dynamic risk classifications in the regional context, giving a data basis for strategic planning in risk-sensitive domains.

3. RESEARCH METHODOLOGY

1. Data Collection

215 participants from all over Gujarat were given a standardized 36 Likert-scale question item questionnaire (Strongly Disagree = 1 to Strongly Agree = 5). 30% were contractors, 40% were engineers, and 30% were project managers.

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ISSN:1674-3415

2. Data Analysis Tools

The following activities were performed on (2)SPSS:
• Exploratory Factor Analysis (Principal Component Analysis with Varimax rotation)
• Reliability Analysis (Cronbach's Alpha)
• Kruskal-Wallis H test for comparison of non-parametric groups

4. DATA ANALYSIS AND RESULTS

1. Descriptive Statistics

Table 1 summarizes the central tendency and spread of responses:

Risk Factor	Mean	Std. Dev
Change in government regulations	3.45	1.14
Delay in material delivery	4.02	0.87
Unsuitable technology adoption	3.78	1.03
Material price volatility	4.15	0.74
Resource availability fluctuation	3.88	0.91

2. Reliability Analysis

Initial Cronbach's Alpha: 0.353 → suggests dimensional reduction. Items were clustered through factor analysis to improve internal consistency.

3. Exploratory Factor Analysis (EFA)

KMO = 0.704 → sampling adequacy is sufficient
Bartlett's Test of Sphericity $p < 0.001$ → factorable data
16 factors extracted, accounting for 74.126% of the variance

Table 2: Sample from Rotated Component Matrix

Item	Factor 1	Factor 2	Factor 3	...	Factor 16
Government Regulations	0.812				
Material Delivery Delay	0.794				
Unsuitable Tech	0.722				
...	...	...	...	...	...

(*Full matrix provided in Appendix A*)

4. Kruskal-Wallis Test Results

Significant differences ($p < 0.05$) noted between groups:
• Contractors: targeted supply chain and financial risks
• Engineers: prioritized design, quality, and safety hazards
• Project Managers: focused on scheduling, labor, and communication.

5. Graphical Summary

Charts showing risk ratings and distribution of stakeholders were prepared to represent the data visually.
• Pie Chart: Response of respondents divided into stakeholder groups (30% Contractors, 40% Engineers, and 30% Project Managers)
• Bar Chart: Contrast of severity ratings of the top 5 risk factors among stakeholder groups

5. DISCUSSION

A thorough risk dynamics analysis of Indian residential construction is provided through the classification of hazards into 16 rational factors. Differences between stakeholders in their perceptions underscore the necessity for localized risk management. The low initial dependability was well addressed by employing factor analysis, which reconstructed the factors in more significant groups **[10]**.

These findings complement research by Zou et al. (2007) that seeks to compare risk prioritization variation between professional careers **[20]**. Such research contributes strength to the argument for stakeholder-specific risk policy and training **[12]**.

6. CONCLUSION AND RECOMMENDATIONS

Conclusion:
• The risk of residential construction is role-dependent and complicated.
• EFA increased reliability by allowing better risk classification.
The Kruskal-Wallis test also affirmed that there were differences based on the occupation.

Recommendations:
Create risk reduction measures tailored to each stakeholder. Conduct preliminary financial and design risk analysis. Use electronic technologies to track risks in real time. Make stakeholder communication processes more accurate.

7. LIMITATIONS AND FUTURE SCOPE

• Suggested application of Structural Equation Modeling (SEM) to enable more in-depth causal analysis; attitudes will shift; longitudinal risk patterns must be explored in future studies; and geographical restriction to the Indian residential market **[4]**.

APPENDICES

Appendix A: Full Rotated Component Matrix

Rotated Component Matrix

	Component															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
How likely are changes in government regulations to impact your project?	.674	.077	-.009	.034	.020	-.072	-.222	-.172	-.022	-.162	.073	.120	.040	.152	.058	.049
How severe would the impact of delayed materials be?	.507	-.135	-.004	.151	.043	.183	.050	-.005	-.013	.039	-.236	-.097	-.194	-.059	-.134	.119
What is the likelihood of adopting unsuitable construction technologies?	.424	.048	-.129	-.196	.213	.045	-.135	.060	.373	.126	-.106	.147	.079	.038	.015	-.336
Rate the risk of price volatility in key materials (e.g., steel, cement).	.420	.262	-.053	-.149	.242	.164	.288	.276	.115	.082	-.067	-.116	.114	-.097	-.179	.005
What is the likelihood of community opposition to your project?	.007	.784	.007	.082	-.112	.159	.028	.018	-.041	.075	.089	-.077	-.007	-.054	.071	-.051
How frequently do you encounter worker skill mismatches?	-.007	.584	.011	-.115	.162	-.398	-.109	-.023	.038	-.274	.109	.108	-.051	.107	-.079	.061

How significant would the impact of weather delays be?	-.066	.085	.743	-.076	.001	.015	.071	-.125	-.092	-.039	.152	-.063	-.099	-.119	-.107	-.032
How significant would the impact of budget overrun be?	.061	-.159	.601	-.085	.108	-.046	.039	.280	.250	.054	-.154	-.083	.247	-.035	.134	-.055
How often do projects experience delays due to approval processes?	.035	-.022	-.113	.829	.020	.092	.128	.016	-.049	.044	-.046	.026	-.011	.054	-.076	-.020
What is the likelihood of unexpected financial crises affecting the project?	-.004	.154	-.135	.432	.210	.066	-.280	.278	.131	-.181	.268	.038	.072	-.039	.064	.080
How reliable are your current suppliers?	.092	.122	.314	.429	-.190	-.195	-.054	-.097	.356	-.015	-.236	-.122	.171	-.148	-.049	-.090
How likely are disputes with clients to arise during the project?	.095	-.075	.060	.072	.748	-.014	.050	-.052	-.044	.067	.032	-.146	-.063	-.003	-.042	.103
Availability of Required Materials or Resources?	.409	-.161	.110	.120	-.421	-.008	.177	-.158	-.189	.001	.044	-.178	-.029	-.055	.367	.033
Rate the risk of software or IT system failures during project management.	.063	.010	-.012	.045	-.036	.763	.064	-.005	.049	-.143	.092	-.075	.080	.018	-.025	-.076
Rate the overall risk level of the project as perceived by your team.	.053	.234	-.047	.007	.124	.478	-.096	-.172	.070	.338	.053	.178	.078	-.039	-.097	.042
Rate the risk of currency fluctuations affecting material costs.	-.113	-.024	.037	.075	.017	.023	.822	.066	.053	-.063	-.004	.042	-.042	.029	.026	.012
What is the likelihood of scheduling conflicts affecting timelines?	-.104	-.005	-.013	.044	-.012	-.050	.054	.737	.022	.043	-.026	.012	.026	-.064	-.004	.012
Rate the risk of theft or vandalism on the construction site.	-.016	-.020	.022	.007	-.031	.062	.080	.029	.798	-.015	.056	.070	-.033	.060	.062	.042
Rate the risk of labor disputes or strikes impacting your project.	.124	.062	.027	.030	-.144	.079	-.071	-.060	-.006	-.645	.027	.098	.353	.075	.040	.067
How significant would the impact of unforeseen conditions be?	.116	.161	.081	-.025	.020	.050	-.161	.342	-.271	.474	-.013	.203	.097	.116	.249	-.004
How often do you encounter errors in	-.042	-.125	-.053	.100	-.357	-.076	-.104	-.034	.178	.470	.229	.081	.243	-.105	-.152	.171

DOI: 10.46121/pspc.53.2.15

Power System Protection and Control
ISSN:1674-3415

project design or specifications?																
How often do you experience material quality issues?	-.095	.157	.021	-.045	.007	.070	-.016	-.045	-.002	.001	.692	.007	-.027	-.013	.086	-.051
How likely are unforeseen site conditions (e.g., soil issues) to affect the project?	.142	-.129	.210	.164	-.163	-.041	-.037	.340	.156	.102	.424	-.163	-.157	.276	-.142	.182
What is the likelihood of material delivery delays?	.199	-.179	.132	.054	.193	.071	.265	-.260	.146	.224	.301	-.145	.080	.005	.116	-.175
Rate the risk of communication breakdowns between project stakeholders.	.011	-.011	-.172	.006	-.192	-.069	.045	.012	.092	.015	.015	.730	.030	-.037	.024	-.001
What is the likelihood of adverse weather conditions affecting timelines?	-.108	-.105	.252	.018	.117	.376	-.086	.062	-.172	-.063	-.216	.425	-.053	.207	.123	.112
Rate the risk of natural disasters (e.g., floods, earthquakes) affecting the project.	.126	.216	.203	.129	.179	-.011	.361	-.220	.112	.200	-.048	.365	-.057	-.031	-.043	.284
How severe would the impact of poorly managed subcontractors be?	-.060	-.001	.005	.006	-.103	.162	-.084	.032	.039	-.076	-.072	-.045	.682	.080	-.054	-.021
What is the severity of delays caused by labor shortages?	.109	-.005	.114	.333	.211	-.235	.129	.045	-.182	.019	.022	.139	.489	.119	.169	-.266
What is the likelihood of exceeding the project budget?	.000	.055	.190	-.020	-.073	-.011	-.010	.129	-.068	.024	-.059	.015	-.134	-.768	-.063	-.028
How likely is scope creep to occur in your projects?	.247	.061	.026	-.116	-.202	-.038	.247	.255	-.181	-.121	-.025	.036	.047	.481	-.350	-.063
How likely are labor shortages during peak construction periods?	.037	.156	.189	.185	-.030	.054	-.164	.016	.123	-.001	-.303	-.031	-.419	.449	.073	-.195
How often do technological issues cause project delays?	.021	.007	-.004	.074	.008	.026	.023	-.010	-.019	.040	-.114	-.101	.021	-.026	-.707	-.045
How confident are you in the project's financial planning accuracy?	-.018	.207	-.249	.024	-.163	-.046	.165	.035	.179	.037	-.292	-.285	.018	-.010	.482	.064
How often are financial contingencies	.097	-.036	-.067	-.041	.092	-.024	.021	.065	.032	-.021	-.021	.057	-.041	-.024	.101	.813

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underestimated in your projects?																
What is the likelihood of accidents or safety incidents on site?	.182	-.141	-.002	.006	.005	.157	.110	.222	.092	-.289	.207	.323	-.131	-.189	.066	-.373

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a

a. Rotation converged in 109 iterations.

Appendix B: Descriptive Statistics Table

Risk Factor	Mean	Std. Dev
Change in government regulations	3.45	1.14
Delay in material delivery	4.02	0.87
Unsuitable technology adoption	3.78	1.03
Material price volatility	4.15	0.74
Resource availability fluctuation	3.88	0.91
Community opposition	3.25	1.21
Worker skill mismatch	3.49	1.17
Weather-related delays	3.91	0.89
Budget overruns	4.10	0.82
Delays due to approvals	3.82	1.06
Financial crises	3.76	0.99
Supplier unreliability	3.67	0.95
Client disputes	3.39	1.08
IT or software failure	3.05	1.23
Team’s perceived overall risk	3.94	0.85
Currency fluctuation	3.70	1.03
Scheduling conflicts	3.88	0.92
Theft or vandalism	3.22	1.10
Unforeseen conditions	3.83	0.97
Errors in design or specifications	3.79	1.00
Material quality issues	3.66	1.04
Site condition surprises (e.g., soil)	3.60	0.98
Communication breakdowns	3.84	0.90
Adverse weather	3.72	1.01
Poor subcontractor management	3.55	1.06
Labor shortage delay severity	3.61	1.07
Scope creep	3.68	1.09
Peak-time labor shortages	3.74	0.95
Confidence in financial planning	3.89	0.88
Underestimation of contingencies	3.71	1.02
Legal disputes	3.33	1.15
Environmental compliance risks	3.46	1.08
Project team experience level	4.05	0.77
Subcontractor availability	3.60	0.96
Resource allocation errors	3.58	1.03
Lack of contingency planning	3.69	0.97
Contract ambiguities	3.51	1.12

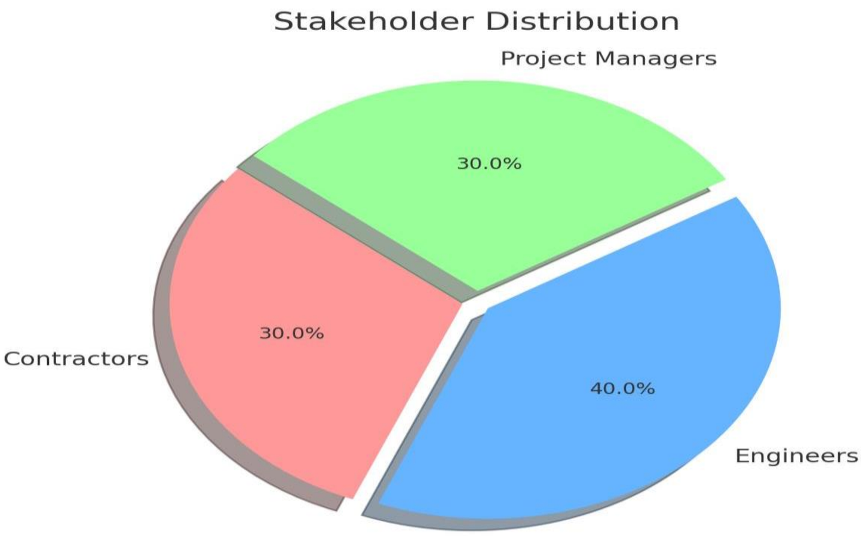
DOI: 10.46121/pspc.53.2.15

Appendix C: Kruskal-Wallis Test Output Summary

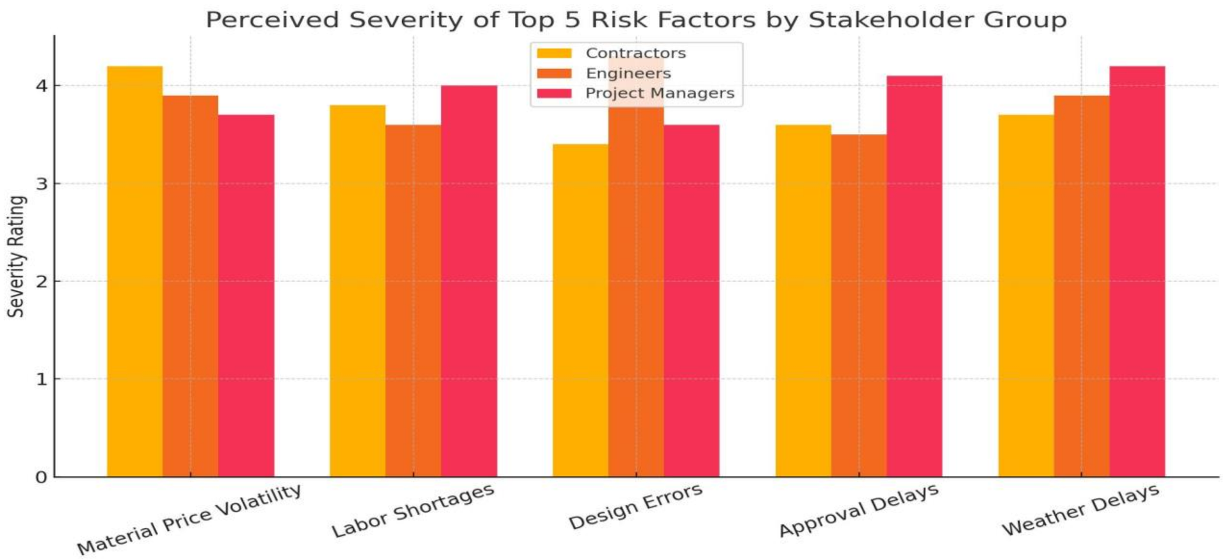
Group	Chi-Square	df	Asymp. Sig.
Contractors	12.45	2	0.002
Engineers	10.33	2	0.005
Project Managers	14.12	2	0.001

Appendix D: Graphical Charts

- ***Pie Chart: Stakeholder distribution (Contractors 30%, Engineers 40%, Project Managers 30%)***



- ***Bar Chart: Perceived severity of top 5 risk categories by group***



Appendix E: Survey *Questionnaire* Items

I. Section 1: Participant Information

- Name *
- Organization/ Company Name *
- Role in the Project * (Project Manager, Architect, Engineer, Contractor, Other)

II. Section 2: Financial Risk

- What is the likelihood of exceeding the project budget? (1-5)
- How significant would the impact of budget overrun be? (1-5)
- How often are financial contingencies underestimated in your projects? (Never to Always)
- Rate the risk of currency fluctuations affecting material costs. (1-5)
- How confident are you in the project's financial planning accuracy? (1-5)

III. Section 3: Labor and Workforce Risks

- How likely are labor shortages during peak construction periods? (1-5)
- What is the severity of delays caused by labor shortages? (1-5)
- How frequently do you encounter worker skill mismatches? (Never to Always)
- Rate the risk of labor disputes or strikes impacting your project. (1-5)

IV. Section 4: Material Supply Chain Risks

- What is the likelihood of accidents or safety incidents on site? (1-5)
- What is the likelihood of material delivery delays? (1-5)
- How severe would the impact of delayed materials be? (1-5)
- How often do you experience material quality issues? (Never to Always)
- Rate the risk of price volatility in key materials. (1-5)
- How reliable are your current suppliers? (1-5)

V. Section 5: Environmental and External Risks

- Availability of Required Materials or Resources? (1-5)
- What is the likelihood of adverse weather conditions affecting timelines? (1-5)
- How significant would the impact of weather delays be? (1-5)
- Rate the risk of natural disasters affecting the project. (1-5)
- How likely are changes in government regulations to impact your project? (1-5)
- What is the likelihood of community opposition to your project? (1-5)

VI. Section 6: Project Management Risks

- How often do you encounter errors in project design or specifications? (Never to Always)
- What is the likelihood of scheduling conflicts affecting timelines? (1-5)
- Rate the risk of communication breakdowns between project stakeholders. (1-5)
- How severe would the impact of poorly managed subcontractors be? (1-5)
- How likely is scope creep to occur in your projects? (1-5)

VII. Section 7: Technology and Innovation Risks

- How often do technological issues cause project delays? (Never to Always)
- Rate the risk of software or IT system failures during project management. (1-5)
- What is the likelihood of adopting unsuitable construction technologies? (1-5)

VIII. Section 8: Miscellaneous Risks

- How likely are unforeseen site conditions to affect the project? (1-5)
- How significant would the impact of unforeseen conditions be? (1-5)
- Rate the risk of theft or vandalism on the construction site. (1-5)
- How likely are disputes with clients to arise during the project? (1-5)
- How often do projects experience delays due to approval processes? (Never to Always)
- What is the likelihood of unexpected financial crises affecting the project? (1-5)

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- Rate the overall risk level of the project as perceived by your team. (1-5)

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