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Applied Tool for Cost Risk Analysis Using Experience Data

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Abstract

This article presents a structured approach to cost risk analysis in project cost estimation by systematizing the use of risk factors and corresponding three-point estimates. Drawing from a dataset of 112 cost risk analyses across five industries, including both public sector quality assurance reviews and standalone assessments, we have developed a standardized framework for categorizing and quantifying cost risk. 14 distinct risk factors were identified and aggregated from an initial set of 49, enabling consistent analysis and comparison across projects. An interactive Power BI dashboard was created to facilitate data exploration, enabling users to analyse trends, compare projects, and assess the variability of individual factors. The tool supports internal quality assurance processes and improves the reliability of probabilistic cost estimates, as represented by S-curves and tornado diagrams. This structured methodology enhances transparency, reduces analyst bias, and provides a reference framework for future risk assessments in similar project contexts.
Keywords: Project management; Quality assurance; Cost risk analysis;

1. Introduction

Risk analysis is a systematic process for identifying, assessing, and quantifying risks and uncertainties in a project, initiative, or decision [1]. The purpose of such an analysis is to understand how various factors may impact goal achievement and to support better planning and risk management.

In addition to the project's cost estimate, a cost risk analysis incorporates various risk factors. A risk factor models the cost-related consequences of identified aspects not included in the baseline estimate nor covered by estimation risk but that are still expected to influence the project cost. The risk factors encompass internal and external conditions, some of which the project may influence, while others may be beyond the projects` control.

We have identified a need to systematize the application of risk factors and the assessment of corresponding three-point estimates. Such a structured and data-driven approach to risk analysis is expected to yield several positive effects:

- Reduced chance of individual risk analysis being influenced by the executing individual(s).
- More thoroughly developed risk factors with stronger argumentative foundations.
- Facilitated internal quality assurance and comparative analysis of the work.
- A reference framework for relevant risk analysis in similar projects.

This study seeks to explore a practical approach to the following research question:

"In what ways can data from risk analyses be structured to identify trends across past cases and help analysts conduct future assessments?"

2. Background

Risk analysis can be divided into a qualitative and a quantitative component [2]. The qualitative part involves describing risks, their causes, and the potential for wanted or unwanted consequences. The quantitative part focuses on assessing numerical values to the range of possible outcomes, enabling the use of these assessments for project prioritization and control.

All methods typically establish and describe a qualitative scenario model as a foundation for subsequent quantification [2]. The quantification process involves a standard probability distribution and defining the exact probability density function by identifying key points on the curve. In Norwegian methodologies, these points are commonly determined using a three-point estimate based on subjective judgment

2.1. Terms in uncertainty analysis

Uncertainty factor / Risk factor

Equation (1) shows the formula for an uncertainty factor, or risk factor, as defined in [1].

$$\textit{Probability of the event occurring} \times \textit{Consequence of the event if it occurs} \qquad (1)$$

In the context of a cost estimate, an uncertainty factor may impact one or more cost elements if the event materializes. Examples of such uncertainty factors include market volatility, design and project maturity, ground conditions, project management, and contract strategy. The selection, number, and definition of uncertainty factors may vary depending on who performs the analyses.

Three-point estimates

For each uncertainty factor, a three-point estimate, also referred to as a range, is established. The three-point estimates consist of values for the best case, most likely case, and worst case. The best-case value reflects the consequence one would expect in the most favourable scenario, assumed to occur in approximately one out of ten instances. Conversely, the worst-case value reflects the consequence anticipated in the least favourable scenario, also assumed to occur in one out of ten instances. These are referred to as the 10th and 90th percentiles (P10 and P90), respectively.

S-curve

The S-curve is a key output from an uncertainty analysis and presents the probability distribution of the project's final cost [3]. In the S-curve, P50 represents the project cost that, according to the uncertainty analysis, has a 50 percent probability of not being exceeded. P85 represents the cost with an 85 percent probability of not being exceeded, based on the same analysis.

Tornado diagram

A tornado diagram is another key output from a risk analysis. It illustrates the overall cost risk based on the risk factors included in the analysis. Whereas the left side represents potential cost reduction, and the right side represents potential cost increase [4]. Fig. 1 presents an example of a tornado diagram.

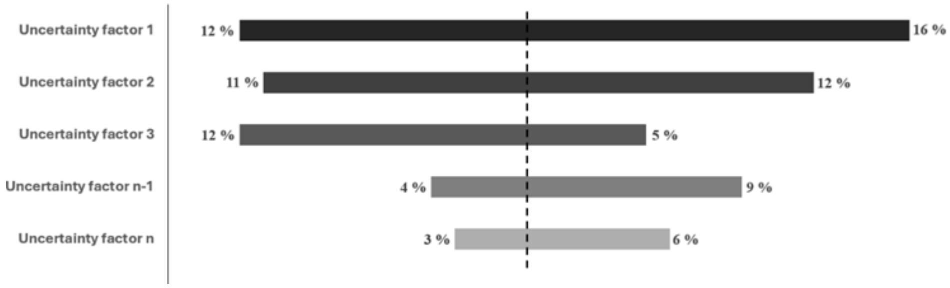

Fig. 1. Tornado diagram with different uncertainty factors

3. Data

This paper reviews 112 cost risk analyses from different projects, including the corresponding S-curves and Tornado diagrams. Out of the 112 analyses, 52 are conducted as a part of the quality assurance process through The Government's Project Model in Norway and 60 are standalone uncertainty analyses. The distribution of assignment types across the 112 projects is shown in Table 1. Examples of included projects are New water supply in Oslo, Majorstuen metro station, Hammerfest airport and Police station in Bergen.

Table 1. Distribution of assignment types (Cost risk analysis, QA1 and QA2)

Total	Cost risk analysis	QA1	QA2
112	60	26	26

4. Methodology

4.1. Collection of data

To apply risk factors from previously conducted risk analyses in future assessments, it was necessary to populate a database with relevant information. The database is populated with information from 112 cost risk analyses. Of which 105 of them are uncertainty analyses conducted by Holte Consulting. In addition, seven uncertainty analyses conducted by other companies are included, which all of them are also conducted through The Government's Project Model. The majority of the analyses are dated within the years 2019-2024.

4.2. Standardization of project industries and categories

The 112 analyses in the database are sorted based on defined categories and industries in each analysis. Based on the description in each analysis we have sorted the analyses into five industries with associated subcategories. The number of industries were chosen to secure and ensure a reasonable number of analyses within each industry, so that it is possible to analyse trends based on the data we have. At the same time, we wanted to ensure that the industries were "small enough" to not include irrelevant projects. The industries and categories applied in the database are presented in Table 2. As shown in the table, the industries *building* and *construction* are overrepresented in this study, both in amount and number of subcategories. This is due to the analysis available for this study, where analyses have been conducted for these industries at a higher frequency than the other three industries.

Table 2. Description of industries used in the database and the distribution across assignment types

Industry	Project categories included within the industry	Total	Cost risk analysis	QA1	QA2
Building	Healthcare, schools, extensions/additions, new construction, renovation, cultural buildings, kindergarten, swimming facilities.	47	28	11	8
Construction	Roads, quay facilities, infrastructure, railway, airport.	52	30	12	10
Defence	Defence	5	0	1	4
Industry	Processing facility	1	1	0	0
IT and telecommunication	IT and telecommunication	7	1	2	4

4.3. Standardization of uncertainty factors

To be able to aggregate the different uncertainty factors used in the 112 included analyses, we considered it necessary to standardize the risk factors across the analyses. In total, 49 unique risk factors were identified across the 112 analyses. Several of them were highly similar and merely linguistic variation of one another. For example:

- Regulatory requirements & Authorities and Requirements
- Maturity in the design & Maturity in the design and solutions
- Project management and leadership & Project management and governance

Based on the descriptions of each risk factor in the project report, and a discretionary and professional assessment of their similarities, we have aggregated the 49 unique risks into 14. The 14 risk factors, with brief descriptions, are presented in Table 3. The descriptions are not exhaustive.

Table 3. Risk factors and the corresponding descriptions

Risk factor	Description of cost consequences due to uncertainty factor
Regulatory framework and conditions	Predictability regarding framework conditions, political guidelines and decisions, framework permits, laws and regulations.
Project governance	Impact from the owner's project governance, level of strategic control, clarity in mandates and collaboration between owner and project management.
Market risk	Market-related factors such as competition market capacity, economic cycles, extraordinary market effects, supply chain stability, project attractiveness, and supplier interest.
Maturity of design	Maturity and quality of the project design, uncertainty regarding project scope, and the level of complexity in the technical design and detailing.
Project management and contract strategy	The project organization's ability to plan, lead and execute the project. Resource capacity, continuity and experience of key personnel, collaboration and the strengths of the selected contract strategy.
Supplier risk	The supplier's execution capability and suitability. Their performance, HSE, coordination across contracts, logistics and material handling.
User requirements	Changes in user requirements or other changes based on operation needs.
External stakeholders	Impact from the direct or indirect influence of external actors and stakeholders.

Interfaces, logistics and local conditions	Impact from adjacent or nearby project. This also includes operations and maintenance, physical conditions, site-specific constraints, and feasibility.
Ground conditions	Ground conditions, soil quality, interfaces with existing infrastructure, underground cables and pipes, archaeology, protected species and areas, and climate factors.
Condition of exiting building	Uncertainty regarding the condition of existing buildings
Wage and price increase	Uncertainty in future wage and price developments.
Currency risk	Uncertainty in currency exchange rates.
Northern Norway addition	Risk due to the project's geographical location in Norway.

4.4. Establishment of the interface for the analysis tool

The interactive dashboard for the database was developed using Power BI. The choice was based on its user-friendly interface and ability to provide meaningful data visualizations [5]. Additionally, dashboards and analysis tools created in Power BI are easily distributed across organizations. Power BI also seamlessly integrates with the database, which is established in Microsoft Excel, and uses it as a data source.

Excel was selected as the database platform because the number of data points was within Excel's manageable capacity. In addition, it simplifies the continued population and maintenance of the database. The database in Excel consists of three sheets containing the following information:

1. Risk analyses included in the database, with general information, industry and category.
2. Categorization of each risk analysis according to the standardization described in section 4.2.
3. Three-point estimates for each risk factor for all the analyses included in the database.

5. Results & Discussion

The dashboard consists of three main dashboards: *Home, Risk Factors* and *Provisions and Additions*.

Fig. 2 shows the dashboard *Risk Factors,* which provides an overview of risk factors for the selected project sample. A filter panel on the left allows users to refine projects by variables such as industry, category, location and base cost estimate. The four information panels on the right illustrate the different types of relevant data. The top-left panel lists the projects that meet the selected filter criteria. The top-right illustrates the average range per uncertainty factor, where factors with larger average ranges are visually emphasized.

Across all 112 projects, "market risk" emerges as the uncertainty factor with the largest average range. In contrast, "user requirements" and "wage and price increase" are examples of factors with lower average variability. The bottom-left shows average "best" and "worst" values per factor, and bottom-right displays extreme values.

In addition to viewing results directly, users can interact with the visual elements. For instance, clicking on an uncertainty factor updates the project register to display only those projects containing the selected factor. Similarly, selecting a specific project dynamically updates the visualizations to reflect data from that project alone.

By selection from a given sample, the dashboard enables analysis of which factors tend to increase or decrease costs in specific project types. Findings of which risk factors that have the highest and lowest average range, can guide future analyses and help decision-makers address key risk areas. However, it is necessary to use the tool with consciousness since the assessments of uncertainty still can be subjective and based on empirical data of past analyses. Continuous use and database updates can strengthen the reliability of the tool's output.

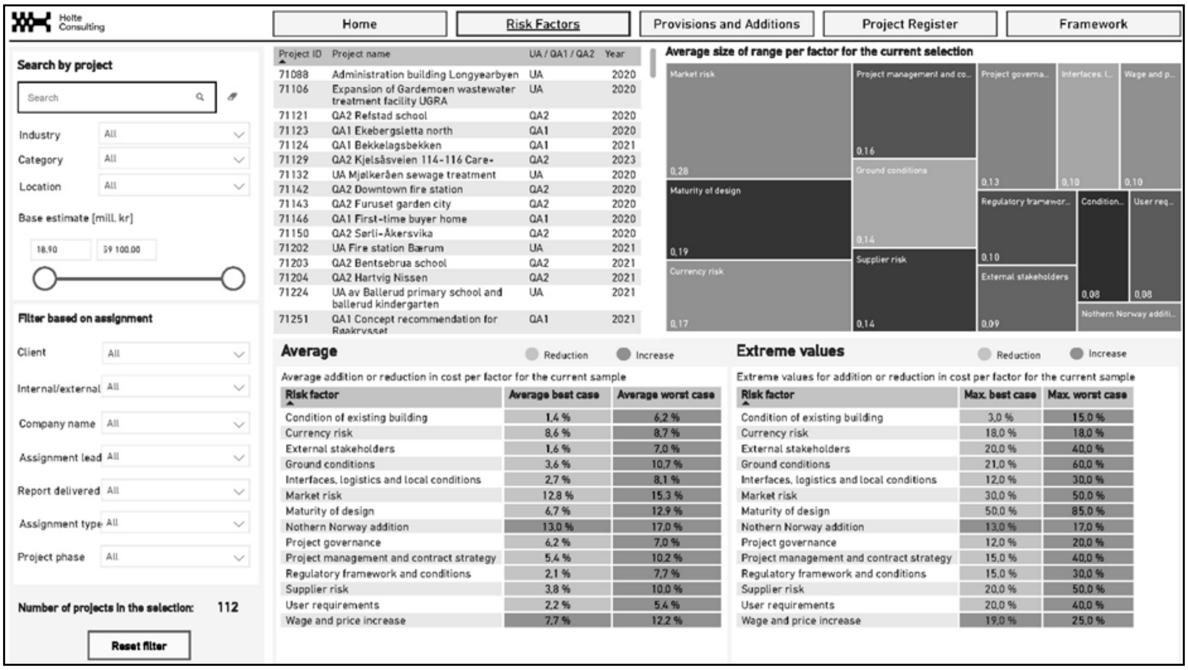

Fig. 2. Dashboard "Risk Factors" in the analysis tool

In addition, the dashboard *Home* gives the user an overview of the data. Such as number of clients, number of projects by location and per year, and the distribution of projects by industry. The dashboard *Provisions and Additions* follows a similar structure to the *Risk Factors* view and displays expected additions and uncertainty provisions for the current selection. Giving the user information to validate if the results of an uncertainty analysis are within a typical range for a given type of project.

6. Conclusion

By systematizing previously unstructured risk factors from past uncertainty analyses, this study has developed an analytical tool that supports quality assurance processes involving uncertainty assessments. The tool enables trend analysis across multiple uncertainty assessments and strengthens the basis for subjective judgments that ultimately form the basis for probabilistic estimates of selected uncertainty factors.

A systematic approach to previous analysis enhances future uncertainty analyses by improving preparedness, simplifying quality assurance of selected factors, and aiding interpretation during post-analysis. Thereby strengthening the justification of uncertainty factors represented in S-curves and tornado diagrams. As more projects are added in the database, the tool will become more robust and applicable.

References

[1] O. J. Klakegg, "Kvalitetssikring av kostnadsoverslag - Felles begrepsapparat," Prosjekt Norge, 2003.
[2] K. Austeng, J. T. Midtbø, I. Jordanger, O. M. Magnussen and O. Torp, "Usikkerhetsanalyse - Kontekts og grunnlag," Concept, 2005.
[3] F. Drevland, Kostnadsestimering under usikkerhet (Concept temahefte nr. 4), Concept NTNU.
[4] Projinsights, "Tornado Diagram: A Simple Guide to Sensitivity Analysis with Examples," 3 December 2024. [Online]. Available: https://www.projinsights.com/tornado-diagram-a-simple-guide-to-sensitivity-analysis-with-examples/. [Accessed 2025].
[5] R.Parthe, "Comparative Analysis of Data Visualization Tools: Power BI and Tableau," International Journal of Research in Engineering, Science and Management, vol. 7, no. 10, 2023.