Cost Predictive Model Adoption in Construction Organisations: A Pilot Study

Hanafi bin Ab. Haris, Norhazren Izatie Mohd, Hamizah Liyana Tajul Ariffin, Mohamad Khairul Aizzat bin Rusmami

Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81300 Johor Bahru, Johor, Malaysia

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ABSTRACT

Accurate construction cost estimation is essential for effective project planning, budgeting, and decision-making. The increasing complexity of construction projects has accelerated the adoption of advanced cost predictive models that complement traditional estimation techniques. However, limited empirical evidence exists regarding the acceptance and application of these predictive approaches within construction organisations. Therefore, this study aimed to examine the cost predictive model approaches adopted by construction organisations from the perspective of Quantity Surveyors. A quantitative research design was employed using a structured questionnaire survey distributed to Quantity Surveyors working in client, consultant, contractor, and subcontractor organisations. A total of 58 valid responses were analysed using descriptive statistics and the Kruskal–Wallis H test. The findings revealed that all seven cost predictive model approaches achieved a high level of agreement, indicating strong industry recognition of both conventional and advanced prediction techniques. Traditional Statistical Models recorded the highest mean score (M = 4.21), followed by Fuzzy Logic and AI-Based Models and Hybrid Models (M = 4.07), while Probabilistic and Bayesian Models obtained the lowest mean score (M = 3.76). Furthermore, the Kruskal–Wallis analysis indicated no statistically significant differences ($p > 0.05$) among respondents from different organisational categories, suggesting a common perception regarding the importance of cost predictive models across the construction industry. The study contributes to the growing body of knowledge on construction cost estimation by providing empirical evidence of practitioners' perceptions towards contemporary predictive approaches. The findings offer practical insights for construction organisations seeking to improve estimation accuracy and support the adoption of intelligent, data-driven cost prediction techniques as part of the industry's digital transformation.

Keywords: Construction cost estimation, Cost predictive models, Quantity Surveyors, Construction organisations, Artificial intelligence, Machine learning.

INTRODUCTION

Construction cost estimation is a fundamental process that directly influences project feasibility, budgeting, procurement strategies, resource allocation, and overall project success. Accurate cost prediction enables project stakeholders to make informed decisions during the planning and execution stages, thereby reducing financial risks and improving project performance. However, the construction industry has become increasingly complex due to volatile material prices, labour shortages, supply chain disruptions, inflation, technological advancements, and uncertain economic conditions, making reliable cost estimation more challenging than ever (Fazil, Lee & Muhamad Tamyez, 2021). These uncertainties have highlighted the limitations of conventional estimation methods, which primarily depend on historical project data and expert judgement.

Traditionally, construction organisations have relied on statistical techniques such as regression analysis, parametric estimation, and analogous cost estimation because of their simplicity, transparency, and ease of implementation. Although these approaches remain widely accepted, they often fail to capture the nonlinear relationships and dynamic interactions among numerous project variables encountered in modern construction projects. Recent advances in artificial intelligence (AI), machine learning (ML), artificial neural networks (ANN), fuzzy logic, hybrid computational models, big data analytics, and probabilistic modelling have demonstrated considerable potential to enhance estimation accuracy by analysing large and complex datasets while accommodating uncertainty in decision-making (Chen et al., 2025). These digital approaches provide opportunities for improving prediction reliability and supporting more effective project planning.

Despite these technological developments, the adoption of advanced cost predictive models within construction organisations remains inconsistent. Previous studies have reported that several organisational and technical factors influence the implementation of these predictive approaches, including data quality, organisational readiness, digital capability, availability of technical expertise, economic considerations, and user familiarity with advanced analytical tools (Zima & Plebankiewicz, 2020; Abed et al., 2022; Padala & Goyal, 2025). Consequently, many organisations continue to depend on conventional estimation methods despite the increasing availability of intelligent predictive technologies.

Furthermore, inaccurate cost estimation continues to contribute to budget overruns, schedule delays, contractual disputes, and inefficient resource utilisation. The growing complexity of construction projects, coupled with limited information during the early planning stage, increases uncertainty and reduces the reliability of traditional estimating techniques (Çebi et al., 2024; Habe et al., 2024; Abdel-Monem et al., 2022). Although advanced predictive models such as Artificial Neural Networks, machine learning algorithms, and probabilistic approaches have demonstrated improved forecasting performance by modelling uncertainty and nonlinear relationships (Hossain et al., 2020; Yun et al., 2022; Alrasheed et al., 2025; Jezzini et al., 2025), empirical evidence regarding their acceptance and application among construction organisations, particularly from the perspective of Quantity Surveyors, remains limited.

This research addresses this gap by investigating the cost predictive model approaches adopted within construction organisations and examining practitioners' perceptions of different predictive techniques. Specifically, the study evaluates the level of agreement among Quantity Surveyors regarding seven cost predictive model approaches and determines whether perceptions differ across organisational categories. The findings provide valuable insights into current industry practices and contribute to a better understanding of how both conventional and advanced predictive models can support more accurate construction cost estimation and informed decision-making in an increasingly digital construction environment.

LITERATURE REVIEW

Evolution of Cost Predictive Models in Construction

Accurate construction cost prediction is essential for project planning, budgeting, procurement, and financial decision-making. Over the past two decades, cost estimation approaches have evolved from conventional statistical techniques towards intelligent computational models capable of analysing complex datasets and addressing uncertainty. This transition has been driven by the increasing complexity of construction projects, rapid digitalisation, and the growing availability of historical project data. Contemporary research suggests that no single predictive model is universally applicable; instead, model selection depends on project characteristics, data availability, organisational capability, and the required level of prediction accuracy (Singh et al., 2024; Chen et al., 2025).

Traditional Statistical Models

Traditional statistical approaches, including linear regression, multiple regression, and parametric estimation, remain among the most widely adopted techniques in construction cost estimation. These models establish mathematical relationships between project costs and measurable project variables, making them transparent, computationally efficient, and easy to interpret (Singh et al., 2024). Their simplicity enables Quantity Surveyors to justify estimation results during feasibility studies and early project planning. However, conventional statistical models assume linear relationships among variables and therefore struggle to represent the nonlinear interactions associated with modern construction projects. Consequently, their prediction accuracy decreases as project complexity increases (Singh et al., 2024).

Artificial Intelligence and Machine Learning Models

Artificial intelligence (AI) has transformed construction cost estimation by enabling predictive models to learn from historical project data and identify complex nonlinear relationships. Artificial Neural Networks (ANN) have demonstrated superior predictive capabilities compared with conventional statistical techniques, particularly when handling multidimensional datasets and uncertain project environments (Alrasheed et al., 2025). Similarly, machine learning algorithms such as Random Forest, Support Vector Machine (SVM), and Gradient Boosting can automatically identify hidden patterns and improve estimation performance through continuous learning (Das et al., 2024; Yun et al., 2022). Despite these advantages, AI-based models present several implementation challenges. Their predictive mechanisms are often difficult to interpret, creating a "black-box" effect that reduces users' confidence in the estimation process. Furthermore, these approaches require large volumes of high-quality training data, substantial computational resources, and personnel with specialised analytical skills, limiting their implementation within organisations possessing lower levels of digital maturity (Alrasheed et al., 2025; Yun et al., 2022).

Fuzzy Logic and Hybrid Models

Fuzzy logic was introduced to overcome the limitations of deterministic estimation methods by representing uncertainty using linguistic variables and expert judgement. Unlike traditional statistical models, fuzzy logic accommodates ambiguous and incomplete information commonly encountered during early project planning (Zima & Plebankiewicz, 2020). However, its performance depends heavily on expert-defined membership functions and inference rules, making model development highly subjective. To overcome the limitations of individual approaches, researchers increasingly advocate hybrid predictive models that integrate ANN, fuzzy logic, machine learning, regression analysis, and probabilistic techniques. Hybrid models leverage the complementary strengths of multiple algorithms, resulting in improved prediction accuracy and robustness under uncertain project conditions (Zima & Plebankiewicz, 2020). Nevertheless, these models require sophisticated model development, greater computational capability, and extensive calibration before practical implementation.

Big Data Analytics and Probabilistic Models

The emergence of digital technologies such as Building Information Modelling (BIM), Internet of Things (IoT), cloud computing, and digital project management systems has facilitated the application of Big Data Analytics (BDA) in construction cost prediction. BDA integrates structured and unstructured data from multiple project sources, enabling more comprehensive and dynamic cost forecasting than traditional estimation approaches (Chaitongrat et al., 2024). However, successful implementation depends on robust digital infrastructure, effective data governance, and cybersecurity measures. Probabilistic and Bayesian models provide an alternative perspective by incorporating uncertainty directly into the estimation process. Instead of generating a single deterministic cost estimate, these approaches produce probability distributions that better represent project risks. Bayesian updating further enhances prediction reliability by continuously refining cost estimates as additional project information becomes available (Jezzini et al., 2025). Although these models support more informed decision-making, they require reliable prior data and advanced statistical expertise, limiting their widespread application within industry practice.

Research Gap

Previous studies consistently demonstrate that advanced predictive techniques outperform conventional statistical methods in terms of prediction accuracy, particularly for complex construction projects (Alrasheed et al., 2025; Das et al., 2024; Chen et al., 2025). Nevertheless, the successful implementation of these technologies depends not only on their technical capabilities but also on organisational readiness, data quality, user competency, and digital infrastructure (Abed et al., 2022; Padala & Goyal, 2025). While considerable research has focused on developing predictive algorithms, comparatively limited attention has been given to understanding how construction organisations perceive different predictive approaches and which models practitioners consider most appropriate for industry implementation. This study addresses this gap by examining Quantity Surveyors' perceptions towards seven major cost predictive model approaches adopted within Malaysian construction organisations.

Table 1: Critical Analysis of Cost Predictive Models

Cost Predictive Model	**Main Characteristics**	**Strengths**	**Limitations**	**Suitable Application**	**Source**
Traditional Statistical Models	Regression and parametric techniques using historical project data	Simple, transparent, easy to interpret, low computational cost	Limited ability to model nonlinear relationships and uncertainty	Early-stage cost estimation and standardised projects	Singh et al. (2024)
Artificial Neural Networks (ANN)	Learns complex nonlinear relationships from historical data	High prediction accuracy and adaptive learning	Black-box nature, requires large datasets and technical expertise	Complex building and infrastructure projects	Alrasheed et al. (2025)
Machine Learning Models	Random Forest, SVM, Gradient Boosting and other learning algorithms	Captures hidden patterns and improves forecasting accuracy	Data-intensive and computationally demanding	Large-scale projects with extensive historical datasets	Das et al. (2024); Yun et al. (2022)
Fuzzy Logic Models	Uses linguistic variables and expert judgement	Effective under uncertainty and incomplete information	Subjective rule development and increasing model complexity	Conceptual estimation and expert-based decision-making	Zima & Plebankiewicz (2020)
Hybrid Models	Combines multiple predictive techniques	Higher prediction accuracy and improved robustness	Complex implementation and higher computational requirements	High-risk and complex construction projects	Zima & Plebankiewicz (2020)
Big Data Analytics (BDA)	Integrates BIM, IoT, cloud and historical project data	Real-time analysis and comprehensive forecasting	Requires digital infrastructure, data governance and cybersecurity	Digital construction and smart project management	Chaitongrat et al. (2024)
Probabilistic & Bayesian Models	Produces probability-based cost predictions	Explicitly incorporates uncertainty and project risk	Requires statistical expertise and reliable prior data	Risk-informed decision-making and long-term projects	Jezzini et al. (2025)

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The literature indicates that construction cost prediction has evolved from deterministic statistical models towards intelligent and data-driven predictive approaches. While traditional statistical models remain valuable because of their transparency and ease of implementation, they are increasingly complemented by AI-based techniques capable of modelling complex nonlinear relationships. Recent studies consistently suggest that hybrid approaches integrating statistical, machine learning, and probabilistic methods achieve superior predictive performance, particularly in uncertain project environments. Nevertheless, technological capability alone does not guarantee successful implementation. Organisational readiness, digital maturity, data quality, and practitioner competency remain critical determinants influencing the adoption of advanced cost predictive models within construction organisations. Consequently, evaluating practitioners' perceptions of these predictive approaches is essential for understanding their practical applicability and supporting future digital transformation in construction cost management.

METHODOLOGY

This study adopted a quantitative research approach to investigate the cost predictive model approaches used in construction organisations. A quantitative design was considered appropriate because it enables the systematic collection and statistical analysis of numerical data to examine respondents' perceptions and identify patterns related to the adoption of cost predictive models (Sciberras & Dingli, 2023). The research employed a cross-sectional questionnaire survey to collect empirical data from Quantity Surveyors involved in construction cost estimation.

Table 2: Summary of Research Methodology

Research Component	**Description**
Research Design	Quantitative cross-sectional survey
Research Strategy	Structured questionnaire survey
Respondents	Quantity Surveyors from client, consultant, contractor, and subcontractor organisations
Sampling Technique	Convenience sampling
Sample Size	58 valid responses
Study Area	Johor, Selangor and Kuala Lumpur, Malaysia
Measurement Scale	Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree)
Main Constructs	Seven cost predictive model approaches
Software	SPSS
Descriptive Analysis	Frequency, percentage and mean analysis
Inferential Analysis	Kruskal–Wallis H Test
Significance Level	α = 0.05

Instrument Development

Data were collected using a structured questionnaire developed from an extensive review of recent literature on construction cost prediction models. The questionnaire comprised two sections. Section A gathered respondents' demographic information, including organisation type, professional designation, years of working experience, and experience in using cost predictive models. Section B measured respondents' perceptions of seven cost predictive model approaches: Traditional Statistical Models, Artificial Neural Networks (ANN), Machine Learning Models, Fuzzy Logic and AI-Based Models, Hybrid Models, Big Data Analytics (BDA), and Probabilistic and Bayesian Models. All measurement items were evaluated using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The Likert scale was selected because it provides a simple and reliable method for measuring respondents' attitudes and perceptions while facilitating statistical analysis (Hurst & Bird, 2018).

Population and Sampling

The target population comprised Quantity Surveyors actively involved in construction cost estimation within client, consultant, contractor, and subcontractor organisations. These professionals were selected because they possess practical knowledge and experience in preparing cost estimates and applying cost predictive approaches throughout the project lifecycle. A non-probability convenience sampling technique was adopted due to the accessibility of industry practitioners involved in cost estimation activities. The questionnaire was distributed electronically to Quantity Surveyors located in Johor, Selangor, and Kuala Lumpur. Based on the Krejcie and Morgan (1970) sampling guideline, the survey achieved 58 valid responses, which were considered sufficient for descriptive and non-parametric statistical analyses (Arce, 2023).

Data Analysis

The collected data were analysed using the Statistical Package for the Social Sciences (SPSS). Three statistical analyses were conducted to address the research objective. First, descriptive statistics, including frequencies, percentages, and mean scores, were employed to summarise respondents' demographic characteristics and determine the level of agreement for each cost predictive model approach (Bulanov et al., 2021; Ahmed, 2024). Mean values were subsequently interpreted using predefined agreement levels. Second, a normality test was performed to determine whether the collected data satisfied the assumptions required for parametric statistical analysis (Yadgarov et al., 2021; Abdi, 2023; Habibzadeh, 2024). Since the data were measured using an ordinal Likert scale and did not satisfy the normality assumption, a non-parametric statistical technique was selected. Finally, the Kruskal–Wallis H test was employed to examine whether statistically significant differences existed in respondents' perceptions of cost predictive model approaches across different organisational categories (client, consultant, contractor, and subcontractor). The Kruskal–Wallis test is an appropriate non-parametric alternative to one-way ANOVA for comparing more than two independent groups measured using ordinal data (Rizk, 2023). Statistical significance was determined at the 95% confidence level ($\alpha = 0.05$), whereby a p-value greater than 0.05 indicates that no statistically significant difference exists among the comparison groups.

RESULTS AND DISCUSSION

Respondents' Demographic Profile

A total of 58 valid responses were collected from Quantity Surveyors employed in client, consultant, contractor, and subcontractor organisations. Consultants represented the largest proportion of respondents (44.8%), followed by contractors (39.7%), clients (13.8%), and subcontractors (1.7%). Most respondents were Provisional Quantity Surveyors (79.3%), indicating that the sample primarily consisted of early-career professionals actively involved in construction cost estimation. Regarding working experience, approximately 65.5% of respondents had less than five years of professional experience, while only 10.3% possessed more than ten years of experience. Furthermore, almost half of the respondents (48.3%) reported having only limited experience with cost predictive models, mainly involving traditional statistical approaches, whereas only 22.4% had experience using statistical or spreadsheet-based predictive techniques. These findings suggest that although Quantity Surveyors regularly perform construction cost estimation, the adoption of advanced predictive technologies remains relatively limited within current industry practice.

Table 3: Respondents' Demographic Profile

Variable	Category	Frequency	Percentage (%)
Organisation	Client	8	13.8
	Consultant	26	44.8
	Contractor	23	39.7
	Subcontractor	1	1.7
Working Experience	< 5 years	38	65.5
	5–10 years	14	24.1
	>10 years	6	10.4
Experience with Cost Predictive Models	No experience	17	29.3
	Basic/Traditional	28	48.3
	Statistical/Spreadsheet Models	13	22.4

Cost Predictive Model Approaches in Construction Organisations

Table 4 presents respondents' perceptions of the seven cost predictive model approaches. Overall, all approaches achieved mean values above 3.70, indicating a consistently high level of agreement among Quantity Surveyors. This finding demonstrates that practitioners acknowledge the importance of both conventional and emerging predictive techniques for improving construction cost estimation.

Traditional Statistical Models recorded the highest mean score (M = 4.21), followed by Fuzzy Logic and AI-Based Models (M = 4.07) and Hybrid Models (M = 4.07). Artificial Neural Networks (M = 4.02) and Big Data Analytics (M = 3.94) also received favourable evaluations, while Machine Learning (M = 3.85) and Probabilistic and Bayesian Models (M = 3.76) obtained comparatively lower, although still high, levels of agreement.

Table 4: Mean Analysis of Cost Predictive Model Approaches

Rank	Cost Predictive Model	Mean	Level
1	Traditional Statistical Model	4.21	High
2	Fuzzy Logic and AI-Based Model	4.07	High
2	Hybrid Model	4.07	High
4	Artificial Neural Networks (ANN)	4.02	High
5	Big Data Analytics	3.94	High

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6	Machine Learning	3.85	High
7	Probabilistic and Bayesian Models	3.76	High

The prominence of Traditional Statistical Models indicates that these techniques remain the preferred approach among Quantity Surveyors due to their simplicity, transparency, and familiarity within professional practice. This observation is consistent with Singh et al. (2024), who reported that regression-based approaches continue to dominate early-stage construction cost estimation because they are easily interpreted and require relatively limited computational resources.

Interestingly, respondents also expressed strong agreement towards AI-based and Hybrid Models, suggesting growing awareness of intelligent prediction techniques within the Malaysian construction industry. This finding supports Chen et al. (2025), Das et al. (2024), and Alrasheed et al. (2025), who concluded that artificial intelligence significantly improves prediction accuracy, particularly for complex projects involving numerous cost variables.

However, Machine Learning, Big Data Analytics, and Probabilistic Models received comparatively lower mean scores. Although these approaches have demonstrated superior predictive capabilities in previous studies, their practical implementation requires extensive datasets, digital infrastructure, computational resources, and specialised analytical expertise. Consequently, their adoption within construction organisations remains relatively limited despite their recognised potential.

Comparison among Construction Organisations

The Kruskal–Wallis H test was conducted to determine whether perceptions differed among respondents working in client, consultant, contractor, and subcontractor organisations. The results indicated that all p-values exceeded the significance threshold of 0.05 (Table 5), demonstrating that no statistically significant differences existed among organisational categories. This finding suggests that Quantity Surveyors across different organisational settings share similar perceptions regarding the usefulness of cost predictive models.

Table 5: Kruskal–Wallis Test Results

Model	**p-value**	**Interpretation**
Traditional Statistical Model	0.642	Not Significant
Artificial Neural Network	0.629	Not Significant
Machine Learning	0.325	Not Significant
Fuzzy Logic & AI-Based Model	0.301	Not Significant
Hybrid Model	0.712	Not Significant
Big Data Analytics	0.420	Not Significant
Probabilistic & Bayesian Model	0.146	Not Significant

Regardless of organisational role, practitioners recognised both traditional and advanced predictive techniques as valuable tools for improving construction cost estimation. The consistency observed across organisational categories may reflect the increasing standardisation of cost estimation practices within the Malaysian construction industry. Digital transformation initiatives and wider exposure to Building Information Modelling (BIM), artificial intelligence, and data analytics have likely contributed to a common understanding of modern cost prediction approaches. Nevertheless, the relatively stronger preference for traditional statistical models indicates that practical implementation of advanced predictive technologies remains at an early stage.

DISCUSSION

The findings demonstrate that construction organisations continue to rely primarily on conventional statistical techniques while simultaneously recognising the potential of artificial intelligence and data-driven predictive approaches. Although Traditional Statistical Models remain the most widely accepted method because of their interpretability and ease of application, respondents acknowledged that AI-based models, including Artificial Neural Networks, Hybrid Models, and Fuzzy Logic, offer considerable advantages for improving estimation accuracy in increasingly complex construction environments.

The lower mean scores obtained for Machine Learning, Big Data Analytics, and Probabilistic Models should not be interpreted as a rejection of these technologies. Instead, they likely reflect practical implementation challenges, including limited digital maturity, insufficient historical datasets, lack of technical expertise, and organisational readiness. These findings are consistent with previous studies reporting that technological capability alone does not determine successful adoption; organisational resources, data quality, and user competency remain equally important factors influencing implementation (Abed et al., 2022; Padala & Goyal, 2025).

Overall, the results indicate that the Malaysian construction industry is currently transitioning from traditional cost estimation practices towards intelligent predictive systems. Future implementation should therefore focus on integrating conventional statistical methods with advanced AI-driven approaches to improve estimation accuracy while maintaining transparency and practitioner confidence. Such integration would enable construction organisations to benefit from enhanced predictive performance without sacrificing the interpretability required for professional decision-making.

CONCLUSION

This study examined the cost predictive model approaches adopted by construction organisations from the perspective of Quantity Surveyors. The findings revealed a high level of agreement for all seven predictive model approaches, indicating that both conventional and advanced techniques are recognised as valuable tools for improving construction cost estimation. Among the evaluated approaches, Traditional Statistical Models achieved the highest level of agreement, suggesting that they remain the preferred method in industry practice due to their simplicity, transparency, and ease of implementation. Nevertheless, respondents also expressed positive perceptions towards Artificial Neural Networks, Fuzzy Logic and AI-Based Models, Hybrid Models, Big Data Analytics, and Probabilistic Models, reflecting an increasing awareness of intelligent and data-driven cost prediction techniques.

The Kruskal–Wallis analysis further demonstrated that no statistically significant differences existed among respondents from client, consultant, contractor, and subcontractor organisations. This finding indicates a shared industry perspective regarding the importance of cost predictive models, irrespective of organisational role. Although advanced predictive approaches have demonstrated superior forecasting capabilities in previous studies, their practical adoption remains constrained by challenges related to organisational readiness, data availability, digital infrastructure, and technical expertise. The study contributes to the growing body of knowledge on construction cost estimation by providing empirical evidence on practitioners' perceptions of contemporary cost predictive models within the Malaysian construction industry. From a practical perspective, the findings provide useful insights for construction organisations, professional Quantity Surveyors, and policymakers seeking to enhance estimation accuracy and support digital transformation initiatives. The results also suggest that integrating traditional statistical techniques with emerging artificial intelligence and machine learning approaches may provide a more balanced and effective strategy for future construction cost prediction.

This research is limited by its relatively small sample size and geographical coverage, which focused on Quantity Surveyors from selected regions in Malaysia. Consequently, the findings may not fully represent the broader construction industry. Future studies should include larger and more diverse samples, incorporate additional construction stakeholders such as project managers, engineers, and clients, and evaluate the actual predictive performance of different cost estimation models using real project datasets. Comparative studies involving Building Information Modelling (BIM), Artificial Intelligence, and Digital Twin technologies would also provide valuable insights into the future development of intelligent construction cost prediction systems.

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