The Impact of Automation Technologies on Cost Estimation Accuracy and Efficiency in Quantity Surveying Practice in Malaysia

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Abstract—**Digital transformation in the construction industry has accelerated the adoption of automation The rapid development of digital technology in line with the Construction 4.0 agenda has accelerated the use of automation technology in the construction industry, especially in Quantity Surveying (QS) practices. Technologies such as Building Information Modelling (BIM), Artificial Intelligence (AI), digital cost estimating software and automated quantity surveying systems have the potential to improve the cost estimating process by improving data accuracy, reducing human error and increasing operational efficiency. However, empirical evidence regarding the impact of automation technology on cost estimating performance among Quantity Surveying practitioners in Malaysia is still limited. Therefore, this study aims to identify the level of automation technology usage and examine its relationship with the accuracy and efficiency of cost estimating in Quantity Surveying practices in Malaysia. This study uses a quantitative approach through a cross-sectional survey design. Data were collected using an online questionnaire distributed to 80 Quantity Surveying practitioners from Kelantan, Kuala Lumpur, Selangor, Johor and Penang through purposive sampling and convenience sampling methods. The data obtained were analysed using the Statistical Package for Social Sciences (SPSS) software through descriptive statistical analysis and Pearson Correlation. The findings of the study showed that the level of automation technology usage among Quantity Surveyors was at a moderately high level with an overall mean score of 3.82. In addition, there was a significant positive relationship between automation technology and cost estimation accuracy ($r = 0.63$, $p < 0.05$) and cost estimation efficiency ($r = 0.71$, $p < 0.05$). The results of the study proved that automation technology contributed positively to increasing the reliability of cost estimation, reducing manual workload, accelerating information processing and increasing professional productivity. Overall, this study emphasizes the important role of automation technology in supporting the digital transformation of the Quantity Surveyor profession and provides practical implications for the industry, professional bodies and educational institutions in strengthening digital competencies and expanding the use of technology sustainably in the Malaysian construction industry.**

Keywords— Automation technology, Quantity Surveying, Cost Estimation, Building Information Modelling (BIM), Digital Transformation

I. INTRODUCTION

The construction industry is undergoing significant transformation driven by the advancement of digital technologies and the emergence of the Construction 4.0 agenda. Technologies such as Building Information Modelling (BIM), Artificial Intelligence (AI), cloud computing, and digital information systems are increasingly being adopted to improve productivity, project performance, and decision-making processes throughout the project lifecycle [1], [11].

Within this evolving environment, the Quantity Surveying (QS) profession is required to adapt to digital transformation in order to remain competitive and relevant. Traditionally, QS practitioners have relied on manual measurement, spreadsheets, and professional judgment for cost estimation and cost management activities. Although these approaches remain useful, they are often associated with repetitive tasks, longer processing times, and a greater risk of human error [2], [3].

The adoption of automation technologies has significantly changed cost estimation practices in the

construction industry. Technologies such as BIM, digital estimating software, automated quantity take-off

systems, and AI applications enable quantity surveyors to perform cost estimation activities more efficiently and accurately. These technologies facilitate automated calculations, improve information consistency, reduce manual errors, and support better decision-making processes [4], [5].

In Malaysia, various initiatives have been introduced to promote digital transformation within the construction industry. Through the Construction 4.0 Strategic Plan, the Construction Industry Development Board (CIDB) Malaysia has encouraged the adoption of BIM and other digital technologies to improve industry productivity, project delivery performance, and competitiveness [1], [11]. As a result, the use of automation technologies among QS practitioners is becoming increasingly important.

Despite these developments, empirical studies examining the direct impact of automation technology on cost estimation performance among Malaysian QS practitioners remain limited. Most previous studies have focused on technology implementation challenges and adoption issues rather than evaluating the influence of automation technologies on cost estimation outcomes. Consequently, there remains a need to investigate how automation technology affects cost estimation accuracy and efficiency within QS practice.

Therefore, this study aims to investigate the level of automation technology adoption and examine its relationship with cost estimation accuracy and cost estimation efficiency among Quantity Surveying practitioners in Malaysia.

II. LITERATURE REVIEW

A. Automation Technology in Quantity Surveying Practice

The construction industry is undergoing significant changes as a result of the application of digital technology in line with the Construction 4.0 agenda. This technology aims to improve project performance, productivity, information management and the effectiveness of decision-making processes throughout the project life cycle. Among the technologies that are increasingly used in the construction sector are Building Information Modelling (BIM), Artificial Intelligence (AI), cloud-based systems, digital cost estimating software and automated data management platforms [1], [11].

In Quantity Surveying practice, automation technology has changed the traditional approach to quantity surveying, cost estimating and project cost management. Traditionally, quantity surveyors relied on manual measurements, the use of electronic spreadsheets, printed drawings and professional judgment in preparing cost estimates. Although this approach is still relevant, it is often associated with time-consuming work processes, repetitive tasks and the risk of calculation errors [2], [3].

Automation technology allows quantity surveyors to carry out cost estimating activities more systematically and efficiently. BIM-based Quantity Take-Off (QTO) systems allow quantities to be obtained directly from digital models, thereby reducing the need for manual measurements and improving information consistency [2]. In addition, digital cost estimating software helps practitioners manage project cost data, produce estimates and update information more effectively.

BIM is one of the most widely used technologies in the surveying profession. According to CIDB Malaysia, BIM facilitates information integration, collaboration and data sharing between project stakeholders, thus improving the effectiveness of project management and cost control [1]. BIM also provides an integrated digital environment that supports accurate quantity measurement and more systematic management of project information throughout the project implementation [12].

In addition to BIM, AI technology is also receiving increasing attention in the construction industry. AI applications have the potential to automate routine tasks, analyse large amounts of project data, support cost forecasting and improve decision-making processes. Although the use of AI in the surveying profession in Malaysia is still at a limited level, recent studies have shown that this technology has the potential to increase productivity, reduce human error and strengthen cost management capabilities in the future [5].

Overall, automation technology is increasingly recognized as a key driver of digital transformation in the surveying profession. The use of BIM, AI and digital software provides opportunities for practitioners to improve professional performance and the effectiveness of construction project implementation.

B. Cost Estimating Accuracy in Quantity Surveying Practice

Cost estimation accuracy is one of the most important aspects of quantity surveying practice because it directly impacts project budget preparation, financial planning, tender evaluation and cost control activities. Accurate cost estimation enables stakeholders to make more effective decisions and reduces the risk of cost overruns during project implementation [2].

Traditionally, cost estimation activities have relied heavily on manual calculations, quantity measurements, previous cost data and professional judgment. Although experienced practitioners are able to produce satisfactory estimates using conventional methods, manual processes are still prone to errors, information omissions and data inconsistencies that can affect the financial performance of the project [3].

The use of automation technology has improved the accuracy of cost estimation by improving data quality and reducing reliance on manual processes. BIM-based estimating systems allow quantities to be generated directly from the project model, thus reducing measurement errors and increasing the accuracy of quantity data [4]. In addition, automated systems help to improve information consistency and reduce duplication of work during the project development process.

Digital cost estimating software also contributes to increased accuracy through more systematic cost data management and access to constantly updated project information. Through automated calculations and the use of integrated databases, practitioners can reduce calculation errors and produce more reliable estimates [2].

Recent studies have also shown that AI technology has the potential to improve the accuracy of cost estimating through predictive analytics and data-driven modelling. AI applications are able to analyse past project data, identify cost patterns, and support a more accurate cost forecasting process [5]. Therefore, automation technology is increasingly seen as an important instrument in improving the accuracy of cost estimation and the effectiveness of project cost management.

C. Cost Estimating Efficiency in Quantity Surveying Practice

In addition to accuracy, efficiency is another important performance indicator in quantity surveying practice. Cost estimating efficiency refers to the ability of practitioners to complete estimating activities in a shorter period of time without compromising the quality and reliability of the work.

The traditional cost estimating process typically involves extensive manual measurements, repetitive calculations, and time-consuming document reviews. This can lead to longer estimate preparation times and reduced organizational productivity, especially for large-scale and complex construction projects [3].

Automation technology has helped improve operational efficiency by reducing repetitive tasks and accelerating information processing. BIM-based QTO systems allow quantities to be generated automatically, thus reducing the time required for measurement activities compared to conventional methods [2], [4]. In addition, digital cost estimating software facilitates the process of cost calculation, report preparation, and project data management in a faster and more systematic manner.

The use of digital technology also allows project information to be updated in real time, thus reducing delays caused by design changes or data revisions. As a result, quantity surveyors can respond more quickly to project changes and produce cost estimates in a shorter period of time.

In addition, AI technology has the potential to improve efficiency through automated data analysis, predictive modelling, and intelligent decision support systems. This capability allows practitioners to focus on more valuable analytical and strategic activities rather than repetitive routine tasks [5].

Previous studies have shown that organizations that implement digital technology typically experience increased productivity, operational effectiveness, and workflow performance [2], [4]. Therefore, increased efficiency is one of the key factors driving the adoption of automation technology in the quantity surveying profession.

D. Technology Adoption and Digital Transformation in the Quantity Surveying Profession

The success of automation technology implementation depends not only on the capabilities of the technology itself, but also on the willingness of users to accept and use it effectively. The Technology Acceptance Model (TAM) introduced by Davis [10] explains that technology acceptance is influenced by users' perceptions of the usefulness and ease of use of a technology.

In surveying practice, automation technology offers various benefits such as increased estimation accuracy, reduced manual workload, increased productivity and more effective project information management. When practitioners see the technology as useful and easy to use, they are more likely to integrate it into their daily work practices.

Although the benefits of digital technology are increasingly recognized, various challenges still affect its adoption in the surveying profession. Previous studies have identified several key barriers such as implementation costs, lack of technical expertise, inadequate training, resistance to change and lack of management support [3], [4]. These challenges can slow down the adoption of more advanced technologies, especially in small and medium-sized organizations.

The Malaysian construction industry is also actively promoting digital transformation through various initiatives introduced by CIDB Malaysia through the Construction 4.0 Strategic Plan [11]. These initiatives aim to accelerate the adoption of technology, increase industry competitiveness and strengthen workforce readiness in the digital construction environment.

As the use of technology and data increases in the construction industry, surveying practitioners need to strengthen their digital competencies to ensure the profession remains relevant and competitive. Therefore, understanding the impact of automation technology on professional performance is essential in supporting the sustainability of the surveying profession in the future.

E. Research Gaps

The literature highlights that automation technologies such as BIM, AI and digital cost estimating software have great potential in improving the effectiveness of construction cost management. Most previous studies have focused on BIM implementation, technology adoption challenges and digital transformation initiatives in the construction industry [2], [3], [4].

However, empirical studies that specifically examine the relationship between the use of automation technology and cost estimating performance among quantity surveyors are still limited, especially in the Malaysian context. Most studies focus more on the barriers and benefits of technology adoption than directly assessing the impact of automation technology on cost estimating outcomes.

In addition, there is still a lack of empirical evidence explaining whether automation technology has a greater impact on the accuracy or efficiency of cost estimating. This gap indicates the need to conduct more in-depth studies to understand the true impact of the use of automation technology in quantity surveying practices.

Accordingly, this study was conducted to identify the level of automation technology adoption and examine its relationship with the accuracy and efficiency of cost estimating among quantity surveyors in Malaysia.

III. CONCEPTUAL FRAMEWORK

A. Conceptual Framework

The construction industry is increasingly adopting automation technology to improve project performance, productivity and information management effectiveness. In surveying practices, technologies such as Building Information Modelling (BIM), Artificial Intelligence (AI), digital cost estimating software and automated quantity surveying systems have transformed traditional approaches to cost estimating and project cost management [1], [2], [5].

Previous studies have shown that automation technology contributes to increasing the accuracy of quantity surveying, reducing calculation errors, improving information consistency and accelerating the cost estimating process [2], [4]. This technology also supports more effective project information management through automation, digital integration and real-time data updates [1], [12].

Based on the literature review, automation technology is set as the independent variable in this study, while cost estimating accuracy and cost estimating efficiency act as the dependent variables. The conceptual framework developed is based on the assumption that the increased use of automation technology enables surveying practitioners to perform cost estimating activities more accurately and efficiently.

Therefore, this study suggests that automation technology has a positive influence on cost estimating accuracy and cost estimating efficiency in surveying practices.

This research framework is also supported by the Technology Acceptance Model (TAM) introduced by Davis [10]. This model explains that an individual is more likely to accept and use a technology when the technology is considered useful and easy to use. Therefore, when automation technology is seen to be able to increase work accuracy, productivity and efficiency, surveying practitioners are expected to be more likely to integrate the technology into their professional practices.

B. Hypothesis Development

Hypothesis 1 (H1): Relationship between Automation Technology and Cost Estimation Accuracy

Cost estimation accuracy is one of the most important performance indicators in surveying practices because it affects project budget preparation, tender evaluation, financial planning and cost control. Accurate cost estimates can help stakeholders make more effective decisions and reduce the risk of cost overruns during project implementation [2].

Automation technologies such as BIM, digital cost estimating software and automated quantity surveying systems have been introduced to improve the accuracy of construction cost estimation. BIM-based systems allow quantities to be extracted directly from digital models, thereby reducing manual measurement errors and improving data consistency [4]. In addition, digital cost estimating software supports more systematic cost data management and automates the calculation process, thus reducing the possibility of human error.

AI technology also shows potential in improving the accuracy of cost estimation through predictive analysis and data-driven modelling. AI applications are able to analyse previous project information, identify cost patterns and produce more reliable forecasts [5].

Previous studies have reported that the use of digital technology has a positive impact on the quality and reliability of construction cost information [2], [4], [5]. Therefore, increasing the level of use of automation technology is expected to improve the accuracy of cost estimation among quantity surveyors.

Based on the discussion, the following hypotheses are proposed:

H1: There is a significant positive relationship between automation technology and the accuracy of cost estimation in quantity surveyors.

Hypothesis 2 (H2): Relationship between Automation Technology and Cost Estimating Efficiency

Cost estimating efficiency refers to the ability of quantity surveyors to complete estimating activities in a shorter period of time without compromising the quality and accuracy of the work. In today's construction industry environment, efficiency is increasingly important due to increasing project complexity, time constraints and higher customer expectations [3].

Automation technology contributes significantly to increasing efficiency by reducing repetitive manual tasks, accelerating information processing and automating the calculation process. BIM-based quantity surveying systems enable quantities to be generated faster than conventional methods, while digital cost estimating software improves workflow efficiency by automating cost calculations and reporting [2], [4].

In addition, AI technology offers opportunities to improve operational efficiency through automated data analysis, predictive modelling and intelligent decision support systems. This capability allows practitioners to focus on more strategic and analytical tasks rather than repetitive routine activities [5].

Previous studies have shown that organizations that implement digital technologies typically experience increased productivity, operational effectiveness and workflow performance [2], [4]. Therefore, the increased use of automation technology is expected to contribute positively to cost estimation efficiency among quantity surveying practitioners.

Based on the discussion, the following hypothesis is proposed:

H2: There is a significant positive relationship between automation technology and cost estimation efficiency in quantity surveying practices.

IV. RESEARCH METHODOLOGY

A. Study Design

This study uses a quantitative approach with a cross-sectional survey design to examine the impact of automation technology on the accuracy and efficiency of cost estimating among quantity surveyors in Malaysia. The quantitative approach was chosen because it is suitable for studying the relationship between variables objectively through statistical analysis based on numerical data [6].

The survey method was used because it allows data collection from a number of respondents in a short period of time and facilitates researchers to obtain information related to respondents' perceptions and experiences of the use of automation technology in professional practice. In addition, this approach is often used in studies involving technology acceptance, digital transformation and organizational performance in the construction industry.

B. Population and Sampling Techniques

The target population of this study consists of quantity surveyors who are directly involved in cost estimating activities, cost planning, preparation of tender documents and cost management of construction projects in Malaysia. Respondents consist of consulting quantity surveyors, contractor quantity surveyors, professional quantity surveyors and cost management practitioners serving in the public and private sectors.

Data collection focused on quantity surveyors operating in Kelantan, Kuala Lumpur, Selangor, Johor and Penang. The selection of these states was based on the rapid pace of construction activities and the existence of organizations that actively use digital technology in construction project management.

This study used non-probability sampling involving a combination of purposive sampling and convenience sampling. Purposive sampling was used to ensure that the selected respondents had experience and knowledge related to the use of automation technology in quantity measurement practices. Subsequently, convenience sampling was used to facilitate the distribution of the questionnaire through professional networks, industry contacts and online platforms [7].

A total of 80 complete sets of questionnaires were successfully collected and used in the study analysis. Although the sample was focused on five specific states, the respondents involved represented a variety of organizational backgrounds and different levels of professional experience.

C. Study Instrument

This study used a structured questionnaire as the main instrument for data collection. The questionnaire was developed based on previous studies related to Building Information Modelling (BIM), automation technology, digital transformation and cost estimation performance in the construction industry [2], [4], [5].

The questionnaire consists of four main sections:

Section A: Respondent demographic information covering gender, age, work experience and type of organization.

Section B: Use of automation technology covering the use of BIM, digital cost estimating software, workflow automation, digital cost management practices and Artificial Intelligence (AI) related applications.

Section C: Cost estimating accuracy which measures respondents' perceptions of reduced calculation errors, accuracy of quantity measurement, reliability of estimates and consistency of cost information.

Section D: Cost estimating efficiency which assesses aspects of time saving, reduced manual workload, increased productivity and speed of information processing.

All items are measured using a five-point Likert Scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). This scale is widely used in social science research as it is suitable for measuring respondents' perceptions, attitudes and level of agreement with a statement [8].

D. Data Collection Procedure

The study data were collected using an online questionnaire developed through the Google Forms platform. The questionnaire link was distributed to surveyors through social media, professional networks and construction industry communication channels.

The data collection process was carried out over a period of several weeks to ensure a satisfactory response rate. Respondent participation was voluntary and all information obtained was kept confidential and used for academic purposes only. To ensure data quality, incomplete questionnaires or those with insufficient information were removed from the final analysis.

E. Data Analysis

The data obtained were analysed using the Statistical Package for Social Sciences (SPSS) software. Descriptive and inferential statistical analysis were used to achieve the stated study objectives.

Descriptive statistical analysis involving frequencies, percentages, mean and standard deviations was used to describe the demographic profile of the respondents and determine the level of use of automation technology among surveyors. The interpretation of the mean score is based on the range shown in Table I.

Table I:
Mean Score Interpretation

Mean Score	Interpretation
1.00 – 2.33	Low
2.34 – 3.66	Medium
3.67 – 5.00	High

To test the relationship between the study variables, Pearson Correlation analysis was used to assess the relationship between automation technology and cost estimation accuracy and cost estimation efficiency. This analysis is suitable for determining the strength and direction of the relationship between two variables that are measured continuously [9].

The interpretation of the strength of the correlation coefficient is based on the range shown in Table II.

Table II:
Interpretation of the Strength of Pearson Correlation Coefficient

Mean Score	Value Interpretation
0.00 – 0.19	Very Weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very Strong

A correlation coefficient value close to +1 indicates a strong positive relationship, while a value close to 0 indicates a weak relationship. In this study, the significance level for all statistical tests was set at $p < 0.05$.

Based on the study objectives, two hypotheses were developed and tested as follows:

H1: There is a significant positive relationship between automation technology and the accuracy of cost estimation in quantity measurement practices.

H2: There is a significant positive relationship between automation technology and the efficiency of cost estimation in quantity measurement practices.

V. RESULTS AND DISCUSSION

A. Respondent Demographic Profile

A total of 80 Quantity Surveying (QS) practitioners from Kelantan, Kuala Lumpur, Selangor, Johor, and Pulau Pinang participated in this study. The respondents represented various organisational backgrounds, including quantity surveying firms, contractor organisations, property developers, and government or academic institutions.

Table III:
Respondent Demographic Profile

Demographic	Category	Frequency	Percentage (%)
Gender	Male	46	57.5
	Female	34	42.5
Age	21–30 years	18	22.5
	31–40 years	35	43.8
	41–50 years	20	25.0
	51 years and above	7	8.7
Work Experience	<5 years	16	20.0
	5–10 years	31	38.8
	11–15 years	21	26.2
	>15 years	12	15.0
Organisation Type	QS Firm	42	52.5
	Contractor	20	25.0
	Developer	9	11.3
	Government / Academic	9	11.2

As presented in Table III, male respondents constituted the majority of the sample, accounting for 57.5% of the total respondents, while female respondents represented 42.5%. In terms of age distribution, respondents aged between 31 and 40 years recorded the highest proportion (43.8%), indicating that most participants were mid-career professionals actively involved in quantity surveying practice.

Regarding professional experience, the largest group of respondents possessed between five and ten years of working experience (38.8%), followed by those with eleven to fifteen years of experience (26.2%). This finding suggests that the collected responses were obtained from practitioners with substantial exposure to construction cost management and estimation activities. Furthermore, more than half of the respondents were employed in quantity surveying firms (52.5%), reflecting the relevance of the sample to the objectives of the study.

B. Level of Aumation Technology Adoption in QS Practice

This section examines the level of automation technology adoption among QS practitioners in Malaysia.

Descriptive statistical analysis was performed using mean scores and standard deviations.

Table IV:
Level of Automation Technology Adoption

Item	Mean	SD	Interpretation
BIM supports cost estimation	4.12	0.73	High
Digital software improves cost data management	4.20	0.68	High
Automation technology reduces manual work	3.95	0.79	High
Digital technology accelerates work processes	3.88	0.82	High
AI adoption in QS practice	3.10	0.94	Moderate
Overall Mean	**3.82**	**0.79**	**High**

Overall Mean = 3.82 (Moderately High Level)

Table IV indicates that the overall level of automation technology adoption among QS practitioners is high, with an overall mean score of 3.82. The highest mean score was recorded for the utilisation of digital software in improving project cost data management (M = 4.20, SD = 0.68). This finding highlights the growing importance of digital solutions in facilitating efficient data storage, management, and retrieval within construction cost management processes.

Similarly, BIM utilisation for cost estimation recorded a high mean score (M = 4.12, SD = 0.73), demonstrating that BIM has become increasingly recognised as a valuable tool for enhancing quantity take-off processes and improving cost estimation practices. The findings also indicate that automation technologies contribute to reducing manual workloads (M = 3.95) and accelerating work processes (M = 3.88), thereby enhancing productivity and operational efficiency.

Conversely, AI adoption recorded the lowest mean score (M = 3.10, SD = 0.94), suggesting that AI implementation remains at a relatively early stage within the Malaysian QS profession. This may be attributed to implementation costs, limited technical expertise, organisational readiness issues, and concerns regarding the reliability of AI-based applications.

Overall, the findings suggest that BIM and digital technologies have gained substantial acceptance among QS practitioners, whereas the adoption of AI technologies is progressing at a comparatively slower pace.

C. Relationship Between Automation Technology and Cost Estimation Accuracy

Pearson Correlation analysis was conducted to examine the relationship between automation technology adoption and cost estimation accuracy.

Table V:
Pearson Correlation Analysis: Automation Technology and Cost Estimation Accuracy

Variable	r	p-value	Interpretation
Automation Technology ↔ Cost Estimation Accuracy	0.63	0.000	Strong Positive Relationship

The results presented in Table V reveal a statistically significant positive relationship between automation technology and cost estimation accuracy ($r = 0.63$, $p < 0.05$). The correlation coefficient indicates a strong positive relationship, suggesting that higher levels of automation technology adoption are associated with greater accuracy in cost estimation activities.

The findings imply that automation technologies such as BIM, digital estimating software, and automated data management systems contribute to reducing calculation errors, improving quantity measurement precision, and enhancing the consistency of project cost information. These technologies enable practitioners to access more accurate and integrated project data, thereby supporting more reliable

estimation outcomes.

The findings are consistent with previous studies which reported that digital technologies facilitate systematic information integration and improve the quality of cost-related project data [4]. Therefore, the results support the proposition that automation technology plays a significant role in improving cost estimation accuracy within quantity surveying practice.

Based on the findings, **Hypothesis 1 (H1) is accepted**.

D. Relationship Between Automation Technology and Cost Estimation Efficiency

Pearson Correlation analysis was also performed to investigate the relationship between automation technology adoption and cost estimation efficiency.

Table VI:
Pearson Correlation Analysis: Automation Technology and Cost Estimation Efficiency

Variable	r	p-value	Interpretation
Automation Technology ↔ Cost Estimation Efficiency	0.71	0.000	Strong Positive Relationship

Table VI shows a statistically significant positive relationship between automation technology and cost estimation efficiency ($r = 0.71$, $p < 0.05$). The correlation coefficient indicates a strong positive relationship and represents the strongest relationship identified in this study.

The findings demonstrate that increased adoption of automation technologies contributes significantly to operational efficiency within QS practice. Digital technologies facilitate faster preparation of cost estimates, reduce repetitive manual tasks, improve data processing capabilities, and enhance professional productivity. Consequently, QS practitioners are able to allocate more time to analytical and strategic activities rather than routine calculations and administrative tasks.

Interestingly, the relationship between automation technology and cost estimation efficiency was found to be stronger than its relationship with cost estimation accuracy. This suggests that the benefits of automation technology are more immediately observable in terms of productivity improvement, workflow optimisation, and time savings.

The findings support previous studies which emphasised that digitalisation within the QS profession contributes significantly to operational effectiveness and improved project cost management performance [2].

Based on the findings, **Hypothesis 2 (H2) is accepted**.

E. Discussion

Overall, the findings demonstrate that automation technology adoption among Malaysian QS practitioners is at a high level, with BIM and digital software being more widely utilised than AI technologies. This reflects the ongoing digital transformation occurring within the construction industry and highlights the increasing importance of technology-driven approaches in construction cost management.

The study further revealed that automation technology has significant positive relationships with both cost estimation accuracy and cost estimation efficiency. However, the relationship with efficiency was found to be stronger, indicating that automation technologies provide more immediate and visible benefits in terms of productivity enhancement and workflow optimisation.

Despite these positive developments, the adoption of emerging technologies such as AI remains relatively limited within the Malaysian QS profession. This situation may be influenced by implementation costs, insufficient professional training, organisational readiness, and the level of digital competency among practitioners.

These findings are consistent with previous studies that identified technological readiness, professional competencies, and organisational support as critical factors influencing successful digital transformation

within the quantity surveying profession [3], [5]. Consequently, continued efforts are required from industry stakeholders, professional bodies, and higher education institutions to strengthen digital competencies and encourage wider adoption of advanced automation technologies.

The findings also support the objectives of Construction 4.0 initiatives, which emphasise the integration of digital technologies, automation systems, and intelligent information management to enhance the competitiveness and sustainability of the construction industry.

VI. CONCLUSION

This study investigated the impact of automation technology on cost estimation accuracy and efficiency among Quantity Surveying (QS) practitioners in Malaysia. The findings revealed that the adoption of automation technology is at a high level, with digital software and Building Information Modelling (BIM) being the most widely utilised technologies, while Artificial Intelligence (AI) remains at an early stage of implementation.

The results further demonstrated significant positive relationships between automation technology and both cost estimation accuracy ($r = 0.63$, $p < 0.05$) and cost estimation efficiency ($r = 0.71$, $p < 0.05$). These findings indicate that automation technologies contribute positively towards improving estimation reliability, reducing manual work, and enhancing operational productivity within QS practice.

This study contributes to the understanding of digital transformation within the Quantity Surveying profession by providing empirical evidence on the benefits of automation technology adoption. The findings also highlight the importance of continuous investment in digital technologies, professional training, and competency development to support the implementation of Construction 4.0 initiatives.

Although the study was limited to respondents from five states in Malaysia and employed non-probability sampling techniques, it provides useful insights into current automation technology practices among QS practitioners. Future studies are recommended to involve larger samples and examine the impact of emerging technologies such as AI-driven cost estimation systems and digital twin technologies on Quantity Surveying performance.

Overall, automation technology has significant potential to enhance cost estimation performance and support the continued digital transformation of the Quantity Surveying profession in Malaysia.

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DECLARATION OF GENERATIVE AI USAGE

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with language editing, grammar checking, manuscript organisation, and formatting. The authors critically reviewed and revised all generated content and take full responsibility for the final version of the manuscript.

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