Integrating BIM-Based Automated Measurement and Centralized Pricing Dashboards for Enhanced Pre-Tender Cost Management in Quantity Surveying Practice

Shee Yuan Chang., Low Kee Liang., Nurul Awadah Binti Zazali., Nur Fatiha Binti Zamri., Noor Wahidah Binti Yazid., Hamizah Liyana Tajul Ariffin., Norhazren Izatie Mohd

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

DOI: https://doi.org/10.47772/IJRISS.2026.10200160

Received: 11 February 2026; Accepted: 16 February 2026; Published: 27 February 2026

ABSTRACT

Pre-tender cost estimation in Malaysian Quantity Surveying (QS) firms continues to rely heavily on manual 2D quantity take-off and spreadsheet-based pricing, resulting in fragmented data, repetitive work, and reduced cost reliability. Despite the availability of BIM tools and digital platforms, existing practices lack an integrated workflow that links automated quantity measurement with live, centralized pricing during the pre-tender stage. This study addresses this gap by proposing an integrated digital workflow that combines BIM-based automated measurement using Glodon software with real-time pricing visualization through Google Looker Studio. The research adopts a system development and workflow analysis approach, in which the proposed system is conceptually designed and demonstrated based on identified limitations in current QS practices, supported by the literature. The system has not been tested on a live project but has been evaluated through functional comparison and process mapping. The proposed workflow demonstrates potential improvements in coordination, reduction of repetitive manual tasks, and enhanced reliability of pre-tender cost information, offering a QS-focused contribution to digital cost management practice

Key Words: Quantity Surveying, Pre- Tender Estimation, Bim Measurement, Cost Reliability

INTRODUCTION

The study area focuses on the work process in a Quantity Surveying (QS) firm in Malaysia. A QS firm supports cost management functions such as measuring construction elements, preparing Bills of Quantities (BQs), cost estimating, tendering, and administering Variation Orders (VOs), which are necessary for alignment with construction project delivery (Ashworth & Perera, 2018). Normally, a QS firm has diversified teams for pre-contract, post-contract, measurement, and documentation work, each specialized and collaborating to achieve cost accuracy and meet client needs (Ismail et al., 2021).

In terms of work culture, many Malaysian QS firms still use manual methods on a daily basis. It has been observed that manual take-offs from 2D drawings and spreadsheet-based estimating are still widely practised by different individuals who handle separate files in a QS office. This leads to fragmented information and inefficiencies (Naji et al., 2020; Shamsuddin et al., 2022). The lack of centralized data has resulted in a slow workflow, repetitive tasks, difficulty in retrieving past project information, and a higher risk of human error in these firms' problems, which have been strengthened in projects that are complicated and have design changes and VO cases (Mehrbod et al., 2019; Zainon et al., 2021).

Decision-making plays a crucial role in such a setting, as QS decisions affect project costs, tender competitiveness, and client satisfaction. Slow or inaccurate decisions may result in delays, cost overruns, and disputes, as noted in recent studies on Malaysian cost management practice (Yap & Lee, 2020). Hence, the use of digital solutions, such as automated measurement via Glodon and centralized cost data dashboards in

Google Data Studio, can be considered to improve collaboration, speed, and accuracy of the work. It can deliver faster, more reliable cost information in construction projects if digital tools are adopted as standard practice. Besides, digital tools make QS more efficient, increase data transparency, and improve decision-making quality. (Samsurijan et al., 2023; Mohd-Zain et al., 2024).

Although digital solutions such as Building Information Modelling (BIM)-based measurement applications and cost data dashboards are increasingly available, their practical implementation within Malaysian Quantity Surveying (QS) firms remains fragmented and inconsistent. The existing body of literature predominantly addresses BIM adoption, digital transformation, and cost management systems as discrete domains, with limited attention given to their functional integration within QS pre-tender processes and cost decision-making workflows.

More specifically, there is insufficient empirical investigation into how automated quantity take-off (QTO) systems can be systematically linked to centralized, real-time cost data platforms to support coherent, responsive cost planning. Current studies rarely examine the operational interface between measurement automation and dynamic cost intelligence, particularly in the context of managing design revisions and variation orders, areas that traditionally rely on labour-intensive manual recalculations and dispersed cost references. This fragmentation in the literature reveals a substantive research gap. There is a need for rigorous evaluation of the constraints inherent in prevailing manual practices, followed by the development and validation of an integrated digital workflow model tailored to the procedural, regulatory, and organizational realities of Malaysian QS practice. Such research would contribute not only to theoretical discourse on digital integration in construction cost management but also to practical frameworks that enhance efficiency, accuracy, and decision transparency in pre-contract cost operations.

Problem Statement

One of the largest problems Quantity Surveying (QS) consultancy firms face is the reliance on conventional methods for measuring and pricing works. Despite the availability of digital tools, many QS practitioners continue to rely on manual take-off from 2D drawings and spreadsheet-based measurement, resulting in an unorganized, scattered, and difficult-to-trace chain of information. These customary methods lead not only to estimation errors but also to inefficiencies, as demonstrated by studies showing that manual cost estimation is less accurate and less consistent than digital approaches such as BIM-based systems (Olatunji et al., 2010). As a result, QS staff are required to repeatedly check quantities, increasing the likelihood of human error and reducing the overall reliability of pre-tender cost estimates (Ismail et al., 2021).

The firm`s efficiency in carrying out its core business functions and accuracy are directly affected by this problem. The manual takeoff process is labour-intensive and lacks the scalability required for high-rise buildings, especially when each floor has different reinforcement and structural details, as QS staff must repeat their measurement tasks for each floor. This repeated-measurement process increases preparation time during the pre-tender stage and places additional workload on QS personnel, potentially delaying tender submissions and reducing productivity (Wen, 2023). Due to the lack of a centralized pricing system, QS staff primarily use different unit rates maintained in their personal files, leading to inconsistent pricing across projects and increasing the likelihood of tender inaccuracies or cost overruns.

Real-world industry situations demonstrate that QS staff need to refer to previous projects, suppliers should be contacted individually, and waiting days for a quotation response is the norm, which slows down decision-making and tender preparation. These problems are consistent with research findings indicating that the Malaysian QS profession continues to face fragmented data management, limited digital readiness, and overreliance on manual processes (Lim et al., 2024). Consequently, the lack of an integrated workflow linking quantity measurement and pricing information continues to affect cost accuracy, time efficiency, and tender reliability (Yin & Hong, 2024). This highlights the need to examine the limitations of current manual pre-tender practices and to explore a more reliable approach to support accurate and timely cost decision-making in QS practice.

LITERATURE REVIEW AND THEMATIC SYNTHESIS

Overview of Current Malaysian Practice

Quantity surveying (QS) practices in Malaysia rely largely on conventional methods, using 2D drawings, scale rulers, printed plans, and individual Excel spreadsheets for measurement and pricing. Research findings indicate that a majority of QS officers manually perform quantity take-offs from paper drawings or 2D CAD files while also recording cost data on their personal laptops, resulting in fragmented data and inconsistent pricing (Khalid, 2021; Yap et al., 2023). According to Lam et al. (2022), traditional manual take-off remains the primary method, despite the availability of more BIM-based tools.

The manual workflows exhibit structural inefficiencies, including redundant measurement tasks and an elevated risk of omission. For instance, the requirement for high-rise buildings that entails repetitive take-offs for each floor increases labour time and the risk of omission or duplication. (Soon et al., 2024; Chong & Wang, 2022). Besides that, pricing data suffers from fragmentation, leading to decentralized cost intelligence and inconsistent unit rates, which not only slows the tender preparation process but also reduces the data trustworthiness (Aziz et al., 2020; Muhammad et al., 2023). From the literature review, it is observed that the QS profession is slow to adopt digital tools because professionals are reluctant to change, lack training, and have been working in the same way for a long time (Yap et al., 2023; Rahman et al., 2021).

From a decision-making perspective, these limitations expose QS practices to a high degree of human error, especially under tight tender timelines and design changes. The lack of a centralized data environment prevents efficient verification, updating, and reuse of historical cost information, making it difficult to respond quickly to revisions and variation orders. As a result, traditional methods are unable to support accurate, timely, and consistent cost decisions in increasingly complex construction projects.

On the other hand, BIM-based quantity take-off enables automated extraction, reduces the risk of error, and offers greater project standardization (Lam et al., 2022; Abdullah & Ismail, 2020). Nevertheless, QS companies are mostly opting for the continuation of the manual and using isolated spreadsheets only, which is a clear indication of the digital transformation gap, and this gap is the reason for the loss of efficiency and the inability to be competitive in fast-moving tender environments (Khalid, 2021; Shakhmenko et al., 2020).

Literature Analysis Table

Summary of the current state of research on BIM integration for cost management:

Theme	Key Findings	Research Gaps	Sources
BIM-Based Quantity Take-Off vs. Manual	BIM reduces time spent on quantity takeoff and increases accuracy by minimizing the need for human interpretation.	Most studies focus on extraction but do not connect it to real-time pricing.	Lam et al. (2022); Abdullah & Ismail (2020).
Centralized Data	Common Data Environment (CDE) avoids "Information Islands" and facilitates collaboration between project stakeholders.	Research does not focus on pre-tender workflows specifically designed for QS firms.	Ashworth & Perera (2018); Laursen & Thorlund (2016)
BIM Adoption in Malaysia	Adoption is increasing but is hindered by the high cost of software, lack of standards and change resistance.	There is a lack of empirical evidence supporting the integration of workflows using software such as GLODON and Looker Studio.	Khalid (2021); Yap et al. (2023); Rahman et al. (2021)
Automated Pricing & Dashboard	Digital databases offer "a single source of truth" that automatically updates during design changes.	The working interfaces between measurement automation and dynamic cost-intelligence are an area that has been under-explored.	Laursen & Thorlund (2016)

Analysis of the literature reveals that while BIM-based measurement and the creation of centralized data environments have been researched individually, limited research has been conducted on integrating these two processes within QS pre-tender workflows, especially in Malaysia.

Thematic Synthesis of Existing Literature

The global discourse on BIM has shifted from simple 3D visualization to 5D cost estimation and data-driven decision-making. The literature can be synthesized into three primary themes that underscore the necessity for an integrated workflow.

Firstly, transition from an interpretation-driven to a data-driven workflow. The traditional method requires QS to interpret 2D drawings as they study building designs, but this process leads to human errors because it demands extensive effort (Khalid, 2021; Shamsuddin et al., 2022). Emerging research highlights that BIM-based measurements, such as Glodon, transform this into a data-driven process that allows users to extract quantities from 3D models with improved accuracy and auditability.

Secondly, breaking down “information islands” through integration. A major challenge identified in both global and Malaysian contexts is the existence of “information islands” where cost data remains fragmented across personal laptops and isolated spreadsheets (Aziz et al., 2020; Muhammad et al., 2023). Although the Common Data Environment (CDE) promotes better collaboration and data sharing (Laursen & Thorlund, 2016), academic studies treat BIM adoption and cost management as separate fields (Rahman et al., 2021; Yap et al., 2023). There is a critical need for frameworks that operationalize the linkage of these systems to provide a unified data flow.

Lastly, enhance responsiveness to design revisions. The manual recalculation of costs for every design change is a structural inefficiency that slows tender submissions (Chong et al., 2022; Soon et al., 2024). The literature indicates that 5D BIM models enable near-real-time updates to schedules and costs as changes happen (Lam et al., 2022; Davies & Wilkinson, 2020). Nevertheless, the combination of automated quantities with a pricing dashboard for quick pre-tender decision-making remains a significant research limitation.

Technological Solution And Available Tools

Measurement Workflow: Comparative Analysis of Excel-Based and BIM-Based (Glodon) Approaches

The evolution from Excel-based manual measurement to BIM-based measurement platforms such as Glodon represents a substantive transformation in quantity surveying practice rather than a mere software substitution. Traditional Excel-based workflows are fundamentally drawing-dependent and manually executed. Quantities are derived from 2D drawings using scale interpretation, manual dimension extraction, and spreadsheet tabulation. This approach relies heavily on the quantity surveyor's individual competence, concentration, and experience. The process is linear, labour-intensive, and highly susceptible to cumulative human error, particularly in large-scale or complex projects.

In contrast, BIM-based measurement using Glodon operates within a model-centric environment where quantities are extracted directly from an object-based 3D model. The measurement process becomes data-driven rather than interpretation-driven. Quantities are dynamically linked to model elements, enabling automatic updates when design modifications occur. This integration significantly enhances responsiveness to design revisions and reduces repetitive manual recalculation. However, it must be acknowledged that automation shifts the locus of risk from arithmetic and transcription errors to potential modelling inaccuracies. The reliability of automated outputs is therefore contingent upon the accuracy, completeness, and governance of the BIM model.

The divergence between these approaches becomes particularly pronounced in high-rise or repetitive building typologies. In Excel-based workflows, identical floors require separate measurement exercises, resulting in redundant effort and increased exposure to inconsistency. BIM platforms enable replication of model elements across similar floors, with quantities recalculated automatically. This scalability improves efficiency and standardization but presupposes structured modelling protocols to prevent systematic propagation of modelling errors.

At the pre-tender stage, where deadlines are compressed and design information may still be evolving, the limitations of manual measurement are amplified. The absence of structured tracking mechanisms in Excel complicates verification and auditability. Quantity surveyors often rely on personal notes or informal documentation to monitor progress, increasing the risk of omission before tender submission. BIM-based tools, by contrast, offer visual tracking of measured components within the model environment, enhancing transparency and internal quality control.

While Excel remains widely accepted due to familiarity and low technological barriers, its structural constraints, particularly in speed, revision management, scalability, and error exposure, pose significant risks in contemporary tendering environments. BIM-based solutions such as Glodon provide measurable advantages in efficiency, adaptability, and measurement reliability. Nevertheless, successful implementation requires organizational digital capability, disciplined modelling standards, and appropriate training. The technological shift, therefore, represents not merely automation but a reconfiguration of measurement governance and risk management within quantity surveying practice.

Table 1: Comparative Analysis of Excel-Based and BIM-Based (Glodon) Measurement

Analytical Criteria	Excel-Based Measurement	BIM-Based Measurement (Glodon)	Critical Implication
Measurement Logic	Manual extraction from 2D drawings using scale and spreadsheet tabulation	Automated extraction from 3D object-based BIM model	Shift from interpretation-driven to data-driven workflow
Handling of Repetitive Floors	Each floor measured separately, even if identical	Model elements duplicated across floors with automatic quantity updates	BIM improves scalability and reduces redundant effort
Design Revisions	Requires full or partial remeasurement for each drawing revision	Quantities update automatically when model changes	BIM enhances responsiveness, but dependent on model accuracy
Risk of Error	High risk of misreading, omission, double-counting, and transcription errors	Reduced computational error; risk shifts to modelling accuracy	Error profile changes rather than eliminated
Measurement Tracking	No integrated tracking; relies on manual notes	Model-based visualization and tracking of measured components	BIM improves auditability and verification
Speed and Productivity	Labour-intensive and time-consuming	Faster due to automated computation	Significant efficiency gains in large-scale projects
Visualization Support	Limited to 2D drawings; higher cognitive load	3D visualization enhances spatial understanding	Improved clarity in complex structural interpretation
Pre-Tender Suitability	Vulnerable under tight deadlines and evolving designs	More adaptable to revisions and rapid re-pricing	BIM better aligned with dynamic tender environments

Overall, the comparison demonstrates that BIM-based measurement platforms offer structural advantages over manual Excel-based methods, particularly in projects characterized by complexity, repetition, and frequent design changes. However, the transition demands institutional readiness, standardized modelling practices, and digital competency to ensure that automation translates into genuine reliability rather than unverified computational output.

Pricing Information Management: Comparative Analysis of Shared Folders and Google Looker Studio

Effective pricing management at the pre-tender stage requires accuracy, traceability, and real-time coordination among quantity surveying (QS) teams. Traditionally, shared folders such as Microsoft OneDrive or Google Drive are used to store Excel spreadsheets, supplier quotations, and PDF pricing documents. While these platforms facilitate file sharing and centralized storage, they primarily serve as static repositories rather than integrated pricing management systems. In this environment, pricing data is stored as discrete documents, and multiple versions of the same file may coexist. This often results in inconsistencies, outdated references, and parallel pricing calculations within the same tender exercise.

Manual updating is a defining limitation of shared-folder-based systems. Users must open individual Excel files, revise unit rates or supplier quotations, save new versions, and ensure that other team members are informed. When several users work concurrently, there is a heightened risk of overwritten data, untracked modifications, and formula errors. Spreadsheet risk literature consistently identifies version control problems and human error as persistent weaknesses in collaborative spreadsheet environments (Panko, 2018). Consequently, data accuracy depends on user discipline rather than on system governance.

In contrast, Google Looker Studio is a data visualization and business intelligence platform that connects directly to controlled data sources, such as Google Sheets. Instead of storing multiple independent pricing files, Looker Studio references a single structured dataset. When a unit rate or supplier price is updated in the connected sheet, the dashboard automatically reflects the change. This real-time synchronization reduces the need for repetitive consolidation and minimizes discrepancies across team members' pricing references. Research on business intelligence systems suggests that centralized dashboards improve data visibility and support more timely decision-making by establishing a single source of truth (Laursen & Thorlund, 2016).

Another structural distinction lies in data integration and automation. In shared-folder systems, combining multiple supplier quotations requires manual copying, linking, or formula-based consolidation across spreadsheets. This process is labour-intensive and increases the risk of formula-related errors. Looker Studio, by contrast, provides data blending, enabling multiple data sources to be integrated into a unified dashboard environment. Automated data refresh mechanisms ensure that dashboards update automatically once the data connection is established, without manual intervention. This significantly reduces redundant administrative tasks and enhances pricing consistency during tender preparation.

From a collaboration and governance perspective, shared folders allow file upload, download, and editing, but once files are downloaded locally, centralized control is effectively lost. Although folder access can be restricted, version proliferation remains difficult to prevent. Looker Studio supports role-based access control, allowing users to be granted view-only or edit permissions. Because dashboards reference centralized datasets, users interact with live data without directly altering the raw source unless authorized to do so. This structure strengthens data integrity and accountability.

Searchability and analytical capability also differ substantially. In shared-folder systems, users must manually search through directories and compile supplier quotations from separate files. As document volume increases, retrieval becomes inefficient. Looker Studio enables interactive filtering by supplier, material category, or date, allowing pricing comparisons within a single analytical interface. This improves transparency and supports rapid decision-making during time-sensitive pre-tender evaluations.

Overall, shared folders provide basic storage and file-sharing functionality but lack structured governance, automation, and analytical integration. Google Looker Studio offers a more systematic and centralized approach to pricing management by integrating real-time data connectivity, visualization, and controlled collaboration. While shared folders may remain suitable for small-scale or low-complexity projects, dashboard-based systems provide stronger support for coordinated, data-driven pricing decisions in dynamic pre-tender environments.

Table 2: Comparative Analysis of Shared Folders and Google Looker Studio for Pricing Management

Analytical Criteria	Shared Folder (OneDrive/Google Drive)	Google Looker Studio	Critical Implication
Primary Function	File storage and sharing of Excel, PDF, and quotation documents	Interactive data visualization and dashboard reporting	Shift from document repository to analytical platform
Data Structure	Static files; multiple versions may coexist	Connected to centralized, controlled data sources (e.g., Google Sheets)	Reduces version control issues
Data Updating	Manual file-by-file editing and replacement	Automatic updates when source data changes	Enables real-time pricing consistency
Collaboration	Concurrent editing possible but prone to overwriting and duplication	Multi-user access with tracked edits and role-based permissions	Improved governance and accountability
Data Accuracy	High risk of untracked changes and spreadsheet errors	Single live dataset reduces inconsistencies	Establishes single source of truth
Data Integration	Manual copying, linking, and formula consolidation required	Built-in data blending across multiple sources	Enhances efficiency and reduces formula errors
Automation Level	Limited; updates largely manual	Automated dashboard refresh via live data connection	Minimizes redundant administrative tasks
Search & Analysis	Manual file searching and compilation	Interactive filters, charts, and consolidated views	Supports faster analytical decision-making
Security & Access Control	Folder-level restriction; control lost after download	Controlled dashboard permissions; centralized data retained	Strengthened data governance
Suitability for Centralized Pricing	Risk of scattered and outdated files	Centralized, live, and synchronized pricing database	Better aligned with dynamic pre-tender workflows

The analysis demonstrates that while shared folders enable collaborative storage, they do not inherently resolve issues of pricing consistency, automation, and governance. In contrast, Google Looker Studio provides an integrated framework for centralized, real-time pricing management, thereby strengthening reliability and coordination in pre-tender cost estimation.

Coventional Manual Qs Workflow

Figure 1 illustrates the conventional manual QS workflow at the pre-tender stage and visually reinforces the structural inefficiencies discussed earlier. The process begins with a manual pre-tender method that bifurcates into two primary streams: manual take-off and manual pricing. Both streams ultimately converge on preparing the Bill of Quantities (BQ) with rates before proceeding to the tendering stage.

On the measurement side, the figure shows that manual take-off relies on handwriting, Excel, or spreadsheets derived from 2D drawings. Although Excel introduces partial digitization, the workflow remains fundamentally manual because quantities must still be interpreted, extracted, and input by the QS. This aligns with the earlier discussion that manual measurement is interpretation-driven and heavily dependent on individual competency. The absence of automation increases the risk of omission, double-counting, and scaling errors. Furthermore, each design revision requires repeated remeasurement, compounding inefficiencies.

On the pricing side, the workflow depends on telephone communication and hardcopy quotations to establish unit rates. This fragmented data-acquisition process lacks centralized validation and real-time synchronization. Rates are manually transferred into spreadsheets before being incorporated into the BQ. As previously analyzed, manual consolidation introduces the risk of outdated quotations, transcription errors, and inconsistent pricing references across team members.

The convergence point “Bill of Quantities with Rates” represents the integration of two independent manual streams. Because both measurement and pricing processes are labour-intensive and sequential, the cumulative effect results in longer preparation periods, higher labour costs, and reduced accuracy and effectiveness, as explicitly indicated in the lower section of the figure. These outcomes are not incidental but structurally embedded within the workflow design. Each stage depends on human intervention rather than system automation, thereby increasing variability and reducing scalability.

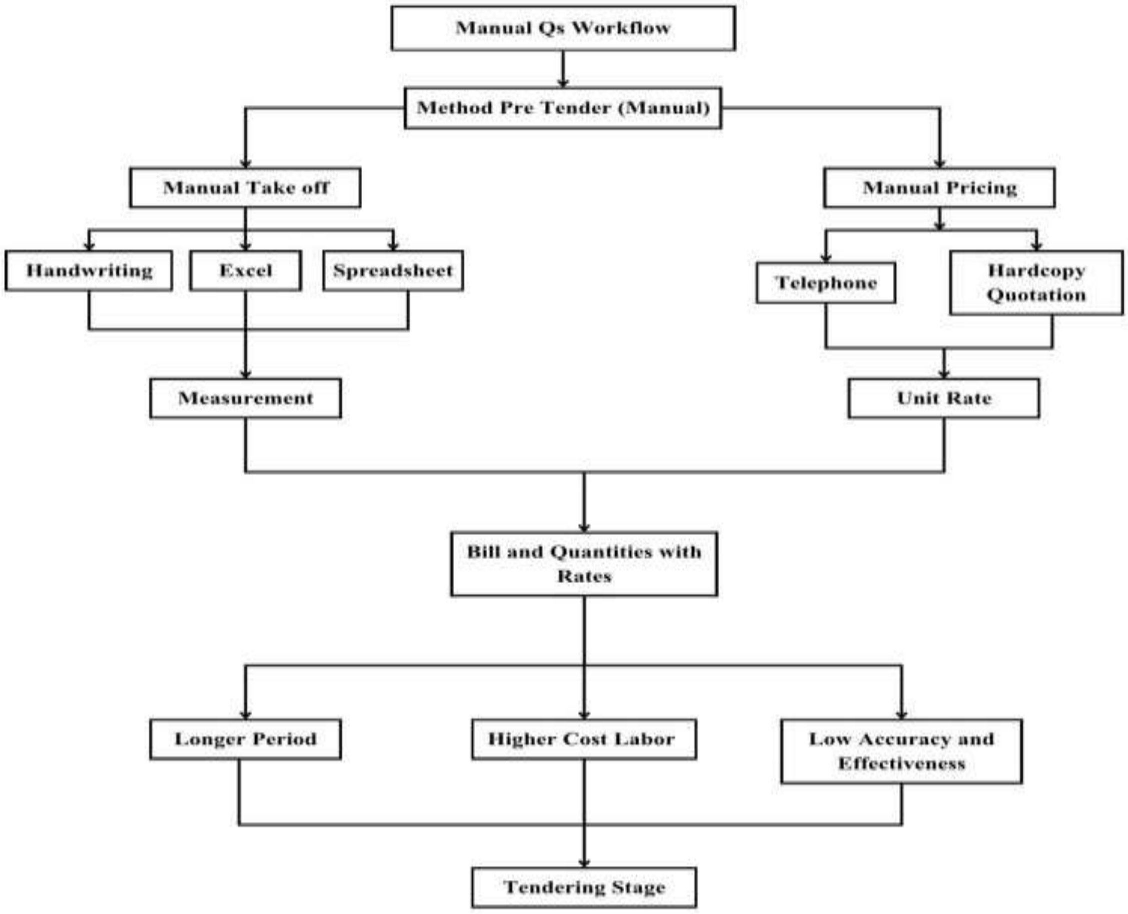

Figure 1: conventional manual QS workflow at the pre-tender stage

The diagram also highlights a critical systemic limitation: there is no feedback loop or dynamic linkage between measurement and pricing. Any change in quantities requires manual rate adjustments and the recalculation of totals. This linear, static architecture contrasts sharply with integrated digital workflows, in which measurement outputs and pricing databases are interconnected and automatically synchronized.

Therefore, Figure 1 does not merely depict a traditional process; it visually substantiates the argument that manual QS workflows at the pre-tender stage are inherently prone to time inefficiencies, elevated labour input, and accuracy constraints. These structural weaknesses justify exploring an integrated BIM-based measurement system and a centralized pricing dashboard, as previously discussed.

Conceptual Development Of An Integrated Digital Workflow For Qs Practice

The proposed system integrates Glodon Software for automated measurement with Google Looker Studio for centralized pricing management. This framework is developed as a direct response to identified structural inefficiencies in traditional quantity surveying (QS) practices such as fragmented data and labor-intensive manual take-offs

The ETL – Based Process Architecture

The proposed system is structured around integrating Glodon Software for automated measurement and Google Data Studio for centralized pricing management. The framework is conceptually developed in response to identified inefficiencies in current quantity surveying (QS) practices and is grounded in existing scholarship on digital cost management (Yi et al., 2023). Automated measurement systems based on BIM principles have demonstrated effectiveness in improving both the speed and accuracy of cost estimation, indicating that platforms such as Glodon represent a strategic investment for firms engaged in multi-project environments (Olatunji et al., 2010). The system operates on an Extract, Transform, Load (ETL) methodology, creating a digital interface between the design model and the final cost output.

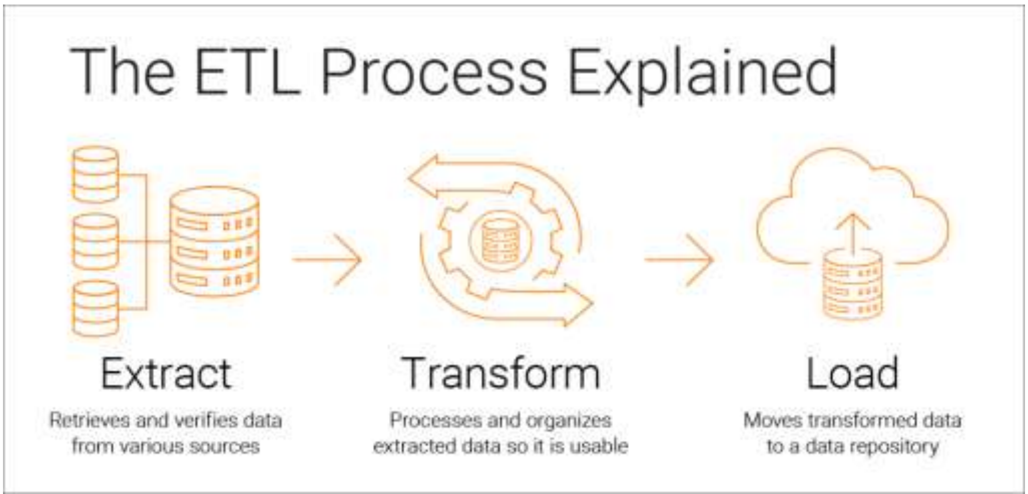

Figure 2: Three-phase ETL process for BIM-based automated measurement and cost integration

Phase 1 – Automated Data Acquisition (The Extraction)

Glodon Software is defined as the Data Acquisition Engine. Rather than simply measuring, this stage represents the automated retrieval of geometric data and semantic attributes directly from the Building Information Model (Rashidi et al., 2024). By using BIM-based Quantity Take-off (QTO), the framework replaces error-prone, manual 2D interpretations with a process that extracts precise quantities fromhe model's element properties (Tatt Soon et al., 2024). This stage ensures the reliability of the predicted cost, which is fundamentally dependent on the precision of the initial quantities provided (Rashidi et al., 2024). To formalize this, we emphasize that this phase handles the unique identification of elements (such as GUIDs), ensuring that every extracted data point can be traced back to a specific component in the virtual design andstablishing a clear audit trail (Morales Yglesias, 2022).

Phase 2 – Data Normalization and Integration (Data Transformation)

In stage 2, the extracted raw geometric data is migrated to a cloud-based Common Data Environment (CDE) utilizing Google Sheets. This stage serves as the vital bridge where automated measurement data meets centralized pricing intelligence, transforming static quantities into dynamic, goal-oriented financial metrics.

Historically, QS teams have managed datasets across individual Excel spreadsheets, isolated email communications, and printed documentation, resulting in highly fragmented records (Kadcha et al., 2022). Poor digitalization has been identified as a contributing factor to disorganized data structures and workflow bottlenecks (Deshapriya et al., 2024). In high-rise construction projects, repetitive measurement tasks are often performed manually, increasing the risk of human error, particularly in the interpretation of complex structural components (Ismail et al., 2021). This framework replaces those scattered personal files with a standardized shared Google Sheet. This single, structured database contains comprehensively defined item descriptions, uniform unit rates, and verified supplier quotations. By centralizing this intelligence, the framework eliminates version-control issues and safeguards against orwritten data or parallel pricing calculations (Kadcha et al., 2022).

This phase conceptually and digitally links the automated quantities generated from the BIM model to current market rates within structured pricing database (Kadcha et al., 2022). Instead of relying on manual copying, linking, or complex formula-based consolidation, which are highly exposed to human error, this process leverages data blending. Physical quantities such as cubic meters of concrete are mapped to specific economic resources and up-to-date supplier details (Kadcha et al., 2022).

Phase 3 – Load (Visualization & Decision Support)

The final stage, as depicted in F*igure 2,* involves loading the integrated data into Google Looker Studio via live data connectors.

Rather than relying on static, disconnected files, the platform uses automated data refresh mechanisms to generate a cost summary or Bill of Quantities with Rates. The dashboard connects directly to the controlled data source, and it updates dynamically as design revisions occur. This creates a vital feedback loop: when design modifications or a Variation Order (VO) alter the quantities in the BIM model, these changes are instantly reflected in the pricing dashboards without requiring manual intervention or labour-intensive recalculation.

The output is an interactive visual dashboard that provides structured insights for tender preparation and real-time managerial cost control. The platforms enable interactive filtering by supplier, material category, or date, allowing for rapid pricing comparisons within a single analytical interface. By moving beyond mere static reporting to aggregating, analyzing, visulizing and sharing data, this stage strengthens the decision architecture of QS firms (Kadcha et al., 2022). It effectively elevates the Quantity Surveyor's role from manual data compilation to strategic, data-driven decision-making in fast-moving tender environments.

Expected Benefits of the Integrated System

The analysis suggests that automating measurement activities is essential to minimize computational errors and reduce processing time. Automated quantity extraction not only enhances measurement accuracy but also ensures that data are stored in a structured and auditable format (Monteiro & Martins, 2013). Furthermore, establishing a centralized pricing platform enables uniform access to current unit rates and supplier data, thereby strengthening internal consistency across projects. Integrated digital systems have been shown to facilitate faster decision-making and improve organizational communication flows (Ong, Peh & Fariq, 2022).

By synchronizing measurement and pricing information, the system improves traceability of design modifications, particularly those associated with Variation Orders. The ability to dynamically reflect quantity changes within pricing dashboards enhances transparency and supports more informed cost control. However, it must be emphasized that these advantages are projected outcomes derived from system design principles rather than empirically validated performance metrics.

Limitations and Implementation Considerations

Despite its conceptual contribution, the proposed integrated digital workflow remains subject to several important limitations.

First, the system has not been empirically applied to a live Quantity Surveying (QS) consultancy project. The framework is conceptually designed and process-mapped, but no pilot study is conducted to compare the performance of the traditional manual workflow with the suggested BIM workflow of automated measurement and a centralized pricing dashboard. Consequently, the perceived gains in time efficiency, minimization of the measurement errors, responsiveness to design changes, and pricing predictability are conceptually deduced instead of being empirically confirmed (Olatunji et al., 2010; Lam et al.,2022; Samsurijan et al., 2023)

Second, the efficacy of the measurement element depends on users' ability to work with the Glodon software, such as TAS, TRB, and TBQ. Although quantity extraction through BIM minimizes computing and transcription errors (Abdullah and Ismail, 2020), the reliability of the automated results can be undermined by modelling inaccuracies unless modelling standards are properly managed (Motawa and Almarshad, 2013). The transition to the model-based over the manual measurement system transitions the risk profile, as opposed to risk removal, which other sources have found to be characteristics of the digital tools, necessitating both the organization of capabilities and the standardization of the procedure (Nati et al., 2020; Rahman et al., 2021). Standard modelling protocols and structured training are therefore necessary to achieve reliable quantity generation.

Third, the pricing dashboard platform relies on responsible data management in the integrated Google Sheets database. Whereas Google Looker Studio enables real-time synchronization and centralized visualization, the accuracy of the dashboards depends on the purity and stability of the source data. The literature review of the spreadsheet risk points to the ongoing problem of untraceable changes, formula errors, and version disparities within the collaborative setting (Panko, 2018), whereas the research on digital cost management in Malaysia cities difficulties connected to the incomplete pricing data and the fragmented reference of the rates (Aziz et al., 2020; Muhammad et al., 2023). The system can recreate old or varying prices despite the digitization of the interface, due to the lack of standardized processes for updating unit rates, supplier offers, and item categories.

Fourth, it must be implemented through organizational preparedness and a gradual rollout. The initial configuration, data organization, and employee training can be very time-consuming, especially in companies that have used traditional spreadsheet-based methods. The literature on BIM adoption models suggests a gradual introduction and institutional adoption to minimise operational disruption (Succar, 2009). In contrast, the literature on Malaysian QS practice identifies resistance to change and insufficient digitalisation of the entity as feasible limitations (Naji et al., 2020; Rahman et al., 2021). As such, gradual implementation and sequential improvement are advised to reduce the risk of implementation.

The limitations of the current research can be mitigated in future research by implementing the suggested pilot on at least one of QS consultancy's projects, where the traditional manual workflow is directly compared with the integrated digital system. The indications of performance measured in the comparative evaluation should include the time needed to take-off the quantity (Olatunju et al., 2010; Lam et al., 2022), the rate of making measurement and pricing mistakes (Panko, 2018; Abdullah and Ismail, 2020), the rate of reflecting design change and Variation Orders (Yap and Lee, 2020; Zainon et al., 2021), and the uniformity of unit rates between team members (Aziz et al., 2020; Muhammad et al., 2023). The empirical validation of these indicators would contribute greatly to the methodological rigour and rebrand the offered workflow as a digital cost management model subject to empirical validation in place of a mere conceptual framework, which is in line with the principles of BIM implementation and performance assessment (Succar, 2009; Motawa and Almarshad, 2013).

CONCLUSION

This study advances the discourse in construction management and quantity surveying by critically repositioning digitalization as a challenge of workflow integration rather than a purely technological adoption issue. Although BIM and cloud-based platforms have been widely examined at an industry or strategic level, comparatively limited scholarship has examined how automated measurement systems and real-time pricing dashboards can be combined operationally within everyday QS workflows, particularly at the pre-tender stage. This study addresses that gap by examining integration at the procedural level, where measurement and pricing decisions directly shape cost outcomes.

Rather than reiterating generalized claims about the benefits of digital tools, the analysis interrogates the structural weaknesses embedded in conventional manual QS workflows—namely, fragmented data storage, repetitive measurement tasks, decentralized pricing references, and limited traceability. The findings suggest that inefficiencies in QS practice are not solely attributable to the absence of technology, but to the lack of integration between measurement and pricing systems. By conceptually linking BIM-based automated quantity extraction with centralized cloud-based pricing dashboards, the study demonstrates how digital tools can be aligned to reconfigure workflow logic, improve data synchronization, and strengthen internal cost governance.

Importantly, this research's contribution lies in reframing digital transformation as an issue of process coherence and decision architecture. The proposed integration model highlights improvements in data consistency, auditability, responsiveness to design changes, and reliability of cost outputs in dynamic tender environments. However, these improvements are conceptual rather than empirically validated, and their realization remains contingent upon structured implementation, user competency, and disciplined data governance.

Overall, this study provides a QS-centric perspective that shifts attention from technology acquisition to workflow redesign. By emphasizing integration over isolated tool adoption, it provides a structured foundation for consulting firms seeking to improve cost control, decision accuracy, and operational efficiency on increasingly complex construction projects.

ACKNOWLEDGEMENT

This article is part of research FRGS/1/2023/SSI02/UTM/02/4, Minimising Dispute Occurrence Framework Through Building Information Modelling, Fundamental Research Grant Scheme, R.J130000.7852.5F628, Ministry of Education.

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