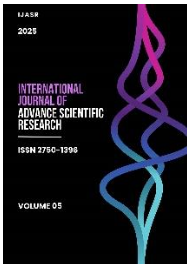
International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 07 Pages: 115-122
OCLC – 1368736135
Crossref doi Google Scholar WorldCat MENDELEY
ISSN-2750-1396



Journal Website: http://sciencebring.com/index.php/ijasr

Copyright: Original content from this work may be used under the terms of the creative commons attributes 4.0 licence.

Research Article

Integrating Building Information Modeling for Accurate Quantity Take-Off and Cost Estimation: Ontological, Processual, and Professional Perspectives

Submission Date: July 01, 2025, **Accepted Date:** July 15, 2025,
Published Date: July 31, 2025

Dr. Alejandro M. Ríos
Department of Civil and Construction Engineering, Universidad Nacional de Córdoba, Argentina

Abstract

Building Information Modeling has progressively transformed the practices of quantity take-off and cost estimation in construction projects by introducing data-rich, model-based workflows that promise greater accuracy, transparency, and efficiency than traditional methods. Despite widespread adoption of BIM tools across design and construction phases, persistent challenges remain related to semantic consistency, modeling guidelines, professional roles, and the reliability of automated quantity extraction. This research develops a comprehensive and theoretically grounded examination of BIM-based quantity take-off and cost estimation by synthesizing insights from empirical case studies, ontological approaches, professional practice analyses, and methodological frameworks documented in the existing literature. Drawing strictly on prior academic and professional references, the study explores how BIM-enabled quantity take-off systems operate across tendering, design development, infrastructure, and facilities management contexts. Particular attention is given to the role of software platforms such as Autodesk Revit and Cubicost, ontology-driven algorithms for reinforced concrete quantities, and emerging integrations with sustainability and early-stage decision-making processes. The methodological approach of this research is qualitative and interpretive, relying on structured literature analysis to trace conceptual linkages, methodological evolution, and professional implications. Findings indicate that while BIM significantly reduces human-induced errors and enhances coordination between design and cost information, its effectiveness is contingent upon modeling discipline, semantic clarity, and the evolving competencies of quantity surveyors. The discussion highlights theoretical implications for construction informatics, identifies limitations inherent in current BIM-based quantity take-off practices, and outlines future research directions focusing on semantic healing, interdisciplinary collaboration, and lifecycle-oriented

cost intelligence. The study concludes that BIM-based quantity take-off is not merely a technological shift but a paradigmatic transformation in how construction quantities, costs, and professional responsibilities are conceptualized and managed.

Keywords

Building Information Modeling, Quantity Take-Off, Cost Estimation, Ontology-Based Modeling, Construction Management, Quantity Surveying

Introduction

The construction industry has long been characterized by its reliance on manual, document-centric processes for quantity take-off and cost estimation. Traditionally, these activities have been performed through the interpretation of two-dimensional drawings, specifications, and bills of quantities, requiring significant professional judgment and experience. While such approaches have supported the delivery of countless projects, they are also associated with a high susceptibility to errors, inefficiencies, and inconsistencies, particularly in complex and large-scale developments. As projects increase in scale, technical sophistication, and stakeholder diversity, the limitations of conventional quantity take-off methodologies have become increasingly evident.

Building Information Modeling has emerged as a response to these challenges by offering a digital representation of physical and functional characteristics of built assets. BIM enables the integration of geometric, semantic, and relational data within a single model environment, thereby providing a shared knowledge resource for information about a facility throughout its lifecycle (Azhar et al., 2008; Sacks et al., 2018). One of the most frequently cited advantages of BIM lies in its potential to automate or semi-automate quantity take-off processes, allowing quantities to be derived directly from the model rather than inferred from drawings. This capability has profound implications for cost estimation, tendering accuracy, time analysis, and overall project governance.

Despite the apparent benefits, the implementation of BIM-based quantity take-off has not been without difficulty. Studies have shown that inaccurate or inconsistent modeling practices can undermine the reliability of automated quantity extraction, leading to discrepancies between model-derived quantities and actual construction requirements (Monteiro & Martins, 2013). Furthermore, the semantic structure of BIM models often lacks the precision required for exact quantity take-off, particularly for complex construction elements such as reinforced concrete assemblies (Liu et al., 2016; Ergen, 2024). These challenges are compounded by variations in software capabilities, organizational maturity, and professional competencies.

In developing countries and emerging economies, BIM adoption is further influenced by regulatory frameworks, educational preparedness, and industry culture. Case studies from Indonesia, for example, demonstrate both the promise and the practical constraints of applying BIM tools such as Autodesk Revit and Cubicost for tender-stage quantity take-off and cost planning (Anindya &

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 07 Pages: 115-122
OCLC – 1368736135

Gondokusumo, 2020; Dwi Novita & Pangestuti, 2021; Apriadi, 2024). These studies highlight improvements in efficiency and accuracy while also revealing gaps related to standardization, interoperability, and user expertise.

Another dimension of BIM-based quantity take-off relates to the evolving role of quantity surveyors and cost professionals. As BIM integrates design and cost information more tightly, traditional professional boundaries are challenged, necessitating new competencies and collaborative practices (Olanrewaju & Anahve, 2015; Hartmann et al., 2012). The quantity surveyor's role is no longer confined to post-design measurement but increasingly involves early-stage cost advice, model validation, and information management within a BIM-enabled environment.

The literature also points toward an expansion of BIM-based quantity take-off beyond cost estimation alone. Emerging applications include embodied greenhouse gas emissions calculation, target value design, and facilities management, all of which rely on accurate and semantically rich quantity information (CRC Construction Innovation, 2007; Forth, 2023; Tiwari et al., n.d.). These developments suggest that quantity take-off is becoming a foundational data layer for broader performance analyses across the building lifecycle.

Despite the growing body of research, there remains a need for integrative and theoretically elaborated studies that connect technical, professional, and organizational perspectives on BIM-based quantity take-off. Many existing studies focus on specific software tools or isolated case studies without sufficiently situating their findings within a broader conceptual framework. Moreover, the rapid evolution of ontological approaches and semantic modeling techniques calls for deeper examination of how these innovations address long-standing challenges in quantity accuracy and reliability.

This research addresses these gaps by providing an extensive and theoretically grounded analysis of BIM-based quantity take-off and cost estimation practices, drawing strictly on established academic and professional references. By synthesizing insights across multiple domains, the study aims to contribute to a more holistic understanding of how BIM reshapes quantity take-off processes, professional roles, and decision-making practices in contemporary construction projects.

METHODOLOGY

The methodological approach adopted in this research is qualitative, interpretive, and grounded in structured literature analysis. Rather than generating new empirical data, the study systematically examines and synthesizes existing scholarly and professional works that address BIM-based quantity take-off, cost estimation, and related professional practices. This approach is particularly appropriate given the conceptual and methodological diversity of the field, as well as the study's objective of achieving deep theoretical elaboration rather than statistical generalization.

The primary data sources for this research consist exclusively of peer-reviewed journal articles, conference proceedings, professional handbooks, and authoritative industry reports explicitly provided in the reference list. Each source was examined in detail to identify its contributions to understanding BIM-based quantity take-off from technical, methodological, professional, and organizational perspectives. Particular attention was paid to how different authors conceptualize quantity take-off, the assumptions underlying their methods, and the contexts in which their findings are situated.

The analysis process involved several iterative stages. First, the literature was categorized into thematic clusters, including BIM-based quantity take-off methodologies, software-specific applications, ontological and semantic approaches, professional roles and responsibilities, and lifecycle-oriented applications such as facilities management and sustainability assessment. This thematic organization enabled a structured comparison of perspectives while avoiding fragmentation of the analysis.

Second, within each thematic cluster, the literature was examined for points of convergence and divergence. For example, studies focusing on Autodesk Revit-based quantity take-off were compared with those examining specialized cost estimation tools such as Cubicost to identify differences in accuracy, workflow integration, and user requirements (Anindya & Gondokusumo, 2020; Dwi Novita & Pangestuti, 2021). Similarly, ontological approaches to quantity take-off were analyzed in relation to more traditional rule-based or geometry-driven methods (Liu et al., 2016; Ergen, 2024).

Third, the analysis emphasized theoretical implications and underlying assumptions. Rather than treating BIM as a neutral technological tool, the study interrogates how modeling standards, semantic structures, and professional practices shape the outcomes of BIM-based quantity take-off. This interpretive lens draws on construction informatics and management theory to explore the socio-technical nature of BIM implementation (Hartmann et al., 2012; Sacks et al., 2018).

Throughout the methodology, care was taken to maintain fidelity to the original sources and to avoid extrapolations beyond what the literature supports. All major claims and interpretations are explicitly grounded in cited works, ensuring transparency and academic rigor. The absence of numerical analysis or visual representations is intentional and aligns with the study's focus on conceptual depth and descriptive explanation.

RESULTS

The synthesis of the reviewed literature reveals several interrelated findings concerning the application of BIM for quantity take-off and cost estimation. These findings are organized around key dimensions of practice and theory, including accuracy and efficiency, software and workflow integration, semantic and ontological modeling, professional roles, and extended applications across the project lifecycle.

One of the most consistently reported outcomes of BIM-based quantity take-off is the improvement in accuracy compared to traditional manual methods. Studies examining the use of Autodesk Revit for quantity extraction demonstrate that model-based quantities reduce human calculation errors and provide greater consistency across project revisions (Dwi Novita & Pangestuti, 2021). Because quantities are directly linked to model elements, changes in design geometry automatically update quantity outputs, thereby minimizing the risk of outdated or conflicting information during tendering and cost planning stages.

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 07 Pages: 115-122
OCLC – 1368736135

The application of specialized cost estimation software such as Cubicost further enhances this accuracy by providing tools specifically designed for quantity take-off and cost analysis. Anindya and Gondokusumo (2020) found that Cubicost facilitated more detailed and reliable quantity calculations during the tender process, particularly for complex building components. However, their findings also underscore the dependency of such tools on the quality and completeness of the underlying BIM model.

Another significant result concerns the integration of time and cost analysis within BIM environments. The case study of the Bintang Bano Dam illustrates how BIM enables simultaneous consideration of quantities, costs, and schedules, supporting more informed decision-making during project planning (Apriadi, 2024). This integration reflects a shift from isolated cost estimation toward multidimensional project analysis, where quantity take-off serves as a foundational input for broader performance evaluations.

Despite these advantages, the literature also reveals persistent challenges related to semantic consistency and modeling guidelines. Monteiro and Martins (2013) highlight that BIM models are often developed primarily for design visualization rather than quantity take-off, resulting in ambiguities and omissions that compromise automated quantity extraction. These issues are particularly pronounced in the absence of standardized modeling guidelines tailored to quantity-oriented objectives.

Ontological and semantic approaches represent a significant advancement in addressing these challenges. Liu et al. (2016) demonstrate that ontology-based semantic modeling enables more precise interpretation of BIM elements for quantity take-off in light-frame building construction. By explicitly defining the relationships between geometric components, construction methods, and quantity rules, ontologies reduce reliance on implicit assumptions and manual interpretation. Ergen (2024) extends this approach by developing ontological algorithms for exact quantity take-off of reinforced concrete items, highlighting the potential for high precision in complex construction contexts.

The literature also points to important findings regarding professional roles and responsibilities. Olanrewaju and Anahve (2015) emphasize that quantity surveyors are increasingly required to engage with BIM models directly, moving beyond traditional measurement tasks toward roles involving information coordination and procurement strategy. This shift is further reinforced by studies on model-based estimating and target value design, which position quantity take-off as an iterative and collaborative process rather than a one-time calculation (Tiwari et al., n.d.).

Finally, the results indicate an expansion of BIM-based quantity take-off into facilities management and sustainability assessment. The Sydney Opera House case demonstrates how BIM supports long-term facilities management by providing reliable quantity and asset information throughout the building lifecycle (CRC Construction Innovation, 2007). Similarly, research on embodied greenhouse gas emissions shows that accurate quantity data extracted from BIM models is essential for early-stage environmental performance analysis (Forth, 2023).

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 07 Pages: 115-122
OCLC – 1368736135

Discussion

The findings of this research underscore the transformative potential of BIM-based quantity take-off while also revealing its inherent complexities and limitations. At a theoretical level, BIM challenges traditional epistemologies of quantity measurement by shifting the locus of knowledge from human interpretation of drawings to digitally encoded model semantics. This shift has profound implications for how accuracy, responsibility, and professional judgment are conceptualized within construction practice.

One of the central theoretical implications concerns the relationship between model fidelity and quantity reliability. While BIM enables automated quantity extraction, the literature consistently emphasizes that the accuracy of these quantities is contingent upon disciplined modeling practices (Monteiro & Martins, 2013; Sacks et al., 2018). This dependency challenges the assumption that automation inherently guarantees accuracy and highlights the socio-technical nature of BIM implementation. Models are not neutral artifacts but products of human decisions, standards, and organizational priorities.

Ontological approaches offer a compelling response to these challenges by formalizing the semantic structure of construction knowledge. The development of ontological algorithms for quantity take-off represents a move toward greater epistemic rigor, as quantities are derived from explicitly defined rules and relationships rather than implicit conventions (Liu et al., 2016; Ergen, 2024). However, these approaches also raise questions about scalability, interoperability, and the resources required for ontology development and maintenance.

From a professional perspective, the integration of BIM into quantity surveying necessitates a redefinition of competencies and responsibilities. The quantity surveyor's role increasingly intersects with information management, model validation, and interdisciplinary coordination (Olanrewaju & Anahve, 2015). While this evolution enhances the strategic relevance of the profession, it also requires substantial investment in education and organizational change. Resistance to such change may limit the realization of BIM's full potential, particularly in contexts where traditional practices remain deeply entrenched.

The discussion also highlights limitations in the existing literature. Many studies focus on building projects, with comparatively less attention to infrastructure and roadway construction, although recent work by Parate et al. (2025) begins to address this gap. Additionally, while sustainability-oriented applications of BIM-based quantity take-off are emerging, they remain underexplored relative to cost and time analysis.

Future research should therefore pursue several directions. First, greater empirical validation of ontological quantity take-off systems across diverse project types is needed to assess their robustness and generalizability. Second, longitudinal studies examining the professional impacts of BIM adoption on quantity surveyors would provide valuable insights into skill development and role transformation. Third, the integration of quantity take-off with sustainability and lifecycle performance metrics warrants deeper theoretical and methodological exploration.

Conclusion

This research has provided an extensive and theoretically elaborated examination of BIM-based quantity take-off and cost estimation, drawing strictly on established academic and professional references. The analysis demonstrates that BIM represents a fundamental shift in how quantities are generated, interpreted, and utilized within construction projects. By embedding quantity information within data-rich digital models, BIM enhances accuracy, efficiency, and integration across design, cost, and time dimensions.

However, the study also reveals that the benefits of BIM-based quantity take-off are not automatic. They depend on disciplined modeling practices, semantic clarity, and the evolving competencies of construction professionals. Ontological approaches offer promising solutions to long-standing challenges in quantity accuracy but introduce new considerations related to complexity and implementation.

Ultimately, BIM-based quantity take-off should be understood not merely as a technological innovation but as a paradigmatic transformation in construction knowledge management. Its successful adoption requires alignment between tools, processes, and professional practices. By synthesizing insights across technical, professional, and organizational domains, this research contributes to a deeper understanding of BIM's role in reshaping quantity take-off and cost estimation in contemporary construction.

References

1. Anindya, A. A., & Gondokusumo, O. (2020). Kajian penggunaan Cubicost untuk pekerjaan quantity take off pada proses tender. Jurnal Muara Sains, Teknologi, Kedokteran Dan Ilmu Kesehatan, 4(1), 83. https://doi.org/10.24912/jmstkik.v4i1.6718
2. Apriadi, A. (2024). The application of building information modelling (BIM) for cost and time analysis: Bintang Bano Dam, West Sumbawa, Indonesia. AIP Conference Proceedings, 2927(1). https://doi.org/10.1063/5.0192688
3. Azhar, S., Nadeem, A., Mok, A. Y. N., & Leung, B. H. Y. (2008). Building information modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects. In Proceedings of the First International Conference on Construction in Developing Countries ICCIDC–I, Karachi, Pakistan.
4. CRC Construction Innovation. (2007). Adopting BIM for facilities management: Solutions for managing the Sydney Opera House.
5. Dwi Novita, R., & Pangestuti, E. K. (2021). Analisa quantity take off dan rencana anggaran biaya dengan metode building information modeling (BIM) menggunakan software Autodesk Revit 2019. Jurnal Teknik Sipil.
6. Ergen, F. (2024). Development of ontological algorithms for exact QTO of reinforced concrete construction items. Structures, 60. https://doi.org/10.1016/j.istruc.2024.105907
7. Forth, K. (2023). Calculation of embodied GHG emissions in early building design stages using BIM and NLP-based semantic model healing. Energy and Buildings, 284.

8. Hartmann, T., van Meerveld, H., Vossebeld, N., & Adriaanse, A. (2012). Aligning building information model tools and construction management methods. Automation in Construction, 22, 605–613.
9. Kula, B., Ilter, D. A., & Ergen, E. (2018). Building information modelling for performing automated quantity takeoff. In Proceedings of the 5th International Project and Construction Management Conference, Kyrenia, Cyprus.
10. Liu, H., Lu, M., & Al-Hussein, M. (2016). Ontology-based semantic approach for construction-oriented quantity takeoff from BIM models in the light-frame building industry. Advanced Engineering Informatics, 30, 190–207.
11. Monteiro, A., & Martins, J. P. (2013). A survey on modeling guidelines for quantity takeoff-oriented BIM-based design. Automation in Construction, 35, 238–253.
12. Olanrewaju, A., & Anahve, P. J. (2015). Duties and responsibilities of quantity surveyors in the procurement of building services engineering. Procedia Engineering, 123, 352–360.
13. Parate, H., Kishore Bandela, & Paniteja Madala. (2025). Quantity take-off strategies: Reducing errors in roadway construction estimation. Journal of Mechanical, Civil and Industrial Engineering, 6(3), 01–09. https://doi.org/10.32996/jmcie.2025.6.3.1
14. Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, facility managers. John Wiley & Sons.
15. Tiwari, S., Odelson, J., Watt, A., & Khanzode, A. Model based estimating to inform target value design. AECbytes.