Proceedings of the 5th International Conference on Signal Processing and Machine Learning
DOI: 10.54254/2755-2721/120/2025.19488

Exploring the Effectiveness of Big Data in Profitability of Construction Projects

Haotian Yang[1,a,*]

[1]*University College London, London, WC1E 6BT, United Kingdom*
a. mayer000806@gmail.com
**corresponding author*

Abstract: The complexity of construction projects is generally high, requiring the collection and processing of data from diverse sources. Big data-based analytics and technologies can help such a project in different ways to improve profitability. However, their use comes with inherent risks, particularly concerning data security and accuracy. Data accuracy is a concern, as it directly impacts the credibility and reliability of Big Data analytics outcomes. The research examines the effectiveness of Big Data in the profitability of construction projects through extensive literature review and case analysis. Findings highlight that data accuracy is a key determinant of profitability in this context. Construction firms need to enforce policies and procedures to ensure data quality, credibility and accuracy while performing data collection. With accurate data, firms can leverage analytics to make informed, data-driven decisions that drive project success.

Keywords: Big Data analytics, construction projects, BIM, construction project profitability.

1. Introduction

Construction projects are complex and unique for different reasons. They require a large workforce with diverse skill sets and the involvement of different stakeholders. Such projects are subjected to uncertainties like natural calamities and losses due to that. Typically, construction projects are one-time but long-duration projects that require different levels of coordination and management efforts by managers, and subcontractors. On one hand, these projects are characterized by high levels of risks and uncertainties; on the other hand, they often face tight duration, budget, and resource-related constraints. As a result, decision-making to ensure profitability while meeting project goals is particularly challenging. The research aims to explore the effectiveness of the use of Big Data technologies in project management for profitability analysis in construction projects.

In recent years, the worldwide construction industry has geared towards technology adoptions in different ways including Building Information Modeling to various predictive analytics tools. Despite this shift, the industry still grapples with challenges, including high initial costs, a lack of skilled workers, and issues related to data quality and security. However, the advantages offered by technology—such as informed risk assessments, supply chain optimization, and real-time tracking and monitoring—are instrumental in reducing risks and cost implications.

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2. Literature Review

Profitability analysis in construction projects evaluates financial performance through revenue, cost, and financial metrics analysis. Key factors include precise material, labor, and equipment cost data, effective scheduling, risk management, and supply chain efficiency [1]. Accurate project tracking reduces delays and cost overruns, while financial control prevents losses. Advanced tools like BIM, AI, and Big Data enhance cost estimation, scheduling, and predictive analytics, aiding informed decision-making and improved financial outcomes.

The literature review has helped to find out how the construction industry is adopting Big Data, AI and other technologies for profitability and project management. There are potential benefits and several barriers related to the adoption. The field is still maturing as the technology domains are also advancing. The industry still lacks suitable infrastructure for the wide-spread adoption of Big Data technologies for construction projects of different sizes and complexities. It has been found that there is still not enough literate evidence available on profitability and effectiveness analysis for Big Data technology adoption in construction projects. It lacks evidence of direct relations on project profits due to such technology adoptions at different aspects of a project like planning, execution, monitoring, risk management, monitoring and control over short and long terms.

3. Research Design and Methodology

The research is exploratory in nature, aiming to investigate the problems that cause possible barriers to Big Data technology adoption and profitability in the construction industry. The study will utilize qualitative methods for data collection and data analysis. Data will be gathered through a review of existing literature and case studies, focusing on secondary data from reliable sources such as journals, industry reports, news articles, and market analysis from reputable institutions. The qualitative data analysis process will follow methods for systematic literature review and case study analysis techniques, which will enable the examination of the collected data from both vertical and horizontal perspectives. The systematic literature review will explore various aspects of Big Data technology's role in construction project management, while the case study analysis will link theoretical findings to practical applications. This approach will offer insights into how Big Data can be utilized to improve profitability in construction projects, with an emphasis on real-world cases where Big Data has been implemented with varying results.

4. Analysis on the current status of application of big data technology in construction projects

Big Data technologies is an umbrella term that encompasses the overlapping of statistics, artificial intelligence, and other emerging information and communication technologies. The emergence of Building Information Modelling or BIM technology hass paved the path for leveraging opportunities from technology adoption in the construction industry. BIM solutions attempted first to integrate engineering and construction data from different processes, and resource-related data from different stages of a construction project into a single model for faster data analysis, and transparency. The combination of AI and BIM can help in the utilization of Big Data technologies in different ways, especially for project delivery and control processes [2]. According to the Project Management Institute, cost management is a critical aspect of project budget control. Cost estimations sets the foundation for further monitoring and controlling to achieve budget goals. At different stages of a project life cycle, cost estimation is an iterative process to estimate and update details based on the available information. Cost estimation is important for the economic feasibility analysis of a project. Miranda and others have highlighted the importance of Big Data technologies for predictive cost analysis at the early stages of construction projects. According to them, accuracy is the most critical

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feature for decision-makers [3]. Project cost management using Big Data technologies not only helps with budget forecasting and projections, but also helps with the early detection of anomalies from operational and financial data. Technologies are used for building simulation models depending on historical data and real-time information. It also helps in quality management. Big Data strategies are used to collect data from heterogeneous sources to identify trends and areas for improvement. The use of artificial intelligence or AI, and predictive analytics helps to find out such trends and to take preventive measures to avoid errors [4].

Simulations support to understand different scenarios like economic fluctuations, and changes in labour and material prices to estimate the financial impact on the project. It also helps to assess risks related to supply chain disruptions, project delays, and chances of accidents in a construction project. Thus, it helps in risk identification, assessment, and mitigation. Risk management helps to monitor and control project budgets effectively by making data-driven decisions [5]. Simulations are particularly useful for understanding potential scenarios such as economic fluctuations or changes in labor and material prices, allowing for an estimation of the financial impact on the project. They also aid in assessing risks related to supply chain disruptions, project delays, and accidents.

Big Data technologies can be used for real-time data tracking and control for project costs in different ways. Internet of Things (IoT) sensor-enabled networks can monitor the performance of machinery, equipment, and materials in construction projects. It can collect real-time information about material usage, equipment performance, and labour productivity to identify potential cost overruns due to inefficiencies [6]. Automated alerts can be set up by project managers to track deviations from project baseline costs, schedule, and scope. Such alerts can help to take preventive measurements to mitigate risks and take proper actions in a timely manner [7]. Big Data can also optimize resources during allocation and usage through real-time data collection and analysis. It helps adjust budgets and plans, influencing risk analysis and overall budget control [5].

Additionally, Big Data technologies can enhance financial performance analysis in construction projects by utilizing key performance indicators (KPIs), cash flow forecasting tools based on predictive analytics, and variance analysis simulations. Forecasting cash flow using historical data and project milestones optimizes financial planning. Tracking KPIs aids in making informed decisions and evaluating project profitability. Simulation results, coupled with real-time tracking data, allow for the identification and analysis of variances between planned, expected, and actual costs, helping to implement corrective actions and maintain budget adherence. Big data technologies can also be applied for supplier performance analysis based on historical data on quality, delivery, and pricing. It helps to find a cost-effective and reliable supplier for a project. At the same time, it can help to develop contingency plans in case of a supply chain disruption. Inventory control and optimisation based on historical demand patterns and real-time usage can help in reducing holding costs and better utilization of materials [8]. Big data technologies can be used in construction projects for financial performance analysis using various key performance indicators or KPIs, cash flow forecasting tools using predictive analytics, and variance analysis-based simulations. Cash flow forecasting using historical data and project milestone data can help in the optimization of financial planning [9]. Tracking KPIs can help in making informed decisions and to assess project profitability. Simulation results and real-time tracking data can be used to identify and analyse variances between planned, expected, and actual costs, derivations and possible corrective measurements to remain within budget.

5. Potential Issues

The construction industry is highly data-intensive, generating vast amounts of data. However, much of this data remains underutilized due to slow technology adoption. Big data, as a relatively new technology, has not yet been adopted by the construction industry properly [10]. There are inherent

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vulnerabilities and risks in adopting Big Data technologies for project management in the construction industry. As data is accessed by different stakeholders and systems for different purposes, the risk of advanced security breaches increases. One structural concern is ensuring error-free analysis. To make reliable decisions, it is essential to ensure that the data collected is accurate. Inaccurate data can lead to misinformed decisions, missed opportunities, financial losses, operational inefficiencies, security breaches and reputational damage [11].

Construction firms take different approaches to profitability. Studies have shown that there is a trend of starting with some planned margins and then eventually having different margins as the project continues. Hence, it requires constant monitoring and a wide-range of data collection activities [6].

The successful integration of Big Data technologies with construction management requires a skilled workforce that is capable of leveraging the benefits of the technologies. However, there is a notable gap in the industry's existing workforce, which often lacks the necessary skills and expertise to work with Big Data. This is a critical barrier to technology adoption and transformation in the construction industry [12]. Additionally, integrating AI and Big Data technologies with project management practices requires a significant upfront financial investment. Firms must procure the necessary hardware, software, and skilled labor to develop the required IT infrastructure. For small to medium-sized firms, this initial cost can strain their budgets, making the perceived high cost a major barrier to entry. This financial challenge contributes to the delayed adoption of these technologies across the industry.

6. Effectiveness Analysis

Construction projects are data-intensive and require the collection, processing, and analysis of data from diverse sources. Data accuracy is important in such a case so that data analytics can produce accurate and relevant results. The construction industry is going through a transformative phase supported by Big Data. It helps in streamlining operations, increasing productivity and efficiency of processes, resource utilization, risk management, and enhancing safety measurements. Once data accuracy is ensured, it can significantly reduce cost and improve profitability. However, there is a direct relationship between profitability and data accuracy for Big Data technologies. If data accuracy is poor, then there will be losses incurred from poor decision-making regarding different aspects of project management. On the other hand, if accuracy is high, then it increases profitability by meeting project goals. Building Information Modeling or BIM tools helps in collaboration, coordination, and decision-making while integrating systems and Big Data analytics in construction projects.

Efficient data capture is the basis of data accuracy in the construction industry. To manage the inherent challenges associated with data accuracy, it is crucial to maintain high-quality and timely data capture. A set of protocols and constraints must be maintained to ensure efficient and accurate data capture. Additionally, appropriate security measures must be implemented to prevent unauthorized tampering or alteration of data. Cloud platforms should be used for data analytics to ensure scalability, centralized data processing, and connectivity with various systems through middleware. By adhering to these conditions, construction firms can derive actionable insights from their collected data, enabling data-driven decision-making and ultimately boosting profitability.

7. Conclusion

The research concludes that there is an inherent and critical relationship between data accuracy and profitability from using Big Data technologies in construction projects. Due to the inherent complexities and scale of construction projects, it is difficult to manage and ensure profitability. Such projects are fraught with various uncertainties and risks. However, Big Data technologies help

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improve operations, resource optimization, and overall management in an efficient way while reducing risk impacts to a significant level. Thus, it helps in improving profitability in the long run.

Data accuracy is a critical aspect. Low accuracy can lead to substantial losses or even project failure, while high accuracy enhances profitability and provides more predictable outcomes. Despite these advantages, there are challenges like significant initial cost, lack of skilled and experienced workforce to effectively utilize these technologies, and cyber security risks. Thes challenges make it challenging for small and large construction projects to adopt Big Data technologies. But the overall construction industry is shifting towards embracing Big Data analytics for improved processes, and more profitability.

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