The Role of Digital Tools in Reshaping Business Models and Value Networks

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Abstract
The construction industry is experiencing a significant transformation driven by the adoption of digital tools and technologies, which are reshaping traditional business models and value networks among stakeholders. The construction industry faces challenges, including inefficient processes, cost overruns, and operations that negatively impact the environment. This study investigates how digitally driven construction business models can optimize stakeholder engagement, enhance efficiency, and promote sustainability within the South African construction industry. The study adopts a case study research design of a large infrastructure project in South Africa in data collection. The study found that respondents perceive that digital tools significantly enhance operational efficiency, collaboration, and stakeholder engagement. Based on these findings, the study concludes that embracing digital transformation is essential for the South African construction industry to thrive in an increasingly competitive landscape and recommends that stakeholders in the construction industry, including the government, adopt digital tools to improve project performance.

Keywords: Affordable Housing, Carbon Emissions, Innovative Building Technologies, LCA, SDG 11, Sustainability assessment.

1 Introduction

Historically, the construction sector has been known for its conservative practices and a slow pace of innovation (Windapo, 2021). This reluctance to embrace change has often resulted in inefficiencies, cost overruns, and project delays. However, the construction industry is undergoing a transformative phase characterized by adopting digital tools and technologies (Locatelli, 2021) and digitally driven construction business models that leverage advanced technologies to enhance operational efficiency and stakeholder engagement (Omrany et al., 2023).

Digital tools encompass various applications, software, and machinery that facilitate various phases of construction projects, from design and planning to execution and maintenance (Windapo, 2021). The integration of these technologies is not merely a trend but a necessity for modern construction firms aiming to remain competitive in an increasingly complex market. These digital innovations enhance construction methods and processes, making them indispensable for achieving project goals, including cost-effectiveness, timely completion, and adherence to quality standards (Windapo, 2021). The evolution of construction business models is pivotal as it defines how companies create value for their customers and generate profits (Pekuri, et al., 2013).

A value network consists of interconnected relationships among organizations and individuals, facilitating interactions that benefit all stakeholders involved (Reypens et al., 2016). On construction projects, a key challenge lies in balancing project costs, completion time, and quality—essentially striving for construction efficiency (Harris et al., 2021). This study examines how digitally driven construction business models optimize stakeholder engagement, enhance efficiency, and promote sustainability within the South African construction industry. Central to this transformation is the imperative of sustainability, which addresses pressing environmental concerns and resource scarcity through eco-conscious practices and resource optimization enabled by digital technologies (Nikmehr, et al., 2021). According to Nikmehr et al. (2021), digital technologies can improve construction performance regarding business results such as profitability, revenue generation, and sustainability outcomes.

The rationale for this study is grounded in the increasing adoption of digital technologies within the South African construction sector and their potential to reshape traditional business models and value networks. Understanding how digitalization influences value networks, sustainability, and efficiency is crucial for construction firms aiming to adapt and thrive in a rapidly evolving landscape. The following sections outline the literature review, including the key concepts used in the study, the research methodology, findings, and conclusions.

1.1 Background

The construction industry faces substantial efficiency challenges, primarily due to fragmented value chains that often lead to delays, cost overruns, and inefficiencies (Ikuabe et al., 2023). Poor collaboration and inadequate information sharing among stakeholders exacerbate these issues, creating a pressing need for a cohesive approach to integrating digital technologies that streamline processes and enhance communication across the value chain (Zulu et al., 2023). Sustainability challenges are equally critical, as the construction sector is a major contributor to resource depletion, waste generation, and carbon emissions (Spence & Mulligan, 1995). Addressing these challenges necessitates a comprehensive understanding of how digital technologies can be leveraged to optimize value networks and improve project performance, thereby making sustainability an integral aspect of the industry's evolution.

The South African construction industry is plagued by inefficiencies, delays, and a significant environmental impact (Ikuabe et al., 2023). Fragmented value chains and poor collaboration and information sharing among stakeholders contribute to these challenges. While digital technologies present promising solutions (Nikmeh et al., 2021), their adoption and integration into construction business models remain limited (Windapo). This study aims to address these gaps by examining the role of digital tools in enhancing stakeholder engagement, improving efficiency, and promoting sustainability in the construction sector.

1.2 Overview of Business Models, Digital Technologies and Value Networks in Construction

Business Models

Business models are critical frameworks that define how organizations create value for their customers and generate profits from their operations (Pekuri et al., 2013). In the construction industry, business models often remain underexplored, leading to misunderstandings about how value is created and delivered to clients. Traditional perspectives on business models emphasize understanding client needs and aligning resources effectively (Abeynayake et al., 2022). However, Kelly et al. (2014) argue that construction managers associate business models with project delivery methods and contract structures, not client value generation. This divergence from conventional frameworks can hinder systematic value creation analysis, particularly at the management level in construction.

Construction business models can be measured through various metrics, including profitability, customer satisfaction, and operational efficiency. Tools such as the Business Model Canvas can be employed to visualize and analyze the components of a business model, including value propositions, customer segments, and revenue streams (Osterwalder et al., 2015).

Digital Technologies in Construction

Digitalization refers to integrating digital technologies into business processes, fundamentally altering how companies operate and create value (Denner et al., 2018). In the construction sector, digital tools such as Building Information Modelling (BIM), drones, the Internet of Things (IoT), and project management software are pivotal in enhancing operational efficiency and collaboration (Windapo, 2021). Despite the potential benefits, adopting these technologies has been slow, often due to perceived costs, lack of digital literacy, and uncertainty regarding return on investment (Zulu et al., 2023).

Performance indicators such as project completion time, cost savings, and error reduction rates can assess digital technologies' effectiveness. For instance, the implementation of BIM can be evaluated based on its impact on design coordination and project management efficiency (Azhar, 2011). Surveys and case studies also provide insights into the extent of digital adoption and its perceived benefits among construction firms (Zulu et al., 2023).

Value Networks

A value network is a collection of relationships among businesses and individuals that collaborate to create value for the entire group (Peppard & Rylander, 2006). In construction, value networks facilitate stakeholder collaboration, improving project outcomes and enhancing efficiency (Dang et al., 2024). Integrating digital technologies within these networks fosters real-time data sharing and communication, which is essential for modern construction practices (Brandín & Abrishami, 2024).

Value networks' effectiveness can be measured through collaboration metrics, such as the frequency of stakeholder interactions, the speed of information exchange, and the level of stakeholder satisfaction. Additionally, project performance metrics, including time to completion and budget adherence, can indicate their efficiency (Takim & Akintoye, 2002).

1.3 Relationship Between Identified Concepts and Constructs

The relationship between business models, digital technologies, and value networks is integral to understanding how the South African construction industry can evolve. This study proposes that a well-defined business model incorporating digital technologies can enhance value creation by improving operational efficiency and client satisfaction, as shown in Figure 1. For example, adopting BIM within a construction firm's business model can streamline project workflows, reduce errors, and enhance stakeholder collaboration (Omrany et al., 2023). Furthermore, integrating digital tools into value networks facilitates real-time communication and data sharing, essential for effective project management (Windapo, 2021). This interconnectedness allows construction firms to respond more effectively to client demands for innovation and customization, ultimately leading to improved project outcomes. Conversely, the slow adoption of digital technologies can hinder the effectiveness of business models and value networks, leading to inefficiencies and reduced competitiveness (Zulu et al., 2023).

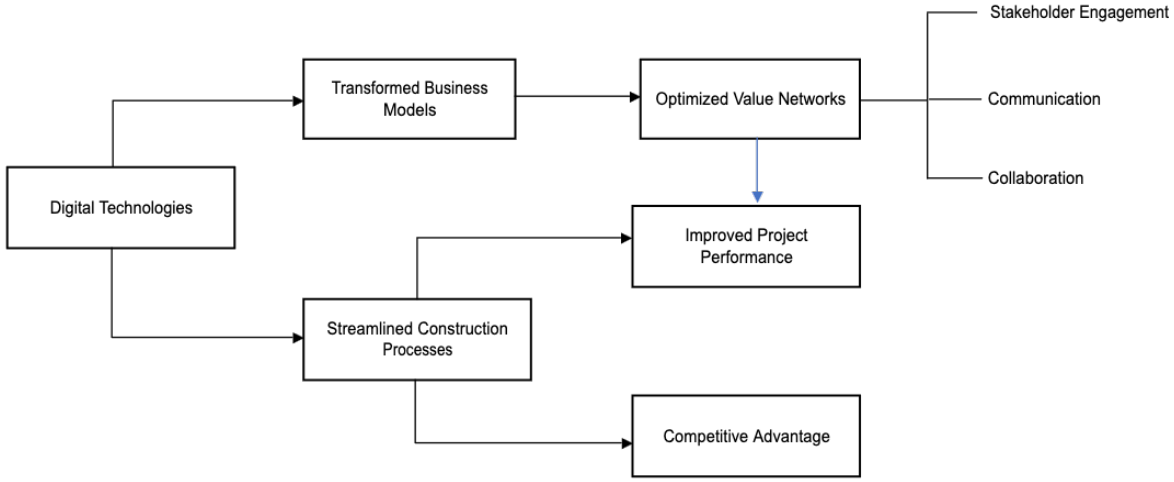

Figure 1: Conceptual Framework showing the relationship between Digital Technologies, Business Models, Value Networks and Performance

Therefore, this study employs this theoretical framework to guide it and support the assertion that integrating digital innovation into work processes and collaboration is crucial for construction firms to thrive in an increasingly complex and competitive environment.

2 Materials and Methods

The research philosophy adopted for this study is rooted in the constructivist paradigm, which emphasizes understanding phenomena through participants' subjective experiences and perceptions (Mbanaso et al., 2023). This approach is particularly relevant in exploring the adoption of digital tools in the South African construction industry, as it allows for a nuanced understanding of how various stakeholders interpret and integrate these technologies into their business models. Constructivism supports the exploration of diverse perspectives, accommodating the complexities and dynamism inherent in digital transformation (Creswell & Plano Clark, 2023).

This study employs semi-structured interviews to obtain data from 25 stakeholders working on a large infrastructure project in South Africa. These interviews explore the motivations and experiences of stakeholders in greater depth and facilitate an understanding of the contextual factors influencing digital tool adoption and its impact on business practices. The case study provides practical insights into the real-world application of these digital tools. A stratified random sampling technique was employed to ensure representation from all key segments of the construction industry. The sample was divided into strata based on respondents' roles on the project, including project managers, engineers, architects, contractors, and suppliers, ensuring that each subgroup is proportionately represented in the final sample.

The data was analyzed using descriptive statistics and thematic and content analysis to identify trends and uncover key themes and insights. This approach enables an examination of quantitative trends and the stakeholders' qualitative experiences. Ethical considerations were addressed by providing the participants with informed consent forms, ensuring their understanding of the study's purpose and their right to withdraw at any time. Confidentiality was maintained throughout the research process, and data was securely handled and reported in an aggregated form.

3 Results

This section presents the key findings from the semi-structured interviews to explore the drivers of digitally-driven construction business models in South Africa. It presents the background details of the respondents, the key drivers of digital adoption, and the project's performance ratings following the implementation of digital technologies.

3.1 Backgound details of the respondents

The study revealed a diverse representation of roles within the cohort of 25 respondents, with architects constituting the largest group of respondents (32%), followed by project managers (20%) and contractors (12%). The "Other" category, which includes roles such as quantity surveyors and construction regulators, accounted for 24% of the responses. This diversity reflects the collaborative nature of value networks in the construction project, where multiple stakeholders contribute to a project's success. The prominence of architects and project managers underscores their critical role in driving the adoption of digital tools, particularly in project design and management—areas where digital transformation can significantly enhance outcomes. The diverse representation in the "Other" category indicates that digital adoption extends beyond traditional construction functions, affecting regulatory and financial management processes as well. This highlights the necessity for a multi-disciplinary approach to implementing digital technologies across the project lifecycle.

3.2 Key Drivers of Digitally Driven Construction Business Models

The study identified several key drivers behind the adoption of digital technologies in construction business models, including efficiency improvement (68%), technological advancements (60%), cost reduction (56%), competitive advantage (56%), client demand (40%), regulatory compliance (24%), and sustainability goals (20%) as shown in Table 1. The respondents were asked to tick all applicable responses.

Table 1: Key Drivers of Digitally Driven Construction Business Models

Driver	Frequency	Percentage (%)
Efficiency Improvement	17	68%
Technological advancements	15	60%
Cost reduction	14	56%
Competitive Advantage	14	56%
Client Demand	10	40%
Regulatory Compliance	6	24%
Sustainability	5	20%

Efficiency improvement emerged as the most frequently cited driver, with 68% of respondents identifying it as the primary motivation for adopting digital tools. Technologies such as Building Information Modelling (BIM) and project management software streamline processes, reduce delays, and optimize resource allocation, aligning with previous studies' findings demonstrating how digital tools enhance productivity (Azhar, 2011).

Technological advancements were cited by 60% of respondents as a significant driver. The integration of cutting-edge technologies, including AI and IoT, has transformed project management and execution, enabling real-time monitoring and predictive analytics. This shift underscores the industry's move towards more sophisticated, data-driven decision-making processes.

Cost reduction was identified by 56% of respondents as a key driver of digital adoption. Digital tools minimize waste and errors, leading to significant cost savings, which is critical in an industry facing financial pressures. The findings suggest improved accuracy and reduced rework through digital tools contribute to better cost control and competitiveness.

The desire for competitive advantage was also highlighted by 56% of respondents. By leveraging digital technologies, firms can differentiate themselves in a market where clients increasingly demand innovative and efficient solutions. This competitive edge is vital in a landscape where sustainability and technological innovation are paramount.

Client demand for innovation and sustainability was noted by 40% of respondents, emphasizing the need for construction firms to adopt digital tools to meet evolving client expectations. Regulatory compliance (24%) and sustainability goals (20%) also emerged as important drivers, reflecting the construction industry's response to increasing environmental regulations and the need for sustainable practices.

3.3 Insights on Digital Tools adopted on the project

The most widely adopted digital tools in the surveyed project included BIM (60%), project management software (52%), and drones (32%). Others were Drones (32%), Augmented Reality/Virtual reality (24%) and IoT Devices (8%).

3.4 Impact of Digitally Driven Business Models on Project Performance

The overall project performance ratings following the implementation of digital tools were overwhelmingly positive, with 68% of respondents rating performance as "Very Good" and 12% as "Excellent," on a scale of 1 to 4, where 1 represents Fair and 4, Excellent. This indicates a strong correlation between digital adoption and improved project outcomes. The responses indicate a strong consensus among stakeholders that digitally driven business models positively influence project delivery. Key themes include increased efficiency and productivity, cost savings, improved collaboration and communication, enhanced monitoring and reporting, and scalability and innovation.

Many respondents emphasized that digital business models enhance efficiency by optimizing workflows and reducing task time. This aligns with previous research findings that highlight digital tools' role in streamlining construction processes (Zulu et al., 2023). Furthermore, respondents noted that digital tools lead to operational cost savings by minimizing manual labour and improving accuracy. This reflects the broader trend in the construction industry, where digital technologies contribute to better financial performance.

It also emerged that many respondents perceived that digital tools facilitate better communication and collaboration among stakeholders, enhancing project coordination and reducing rework. This finding is consistent with literature emphasizing effective communication's importance in successful project delivery (Ikuabe et al., 2023). Furthermore, respondents noted that tracking project progress in real-time improves transparency and accuracy in reporting, which is crucial for effective project management. They also noted that digital business models enable scalability and foster innovation, allowing firms to adapt to changing market demands and remain competitive.

3.5 Value Networks in Digitally Driven Construction Business Models

Respondents highlighted that digital tools enhance communication and collaboration within construction business models, optimizing value networks by facilitating information exchange and decision-making.

3.6 Impact of Digitally Driven Business Models on Efficiency and Sustainability

The study revealed that digitally driven business models significantly enhance efficiency and sustainability in construction projects. A majority of respondents rated the impact as significant or very significant, indicating a strong perception of digital technologies' benefits.

4. Discussion

The findings from this study highlight the transformative potential of digital tools in reshaping traditional business models and value networks within the South African construction industry. As highlighted in the literature, the construction sector has historically been characterized by inefficiencies and a reluctance to innovate (Windapo, 2021). However, the current study reveals a shift towards embracing digitalization, which aligns with the findings of Locatelli (2021) and Onrany et al. (2023), who argue that digital tools are not merely enhancements but essential components for modern construction practices.

The study found efficiency improvement as the most significant driver for adopting digital technologies, with 68% of respondents identifying it as a primary motivation. This finding supports previous research emphasizing the role of digital tools, such as Building Information Modelling (BIM), in streamlining construction processes and enhancing productivity (Azhar, 2011). The strong relationship between digital adoption and improved project performance, as evidenced by 68% of respondents rating performance as "very good," further supports the notion that digitization is pivotal for operational success in construction (Ikuabe et al., 2023). Moreover, the study's identification of technological advancements as a key driver (60%) aligns with previous studies suggesting that integrating advanced technologies, including AI and IoT, can significantly enhance project management and execution (Zulu et al., 2023). This shift towards data-driven decision-making reflects a broader trend in the industry, where firms that leverage digital tools gain a competitive edge, a sentiment echoed by 56% of respondents who cited competitive advantage as a motivation for digital adoption.

The findings also highlight the importance of stakeholder engagement in digital-driven business models. The respondents emphasized that digital tools facilitate better communication and collaboration, thereby optimizing value networks. This aligns with previous work by Peppard and Rylander (2006), which posits that effective value networks are essential for enhancing project outcomes. The study's insights into how digital tools improve information exchange and decision-making processes resonate with the findings of Dang et al. (2024), who advocate for integrating digital technologies to promote collaboration among stakeholders.

4 Conclusions

This study examines how digitally driven construction business models optimize stakeholder engagement, enhance efficiency, and promote sustainability within the South African construction industry. The findings from the study show that the key driver of digitally-driven business models is the need for companies to improve efficiency and that the overall project performance ratings following the implementation of digital tools were positive. It was also found that digital tools are reshaping traditional business models and value networks within the South African construction industry, bringing about stakeholder engagement, collaboration, competitive advantage and streamlining processes. The findings contribute to the knowledge of how digitalization reshapes business models and value networks in the construction industry, reinforcing the notion that digital tools are integral to modern construction practices. Based on these findings, the study concludes that construction firms that embrace digitalization and reshape their business models will have optimized value networks, efficient processes and improved project performance.

The study recommends that construction firms prioritize integrating technologies such as BIM and project management software into their processes to streamline workflows and improve project outcomes. The study also recommends that construction firms should prioritize training programs to enhance digital literacy among employees to ensure that stakeholders are equipped to utilize digital tools and technologies effectively and that project organizations should set up collaborative platforms that facilitate real-time communication and information sharing among stakeholders towards improving project coordination and reducing inefficiencies. The small sample size limits the study's findings. Further research can be undertaken using a larger sample size to further explore the dynamics of digital transformation in construction and the impact of digital tools on various aspects of construction, including sustainability and stakeholder engagement, to provide generalizable results.

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References

Abeynayake, D. N., Perera, B. A. K. S., & Hadiwattege, C. (2022). A roadmap for business model adaptation in the construction industry: a structured review of business model research. *Construction Innovation*, *22*(4), 1122-1137.

Azhar, S. (2011). Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership and Management in Engineering*, *11*(3), 241-252

Creswell, J. W., & Plano Clark, V. L. (2023). Revisiting mixed methods, research designs twenty years later. *Handbook of mixed methods research designs*, 21-36.

Dang, P., Geng, L., Niu, Z., Chan, M., Yang, W., & Gao, S. (2024). A value-based network analysis for stakeholder engagement through prefabricated construction life cycle: evidence from China. *Journal of Civil Engineering and Management*, *30*(1), 49-66.

Denner, M. S., Püschel, L. C., & Röglinger, M. (2018). How to exploit the digitalization potential of business processes. *Business & Information Systems Engineering*, *60*, 331-349.

Harris, F., McCaffer, R., Baldwin, A., & Edum-Fotwe, F. (2021). *Modern construction management*. John Wiley & Sons.

Ikuabe, M., Aigbavboa, C., & Adekunle, S. (2023). Towards smart construction sites for effective project delivery. In *Proceedings of International Structural Engineering and Construction* (Vol. 10, No. 1, pp. CON-35). ISEC Press.

Kelly, J., Male, S., & Graham, D. (2014). *Value management of construction projects*. John Wiley & Sons.

Locatelli, M., Seghezzi, E., Pellegrini, L., Tagliabue, L. C., & Di Giuda, G. M. (2021). Exploring natural language processing in construction and integration with building information modeling: A scientometric analysis. *Buildings*, *11*(12), 583.

Mbanaso, U. M., Abrahams, L., & Okafor, K. C. (2023). Research philosophy, design and methodology. In *Research Techniques for Computer Science, Information Systems and Cybersecurity* (pp. 81-113). Cham: Springer Nature Switzerland.

Nikmehr, B., Hosseini, M. R., Martek, I., Zavadskas, E. K., & Antucheviciene, J. (2021). Digitalization as a strategic means of achieving sustainable efficiencies in construction management: A critical review. *Sustainability*, *13*(9), 5040.

Omrany, H., Al-Obaidi, K. M., Husain, A., & Ghaffarianhoseini, A. (2023). Digital twins in the construction industry: a comprehensive review of current implementations, enabling technologies, and future directions. *Sustainability*, *15*(14), 10908.

Osterwalder, A., Pigneur, Y., Bernarda, G., & Smith, A. (2015). *Value proposition design: How to create products and services customers want*. John Wiley & Sons.

Pekuri, A., Pekuri, L., & Haapasalo, H. (2013). The role of business models in Finnish construction companies. *Australasian Journal of Construction Economics and Building, The*, *13*(3), 13-23.

Peppard, J., & Rylander, A. (2006). From value chain to value network: Insights for mobile operators. *European Management Journal*, *24*(2-3), pp. 128–141.

Reypens, C., Lievens, A., & Blazevic, V. (2016). Leveraging value in multi-stakeholder innovation networks: A process framework for value co-creation and capture. *Industrial marketing management*, *56*, 40-50.

Spence, R., & Mulligan, H. (1995). Sustainable development and the construction industry. *Habitat International*, *19*(3), 279–292.

Takim, R., & Akintoye, A. (2002, September). Performance indicators for successful construction project performance. In *18th Annual ARCOM Conference* (Vol. 2, No. 4, pp. 545–55).

Windapo, A. O. (2021). The construction industry transformation and the digital divide: Bridging the gap. *South African Journal of Science*, *117*(7-8), 1-4.

Zulu, S. L., Saad, A., Ajayi, S., & Unuigbe, M. (2023). Determinants of an effective digital transformation in construction organizations: a qualitative investigation. *Built Environment Project and Asset Management*, *13*(6), 896-912.