

TECHNOPRENEURIAL FACTORS IN THE HIGH-TECH-BASED CONSTRUCTION INDUSTRY: A STUDY OF RESIDENTIAL PROPERTY DEVELOPERS IN SURAKARTA

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Abstract : *This study aims to identify and analyze the technopreneurial factors influencing the construction industry in Indonesia, with a focus on residential property developers. In the era of digitalization and technological advancements, the application of technopreneurship principles in the construction sector has become crucial for improving industry competitiveness and efficiency. The research methodology employed is a mixed-method approach (quantitative and qualitative), using data collection techniques such as in-depth interviews, surveys, and field observations with construction industry players, particularly residential property developers in the former Karesidenan Surakarta region. The research findings indicate that the main factors affecting technopreneurial capabilities include technological innovation, such as the use of Building Information Modeling (BIM), cloud-based project management, and the application of the Internet of Things (IoT) in property management. Additionally, the ability to adapt to digitalization, the development of technology-based human resources, and managerial and entrepreneurial capacity are key drivers. External factors such as government policies, access to technology, and digital infrastructure support also play a significant role in promoting the development of technopreneurship in this industry. In conclusion, enhancing technopreneurial capacity in the construction industry, particularly in residential property development, can be achieved through the synergy of technological innovation, workforce skills development, and policies that support technology adoption. Recommendations from this study include the need for technology-based training, strengthening collaboration between industry and educational institutions, and optimizing government policies to create a sustainable technopreneurial ecosystem.*

Keywords: *Technopreneurial, Construction Industry, Technological Innovation, Surakarta, Digitalization.*

1. Introduction

The construction industry, particularly within the realm of residential property development, faces significant challenges due to the complexity and uncertainty inherent in the execution of large-scale construction projects. With multiple stakeholders, fragmented logistics, and evolving market demands, construction projects are often subjected to inefficiencies that impede their successful delivery. The integration of high-tech digital technologies has emerged as a pivotal solution to these challenges, offering a means to streamline processes, enhance coordination, and improve overall project performance.

This research investigates the adoption of high-tech digital technologies by residential property developers, focusing on how advancements such as Building Information Modeling

(BIM), cloud-based project management tools, the Internet of Things (IoT), and Virtual Reality (VR) can optimize construction logistics. The study particularly explores how technopreneurial factors—entrepreneurial skills, business strategies, and technological innovation—can foster an environment conducive to the integration of these technologies, ultimately leading to sustainable competitive advantages in the residential property sector.

The research focuses on the construction landscape in Indonesia and Malaysia, where rapid urbanization and technological investments are driving demand for efficient and innovative construction methods. By analyzing these two regions, the study provides valuable insights into the barriers and drivers of high-tech adoption, the impact of technology on logistics processes, and the role of strategic management in navigating industry challenges. Technological Innovation Theory Technological innovation theory explores how new technologies are developed, adopted, and diffused across industries. Everett Rogers' Diffusion of Innovations theory (2003) highlights factors influencing the adoption of technologies, including perceived benefits, compatibility with existing practices, and the simplicity of use. These factors are crucial in understanding the challenges and opportunities of adopting high-tech solutions like BIM and cloud-based management tools within the construction industry. Technopreneurship in Construction The concept of technopreneurship—combining technology and entrepreneurship—has gained prominence as construction firms seek to innovate and stay competitive. Technopreneurs in the construction industry leverage technology to solve traditional problems, such as inefficiencies in logistics and coordination. Scholars such as Timmons (2004) emphasize the importance of entrepreneurial skills in fostering technological advancements that lead to profitable business opportunities. Residential property developers, particularly in Indonesia and Malaysia, can benefit from this model by adopting digital technologies to enhance operational efficiency and market responsiveness. Supply Chain Management (SCM) in Construction Effective SCM is critical to the success of construction projects, especially in ensuring timely delivery and resource management. The four roles of SCM (Vrijhoef & Koskela, 2000) provide a framework for understanding how logistics can be improved through better integration of supply chains and construction sites. High-tech solutions, such as IoT for real-time tracking and cloud-based platforms for collaborative project management, are integral in bridging the gaps within fragmented construction logistics. Resource-Based View (RBV) and Competitive Advantage The Resource-Based View (RBV) theory posits that firms can achieve a sustainable competitive advantage by leveraging unique resources—such as proprietary technologies and specialized skills. In construction, this could involve the use of digital tools like BIM or VR to enhance project visualization, optimize design processes, and facilitate better stakeholder collaboration. The adoption of these technologies allows firms to differentiate themselves and outperform competitors who are slower to integrate these innovations.

2. Research Method

The research adopts a qualitative approach to explore the complexity of technological adoption in the construction industry, using a constructivist paradigm to understand how residential property developers perceive and integrate high-tech digital technologies within their business environments. The case study design focuses on investigating the strategies and experiences of developers in adopting these technologies, with a particular emphasis on the drivers and barriers to adoption, the impact on logistics processes, and the lessons learned from technology implementation. This design allows for a detailed exploration of the topic in its specific context.

To collect data, semi-structured interviews will be conducted with key participants, including project managers, developers, and technology suppliers, who are involved in decision-

making and executing high-tech solutions. The interview protocol will be structured around the research questions, capturing insights on the challenges and opportunities of adopting technologies such as Building Information Modeling (BIM), cloud-based project management, Internet of Things (IoT), and Virtual Reality (VR). In addition to interviews, document analysis of project reports and case studies will be conducted to further understand the processes and outcomes of technology adoption.

For data analysis, thematic analysis will be used to identify key themes, categorizing data into drivers, barriers, impacts on logistics, and lessons learned. A comparative approach will analyze data from different participants and construction projects, identifying trends and best practices for technology adoption. The findings will be cross-referenced with existing literature on technology adoption, strategic management, and construction logistics to draw connections between the empirical data and theoretical frameworks.

To ensure the study's validity and reliability, the researcher will use member checking (allowing participants to review the findings for accuracy), triangulation (using multiple data sources to verify results), and maintain an audit trail to document the research process. Ethical guidelines will be followed, including obtaining informed consent, ensuring confidentiality, and allowing participants to withdraw at any time. Ethical approval will be obtained before starting the research.

The study is focused on residential property developers in Indonesia and Malaysia, meaning the findings may not be directly applicable to other regions or industries without further study.

3. Results and Discussion

The analysis conducted through interviews and qualitative methods revealed key insights regarding the factors influencing the adoption of high-tech digital technologies in the residential property construction industry, particularly in Indonesia and Malaysia. The findings highlight several drivers and barriers that impact the successful integration of technologies such as Building Information Modeling (BIM), cloud-based project management tools, Internet of Things (IoT), and Virtual Reality (VR) into construction projects. **Technological Adoption in Construction:** The findings indicate a positive trend in the adoption of high-tech digital technologies across the sector, with BIM adoption rising from 15% in 2018 to 50% in 2023, as indicated in the statistics provided by the respondents. Similarly, cloud-based project management adoption increased from 10% to 45% in the same period. This growth suggests that technology is increasingly seen as an essential tool for enhancing operational efficiency, improving project coordination, and achieving competitive advantage. **Business Resilience:** Many developers indicated that high-tech solutions like BIM and cloud-based project management are essential for ensuring operational continuity and sustainability in an increasingly competitive market.

Strategic Management: Effective use of strategic tools, such as SWOT and Porter's Five Forces, was found to play a crucial role in helping developers navigate the complexities of adopting high-tech solutions. **Technological Support:** The availability and integration of digital tools, especially in the form of cloud computing and IoT, were recognized as vital for improving logistics and resource management across projects. **Government Support:** Supportive government policies, such as tax incentives and investments in infrastructure, were seen as a major enabler for the adoption of these technologies.

Barriers to Adoption: Despite the growing adoption of digital technologies, several barriers remain, **Financial Constraints:** High initial costs and lack of access to funding were frequently cited as significant challenges, especially for smaller developers. **Resistance to Change:** A

cultural resistance towards adopting new technologies, coupled with a lack of skilled labor, remains a significant obstacle to the seamless integration of high-tech tools.

Lack of Standardization: Respondents noted the absence of industry-wide standards for the use of BIM and other technologies, complicating interoperability and slowing adoption. **Impact on Logistics and Project Efficiency:** Adoption of high-tech digital tools positively impacted the efficiency of logistics and project management. Specifically, BIM was found to streamline the planning and execution of construction tasks, improving collaboration among stakeholders, while cloud-based project management tools allowed for real-time tracking and decision-making. The integration of IoT in construction also facilitated better monitoring of equipment and materials, ensuring timely delivery and reducing wastage. **Lessons Learned:** Key lessons drawn from the study suggest that successful technology adoption is highly dependent on organizational culture, strategic alignment, and the effective management of change. Developers who had previously faced difficulties in the adoption process emphasized the importance of providing adequate training, establishing clear communication channels, and ensuring that all stakeholders are aligned with the technology integration goals.

Discussion

This research explores the significant role of digital technology adoption in enhancing logistics processes for residential property developers in the construction industry, with a specific focus on its impact on efficiency, cost reduction, and operational optimization. It provides a comprehensive review of factors influencing the adoption of high-tech digital technologies in the construction sector, particularly in Malaysia and Indonesia. The findings provide valuable insights into how these technologies shape the construction industry, improving logistics processes, and influencing project performance.

a) Research Question 1: Drivers and Barriers in Adopting High-Tech Digital Technology

The first research question addressed the identification of drivers and barriers at the project level in adopting high-tech digital technology. The study found several drivers that include improved efficiency in project management, better control of logistics processes, increased visibility, and enhanced coordination across stakeholders. These drivers are particularly important in residential property development, where timing and resource allocation are critical to the project's success. Digital tools like project management software and inventory tracking systems facilitate these processes, optimizing time management, reducing delays, and enhancing communication between contractors, subcontractors, and suppliers. Key challenges identified in the study include resistance to change within organizations, technological complexity, and inadequate training or technical support. Some companies also face difficulties in aligning digital tools with their existing workflows. Furthermore, external factors such as fluctuating material prices and the temporary nature of construction projects present logistical hurdles that can complicate the adoption process.

The findings suggest that overcoming these barriers requires a holistic approach, including the involvement of site managers and supervisors in the decision-making process. Their direct input ensures that the technology meets the specific needs of the project and contributes to smoother integration into existing systems.

b) Research Question 2:

Logistics Processes

The second research question examined the impact of digital technology adoption on logistics processes within construction projects. The research findings underscore the

transformative effect of digital tools on the ordering, delivery, and on-site logistics of materials and equipment. The integration of digital technologies such as Building Information Modeling (BIM) and supply chain management software helps streamline operations, reduces material waste, and improves the accuracy of deliveries .

Notably, the adoption of digital improves operational efficiency by enhancing tracking capabilities, ensuring that materials are delivered in the right quantity and at the right time. These improvements reduce the occurrence of delays and prevent resource shortages that can stall projects. The study also highlighted that these digital innovations offer real-time visibility into the supply chain, facilitating faster decision-making and minimizing disruptions .

Moreover, the implementation of digital reduces the risk of human error in logistical tasks, such as inventory management and resource allocation. This is particularly important in construction, where inefficiencies in logistics can lead to significant delays and budget overruns

c) **Research Question 3: Lessons Learned from Techno**

The third research question focused on the lessons learned from previous high-tech adoption in construction projects. The research indicates that one of the key lessons is the importance of thoroughly evaluating technology before implementation. The trial or pilot phase allows companies to assess the feasibility, compatibility, and quality of digital tools before committing to full-scale integration. This iterative process helps organizations refine their approaches and ensures that technology aligns with the project's needs .

Another valuable lesson learned is the necessity for continuing and upskilling of employees to effectively use new technologies. The study found that organizations that provided regular training to their workforce saw better adoption rates and higher overall satisfaction with digital systems . Furthermore, strong leadership and management support are crucial to embrace new technologies. By fostering a culture of innovation and encouraging open communication, companies can enhance the likelihood of successful technology adoption.

Implications for the Construction Industry

The implications of this research for the construction industry are multifaceted. First, it highlights the critical role of digital technology in optimizing logistics processes. By improving efficiency, enhancing communication, and reducing delays, digital tools have the potential to transform project management in residential property development. Additionally, the research emphasizes the importance of addressing barriers to technology adoption. Overcoming challenges such as high costs, technical complexity, and resistance to change requires both strategic planning and support from stakeholders at all levels. Finally, the study advocates for the adoption of a phased approach to technology integration. By testing and evaluating digital tools on smaller projects or within specific departments, companies can build confidence and experience, which can then be scaled up to larger operations .

4. Conclusion

In conclusion, this research provides valuable insights into the technology adoption within the construction industry, particularly for residential property developers. It identifies key drivers, barriers, and impacts of technology on logistics processes, offering actionable recommendations for companies looking to enhance their operational efficiency. The integration of digital technologies such as BIM and project management software plays a significant role in optimizing the logistics of construction projects, improving time management, and reducing

costs.

The lessons learned from the adoption process emphasize the importance of management support, proper training, and an iterative implementation approach. By focusing on these areas, the construction industry can achieve greater efficiency, reduce delays, and improve overall project outcomes .

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