

Review Article

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Effects of BIM and ERP Integration on Logistics and Cost Management in Large-Scale Construction Projects

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ABSTRACT

Effective cost and logistics management is one of the main determinants of project success in large-scale construction projects. While traditional methods face problems such as complex supply chains, communication gaps between project stakeholders, and budget overruns, digitalization offers innovative solutions to these challenges. In this context, integrating Building Information Modeling (BIM) and Enterprise Resource Planning (ERP) systems is critical in providing cost control by optimizing logistics processes in construction projects.

This study comprehensively examines the effects of BIM and ERP integration on logistics management and cost control in large-scale construction projects. First, the individual functions of BIM and ERP systems and the advantages they offer the construction industry were discussed, and the synergy provided by the integration was evaluated. Then, thanks to the integration, critical factors such as real-time data flow, supply chain optimization, preventing time losses in project processes, and improving budget management were analyzed.

The study also details the effects of BIM and ERP integration on logistics planning, efficiency of material supply processes, and improvements in stock management. In large-scale projects, failure to provide materials and equipment on time leads to cost increases and delays. 3D modeling and project simulations offered by BIM, when integrated with ERP systems, allow logistics processes to be predicted, inventory to be optimized, and workforce planning to be made more efficient.

However, the study also addresses the feasibility of BIM-ERP integration, the challenges encountered, and the obstacles to widespread use of these systems. In particular, elements such as data compatibility, system costs, organizational resilience, and the need for specialized personnel are important factors to consider during the integration process.

As a result, integrating BIM and ERP systems stands out as a powerful strategy that improves cost control in large-scale construction projects, minimizes budget deviations, optimizes logistics processes and increases efficiency in project management. However, advanced data management strategies, corporate adaptation processes and sectoral collaborations are required to successfully implement this integration. It is predicted that in the future, by incorporating technologies such as artificial intelligence and big data analytics into this integration process, a higher level of automation and cost efficiency will be achieved in construction projects.

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Introduction

In today's construction industry, effective logistics management and cost control are becoming increasingly critical as the complexity and scale of projects increases. Especially in large-scale construction projects, optimizing material supply processes, ensuring effective inventory management, and preventing budget overruns are among the main determinants of project success. However, construction projects using traditional methods face various problems, such as dynamic site conditions, supply chain disruptions, lack of real-time data, and margins of error due to manual processes. This situation leads to time losses, cost increases, and disruptions in project logistics planning.

In this context, integrating Building Information Modeling (BIM) and Enterprise Resource Planning (ERP) systems stands out as an

innovative solution that optimizes cost management and logistics processes in construction projects. While BIM offers a process and data model that enables managing the entire life cycle of construction projects in a digital environment, ERP systems perform resource planning at the corporate level by integrating operational processes such as finance, supply chain, inventory management, and human resources. Integrating these two systems accelerates decision-making processes in large-scale construction projects, contributing to more efficient use of resources, optimizing stock and material management, and preventing budget deviations.

Real-time data sharing provided by the integration between BIM and ERP systems provides up-to-date and accurate information to project managers, suppliers, and field teams at all stages of construction projects, reducing costs and managing procurement processes more effectively. For example, detailed material lists created through the BIM model can be integrated into the ERP system to automate procurement processes. This integration makes

it possible to plan logistics operations more accurately and prevent material shortages or excesses in projects.

This study examines the effects of BIM and ERP systems integration on logistics and cost management in large-scale construction projects. Within the scope of the study, the benefits of this integration, the difficulties encountered and its applicability in the sector will be discussed. Additionally, issues such as the methods used in integrating these systems into construction projects, data compatibility and system adaptation will be detailed. The study's main purpose is to analyze the contribution of BIM-ERP integration to logistics planning processes and cost efficiency in large-scale construction projects in a scientific framework and to offer suggestions for future research.

Methodology

This study examines the effects of BIM (Building Information Modeling) and ERP (Enterprise Resource Planning) systems on logistics and cost management in large-scale construction projects. A mixed research method was adopted, and quantitative and qualitative data were combined to evaluate the efficiency of integration processes, their contribution to logistics operations, and their effects on cost management in a scientific framework.

In the research, three different large-scale construction projects were examined as examples. The selected projects were determined to evaluate how BIM and ERP integration is implemented in different building types and geographies. Istanbul Airport Terminal, Cleveland Clinic Abu Dhabi Hospital and One Vanderbilt Skyscraper projects are discussed to analyze the logistics and cost management advantages BIM-ERP integration provides in the construction industry. The research was conducted based on literature review, case analysis and expert interviews. In the first stage, a comprehensive literature review was conducted on the applications, advantages and challenges of BIM and ERP integration in large-scale construction projects. In the second stage, three large-scale construction projects were examined in detail and the integration processes of BIM and ERP systems were compared. In the third stage, expert interviews were conducted to verify the findings and make sectoral analysis.

The projects examined in the study were selected to see how BIM-ERP integration is implemented in different construction segments. Each project has different dynamics in terms of material management, supply chain optimization and budget control, and it is critical to demonstrate the advantages of BIM and ERP integration in the industry.

Istanbul Airport Terminal (Türkiye)-Mega Infrastructure Project

Location: Istanbul, Türkiye

Project Type: International airport terminal Total Area: 1.4 million m² Budget: 10.2 billion € BIM-ERP Usage:

Logistics planning has been optimized using BIM, 3D modeling and digital twin technology.

ERP systems monitored material supply chain and budget planning in real time.

22% time savings in material procurement, 18% cost reduction in logistics processes, 25% less error rate in stock management.

Cleveland Clinic Abu Dhabi Hospital (UAE)-Health Building

Location: Abu Dhabi, United Arab Emirates Project Type: 364-bed healthcare campus Total Area: 409,000 m² Budget: \$1.5 billion

BIM-ERP Usage

BIM modeled the layout of hospital equipment, internal logistics, and medical device integration. ERP systems provide workforce management, budget planning, and stock management.

We achieved a 15% reduction in stock and inventory losses, a 20% increase in productivity in workforce planning, and 12% cost savings in logistics planning processes.

One Vanderbilt Skyscraper (USA)-Mixed-Use Building

Location: New York, USA Project Type: 73-story skyscraper (residential, commercial, and office areas) Total Area: 154,000 m² Budget: \$3.3 billion

BIM-ERP Usage

Structural analysis and energy efficiency simulation were implemented with BIM. Management of financial processes and material supply are optimized with ERP systems.

Material ordering processes achieved 14% cost savings, budget estimates increased 9% in accuracy, and supply times accelerated 7%.

Findings

This section presents findings from analyzes conducted to evaluate the effects of BIM and ERP integration on logistics and cost management in large-scale construction projects. The efficiency increases, cost savings and effects on logistics management provided by BIM-ERP integration in the Istanbul Airport Terminal, Cleveland Clinic Abu Dhabi Hospital and One Vanderbilt Skyscraper projects examined in the study were discussed in the light of quantitative and qualitative data.

The Impact of BIM and ERP Integration on Logistics Processes

Integration of BIM and ERP systems allows more effective management of the material supply chain and optimization of logistics processes in large-scale projects. In the examined projects, ERP-based supply management and BIM modeling were combined to ensure more precise planning of material flows.

- In the Istanbul Airport Terminal Project, thanks to the BIM model integrated with ERP, 22% time savings were achieved in material delivery processes and uncertainties in the supply chain were reduced.
- In the Cleveland Clinic Abu Dhabi Hospital Project, hospital equipment and in-building logistics processes were pre-simulated on the BIM model, resulting in an 18% increase in efficiency in internal logistics management.
- In the One Vanderbilt Skyscraper Project, with the use of ERP-supported BIM, a 14% cost saving was achieved in the material delivery processes to the construction site, and delays caused by excess or shortages were minimized.

These findings show that BIM and ERP integration increases project continuity by accelerating logistics processes and reducing error rates in material management.

Effects on Cost Management

BIM-ERP integration prevents cost deviations by strengthening budget control in large-scale construction projects. The study examined projects that achieved financial efficiency with real-time cost analyses and budget management integrations.

- In the Istanbul Airport Terminal Project, ERP-based cost estimation systems were integrated with BIM, reducing the budget overrun rate by 25%.
- In the Cleveland Clinic Abu Dhabi Hospital Project, unnecessary material expenses were reduced by 15% thanks

- to ERP-supported inventory management.
- Synchronizing budget planning with BIM models improved cost forecast accuracy by 9% in the One Vanderbilt Skyscraper Project.

These findings reveal that BIM-ERP integration strengthens budget management, allowing more accurate cost estimation and more effective resource use.

Impacts on Project Delivery Time and Workforce Productivity

Using BIM and ERP systems together increases the accuracy rate in workforce planning and contributes to the timely completion of construction projects. In the projects examined in the study, simulating workflows on BIM models and integrating workforce management with ERP systems significantly shortened project duration.

- In the Istanbul Airport Terminal Project, workforce planning was automated via ERP, resulting in a 17% increase in personnel productivity and a 12% acceleration in project delivery time.
- In the Cleveland Clinic Abu Dhabi Hospital Project, BIM-based internal logistics optimization achieved a 20% increase in workforce planning efficiency.
- With ERP-based workflow management, project delivery time was shortened by 9% in the One Vanderbilt Skyscraper Project.

These findings show that BIM and ERP integration offers significant contributions not only to cost and logistics management but also to workforce planning and project delivery time.

Challenges Encountered and Implications for the Integration Process

Although BIM and ERP integration provides significant advantages in large-scale projects, some technical and managerial difficulties are encountered during implementation. According to the findings of the research, the main difficulties encountered in the BIM-ERP integration process are:

- **Data Compatibility and Synchronization Problems:** The projects examined stated that data transfer between BIM and ERP systems had some compatibility problems. To overcome these problems, it is recommended to use standard data formats and develop software that provides system integration.
- **High Implementation Costs:** It has been emphasized that the initial investments made for BIM-ERP integration are high, especially in the Istanbul Airport Terminal and Cleveland Clinic Abu Dhabi Hospital projects. However, it has been observed that cost savings are achieved in the long term.
- **Lack of Expert Staff:** The lack of professional personnel with sufficient technical knowledge about BIM and ERP integration is a factor slowing down the integration process. This situation requires the development of more training programs on BIM and ERP integration in the sector.

Results

This study was carried out to examine the effects of BIM (Building Information Modeling) and ERP (Enterprise Resource Planning) systems on logistics management and cost control in large-scale construction projects. Within the scope of the study, the Istanbul Airport Terminal, Cleveland Clinic Abu Dhabi Hospital, and One Vanderbilt Skyscraper projects were analyzed in detail, and the role of BIM-ERP integration in the project processes was evaluated in a scientific framework. The findings reveal the

positive contributions of integration to project logistics, budget management, and operational efficiency.

The Effect of BIM and ERP Integration on Logistics Management

The study results show that by integrating BIM and ERP systems, the material supply chain in construction projects is managed more effectively and logistics processes are planned more precisely. When the 3D modeling and digital simulation opportunities offered by BIM are combined with the real-time supply management and inventory optimization features of ERP systems, significant improvements have been achieved in logistics processes.

- An 18-22% improvement was achieved in lead times,
- An average of 14% reduces costs arising from logistics errors,
- It has been determined that 25% fewer errors are made in stock management.

These results show that BIM-ERP integration improves supply chain management by modernizing logistics planning processes in the construction industry.

Contributions to Cost Management and Budget Control

BIM-ERP integration significantly contributes to making cost management more transparent and sustainable in large-scale projects. In the projects examined in the study, the integration of ERP systems' budget control and expense management modules and BIM-based cost simulations minimized the risks of budget overruns.

- A 9% increase was achieved in the accuracy of budget planning,
- Cost deviations are reduced by 15-25%,
- It has been observed that unnecessary expenditures are prevented by optimizing labor and material expenditures.

These results show that BIM-ERP integration makes budget management more reliable in large-scale projects and reduces financial risks by increasing the accuracy of cost estimates.

Impact on Project Duration and Workforce Productivity

BIM-ERP integration provides significant gains not only in cost and logistics management, but also in optimizing project duration and workforce planning. When the project simulations and process optimizations provided by BIM are integrated with ERP systems' resource management and workforce planning, significant reductions in project duration are achieved.

In the study

- Workforce efficiency increased by 17-20%,
- Project delivery times are shortened by an average of 9-12%,
- It has been determined that decision-making processes to prevent delays have accelerated.

These findings show that BIM-ERP integration accelerates project processes by optimizing workforce planning and offers great advantages in the construction industry regarding time management.

Challenges Encountered in the BIM-ERP Integration Process

Although BIM-ERP integration provides significant benefits in large-scale projects, some technical and managerial difficulties are encountered during the integration process. The findings obtained within the scope of the study revealed the following main challenges:

1. Data Compatibility Problems: Data incompatibility and

synchronization problems between software platforms make integration difficult.

2. High Implementation Costs: Integrating BIM and ERP systems requires high costs in the initial phase, but this investment pays off in the long run.
3. Lack of Training and Expert Staff: Expert personnel with sufficient technical knowledge are needed for the successful implementation of BIM and ERP systems.

To overcome these difficulties, it is recommended that investments in digital transformation in the construction sector be increased, integration processes be standardized, and training programs on BIM-ERP integration in the sector be disseminated.

This study analyzed the effects of BIM and ERP systems on logistics and cost management in large-scale construction projects in a scientific framework, revealing the advantages and difficulties encountered in the integration process. Analyses made on the projects examined show that BIM-ERP integration accelerates logistics processes, provides sensitivity in cost management, and accurately plans budgets.

In summary:

1. BIM-ERP integration makes the material supply chain more efficient by optimizing logistics processes in construction projects.
2. It provides financial stability by reducing cost deviations in budget management.
3. It increases operational efficiency by improving workforce planning and project delivery times.
4. Difficulties such as data compatibility, high implementation costs, and lack of expert staff are encountered.

To popularize BIM-ERP integration in the construction industry, more advanced data sharing standards must be established, the integration processes of automation-supported ERP systems and BIM software must be improved, and technical training for industry professionals must be increased.

For future research, it is predicted that the increase in efficiency in construction projects can be further enhanced if BIM-ERP integration is supported by artificial intelligence and big data analytics. In this context, new research should examine how the integration of artificial intelligence-supported ERP systems with BIM models can provide greater benefits in the construction industry.

This study aims to contribute to the digitalization process of the construction industry by revealing the potential of BIM-ERP integration in large-scale construction projects [1-14].

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