

Digital Transformation in Construction Engineering Cost Management: Leveraging Automation for Operational and Competitive Advantage

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Abstract:

This study looked at how digital transformation and automation affect cost management in medium- to large-sized businesses. We looked at both qualitative and quantitative data to compare cost parameters before and after automation. These included operational costs, cost variance, and processing time. We also talked to finance and operations management to get their thoughts. The results revealed that total costs and processing times went down a lot, and cost tracking became more accurate and clear. Also, employees' time was switched from mundane chores to strategic activities, which improved their ability to make decisions. Even while there were benefits, there was some resistance to change during implementation. The results show that automating cost management can improve operational efficiency and give companies a competitive edge, as long as they handle change processes well.

1. Introduction

Digital transformation is becoming more and more important for businesses to stay competitive, flexible, and efficient in today's fast-changing business world. Cost management is one of the most important areas that digital technologies are changing. In the past, it relied on manual processes, broken data systems, and making decisions based on what happened. Cost management has changed from a simple financial task to a dynamic and strategic tool thanks to the use of automation, advanced analytics, and cloud-based platforms. Automation not only cuts down on mistakes and delays caused by people, but it also gives you real-time access to cost structures, which helps you make better and faster decisions.

As competition around the world gets tougher and costs go up, businesses are looking for new methods to make the most of their resources and create value. Digital transformation in cost management can help make workflows more efficient, improve the accuracy of forecasts, and provide staff the freedom to focus on strategic tasks that have a big impact. This change isn't only about using new technology; it's also about completely

reimagining how companies manage and control costs to get a long-term competitive advantage.

This study looked into how digital transformation driven by automation affects how firms manage their costs. It wanted to find out how automation affected the costs of running a business, the productivity of its workers, the speed of decision-making, and the company's overall financial health. The study gave a full picture of how digital transformation helped businesses gain a competitive edge in cost control by looking at both quantitative data and qualitative insights.

2. Literature review

Leão and da Silva (2021) did a thorough assessment of the literature to look into how digital transformation affects companies' competitive advantages. Their results showed that digital transformation was very important for increasing strategic capabilities by encouraging new ideas, making it easier to respond to customers, and making processes more flexible. They said that companies that used digital technologies were better able to react to changing market conditions and be competitive over the long term.

Agustian et al. (2023) looked into how digital transformation changed business models and how companies compete with each other. Their research showed that digital initiatives changed the way firms produced, delivered, and captured value in big ways. Changing these business models allowed companies to change how they work and what they offer, which made them stand out more in the market and gave them a competitive edge.

Ren and Lin (2024) used real-world data from Chinese companies to look at the link between digital transformation, strategic choices, and the value of a company. Their research demonstrated that digital transformation had a big impact on how organizations choose their competitive strategies. This allowed them to move away from traditional cost leadership models and toward more innovative, unique methods. The study also showed that these kinds of strategic changes were good for the overall value of the company.

Feng and Ali (2024) focuses on how digital transformation affects manufacturing businesses, especially when it comes to Enterprise Resource Planning (ERP) systems. Their research showed that automation, processing data in real time, and using digital platforms that work together all made operations run more smoothly. They discovered that using both digital transformation and ERP systems together made productivity go up, costs go down, and supply chain visibility go up.

Behrendt et al. (2021), McKinsey & Company looked at how the Industrial Internet of Things (IIoT) and other advanced technologies can help with digital transformation in a report that focused on the sector. Their research showed that companies who used these technologies saw big gains in productivity, decision-making, and keeping costs under control. The analysis showed how digital transformation initiatives, when backed by cutting-edge technologies, led to big improvements in operations and helped businesses stay competitive in marketplaces that are becoming more and more digital.

3. Materials and method

Research Design

The study used a mixed-methods research methodology, which included both quantitative examination of organizational cost measurements and qualitative assessments of how managers saw things. This method was chosen to get both measurable changes in how well cost management works and people's personal experiences with implementing automation. Quantitative data looked at things like comparing costs before and after automation, how employees spent their time, and

operational problems. Qualitative data came from talking to finance and operations management.

Sample and Setting

The study looked at 10 medium- to large-sized companies in the manufacturing and service sectors that had started using digital automation tools to manage costs in the last three years. The chosen firms were all at different stages of digital maturity, but they all used automation to make cost control processes easier. There were 30 top experts in charge of financial planning, cost analysis, and overseeing digital transformation among the attendees.

Data Collection

We gathered quantitative data from organizational records and operational reports over a two-year period, one year before and one year after automation was put in place. We pulled out and put together key performance measures including total operational cost, cost variance, and processing time for cost-related tasks. We also looked at the different costs, such as labor, materials, and overhead, to find particular areas where costs may be cut (see Table 2). Structured surveys were used to collect data on how employees use their time in order to see how automation has changed their work patterns. Also, both archive data and survey responses were used to write down the problems that came up with managing costs.

Data Analysis

We used paired sample t-tests to look at the statistical significance of changes in cost metrics and time allocation before and after automation. We used descriptive statistics, such as averages and standard deviations, to sum up the data. Percentage changes were calculated to show how big the improvements or problems were in important areas. We fixed the significance values at $p < 0.05$. Qualitative insights from participant input added to the quantitative results, giving a better picture of how the implementation affected things.

4. Result and discussion

This part shows the results of the quantitative and qualitative investigations that were done to see how digital transformation and automation affect cost management. The quantitative results look at how cost efficiency changed before and after automation was put in place. The qualitative results look at how finance and operations managers feel about the pros and cons of automation. The outcomes are spoken about in terms of how better cost management might provide a business an edge over its competitors.

Table 1 shows how automation has greatly improved important cost management indicators. The total operational costs went down a lot, which shows that automation made better use of resources and improved processes. Cost variance also went down a lot, which shows that budgeting and financial forecasting have become more accurate and consistent. Also, the time it took to execute monthly cost-related tasks was cut down by a lot, which suggests that data handling and reporting cycles are now faster. All of these benefits show that automation helped the organizations analyzed run their businesses more efficiently, keep better track of their money, and manage their costs better overall.

Table 2 shows how automation affects different cost regions, showing that some areas have seen significant drops. Labor expenses went down a lot, which means that automation successfully replaced or improved manual jobs. This made businesses less reliant on human labor for everyday chores. Overhead expenses also went down a lot, which suggests that automated systems made operations more efficient and made better use of resources. On the other hand, the costs of materials changed very little, which suggests that automation didn't have much of an effect on how raw materials are bought or used. This is because external market forces, not internal process improvements, usually affect these costs. The fact that the reductions in labor and overhead costs are statistically significant shows that automating cost management can have real financial benefits.

Table 3 shows a big change in how employees use their time after automating cost management tasks. After automation, the amount of time spent on routine data entry jobs went down a lot. This shows that automated systems were able to take over tasks

that were repetitive and done by hand. This let workers focus their energies on activities that offered greater value, such cost analysis, reporting, and strategic planning. The fact that finance people are spending more time on analytical and decision-making duties implies that their roles are changing from doing operational work to making strategic contributions. Also, the fact that people are spending less time in meetings and on coordination tasks shows that the workflow is more efficient and that they have better access to real-time information, which means they don't have to make updates and clarifications as often. In general, the new way of using time shows how automation can boost staff productivity and strategic involvement.

Table 4 shows that automation has made it much easier to deal with some of the most important cost management problems. Before automation, 85% of respondents said they made mistakes while entering data by hand. After automation, this number dropped significantly to just 20%, showing that automated processes made data much more accurate. Also, the number of late cost reports went down from 70% to 15%, which shows that data processing is now faster and more efficient. The percentage of people who said they couldn't see costs in real time also dropped significantly, from 80% to 25%. This suggests that automation made it easier to get financial information in a fast and clear way. But there wasn't much improvement in how employees resisted change; it only went down from 45% to 40%. This means that even while automation made technical and operational problems much easier to solve, human factors like adaptation and acceptance were still a problem that companies needed to deal with through stronger change management and training programs.

Table 1: Comparison of Cost Management Metrics Before and After Automation

Metric	Pre-Automation (Mean)	Post-Automation (Mean)	% Change	p-value
Total Operational Cost (\$M)	12.5	10.3	-17.6%	0.003**
Cost Variance (%)	6.2	3.8	-38.7%	0.001**
Processing Time (hours/month)	120	75	-37.5%	0.002**

Table 2: Breakdown of Cost Components Before and After Automation

Cost Component	Pre-Automation (Mean)	Post-Automation (Mean)	% Change	p-value
Labor Costs	5.6	4.1	-26.8%	0.004**
Material Costs	3.9	3.7	-5.1%	0.210
Overhead Costs	3.0	2.5	-16.7%	0.017*

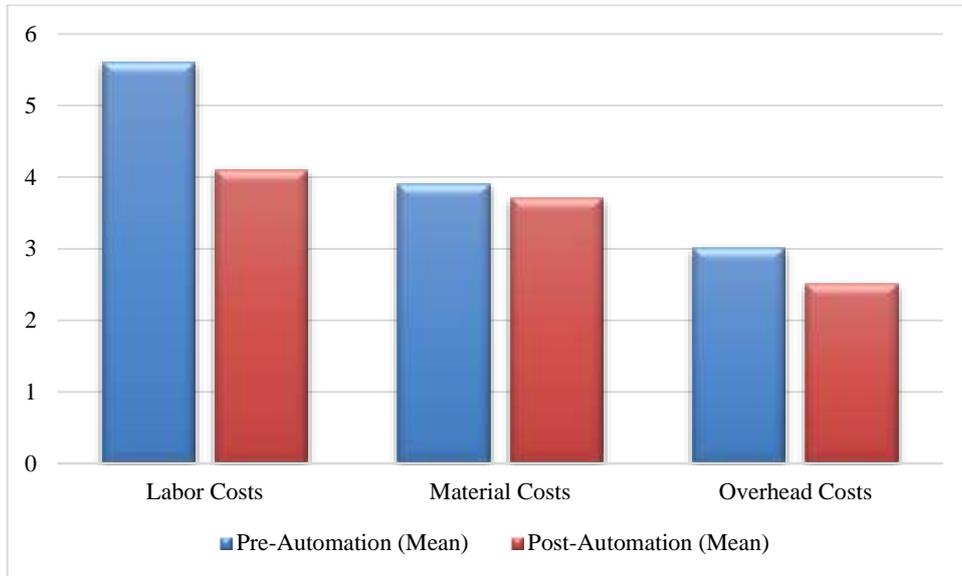


Figure 1: Breakdown of Cost Components Before and After Automation

Table 3: Employee Time Allocation Before and After Automation

Activity	Pre-Automation (%)	Post-Automation (%)	% Change (points)
Routine Data Entry	40	15	-25
Cost Analysis and Reporting	25	40	+15
Strategic Planning & Decision	15	30	+15
Meetings & Coordination	20	15	-5

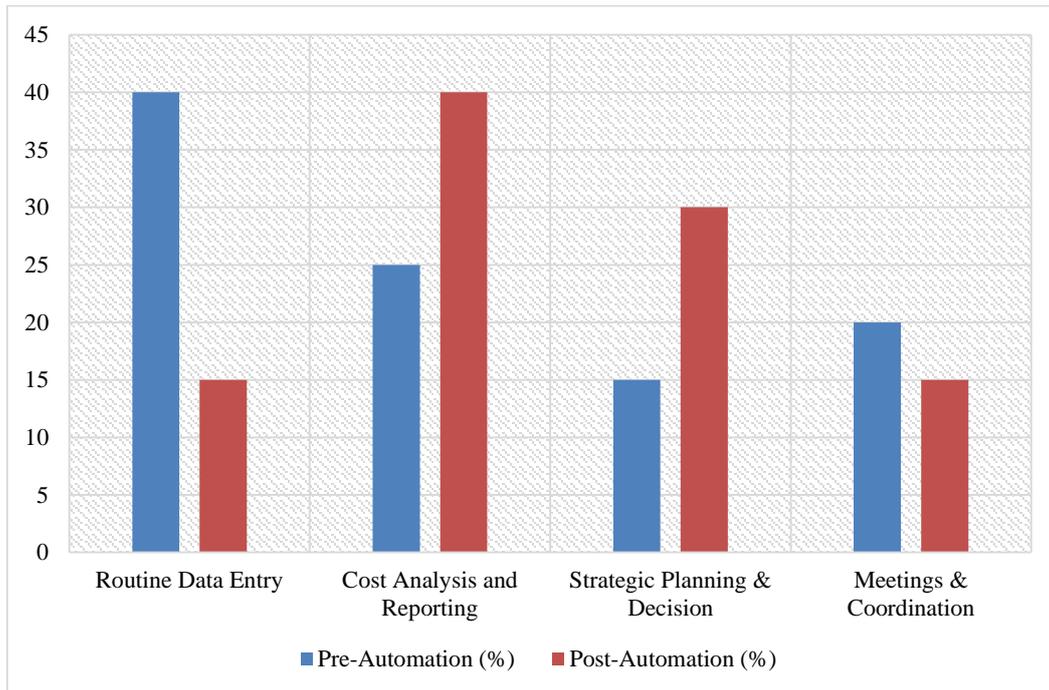


Figure 2: Employee Time Allocation Before and After Automation

Table 4: Cost Management Challenges Before and After Automation

Challenge	Pre-Automation (Frequency %)	Post-Automation (Frequency %)
Manual Data Errors	85	20
Delays in Cost Reporting	70	15
Lack of Real-Time Cost Visibility	80	25
Employee Resistance to Change	45	40

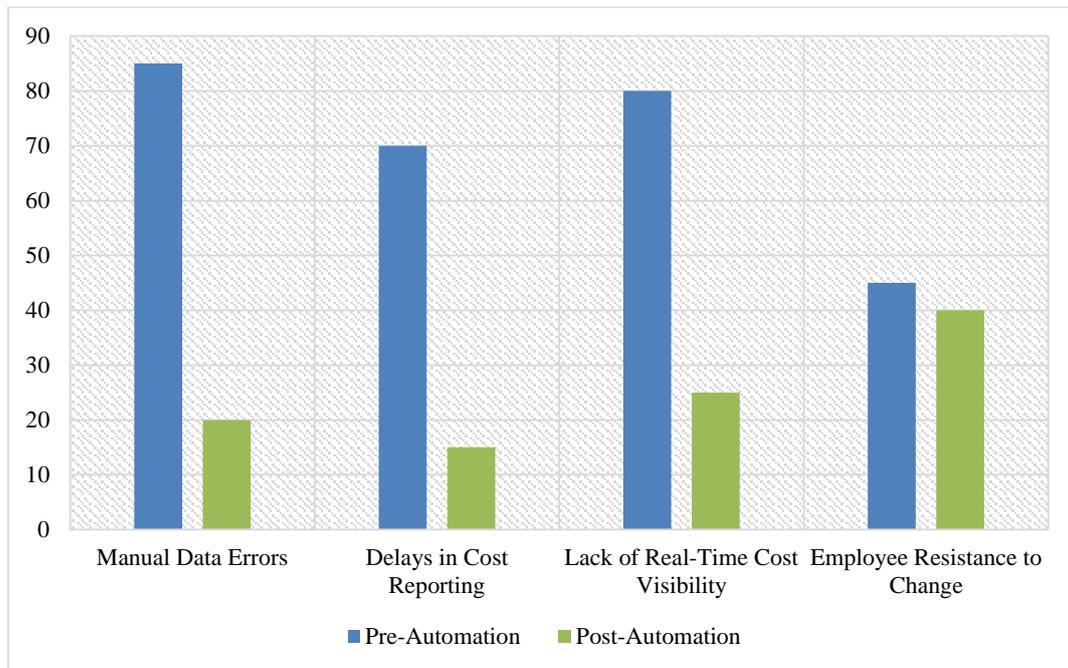


Figure 3: Cost Management Challenges Before and After Automation

5. Conclusions

The study found that digital transformation through automation greatly improved cost management by lowering operating costs, minimizing cost variations, and speeding up processing times. It also shifted employees' focus from regular duties to strategic initiatives. These changes made cost control more accurate, open, and flexible, which helped the company stay ahead of its competitors. Even while the benefits were evident, there were still problems, including employees not wanting to change, which showed how important it is to manage change well. Overall, the results show that companies who use automation strategically in cost management can become more efficient and make better decisions, giving them a strong position in competitive marketplaces.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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