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Unlocking Digital Construction Management Software to Support Cash Flow and Profitability Analysis

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ABSTRACT: Effective financial planning and control of construction projects depend on proper cash flow and profitability analytics to achieve successful outcomes. Digitalization of construction data, through construction management software tools, has gained momentum in the past 5 to 10 years. Procore is a leading example of such solutions, holding approximately 6.2% of the global construction software market and ranking second in the category. While offering avenues for collecting and organizing the data of construction operations and administrative processes, the full potential of descriptive and predictive analytics of these tools, alongside ERP systems, for managing project cash flows remains untapped. This study explores and discusses the analytics that can be derived from Procore, and one ERP system, to improve cash flow planning and control, and profitability monitoring and improvement for construction contractors. In this regard, an approach is developed to extract and aggregate cashflows from the data of transactions, and three use cases are enabled accordingly: (i) evaluating payment delay's impacts on profit using ERP system data; (ii) evaluating financial impacts of change orders; and (iii) performing cash activity–flow cross-analyses to improve project liquidity and resource allocation. Results of applying the proposed method to real MEP-related data and data of a sample project shed some light on how untimely payments, different project activities and types of change orders affect the contractors' cash flow and profitability. By harnessing construction data properly, contractors can be empowered towards improved project planning and control practices.

1. INTRODUCTION

Financial planning and control are essential for construction project management, ensuring financial stability and profitability amid challenges such as cost overruns, delays, and resource inefficiencies. Digital construction management software such as Procore along with enterprise resource planning (ERP) systems are enhancing construction financial management by addressing these challenges through centralized systems for project tracking, integration, and analysis of financial data. Procore streamlines processes such as those related to budget management, change order tracking, and cash flow analysis, enabling data-driven support for decision making and reducing errors or disputes that can jeopardize profitability. Additionally, its collaborative features enhance communication between teams, mitigating risks and optimizing resource allocation. By integrating with ERP systems, these tools can facilitate seamless data flow, improving financial control and transparency. However, even with such tools, construction financial management continues to face critical challenges. One major issue is not to benefit from advanced analytics capabilities in Procore and ERP systems. While these tools excel in data logging/accessibility and basic reporting, they fall short in controlling projects' cash flows in a timely manner and delivering insightful descriptive and predictive analytics. Without these capabilities, construction firms struggle to adopt

proactive financial management practices, leaving them vulnerable to inefficiencies and missed opportunities for enhancing profitability.

Another major challenge is the widespread fragmentation of data systems within the construction industry. Financial data is often isolated across multiple departments, tools, and formats, resulting in misaligned timelines and priorities that hinder seamless integration and comprehensive analysis. For example, while financial managers typically monitor receivables and payables on a monthly or bi-weekly basis in ERP systems, project managers frequently require a weekly overview of expenses and invoices billed to the owner in project management platforms such as Procore, which creates discrepancies in reporting cycles and challenges in aligning project cash flows with financial planning objectives. The fragmentation also results in inconsistencies, delays in reporting, and a lack of actionable insights, hindering the ability to create a unified financial picture for projects in a timely manner. As a result, project and financial managers are often forced to rely on incomplete or outdated information, exacerbating risks. Therefore, the goal of this research is to establish a streamlined approach for transforming raw cash flow data into actionable insights by integrating advanced analytics, enabling precise financial control and informed decision-making. By tackling these issues, construction firms can unlock the full potential of digital tools, streamline financial management processes, and achieve sustained profitability in a highly competitive industry.

2. LITERATURE REVIEW

Data analytics, as one of the key components of the modern digital era (Wijayarathne et al. 2024), is a vital service that digital construction management software provides for construction businesses, specifically in the financial management domain. In this context, two angles need to be combined and integrated: first, gathering raw data using different systems, and second, processing this data into insightful information and actionable analytics, as conceptualized by the Data, Information, Knowledge, Wisdom (DIKW) pyramid (Baskarada and Koronios 2013), in an automated manner. Building on this, the study by Atuahene et al. (2023a) examines the transformative potential of big data in construction, identifying key capabilities required for effective utilization across multiple dimensions, including people, knowledge, technology, data, and the environment. Their research findings demonstrate that integrating big data analytics capabilities, such as fostering collaboration between construction professionals and data experts, utilizing robust systems such as Autodesk for real-time data management, and developing frameworks for documenting lessons learned, can drive digital transformation in construction. These practices enhance decision-making, process efficiency, and competitive advantage through data-driven insights and industry-specific tools.

However, a significant barrier is fragmentation within the construction ecosystem. This includes differing standards, disconnected workflows, and siloed data practices (Hashim et al. 2024; Nyqvist et al. 2024), which arise from the use of diverse systems and departmental separation. To address this, Hashim et al. (2024) developed a comprehensive framework for cultivating a data-driven culture in construction. Their framework emphasizes the integration of data analytics, democratization, literacy, and leadership with construction software and advanced analytics to overcome fragmentation and enhance digital transformation and competitiveness. The fragmentation issue leads to generating another barrier, the issue of data duplication, which was recognized by (Atuahene et al. 2023b) as a significant challenge during the data generation and storage stages of big data processes in construction. This problem can be effectively addressed by leveraging data analytics and using software tools properly. Yousif et al. (2021) underscore the role of big data platforms in resolving issues of construction data fragmentation and facilitating seamless information sharing. By improving data integration, reducing inefficiencies, and fostering enhanced collaboration and communication, these platforms contribute to the advancement of engineering construction and operations. Such measures highlight the necessity of a strategic, unified approach to fully harness the potential of data analytics in construction financial management.

Digital construction management software requires more advanced and sophisticated analytics for effective project financial planning and control. Existing literature highlights a significant gap in insightful analytics for cash flow and profit planning, revealing limited studies in this area despite the vast potential of leveraging data analytics for project financial management. For instance, Bilal et al. (2019) utilized big data analytics to explore the impact of various project characteristics on profit margins, identifying how factors such as project type, duration, and location influence stakeholder profitability or potential losses. More valuable insights can also be captured through contingencies analysis. Xie et al. (2012) highlight payment delays and change orders impacts, as two critical financial challenges in construction projects that are essential

for effective project control. Most contractors are unable to handle these contingencies effectively, which can severely disrupt cash flows and profitability. The literature review shows the need for more research to overcome the aforementioned shortcomings. Therefore, this paper aims to establish a streamlined approach for transforming raw cash flow data into actionable insights, enabling precise financial control and informed decision-making in construction projects. In detail, the objectives include: (i) recognizing the roles of financial and project managers in cash flow management; (ii) identifying the capabilities of existing digital construction management software; (iii) elaborating an approach for extracting and aggregating cash flow data; and (iv) performing "out-of-box", of software tools, cash flow data analysis for actionable insights.

3. METHODOLOGY

The methodology of the current study presents a structured approach to enhancing cash flow management in construction projects, comprising four interconnected components (Figure 1). The first three steps were performed by literature review, while the final step was developed through use case analysis.

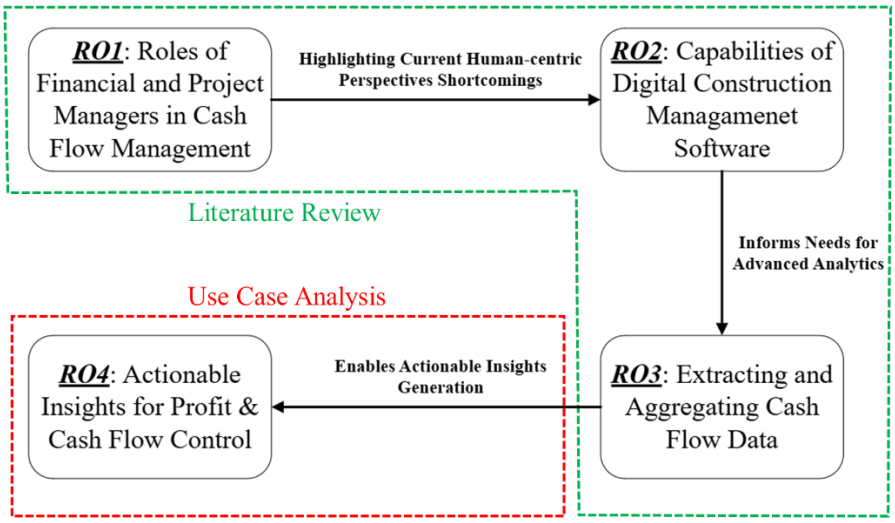


Figure 1. Research Methodology

4. RESULTS AND DISCUSSION

4.1 Roles of Financial and Project Managers in Cash Flow Management

The financial management of construction projects depends on a well-defined allocation of responsibilities among stakeholders to ensure cash flow stability and profitability. However, there is no single standard for the responsibilities of construction financial managers (CFMA 2024). Yet, in Small and Medium Enterprises (SMEs), the financial managers typically oversee all administrative and financial tasks (CFMA 2024); Marketing, estimating, and project management (CFMA 2024); and Interpretation of financial reports to make business recommendations at company-level (Procore 2024). Digital construction management software often defines stakeholder responsibilities and tailors its services, accordingly, ensuring alignment with the specific roles and needs of each participant. For instance, according to Procore (2024), project managers are usually responsible for managing cash flows and return on revenue at the project level. Financial managers work closely with several key roles. They collaborate with the CFO to align financial strategies with overall corporate goals and ensure fiscal responsibility. They also engage with project managers to manage cash flow and return on revenue at the project level, ensuring financial resources are optimally allocated. Additionally, financial managers interact with risk managers to mitigate financial risks, estimators to align cost projections with financial plans, and accountants to ensure accurate financial reporting and compliance with accounting standards (Figure 2). Collaboration between financial and project managers (highlighted in Figure 2) is crucial for controlling cash flow and profitability, as they play a central

role in financial data flow and directly impact a project's financial success by ensuring realistic budgets, steady cash flow, cost control, and real-time financial adjustments.

Figure 2. Financial manager interactions in construction projects

4.2 The Capabilities of Digital Construction Management Software

Procore's analytic capabilities provide useful financial insights through a suite of predefined reports. The two primary groups of financial reports are "*Financials Budget*" and "*Financials*". Each category offers distinct insights into different aspects of project financial management, enabling effective monitoring and decision-making. The 15 "*Financials Budget*" reports offer various measures and metrics useful for budgeting, such as tracking the causes of change events, monitoring budget adjustments and variances, and measuring the percentage of project completion based on costs incurred. Among the 19 "*Financials*" reports, there are valuable insights aligned with cash flow analysis, including tracking commitment payments issued, managing change order contracts, monitoring payments made and received under prime contracts, keeping track of invoices sent and received, managing change order requests, and tracking direct costs incurred on the project (Procore Analytics, 2024). Procore's analytics are primarily descriptive, focusing on past events and basic performance insights. However, they lack advanced tools for robust cash flow and profitability control, as well as predictive or prescriptive capabilities for deeper insights and future outcomes. As shown in Figure 3, which illustrates common data analytics concepts along with varying levels of sophistication and competitive intelligence (Davenport and Harris 2017), Procore's analytics primarily focus on foundational levels and have the potential to expand into deeper diagnostic, predictive, and prescriptive analytics. Incorporating these advanced analytics capabilities would significantly enhance Procore's ability to generate in-depth insights, provide foresight, and optimize project outcomes. By evolving toward these advanced forms of analytics, Procore could fully support a data-driven approach, thereby strengthening project control and improving overall performance.

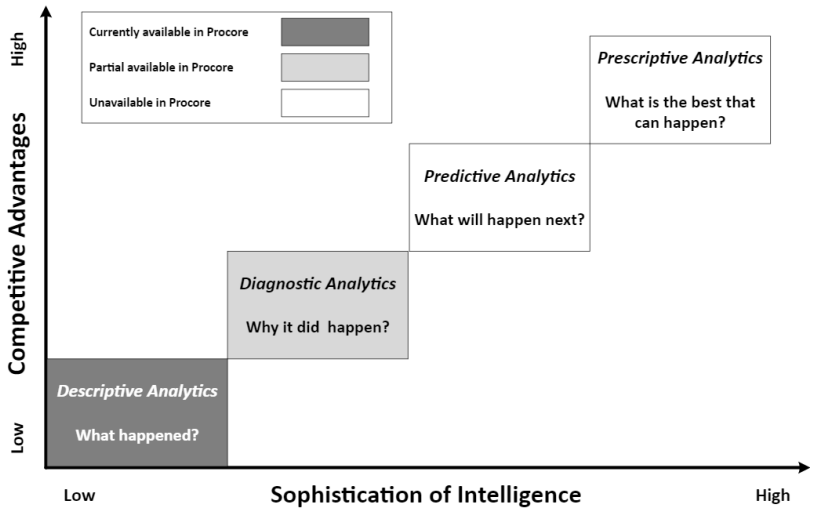


Figure 3. Procore data analytics position based on Davenport and Harris (2017)

Alongside Procore, considering QuickBooks' capabilities as an ERP system, although it can track and forecast cash flow and profitability, its functionality is limited to the business level, relying solely on historical bank account transaction data. This approach lacks connection with construction-specific data, which is truly essential for achieving realistic control, anticipating financial behavior, and gaining a deeper understanding of cash flow and profitability issues in construction projects. All in all, the financial & project

managers need (i) more sophisticated insightful analysis; (ii) data-driven support to control cash flow and profitability efficiently and promptly; (iii) guidance on integrating construction digital tools with financial systems; and (iv) to have a tailored analytics solution. This will directly inform the need for an approach for extracting and aggregating cash flow data.

4.3 Methodology for Extracting and Aggregating Cash Flow Data

The process for managing construction cash flow and profit data integrates data engineering principles to ensure automated and efficient financial management. It begins with *Identifying* key financial data points such as accounts payable and receivable, progress payments, retention amounts, and change orders. These data points are sourced from accounting systems and/or project management platforms. Typical data attributes logged in systems are presented in Figure 4. The *Extraction* step involves retrieving data from identified financial and project management systems using automated methods. APIs such as REST or GraphQL can facilitate programmatic access to data, while HTTP requests can allow for direct retrieval of receivables, payables, invoices, project budgets, etc. data. These requests can be scheduled, such as weekly data pulls, or triggered on demand to ensure consistent updates. Additionally, webhooks can enable event-driven data synchronization by sending real-time notifications whenever specific events occur, such as when an invoice is updated or a payment is received. Automation tools such as Azure Logic Apps or Microsoft Power Automate can also orchestrate the use of HTTP requests and webhooks, ensuring seamless integration, scheduling, and error handling throughout the data extraction process. This ensures that accurate and timely financial data is consistently delivered for the next steps in the pipeline.

The *Preprocessing* stage involves applying data engineering workflows to clean, validate, and transform the extracted data. For example, Python scripts or ETL tools can standardize date formats, handle missing values, and ensure currency consistency across datasets. Data pipelines can also incorporate validation rules to flag discrepancies such as overdue payments, mismatched entries, or incomplete transaction records. In this regard, automated reconciliation processes can be applied to compare extracted financial data with source systems (e.g., QuickBooks, Xero). For example, reconciliation workflows in Azure Logic Apps can compare accounts receivable with payments logged in Procore and flag mismatches for review.

In the *Aggregation* step, data is consolidated into a centralized database, such as Microsoft SQL Server, Azure SQL Database, and Azure Data Lake. This central repository facilitates the integration of project-level cash flow data, enabling detailed financial overviews. By running scheduled scripts, the database can be updated weekly or as frequently as needed. Aggregated data supports the generation of comprehensive cash flow statements, profit and loss reports, and project-specific performance metrics in a timely manner.

The *Analysis* stage leverages analytics tools such as Power BI, Tableau, or other dashboarding tools for advanced modeling and visualization. Live connections to consolidated databases in the previous can ensure dashboards display up-to-date financial metrics. It can provide stakeholders with real-time insights into project profitability, cost overruns, or cash flow health, empowering proactive decision-making. Finally, in the *Storage* phase, data is securely archived in a structured format that facilitates long-term financial analysis and compliance. Cloud storage solutions such as Azure Blob Storage can ensure scalability and reliability. Scheduled processes can automate the archival of weekly or monthly datasets, while audit trails and logs can be maintained to support financial accountability and transparency (See Figure 4).

By integrating these steps into a cohesive, automated manner, construction companies can ensure continuous updates, accurate auditing, reconciliation, and reporting, and improved cash flow and profit management. This approach not only enhances operational efficiency but also provides a solid foundation that enables construction businesses to generate actionable analytics, financial forecasting, and strategy planning.

Figure 4. Methodology for Extracting and Aggregating Cash Flow Data

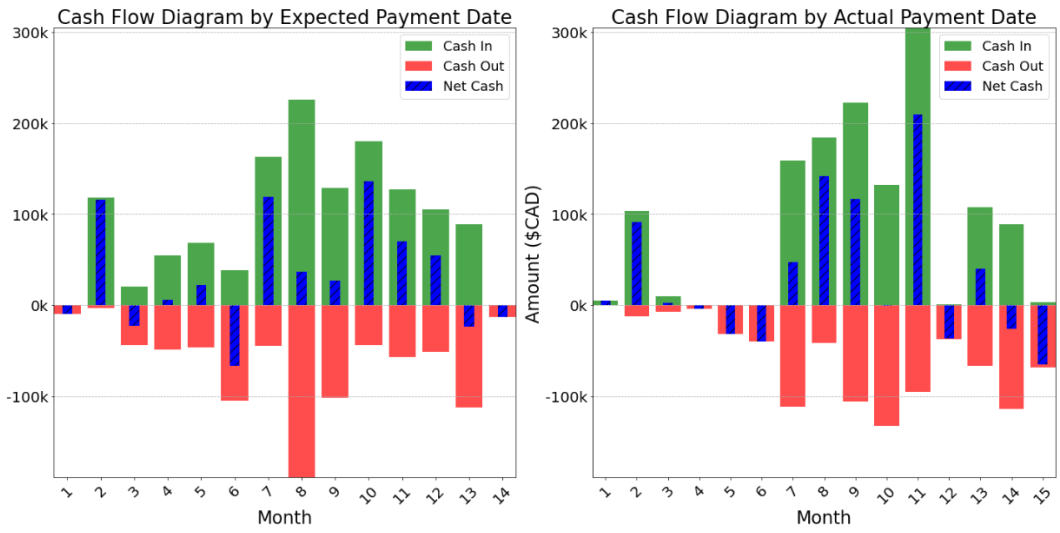
4.4 Actionable Insights for Financial Stability: Use Case Analysis

Accordingly, there are new use cases that construction contractors can potentially apply. The first use case examines how payment delays impact profitability and cash flows, identifying key items that influence financial performance and highlighting high-risk cash flows' points. The second use case demonstrates how change orders and their type, timing, and magnitude can affect project profitability. The third use case focuses on the cross-analysis of project cash flows and schedules to evaluate how different activities contribute to overall liquidity and financial stability. In the following, the three new use cases are further discussed:

4.4.1 New Use Case 1: Payment Delay's Impacts on Profit (from ERP System)

Delays in payments, a common issue in construction, can significantly disrupt cash flow, leading to liquidity challenges and reduced profitability (Andalib et al. 2018). This use case analyzes how payment delays impact project profitability and cash flows by comparing 'expected' versus 'actual' payment dates. By identifying high-risk items and understanding the financial implications, contractors can proactively mitigate these risks, reduce overdrafts, and enhance profitability. Contractors can use these insights to make informed payment management decisions, negotiate better terms, and maintain financial control over the project. The analysis can also help them identify which payers pose more risks and which payees are more tolerant of payment delays. An actual example that can clarify the use case is an industrial waste project (MEP works) in Surrey, BC, initially set at $1,611,081 CAD, and faced scope changes, a 4% increase in contract value. Figure 5 illustrates two cash flow diagrams; one based on the expected payment dates as issued in invoices (a), and the other based on the actual dates when transactions occurred (b). The diagrams demonstrate the fluctuations in cash flows due to untimely payments. When considering the TVM, the Benefit-Cost Ratio (BCR)[1] values for both scenarios are over one, indicating that the benefits outweigh the expenses. However, an incremental BCR analysis revealed that the cash flow based on expected payment dates is a better case. This implies that the cash flows formed by actual transaction dates did not meet the financial efficiency as expected.

[1] BCR is the ratio of discounted benefits to costs for the project, with reference to the present value in the base year in which a project is acceptable for investment with a value over one (Newnan et al. 2020)



(a) based on the expected payment date *(b) based on the actual payment date*

Figure 5. Cash flow diagram for an example project

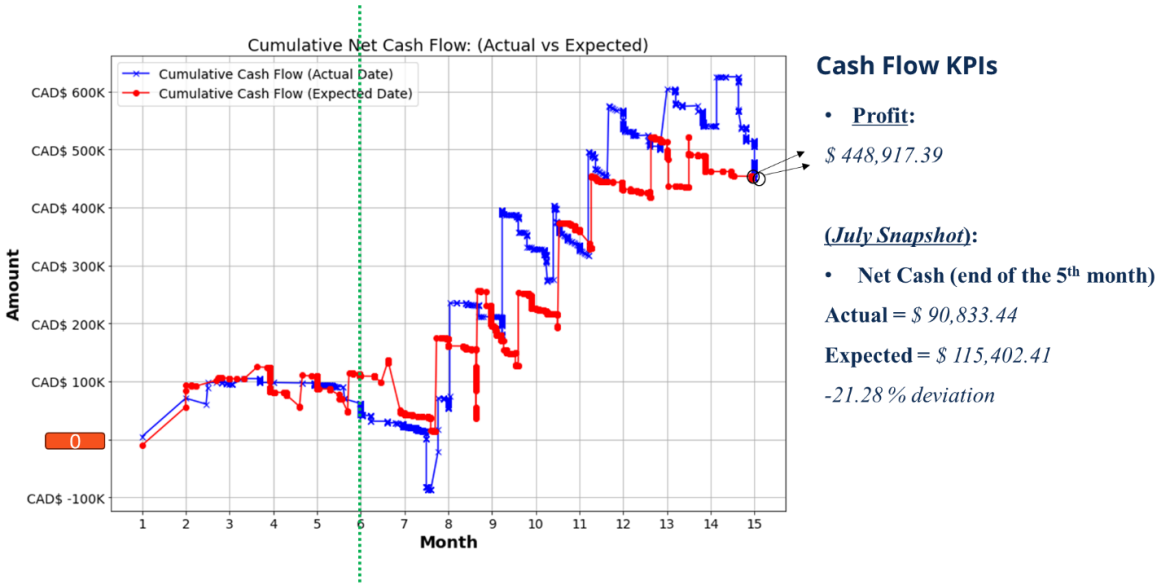


Figure 6. Cumulative net cash flow for an example project

To gain a deeper understanding, the focus now shifts to analyzing the cash flows from a different angle. The cash flow and cumulative net cash flow diagram (Figure 5&6) illustrates the following insights:

Insight #1 - *evaluating profitability, TVM vs. Non-TVM perspectives*: The cumulative net cash flow based on both expected and actual scenarios at the end of the project (15 months) equals 27.86% of the base contract value (i.e. profit margin). While the profit margin of the two scenarios is the same, the Net Present Value (NPV) of cash flows based on expected dates is higher than the actual one when considering the TVM. Surprisingly, there were no penalties for payment delays, likely because the owner's late payments caused delays in paying subcontractors under the 'pay-when-paid' rule.

Insight #2 – *identifying cash flow discrepancies*: The discrepancies between expected and actual payment dates reveal fluctuations. A snapshot from the 5th month shows a net cash deviation of 16.5% from the expected value. Recognizing such discrepancies would help to keep cash flows stable and ensure timely financial adjustments.

Insight #3 – *A call for developing predictive models*: Although these discrepancies did not significantly impact the project's financial health initially, they were not effectively controlled. In the 7th month, a

substantial overdraft of approximately $100k occurred (in cash flows based on actual dates), calling for a considerable amount of the company's capital or financing sources to keep project cash flows in good condition. The above-mentioned discrepancy (in overdraft) indicates a need to develop a predictive model to assist construction businesses avoid such a situation during construction. Linking these analyses to cost codes and amounts helps identify outliers and key items, enabling timely actions to prevent cash shortages.

4.4.2 New Use Case 2: Change Order Impacts (Procore)

This use case examines how change orders, which often increase contract value by 5-10% (Serag et al. 2010) but disrupt cash flow and profitability, impact the financial stability of construction companies. To capture the change orders' effects on profitability, a Power BI dashboard (Figure 7) was developed, using mock data, enabling the three important features. The dashboard visualizes profitability fluctuations over time, providing real-time insights into the financial impact of change orders. It links change order details, such as causes and magnitude, with profitability analysis, enabling construction companies to monitor and act on key financial measures effectively.

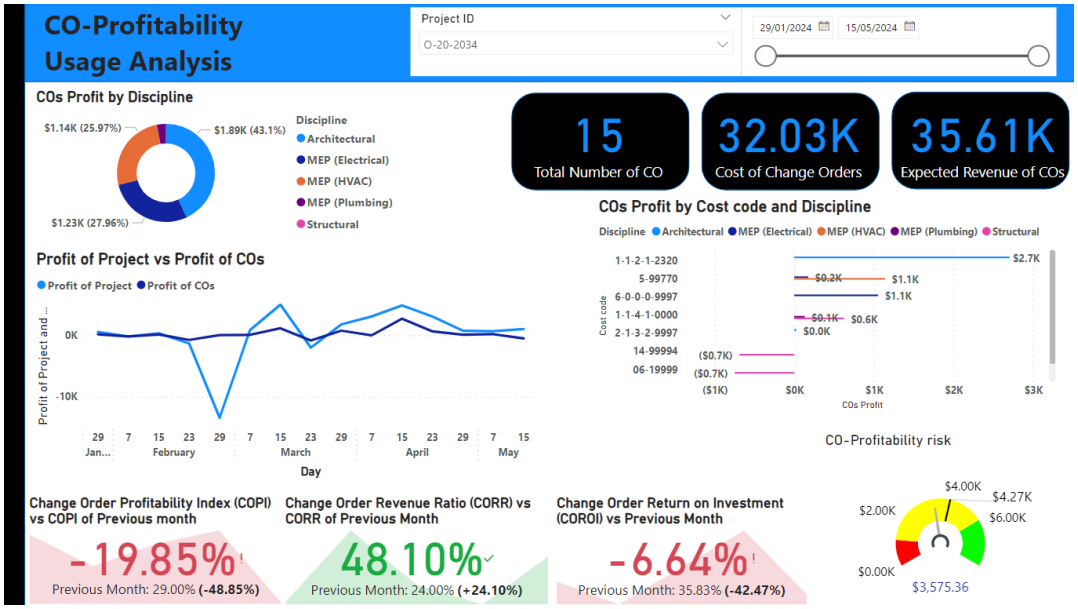
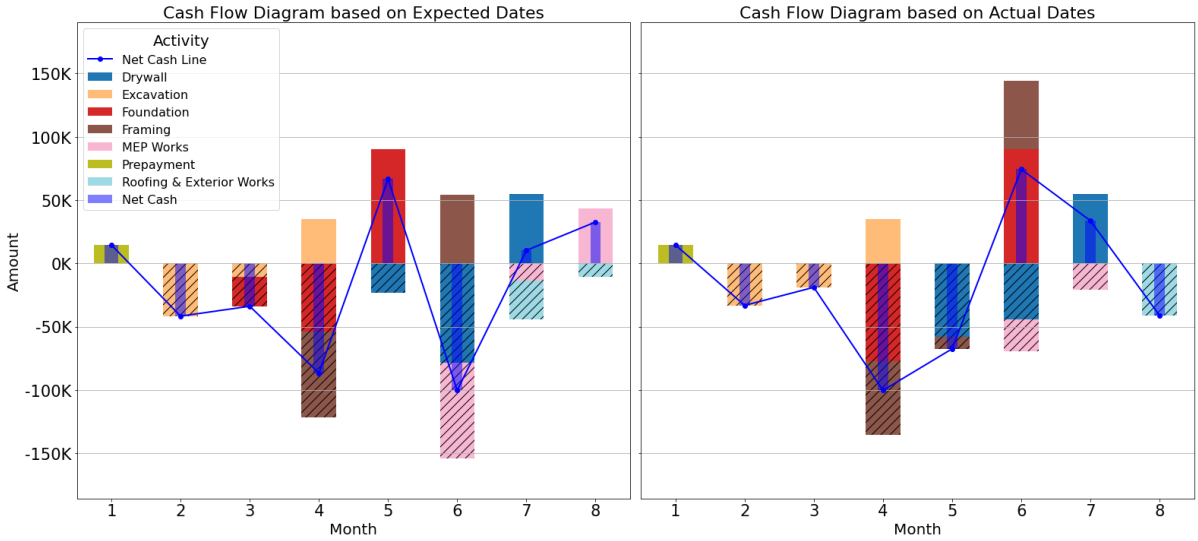


Figure 7. An enhanced dashboard illustrating change order effects on profitability

Feature #1 - *KPIs for monitoring the financial impact of change orders:* This dashboard introduces three KPIs including Change Order Profitability Index (COPI), Change Order Revenue Ratio (CORR), and Change Order Return on Investment (COROI) to better capture the effects of change orders on profitability. COPI is the ratio of profit generated by change orders to the total project profit to date, showing how much of the project's total profitability is attributable to change orders. CORR measures the proportion of total project revenue that comes from change orders. COROI calculates the financial efficiency of change orders by showing the return generated for every dollar spent, as a percentage ratio of net benefits (revenue minus cost) to the cost of change orders. For example, a COPI of -19.85% in May 2024 indicates a significant decline in the contribution of change orders to overall project profitability, down from 29% in April 2024. Despite the high revenue contribution from change orders in May 2024 (CORR = 48.10%), the negative COPI (-19.85%) indicates that the associated costs have outweighed the profits. Feature #2 - *profit linked to cost codes:* The dashboard links profit generated by change orders to specific cost codes, illustrating the contribution of various disciplines and items to overall profitability. Feature #3 - *risk and opportunity signs:* Recognizing that contractors often count on change orders as a source of income, this dashboard incorporates a gauge-based tool to illustrate both downward (risks) and upward (opportunities) signs of change order profitability. The provided dashboard empowers companies to have a precise tool for assessing and monitoring profitability through change orders.

4.4.3 New Use Case 3: Cash Flow-Activity Cross Analysis (Procore)

This use case analyzes project cash flows and activities to enhance financial control by illustrating each activity's contribution to cash flow and assessing the impact of payment delays. It helps project and financial managers identify activities causing cash flow deficits or surpluses, enabling them to adjust schedules and funding to maintain a healthy cash balance. A mock example illustrating the use case involves a set of activities (Figure 8), with a snapshot taken in the 8th month. It is assumed that no significant delays happened in the project work schedule. For instance, given plot (a), it would be beneficial to postpone the execution (or do it in parallel with other activities) and payments of 'Drywall' or 'MEP Works' activities from the 6th month to the 7th and 8th months, if dependencies among activities allow for such adjustments. The delay or advancement of certain activities can be used as a lever to control cash flows. For activities that result in significant outflows, their execution can be postponed until sufficient cash inflows from earlier activities are secured. However, this should not significantly hurt the entire project schedule. Given plot (b), cash flow contributions vary significantly across different activities. For instance, 'Foundation' and 'Framing' activities lead to a notable negative cash flow in the 4th month and positive cash flow in the 6th month. This suggests that these activities are essential for maintaining liquidity during these periods. The negative cash flows in other months, particularly those associated with 'Excavation', 'Drywall', and 'Roofing & Exterior Works' also indicate periods where expenditures outpaced incomes. These outflows, if not managed properly, can lead to liquidity damage and potential project delays as well.



(a) based on expected dates *(b) based on actual dates*

Figure 8. Cash flow - activity cross-analysis example

Delays in owner payments, particularly for major activities, can cause cumulative cash deficits and overdraft risks. For example, late payments for 'Foundation' work could lead to a liquidity crunch. To mitigate this, project managers can secure short-term financing, apply the 'pay-when-paid' rule with vendors, or accelerate client payments. These strategies ensure alignment between activity execution and financial stability, preventing cash flow disruptions and enhancing overall project profitability.

5. CONCLUSION

This study highlights the potential of digital construction management software, particularly Procore and ERP systems, to improve cash flow management and profitability in the construction industry. It identifies critical gaps, including the limited use of advanced analytics, fragmented data systems, and misaligned reporting cycles, which hinder optimal financial oversight. Through a structured methodology, the research develops an approach for extracting, aggregating, and analyzing cash flow data, demonstrating the value of actionable insights in mitigating financial risks and enhancing decision-making. The three use cases,

evaluating payment delays, analyzing the financial impact of change orders, and performing cash flow-activity cross-analyses underscore the transformative role of tailored analytics in controlling cash flow, resource allocation, and project outcomes. By leveraging these findings, construction businesses can bridge current technological gaps, adopt proactive financial strategies, and strengthen profitability in a competitive market.

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