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Assessing the Impact of Digital Supply Chain Management on the Sustainability of Construction Projects

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ABSTRACT

Purpose: The implementation of digital supply chain management (DSCM) has brought about a paradigm shift in the construction industry, which is known for its complex and dynamic nature. This study examines the advantages of implementing a digital supply chain into building projects, focusing on efficient procurement, real-time tracking, and its effects on the sustainability of the project. **Methodology:** A stratified sampling approach is used in the research methodology to collect quantitative data from construction project managers and supply chain specialists using surveys and questionnaires. The study's main objective is to measure how improved stakeholder coordination, real-time tracking, and streamlined procurement procedures affect sustainability and efficiency.
Findings: The results of this study highlight the significant advantages of DSCM in raising the effectiveness of building projects. The results include shortened lead times, improved supply chain visibility, streamlined procurement procedures, and optimal resource allocations.
Originality and conclusions: This paper is focused on the potential difficulties and roadblocks to a successful DSCM implementation. The study provides insightful information for decision-makers and practitioners in the construction sector. To successfully apply DSCM, organizations need to make investments in technology and training, improve teamwork, and create risk-reduction plans.
Keywords: digital supply chain; DSCM; construction industry; project management; real-time data access; sustainability; IT management

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Оценка влияния цифрового управления цепочками поставок на устойчивость строительных проектов

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АННОТАЦИЯ

Цель: внедрение цифрового управления цепочками поставок (DSCM) привело к смене парадигмы в строительной отрасли, которая известна своей сложной и динамичной природой. В данном исследовании рассматриваются преимущества внедрения цифровых цепочек поставок в строительные проекты с акцентом на

эффективные закупки, отслеживание в режиме реального времени и их влияние на устойчивость проектов.
Методология: в исследовании используются стратифицированные выборки для получения количественных данных от менеджеров строительных проектов и специалистов по цепочкам поставок с использованием опросов и анкет. Основная цель исследования — оценить, как улучшенная координация заинтересованных сторон, отслеживание в реальном времени и оптимизированные процедуры закупок влияют на устойчивость и эффективность проектов.
Результаты: полученные данные подтверждают значительные преимущества DSCM в повышении эффективности строительных проектов. Результаты включают сокращение сроков выполнения заказов, улучшение прозрачности цепочек поставок, оптимизированные процедуры закупок и оптимальное распределение ресурсов.
Оригинальность и выводы: в исследовании основное внимание уделяется потенциальным трудностям и препятствиям на пути к успешной реализации DSCM. Исследование содержит полезную информацию для лиц, принимающих решения, и специалистов — практиков в строительном секторе. Для успешного применения DSCM организациям необходимо инвестировать в технологии и обучение, улучшать командную работу и создавать планы по снижению рисков.
Ключевые слова: цифровые цепочки поставок; DSCM; строительная отрасль; управление проектами; доступ к данным в реальном времени; устойчивое развитие; управление ИТ

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Introduction

Modern society is based on construction, which shapes our infrastructure and built environment. The construction sector is essential to a country's economic progress because it creates jobs, builds infrastructure, and advances national prosperity. Nonetheless, the business is characterized by complicated supply chains, complicated procedures, and wide ranges of project scopes. Construction project management efficiency is critical since it directly affects project costs, schedules, and overall success. Construction efficiency may result in considerable cost savings, shortened project timelines, and improved sustainability. Completing a project on time not only benefits the finances but also minimizes disturbances across the entire supply chain and optimizes the return on investment [1]. Moreover, the environmental concerns in developing the sustainable building structure have raised the concern, and it compels the project manager to focus on waste reduction and effective resource management. In this regard, the construction sector has seen a significant shift towards the implementation of digital supply chain management (DSCM). Throughout the project supply chain, DSCM optimizes the movement of resources, sharing information, and materials by utilizing cutting-edge technologies. Connecting different stakeholders, from contractors and customers to suppliers, DSCM improves coordination, visibility, and communication [2]. DSCM has a broad and profound effect on the efficiency of construction projects. Firstly, it streamlines the procurement process: DSCM helps construction businesses cut lead times, negotiate better prices, and source supplies more effectively. By ensuring that goods arrive when needed, this minimizes idle time on building sites and lowers project costs. Secondly, the DSCM helps the real-time tracking and data analytics give project managers insightful information [3]. Better decision-making results from this, making it possible to optimize resources, foresee possible bottlenecks, and resolve problems quickly. Last but not least, DSCM promotes improved coordination amongst diverse stakeholders by cultivating an environment of transparency and accountability [4]. This in turn, reduces the conflict, accelerates problem-solving, and improves the overall efficiency of the construction project. The importance of sustainability in construction projects is undeniable, which has broad societal, economic, and environmental implications. The construction sector may attain these crucial efficiency targets through the use of DSCM, which can improve real-time tracking, coordination/collaboration, and procurement. This will ultimately support the industry's expansion and sustainability.

Figure 1 illustrates the construction project workflow, which follows a systematic progression from planning through execution, monitoring and tracking, to evaluation. The planning stage involves defining the project's needs and scope, finding a qualified team, and creating a rough timeline. During the execution phase, the team is being aligned, deploying resources efficiently, coordinating activities, and ensuring that construction progresses according to plan. The monitoring and tracking phase involves real-time oversight, issue identification, and quality control to maintain adherence to schedule and standards.

Continuous evaluation of project performance allows for the identification of successes and areas for improvement. The lessons learned contribute to refining future projects, enhancing overall project management practices, and ensuring client satisfaction through feedback. By following this structured workflow, construction projects can navigate challenges, optimize resource utilization, and deliver successful outcomes while maintaining quality and client expectations.

Regular evaluation and continuous improvement are integral to the success of the construction process. The efficiency and coordination of building projects can be improved by integrating a DSCM with the conventional project workflow. The digital tools like Building information modeling (BIM) offer the improved communications and real-time data access. Highly sophisticated project management software makes it easier to allocate, purchase, and schedule resources efficiently, allowing project managers to act quickly and decisively. Furthermore, the implementation of digital supply chain technologies improves inventory management by guaranteeing timely procurement and delivery of materials, which reduces delays and expedites construction schedules. Through the utilization of digital innovations in the supply chain, construction projects can attain a smooth progression from planning to execution and assessment, thereby augmenting project success and sustainability.

The implementation of DSCM technologies has been vital in the development of various high profile smart city projects in the United Arab Emirates (UAE). The South of UAE project, a major urban development, integrated DSCM to simplify procurement and logistics for its large-scale construction projects. By utilizing real-time tracking systems and advanced analytics, the project management team could monitor the various activities such as raw material deliveries, optimize inventory levels, and reduce lead times. As a result, the project has achieved a 20% reduction in procurement costs and a 15% reduction in lead times. The management not only cut costs but also helped maintain the determined project schedule, contributing to the overall success of South Dubai as a smart city initiative.

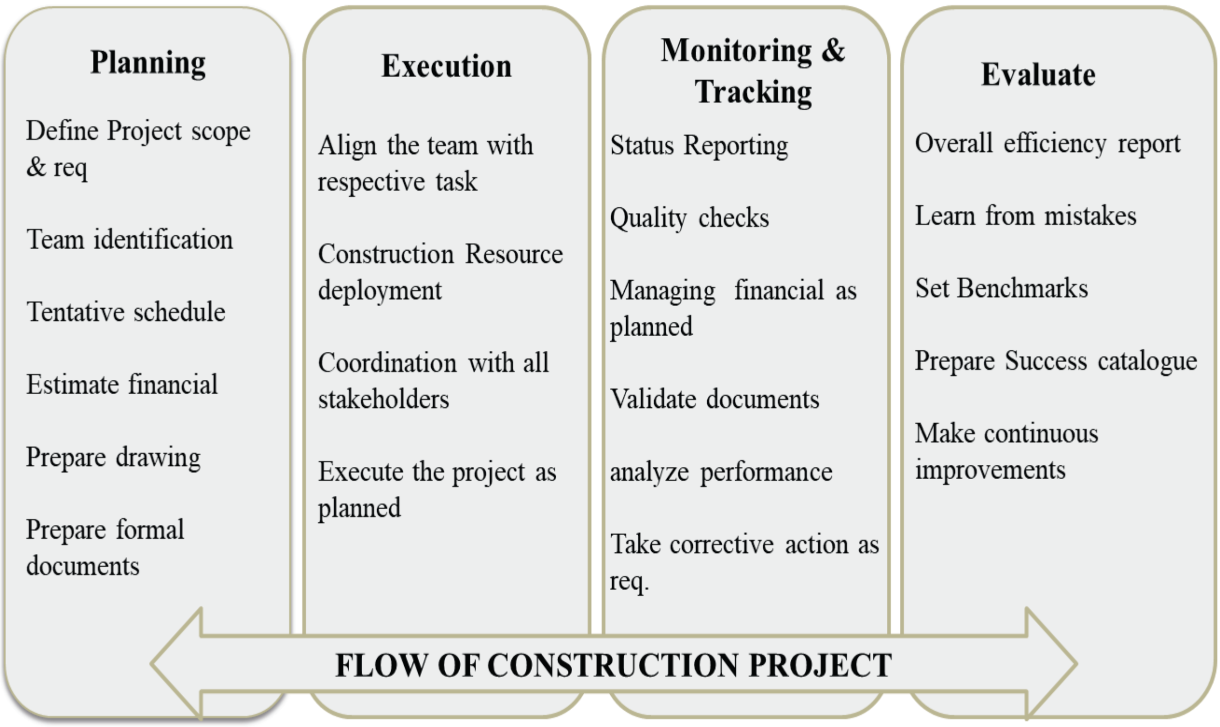

Fig. 1. **Workflow of construction project**

Source: Developed by the authors.

Research objective

The objective of the study is to investigate the digital tools that enhance efficiency, sustainability and resilience for the flow of material, product and information throughout the stakeholders of a construction project.

Research questions

- How can digital tools, such as the Internet of Things (IoT), artificial intelligence (AI) and block chain, be used to track, monitor, and manage the movement of construction materials and products in real-time?
- What are the key challenges and opportunities in implementing digital supply chain solutions in the construction industry?
- How can AI and predictive analytics be used to predict and optimize construction material demand and supply?
- How can digital tools enhance coordination among various stakeholders in the construction supply chain?

Literature review

The construction industry is a vital sector in the global economy, with its direct and indirect effects on employment, infrastructure development, and economic growth. According to the World Economic Forum, over 7% of the global workforce is directly employed in the construction industry, which contributes significantly to job creation and makes up around 13% of the global GDP. Further highlighting its significance in the global context, it acts as a catalyst for economic development by enabling the construction of necessary housing, commercial, and infrastructure structures [1]. Its importance goes beyond mere infrastructure development, encompassing diverse aspects that contribute to the welfare and prosperity of nations worldwide. Recognizing the significance of the construction industry in global development involves identifying its environmental, social and economic impact [5]. While this industry remains integral to the global economy, it faces several challenges and barriers that can be effectively addressed with the adoption of DSCM practices. The integration of digital technologies and processes to optimize the flow of materials, information, and finances along the supply chain in the construction industry, DSCM utilizing the various technologies, including the Internet of Things (IoT), big data analytics, cloud computing, and mobile applications, to streamline supply chain activities, enhance collaboration, and facilitate real-time decision-making [6]. Effective procurement directly impacts cost management, material quality and services, which account for a significant portion of project expenses [7]. Effective procurement strategies can aid in cost optimization by negotiating terms with suppliers, ensuring competitive pricing, and minimizing cost overruns [8]. The success of the project depends upon the availability of material and equipment, while delays in procurement can lead to delays in completing the project and increased costs. Effective procurement ensures the availability of all necessary resources when required, thereby ensuring the meeting of all project deadlines. Procurement strategies can mitigate risks associated with price fluctuations, reliability of suppliers, and market uncertainties. Diversifying suppliers' portfolios and developing contingency plans are vital components of project risk management within the construction industry. Digital supply chain (DSC) provides real-time information and procurement data, allowing management to make better decisions. Digital tools enable cost analysis, demand forecasting, and supplier performance evaluation. It automates the procurement process, reducing manual tasks and chances of errors [9]. It simplifies the entire procurement process, from requisition to payment, improving cost efficiency and reducing administrative overhead. DSC identifies the potential risks through data analysis. It facilitates the proactive monitoring of supplier performance, market trends, and potential disruptions, contributing to a more sustainable procurement process [10]. Real-time tracking of all activities in construction projects is critical for meeting the project timeline. It helps the decision-makers to track progress, identify potential delays, and take proactive measures to keep projects on schedule. Tracking of resources, materials, and equipment usage enables cost control [11]. It helps in avoiding cost overruns, enhancing resource allocation, and minimizing the risk of budget exhaustion. Real-time tracking helps managers to implement quality assurance by monitoring that the right materials and equipment are used as per specifications [12]. This avoids the need for repetition and ensures the construction's long-term durability. Real-time tracking can also enable safety on construction sites. Safety measures are being monitored; potential hazards are detected at an early stage, and proactive risk mitigation is underway. DSC combines the IoT sensors and hardware, which allows the real-time tracking of equipment, material and human resources [13]. Initially, this data is collected and transferred to a central platform for analysis and decision-making; it also provides cloud-based platforms for stakeholders to access real-time tracking information from any specific activity. This enhances coordination and decision-making, irrespective of physical availability, and employs data analytics to develop insights from real-time tracking. These insights help in improving resource allocation, forecasting potential issues, and enhancing project decision-making. Real-time data tracking ensures that project managers are aware of progress in real time regardless of geographical location. They can identify blockages and take corrective actions, thereby ensuring timely completion of the project. The construction industry is a complex and multidimensional sector that relies on smooth coordination among various participants, including investors, architects, contractors, suppliers, and subcontractors. The success of the project depends upon effective communication and collaboration among these parties, quality assurance, and timely delivery [14]. The introduction of DSCM technologies enables transformative capabilities that enhance stakeholder communication in construction projects. Effective coordination ensures that all project activities align to meet the project timeline. Any kind of miscommunication among stakeholders can result in project delays, which have financial implications and can impact the overall efficiency. The participation of all stakeholders in coordination is central to maintaining construction quality. It ensures that all parties are lined up in following project specifications, safety standards, and quality control measures, reducing the probability of rework and errors. Construction projects are recognized for their complexity, involving multiple stakeholders, intricate logistics, and the chances for disruptions at various levels. Lack of communication and coordination among project members often leads to delays, rework, and increased costs. Traditional supply chain management struggles to keep balance with the dynamic nature of construction, resulting in ineffective resource allocation and inadequate visibility into the progress of the project. These challenges need to be addressed for the growth of the industry and to meet the concern for sustainable, cost-effective, and timely project delivery. Various authors in the field have recognized DSCM as a promising solution to the construction industry's persistent challenges. A study [15] suggests a more connected and data-driven approach to supply chain coordination by leveraging technologies such as the IoT and sophisticated project management software. For example, BIM serves as a central repository for project data, encouraging cooperation between various stakeholders and reducing errors by providing a single platform. Real-time monitoring is made possible by the integration of IoT devices, which also makes proactive decision-making possible and offers priceless insights into the dynamics of projects. The previous research [16] suggested digital supply chain solutions place a strong emphasis on improved stakeholder coordination and communication. These technologies facilitate real-time data sharing and dismantle silos, thereby enhancing the coherence and intelligence of the construction ecosystem. This leads to better decision-making, less rework, and eventually a more efficient building process.

We found a substantial gap in identifying the contribution of DSC and application in the construction industry. In terms of resource management, DSCM technologies enabled better forecasting and utilization of construction materials, leading to a 10% reduction in material waste. This not only contributed to cost savings but also supported environmental sustainability goals by reducing the project's ecological footprint (5). This research is focused on how DSCM defines conceptualization within the construction industry, especially streamlining the flow of material, information and resources throughout the project lifecycle. In the construction industry, every project is unique, and that became the real challenge for the supply chain specialists to handle the specific project, whereas this research implies addressing these issues, which enables the managers to smoothen their process in the construction projects.

Methodology

This section explains the research framework, hypothesis, data, and methodology of our study.

Research design

This study applies quantitative research methodology to gather and analyze numerical data. A structured survey is designed to collect responses from a diverse group of participants within the construction industry. To ensure diversity in the sample, a stratified sampling approach is employed. The industry professionals are stratified into distinct groups based on project size, geographical location, and technology adoption level.

Research framework

This is shown in *Fig. 2*.

Hypothesis development

H1: Integration of DSC positively enhances the efficiency of procurement within construction projects.

H2: Integration of DSC positively improves the real-time tracking in construction projects.

H3: The adoption of DSC results in positive effects on collaboration and coordination among all stakeholders in the construction supply chain.

H4: Digitalized procurement practices make a beneficial contribution to the efficiency and sustainability of construction projects.

H5: Real-time tracking positively enhances the efficiency and sustainability of construction projects.

H6: The collaboration and coordination among all stakeholders positively influence the efficiency and sustainability of construction projects.

Data collection

The questionnaires were distributed to supply chain professionals and decision makers in construction industries to gather data on the integration of DSC tools and their impact on the productivity of the construction industry.

Data analysis

The quantitative data collected by the survey was analyzed using statistical software Smart PLS 4. Descriptive statistics was employed to summarize the characteristics of the sample.

Pilot test

A small-scale data collection effort has been made prior to the main data collection from respondents to ensure the pilot test. The pilot test is conducted to ensure that the questionnaire is fully intelligible to respondents and to identify any possible issues that may arise. It also helps to assess the reliability and validity of the questionnaire.

Validity and reliability

Content Validity: The survey questionnaire will be pre-tested to ensure content validity and adjusted accordingly.

Reliability: Reliability of the data will be assessed through test-retest reliability for survey instruments.

Ethical considerations

Informed consent was obtained from survey participants. Respondents' privacy and anonymity was preserved.

Results

This study's first subsection describes the survey respondents' demographics who were involved in determining how DSCM affected construction projects' efficiency. The general qualities and reliability

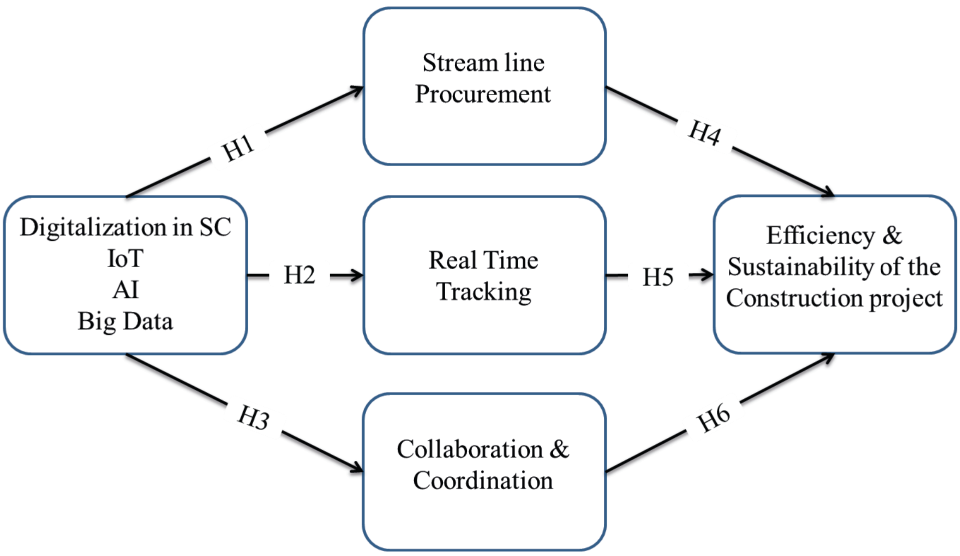

Fig. 2. **Conceptual framework of the study**

Source: Developed by the authors.

of the respondents are then assessed, and the internal consistency of the measurement instruments used is scrutinized. After that, the study presents and discusses the quantitative analysis findings obtained by using partial least square structural modeling, which shows the implications for construction project efficiency in relation to digital supply chain management.

Survey respondents' demographics

The research paper explores the demographic characteristics of a sample group, focusing on job role, years of experience, company size, geographical location, type of construction projects and the technology adoption level (*Table 1*). Out of a total of 180 questionnaires distributed, 136 were successfully returned; the turnout was 76%.

Measurement model and assessment

This is shown in *Fig. 3*. The researchers employed partial least square structural modeling (PLS 4.0-SEM) to analyze the data. Two types of validity assessments, namely convergent validity and discriminant validity, were utilized to evaluate the measurement model. *Fig. 3* illustrates the research model for this investigation, focusing on the role of the digital supply chain on the efficiency of construction projects.

Convergent validity

Table 2 provides information about a measurement model, including the number of items, factor loadings, composite reliability (CR), and average variance extracted (AVE) for different factors. According to [17], the factor loading must be greater than 0.7 for construct valid-

Table 1
Demographic characteristics of sample group

Factor	Description	Frequency	Percent, %	Cumulative percent, %
Job Role/Position	Project Managers	35	26	26
	Site Supervisors	17	13	38
	Architects	22	16	54
	Engineers	24	18	72
	Construction Workers	38	28	100
Years of Experience in Construction Industry	0 to 5 years	66	49	49
	5 to 10 years	49	36	85
	10 to 15 years	21	15	100
Company Size (Number of Employees)	Small Size Firms 0–50	64	47	47
	Medium Size Firms 50–100	41	30	77
	Large Size Corporation 100+	31	23	100
Geographical Location	Rural	74	54	54
	Urban	62	46	100
Type of Construction Projects	Residential	51	38	38
	Commercial	44	32	70
	Industrial	22	16	86
	Infrastructure (roads, bridges, etc.)	19	14	100
Technology Adoption Level	Early Adopters of Technology	37	27	27
	Moderate Technology Adopters	46	34	61
	Traditional/Non-tech Adopters	53	39	100

Source: Compiled by the authors.

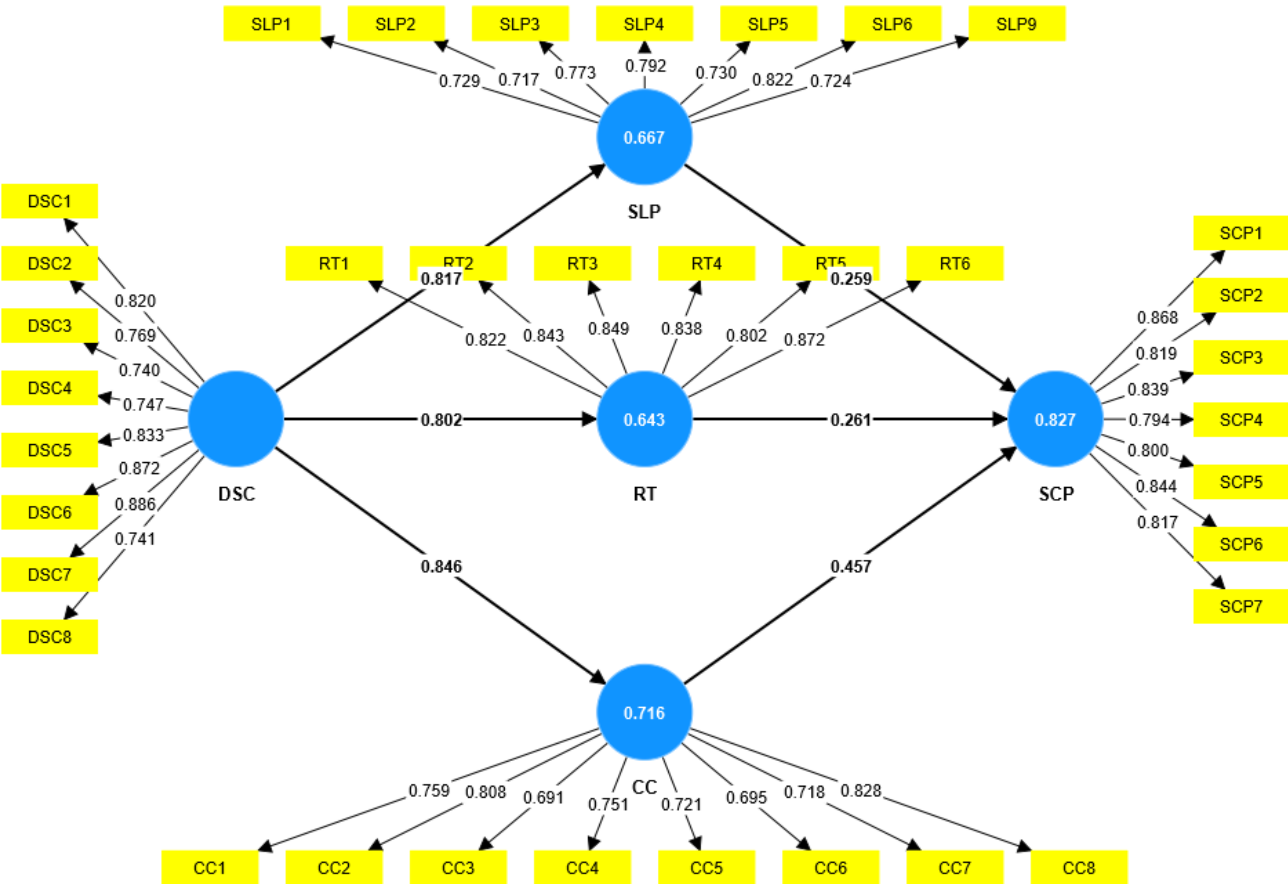

Fig. 3. **PLS path model**

Source: PLS 4.0 SME.

ity, composite reliability should be 0.8, and average variance should be higher than 0.5 for acceptable reliability and convergence of the construct, so the table depicts that all the values are in an acceptable range.

Discriminant validity

Table 3 presents the hetero-trait mono-trait (HTMT) ratios for the correlation between constructs in the study, providing insights into discriminant validity. The table shows the correlation coefficients between different constructs. The HTMT ratios between different constructs provide insights into the hetero-trait correlations, assessing the strength of correlations between different constructs. The values generally suggest that the constructs are distinct from each other, indicating good discriminant validity. Researchers often use these ratios to ensure that the measures are more strongly correlated with their own constructs than with other constructs in the model, supporting the idea that each construct is measuring a unique aspect of the phenomenon under study.

Results of hypothesis

This is shown in *Table 4.* We provide the results of the hypothesis testing in the study assessing the impact of DSCM on the efficiency of construction projects reveal strong and statistically significant relationships. Firstly, DSC demonstrates a remarkably positive impact on streamline procurement (SLP), as evidenced by the high standardized beta coefficient of 0.856 and an extremely low p-value ($p < 0.001$). This implies that the adoption of digital supply chain practices significantly contributes to improved streamline procurement within construction projects. Additionally, DSC positively influences real-time tracking (RT) and coordination and collaboration (CC) with standardized beta coefficients of 0.458 and 0.391, respectively. Both relationships are statistically significant ($p < 0.002$ and $p < 0.001$), highlighting the integral role of digital strategies in enhancing resource utilization and overall construction competence. Furthermore, the study finds that streamline procurement (SLP), real-time tracking (RT), and coordination and collaboration (CC) collectively contribute to sus-

Table 2
Results of measurement model assessment

Construct	Total no of Items	Item	Factor Loading	Composite reliability (CR)	Average Variance (AVE)	Cronbach's alpha
Digital Supply Chain	8	DSC 1	0.77	0.921	0.645	0.92
		DSC 2	0.76			
		DSC 3	0.81			
		DSC 4	0.82			
		DSC 5	0.76			
		DSC 6	0.87			
		DSC 7	0.76			
		DSC 8	0.71			
Streamline Procurement	9	SLP1	0.77	0.877	0.572	0.875
		SLP2	0.76			
		SLP3	0.78			
		SLP4	0.75			
		SLP5	0.82			
		SLP6	0.83			
		SLP7	0.71			
		SLP8	0.84			
		SLP9	0.73			
Real Time	6	RT1	0.79	0.916	0.702	0.915
		RT2	0.61			
		RT3	0.77			
		RT4	0.78			
		RT5	0.76			
		RT6	0.77			
Coordination and Collaboration	8	CC 1	0.81	0.89	0.559	0.887
		CC 2	0.82			
		CC 3	0.81			
		CC 4	0.84			
		CC 5	0.87			
		CC 6	0.81			
		CC 7	0.82			
		CC 8	0.82			
Sustainability in Construction Project	7	SCP1	0.76	0.924	0.683	0.922
		SCP2	0.85			
		SCP3	0.72			
		SCP4	0.81			
		SCP5	0.94			
		SCP6	0.779			
		SCP7	0.821			

Source: PLS 4.0 SME.

Table 3
Hetero trait – Mono trait (HTMT)

	CC	DSC	RT	SCP	SLP
CC					
DSC	0.934				
RT	0.912	0.873			
SCP	0.956	0.891	0.915		
SLP	0.855	0.909	0.878	0.899	

Source: Developed by the authors.

Table 4
Hypothesis testing

Hypothesis	Path	Std Beta	SE	T values	P values	F Square	Decision
H1	DSC → SLP	0.856	0.033	24.752	0.000	0.203	Supported
H2	DSC→ RT	0.458	0.051	15.646	0.002	0.262	Supported
H3	DSC→ CC	0.391	0.045	18.628	0.000	0.292	Supported
H4	SLP→ SCP	0.601	0.080	3.258	0.001	0.123	Supported
H5	RT→SCP	0.722	0.108	2.413	0.016	0.273	Supported
H6	CC → SCP	0.263	0.099	4.642	0.005	0.108	Supported

Source: PLS 4.0 SME.

tainability in construction projects (SCP). The relationships between Streamline procurement → Sustainability in construction projects, real-time tracking → sustainability in construction projects, and coordination and collaboration → sustainability in construction projects are supported with standardized beta coefficients of 0.601, 0.722, and 0.263, respectively. These relationships are statistically significant ($p < 0.001$, $p = 0.016$, and $p = 0.005$), emphasizing that efficient scheduling, optimized resource use, and enhanced construction competence play vital roles in improving overall sustainability in the construction industry. The study underscores the significance of embracing digital supply chain management for achieving efficiency and effectiveness in construction project management.

Discussion

The results of this study reveal a significant positive impact of DSCM on the efficiency of construction projects. The integration of digital tools such as IoT devices, real-time tracking, and data analytics into supply chain processes has evidently aligned the flow of materials and information. This is consistent with the literature indicating that the adoption of digital technology in construction can lead to improved project efficiency and resource utilization [6]. The adoption of DSCM has aligned procurement processes in the construction industry, as supported by a notable reduction in lead times and improved supplier coordination. The comparison between projects with and without DSC solutions highlights that smooth procurement through automated workflows and digital documentation significantly speed up the procurement of materials. This stands in sharp contrast to conventional methods of procurement, where manual processes often result in delays due to paperwork, approvals, and communication gaps [18]. Consequently, the study emphasizes the crucial aspect of DSCM in streamlining procurement, minimizing administrative efforts, and fostering a more agile construction supply chain. There is a noticeable difference in real-time visibility between projects using DSCM tools and those using traditional tracking techniques. Projects integrating digital tools for tracking solutions show enhanced control over the movement of materials, fostering proactive decision-making. Project managers may respond quickly to unanticipated events such as congestion or supplier delays when they use real-time tracking, which also lowers the risk of stockouts and delays. This enhanced visibility is a clear advantage over traditional projects, where interruptions may only be identified retrospectively during project reviews [19]. The study highlights the impact of DSCM on real time tracking and its substantial positive influence on project efficiency. When construction projects using digital supply chain management are compared to those using traditional communication channels, it is evident how much better coordination and collaboration are facilitated by digital solutions. By enabling smooth communication and data sharing between project stakeholders, DSCM platforms dismantle organizational silos and foster a more collaborative workplace. In contrast, traditional projects usually face challenges associated with distorted communication, leading to misunderstandings, delays, and increased chances of errors [20]. The research highlights the significance of DSCM in developing a connected construction ecosystem where all participants are synchronized in real time, facilitating improved project coordination and collaboration [21]. An important benefit noted is the improved coordination and visibility across the construction supply chain. Project managers can keep an eye on the flow of materials, spot possible bottlenecks, and take proactive measures to handle supply chain interruptions because of real-time tracking. Digital platforms help stakeholders communicate and coordinate better, which makes the construction ecosystem more responsive and agile [22]. The information gathered for this study provides support to the idea that DSCM adoption boosts operational effectiveness and lowers costs in building projects. Digital supply chain technologies

Table 5
Cost savings after DSCM

Type of Cost	Description	Cost	Remarks
Initial Setup Costs	Technology Costs: Software, hardware, integration, and customization of DSCM systems	1,500,000–2,000,000	A medium-sized construction firm investing in DSCM for procurement efficiency
Training Costs	Training personnel (project managers, procurement teams) to use DSCM tools	2000–5000 per employee	Training costs for a team of 20 employees range from 40,000 to 100,000
Ongoing Operational Costs	Maintenance Costs: Subscription fees, software updates, system maintenance (cloud-based or on-premises)	100,000–200,000 Annually	Cloud-based DSCM system maintenance for a year
Cost Savings Post-Implementation	Reduced Procurement Costs: Automation and improved supplier management reduce procurement inefficiencies	5–15% reduction in procurement costs	Estimated savings of 50,0000–150,0000 on procurement for a mid-sized project
Decreased Lead Times	Real-time tracking reduces material delays, improving project timelines	20–30% reduction in lead times	Savings of 500,000–1000,000 by avoiding project delays on a mid-sized project.
Resource Optimization:	Better labor and material utilization minimize waste and inefficiency	5–10% savings in labor and material costs	1000,000+ savings through optimal resource allocation in a large construction project
Profitability Improvements	Increased Overall Profitability: Cost reductions and efficiency gains lead to higher profit margins	10–20% increase in project profitability	Estimated profitability increase of 2000,000+ for a large construction project

Source: Developed by the authors.

help to reduce idle time, minimize delays, and optimize inventory management, all of which lead to a more economical project execution. This is consistent with the research findings of [23] that highlight how digital technologies can reduce costs in the construction supply chain management process.

Cost savings after implementation of DSCM

Implementing DSCM can dramatically cut expenses while increasing efficiency. Initial setup expenditures range from 1.5 to 2 million, with training costs ranging from 40,000 to 100,000 per team. Annual operating expenditures range from 100,000 to 200,000. Following implementation, DSCM can result in a 5–15% reduction in procurement costs, a 20–30% drop in lead times, a 5–10% savings in resource expenses, and a 10–20% gain in total profitability (*Table 5*).

Implication for practice and future research

The findings of this research highlight significant implications for experts in the construction industry. First and foremost, the adoption of DSCM begins as a strategic imperative for enhancing the overall project efficiency. Reluctant adopters of digital tools run the risk of falling behind their competitors and project performance. To ensure a smooth transition, construction organizations must invest in training programs for their employees, ensuring that the entire workforce is equipped with the necessary skills to absorb advanced digital technologies. Moreover, industry professionals and stakeholders are encouraged to explore collaboration platforms combined with DSCM for smooth coordination and data sharing, ultimately promoting a more collaborative and efficient project environment. Developing mechanisms for continuous monitoring of DSC processes and adapting strategies based on real-time data insights is vital for navigating the complex nature of construction projects. The study provides opportunities for more investigation in a number of important areas. First, strategic planning requires an understanding of the long-term effects of DSCM on the results of construction projects and the resilience of the sector as a whole. In order to gain insight into the universal applicability of DSCM solutions, researchers should also look into how well they scale across projects of different sizes and complexity. There is potential to improve efficiency, security, and transparency in construction supply chains by investigating the integration of new technologies such as block chain with DSCM. Furthermore, it is imperative to investigate the ways in which DSCM impacts sustainable practices in the construction sector. Understanding the role of DSCM in promoting environmentally friendly supply chain practices will help steer the industry towards more responsible and eco-friendly approaches as sustainability becomes a central focus. In summary, the implications for practice underscore the importance of embracing DSCM, investing in training, and utilizing collaboration platforms, while future research should focus on the long-term impact, scalability, integration of emerging technologies, and sustainability aspects of DSCM in construction projects.

Conclusions

This research illustrates the transformative role of DSCM in revolutionizing the efficiency of the construction industry. The evidence from the statistical results underscores the role of DSCM in smoothening procurement processes, enhancing real-time tracking, and raising improved coordination and collaboration among all stakeholders. The implications of DSCM for practice are clear, urging construction industry decision makers to embrace DSCM as a tactical imperative for uplifting project performance and competitiveness. The results not only recommend the adoption of DSCM but also emphasize the necessity of investing in workforce training, the implication of collaboration platforms, and the development of a continuous monitoring system. These measures are pivotal for taking full advantage of the benefits derived from DSCM and making certain a smooth transition to a digital supply chain in the construction industry that is more responsive in the long run. The study prepares the ground for more research in this crucial aspect. Researchers should look into the long-term effects of DSCM on project outcomes and industry resilience, as this is an interesting topic. Digital supply chain solutions for the construction industry will continue to evolve as a result of research into the integration of emerging technologies like block chain and an understanding of how scalable DSCM is across projects of different sizes. Furthermore, investigating the impact of DSCM on sustainable practices is consistent with the industry's growing commitment to ecologically conscious approaches. In summary, this study explains the benefits of DSCM in the construction industry today and anticipates that digitalization will be crucial in forming a more productive, cooperative, and sustainable sector of the market. Stakeholders can confidently navigate the changing construction project landscape by taking into account the insights gained from this study. They can also seize the opportunities that DSCM offers for the benefit of individual projects, organizations, and the industry as a whole.

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Anwer Baz Khan — literature review, validation of results, and investigation of theoretical framework. Reviewed the final manuscript and provided critical revisions to improve the research quality.

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