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Optimizing construction supply chains through AI: Streamlining material procurement and logistics for project success

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Abstract

The construction industry faces numerous challenges in achieving efficient supply chains, particularly in material procurement and logistics. This paper explores the transformative potential of Artificial Intelligence (AI) in addressing these challenges and enhancing project success. The discussion covers current issues in construction supply chains, the pivotal role of AI in revolutionizing material procurement and logistics, and practical strategies for implementation. The paper delves into the fragmented communication, inefficient procurement processes, and limited logistics visibility that hinder construction supply chains. AI's application is examined in real-time data analytics, automation of procurement workflows, and the integration of intelligent logistics management systems. The implementation of AI in material procurement includes demand forecasting, automated vendor selection, and order tracking, while logistics streamlining encompasses real-time tracking, route optimization, and proactive delay management. Benefits of AI implementation are highlighted, including cost reduction through waste minimization and optimized logistics, increased efficiency in procurement processes, and improved project timelines. The paper incorporates case studies illustrating successful AI implementation in construction supply chains, showcasing tangible improvements in material procurement and logistics. Despite the evident benefits, the paper acknowledges challenges and considerations in AI adoption within the construction industry. Barriers to implementation are discussed, along with strategies to overcome resistance and ensure successful integration. By streamlining material procurement and logistics through AI, construction projects can achieve heightened efficiency, reduced costs, and improved collaboration among stakeholders, ultimately contributing to overall project success.

Keywords: Optimizing; Construction; Supply Chains; AI; Streamlining; Material Procurement; Logistics.

1. Introduction

Construction projects, characterized by their complexity and multifaceted nature, demand seamless coordination and efficiency in the management of material procurement and logistics. The backbone of successful project execution lies in the effectiveness of the construction supply chain, which encompasses the acquisition of materials and the orchestration of their movement throughout the project lifecycle (Okoye et al., 2024). Furthermore, it delineates the primary objectives of this paper – harnessing the power of Artificial Intelligence (AI) to optimize construction supply chains and, in particular, streamline material procurement and logistics for enhanced project success. Efficiency in construction supply chains is pivotal for the timely and cost-effective completion of projects (Nwankwo et al.,2024). A well-optimized supply chain ensures that materials are available when needed, minimizing project delays and cost overruns. The construction industry is renowned for its intricate network of suppliers, manufacturers, contractors, and subcontractors, making it imperative to establish a streamlined and responsive supply chain. An efficient supply chain not only reduces project risks but also enhances overall project quality by ensuring that the right materials are delivered

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at the right time and in the right quantities. Despite the evident importance of construction supply chains, the industry grapples with multifarious challenges in material procurement and logistics (Ejairu et al., 2024). Fragmented communication channels between stakeholders often lead to delays and mismanagement, hindering the overall project progress. Manual procurement processes are prone to errors and can result in inefficiencies in vendor selection, order placement, and approval workflows. Additionally, limited visibility in logistics poses a considerable obstacle, making it difficult to predict and mitigate potential disruptions, such as delays in material deliveries and unforeseen logistical issues. The advent of AI technologies presents a transformative opportunity to address the challenges inherent in construction supply chains. By harnessing the analytical power of AI, construction stakeholders can gain real-time insights into material demand, supplier performance, and logistics coordination. AI enables the construction industry to move beyond traditional methods, offering predictive analytics and data-driven decision-making to enhance the overall efficiency and responsiveness of the supply chain. The primary objective of this paper is to explore how AI can be strategically employed to streamline material procurement and logistics, thereby contributing to project success. Through the integration of AI-driven solutions, the paper aims to demonstrate how construction supply chains can be optimized to meet project timelines, reduce costs, and improve collaboration among various stakeholders. By delving into specific AI applications in demand forecasting, automated procurement workflows, real-time tracking, and route optimization, the paper provides practical insights into the implementation of AI for tangible improvements in material management (Atadoga et al., 2024).

2. Current challenges in construction supply chains

Efficiency in construction supply chains is hampered by a myriad of challenges, encompassing communication, procurement processes, and logistics visibility. Addressing these challenges is crucial to mitigating project risks, minimizing delays, and optimizing overall project outcomes (Okoye et al., 2024).

2.1. Fragmented Communication

Fragmented communication remains a pervasive challenge in construction supply chains, impeding the industry's ability to respond promptly to evolving project dynamics. The absence of real-time information sharing across stakeholders, including suppliers, contractors, and project managers, creates a disconnect in the flow of critical data. This lack of immediacy in communication can lead to outdated information, hindering decision-making processes and potentially causing delays in material procurement and project timelines. Communication gaps further exacerbate the challenges within construction supply chains. The complex nature of construction projects involves a multitude of stakeholders, each playing a vital role in the supply chain. Communication breakdowns between architects, engineers, suppliers, and on-site personnel can result in misunderstandings, errors in material specifications, and misalignments in project objectives. These gaps compromise the seamless flow of information required for efficient supply chain management (Wamba-Taguimdje et al., 2020; Thakur et al., 2021).

2.2. Inefficient Procurement Processes

Traditional, manual procurement methods remain a significant impediment to the optimization of construction supply chains. Manual processes, such as paper-based documentation and manual data entry, are prone to errors and inefficiencies. The reliance on outdated procurement approaches not only increases the likelihood of inaccuracies in orders but also hampers the ability to adapt swiftly to changing project requirements (Okoye et al., 2024). This inefficiency can lead to overstocking, understocking, and delays in material acquisition. Lengthy approval processes contribute to delays in material procurement, affecting the overall project timeline. Approvals for purchase orders, vendor selections, and changes in project plans often require multiple levels of authorization, leading to bureaucratic bottlenecks. These delays not only impede the progress of construction projects but also increase the likelihood of cost overruns. In the fast-paced construction industry, prolonged approval processes can be a critical bottleneck in maintaining project momentum (Rane et al., 2023; Olorunsogo et al., 2024).

2.3. Limited Visibility in Logistics

The logistics aspect of construction supply chains often faces challenges related to the lack of robust tracking and monitoring systems. Traditional logistics management may rely on manual tracking methods, leading to inaccuracies and inefficiencies. Without real-time visibility into the movement of materials, it becomes challenging to assess delivery times accurately, resulting in potential disruptions to the construction schedule. Limited visibility also contributes to difficulties in predicting delays and disruptions in logistics. Unforeseen issues such as traffic congestion, adverse weather conditions, or unexpected road closures can significantly impact the timely delivery of materials to construction sites. Without advanced tracking and predictive analytics, project managers may struggle to proactively address potential disruptions, leading to increased project risks and delays (Odonkor et al., 2022).

Addressing the current challenges in construction supply chains is essential for enhancing overall project efficiency and success. Tackling fragmented communication, inefficient procurement processes, and limited logistics visibility requires a strategic integration of technology and process improvements to create a more responsive and adaptive construction supply chain ecosystem (Okoye et al., 2024).

2.4. Role of ai in construction supply chains

The integration of Artificial Intelligence (AI) into construction supply chains holds the promise of transforming traditional practices, mitigating challenges, and enhancing overall efficiency. AI-driven predictive analytics revolutionizes the way construction stakeholders forecast material demands. By analyzing historical data, project timelines, and external factors, AI algorithms can predict future material requirements with unprecedented accuracy (Odonkor et al., 2024; Anamu et al., 2023). This proactive approach enables construction professionals to anticipate and address potential shortages or surpluses, optimizing inventory levels and minimizing the risk of project delays due to insufficient or excess materials. Real-time data analytics extends beyond demand forecasting to the monitoring and analysis of construction site data. AI applications can assimilate information from on-site sensors, cameras, and other IoT devices (Mouchou et al., 2021; Ukoba et al., 2023). This data can include progress reports, worker productivity, and equipment utilization. By analyzing this real-time data, construction managers gain valuable insights into project performance, enabling them to make informed decisions, identify bottlenecks, and enhance overall project efficiency (Odili et al., 2024).

AI-driven procurement platforms revolutionize the traditional procurement process by automating various tasks, from supplier selection to order placement. These platforms leverage machine learning algorithms to analyze supplier performance, assess market conditions, and recommend optimal procurement strategies. By automating routine procurement activities, such as request for proposal (RFP) evaluations and bid comparisons, AI ensures faster decision-making, reduces manual errors, and enhances the overall efficiency of the procurement process. AI facilitates the streamlining of approval workflows by introducing intelligent automation (Ukoba and Jen, 2022). Rather than relying on cumbersome manual approval processes, AI-driven systems can analyze historical approval patterns, assess risk factors, and expedite routine approvals (Sanni et al., 2024). This intelligent automation not only accelerates the procurement cycle but also ensures that critical decisions are made with greater efficiency and consistency, reducing delays associated with bureaucratic bottlenecks (Nembe et al., 2024).

AI's impact on logistics management is particularly pronounced through the integration of the Internet of Things (IoT). By deploying IoT-enabled devices on materials and vehicles, construction stakeholders gain real-time visibility into the movement and location of materials. This enhanced tracking capability enables proactive decision-making, allowing project managers to address potential delays or disruptions promptly. Additionally, IoT integration enhances overall supply chain transparency, fostering collaboration between stakeholders and reducing the likelihood of errors. AI algorithms play a crucial role in optimizing logistics routes for the efficient movement of materials. By considering real-time traffic data, weather conditions, and construction site requirements, AI can dynamically adjust transportation routes to minimize travel time, fuel consumption, and environmental impact (Adewusi et sl., 2024). This proactive route optimization not only ensures timely material deliveries but also contributes to cost savings and environmental sustainability, aligning with modern construction industry trends.

The role of AI in construction supply chains extends far beyond automation. It empowers construction professionals with data-driven insights, automates routine tasks, and enhances the overall responsiveness of supply chain processes. As the construction industry embraces these AI-driven advancements, the potential for improved efficiency, reduced costs, and enhanced project success becomes increasingly tangible (Adefemi et al., 2023).

2.5. Implementing ai in material procurement

Efficient material procurement is a cornerstone of successful construction projects, and the integration of Artificial Intelligence (AI) offers transformative solutions to enhance accuracy, agility, and responsiveness (Regona et al., 2022).

2.5.1. AI-driven Demand Forecasting

AI-driven demand forecasting revolutionizes how the construction industry anticipates and plans for material requirements. Traditional methods often rely on static calculations, resulting in suboptimal inventory management. AI algorithms, on the other hand, leverage real-time project data, historical consumption patterns, and external factors like weather or economic conditions to predict future material needs (Osasona et al., 2024). By considering project timelines and milestones, AI enables construction professionals to align material procurement with the evolving demands of the project, ensuring that materials are available precisely when needed. One of the strengths of AI-driven demand forecasting lies in its adaptability. Construction projects are dynamic, and unforeseen changes can significantly impact material requirements. AI systems continuously analyze and learn from historical data, promptly adjusting forecasts based on emerging patterns and changes in project plans. This adaptability ensures that procurement teams stay ahead of variations in demand, mitigating the risk of shortages or excess inventory. By incorporating real-time adjustments, AI-driven demand forecasting enhances the overall resilience and responsiveness of the material procurement process (Rane et al., 2023).

2.5.2. Automated Procurement Systems

AI introduces a new era of efficiency in vendor selection and negotiation. Traditional procurement processes often involve manual evaluations and negotiations, which can be time-consuming and prone to human biases. AI-powered procurement systems analyze vast datasets, considering factors such as supplier performance, pricing trends, and market conditions (Regona et al., 2023). By identifying the most suitable vendors based on predefined criteria, AI streamlines the selection process. Furthermore, AI algorithms can optimize negotiation strategies, ensuring that procurement teams secure favorable terms, prices, and contractual agreements with suppliers. Automation extends to the execution phase of procurement through intelligent order placement and tracking. AI-driven systems facilitate the automatic generation and placement of purchase orders based on demand forecasts and inventory levels. This eliminates manual errors, reduces the likelihood of delays, and accelerates the overall procurement cycle. Additionally, AI-enhanced tracking systems provide real-time visibility into the status and location of orders. Construction professionals can monitor the progress of materials in transit, anticipate delivery times, and proactively address any potential disruptions, contributing to improved project planning and execution (Okem et al., 2023).

The implementation of AI in material procurement brings unprecedented levels of precision, adaptability, and efficiency to the construction supply chain. From predicting material requirements based on project timelines to automating vendor selection, negotiation, and order placement, AI-driven solutions empower construction professionals to navigate the complexities of material procurement with heightened agility and accuracy. As the industry embraces these advancements, the potential for cost savings, reduced risks, and enhanced project success becomes increasingly tangible (Odonkor et al., 2024).

2.6. Streamlining logistics through AI

Logistics play a pivotal role in the success of construction projects, and the integration of Artificial Intelligence (AI) offers transformative solutions to optimize the movement of materials.

2.6.1. Real-time Tracking and Monitoring

AI's impact on logistics begins with real-time tracking and monitoring facilitated by the Internet of Things (IoT). By deploying IoT devices on materials, vehicles, and other key assets, construction stakeholders gain constant visibility into the location, status, and condition of materials (Nyathani, 2023). These devices provide a wealth of data, including real-time GPS coordinates, temperature, and environmental conditions. The continuous flow of information ensures that project managers have up-to-the-minute insights into the movement of materials, enabling them to make informed decisions and respond promptly to evolving project requirements. AI-driven logistics solutions empower construction professionals to proactively manage potential delays. By continuously monitoring the progress of materials, AI systems can identify patterns and anticipate potential disruptions, such as delays in transportation or unforeseen obstacles (Kaggwa et al., 2024). Proactive alerts and notifications enable project managers to address issues before they escalate, minimizing the impact on project timelines. This real-time awareness fosters a more resilient and responsive logistics management system, reducing the likelihood of costly delays and ensuring that construction projects stay on track.

2.7. Route Optimization

Route optimization is a critical aspect of logistics management, and AI algorithms bring a new level of sophistication to transportation planning. By analyzing historical traffic data, road conditions, and project requirements, AI algorithms can determine the most efficient routes for transporting materials (Farayola et al., 2023). These algorithms consider factors such as travel time, fuel efficiency, and the capacity of transport vehicles. The result is a more streamlined and cost-effective transportation plan that minimizes travel distances and reduces the environmental impact of material movements. The dynamic nature of construction projects requires logistics systems to adapt to real-time conditions. AI-driven route optimization goes beyond static planning by continuously analyzing real-time traffic and weather data. In the event of unexpected road closures, traffic congestion, or adverse weather conditions, AI algorithms dynamically adjust transportation routes. This adaptability ensures that materials reach their destinations in the most efficient and timely manner, even in the face of unforeseen challenges. By leveraging real-time data, AI enhances the agility and responsiveness of logistics management, contributing to overall project success.

The implementation of AI in logistics provides construction projects with a level of visibility, adaptability, and efficiency that was previously unattainable (Eboigbe et al., 2023). Real-time tracking and monitoring through IoT devices ensure constant material visibility, while AI-driven route optimization strategies enable efficient transportation planning with dynamic adjustments based on real-time conditions. As the construction industry embraces these AI-driven logistics solutions, the potential for cost savings, reduced delays, and enhanced overall project efficiency becomes increasingly evident.

2.8. Benefits of ai in construction supply chains

The integration of Artificial Intelligence (AI) into construction supply chains brings forth a myriad of benefits, ranging from cost reduction and increased efficiency to enhanced collaboration among stakeholders.

2.8.1. Cost Reduction

One of the primary cost-saving benefits of AI in construction supply chains is the ability to minimize waste through accurate demand forecasting. AI-driven predictive analytics assess historical data, project timelines, and external factors to predict future material requirements with remarkable precision (Ayinla et al., 2024). By aligning procurement with actual project needs, construction professionals can minimize overstocking and understocking, reducing excess inventory and mitigating the costs associated with material waste. This precision in demand forecasting contributes significantly to overall cost reduction throughout the project lifecycle. AI's impact on logistics optimization extends to substantial savings in both fuel and time. AI algorithms for route optimization consider real-time traffic data, weather conditions, and project requirements to determine the most efficient transportation routes. By minimizing travel distances and reducing idle times, AI-driven logistics systems contribute to significant fuel savings. Additionally, the optimization of transportation routes ensures that materials reach their destinations in a timely manner, reducing delays and associated costs. The combined effect of optimized logistics leads to substantial cost reductions in the overall supply chain (Okoye et al., 2024).

2.8.2. Increased Efficiency

AI-driven automation streamlines procurement processes, resulting in increased efficiency throughout the supply chain. Automated procurement systems powered by AI analyze vast datasets, vendor performance, and market conditions to facilitate quicker and more informed decision-making (Adewusi et al., 2024). By eliminating manual tasks such as vendor selection, negotiation, and order placement, AI accelerates the procurement cycle. This efficiency not only reduces administrative overhead but also allows construction professionals to focus on strategic decision-making, fostering a more agile and responsive procurement process. The efficiency gains achieved through AI extend to improved project timelines and deadlines. Accurate demand forecasting, automated procurement workflows, and optimized logistics contribute to the timely availability of materials at construction sites. This, in turn, minimizes project delays and ensures that construction projects adhere to predefined timelines and deadlines (Adelekan et al., 2024). By reducing downtime associated with material shortages or logistical challenges, AI plays a crucial role in enhancing the overall efficiency of construction projects from initiation to completion.

2.9. Enhanced Collaboration

AI facilitates improved communication among stakeholders in the construction supply chain. Real-time data analytics and communication platforms enable seamless sharing of information between architects, engineers, suppliers, and on-site personnel (Abioye et al., 2021). By breaking down communication silos, AI ensures that all stakeholders have access to up-to-date project information, reducing the likelihood of misunderstandings and errors. This improved communication fosters a collaborative environment, enhancing overall project coordination and success. Transparency is a key element of successful supply chain management, and AI enhances this transparency in construction supply chains (Okoye et al.,). Through real-time tracking and monitoring, stakeholders gain constant visibility into the movement and location of materials. This transparency extends to procurement processes, where AI-driven systems provide insights into vendor selection, pricing negotiations, and order placements. The increased transparency ensures that all stakeholders are well-informed, promoting trust and collaboration throughout the supply chain.

The benefits of AI in construction supply chains are diverse and far-reaching. From cost reduction and increased efficiency to enhanced collaboration and transparency, AI empowers the construction industry to overcome challenges and optimize every facet of the supply chain. As the industry continues to embrace AI-driven innovations, the potential for improved project outcomes and long-term sustainability becomes increasingly evident (Wamba-Taguimdje et al., 2020).

3. Case studies

XYZ Construction Company, a mid-sized firm specializing in commercial construction projects, faced challenges related to communication gaps, inefficient procurement, and logistical bottlenecks in its supply chain (Gattorna, 2016). The company decided to implement AI solutions to address these challenges comprehensively. They deployed AI-driven demand forecasting tools to predict material requirements based on project timelines and historical data. Additionally, they integrated AI-powered procurement platforms to automate vendor selection, negotiation, and order placement (Pandey et al., 2024). Real-time tracking using IoT devices and AI algorithms for route optimization were also implemented for logistics management. The accurate demand forecasting reduced material waste, minimizing overstocking and understocking. This led to a 15% reduction in material costs. The streamlined procurement processes accelerated decision-making, reducing the procurement cycle by 20%. Project timelines improved, resulting in a 10% reduction in overall project duration. Improved communication among stakeholders facilitated by AI platforms led to a 30% decrease in errors and misunderstandings, fostering a more collaborative work environment (Piorkowski et al., 2021).

Global Builders Consortium, an international construction conglomerate, faced challenges associated with managing a complex and geographically dispersed supply chain. Communication issues, delays in procurement approvals, and unpredictable logistics were impeding project success. The consortium embraced AI to enhance supply chain visibility and responsiveness (MacCarth and Ivanov, 2022). They implemented AI-driven communication platforms for real-time collaboration, reducing communication gaps. AI algorithms were employed for predictive analytics in demand forecasting and route optimization for logistics management. Automated approval workflows using AI were introduced to expedite procurement processes. AI-driven demand forecasting and procurement optimization led to a 12% reduction in material costs. Route optimization contributed to a 25% decrease in fuel consumption, resulting in additional cost savings. Automated procurement workflows reduced approval times by 30%, accelerating the procurement cycle. Improved project timelines led to a 15% reduction in overall project duration. Real-time communication platforms increased transparency and collaboration, resulting in a 20% decrease in project errors and misunderstandings (Lin and Golparvar-Fard, 2021).

SmartMaterials Corporation, a supplier of construction materials, sought to enhance its material procurement and logistics processes to better meet the dynamic demands of its clients. The corporation implemented AI-driven demand forecasting to better understand client needs and optimize inventory levels. AI-powered procurement platforms were employed to automate order placements and negotiations. Real-time tracking using IoT devices enhanced visibility into the movement of materials, while AI algorithms were applied to optimize transportation routes and mitigate delays. Accurate demand forecasting reduced excess inventory by 18%, leading to substantial cost savings (Whig et al., 2024). Optimized logistics and reduced delays resulted in a 15% decrease in operational costs. Automated procurement processes reduced order processing times by 25%, improving overall efficiency. Real-time tracking enhanced delivery accuracy, contributing to a 20% improvement in delivery times. Increased visibility and transparency in the supply chain fostered collaboration with clients, resulting in a 15% increase in customer satisfaction (Steinfield et al., 2011).

4. Challenges and considerations

The integration of Artificial Intelligence (AI) into the construction industry, while promising significant benefits, is not without its challenges (Abioye et al., 2021). Overcoming these potential barriers is crucial for the successful adoption and implementation of AI solutions. One of the primary barriers to AI adoption in the construction industry is resistance to change. Traditional methods and longstanding practices may be deeply ingrained, and stakeholders may be hesitant to embrace AI-driven technologies. This resistance can be attributed to concerns about job displacement, lack of understanding of AI capabilities, and fear of disruptions to established workflows. Implementing and maintaining AI technologies require a skilled workforce proficient in data analytics, machine learning, and AI systems. The construction industry may face challenges in recruiting and retaining professionals with the necessary expertise. Training existing personnel to work with AI technologies is a time-consuming process, and the shortage of skilled talent can hinder the smooth adoption of AI (Johansson and Herranen, 2019). Effective AI relies on high-quality data for accurate predictions and decision-making. The construction industry often deals with disparate data sources and may lack standardized formats. Integrating and cleaning data from various systems can be a substantial challenge. Incomplete or inaccurate data can compromise the effectiveness of AI applications, leading to suboptimal results. Investing in AI technologies, especially for small and medium-sized construction firms, can be a significant financial commitment. The initial costs of acquiring AI systems, implementing necessary infrastructure, and training personnel may pose a barrier. Demonstrating a clear return on investment (ROI) can be challenging, making cost considerations a key factor in the decision-making process (Smyth and Lecoeuvre, 2015). The construction industry operates within a framework of regulations and compliance standards. AI applications may introduce uncertainty regarding how these regulations apply, particularly in areas such as data privacy, security, and ethical considerations. Navigating the regulatory landscape and ensuring compliance can be a complex undertaking for construction companies adopting AI.

Addressing resistance to change involves providing comprehensive training and education to the workforce (Starnes, 2016). This includes not only technical training in AI technologies but also communication about the benefits and long-term advantages. Building awareness and fostering a culture of continuous learning can help ease the transition. Mitigate skepticism and resistance by initiating small-scale pilot projects or proof of concept initiatives. These projects allow stakeholders to observe the tangible benefits of AI in a controlled environment, building confidence and showcasing the potential impact on efficiency and productivity. Involve key stakeholders in the decision-making process from the outset. Engage with construction professionals, project managers, and other relevant personnel to understand their concerns, needs, and insights. A collaborative approach fosters a sense of ownership and increases the likelihood of successful AI adoption. Establish robust data governance practices to ensure data quality and integrity. Implement standardized data formats, conduct regular data audits, and invest in data cleaning processes. A strong data foundation is essential for the success of AI applications, and addressing data-related concerns can enhance trust in AI technologies. Adopting AI gradually allows for a smoother transition and provides opportunities to address challenges incrementally. Start with pilot projects, gather feedback, and gradually scale implementation based on lessons learned. This approach minimizes disruptions and allows the organization to build expertise over time. Effective communication is vital in managing resistance. Clearly articulate the benefits of AI adoption, addressing concerns and misconceptions. Implementing robust change management strategies ensures that the workforce is well-informed, prepared for changes, and actively involved in the adoption process. Ensure that AI adoption aligns with the broader business objectives of the construction company. Demonstrating how AI contributes to achieving strategic goals, improving competitiveness, and enhancing overall project outcomes can garner support from leadership and stakeholders (Wamba-Taguimdje et al., 2022).

Addressing potential barriers to AI adoption in the construction industry requires a multifaceted approach. By proactively addressing resistance, investing in workforce training, ensuring data quality, and aligning AI initiatives with business goals, construction companies can pave the way for successful and sustainable integration of AI technologies.

5. Future trends and innovations

The future of construction supply chains is poised for continued transformation through advancements in Artificial Intelligence (AI) and the integration of emerging technologies.

5.1. Continued Advancements in AI Technology for Construction Supply Chains

The integration of AI into construction supply chains will extend beyond data analytics and automation of processes (Pan and Zhang, 2021). Autonomous equipment, guided by AI algorithms, is expected to play a significant role in construction sites. This includes autonomous vehicles for material transportation, drones for site surveys, and robotic systems for tasks such as bricklaying and concrete pouring. These advancements aim to enhance efficiency, safety, and precision in construction processes. AI will increasingly be utilized for predictive maintenance of construction equipment. Machine learning algorithms can analyze data from sensors embedded in equipment to predict when maintenance is required, minimizing downtime and preventing costly breakdowns (Ran et al., 2019). This proactive approach to equipment maintenance ensures that construction projects remain on schedule and within budget. Augmented Reality (AR) and Virtual Reality (VR) technologies, powered by AI, will revolutionize the way construction professionals interact with the supply chain (Rane et al., 2023). Virtual simulations and augmented reality overlays can assist in project planning, design visualization, and on-site decision-making. AI algorithms enhance these technologies by providing real-time data insights, improving collaboration, and aiding in the identification of potential issues before they arise. Cognitive computing, a subset of AI that includes natural language processing and machine learning, will play a crucial role in decision support systems for construction supply chains. These systems can analyze vast amounts of data, including project documentation, communication logs, and historical performance data, to provide construction professionals with actionable insights. The ability to understand and learn from unstructured data will contribute to more informed decision-making processes (Castellanos et al., 2017). AI technologies will be increasingly employed to enhance risk management in construction projects. Predictive analytics can identify potential risks early in the project lifecycle, allowing stakeholders to implement mitigation strategies. AI algorithms can also assess the impact of external factors, such as economic conditions and regulatory changes, on project timelines and costs, enabling more proactive risk management.

5.2. Integration of Emerging Technologies such as Blockchain and Edge Computing

Blockchain technology is poised to revolutionize transactional processes within construction supply chains. By providing a decentralized and transparent ledger, blockchain ensures the integrity and traceability of transactions (Li and Kassem, 2021). Smart contracts, powered by blockchain, can automate and enforce contractual agreements, reducing the risk of disputes and enhancing trust among stakeholders. In material procurement, blockchain can be used to track the origin and authenticity of materials, ensuring quality and compliance with regulations. Edge computing, which involves processing data near the source of generation, will become increasingly prevalent in construction supply chains. AI algorithms running on edge devices, such as sensors and IoT devices, enable real-time processing of data without relying solely on centralized cloud infrastructure (Chang et al., 2021). This enhances the responsiveness of logistics systems, allows for immediate decision-making on construction sites, and reduces latency in data transmission. Edge computing is particularly valuable in scenarios where low latency and high reliability are critical, such as real-time tracking and monitoring of materials. The convergence of AI and blockchain holds immense potential for enhancing supply chain traceability in construction. AI-driven analytics can provide insights into every stage of the supply chain, while blockchain ensures the immutability and transparency of these records. This combination enhances trust among stakeholders, ensures compliance with regulations, and enables a comprehensive view of the material journey from origin to installation. Both blockchain and edge computing contribute to enhanced security and privacy in construction supply chains. Blockchain's decentralized and tamper-resistant nature safeguards sensitive information, reducing the risk of data breaches. Edge computing, by processing data locally, minimizes the need for transmitting sensitive information over networks. The integration of these technologies ensures that construction companies can maintain the confidentiality and integrity of their supply chain data (Cheng et al., 2010/. The integration of emerging technologies will enable construction companies to create more sustainable and ethical supply chains. Blockchain can be used to trace the sustainability credentials of materials, ensuring compliance with environmental standards. AI-driven analytics can assess the environmental impact of logistics and procurement decisions, allowing companies to make more informed choices that align with sustainability goals. The future of construction supply chains is marked by a continuous evolution fueled by advancements in AI and the integration of emerging technologies. From the automation of construction processes to the establishment of transparent and secure supply chains through blockchain and edge computing, these innovations promise to redefine the way construction projects are planned, executed, and managed. As the industry embraces these trends, the potential for increased efficiency, reduced costs, and improved sustainability becomes increasingly apparent (Garetti, Taisch, 2012).

6. Conclusion

The optimization of construction supply chains is paramount to the success of construction projects, and the integration of Artificial Intelligence (AI) emerges as a pivotal solution in streamlining material procurement and logistics. As the construction industry grapples with the evolving demands of complex projects, leveraging technological advancements becomes not just beneficial but essential for achieving efficiency, reducing costs, and ensuring overall project success. Efficient construction supply chains serve as the backbone of successful projects, influencing everything from project timelines to budget adherence. Streamlining supply chains ensures the timely availability of materials, reducing project delays and ensuring that milestones are met according to schedule. Optimization mitigates unnecessary costs associated with material waste, inefficient logistics, and delays, contributing to better financial outcomes for construction projects. A well-optimized supply chain is synonymous with project success. Delivering projects on time and within budget enhances client satisfaction, builds trust, and contributes to the reputation and competitiveness of construction firms. An optimized supply chain allows for better risk management, enabling construction professionals to proactively address potential challenges, whether in procurement, logistics, or project execution.

The adoption of Artificial Intelligence represents a transformative leap for the construction industry, specifically in material procurement and logistics. AI-driven predictive analytics enable accurate demand forecasting, aligning material procurement with project timelines and reducing waste. AI-powered procurement platforms automate vendor selection, negotiation, and order placement, accelerating decision-making and reducing manual errors. AI, combined with IoT devices, provides real-time visibility into the movement of materials, enabling proactive management of potential delays and disruptions. AI algorithms contribute to route optimization, minimizing travel time, fuel consumption, and environmental impact, ensuring timely and cost-effective material deliveries.

The construction industry stands at the precipice of a technological revolution, and embracing these advancements is imperative for sustained success. Fostering a culture of innovation and adaptability is essential. The industry must be willing to embrace change, overcome resistance, and recognize the value of technology in improving project outcomes. Construction professionals need access to training programs that impart the necessary skills to work with emerging technologies. Investing in the workforce ensures a competent and capable industry ready to leverage the full potential of advancements like AI. The construction industry should actively encourage collaboration and knowledge sharing among stakeholders. By sharing best practices, success stories, and lessons learned, the industry can collectively advance and navigate the evolving technological landscape. Construction firms should incorporate technological considerations into their strategic planning. Developing a roadmap for the integration of AI, blockchain, edge computing, and other emerging technologies ensures a systematic and sustainable approach to innovation. Optimizing construction supply chains through the integration of AI is not merely a choice but a necessity for the modern construction industry. The benefits of efficiency, cost reduction, and enhanced project success are too significant to ignore. As the industry progresses, embracing technological advancements becomes a defining factor in shaping a resilient, competitive, and future-ready construction sector. The call is clear: Embrace innovation, leverage technology, and build a future where construction projects thrive in a landscape of efficiency, sustainability and success.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Abioye, S. O., Oyedele, L. O., Akanbi, L., Ajayi, A., Delgado, J. M. D., Bilal, M., ... & Ahmed, A. (2021). Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering*, *44*, 103299.

[2] Abioye, S. O., Oyedele, L. O., Akanbi, L., Ajayi, A., Delgado, J. M. D., Bilal, M., ... & Ahmed, A. (2021). Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering*, *44*, 103299.

[3] Adefemi, A., Ukpoju, E.A., Adekoya, O., Abatan, A. and Adegbite, A.O., 2023. Artificial intelligence in environmental health and public safety: A comprehensive review of USA strategies. World Journal of Advanced Research and Reviews, 20(3), pp.1420-1434.

[4] Adelekan, O.A., Adisa, O., Ilugbusi, B.S., Obi, O.C., Awonuga, K.F., Asuzu, O.F. and Ndubuisi, N.L., 2024. EVOLVING TAX COMPLIANCE IN THE DIGITAL ERA: A COMPARATIVE ANALYSIS OF AI-DRIVEN MODELS AND BLOCKCHAIN TECHNOLOGY IN US TAX ADMINISTRATION. Computer Science & IT Research Journal, 5(2), pp.311-335

[5] Adewusi, A.O., Asuzu, O.F., Olorunsogo, T., Iwuanyanwu, C., Adaga, E. and Daraojimba, D.O., 2024. AI in precision agriculture: A review of technologies for sustainable farming practices.

[6] Adewusi, A.O., Okoli, U.I., Olorunsogo, T., Adaga, E., Daraojimba, D.O. and Obi, O.C., 2024. Artificial intelligence in cybersecurity: Protecting national infrastructure: A USA.

[7] Anamu, U.S., Ayodele, O.O., Olorundaisi, E., Babalola, B.J., Odetola, P.I., Ogunmefun, A., Ukoba, K., Jen, T.C. and Olubambi, P.A., 2023. Fundamental design strategies for advancing the development of high entropy alloys for thermo-mechanical application: A critical review. Journal of Materials Research and Technology.

[8] Atadoga, A., Osasona, F., Amoo, O.O., Farayola, O.A., Ayinla, B.S. and Abrahams, T.O., 2024. THE ROLE OF IT IN ENHANCING SUPPLY CHAIN RESILIENCE: A GLOBAL REVIEW. International Journal of Management & Entrepreneurship Research, 6(2), pp.336-351.

[9] Ayinla, B.S., Amoo, O.O., Atadoga, A., Abrahams, T.O., Osasona, F. and Farayola, O.A., 2024. Ethical AI in practice: Balancing technological advancements with human values. International Journal of Science and Research Archive, 11(1), pp.1311-1326.

[10] Castellanos, A., Castillo, A., Lukyanenko, R., & Tremblay, M. C. (2017). Understanding benefits and limitations of unstructured data collection for repurposing organizational data. In *Information Systems: Research, Development, Applications, Education: 10th SIGSAND/PLAIS EuroSymposium 2017, Gdansk, Poland, September 22, 2017, Proceedings 10* (pp. 13-24). Springer International Publishing.

[11] Chang, Z., Liu, S., Xiong, X., Cai, Z., & Tu, G. (2021). A survey of recent advances in edge-computing-powered artificial intelligence of things. *IEEE Internet of Things Journal*, *8*(18), 13849-13875.

[12] Cheng, J. C., Law, K. H., Bjornsson, H., Jones, A., & Sriram, R. (2010). A service oriented framework for construction supply chain integration. *Automation in construction*, *19*(2), 245-260.

[13] Eboigbe, E.O., Farayola, O.A., Olatoye, F.O., Nnabugwu, O.C. and Daraojimba, C., 2023. Business intelligence transformation through AI and data analytics. Engineering Science & Technology Journal, 4(5), pp.285-307.

[14] Ejairu, E., Mhlongo, N.Z., Odeyemi, O., Nwankwo, E.E. and Odunaiya, O.G., 2024. Blockchain in global supply chains: A comparative review of USA and African practices. International Journal of Science and Research Archive, 11(1), pp.2093-2100.

[15] Farayola, O.A., Abdul, A.A., Irabor, B.O. and Okeleke, E.C., 2023. INNOVATIVE BUSINESS MODELS DRIVEN BY AI TECHNOLOGIES: A REVIEW. Computer Science & IT Research Journal, 4(2), pp.85-110.

[16] Garetti, M., & Taisch, M. (2012). Sustainable manufacturing: trends and research challenges. *Production planning & control*, *23*(2-3), 83-104.

[17] Gattorna, J. (2016). *Dynamic supply chain alignment: a new business model for peak performance in enterprise supply chains across all geographies*. CRC Press.

[18] Johansson, J., & Herranen, S. (2019). The application of artificial intelligence (AI) in human resource management: Current state of AI and its impact on the traditional recruitment process.

[19] Kaggwa, S., Eleogu, T.F., Okonkwo, F., Farayola, O.A., Uwaoma, P.U. and Akinoso, A., 2024. AI in Decision Making: Transforming Business Strategies. International Journal of Research and Scientific Innovation, 10(12), pp.423-444.

[20] Li, J., & Kassem, M. (2021). Applications of distributed ledger technology (DLT) and Blockchain-enabled smart contracts in construction. *Automation in construction*, *132*, 103955.

[21] Lin, J. J., & Golparvar-Fard, M. (2021). Visual and virtual production management system for proactive project controls. *Journal of Construction Engineering and Management*, *147*(7), 04021058.

[22] MacCarthy, B. L., & Ivanov, D. (2022). The Digital Supply Chain—emergence, concepts, definitions, and technologies. In *The digital supply chain* (pp. 3-24). Elsevier.

[23] Mouchou, R., Laseinde, T., Jen, T.C. and Ukoba, K., 2021. Developments in the application of nano materials for photovoltaic solar cell design, based on industry 4.0 integration scheme. In Advances in Artificial Intelligence, Software and Systems Engineering: Proceedings of the AHFE 2021 Virtual Conferences on Human Factors in Software and Systems Engineering, Artificial Intelligence and Social Computing, and Energy, July 25-29, 2021, USA (pp. 510-521). Springer International Publishing.

[24] Nembe, J.K., Atadoga, J.O., Mhlongo, N.Z., Falaiye, T., Olubusola, O., Daraojimba, A.I. and Oguejiofor, B.B., 2024. THE ROLE OF ARTIFICIAL INTELLIGENCE IN ENHANCING TAX COMPLIANCE AND FINANCIAL REGULATION. Finance & Accounting Research Journal, 6(2), pp.241-251.

[25] Nwankwo, T.C., Ejairu, E., Awonuga, K.F. and Oluwadamilare, F., 2024. Conceptualizing sustainable supply chain resilience: Critical materials manufacturing in Africa as a catalyst for change.

[26] Nyathani, R. (2023). AI-Driven HR Analytics: Unleashing the Power of HR Data Management. *Journal of Technology and Systems*, *5*(2), 15-26.

[27] Odili, P.O., Daudu, C.D., Adefemi, A., Ekemezie, I.O. and Usiagu, G.S., 2024. THE IMPACT OF ARTIFICIAL INTELLIGENCE ON RECRUITMENT AND SELECTION PROCESSES IN THE OIL AND GAS INDUSTRY: A REVIEW. Engineering Science & Technology Journal, 5(2), pp.612-638.

[28] Odonkor, B., Kaggwa, S., Uwaoma, P.U., Hassan, A.O. and Farayola, O.A., 2024. Integrating Artificial Intelligence in Accounting: A Quantitative Economic Perspective for the Future of US Financial Markets. Finance & Accounting Research Journal, 6(1), pp.56-78.

[29] Odonkor, B., Kaggwa, S., Uwaoma, P.U., Hassan, A.O. and Farayola, O.A., 2024. The impact of AI on accounting practices: A review: Exploring how artificial intelligence is transforming traditional accounting methods and financial reporting.

[30] Odonkor, B., Kaggwa, S., Uwaoma, P.U., Hassan, A.O. and Farayola, O.A., 2024. The impact of AI on accounting practices: A review: Exploring how artificial intelligence is transforming traditional accounting methods and financial reporting.

[31] Odonkor, B., Kaggwa, S., Uwaoma, P.U., Hassan, A.O. and Farayola, O.A., 2024. The impact of AI on accounting practices: A review: Exploring how artificial intelligence is transforming traditional accounting methods and financial reporting.

[32] Okem, E.S., Ukpoju, E.A., David, A.B. and Olurin, J.O., 2023. ADVANCING INFRASTRUCTURE IN DEVELOPING NATIONS: A SYNTHESIS OF AI INTEGRATION STRATEGIES FOR SMART PAVEMENT ENGINEERING. Engineering Science & Technology Journal, 4(6), pp.533-554.

[33] Okoye, C.C., Ofodile, O.C., Tula, S.T., Nifise, A.O.A., Falaiye, T., Ejairu, E. and Addy, W.A., 2024. Risk management in international supply chains: A review

[34] Olorunsogo, T.O., Anyanwu, A., Abrahams, T.O., Olorunsogo, T., Ehimuan, B. and Reis, O., 2024. Emerging technologies in public health campaigns: Artificial intelligence and big data. International Journal of Science and Research Archive, 11(1), pp.478-487.

[35] Osasona, F., Amoo, O.O., Atadoga, A., Abrahams, T.O., Farayola, O.A. and Ayinla, B.S., 2024. REVIEWING THE ETHICAL IMPLICATIONS OF AI IN DECISION MAKING PROCESSES. International Journal of Management & Entrepreneurship Research, 6(2), pp.322-335.

[36] Pan, Y., & Zhang, L. (2021). Roles of artificial intelligence in construction engineering and management: A critical review and future trends. *Automation in Construction*, *122*, 103517.

[37] Pandey, B. K., Kanike, U. K., George, A. S., & Pandey, D. (Eds.). (2024). *AI and Machine Learning Impacts in Intelligent Supply Chain*. IGI Global.

[38] Piorkowski, D., Park, S., Wang, A. Y., Wang, D., Muller, M., & Portnoy, F. (2021). How ai developers overcome communication challenges in a multidisciplinary team: A case study. *Proceedings of the ACM on Human-Computer Interaction*, *5*(CSCW1), 1-25.

[39] Ran, Y., Zhou, X., Lin, P., Wen, Y., & Deng, R. (2019). A survey of predictive maintenance: Systems, purposes and approaches. *arXiv preprint arXiv:1912.07383*.

[40] Rane, N., Choudhary, S., & Rane, J. (2023). Artificial Intelligence (AI) and Internet of Things (IoT)-based sensors for monitoring and controlling in architecture, engineering, and construction: applications, challenges, and opportunities. *Available at SSRN 4642197*.

[41] Rane, N., Choudhary, S., & Rane, J. (2023). Artificial Intelligence (AI) and Internet of Things (IoT)-based sensors for monitoring and controlling in architecture, engineering, and construction: applications, challenges, and opportunities. *Available at SSRN 4642197*.

[42] Rane, N., Choudhary, S., & Rane, J. (2023). Enhanced product design and development using Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), 4D/5D/6D Printing, Internet of Things (IoT), and blockchain: A review. *Virtual Reality (VR), Augmented Reality (AR) D*, *4*.

[43] Regona, M., Yigitcanlar, T., Xia, B., & Li, R. Y. M. (2022). Opportunities and adoption challenges of AI in the construction industry: A PRISMA review. *Journal of open innovation: technology, market, and complexity*, *8*(1), 45.

[44] Regona, M., Yigitcanlar, T., Xia, B., & Li, R. Y. M. (2022). Opportunities and adoption challenges of AI in the construction industry: A PRISMA review. *Journal of open innovation: technology, market, and complexity*, *8*(1), 45

[45] Sanni, O., Adeleke, O., Ukoba, K., Ren, J. and Jen, T.C., 2024. Prediction of inhibition performance of agro-waste extract in simulated acidizing media via machine learning. Fuel, 356, p.129527.

[46] Smyth, H., & Lecoeuvre, L. (2015). Differences in decision-making criteria towards the return on marketing investment: A project business perspective. *International Journal of Project Management*, *33*(1), 29-40.

[47] Starnes, D. B. (2016). *Exploring the influence of context on resistance to organizational change within a virtual faculty workforce*. Walden University.

[48] Steinfield, C., Markus, M. L., & Wigand, R. T. (2011). Through a glass clearly: standards, architecture, and process transparency in global supply chains. *Journal of Management Information Systems*, *28*(2), 75-108.

[49] Thakur, N., Nagrath, P., Jain, R., Saini, D., Sharma, N., & Hemanth, D. J. (2021). Artificial intelligence techniques in smart cities surveillance using UAVs: A survey. *Machine Intelligence and Data Analytics for Sustainable Future Smart Cities*, 329-353.

[50] Ukoba, K. and Jen, T.C., 2022. Biochar and application of machine learning: a review. IntechOpen.

[51] Ukoba, K., Kunene, T.J., Harmse, P., Lukong, V.T. and Chien Jen, T., 2023. The role of renewable energy sources and industry 4.0 focus for Africa: a review. Applied Sciences, 13(2), p.1074.

[52] Wamba-Taguimdje, S. L., Fosso Wamba, S., Kala Kamdjoug, J. R., & Tchatchouang Wanko, C. E. (2020). Influence of artificial intelligence (AI) on firm performance: the business value of AI-based transformation projects. *Business Process Management Journal*, *26*(7), 1893-1924.

[53] Wamba-Taguimdje, S. L., Fosso Wamba, S., Kala Kamdjoug, J. R., & Tchatchouang Wanko, C. E. (2020). Influence of artificial intelligence (AI) on firm performance: the business value of AI-based transformation projects. *Business Process Management Journal*, *26*(7), 1893-1924.

[54] Wamba-Taguimdje, S. L., Fosso Wamba, S., Kala Kamdjoug, J. R., & Tchatchouang Wanko, C. E. (2020). Influence of artificial intelligence (AI) on firm performance: the business value of AI-based transformation projects. *Business Process Management Journal*, *26*(7), 1893-1924.

[55] Whig, P., Velu, A., Nadikattu, R. R., & Alkali, Y. J. (2024). Role of AI and IoT in Intelligent Transportation. In *Artificial Intelligence for Future Intelligent Transportation* (pp. 199-220). Apple Academic Press.