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"Artificial intelligence enabled Demand Sensing: Enhancing Supply Chain Responsiveness"

Dilip Kumar Vaka,
Supply Chain Architect, Bentonville,
Arkansas, US,
Email ID: dilip4sap@gmail.com

Abstract

Supply Chain Risk Management (SCRM) stands as an evolving domain of study encompassing the multifaceted tasks of identifying, assessing, mitigating, and monitoring risks or unexpected events within supply chains. Despite sustained research efforts dedicated to SCRM, industries continue to grapple with the challenges of effectively managing supply chain risks. In response to this, supply chain managers are increasingly turning towards data-driven decision-making strategies, leveraging diverse data sources to predict uncertainties more accurately and proactively. In this context, the attributes of Artificial Intelligence (AI) and Machine Learning (ML) emerge as highly promising techniques for enhancing SCRM practices. While the potential benefits of AI and ML in SCRM are widely acknowledged, their application in this field remains relatively nascent. This paper seeks to address this gap by providing a systematic and comprehensive review of existing literature, delving into the various AI and ML methods employed across different phases of SCRM. Additionally, it explores the diverse categories of supply chain risks and examines the range of AI techniques utilized in relevant studies. To facilitate this review, we have analyzed research articles sourced from three prominent scientific databases, spanning the period from 2010 to 2021. Through this extensive analysis, we aim to uncover unexplored dimensions and identify gaps in current research, shedding light on challenges associated with the implementation of AI technologies in SCRM. Moreover, we present insightful recommendations and potential avenues for future research, aimed at advancing the integration of AI and ML in SCRM practices and fostering more resilient and adaptive supply chains in the years to come.

Keywords: AI (Artificial Intelligence), Digital supply chain, Selective data transition, Machine learning (ML)

I. INTRODUCTION

Figure 1. Path to Digital S4 Hana Journey[Ref 7]

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Efficient supply chain management (SCM) must ensure the flexible and uninterrupted flow of products and materials in all stages with minimum cost. The organizations function with high risks of disruptions in increasingly dynamic environments due to unexpected and unprecedented events like natural disasters, demand fluctuation, government policy changes. These events always affect SCs and threaten their uninterruptedness, goals, and profitability. Given this, COVID-19 is a new type of environmental disruption that impacts the current business environment. It originates various risk factors such as supply interruption, shortage of materials, demands uncertainty, production shutdown, and increase in lead time. Hence, companies must also prepare to continually and efficiently monitor and reduce these threats. There has been a significant focus on identifying these risks, assessing them effectively, managing them proactively, and monitoring their continuous progression. This COVID-19 outbreak indicates the need for transforming the existing SC in terms of ability to adapt (flexibility), ability to recover (resilience), and ability to withstand (robust) against the disruptions in this dynamic environment. The SC, which can analyze the alternatives and redesign the flow when disruption occurs, can be described as a Smarter supply chain. It is about the digitalization of SC which also incorporates the planning and production sequence to create a visible, responsive, and agile network with the help of digital technologies. This kind of transformation of processes, activities, and products is known as digital transformation. Example: Industry 4.0. Also, the recent studies highlight introducing digitalization for improving SC efficiency and proceeding with this transition discover more opportunities for the researchers and SC practitioners.

The researchers have employed Multi-Criteria Decision Making (MCDM), Mathematical optimization programming, and AI techniques for achieving the SCRM objectives Though the research in SCRM has had a long history, the industries are still facing difficulties in managing the SC risks due to the global pandemic. The impacts of known and predictable disruptions such as demand fluctuations and environmental disasters have received considerable attention in previous studies. But the most complex decision-making case like unpredictable disruptions has not been discussed much so far. Also, the existing research articles highlight the scarcity in risk monitoring. In this present data-driven world, conventional techniques are not the most appropriate for monitoring the SC risks. The researchers should consider a data-focused method that captures the real-time information and apply them in the SCRM. In addition, the studies indicate the need for an interdisciplinary approach in this field. These gaps indicate SCRM as an underexplored area lacks holistic approaches such as end-to-end visibility and real-time perception. Recent articles show the growing interest among researchers in predicting uncertain events accurately using the techniques that fall under AI. AI can enhance SC resilience by improving transparency through continuous monitoring, minimizing the impact of sudden disruptions. Therefore, the recent research highlights that AI has ushered in a new paradigm of transformation to improve SC decision-making through automated technologies that can leverage knowledge and data. This survey contributes to a better understanding of how far this transition has progressed in terms of SCRM. In addition, it provides a road map for the future.

AI leads to problem-solving with higher speed, accuracy, and a more significant number of inputs than traditional approaches. However, only recent technology advancements have demonstrated that AI has wide applications in numerous areas, including SCM explored the role of AI and ML solutions that aid in transforming the risk management process. Most industries are transitioning their techniques from reactive to proactive, manual to automated operations, and forecasting to prediction in production planning. Along with its growing importance in businesses, AI is gaining a more prominent and widespread presence, and presently it is being investigated from a more holistic perspective. Also, AI and ML techniques will revolutionize the risk management process through predictive analytics Therefore, advanced and predictive data analytics has become a significant component in SCRM decision-making. Given this, it is more relevant to exploit AI using some powerful techniques such as ML, Deep learning (DL), and Natural language processing.
These recent techniques can extract valuable insights from online textual information and social media data to identify risks related to SC Among the various text mining applications, the undiscovered avenue like risk management can become a promising avenue for future research. Therefore, the recent integration of AI techniques into Supply Chain Risk Management (SCRM) has the potential to enable organizations to maintain consistent progress even amidst unpredictable circumstances. Supply Chain Management (SCM) and its related domains stand to significantly benefit from the implementation of AI applications. Nevertheless, certain areas such as supplier selection, supply chain network (SCN) design, and SCRM have not received adequate attention in this regard. Although the significant level of interest from SC practitioners and

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researchers is thus high, there is a need to investigate recent advances of AI in the field of SCRM (e.g., the recent achievements of systems like IBM Watson and Deep Mind's Alpha Go).

In this regard, this paper aims to conduct a systematic review of the research related to SCRM utilizing the power of AI such as automated learning, precise decision-making, and proactive and predictive risk management to meet the challenges in uncertain environments.

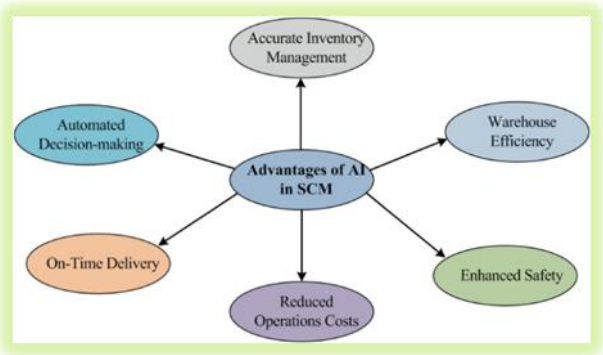

Figure 2:Supply Chain advantages with AI[Ref 8]

1.1. AI is a game changer in Supply Chain Management

Despite supply chains becoming more complex and harder to manage, AI-enabled supply-chain management has allowed early adopters to improve logistics costs by 15 percent, inventory levels by 35 percent, and service levels by65 percent, compared with slower-moving competitors.

1.2. Reduce risks by tracking trends

Supply chain professionals have to keep a lot of plates spinning as they work to mitigate supply chain risks in real time. "You can't keep up with everything," said Walter Sun, SVP and global head of AI at SAP. AI can help by tracking news, events, and relevant issues that may have a material impact on supply. AI can also analyze this data to help predict the potential for minor supply chain hiccups—or major catastrophes.
"Predictive analytics is impacting many parts of the supply chain, specifically procurement," said Eva Ponce, executive director of the Omni channel Supply Chain Lab at MIT. Predictive analytics enhances procurement by forecasting demand, predicting supplier performance, pricing trends, and optimizing inventory monitoring and performance. A data-driven approach enables organizations to make informed decisions and improve overall efficiency and cost savings. It is almost like you have a human assistant sitting next to you who could alert you to things you otherwise wouldn't have known about," Sun said. Supply chain planners can also use generative AI to manage daily tasks, such as writing emails to vendors to request updates. Doing so frees up time to focus on more important issues, such as tracking and crisis management.

1.3. Prepare for multiple outcomes

AI tools can predict trends in demand based on external factors, such as market patterns and weather data. While the use of machine learning in forecasting is nothing new, advancements in AI technology will only make it more powerful—and leave supply chain managers better prepared. "An accurate forecast has been an obsession for supply chain professionals," Ponce said.
While AI tools that analyze historical data and identify likely outcomes can help ensure more accurate inventory levels, reduce waste, and minimize shortages, it's not a crystal ball. Ultimately, there's no way to know which potential outcome will occur, so it's important to plan for more than one.
Events such as the pandemic-induced shortages or the Suez Canal blockage, which delayed worldwide shipping for months, can cause disruptions that are difficult to plan for. Beyond analyzing simple historical patterns—sales during seasonal holidays in the U.S., for instance—AI

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can model several "what-if" scenarios based on hundreds of data points. "As soon as one of [these scenarios] does happen, you can have a mitigation plan ready immediately," Sun said.

1.4 Personalize the customer side of the equation

Sales is a critical part of the supply chain since customers are the ultimate destination for products. To keep customers happy, personalized experiences are becoming essential. For example, Walmart is launching a new generative AI search feature that allows customers to search for products by use case, rather than by specific product. For instance, shoppers can search for phrases such as "dinosaur-themed birthday party" and receive a list of products tailored to that search.
Chatbots and AI shopping assistants can also provide customers with personalized shopping suggestions based on previous orders, historical data, and current shopping trends. For instance, recommendations are often based on what other customers have bought alongside another product. If someone buys a certain laptop, AI can automatically suggest relevant docking stations or cases. "It saves users a lot of time," Sun said. Easy transactions like these can help develop loyal customer relationships and drive demand.

1.5 Be thoughtful about the AI rollout

Incorporating AI for supply chain management requires careful planning. "One of the most common reasons I have seen companies fail when implementing disruptive technologies like AI is when they are rushing, with a lack of clear vision," Ponce said.
Start by determining how AI implementation will align with broader business goals, such as driving efficiency, reducing risk, and better time management. Next, evaluate your company's existing technology assets. As Ponce put it, the questions you should be asking are, "What is the current state of [your] AI capabilities, and how ready is the IT infrastructure to support AI deployment?" Then, identify the tools and technology your company needs to fill in those gaps. Another factor to consider is the skills and talent required to develop, deploy, and maintain AI solutions. Some organizations will need to hire new talent to do this, but all companies should help employees up skill and stay competitive in the ever-changing field of AI.

II. AI SUPPLY CHAINTRANSFORMATION JOURNEY

Transforming a supply chain is an ambitious undertaking, and companies should be fully aware of the challenges.

Value-creation identification, strategy, and road map
As a first step, companies need to identify and prioritize all pockets of value creation across all functions, from procurement and manufacturing to logistics and, ultimately, commercial. Less than one-third of companies perform an independent diagnostic at the outset, but this exercise can ensure companies have an accurate list of all the value-creation opportunities.Clearly defining a digital supply-chain strategy helps support the company's business strategy and ensures better alignment with its digital program. In addition, a solution-agnostic assessment enables companies to identify the process redesign, organizational changes, and capabilities required to boost performance as well as create a strategic road map.

Design of target solution and vendor selection
The complexity of supply chains—from demand forecasting to planning optimization and digital-execution tracking—means that finding one provider that can meet all of these needs is increasingly unlikely. Executives should recognize that the right answer for their company won't necessarily be the one recommended by the providers, whose goal is often to push for a single end-to-end solution.

Solution design and vendor selection can help support the digital supply-chain strategy. Often, the best approach is a combination of different solutions from different providers, implemented by different systems integrators. Companies that select a suite of solutions must make integration a top priority.

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Implementation and systems integration
Many companies haven't had sufficient experience in implementing organization-wide technology. Once companies select solutions, the risks are falling behind the implementation schedule and coming in over budget while losing focus on the primary objective: to properly address value-creation levers from the first pitfall. Only 25 percent of supply-chain leaders reported feeling their objectives are aligned with the incentives of their systems integrators.
Companies should take a holistic approach to implementation and systems integration. By optimizing the end-to-end value, companies can implement solutions that deliver value in the short term and are more sustainable over the long term (see sidebar "An end-to-end approach to supply-chain optimization").

Change management, capability building, and full value capture
Even while focusing on tech solutions, companies must attend to vital supporting elements, such as organization, change management, and capability building. Our research suggests this task is a common challenge: for example, only 13 percent of executives report that their organizations are sufficiently prepared to address their skills gaps.
To ensure adoption of new solutions, companies must invest in change management and capability building. Employees will need to embrace new ways of working, and a coordinated effort is required to educate the workforce on why changes are necessary, as are incentives to reinforce the desired behaviors. Supply-chain management has never been more formidable, but help is on the way. AI will be able to provide teams with deeper insights at a much higher frequency and granularity than ever. However, this visibility alone will not be enough to capture more value from AI-based supply-chain solutions. Any sizable technology investment must be matched by organizational changes, business process updates, and up skilling efforts. Only then will companies capture the expected ROI.

III. TYPICAL USE CASES FOR APPLYING AI IN SUPPLY CHAIN

Figure 3: Use cases of AI Supply chain[Ref 9]

There are many artificial intelligence supply chain uses cases. Any supply chain process that can benefit from the power of prediction, is a good candidate for the application of AI.

Demand forecasting: Many enterprises employ limited demand forecasting and demand sensing capabilities that are inflexible, based on insufficient data, and inaccurate. AI can improve visibility across demand signals, flexible segment-specific demand models, and a constantly updated forecast as new data becomes available. This improves operational efficiency, order fill rates, service levels, and planner productivity.

Production planning: Manufacturing scheduling is complex and made harder by evolving customer demand, supplier uncertainties, broader market movements, and operational constraints. Traditional rule-based planning systems and deterministic optimizers fail to respond to the ever-changing market conditions and do not consider all operational constraints. AI can create optimized production schedules based on selected objective functions and operational constraints,

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adjusting and fine-tuning production to meet the latest demand picture and supply conditions. AI-driven production planning can improve customer on-time delivery, prioritize production across products, minimize production and distribution costs, and minimize the cost of last-minute changes.

Inventory Planning: Most companies use material requirements planning (MRP) for inventory planning, which usually lacks the ability to apply advanced optimizations, respond to dynamic changes in data during the execution of plans, and model supply chain uncertainties. As a result, companies often adopt conservative inventory policies to maintain a buffer against uncertainties that MRP systems cannot account for, leading to a higher cost of inventory and higher markdowns. AI can model real-world uncertainties in demand and supply, continuously optimize and reset reorder parameters, and optimize assortment mix and inventory levels. AI-based inventory planning reduces unwanted inventory levels, improves visibility of critical uncertainties, and improves order fulfillment rates.

Sourcing: Most enterprises lack holistic visibility into sourcing operations, leaving unwarranted price variations undetected and exposing their operations to undue supplier risk. Artificial Intelligence in supply chain sourcing can help provide a unified view of all activities to identify anomalous price changes, supplier risk profile changes, and emerging cost-saving opportunities. AI-based sourcing helps comprehensive monitoring of sourcing activity, mitigating supplier risks, and improving operational efficiency.

Supply Network Design: Many supply networks are a culmination of one-off decisions or designed based on rules-based simulations, that lead to rigidities in the supply chain and undue risk. AI-powered scenario modelling helps design flexible and disruption-resistant supply chain strategies with holistic, interconnected scenarios and a focus on system-wide optimization. This leads to long-term agility, cost advantage, risk mitigation, and customer responsiveness.

Logistics Management: Transportation and logistics are often the cause of supply chain disruptions and can have a ripple effect. AI is useful in identifying the impact of emerging logistical issues and taking proactive and timely actions based on likely scenarios. Transportation routes can be AI-optimized for desired objectives, such as cost, delivery times, or risk, and can recommend alternative routes as new conditions emerge. AI-driven logistics management can help find the right balance between transportation costs, customer responsiveness, and delay risks.

Warehouse Management: AI can optimize warehouse operations by identifying packages at risk of delivery delay, optimizing routes, and automation with robotics. This can have a material impact on warehouse throughput, operating costs, and customer responsiveness.

Supply Risk Management: AI can monitor supplier health, learn from supplier delivery history, and identify orders at the highest risk of delays, thereby improving customer delivery and reducing cost.

Sustainable Operations: Supply chain operations – from sourcing and contract manufacturing to warehousing and transportation – can have a significant carbon footprint. Measuring, monitoring, and assessing the environmental impact of supply chain operations and accordingly identifying initiatives to improve their sustainability, is a role that AI is perfectly suited for.

IV. KEY STEPS IN IMPLEMENTING AI IN SUPPLY CHAIN

Create a Supply Chain Digital Twin

A supply chain digital twin is a virtual replica and a parallel version of an organization's physical supply chain and its supplier network. Like the physical world, the digital network is interconnected and vast – representing millions of SKUs, thousands of suppliers and customers, hundreds of warehouses and logistics centers, and innumerable routes connecting each node. This supply chain digital twin provides end-to-end, granular traceability of materials and goods from source to destination. It contextualizes movements and activity across logistics networks with external factors, providing all relevant information to make sense of what has happened and is going to happen at any point across time and space of the supply chain.

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By deploying a supply chain digital twin, an organization gains unprecedented visibility, and therefore predictability and control, into its distributed and interconnected production networks. The sources of supply chain data in large manufacturing organizations are often legacy enterprise systems such as ERP, MRP, Analytics and CRM systems. Other relevant data include demand forecasts, planning calendars, and sensor data, as well as external sources such as weather, GIS, market data, social media, pricing, and any other relevant data. To start, data must be ingested, deduced, cleansed, transformed, normalized, and finally prepared for analytics.

Ingest Data and Make Predictions, Recommendations in Near Real-Time
In a traditional operation, supply chain managers and planners are typically forced to work with inconsistent and outdated data. This results in manual processes to adjust inventory levels, evaluate risks, and generate sub-optimal plans.AI-driven smart supply chain solutions offer a quantifiable shift from traditional manual operations to the creation of data-driven, automated, and predictive real-time recommendations. AI-enabled supply
chains can receive demand signals as they arrive, updating demand forecasts and supply risks dynamically. This provides companies with greater agility, while ensuring that the supply chain is recognizing and resolving risks as they occur.

AI-driven supply chain management applications model uncertainties to allow supply chain professionals to optimize re-order parameters by part and by location and to gain visibility throughout their supply chain operations. For example, supply chain professionals can now identify vulnerable sources of raw materials or weaknesses in hubs and aggregation points. Planners and operations managers gain insight into potential delays and recommendations that result in improved (On Time In Full) OTIF performance leading to increased customer satisfaction. C3 AI Inventory Optimization is an example of an AI-driven application that combines supply chain digital twin functionality with AI and machine learning models that improve visibility, reduce inventory holding costs and increase productivity of inventory analysts through automated recommendations. This application is designed to model and learn from uncertainties and provide recommendations that are used as inputs into existing MRP modules.

Apply AI to Your Highest-Value Use Cases
Not all AI and supply chain use cases are equally valuable for your enterprise. Selecting the right opportunity with the right parts of your supply chain can have a significant impact on the trajectory of your program. Assess AI opportunities in your supply chain based on the economic value they can generate and the level of complexity in implementing the AI application. When deciding on the best AI technology to employ, it is crucial to prioritize the scalability and adaptability of the chosen solution. This ensures that future business growth and changes in the environment are effectively addressed.

V. CONCLUSION

The impact of AI on supply chain management cannot be overstated. From forecasting and demand planning to inventory optimization, supply chain visibility, enhanced customer experience, and predictive maintenance, AI has
revolutionized the way businesses handle their logistics and operations. Embracing AI technologies has become a necessity for organizations looking to stay competitive in today's fast-paced and ever-changing market. As AI continues to advance, supply chain management will evolve further, unlocking even greater opportunities for efficiency, cost reduction, and customer satisfaction. Businesses that capitalize on AI's potential are bound to thrive in the dynamic landscape of modern supply chains.

REFERENCES

1. Sallomi, Paul. "Artificial Intelligence Goes Mainstream". The Wall Street Journal. The Wall Street Journal - CIO Journal - Deloitte. Retrieved 9 May 2017.
2. Panayotov, Vassil; Chen, Guoguo; Povey, Daniel; Khudanpur, Sanjeev (2015). "Librispeech: An ASR corpus based on public domain audio books". 2015 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). pp. 5206–5210. doi:10.1109/icassp.2015.7178964. ISBN 978-1-4673-6997-8. S2CID 2191379. Retrieved 2023-10-18.
3. Oliver, R. K.; Webber, M. D. (1992) [1982]. "Supply-chain management: logistics catches up with strategy". In Christopher, M. (ed.). Logistics: The Strategic Issues. London: Chapman Hall. pp. 63–75. ISBN 978-0-412-41550-0.
4. Alizamir, S., Alptekinoglu, A., & Sapra, A. (1981). Demand management using responsive pricing and product variety in the presence of supply chain disruptions: Working paper, SMU Cox School of Business.
5. https://www.sciencedirect.com/science/article/abs/pii/S0360835222002765
6. https://www.sciencedirect.com/science/article/abs/pii/S0360835222002765
7. https://community.sap.com/t5/technology-blogs-by-sap/creating-the-utility-digital-roadmap-for-the-sap-s-4hana-journey/ba-p/13234371
8. https://link.springer.com/chapter/10.1007/978-3-030-85383-9_4
9. https://datenwissen.com/blog/transform-logistics-ai/