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Artificial Intelligence in Supply Chain Risk Management: Perspectives on Optimization and Resilience

Zouirchi Houda

Faculty of Legal, Economic and Social Sciences of Mohammedia Hassan II University Casablanca

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Abstract

Supply chains, often impacted by major crises such as global financial crises, must adopt more robust and responsive strategic approaches to enhance their resilience. In this context, artificial intelligence (AI) emerges as a promising solution to transform risk management in logistics. This article explores the link between AI and the supply chain, highlighting its advantages over traditional data analysis methods.

AI, through its sophisticated algorithms, enables task automation, enhances the speed and accuracy of decision-making, and optimizes overall performance. The results of our study reveal that integrating AI into logistics processes offers several benefits. It notably allows for the automation of certain tasks, improves the speed and comprehensiveness of decisions, strengthens trust in operations, and optimizes the overall performance of the supply chain. Furthermore, logistics managers are encouraged to train in new technologies to adapt to sector evolutions and maintain their competitiveness.

***Corresponding author:** Zouirchi Houda, Faculty of legal, Economic and Social Sciences of Mohammedia Hassan II University Casablanca, Morocco.

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Introduction

Technological progress is accelerating at an increasingly rapid pace, accompanied by the growing complexity of business operations. To ensure effective development, companies must rely on decision-making tools driven by advanced technologies. This, in turn, requires access to and use of vast amounts of data. In this context, industrial firms are compelled to stay up to date with technological transformations in order to survive in highly competitive environments—especially in the logistics sector, which is inherently complex due to the sheer volume of data

and number of stakeholders involved. Artificial Intelligence (AI) is a term coined by computer scientist John McCarthy in 1955–1956, as part of the Logic Theorist program developed by Allen Newell, Cliff Shaw, and Herbert Simon, and presented at the Dartmouth College Conference on Artificial Intelligence. McCarthy defined AI as "the science and engineering of making intelligent machines." AI, which refers to the use of computerized systems to perform tasks typically carried out by human intelligence, has rapidly become a subject of growing interest. Given the increasing reliance on AI, it is difficult to envision a sector that will not be influenced by it. Similar to the emergence of computers and spreadsheets, which initially appeared to affect only a few businesses, AI is now becoming indispensable across all industries. It plays a critical and evolving role in how we interpret and interact with the world around us. The use of AI in supply chain management is emerging as a key driver of business success. However, managing supply chain risk remains a major challenge due to its inherent complexity and uncertainty. In this regard, AI is increasingly seen as a potential solution to improve supply chain risk management. It can help identify potential risks, predict future disruptions, enhance supply chain visibility, and provide real-time insights to support more informed decision-making. This growing relevance raises the central question of how AI can enhance risk management practices within the supply chain. This discussion focuses on addressing visibility issues within the supply chain—issues that, if resolved, could significantly reduce both delays and costs. The implementation of AI technologies in supply chain management presents a powerful opportunity for decision-makers and operational teams alike, particularly in a field characterized by high uncertainty and constant risk. While various tools exist in the field of Supply Chain Risk Management (SCRM), many remain limited in their predictive capabilities and in the speed at which decisions can be made. Thus, given the rapid technological advancements, the accessibility of big data, and the increasing computational power available, the integration of AI is becoming not only beneficial but essential in the fields of logistics and international trade. Now and in the years to come, the exponential growth of data requires supply chain managers to enhance their processing capacity while maintaining efficiency and reliability. Among the most promising innovations in this area is predictive logistics, which leverages AI to forecast and mitigate supply chain risks proactively. Based on the established link between artificial intelligence and supply chain risk management, this leads us to the following research question : To what extent can artificial intelligence improve supply chain risk management ?

To address this core question, we propose two sub-questions:

- Can artificial intelligence facilitate supply chain risk management?
- Should artificial intelligence be implemented in industrial organizations?

The objective of this article is to highlight the importance of applying artificial intelligence to supply chain risk management and to demonstrate the added value it can offer to businesses—especially in terms of gaining a technological edge over competitors.

Literature Review

The Evolution of The Supply Chain Over Time

The first "thinking machines" appeared in science fiction stories. For example, in 1921, the Czech playwright Karel Čapek introduced the concept in his theatrical play Rossum's Universal Robots. The play depicts robots as machines capable of thinking, designed to be an extraordinarily cheap, productive, and uncomplaining labor force. However, these robots lack spiritual life and emotions. Over time, millions of robots gradually replace humans, and the RUR company amasses billions in profits. Humans become obsolete and useless, offering no added value compared to these intelligent robots. Furthermore, as early as 1950, scientists began to seriously consider the idea of thinking machines. British mathematician Alan Turing published a seminal article titled "Computing Machinery and Intelligence", in which he explored the question of whether machines could think. He proposed a method to determine if a machine could exhibit human-like intelligence—what he called the "Imitation Game", now famously known as the Turing Test. In this publication, Turing made strikingly accurate predictions about the future of computing: "I believe that in about fifty years' time it will be possible to program computers, with a storage capacity of about 10^9, to play the imitation game so well that an average interrogator will not have more than a 70

percent chance of making the right identification after five minutes of questioning," he forecasted.

Soon after, in 1956, a group of American scientists—including John McCarthy, Marvin Minsky, Nathaniel Rochester, and others—gathered at Dartmouth College for a now-historic conference titled « The Dartmouth Summer Research Project on Artificial Intelligence ». It was during this event that the term "Artificial Intelligence" (AI) was officially coined. Their initial research focused on understanding and replicating human learning and intelligence mechanisms in machines. Following this momentum, the first AI software (the Logic Theorist) was developed by American researchers Herbert Simon and Allen Newell. This program was capable of autonomously proving mathematical theorems, marking a major milestone in the history of AI. Around the same time, AI found another practical application: machine translation. Fueled by the Cold War tensions between the USSR and the USA, researchers developed systems that could translate 49 Russian sentences into English, highlighting AI's potential in linguistics and international communication. A significant breakthrough came in 1957 when linguist Noam Chomsky introduced mathematical models of language (generative grammar), enabling machines to process and understand human language more effectively. This development laid the foundations for natural language processing (NLP), a crucial branch of modern AI. Later, in 1965 at MIT, Joseph Weizenbaum developed the computer program ELIZA, which was designed to simulate a psychotherapist during therapeutic interviews. ELIZA could mimic human conversation by rephrasing user inputs, offering a glimpse into the potential of human-machine interaction in the psychological field. Between the 1960s and 1970s, interest in AI research declined significantly due to growing criticism. Many detractors argued that intelligence could not be reduced to mere calculation and emphasized the importance of human emotions and subjective experience. This period became known as the "AI Winter", characterized by reduced funding and skepticism. It also served as a moment of reflection, during which researchers recalibrated their ambitions and focused on more realistic, achievable goals. In the 1980s, AI research saw a revival in the United States with the emergence of expert systems. The aim was to enable machines to replicate the decision-making processes of human experts in specific domains, such as medicine, finance, or credit card fraud detection. This period also marked the development of learning algorithms, which allowed computers to tackle more complex problems than ever before. By the early 1990s, AI was reintegrated into research laboratories, stimulated by advances in computing power and the growing availability of big data. A symbolic milestone occurred in 1997, when IBM's Deep Blue defeated reigning world chess champion Garry Kasparov, marking the first time an AI had beaten a human champion in such a cognitively demanding game. That same year, speech recognition software developed by Dragon Systems was integrated into Microsoft Windows. This era also marked the rise of deep learning, enabling significant progress in handwriting and image recognition. New techniques were also developed to detect fraud, such as forged checks and unauthorized transactions. Today, artificial intelligence has entered a new era. The exceptional increase in data storage capacity and the accumulation of vast datasets have significantly improved the performance of algorithms. Technological advancements have ushered in the age of Deep Learning, which allows machines to learn from large volumes of data with unprecedented accuracy. AI now permeates multiple sectors, enhancing operational efficiency and driving extreme levels of effectiveness and productivity.

How Artificial Intelligence Works

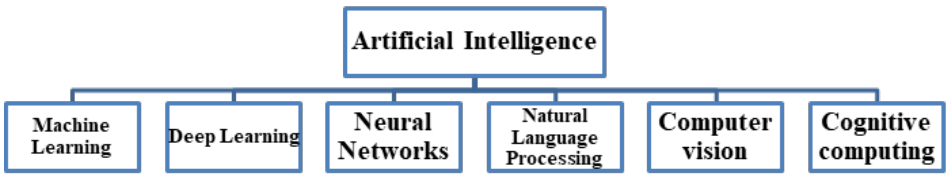
Building an AI system is a careful and methodical process that involves integrating human-like attributes and capabilities into a machine, then leveraging its computational power to exceed human limitations. The ultimate goal is not just to replicate human thinking, but to enhance decision-making, automate tasks, and generate insights that humans alone may not be able to achieve as efficiently. To truly understand how artificial intelligence operates, it is essential to explore its key subfields and examine how these areas can be applied across various business sectors, such as logistics, finance, healthcare, and marketing.
The most prominent AI subdomains include:

- Machine Learning (ML): Enables systems to learn from data and improve their performance over time without being explicitly programmed. It is widely used for predictive analytics, fraud detection, and customer behavior analysis.

- Natural Language Processing (NLP): Allows machines to understand, interpret, and respond to human language. NLP is commonly applied in chatbots, sentiment analysis, and voice assistants.
- Computer Vision: Empowers machines to interpret visual data from the world, such as images and videos. It is used in facial recognition, quality inspection in manufacturing, and autonomous vehicles.
- Robotic Process Automation (RPA): Involves automating repetitive tasks through software robots, often used in administrative processes, HR, and supply chain documentation.
- Expert Systems: Simulate the decision-making ability of a human expert. They are often implemented in areas like medical diagnostics or risk assessment.
- Deep Learning: A subset of machine learning that uses neural networks with many layers to analyze large volumes of data. Deep learning excels in pattern recognition and is used for image classification, speech recognition, and language translation.

By combining these technologies, AI systems can replicate cognitive functions such as perception, reasoning, problem-solving, and learning. This allows companies to not only automate workflows but also to gain strategic advantages through smarter insights and optimized processes.

Figure 1: The subfields of Artificial Intelligence



Source : Developed by the Authors

Machine Learning (ML) teaches a machine how to draw conclusions and make decisions based on past experience. It identifies patterns and analyzes historical data to derive meaning from data points and reach possible conclusions—without relying on human intervention. This ability to automate data-driven conclusions saves companies time and supports better decision-making.

Learning can take three forms:

- Supervised learning, where the machine is trained on labeled data provided by humans;
- Unsupervised learning, where the algorithm uncovers hidden structures in data without prior labeling;
- Reinforcement learning, where the system learns behavior through trial and error, receiving feedback from its actions to optimize its performance.

Deep Learning (DL) is a subset of machine learning that uses mathematical functions to model how input contributes to output. These functions are capable of isolating non-linear patterns in data, enabling the system to establish meaningful connections between information and outcomes. This process is called learning, and the underlying method is referred to as training.
Neural Networks operate in ways similar to human brain cells. They involve a series of computations that capture the relationships among various underlying variables, processing data in a manner that mimics the human brain.

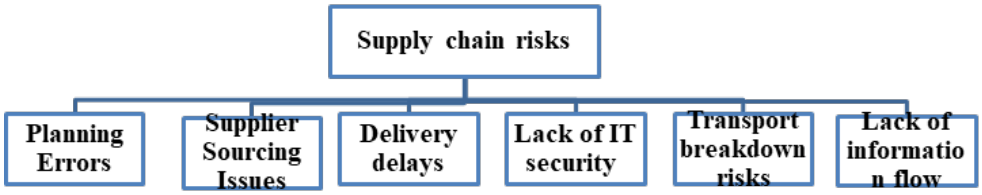
Natural Language Processing (NLP) is the science of teaching machines to read, understand, and interpret

Computer Vision algorithms attempt to analyze visual input by breaking down an image and focusing on different components of the object. This allows the machine to classify and learn from sets of images, improving its ability to make optimal decisions based on past visual experiences. Cognitive Computing algorithms strive to replicate human reasoning by analyzing text, speech, and objects in a way that mirrors human thought processes. The goal is to produce the most accurate and contextually appropriate outcome possible.

Types of Supply Chain Risks

The concept of risk refers to any event that prevents a company from achieving its objectives. The most effective way to understand supply chain risks is to approach them from both a dynamic and historical perspective, as the way these risks have been addressed over the past 15 to 20 years has evolved significantly—both in terms of scope and the nature of risks considered by supply chain managers. Initially, risks were mainly industrial and logistical in nature, focusing on ensuring the safety of personnel and equipment, such as preventing accidents and material damage. Gradually, attention shifted toward a broader range of operational risks, especially those related to suppliers, including their financial stability, supply chain capabilities, and organizational performance. Today, the risk landscape has expanded further to include cybersecurity threats and reputational risks. Organizations must now consider a wide spectrum of potential disruptions, recognizing that not everything can be anticipated. In the current context, the idea of zero risk in supply chain management is no longer realistic. Instead, companies must focus on business continuity planning, adapting to disruptions based on the nature of their relationships with supply chain partners, and leveraging technological advancements to improve risk detection, response, and resilience.

Figure 2 : Supply chain-related risks



Source : Developed by the Authors

- These risks stem from multiple factors that hinder the smooth functioning of the supply chain. They result from actions and decisions made by the company itself as well as by its partners. Internally, we can identify the following categories:
- **Planning Errors**

A planning error in the supply chain can have significant repercussions on the entire production and product delivery process. Such errors may result in delivery delays, overstock or stockouts, additional costs due to emergency shipping or urgent production, increased storage expenses, poor resource allocation, and ultimately, a decline in customer satisfaction.

- **Lack of It Security In The Supply Chain**

The absence of IT security within the supply chain represents a major threat to businesses. Due to the digital interconnection between suppliers, manufacturers, distributors, and customers, any vulnerability can be exploited by cybercriminals to access sensitive data or disrupt operations. To mitigate these risks, it is essential to implement robust security measures—such as firewalls, encryption, and intrusion detection systems—train supply chain partners, enforce strict cybersecurity policies, and prepare for potential cyberattacks through business continuity and incident response plans. Collaboration among all stakeholders in the supply chain is critical to ensuring system resilience and protecting the integrity of operations.

- **Quality Defects in the Supply Chain**

Quality defects within the supply chain can negatively impact customer satisfaction, brand image, and overall profitability. These issues can occur at any stage—from production to final delivery. To address them, companies must implement strict quality control procedures, identify risk-prone areas using tools such as supply chain mapping, strengthen training and communication with suppliers, and establish effective quality management systems. A proactive, collaborative, and structured approach is essential to preventing defects and ensuring consistent quality throughout the entire supply chain.

- **Supplier Sourcing in the Supply Chain**

Supplier sourcing is a critical stage in the supply chain, but it can also generate various issues such as delays, quality defects, cost overruns, non-compliance, or reputational damage. To prevent these risks, companies must establish strict selection criteria, conduct rigorous supplier evaluations, maintain clear and consistent communication, formalize commitments through well-defined contracts, monitor supplier performance regularly, and diversify their sourcing strategies to reduce dependency and exposure to risk.

- **Lack of Information Flow in the Supply Chain**

Insufficient information flow within the supply chain can lead to delays, additional costs, stock mismanagement, and poor coordination between stakeholders. To overcome this, it is crucial to establish effective communication channels, adopt integrated information systems (such as ERP, SCM, and traceability tools), and foster transparency and trust among partners. Training supply chain actors in communication, collaboration, and the use of digital tools is also essential to strengthening the efficiency and reliability of information flow throughout the supply chain.

- **Delivery Delays in the Supply Chain**

Delivery delays are a major concern that can impact customer satisfaction, cause financial losses, damage a company's reputation, and disrupt production schedules. Such delays may stem from logistical issues, planning errors, or supplier failures. To address these challenges, companies must implement robust processes, including order tracking, rigorous planning, close coordination with suppliers, clear contractual agreements, and regular performance monitoring. In the event of a delay, transparent communication with customers and partners is essential to mitigate the impact and identify corrective solutions.

- **Transport Damage Risks in the Supply Chain**

Transport damage poses a significant risk that can lead to losses, product damage, delays, and additional costs. Such incidents may result from accidents, theft, mishandling, or adverse environmental conditions. To mitigate these risks, companies should use appropriate packaging, select reliable carriers, obtain transport insurance, and ensure compliance with documentation and customs procedures. These measures help minimize the financial and operational impacts of transport-related incidents.

The Adoption of Artificial Intelligence in Supply Chain Risk Management

The integration of Artificial Intelligence (AI) into supply chain risk management represents a major strategic evolution. By enabling real-time processing of large volumes of structured and unstructured data, AI improves the anticipation, detection, and mitigation of risks across the supply chain.

Key applications include predictive analytics, Natural Language Processing (NLP), computer vision, and Robotic Process Automation (RPA). These technologies support proactive decision-making and enhance supply chain visibility, responsiveness, and resilience. While implementation poses challenges—such as data quality and organizational readiness—AI emerges as a powerful driver of competitive advantage and risk control in increasingly complex and uncertain environments.

Empirical Literature Review

Table 1: Empirical Literature Review

Study	Research question	Context	Methodology	Key findings
Choi et al. (2018)	The impact of AI on risk management and supply chain optimization.	Study conducted during the global economic recession.	Multi-industry case study, including interviews with supply chain professionals	AI improves supply chain resilience by reducing response times during crises and optimizing real-time decision-making.
Li et al. (2019)	How effective is AI for managing logistics risks during a crisis?	Study conducted in the automotive sector during a global supply crisis.	Comparative analysis of AI usage in companies facing crisis situations.	AI helps anticipate supply chain disruptions, reducing financial and operational risks during crises.
Agarwal et al. (2020)	How can AI be used to improve risk management in the supply chain?	Study conducted in the distribution and logistics sector.	Quantitative analysis based on historical data and simulations.	AI helps predict risks related to internal and external disruptions and optimizes planning and restocking processes.
Jabbour et al. (2021)	How can AI transform supply chain risk management in the manufacturing sector?	Industrial context, especially in manufacturing and production companies.	Empirical research based on surveys and statistical analysis.	Integrating AI into logistics processes increases risk visibility and enables optimized decision-making for inventory and supplier management.
Xu et al. (2022)	Applications of AI in reducing human and logistical error risks.	Context of supply chain industrialization and automation.	Case study in companies using automated and AI-driven systems.	AI reduces human error by automating logistics decisions, thus enhancing productivity and supply chain resilience.

Source : Developed by the Authors

This table can be adjusted based on our research and the sources we have collected. It summarizes the key elements of each study, providing an overview of how AI contributes to optimization and resilience in supply chain risk management.

Methodology

Research Methodology

This study adopts a qualitative approach, considered the most appropriate to address the research question related to the integration of Artificial Intelligence (AI) in supply chain risk management within an industrial company. The objective is to understand the perceptions of company managers regarding supply chain risks and the potential use of AI to manage them. The chosen method is a survey-based investigation, relying on the collection of information from a targeted sample of respondents through semi-structured interviews. This qualitative and exploratory approach is detailed in the following sections.

Data Collection Methods

Survey Method

To achieve the theoretical objective and respond to the research question, we opted for a qualitative method, which is particularly suitable for studies aiming to explore specific perceptions and experiences in depth (Berg, 2003). A survey-based approach was chosen as the data collection technique, as it allows researchers to ask a set of targeted questions to a sample of individuals in order to gather insights on specific topics. Other qualitative methods, such as focus group interviews or projective techniques, were considered but ultimately dismissed due to budget, time, and human resource constraints. The survey is defined as a method of collecting information by asking questions to a sample of individuals drawn from a target population (Lessard-Hébert, 2010).

To conduct the survey, an interview guide was developed, and the following steps were undertaken :

- Selection of the sample
- Development of the interview guide
- Choice of the mode of administration
- Collection, analysis, and interpretation of the results

Sample Selection

Sample selection is a crucial phase, as it determines the quality and relevance of the results. The target population of this study consists of managers from an industrial company located in the Casablanca region, including individuals of different genders, ages, and places of residence. This diversity ensures that the sample is representative. The sampling frame corresponds to the entire group of managers within the company.

Sampling Frame

The sampling frame consists of the list of all managers within the industrial company. This list ensures that each unit has a chance to be included in the survey. Sampling must be based on a clearly defined framework in order to ensure representativeness, thereby guaranteeing the validity and reliability of the results.

The selection of a sample :

The selection of the sample is based on the desired size, the level of precision required, and constraints related to data collection (Miles & Huberman, 1994). Two main sampling methods are typically considered: probabilistic and non-probabilistic approaches. In this study, we opted for a non-probabilistic convenience sampling method. Although this method does not rely on random selection, it is commonly used when the sampling frame is not exhaustive but when it is still possible to study a representative portion of the managers within an industrial company. Accordingly, we adopted an exploratory qualitative approach to collect data directly from the logistics department managers of the company.

Qualitative Method Using an Interview Guide

Semi-structured interviews were used to collect the data. This type of interview allows for an in-depth exploration of key themes while providing flexibility in responses and maintaining a structured flow of discussion. The interview guide, developed following the methodology of S. Ganassali (2014), includes 15 main questions focused on three core themes:

- Supply chain risk management
- Understanding of artificial intelligence
- Perspectives on the use of AI in risk management

Analysis of the Results

The collected data were analyzed using Thematic Content Analysis (TCA), a widely recognized method for analyzing qualitative data (Auerbach & Silverstein, 2003). This approach involves transcribing the interviews, coding the information obtained, and organizing it into emerging themes. According to Andreani & Conchon (2005), content analysis enables researchers to identify relevant categories and themes in order to better understand the responses provided.

Transcription of the Content :

The first step in the analysis consists of fully transcribing the interviews verbatim, which provides a written version of the participants' responses. This step facilitates the reading and interpretation of the data.

Coding

The data collected during the interviews were coded line by line. This process helps identify recurring themes and assign categories to the information gathered. Coding contributes to organizing the data, making the analysis easier and allowing the extraction of relevant insights.

Processing and Interpretation of the Results

After coding, the content is processed to extract meaningful insights. The interpretation of the data (taking into account the theoretical aspects related to artificial intelligence and supply chain risk management) allows us to draw conclusions regarding the relevance of AI adoption in this field. The conclusions derived from this analysis provide valuable insights for companies seeking to integrate AI into their supply chain risk management strategies.

Discussion

The interviews conducted provided detailed and nuanced information on supply chain-related risks, the understanding of Artificial Intelligence (AI), and its application in risk management. The collected data were analyzed based on predefined themes, while additional themes emerged progressively throughout the analysis.

Theme I: Understanding Supply Chain Risks

The supply chain risks identified mainly concern delivery delays, quality issues, and costs. Disruptions in any of these areas affect the entire supply chain process, from production to the final customer. The major risks mentioned include:

- Any delay in production leads to a chain reaction, affecting all downstream processes.
- Payment delays can result in delays in transport documentation, thereby impacting delivery timelines.
- These risks often stem from new suppliers or failures within the suppliers' own supply chains. The company identifies risks at various levels of the supply chain, particularly:
- At the supplier level (e.g., quality of raw materials),
- In international transportation (e.g., delays, congestion, damage to containers),
- And financial issues related to cash flow.

Theme II: Knowledge of artificial intelligence

Table 2: Understanding of Artificial Intelligence (AI) in the Context of Supply Chain Management

Aspect	Observations
Perception of AI	A set of tools designed to replicate human reasoning in order to anticipate supply chain risks.
Perceived Benefits	– Prevention and anticipation of risks. – Less focused on solving existing problems.
Current Use	AI is not yet operationally implemented in supply chain management.
Identified Challenges	– Requires continuous input of scenarios to generate relevant forecasts.
Future Potential	– Development of an "ideal roadmap". – Risk of turning tasks into repetitive, challenge-free routines.

Source : Developed by the Authors

Theme III : Perspectives on the Use of AI to Manage Supply Chain Risks

AI is perceived as a tool to enhance responsiveness and execution speed, particularly in managing supplier-related risks. Once properly fed with data and configured, AI could offer personalized and rapid solutions tailored to specific scenarios. However, a potential concern is the reduction in human resources, as AI may automate tasks that are currently performed by human teams. The implementation of AI faces numerous obstacles. The main challenge lies in the continuous feeding of the AI database, a critical phase for its success. It is also necessary to allocate both human and financial resources for training, data input, and the configuration and programming phases, in order to optimize AI outcomes. The interview results indicate that, although AI offers significant potential for supply chain risk management, its adoption requires substantial investments in human and financial resources, as well as considerable time for system setup and data integration. AI could transform supply chain risk management by providing faster and more tailored solutions, but its integration into companies remains a complex and demanding process [1-10].

Conclusion

In conclusion, artificial intelligence can be defined as a system capable of influencing real or virtual decisions based on a set of goals defined by humans. It fundamentally differs from traditional data analysis techniques and, as such, offers promising support for logistics managers by helping them optimize and simplify their work. This study aimed to highlight the impact of using such a system within the supply chain. In the wake of global financial crises, supply chains are facing more severe challenges than ever before. Supply chain management must now be rethought through strategic approaches to improve resilience in the face of sudden disruptions. This article has generated an important discussion on how artificial intelligence can contribute to making supply chains more responsive and resilient, particularly in terms of risk management. We explored the technological levers (namely AI technologies) and discussed how they can be applied to specific supply chain processes and which performance attributes can be improved. The contribution of this work is both theoretical and practical, offering insights into supply chain optimization and particularly into the integration of AI within companies.

Finally, based on our findings, we recommend that logistics managers integrate artificial intelligence into their operations, given the advantages it offers. AI can help automate repetitive tasks, leading to faster execution, greater accuracy, and more comprehensive decision-making—ultimately enhancing supply chain performance. We also encourage managers to embrace technological change by training in emerging digital tools to remain competitive and maintain their relevance in the profession.

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