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Risk management in global supply chains using predictive artificial intelligence

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Abstract
We live in an age of globalization where we constantly face threats bought by geopolitical vulnerability as well as pandemics, climate change and cyber threats. Traditional risk management methods only respond after the obstruction has taken place and the business continuity has been broken. This study helps us examine how predictive AI can transform global supply chain risk management from a reactive approach into a prescriptive and adaptive system. Our target is to rely on secondary data of academic studies, industry publications, OECD models that delve into AI strengthening of warning systems, data-driven decision-making, and simulation of scenarios. The findings highlight that machine learning algorithms are capable of anticipating obstructions by analyzing real time logistics, environmental data, trade, by which it strengthens responses and business resilience. In addition, AI-driven data ecosystems foster the connection between the public and the private sector by enhancing the level of transparency and increasing the speed of the recovery process. By initiating these technologies, organizations can be better at predicting potential risks, allocating resources more efficiently, and sustaining operations even during the global crisis. The paper concludes by stating that predictive AI is not only an application of technology but a business approach that enables firms to establish better, smarter, and more resilient supply chains. In the uncertain world, there is a possibility of AI becoming the means of redefining the global risk management to offer a stable, adaptable, and sustainable future of businesses throughout the world.

Keywords: Artificial intelligence (AI), supply chain, risk management, global logistics, resilience, machine learning, data analytics

Introduction
In the modern globalized environment, supply networks are responding to increasing risks of political instability, epidemics, natural disasters, cyber-attacks, or market volatility. The traditional techniques of dealing with these threats that are mostly based on the previous history, last-minute patching, and intuition are no longer effective in the face of rapid, convoluted disruptions (Ivanov and Dolgui, 2021) [9]. As an example, consider the coronavirus outbreak. It demonstrated the existence of fundamental weaknesses in the logistical systems of countries, demonstrating the extent to which we require foresight tools that can help predict problems before they occur (Queiroz *et al*., 2020) [10].
Predictive AI is emerging as a major contributor towards developing more powerful responses in this case. Rather than merely responding, such smart tools apply machine learning and deep data scans to identify problems early due to pattern tracking over live info feeds. Since they draw on sources such as weather alerts, shipment monitors, social media or supplier activity, minor red flags usually appear before a real disaster occurs. Having such an advantage, businesses act quicker, changing in the moment based on the information synthesized in piles of mixed-up data. By transferring this manner, supply networks begin to operate differently not as trouble-takers, but as trouble-preventers.
According to the latest research, predictive AI helps companies to be flexible, make better predictions, and be stronger when issues arise (Choi, Wallace, and Wang, 2022) [1]. In addition to being able to identify risks earlier, the tools also allow the teams to test various outcomes-enabling to shape decisions with solid data and simplify how resources are utilized (Ivanov, 2023) [2].

Nevertheless, despite promise continuing to accumulate, there are challenges such as data messiness, biased algorithms, lack of clarity, or readability of results that hinder extensive deployment (Tiwari, Daryanto, and Wee, 2022) [6]. The way out of this is to construct transparent mechanisms so that AI forecasting fits well within the normal risk practices and corporate controls.

This paper examines the relationship between predicting technology and managing risks in global supply chain through addressing three key objectives: first, identifying key risk factors in global supply chain; second, evaluating the capacity of current predictive AI solutions to address risk factors, rather than respond to them afterward; and third, proposing an integrated way to incorporate intelligent data analysis directly into risk management strategies. It provides practical and academic knowledge on how to utilize futuristic systems to enhance flexibility, maintain operations without challenges, or achieve competitive advantage in the face of the changing world trading environments.

Literature Review

The Supply-chain resilience artificial intelligence and big data analytics: A systematic literature review

The paper gathers and summarises the available literature, categorises technologies such as ML, NLP, prescriptive analytics, list application in digital twins, demand forecasting, anomaly detection, routing and summarises barriers data quality, interpretability, organisational readiness. Our introduction is a solid documentation of the necessity of looking ahead tools and catalogues the type of disruption, our research paper takes one step further, and methodically demonstrates what AI techniques have been used on which types of disruption and in which areas the evidence is weak. Concisely, they transform the need of predictive tools claim into a mapped research portrait and uses synthetic to respond to research queries.

Ensuring supply chain resilience with industry 4.0: A systematic literature review under the impression of the COVID-19 Pandemic

This review directly connects Industry-4.0 technologies (IoT, cloud, digital twins and analytics) to the results of resilience in the context of COVID-19. Evidence contained in the review, such as case data, refers to the fact that digitalisation (real-time sensors, connectivity, digital twins) enhanced visibility and agility, but organisational and governance barriers are mentioned as well. It offers the technological palette and COVID times grounding upon which the argument that predictive AI should be closely integrated with Industry infrastructures (sensors, real-time feeds, simulation platforms) will be effective.

I chose the two articles as they are a close link between the theoretical and operational methodologies. Selection was based on the following criteria.

- **Strength on the study:** Recent systematic reviews 2020-23 are extensively referred to thus it needed to know the strength.
- **Diversity compatibility:** Every research article must be compatible with each other at the same time to render it pertinent to the study.

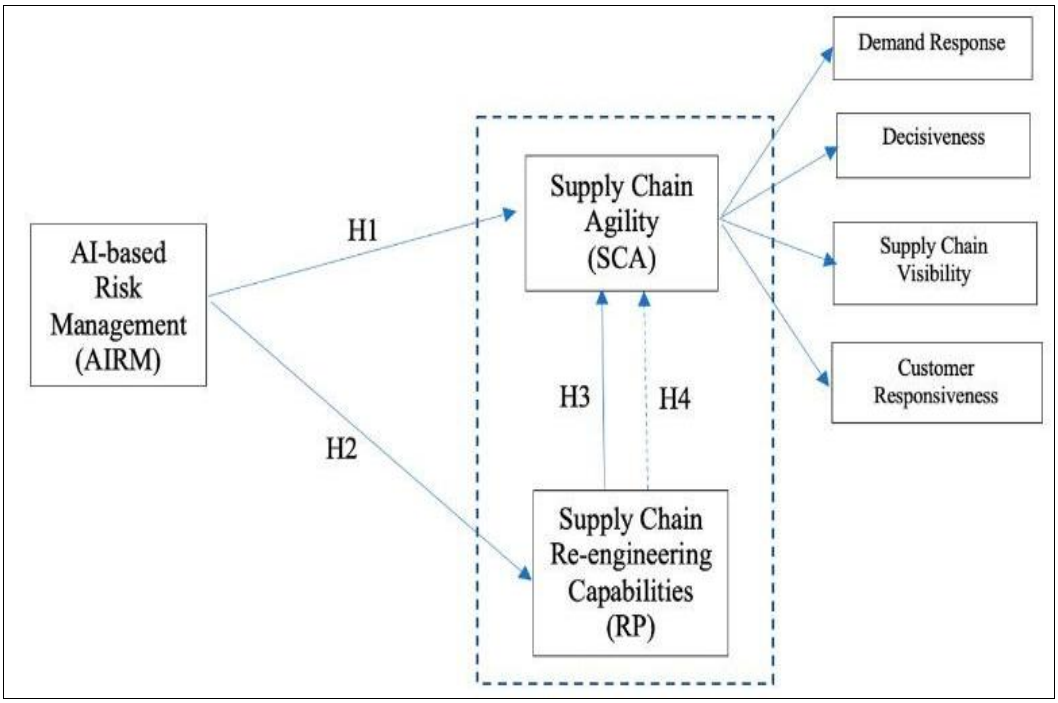

Fig 1: Conceptual Model of the Study

Adapted from" (Artificial intelligence-driven risk management for enhancing supply chain agility: A deep-learning-based dual-stage PLS-SEM-ANN analysis)", by YK Dwivedi, *et al.* 2024 [8], International Journal of Production Research. 62(15):5535-5555, https://www.tandfonline.com/doi/full/10.1080/00207543.2022.2063089

Methodology

The research approach is secondary qualitative in nature, since it concentrates on reviewing and critically analysing the available academic literature regarding the topic of risk management in global supply chains and the use of predictive artificial intelligence (AI). This methodology aims to learn more about how predictive artificial

intelligence tools can be used to recognize, evaluate and prevent potential supply chain interference, and transform risk management as a reactive system to a proactive system.

Data Collection

The data were gathered using the significant online databases, including Google Scholar, ScienceDirect, ResearchGate, and Shodhganga. The sources have been selected based on their reliability and the availability of peer-reviewed articles. Predictive AI, supply chain risk, risk management, AI-driven analytics, and digital transformation in logistics were in turn the keywords with which one could find materials that have been published over the past several years and include the latest developments.

Favor was also placed on articles that outlined real-life usage, architecture and case implementation of AI technologies in the supply chain environment. Eligible papers were referred to be viewed in detail depending on their scope, depth of research and relevance with the topic.

Data Analysis

The chosen articles were analysed thoroughly to find the common patterns, themes, and conceptual framework around predictive AI and risk management. The approach to the thematic analysis was to cluster the findings based on the general themes like the nature of supply chain risks, predictive modelling, advantages of AI implementation, limitations, and challenges.

The comparisons between the studies were conducted to reveal consistent and contradictory points of view. The information was consequently synthesized to construct a better picture of how predictive AI can be used to create resilience and agility within global supply chains. Findings were grouped to demonstrate patterns in the field of research, the changing role of AI technologies, and gaps that should be closed by conducting additional studies.

Research Design

This research is based on the systematic literature review design that is used to answer a certain research question by collecting, filtering, and interpreting secondary data. This was organized into three phases

- **Identification:** Filing and choosing the most pertinent academic papers.
- **Evaluation:** The critical assessment of the quality, the credibility of the study and the methodology.
- **Synthesis:** Integrating the learnings to make general conclusions regarding the usefulness of predictive AI in managing risks.

The design will ensure a comprehensive understanding of the subject in a short span of time and will indicate the broad direction of the current study in the area as the analysis of existing knowledge will be conducted instead of obtaining new primary data. The experience of this review was then concluded to give insights and suggestions on the potential path the study can follow in the future, specifically how AI can be applied alongside the sustainability, resilience, and real-time decision-making in supply chain management. Furthermore, it offers a systematic basis of future empirical research that will possibly confirm these findings by putting them into practice. In this way, the findings will not only play a role in enhancing academic knowledge but also being used in improving the strategic development of the current supply chain practices.

Table 1: Demographic Analysis

Demographic characteristics	Category	Frequency	Percent
Gender	Female	131	52.0
	Male	121	48.0
Age (years)	30 and below	90	35.7
	Between 31 and 40	107	42.5
	Between 41 and 50	45	17.9
	51 and above	10	4.00
Number of years with organisation (years)	Less than 1	17	6.70
	1-2	65	25.8
	3-5	88	34.9
	6-10	45	17.9
	11-20	22	8.70
	Above 20 Years	15	6.00
Job position	Executive (e.g. Officer, Accountant, Senior Accountant, Engineer, Senior Engineer, Staff Engineer, System Analyst, Assistant Manager, etc.)	127	50.4
	Senior Staff Engineer / Principal Engineer / Manager / Senior Manager / Head of Department	86	34.1
	General Manager / Director / Senior Director / Executive Director / Managing Director / Chief Executive Officer / Vice President / President / Chairman	20	7.90
	Other	19	7.50
Age of firm (years)	< 5 Years	22	8.70
	5 ≤ Years < 10 Years	75	29.8
	> 10 Years	154	61.1
Category of organization product	Electrical and electronics	48	19.0
	Chemical	19	7.50
	Textile	17	6.70
	Food	63	24.9
	Rubber and plastic	34	13.4
	Machinery and hardware	34	13.4
	Others	38	15.0
Number of employees	Less than 5	26	10.3
	5 to <75	134	53.0
	75 to ≤200	57	22.5
	>200	36	14.2%

Adapted from" (Artificial intelligence-driven risk management for enhancing supply chain agility: A deep-learning-based dual-stage PLS-SEM-ANN analysis)", by Y.K. Dwivedi *et al*. 2024 [8], International Journal of Production Research. 62(15):5535-5555, https://www.tandfonline.com/doi/full/10.1080/00207543.2022.2063089

Findings

- Predictive artificial intelligence (AI) is a developing technology in world supply chains that can be used to assist companies to shift to proactive strategies instead of reactive ones to supply chain risk management.
- AI allows organizations to predict disruptions based on real-time information provided by different sources like logistics, weather predictions, social media, and the market.
- It enhances the identification and evaluation of risks as it identifies patterns that cannot be identified using traditional methods to improve preparedness to demand, supply and transport related risks.
- Research always indicates enhanced accuracy in decisions, reduced lead times and increased operational efficiency in companies implementing AI-based prediction models.
- Predictive AI offers real-time visibility and this ensures that businesses can monitor performance and respond promptly to disruptions.
- Some of its major challenges involve data quality, lack of competent professionals, high costs, privacy and limited technological preparedness particularly in smaller businesses.
- To implement it effectively, the balance should be based on technology, human expertise, and data management.
- It is necessary that future research should be directed towards the integration of predictive AI with sustainability, resilience and ethical practices in global supply chain management.
- According to the studies reviewed, effective adoption of AI reinforces the partnership and trust of supply chain partners.
- Also, predictive AI is beneficial in improving strategic decision-making, as it provides information based on the available data to plan and allocate resources.

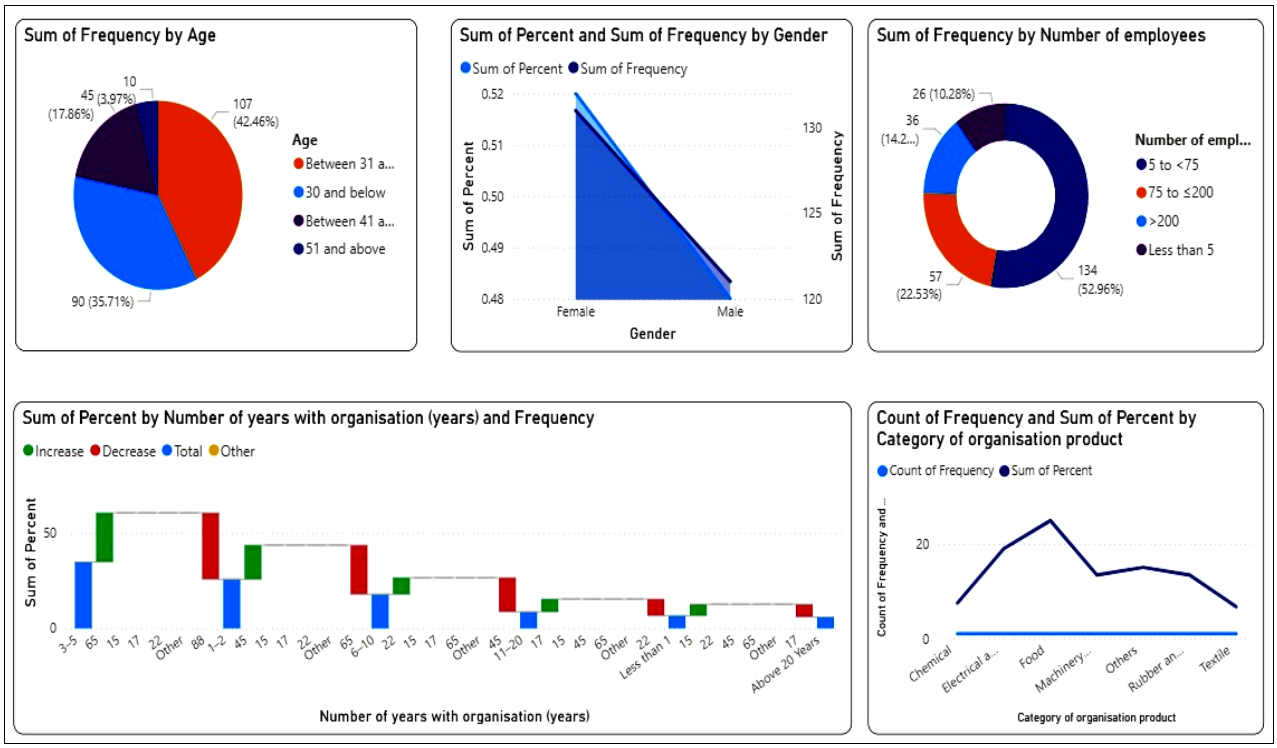

Fig 2: Distribution of data based on frequency and percentage (Created by the author using Power BI)

Conclusion

This paper has examined how predictive artificial intelligence (AI) is transforming risk management in international supply chains by changing the tradition of reactive to proactive approaches. The literature review has revealed that predictive AI enhances the capacity of organizations to anticipate possible disruption, evaluate risks precisely, and act with speed due to real-time data analysis. Working with various sources of information like logistics, weather predictions and market dynamics, AI solutions help companies to make better decisions, gain greater resiliency, and continue operating as situations change. Simultaneously, the study also emphasized the fact that the efficiency of predictive AI relies on the quality of data, qualified human supervision, and technological preparation. The high implementation cost, privacy and low level of digital infrastructure are barriers hindering it, particularly in small organizations. Thus, effective implementation is a compromise of technology, human resource and strategic investment.

To sum up, predictive AI introduces a promising avenue to more intelligent, more flexible and future-proof supply chains. The combination of AI and sustainability, ethical governance, and real-time decision systems will become essential as the global risks continue to develop. Future studies ought to be aimed at coming up with common

frameworks that can be used to align predictive analytics with responsible, transparent and collaborative supply chain activities in order to achieve long term resiliency and competitiveness.

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