Revolutionizing industrial efficiency through generative AI: case studies and impacts on supply chain operations

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Abstract. With the advancement of Industry 4.0, the manufacturing industry is working to create a new smart industrial world through computerization, digitization and intelligence enhancement. Gen AI is primarily characterized by its ability to generate novel data patterns and solutions rather than merely analyzing predefined data inputs. This paper explores the transformative impact of Gen AI on supply chain efficiency in industrial engineering and logistics. Key applications include inventory optimization, predictive maintenance, fraud detection, risk management, logistics optimization, and demand forecasting. The study shows that Gen AI significantly improves operational efficiency and reduces stress for industrial workers by providing dynamic data-driven solutions. Through real-world case studies, including companies, this study demonstrates how Gen AI can revolutionize supply chain management and increase productivity. Despite its significant benefits, Gen AI still faces several challenges due to its cutting-edge nature. Further, in-depth research is needed in the future as the number of relevant cases and literature increases.

1 Introduction

According to Wikipedia, the definition of Industry 4.0, also called productive forces 4.0, is a high technic plan offered by the German government, also known as *The 4th Industrial Revolution* [1]. The core concept of Industry 4.0 is to enhance the computerization, digitization, and intellectualization of manufacturing [2]. Its technological foundation is based on intelligent integrated sensing and control systems and the Internet of Things (IoT), aiming to construct a new type of intelligent, wise, conscious industrial world [3]. By collecting and analyzing big data, it utilizes existing resources to make precise predictions and generate a product solution that meets the customer fully.

Unlike traditional artificial intelligence that analyzes inputs to produce predetermined outputs, generative AI (Gen AI) can create novel patterns and trends within data. It can anticipate unforeseen situations and propose solutions that are not explicitly programmed. Furthermore, generative AI can generate new original content, predictions, and data-driven strategies [4]. There are significant differences between AI-powered supply chains and traditional supply chains. Traditional supply chain operations tend to be reactive, relying on

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static planning, manual analysis, and generic solutions. On the other hand, Gen AI-driven supply chain operations are more proactive, employing dynamic optimization, automated insights, and customized strategies to improve overall operational efficiency and responsiveness [5].

At the end of 2022, with the advent of ChatGPT, Gen AI gained significant attention and began to impact various aspects of people's lives. Many have expressed concerns that such highly intelligent AI will severely disrupt industries and lead to unemployment. Among them, many believe that the impact of Gen AI on the industrial field is particularly severe. However, the author argues that if Gen AI is used properly, the efficiency of the industrial field will be greatly improved. Instead of causing a large amount of unemployment, it will greatly reduce the work pressure on practitioners.

This study will start from the fields of industrial engineering and logistics engineering, analyzing practical cases where Gen AI has improved supply chain efficiency. By doing so, this study aims to demonstrate how, when employed correctly, Gen AI can greatly enhance the efficiency of industrial processes and logistics operations.

2 Generative AI

According to Wikipedia, Gen AI refers to an AI system capable of producing text, images, or other media responding to user requests, such as ChatGPT [6, 7]. Generative models learn the patterns and structures of input data and then generate new content similar to the training data but with a certain degree of novelty rather than just classifying or predicting data [8].

The advent of generative AI, led by ChatGPT, has replaced traditional AI in various industries. Unlike traditional AI, Gen AI employs machine learning methods to replace manually defined rules and logics. Gen AI utilizes a vast amount of data for learning and training, gradually achieving self-evolution of databases and algorithms. In terms of versatility, Gen AI covers a wider range of tasks and domains than traditional AI, encompassing the generation of images, audio, text, etc. While traditional AI focuses on solving problems following users' thoughts and methods, Gen AI can analyze data and provide processing suggestions and solutions. As shown in Table 1, compared to traditional AI, Gen AI represents a higher level of intelligence.

Table 1. Comparison between LLM and SLM [9].

Aspect	Large Language Model, LLM	Small Language Models, SLM
Scale	Hundreds billion of parameters	Number of parameters can less than 15 million
Requirement	May need hundreds of GPU	Can use mobile device processors
Performance	Can deal with complicated and various assignment	Can deal with some easy assignment
Arrangement	The deploy needs large amount of basic facility	Easy to deploy in limited resources environment
Training	The training may need several months	Can be trained in one week

Large-scale language modeling (LLM) offers several advantages. First, LLMs excel in contextual understanding, accurately capturing subtle contexts, making them ideal for tasks that require deep understanding and creativity. Second, they can generate high-quality, coherent text critical for applications such as content generation, translation, and chatbots. In addition, large models stand out for their versatility, which allows them to be fine-tuned for specific tasks, leading to a wide range of applications in various natural language processing (NLP) domains. While LLMs offer several advantages, they have some significant drawbacks. First, they are resource-intensive and computationally expensive, requiring large amounts of memory and powerful hardware and power support. Second, due to the huge

amount of training data used, large models may perpetuate biases present in the data. In addition, inference is slow, adversely affecting real-time applications [10].

Small Language Models (SLMs) have several advantages. First, they are resource-efficient, requiring less computational power and memory, making them more convenient and cost-effective. Second, small models reason faster, making them suitable for real-time applications like chatbots. In addition, small models may exhibit less bias due to the smaller training data. However, small models also have some shortcomings. They need to improve more when dealing with complex contexts, which may result in less coherent generated text. In addition, for tasks that require deep language understanding and high-quality output, small models may not perform as well as large models [10].

3 How Gen AI is transforming supply chain operations

Inventory Optimization. Gen AI inventory management system adopts advanced algorithms to ensure that the enterprise's stock is maintained at the most reasonable level. These systems analyze historical sales data, considering lead times, seasonality, and market trends. By establishing probabilistic models that simulate varying scenarios of inventory demand, Gen AI inventory management systems can provide accurate product availability at the right time, minimizing the risk of stockouts [4].

Predictive Maintenance. Gen AI logistics models assist in predictive maintenance by identifying anomalies and patterns indicative of equipment failures. The models detect anomalies by analyzing factors such as temperature, vibration, and mechanical sounds, ensuring the stable operation of equipment systems. This way, expensive equipment can have a longer lifespan, ensuring punctual delivery [4].

Fraud Detection. Utilizing Generative Adversarial Networks (GANs), Gen AI is becoming a powerful tool in combating fraud. GANs consist of 2 neural networks, a generator and a discriminator, which compete against each other. The generator produces data, while the discriminator evaluates whether the generated data is authentic (diagram, arrows). This process enables GANs to create highly realistic data simulations to identify anomalies or patterns indicative of potentially fraudulent activities [4].

Supply Chain Risk Management. Gen AI, used in supply chain planning, analyzes historical data and external factors to identify vulnerabilities, significantly enhancing supply chain risk management. AI models predict potential disruptions through data analysis and risk identification, enabling companies to make informed decisions to mitigate upcoming risks, reduce exposure, and ensure operational stability [4].

Logistics Optimization. Gen AI enhances transportation efficiency in supply chains by analyzing real-time data to optimize and alter delivery routes, saving labor, resources, and time and reducing transportation costs. By processing this information, generative AI in the supply chain can generate and adjust routes in real-time. Generative AI logistics solutions are revolutionizing the transportation and delivery aspects of the supply chain [4].

Demand Forecasting. Gen AI is widely applied in demand forecasting for supply chain management. Gen AI logistics models create highly accurate demand fulfillment models by analyzing vast amounts of historical sales data, market trends, and other influencing variables through advanced algorithms. AI forecasting is crucial in determining optimal stock levels, production plans, and distribution strategies, enabling businesses to meet customer demands more precisely and efficiently [4].

Warehouse Layout Optimization. Gen AI enhances warehouse layout optimization in supply chains by analyzing multiple factors impacting operational efficiency. It dynamically adjusts layouts, sequences products based on demand, and analyzes the impact of product demand and detention time in the warehouse. Amazon fulfillment centers, for instance,

leverage AI and robotics to optimize warehouse operations. Gen AI in supply chains can identify frequently accessed items and suggest their placement closer to packing stations [4].

4 Supply chain gains benefits from Gen AI.

With reference to the case study from EY, this part analyzes the four areas of supply chain, procurement, production, and logistics [11].

4.1 Supply chain management

Demand Forecasting. Many companies use AI to analyze large historical sales datasets, market trends, and other variables to develop demand models. Gen AI can help to create optimal inventory levels, production schedules, and distribution plans to meet customer demand. A recent industry example of using Gen AI for demand forecasting is the case study of Domino's Pizza in the UK and Ireland， utilizing AI to enhance the quality of their demand forecasts, improve customer experience, and ensure timely product delivery. After the implementation, the company's forecast accuracy improved, and they continue to integrate AI and analytics technologies into their demand forecasting processes.

Production Planning. Gen AI considers customer changes, production abilities, useable resources, and the priority of orders to help with production planning and scheduling. Similar to Demand Forecasting, Gen AI can effectively reduce difficulties and improve efficiency.

Risk Management. Gen AI can be used to analyze historical data, marketing situations, climate models, and political events to notice the potential risks of the supply chain. Gen AI output risk assessment, scenario simulation, and mitigation strategies to help people lower the risks.

4.2 Production and manufacturing

Product Design. Rapidly generating and evaluating hundreds of alternative designs based on predefined standards accelerates innovation. It can be used in various fields, from designing new mechanical parts to creating more efficient, durable, or aesthetically pleasing consumer products.

Predictive Maintenance. By learning from data collected from factory workshop machines, Gen AI models can create new maintenance schedules correlated with the likelihood of equipment failures. This allows manufacturers to adjust maintenance plans only when necessary, reducing downtime and costs while extending the lifespan of the equipment.

4.3 Logistics

Global Trade Optimization. Analyze many variables, including tariffs, customs regulations, trade agreements, and transportation costs, to recommend the most efficient and cost-effective trade routes and strategies. This helps companies navigate the complex international trade network, ensuring compliance while minimizing costs'.

Logistics Network Design. Consider factors such as warehouse locations, transportation routes, and demand patterns to optimize the logistics network design for the most efficient configuration. This can shorten delivery times, reduce costs, and improve service levels. Example: United Parcel Service (UPS)'s On-Road Integrated Optimization and Navigation (ORION) system uses advanced algorithms to process the daily delivery information and optimize each driver's delivery route. According to relevant reports, ORION helps UPS save

millions of miles of delivery mileage and millions of gallons of fuel consumption on average every year.

5 Conclusion

Through a series of case studies, Gen AI has positively impacted the industrial supply chain sector. It helps companies understand customer needs, provide production and supply-demand forecasts, reduce the likelihood of risks, minimize losses, and aid in planning logistics routes and lowering transportation costs.

With recent technological advancements, generative AI has been widely applied across various industries. As technology progresses, professionals in all fields must keep up with the times. The author believes that relevant professionals should focus on learning how to use new generative AI tools to enhance productivity, reduce work time and effort, and achieve more efficient results. The era of big data and AI has arrived, and proficiency in generative AI for data processing and prediction has become a mainstream trend in job requirements. Therefore, individuals should strive to master these technologies to gain better returns.

The study uses case analysis to research Gen AI use in the industrial supply chain area. And there is something that needs to be improved while concluding. There were troubles when the author collected the case and researched because the topic of Gen AI seems novel; the cases about Gen AI are limited, and the research depth needs to be further. In the future, when more and more articles and cases appear, the research needs to be improved, and then the author can get more valuable conclusions.

References

1. Gao, Y., Guess what “industry” is? Business Weekly (2016).
2. Zukunftsprojekt Industrie. Internet Archive (2014).
3. Jasperneite, J., Was hinter Begriffen wie Industrie 4.0 steckt (2024)
4. Yandrapalli, V., Revolutionizing supply chains using power of generative ai. Int. J. Res. Publ. Rev., 4(12), 1556-1562 (2023)
5. Fosso Wamba, S., Guthrie, C., Queiroz, M. M., & Minner, S., ChatGPT and generative artificial intelligence: an exploratory study of key benefits and challenges in operations and supply chain management. Int. J. Prod. Res., 62(16), 5676-5696 (2024)
6. Griffith, E., & Metz, C., Anthropic said to be closing in on $300 million in new AI funding. N.Y. Times (2023)
7. Lanxon, N., Bass, D., & Davalos, J., A cheat sheet to AI buzzwords and their meanings. Bloomberg (2023).
8. Pasick, A., Artificial intelligence glossary: neural networks and other terms explained. N.Y. Times, 27 (2023)
9. Jovanovic, M., & Campbell, M., Compacting AI: In Search of the Small Language Model. Computer, 57(08), 96-100 (2024)
10. Chang, Y., Wang, X., Wang, J., Wu, Y., Yang, L., Zhu, K., & Xie, X., A survey on evaluation of large language models. ACM Trans. Intell. Syst. Technol., 15(3), 1-45 (2024)
11. Dutta, S., & Steinberg, G., How supply chains benefit from using generative AI (2023)