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Research on New Applications of Generative AI in the Supply Chain Field

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ABSTRACT
In the increasingly complex and uncertain global supply chain environment, the traditional supply chain management model has revealed many limitations. This study breaks through the traditional research framework and explores the potential of generative artificial intelligence in key supply chain processes. By leveraging its powerful content generation and data processing capabilities, the study deeply analyzed the complex causal relationships and potential patterns in supply chain data, effectively compensating for the shortcomings of traditional methods in complex and dynamic scenarios. This study adopts a mixed approach, including a case study of AWS, to analyze how generative artificial intelligence empowers traditional automotive enterprises. Additionally, a generative artificial intelligence prediction model based on the Generative Adversarial Network (GAN) was constructed to analyze and verify how generative artificial intelligence assists in making supply chain decisions. The results of this study not only reveal numerous new application scenarios of generative artificial intelligence, analyze the deficiencies of traditional supply chains, but also help enterprises build more resilient supply chains, reduce costs, improve efficiency, enhance competitiveness, and verify the application value of generative artificial intelligence. At the same time, it also promotes the development of supply chain management theory.

KEYWORDS
Generative AI; Traditional supply chain; Automotive supply chain; Intelligent transformation; Supply chain new scenarios

1 Introduction

In the context of digital transformation and Industry 4.0, the global market demands are constantly changing, and the problems existing in the traditional supply chain management model are becoming increasingly prominent. However, their drawbacks have not been fully recognized. On the contrary, generative artificial intelligence possesses powerful data processing and intelligent decision-making capabilities, and its application in the intelligent transformation of supply chain still has great research potential. Currently, most studies rely on empirical models, and the exploration of the application of generative artificial intelligence in supply chains is relatively superficial, with many limitations: the research perspective is scattered, and the collaborative optimization of the entire process has not been achieved; the research on data processing and intelligent decision-making mechanisms is insufficient; the industry adaptability is poor, for example, research in the automotive manufacturing field is relatively weak. In addition, there are no studies that systematically compare the differences between generative artificial intelligence and traditional supply chain models, nor have they fully explored its new application scenarios and development potential.

This study analyzed the traditional automotive supply chain based on Amazon Web Services (AWS) and constructed a supply chain decision model based on generative artificial intelligence technology. It analyzed the impact of generative artificial intelligence on the supply chain operation model from both practical and theoretical perspectives. Through multi-dimensional comparisons with traditional models, new application models were explored, implementation experiences were sought, and the application prospects in the new supply chain were envisioned. The research results will help enterprises achieve the intelligent upgrade of the supply chain and promote the high-quality development of the industry. This research has important theoretical and practical value.

2 The core technologies and characteristics of generative AI

Generative artificial intelligence is based on deep learning and natural language processing as its core technologies. The former uses deep neural networks to process serialized data, while the latter acquires contextual understanding through extensive text training. The combination of these two enables it to accurately extract key information in complex business scenarios, making it a key technology widely used in the industrial sector. It has the ability to generate content and can process large amounts of non-standard and unstructured data in real time. It is also good at simulating dynamic scenarios. Moreover, it can automate previously difficult-to-achieve processes and integrate with other artificial intelligence technologies, driving enterprise digital transformation [1].

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3 Examples of the application of generative artificial intelligence in the supply chain transformation of automotive enterprises

In the entire supply chain process of automotive enterprises, generative AI demonstrates multi-dimensional enabling value. In the product design stage, it can quickly generate three-dimensional designs based on two-dimensional design drawings, helping to present the product in a three-dimensional form and significantly improving the design efficiency; during engineering design, in response to the requirements of automotive strength, aesthetics, and structural simplification, generative AI can quickly produce hundreds or thousands of structural solutions based on given targets, and push them to the verification and testing stage for iterative optimization until the optimal design is locked; in the development of autonomous driving, through a single real-road test, generative AI can extend various scenarios and samples, continuously train to promote technology implementation; in factory design, it can quickly generate drawings such as warehouse structures and shelf layouts based on design intentions and provide three-dimensional visualization, efficiently optimizing factory design and creating a digital factory; in the production and manufacturing stage, generative AI can parse massive business data in natural language and form intuitive on-site guidance and interaction; in the marketing and after-sales service fields, on the one hand, it can generate an unlimited combination product configurator, vividly presenting the product through three-dimensional animations; on the other hand, it can penetrate the after-sales maintenance process to help improve efficiency and comprehensively reshape the operation mode of the automotive supply chain[2].

3.1 Case study of aws empowering traditional automotive manufacturers

AWS stands for Amazon Web Services. It is the world's leading cloud service provider under Amazon. With a rich product line of cloud services and strong technical capabilities, it has actively made plans in the field of generative AI and has collaborated with many traditional automakers, helping them accelerate digital transformation, enhance production efficiency and market competitiveness.

(1) AWS is providing services for BMW, BYD, Xiaopeng, and LiDai, etc. around the field of autonomous driving. AWS has enhanced the training efficiency of autonomous driving models by leveraging high-performance GPU computing power in the cloud. At the same time, it has empowered the development and testing phases through generative AI technology. Its large-scale models can automatically label and identify corner cases in autonomous driving video clips, and support developers in conducting interactive dialogue queries on PB-level data, providing support for model training optimization[3].

(2) AWS utilizes generative artificial intelligence to enhance the functionality of automotive voice assistants, enabling them to create intelligent vehicles for numerous automobile manufacturers (such as NETA). Generative artificial intelligence allows for more natural language understanding and communication, enabling it to comprehend the "subtle meanings" of users. At the same time, it can also sense the user's emotions and intonation, and respond differently based on the user's emotions, providing precise personalized content recommendations and attentive services. In multiple countries, multiple languages, and various network environments, it can ensure that data connection and response time are less than 200 milliseconds.

(3) Generative AI is reshaping the marketing landscape of the automotive industry. It can generate highly realistic advertising images and videos based on user profiles, with the material effects approaching those of real-life shooting. These customized advertisements reduce the cost of enterprise advertising production, increase conversion rates, and achieve cost reduction and efficiency improvement. In the cooperation between AWS and Lotus Cars, generative AI provides 3D real-time vehicle rendering services, offering personalized customization services and immersive car-buying experiences to users. Lotus can recommend and preview new vehicle configurations through 3D displays, allowing customers to intuitively experience the visual effects of the cars, including their unique accessories, colors, and decoration kits.

4 Quantitative analysis of the gains and benefits of generative AI for supply chains

The generative artificial intelligence supply chain decision-making model based on Generative Adversarial Network (GAN) has been completed. The GAN consists of two competing neural networks. Through the adversarial training of the generator and the discriminator, this model solves the problems of sparse supply chain data and complex scenarios, and also enables the model to generate more diverse data, thereby improving the accuracy and efficiency of supply chain decision-making[4].

4.1 Data set analysis

We collect a dataset of intelligent logistics supply chain from the internet. In this dataset, we select three feature dimensions: temperature during transportation, transportation speed, and whether there is a transportation delay, to conduct decision analysis.

4.2 Code overview

The code first loads and cleans the logistics data (temperature, transportation speed, delay situation), then uses GAN to train to generate simulated data to enhance the dataset, subsequently combines the original and generated data to train a random forest classifier, and finally, based on the model, conducts delay risk assessment for different scenarios and provides decision recommendations.

4.3 Analysis of the running results

The random forest model enhanced by the Generative Adversarial Network (GAN) performs extremely well in the analysis task. It achieves an accuracy rate of 81% in accurately identifying non-delayed transportation, a recall rate of 77% in identifying delays, and an overall accuracy rate of 73%. The balanced F1 score is also quite good. The table in the following figure is part of the code's running results. Under different temperatures and transportation speeds, this model can predict the probability of delays. The probability of delays will be classified into different delay risk levels, and corresponding supply chain transportation decisions will be made according to the preset operation suggestions. For example, if the delay probability is less than 20% as usually considered, then the decision-makers can take conventional transportation supervision measures.

Table 1 Probability estimation by model

	Temperature(℃)	Waiting Time(min)	Delay Probability
Scenario 1	15	15	71.8%
Scenario 2	25	30	2.2%
Scenario 3	35	45	64.8%

4.4 Advantages and prospects of GAN in supply chain decision-making

(1) New route planning: With its powerful simulation capabilities, GAN builds realistic scenario models for new transportation routes lacking historical data, avoiding decision-making blind spots caused by data absence and providing scientific planning basis.

(2) Special cargo transportation: GAN meticulously simulates the storage changes of different temperature-sensitive goods, thereby optimizing the cold chain plan, significantly reducing the loss risks of traditional trial-and-error methods, and ensuring the quality of goods.

(3) Extreme weather response: GAN generates logistics data under rare climates, compensating for the uncertainty of human experience, making emergency plans more scientific and significantly improving the practical reliability.

5 Comparison of traditional vs generative AI-driven supply chain

5.1 Reactivity vs proactivity

Traditionally, enterprises engaged in supply chain operations were reactive in responding to changes in market demand or addressing issues in certain links (such as supply or transportation) and randomly finding emergency measures to solve problems. For instance, when there were a large number of orders to be fulfilled, they would disperse some inventory; if there was a production halt or logistics congestion in a certain area, they would immediately organize to bring in alternative sources of supply, etc. This was a state of reactive response after the fact. However, if no changes were made promptly, it could lead to losses.

With generative AI-driven supply chains, powerful algorithms and data insight capabilities are integrated, enabling precise signal capture and predictions of demand fluctuations or supply risks. For example, it can predict the early surge in regional demand caused by promotional activities starting from next month, or potential disruptions in raw material supply caused by natural disasters, and actively seek solutions. This transforms enterprises from passive responses in the past to proactive responses, making risk prevention more predictive and efficient[5].

5.2 Static planning vs dynamic optimization

The traditional supply chain planning model is a fixed framework model. Once established, it will operate automatically according to the original model without the need for manual modification of parameters or data refreshing. However, the market environment is dynamic, with new consumption trends and changes in logistics costs constantly evolving, not remaining constant. Therefore, a fixed model cannot be used for calculation. For example, in the case of static and dynamic transportation routes, they cannot remain unchanged throughout the peak season, which would lead to transportation delays as this period is quite tight.

Compared to dynamic optimization based on generative artificial intelligence, the former is more like a real-time changing intelligent system that can continuously learn from a large amount of real-time data. For instance, changes in order quantities, changes in costs, and other possible changes can all be used as the basis for optimization. It can decide at any time how to change production plans, inventory layouts, transportation routes, and other behavioral patterns to make the entire supply chain more flexible and better able to cope with market fluctuations, maintaining its own efficient operation at all times[6].

5.3 Manual analysis vs automatic generation of insights

Traditional supply chain data analysis requires a lot of effort and is prone to errors. In the face of numerous reports and various data, manual screening, classification, calculation, and model construction will consume a great deal of time and energy. Even if it is completed, it still relies on human efforts. However, human energy is limited, and in the face of massive data, it is very easy to make mistakes. For example, data entry errors or statistical logic errors may lead to results that do not match the actual situation, which will affect the next judgment.

Compared with traditional supply chains, supply chains based on generative artificial intelligence have stronger insight. By using machine learning algorithms, it can quickly absorb knowledge from a large amount of data, automatically discover hidden patterns, identify potential risks or opportunities, and within a short period of time, based on order information, logistics trajectories, market feedback, etc., extract important information such as demand forecasting, cost optimization points, supply chain bottlenecks, etc., to help enterprises make correct decisions.

5.4 General solutions vs custom strategies

Traditional supply chains are designed as universal solutions for different industries and enterprises. For instance, fast-moving consumer goods require small batches and high-frequency deliveries, while heavy industry involves large-tonnage and long-term supply. If the above processes are simply applied to another scenario without considering the specific business models, markets, and resources within the supply chain, it will fail to address the existing pain points. This may lead to suboptimal results and increase costs.

Generative AI-driven supply chains are "tailored to individuals", enabling in-depth insights into the business processes, data characteristics, pain points, and opportunities of each supply chain. For example, for e-commerce enterprises, they can be tailored to create inventory delivery linkage strategies centered on rapid response; for manufacturing enterprises, they can be created to provide collaborative solutions for flexible production and supply, thereby creating value for the supply chain.

6 Future trends of generative AI-driven supply chains

(1) Embedded applications: Humans are core controllers, with AI providing guidance. In retail apps, for example, systems proactively push products when users input needs. Generative AI helps merchants grasp customer thoughts accurately, offering recommendations that meet potential needs.

(2) Copilot mode: Focuses on human-AI collaboration. AI independently searches digital tools, relevant data and makes associations to handle complex problems. For instance, a machine learning virtual space for sales estimates and inventory of numerous stores aids planners in scheduling and inventory optimization, boosting efficiency and accuracy.

(3) Agent mode: AI handles most work, automating most enterprise business processes. It participates in supplier supply and procurement negotiations, avoiding corruption and suboptimal solutions, and making upstream-downstream cooperation rapid, fair and transparent[7].

7 Conclusion

This study explored the application of generative artificial intelligence in supply chain transformation and made significant findings. Through a case study of AWS Company in the automotive supply chain, it revealed the capabilities of generative artificial intelligence in enhancing value in multiple dimensions, improving design efficiency, achieving personalized marketing, and optimizing after-sales services. The generative AI decision model constructed based on the Generative Adversarial Network (GAN) effectively solved problems such as data sparsity and complex scenarios, and verified its practical decision-making support capabilities in dealing with complex supply chain dynamics. Through a comparative analysis with traditional supply chains, some key conclusions were drawn: generative artificial intelligence shifts the supply chain from being passive to active, from being static to dynamic optimization, from being manual to automated insight generation, and from being general to customized solutions. This transformation improves the risk-resistance ability, operational efficiency, and cost-effectiveness in supply chain operations. Theoretically, this study enriches the theory of supply chain management, constructing a clear framework for the application of generative artificial intelligence and connecting advanced artificial intelligence technologies with traditional supply chain management. From a practical perspective, it provides practical guidance: enterprises can utilize generative artificial intelligence to build an elastic supply chain that can adapt to market fluctuations, reduce wasted resource usage, and enhance competitiveness. These verified application scenarios provide a clear path for intelligent transformation, and the automotive supply chain is an example that other industries can follow.

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