

Challenges and Optimization Strategies of AI Applications in Supply Chain Management

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Abstract: As globalization accelerates and market dynamics grow increasingly complex, supply chain management has emerged as a pivotal factor in determining corporate competitiveness. Concurrently, the rapid advancement of artificial intelligence (AI) technology has positioned its application as a critical solution for addressing supply chain optimization challenges. This study reviews the challenges faced by AI applications in supply chain management, proposes feasible optimization solutions and suggestions, and aims to help enterprises correctly apply AI technology to achieve cost reduction and efficiency improvement. Research has found that AI applications currently face challenges such as high initial investment, data security, and talent shortages. To address these issues, the study focuses on three critical industries—automotive, medical, and information technology—analyzing their unique challenges and exploring targeted solutions. This article suggests that enterprises reduce investment risks, improve data access mechanisms, and strengthen talent cultivation and introduction, to promote the broader integration of artificial intelligence within supply chain operations.

Keywords: Supply Chain Optimization, Artificial Intelligence, Case Analysis.

1. Introduction

In recent years, with the continuous maturity of emerging technologies such as big data, cloud computing, Internet of Things (IoT), and blockchain, artificial intelligence technology has become a new way for enterprises to solve supply chain optimization problems. Researchers classified the artificial intelligence technologies used in supply chain management through bibliometric analysis, revealing various methods used in the research. Tatarczak believes that artificial intelligence networks (ANN), fuzzy logic, genetic algorithms (GA), data mining, and support vector machines (SVM) are key technologies that help strengthen decision-making, optimize operations, and improve overall supply chain performance [1]. Aggarwal confirmed the effectiveness of machine learning (ML) algorithms, robotic process automation (RPA), and AI-driven IoT in optimizing supply chain sustainability such as demand forecasting, process and inventory monitoring [2]. Each technology offers unique benefits and can be effectively leveraged across various aspects of supply chain operations, such as predicting demand, optimizing stock levels, and assessing potential risks within the supply network.

However, despite the abundant information provided by the research, there is still a lack of research on the challenges faced by enterprises in the face of Artificial Intelligence (AI) transformation, which leads to certain limitations in the comprehensive understanding of the current development status of AI applications. Nowadays, enterprises are facing the daunting challenge of transitioning from traditional supply chain management to intelligent supply chain management. How to fully and correctly integrate and apply AI technology to help enterprises achieve cost saving and efficiency gain in complex supply chain structures has turned into a pressing issue. This article aims to reveal the practical application status of AI technology in enterprises through an in-depth analysis of relevant literature and practical cases at home and abroad and explore the challenges and optimization suggestions it faces, providing effective theoretical support and improvement ideas for enterprises.

2. Problem Statement

2.1. Unbalancing Costs and Returns

The primary challenge that enterprises face when deploying artificial intelligence technology is the large initial capital expenditure and its uncertainty with investment returns. Specifically, the high cost of hardware procurement, software development expenses, and initial investment in data infrastructure construction all constitute significant financial burdens. Gartner's annual financial report shows that the initial investment cost of a digital supply chain management system accounts for 20% of a company's total investment and requires an additional 5% to 10% for system maintenance and updates [3]. The scale effect of these early-stage investments makes it difficult for companies to achieve significant economic benefits in the short term, thereby increasing financial pressure. In addition, due to the long investment return cycle of AI technology and the influence of various factors such as market fluctuations and technological maturity, decision-makers face significant risks when promoting AI projects. Therefore, how to effectively balance initial capital expenditures and expected investment returns has become a key issue that enterprises urgently need to address in the application of AI technology.

2.2. Data Privacy and Security Issues

The complexity and multi-party participation characteristics of supply chain management make AI systems heavily dependent on the flow and processing of large amounts of data during operation. However, there are potential privacy breaches and security risks in the collection, transmission, storage, and use of data. Especially in cases where the supply chain involves multiple stakeholders, the complexity and diversity of data flow further exacerbate the difficulty of data privacy protection. As reported by IBM's Data Breach Report, the average expense of data breaches for enterprises in 2023 reached \$4.35 million [3]. Therefore, how to effectively protect the data privacy of all parties while ensuring data security has emerged as a pressing concern that demands immediate attention in the integration of AI technology within supply chain operations.

2.3. Talent Shortage and Job Loss

The professionalism of AI technology requires enterprises to possess composite talents with both technical capabilities and management experience. However, the current shortage of such talent in the market makes it difficult for companies to quickly form teams with the necessary capabilities, which in turn affects the smooth deployment and application effectiveness of AI technology [4]. In addition, the automation integration of AI technology in the supply chain may lead to the disappearance of some traditional positions, triggering potential unemployment risks. Studies indicate a notable positive correlation between artificial intelligence and the unemployment rate, which

validates the view that the labour market is negatively affected by the development of AI [5]. How to balance technological progress and human capital optimization, and reduce the social impact caused by technological substitution, has also emerged as a significant concern that businesses must consider comprehensively in promoting AI technology.

3. Recommendations and Optimization Strategies

3.1. Cost Optimization in Automotive Industry AI Deployment

In response to the challenge of high initial investment and uncertain returns, Audi's strategy of partnering with suppliers and technology providers to share risks and costs serves as a practical solution for cost optimization in AI deployment within the automotive industry.

Audi is a highly regarded German automotive company worldwide, and the COVID-19 pandemic has intensified challenges including workforce deficits and a surge in vehicle demand [6]. Artificial intelligence is believed to help supply chain management make its operations more predictable, transparent, and fast [6]. Traditional information analysis techniques rely on historical sales data and basic statistical models, often unable to accurately capture evolving customer behaviour and the impact of external factors [7]. To address this challenge, Audi plans to further strengthen its sustainable development endeavors in the future via digital surveillance of the supply chain.

In October 2020, Audi partnered with Austrian startup Prewave to use its developed automatic speech recognition system to collect information from accessible digital platforms and social media channels for real-time screening of suppliers' sustainability risks [8]. By analyzing a large amount of publicly available information, AI systems can monitor suppliers' sustainability performance in real time and identify potential sustainability violations including ecological degradation, infringements on human rights, and unethical practices. Through the intelligent risk warning system, Audi can detect potential problems in the supply chain earlier, intervene and rectify them before they escalate, and reduce negative impacts.

By collaborating with AI application suppliers, Audi can achieve more efficient supply chain sustainability monitoring and risk management on a global scale. These measures have helped Audi optimize its supply chain risk management and enhance its competitiveness in global supply chain management. Although Audi needs to spend extra time and human resources reviewing whether suppliers meet Audi's sustainability requirements for business partners, Audi avoids the high development costs of self-developed AI systems and reduces investment risks. When faced with a large initial capital expenditure of AI applications leading to unstable investment returns, enterprises should actively explore cooperation models with suppliers and technology providers to alleviate financial pressure and decision-making risks.

3.2. Data Privacy and Security in Medical AI

When facing the inherent data privacy and security challenges in the integration of artificial intelligence within the realm of supply chain management, hospitals have established a robust access control mechanism within their Hospital Information Systems (HIS) to protect the secrecy and precision of healthcare records. This mechanism serves as a model for how enterprises can effectively address data privacy and security issues.

A HIS is the core part of modern hospital construction and development, responsible for collecting, storing, and processing various data generated in medical operations. However, in recent years, although he has made significant progress in data security, security vulnerabilities in its application areas remain the main risk factor for medical data privacy breaches [9]. To address this challenge, a hospital in India has implemented a comprehensive access control mechanism in its information system to enhance the privacy and security of medical data [9].

The establishment of an access control mechanism in hospitals involves three interrelated steps: firstly, by using various identity authentication methods such as dynamic passwords, biometric technology, etc., the accuracy of identity and the security of authentication is ensured based on the user's job responsibilities and permissions [9]. Secondly, network access control is based on traditional usernames and passwords, further binding the user's IP address, Virtual Local Area Network (VLAN), and Media Access Control (MAC) address, as well as the IP and physical interface of the connected switch, to enhance restrictions on user network access. Finally, as a defence measure against illegal network operations, operation permission management provides dynamic operation permission management by setting the permissions of servers, computers, files, and other data resources that users can access, based on the roles and schedules of the individuals utilizing the data system and location of business activities, to ensure system security and compliance [10].

The hospital's implementation of multi-level access control mechanisms ensures that sensitive data is only accessed by authorized users, greatly reducing the risk of data leakage. This case study reveals that sophisticated high-level access control technology is an important way for enterprises to eliminate data privacy and security concerns. Establishing a sophisticated access control system enables enterprises to more effectively monitor and control the flow of data, enhancing overall data protection capabilities. This optimization measure helps enterprises significantly improve the level of data privacy and security protection while complying with data protection regulations.

3.3. AI-Driven Human Resource Optimization in IT Industry

To counter the dual challenges of talent shortage and potential job loss due to AI automation, Xiaomi Technology's strategic focus on talent cultivation, introduction, and innovative human-machine collaboration models offers valuable insights for addressing talent-related issues in the IT industry.

Xiaomi Technology is a mobile Internet company with smartphones as its core and built a huge IoT ecosystem. Nowadays, many companies are gradually realizing the close relationship between artificial intelligence and talent development, which has led to an increasingly fierce demand for AI talent in the recruitment market [11]. To deepen talent reserves in the field of AI technology and meet the company's needs for future technological innovation and market competition, Xiaomi Technology has established close cooperation with many top universities. Xiaomi Technology strengthens interaction with university students and identifies outstanding talents in advance by organizing competitions and lectures in the field of AI. Xiaomi has collaborated with over 10 leading academic institutions in China, such as Tsinghua and Peking Universities, to establish post-doctoral research workstations [12]. It recruits outstanding doctoral graduates in fields including artificial intelligence and big data, accelerating the transformation of scientific research achievements into practical applications. These activities not only showcase Xiaomi's strength and influence in the AI field but also provide students with a deeper understanding of Xiaomi's corporate culture and values, thereby increasing their willingness to join Xiaomi. Secondly, Xiaomi has launched a recruitment campaign for AI talents, mainly targeting college graduates. Xiaomi Technology will provide personalized career development paths and abundant training resources for these AI talents, including internal technical exchanges and face-to-face communication opportunities with industry experts, to accelerate their growth. Xiaomi Technology attracts scarce AI talents through cooperation with universities, while also providing career development opportunities for these talents, ensuring that the company can continue to lead in future technological innovation and market competition.

In addition, as an active promoter of AI applications in the technology field, Xiaomi Technology actively explores innovative models of human-machine collaboration. They have collaborated with UiPath to develop an intelligent clearing robot driven by automation tools RPA and AI, which has increased overall financial efficiency by 15 times. The successful application of this intelligent clearing robot is not simply pursuing automation to replace human labour but is committed to freeing

employees from tedious work to do more valuable work. The comprehensive training system and innovative incentive programs within the enterprise enable its employees to effectively avoid unemployment risks through learning AI tools and improving their technical expertise.

When facing the social impact and talent market fluctuations brought by artificial intelligence, enterprises should increase their efforts in talent cultivation and introduction, and design training systems that aligning the nurturing of diverse skills with inspiring and keeping professional talents to fulfill the demands of corporate expansion. At the same time, when enterprises implement intelligent transformation, they should actively explore and promote innovative models of human-machine collaboration to ensure that artificial intelligence technology can complement human resources to improve efficiency, rather than simply replacing them to reduce human resource costs. This strategy not only improves business efficiency but also avoids the social impact of excessive layoffs by the company, reducing the risk of unemployment caused by job loss.

4. Conclusion

Although AI-driven supply chain solutions have achieved significant results, the utilization of AI in managing supply chains. faces multiple challenges such as high initial investment, data privacy and security risks, as well as talent shortages and job losses. This study conducted an in-depth analysis of multiple cases in the automotive, medical, and information technology industries, providing practical and feasible optimization suggestions and improvement ideas for enterprises. To ensure the widespread adoption and effective implementation of AI applications, enterprises should focus on three key areas: reducing investment risks through cooperative models, addressing data privacy and security concerns through the implementation of strong access management measures and adhering to regulations, and tackling talent shortages and unemployment by investing in talent development and promoting human-machine collaboration rather than solely relying on automation.

Against the backdrop of artificial intelligence becoming a hot topic in today's society, many enterprises are accelerating the transformation of intelligent supply chains to seize the opportunities of the times. When facing the decision of intelligent transformation, enterprises should evaluate their situation more carefully and comprehensively. Enterprises need to objectively judge whether their business model, organizational structure, and resource allocation are suitable for the direction of intelligent transformation, and avoid blindly following the trend. The intelligent transformation is a complex and long-term process. When considering intelligent transformation, enterprises should undertake a thorough cost-effectiveness assessment to appraise the prospective advantages and dangers of technology. In addition, enterprises should not only consider technological and economic benefits when making decisions but also take into account social impact and sustainable development, fostering the sound growth of AI in supply chain administration.

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