Research on the Impact of AI Technology Development on the Transformation of Logistics Management in the Tobacco Industry - Take China National Tobacco Corporation (CNTC) as a Case

Mingzheng Du *

University of Nottingham Ningbo China, Ningbo, China

* Corresponding Author Email: hmymd1@nottingham.edu.cn

Abstract. The tobacco industry is a significant component of China's economy, contributing approximately 7% to 10% of the country's GDP in 2024 through tax revenue and profits amounting to 1.6008 trillion yuan. However, the traditional logistics system faces major challenges in meeting modern operational demands. This study explores the theoretical basis of applying artificial intelligence in supply chain management, with a focus on the application of large language models (LLM) and genetic algorithms (GA) in the tobacco logistics system managed by the China National Tobacco Corporation (CNTC), which adopts a centralized three-level organizational structure. The digital transformation of China's tobacco industry began in 2000, progressing through modernization, informatization, and intelligence stages, supported by technologies such as the Internet of Things (IoT) and Radio Frequency Identification (RFID). The research findings indicate that AI technologies have significantly enhanced tobacco logistics through multiple mechanisms: LLM has boosted warehouse operation efficiency; GA has optimized transportation routes; the hierarchical organizational structure has helped address the issue of information silos; and the integration with complementary technologies has amplified the operational improvement effects. The study concludes that AI technologies have positively impacted the digital transformation of China's tobacco logistics by enhancing data processing capabilities, organizational optimization, and technological integration.

Keywords: Artificial intelligence, digital transformation, the tobacco industry's logistics.

1. Introduction

As a conventional sector within the light industry, the tobacco industry has long played a significant role in promoting national economic growth and social development. According to data released by the China Tobacco Corporation, in 2024, the total tax revenue and profits generated by China's tobacco industry reached 1.6008 trillion RMB, accounting for roughly 7% to 10% of the country's annual GDP [1]. As an essential operational component of the industry, tobacco logistics plays a crucial role in ensuring the sector's growth and stability. In recent years, however, the rapid advancement of artificial intelligence (AI) technologies has increasingly exposed the limitations of conventional tobacco logistics systems, which struggle to meet contemporary operational demands. Outdated logistical approaches suffer from issues including inefficiency, high error rates, and substantial labor expenses when compared to cutting-edge AI-driven solutions [2]. Considering rapid technological progress, the tobacco industry must actively investigate how AI can be integrated into logistics processes to support the sustainable and structured advancement of China's tobacco sector.

2. Theoretical background

2.1. AI and relevant algorithms in logistics

The conceptual foundations of artificial intelligence (AI) trace back to the mid-twentieth century, with its formal establishment as a scientific discipline around 1950. As a pivotal branch of computer science, AI seeks to design and develop computational systems capable of replicating core human

cognitive functions—including perception, learning, reasoning, and decision-making [3]. With ongoing technological maturation, its application has become increasingly pervasive within supply chain management, offering transformative potential for operational optimization. A prominent technical paradigm involves training AI systems using large language models (LLMs), which are built upon statistical and neural architectures. These models process textual data segmented into discrete units known as 'tokens', enabling sophisticated information retrieval and the generation of contextually coherent responses to user prompts [4]. Within the tobacco industry, such models can enhance warehouse management through automated reporting and real-time data monitoring, thereby reducing losses during storage and improving inventory accuracy.

Genetic algorithms (GA) represent another significant contribution to the AI toolkit. As a stochastic search and optimization technique inspired by Darwin's theory of natural evolution, genetic algorithms are particularly effective in addressing complex optimization problems within dynamic environments [5]. GA exhibits strong adaptability and effective problem-solving capabilities in addressing dynamic and complex optimization challenges and is widely applicable to key logistical tasks such as path optimization in warehouse operations.

2.2. The logistics system of tobacco

Tobacco products, as a specialized industrial commodity, impose exceptionally stringent requirements on the logistics system. During raw material transportation, enterprises depend on sophisticated distribution network to minimize losses in transit. In storage phases, modern warehousing facilities are essential for precisely controlling environmental parameters such as temperature and humidity, thereby effectively preventing raw material deterioration and ensuring consistent product quality. The distribution of finished tobacco products is equally critical, requiring scientifically designed scheduling mechanisms to efficiently allocate goods from manufacturing sites to retail endpoints, thereby sustaining market supply equilibrium. Operating under China's distinctive state tobacco monopoly system, the corresponding logistics framework is centrally managed and coordinated by CNTC. This integrated system encompasses the entire supply chain—from tobacco leaf procurement and distribution, through manufacturing and processing, to commercial delivery—ensuring efficient, secure, and standardized circulation of tobacco products across the country [6]. At the provincial level, tobacco companies function as central nodes within a vertically integrated industry-commerce management system. Under this framework, industrial enterprises are responsible for production operations, while commercial enterprises manage distribution and sales activities, ensuring coordinated execution across the supply chain. As of the most recent data, the CNTC oversees 50 core provincial-level tobacco companies, comprising 33 commercial enterprises and 17 industrial enterprises [7]. At the grassroots level, prefectural units are responsible for fundamental logistics operations. Following transportation from industrial enterprises to prefectural companies, tobacco products are centrally stored, sorted, and distributed through prefectural logistics centers. These goods are then delivered to retail outlets across respective jurisdictions before reaching end consumers. This end-to-end, vertically integrated process establishes a clear three-tier organizational structure comprising national, provincial, and prefectural levels that enhances operational efficiency and ensures the effective implementation of the tobacco monopoly system.

2.3. The digital transformation of China’s Tobacco Logistics

Digital transformation represents a foundational organizational shift, propelled by the strategic deployment of digital technologies and the systematic integration of core resources and capabilities. This process aims to fundamentally restructure entities—whether organizations, business networks, industries, or societies—by redefining value propositions and generating sustainable benefits for all stakeholders [8]. China Tobacco embarked on its digital transformation at a relatively early stage. Beginning around 2000, the corporation has successfully navigated the transition from traditional logistics toward modernization, informatization, and intelligent operations [9]. This evolution aligns with broader national strategic directives. Notably, China's "14th Five-Year Plan" provides explicit

guidance for digital economy development, emphasizing the deep integration of digital technologies across all industrial sectors to stimulate new growth dynamics [10]. Technologically, China Tobacco has carried out digital practices throughout the entire production chain, achieving automation of production processes through the Internet of Things and big data technologies. At the same time, 5G technology and radio frequency identification technology (RFID) has been introduced to build intelligent storage functions, ensuring the efficient operation of the logistics process [11].

3. Conceptual Model and Methodology

3.1. Conceptual Model

Based on the theoretical review and arguments presented in the previous sections, this study aims to develop a conceptual model that explores the influence of AI technology development on the process of logistics management transformation in the tobacco industry in the context of CNTC. The model integrates concepts from the literature and proposes hypothesized relationships between these concepts.

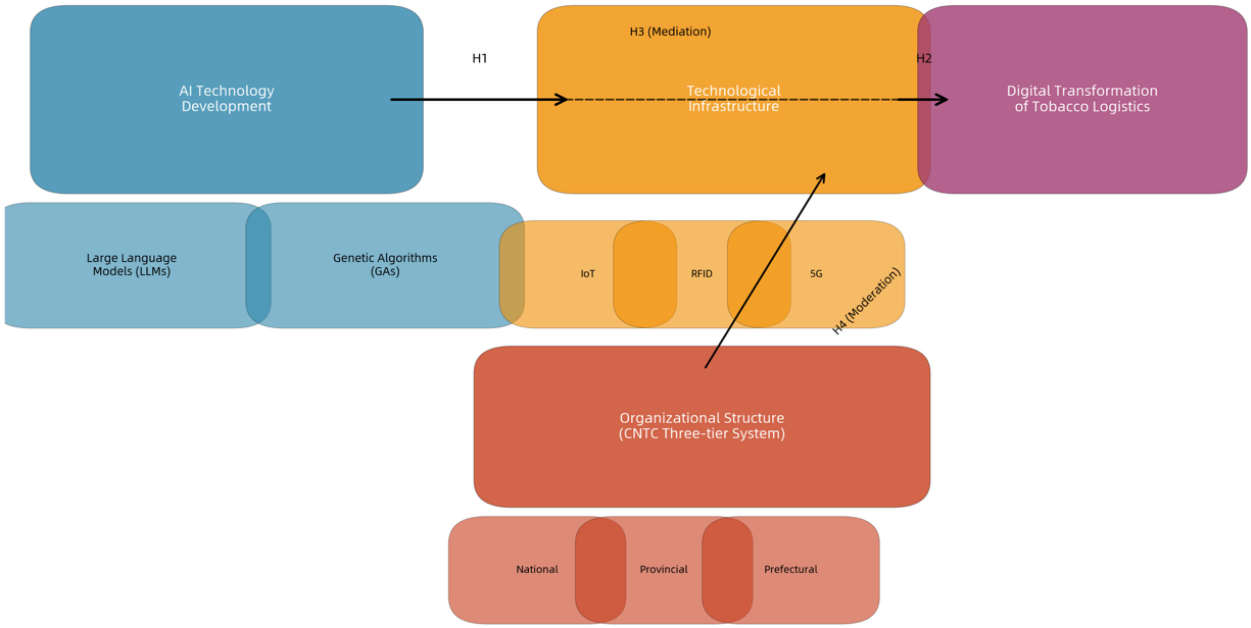


Figure 1. Conceptual Model of AI Technology Impact on Tobacco Logistics Transformation

As shown in Figure 1, the model assumes that AI technology development is the independent variable, which affects the digital transformation of tobacco logistics as the dependent variable. Specifically, AI technology development is measured using LLMs in the processing of intelligent data and decision-making, and the use of GAs in optimizing logistics operations (e.g., routes and warehouses). The CNTC organization structure is measured by its three-tier structure at the national, provincial, and prefectural levels, which may facilitate or hinder the use of AI technologies. Furthermore, the technological infrastructure level is measured using IoT, RFID, and 5G networks, which may mediate the impact of AI development on the digital transformation of tobacco logistics.

In summary, the relationships among the variables in the model can be summarized as follows: (1) AI technology development affects the digital transformation of tobacco logistics; (2) AI technology development affects the technological infrastructure level, which in turn affects the digital transformation of tobacco logistics; (3) the organization structure of CNTC may moderate the direct impact of AI technology development on the digital transformation of tobacco logistics.

3.2. Methodology based on the model

This study employs a mixed research methodology grounded in the theoretical foundations established in the literature review. The research design is informed by the conceptual developments

in artificial intelligence applications within supply chain management, specifically addressing the integration of AI technologies in tobacco logistics systems as outlined in the theoretical background.

Building upon the established theoretical framework of AI technology development, this study operationalizes two primary AI dimensions identified in the literature: Large Language Models (LLMs) for intelligent data processing and decision-making, and Genetic Algorithms (GA) for logistics optimization, as conceptualized in Section 2.1. The research methodology aligns with the digital transformation framework of China's tobacco logistics presented in Section 2.3.

4. Results and Analysis

4.1. LLM and GA

Within this analytical framework, AI technology demonstrates substantial potential for enhancing digital transformation within tobacco industry logistics. Empirical evidence indicates that applying large language models (LLMs) in warehouse management contributes significantly to reducing losses associated with tobacco storage. Research findings reveal that LLMs implementation can decrease equipment downtime by approximately 34.25% and reduce inventory shortages by approximately 40% [12], representing notable operational improvement. Furthermore, studies provide compelling evidence that LLMs substantially streamline warehouse delivery planning processes and shorten decision-making cycles for storage operations, resulting in measurable gains in logistics efficiency [13]. These technological advancements also optimize production and identification processes within warehouse environments, enabling warehouses to operate closer to their theoretical capacity while simultaneously reducing production costs [14]. The cumulative effect of these improvements suggests that AI technologies serve as critical enablers for comprehensive digital transformation across tobacco logistics networks.

From the analytical perspective of genetic algorithms (GA), their application demonstrates significant potential in optimizing tobacco logistics routing—a domain characterized by substantial combinatorial complexity. By leveraging the robust optimization capabilities of GA, inter-provincial transportation routes can be systematically reconfigured to enhance planning effectiveness and adapt to localized operational conditions. This approach contributes measurably to reduced transit durations and improved delivery reliability. Furthermore, the implementation of GA facilitates more efficient allocation of transportation resources, leading to optimized vehicle utilization rates. Through this methodological framework, idle time can be significantly minimized, while transportation costs are concurrently reduced. These operational improvements substantiate the value of genetic algorithms as a computational tool for addressing complex routing challenges within tobacco logistics networks.

4.2. The positive impact of applying AI to logistics from the perspective of organizational structure

Organizationally, China Tobacco operates through a three-tier management system, spanning encompassing national, provincial, and municipal/county levels, while this hierarchical model, established within a monopoly system, has likely enhanced the industry’s operational efficiency and generally supported the digitalization process, it still faces several challenges. A particularly pressing issue involves persistent information silos resulting from the considerable autonomy exercised at the provincial level. This autonomy has led to divergent production models across regions and the absence of unified information-sharing platforms, ultimately impairing inter-provincial data exchange and integration [15]. From this perspective, AI technology seems to offer a potentially powerful solution to these challenges. As discussed in Sections 4.1 and 4.2, LLM and GA within the AI framework appear to show considerable potential for data integration and solving complex problems. This suggests that the strategic application of AI could help build a unified, intelligent information platform, promoting cross-level and cross-regional data collaboration.

At the national level, China Tobacco's centralized governance structure provides an institutional advantage for rapid, large-scale AI deployment, thereby accelerating the broader digital

transformation process. At the provincial level, AI seems capable of assisting various regions with data matching and standardization, leading to more efficient integration based on local characteristics and enhancing collaborative efforts. For municipal and county operations, breaking down information barriers would not only facilitate deeper collaboration between suppliers and marketers, reducing friction caused by information asymmetry, but also significantly improve operational efficiency and response times at the grassroots level.

4.3. The positive impact of applying AI to logistics from the perspective of technological infrastructure

Moreover, AI technology demonstrates its full transformative potential when deployed in synergistic combination with complementary digital technologies—an approach that has yielded documented success across multiple industrial sectors. In fresh food logistics, for instance, research confirms that the deep integration of AI with Internet of Things (IoT) systems significantly enhances transportation efficiency and accelerates delivery processes [16]. Similarly, in the tobacco sector, the collaborative application of AI with enabling technologies such as RFID and industrial robots offers considerable transformative potential. In 2020, China initiated pilot applications integrating AI with RFID and robotic systems, achieving significant improvements in material warehousing efficiency through automated and precision-driven operations [17]. These implementations confirm that AI does not function optimally as a standalone solution, but rather achieves maximum impact when embedded within mature technological ecosystems where it can amplify existing capabilities and generate compounded operational improvements.

5. Conclusion

This study demonstrates the impact of AI technology on the digital transformation of China's tobacco logistics, mainly analyzing three aspects: AI technology itself, the organizational structure of China's tobacco industry, and its technological foundation. In terms of AI technology, both LLM and GA have shown their powerful data processing capabilities, playing a significant role in improving warehouse efficiency and optimizing transportation routes. Regarding the organizational structure, AI technology can help optimize the problem of information silos. At the same time, the interaction between AI and other technologies also holds great potential for optimizing the digital transformation of the tobacco industry.

There are still many issues to be addressed in the research. The focus of this study is on the tobacco sales end, and no exploration has been made on the optimization direction of AI technology in tobacco planting. As the foundation of the tobacco industry, tobacco planting may benefit from the positive assistance of AI technology. In future research, the exploration of tobacco agriculture may become a key point. In addition, with the further development of AI technology, more effective and high-quality data can also be introduced into the research.

References

[1] China National Tobacco Corporation (2025). In 2024, the tobacco industry achieved record-high total tax revenue and fiscal revenue [online]. Available at: http://jl.tobacco.gov.cn/portal/xwzx/hyxw/2025/3/9ca16cd07ca84d94be2100e2301469c6.htm.

[2] Li, B.-H., Hou, B.-C., Yu, W.-T., Lu, X.-B., & Yang, C.-W. (2017). Applications of artificial intelligence in intelligent manufacturing: A review. Frontiers of Information Technology & Electronic Engineering, *18*(1), 86 – 96. https://doi.org/10.1631/FITEE.1601885.

[3] Chumakov E. (2025). History and definitions of AI. European Psychiatry.68 (S1): S61 - S61. doi: 10.1192/j.eurpsy.2025.238.

[4] Cerf, V. G. (2023). Large language models. Communications of the ACM, 66 (8), 7. https://doi.org/10.1145/3606337.

[5] Vikhar, P. A. (2016). Evolutionary algorithms: A critical review and its future prospects. In 2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication (pp. 261-264). IEEE. https://doi.org/10.1109/ICGTSPICC.2016.7955260.

[6] Fan, W. and Feng, W. (2017). Research on routing optimization problem of cigarette logistics vehicle with time window based on hybrid genetic algorithm. Advances in Computer Science Research, 61, 658 – 668.

[7] China National Tobacco Corporation (2025). Overview of the Chinese Tobacco Industry [online]. Available at: http://www.tobacco.gov.cn/gjyc/gkxx/202504/ee9021f716d44d859edc752965997f63.shtml.

[8] Gong, C., & Ribiere, V. (2021). Developing a unified definition of digital transformation. Technovation, 102, 102217. https://doi.org/10.1016/j.technovation.2020.102217.

[9] Wang, F. (2023). Research on influencing factors of digital empowerment in tobacco logistics. China Storage & Transport Magazine, *2022*(6), 119 – 120. https://doi.org/10.16301/j.cnki.cn12 - 1204/f.2023.05.016.

[10] National Development and Reform Commission. (2022). The 14th five-year plan for economic and social development and the long-range objectives through the year 2035 of the People's Republic of China. https://www.ndrc.gov.cn/fggz/fzzlgh/gjjzxgh/202203/t20220325_1320207.html.

[11] Zhang, Z. (2025). Research on digital transformation of tobacco enterprises based on the background of digital economy. *Frontier of Economics Research, 8*(2), 1 – 3. https://doi.org/10.12238/cj.v8i2.2287.

[12] Bera, B., Malani, H. A. K., & Zaveri, Y. (2025). The logistics AI revolution: From traditional operations to smart optimization. International Research Journal of Modernization in Engineering Technology and Science, 7 (3). https://www.doi.org/10.56726/IRJMETS70419.

[13] Kmiecik M (2025), "Creating a genetic algorithm for third-party logistics' warehouse delivery scheduling via a large language model". Journal of Modelling in Management, Vol. 20 No. 4 pp. 1138 – 1162, doi: https://doi.org/10.1108/JM2 - 06 - 2024 - 0192.

[14] Shen, X., Zhang, Y., Tang, Y., Qin, Y., Liu, N., & Yi, Z. (2022). A study on the impact of digital tobacco logistics on tobacco supply chain performance: taking the tobacco industry in Guangxi as an example. Industrial Management & Data Systems, *122* (6), 1416 – 1452. https://doi.org/10.1108/IMDS - 05 - 2021 - 0270.

[15] Yang, P., Zhu, Z.-T., Zhu, L., & Wang, X. (2023). Research on the digital transformation of the tobacco industry in the new era. Theory Research, 312 – 314. DOI: 10.12253/j.issn.2096 - 3661.2023.11.102.

[16] Vilas-Boas, J. L., Rodrigues, J. P. C., & Alberti, A. M. (2023). Convergence of Distributed Ledger Technologies with Digital Twins, IoT, and AI for fresh food logistics: Challenges and opportunities. Journal of Industrial Information Integration, 31, 100393. https://doi.org/10.1016/j.jii.2022.100393.

[17] Xu, T. (2020). AI-enabled intelligent industrial robots and their application in warehousing and logistics. Modern Manufacturing Modern Logistics, 44 – 45.