

Research on the Pathways of Empowering New-type Industrialization with Artificial Intelligence

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ABSTRACT

As the core driving force behind the new round of technological revolution and industrial transformation, artificial intelligence (AI) is profoundly empowering the process of new-type industrialization, propelling the manufacturing sector towards intelligent, high-end, and green transformation. Based on the techno-economic paradigm theory, this paper systematically analyzes the internal mechanisms, practical progress, and challenges associated with AI-enabled new-type industrialization. Research indicates that China has achieved notable application outcomes in core industrial processes such as intelligent production scheduling, predictive maintenance, and visual inspection. However, structural bottlenecks persist, including constraints on key core technologies, difficulties in implementing AI in industrial scenarios, a shortage of high-end interdisciplinary talent, and a lack of standardized norms and legal safeguards. To address these issues, this paper proposes strengthening foundational research and breakthroughs in core technologies, expanding typical industrial application scenarios, constructing a multi-tiered talent cultivation system for AI, and accelerating the development of standards and specialized legislation. These measures aim to systematically advance the deep integration of AI with new-type industrialization, providing theoretical foundations and pathway references for building a modern industrial system and realizing the strategy of making China a manufacturing powerhouse.

KEYWORDS

Artificial intelligence; Manufacturing industry; New-type industrialization; And deep integration

1. INTRODUCTION

On November 21, 2024, the blue books titled World Internet Development Report 2024 and China Internet Development Report 2024 were released at the 2024 World Internet Conference Wuzhen Summit. According to the China Internet Development Report 2024, nearly 10,000 digital workshops and smart factories have been established nationwide, demonstrating the deep integration of artificial intelligence (AI) with the manufacturing industry. As a new round of global technological revolution and industrial transformation advances, the deep integration of AI and manufacturing has become the core driving force behind new-type industrialization, with fostering corporate dynamism and promoting integrated development emerging as vital forces propelling this transformation. Advancing AI-enabled new-type industrialization represents a critical technological pathway for accelerating the development of China into a manufacturing powerhouse and cultivating new competitive advantages in its industrial sector [1]. China has explicitly prioritized intelligent manufacturing as its main focus, aiming to expedite smart upgrades in key industries, foster new-quality productive forces, and facilitate the transition from a large manufacturing nation to a strong manufacturing power. While the application of AI in manufacturing has yielded significant benefits—such as optimizing processes, reducing energy consumption, and enhancing production efficiency—its full-scale empowerment still

faces multiple bottlenecks in areas including technology, security, talent, and standardization. These challenges encompass issues such as insufficient computing power supply, the need for intelligent upgrades across entire industrial and ecological chains, limited application scenarios, and a scarcity of skilled professionals.

New-type industrialization represents a novel stage of industrialization characterized by digital technology empowerment, deep industrial integration, and the pursuit of high-quality development, with its driving forces shaped by the interplay of multiple factors. The 2024 Government Work Report proposed deepening research, development, and application of big data, artificial intelligence (AI), and other technologies, while launching an "AI+" initiative. This marked the first inclusion of "AI+" in a Government Work Report. In the industrial sector, AI serves as a critical variable in advancing new-type industrialization. As the core driving force behind this transformation, AI has emerged as a pivotal power, leveraging its robust capabilities in data processing, intelligent decision-making, and automated control to spearhead profound changes in industrial production methods. Amidst the wave of new-type industrialization, AI technology demonstrates powerful leading and driving effects through its unique advantages [2], not only revolutionizing traditional production modes but also opening up entirely new pathways and possibilities for achieving sustainable and high-quality development.

2. STATEMENT OF THE PROBLEM

Currently, academic research on new-type industrialization primarily focuses on four key areas.

First, at the level of connotative characteristics, existing studies have elaborated on the new connotations and features that distinguish new-type industrialization from traditional industrialization, based on its practical foundations and the contemporary context in which it was proposed [3]. Second, in terms of system construction, research has analyzed how to build a new-type industrialization system in the new era from perspectives such as the integration of digital and real economies [4], digital transformation [5], and new-quality productive forces [6-7]. Preliminary explorations have also been conducted into the interactive relationship between new-type industrialization and urbanization [8-9]. Third, regarding quantitative evaluation, studies have measured the development level of new-type industrialization by constructing comprehensive indicator systems, revealing regional disparities and spatial distributions in its current stage [10-11]. Finally, at the level of practical pathways, research has explored implementation strategies for new-type industrialization by analyzing its characteristics and underlying logic, while addressing real-world challenges encountered during its advancement [12-14].

Overall, existing research has conducted valuable explorations of new-type industrialization from multiple dimensions, with some studies offering preliminary discussions on how digitalization influences this process. Against the backdrop of accelerated evolution in a new round of technological revolution and industrial transformation, general-purpose technologies typified by artificial intelligence (AI) have emerged as critical engines driving the transition between old and new growth drivers in the economy and key pillars for establishing technological competitive advantages. This is attributed to their characteristics of broad permeability, outstanding innovation, significant empowerment capabilities, and strong self-generative properties [15]. This paper systematically reviews and analyzes the fundamental driving forces behind industrialization, explores the mechanisms through which AI empowers new-type industrialization based on its techno-economic paradigm features, and further summarizes the major achievements and existing constraints in AI-enabled new-type industrialization at the current stage. Building on this analysis, it proposes practical pathways to accelerate the integration of AI into new-type industrialization.

3. ACHIEVEMENTS IN AI-EMPOWERED NEW-TYPE INDUSTRIALIZATION

In the practical process of AI-empowered new-type industrialization, China's manufacturing enterprises have achieved multiple notable outcomes. Zhongtian Steel has built an enterprise-level intelligent scheduling hub based on Baidu Smart Cloud's Qianfan Large Model, enabling intelligent and dynamically optimized production scheduling while significantly enhancing the responsiveness and resource utilization efficiency of its production systems. Hebei Iron & Steel has implemented predictive maintenance for key equipment by introducing large model technologies, effectively reducing operational and maintenance costs by 5% while improving operational efficiency by 10%. Brilliance BMW has successfully applied an AI-powered visual inspection system to quality control processes for core automotive components, not only substantially improving inspection accuracy but also driving an overall production efficiency increase of nearly 30%. These practices demonstrate that AI technologies are being deeply integrated into core industrial manufacturing processes, providing robust technical support and transformation pathways to advance new-type industrialization.

The intelligent upgrading of high-end equipment integrates AI algorithms, big data analytics, visual recognition, voice interaction, and other technologies to drive greater intelligence in advanced manufacturing equipment such as CNC machine tools, industrial robots, industrial control systems, and sensing and detection devices [16]. Taking the Engineering Innovation Research Institute of China Construction Fifth Engineering Division as an example, its developed intelligent welding robot for bridge steel mesh, leveraging artificial intelligence and automation technologies, achieves fully automated welding operations throughout the entire process. This has significantly enhanced welding efficiency and quality consistency, fully demonstrating the critical role of intelligent equipment in driving the transformation and upgrading of traditional construction industries and establishing new competitive advantages in new-type industrialization. In another collaborative effort, Huawei Cloud and Leju Robot jointly launched the first humanoid robot integrated with Pangu Embodied Intelligence Large Model, named "Kuafu." Empowered by large model technologies, this robot possesses multimodal interaction capabilities, including natural language understanding, visual perception, and tactile feedback, enabling it to autonomously perform diverse industrial tasks such as barcode scanning and packaging, soldering processes, and logistics handling. This showcases the pivotal role of AI technologies in advancing the intelligence of high-end equipment and reshaping new competitive advantages in industrial sectors.

4. CONSTRAINTS ON AI-EMPOWERED NEW-TYPE INDUSTRIALIZATION

As the core driving force behind the new round of industrial transformation, artificial intelligence (AI) technology will further unlock societal growth potential and inject new momentum into the process of new-type industrialization. However, certain constraints currently hinder the full realization of AI-empowered new-type industrialization.

4.1. Breakthroughs in Core AI Technologies Are Urgently Needed

There is an insufficient reserve of key hardware and open-source software for artificial intelligence (AI), leading to critical "chokepoint" issues in core technologies. China urgently needs breakthroughs in foundational and shared AI technologies, particularly with evident shortcomings in chip research and development (R&D) and algorithm innovation. On one hand, core technologies for chip development remain inadequate. China's self-sufficiency in chips is relatively low, with heavy reliance on imports for critical products. Significant technological breakthroughs have yet to be achieved in areas such as AI chips and quantum computing, resulting in relatively lagging innovation

in hardware-related scientific and technological fields. In the realm of AI chips, among the top ten global patent applicants, five are U.S. companies—Intel, IBM, NVIDIA, Google, and Xilinx—while only Baidu from China ranks among them. On the other hand, there is a lack of framework-level algorithm development capabilities. China's domestic AI development ecosystem is still in its infancy, with insufficient deep integration among intelligent applications, development frameworks, system software, and intelligent chips, failing to form a competitive technological system. Key core technologies, such as natural language processing, computer vision, and machine learning, remain constrained by external dependencies, reflecting weak independent R&D capabilities. The open-source software ecosystem is immature, lacking platforms for technological accumulation and sharing, which undermines efficiency and flexibility in AI application development. Furthermore, China faces challenges in foundational theoretical research in AI [17]. Compared to developed countries, there remains a noticeable gap in foundational theories, frontier technological innovation, core algorithm development, critical equipment, and high-end chips within the AI field.

4.2. Significant Obstacles Impede The Rollout of AI In Industrial Application Scenarios

On one hand, the penetration rate of artificial intelligence (AI) in China's industrial sector remains relatively low, leaving substantial room for improvement compared to developed countries in Europe and the United States. There is a gap in the prevalence of AI applications between top-tier Chinese manufacturing enterprises and their counterparts in Europe and the United States. Strengthening the promotion of application scenarios can accelerate the process of AI empowering new-type industrialization. According to data released by Capgemini, the AI application rate among Chinese manufacturing enterprises is merely 11%, significantly lower than that in Europe (51%), Japan (30%), the United States (28%), and South Korea (25%) [18]. Although AI has been explored in numerous industrial scenarios, there are still no clearly cost-effective ones. The practical implementation of AI in industrial scenarios continues to face numerous challenges. On the other hand, industrial scenarios are highly fragmented, with dispersed data and severe cross-industry barriers, posing significant difficulties for the development and training of large models. Meanwhile, the integrated application of industrial large models is constrained by factors such as poor data quality, insufficient annotation resources, high training costs, and a lack of domain-specific knowledge, resulting in low model reliability and high implementation thresholds. Additionally, existing AI application demonstrations are predominantly concentrated among large enterprises. Most small and medium-sized enterprises (SMEs) are limited by weak digital foundations, scarce financial and data resources, and the absence of economically viable large-scale generative AI scenarios. Consequently, overall AI applications remain primarily pilot-based, lacking sufficient appeal for widespread demonstration and promotion.

4.3. The Field of Artificial Intelligence Is Confronted With A Significant Talent Shortage, Along With An Unbalanced And Unreasonable Talent Composition Structure

With the rapid evolution of artificial intelligence (AI) technologies, the demand for innovative and interdisciplinary talent in the AI job market is further expanding. However, the current state of China's AI talent pool is far from optimistic, severely constraining the empowering effects of AI. On one hand, there is a scarcity of high-end interdisciplinary talent in the AI field, with a shortage of high-level professionals. China lacks enough high-caliber AI experts, particularly those capable of driving source innovation. At present, due to the still-developing AI talent cultivation system and the lengthy training cycles involved, there is a critical shortage of AI professionals, especially high-end interdisciplinary talent. On the other hand, the talent structure in the AI field is irrational. There is a deficiency in talent supply across various functional roles within the AI industry, with particularly acute shortages in algorithm development and applied research positions. According to calculations by CCID Consulting, among the talent demands in China's AI sub-sectors, machine learning accounts

for the largest share, reaching 45.6%. Additionally, the demand for talent in intelligent robotics, intelligent chips, computer vision, and intelligent decision-making all exceeds 5.0%. Therefore, there is an urgent need to strengthen talent cultivation in the AI field.

4.4. A Lack Exists in the Standard Systems And Legal Frameworks That Are Adapted to the Evolution of Artificial Intelligence

The lack of standard systems and laws and regulations that are adapted to the development of artificial intelligence (AI) has emerged as a significant institutional bottleneck restricting the in-depth advancement of new-type industrialization. The widespread application of AI has not only reshaped the industrial distribution pattern and spatial correlation structure but also significantly propelled the process of industrial integration. However, at present, China has not yet established a unified standard and normative system during the development of AI technology, resulting in insufficient interoperability and compatibility among different technical systems. There is a certain degree of disconnection between AI technology and low- and medium-end industries, which has notably increased the difficulty of technological application in various industries, especially traditional sectors, and limited their large-scale promotion and in-depth integration. Moreover, legislative work related to AI is relatively lagging, and a systematic legal support system has not yet been formed. Taking the field of autonomous driving as an example, the absence of specialized national-level legislation has severely hindered the standardized development and commercial implementation in this area. Given the typical characteristics of rapid iteration, wide coverage, and diverse scenarios of AI technology, there is an urgent need to construct a corresponding standard system and legal and regulatory framework to better promote the process of AI empowering new-type industrialization.

5. THE IMPLEMENTATION PATHWAYS FOR ARTIFICIAL INTELLIGENCE TO EMPOWER NEW-TYPE INDUSTRIALIZATION

As a general-purpose technology of the Fourth Industrial Revolution, artificial intelligence (AI) is being deeply integrated with the manufacturing industry and actively empowering the new type of industrialization, providing robust material guarantees and technological support for the intelligent transformation of the manufacturing sector and the high-quality development of the economy. This paper proposes practical pathways to accelerate the advancement of AI in empowering the new type of industrialization from the following four aspects.

5.1. Accelerate Technological Breakthroughs And Cultivate Key Core Technologies That Enable Artificial Intelligence To Empower The New Type of Industrialization

New-type industrialization is an industrialization driven by innovation, with the key lying in achieving high-level self-reliance and self-improvement in science and technology. Guided by scientific and technological innovation, efforts should be made to strengthen the research and breakthrough of key core technologies, foster general-purpose technologies represented by artificial intelligence (AI), actively adapt to and lead the new round of scientific and technological revolution and industrial transformation, and empower new-type industrialization. Firstly, it is essential to promote breakthrough development in core AI technologies. Accelerate the achievement of disruptive scientific research outcomes in basic AI theories, original and optimized technologies, as well as common application technologies. Further integrate the scientific and technological innovation resources of enterprises, enhance the in-depth integration of industry, academia, and research led by enterprises, establish a technology research and breakthrough model that combines categorical advancement with vertical and horizontal integration, and expedite the construction and improvement of an independent innovation system for new-type industrialization. Leverage the advantages of China's large market and complete industrial chain to expedite the establishment of a foundational

ecosystem for intelligent computing and development frameworks, thereby overcoming the development challenges in areas such as intelligent chip development and open-source development frameworks in China [19]. Secondly, it is crucial to expedite the creation of an innovation ecosystem that integrates AI technologies with manufacturing technologies. Building on the solid foundation of core AI technologies, accelerate the deep integration of AI with the manufacturing industry, promote the in-depth incorporation of AI technologies into the entire manufacturing process, establish a high-level collaborative advancement system for future manufacturing industries and an innovation ecosystem for technology integration, and drive the research and development of applicable technologies in the industrial field such as AI, 5G, and digital twins, yielding a batch of original and forward-looking achievements.

5.2. Accelerate Scenario Development To Expedite The Application of Artificial Intelligence Technologies in the Industrial Sector

The demonstrative role of typical application scenarios in new-type industrialization serves as a crucial benchmark for evaluating the effectiveness of high-quality development in the manufacturing industry and is instrumental in fostering the emergence of new industries, business formats, and models. Therefore, it is imperative to expedite the development of industrial application scenarios, create conditions for the accelerated deployment of artificial intelligence (AI) technologies in the industrial sector, and enhance the integration of AI with new-type industrialization. Firstly, it is essential to enrich and expand application scenarios. Focusing on technology-based enterprises, platform companies, specialized and innovative small and medium-sized enterprises, and leading enterprises, we should actively explore typical application scenarios and digital transformation models across different industries, sectors, and links, centered around industrial network connectivity, industrial data interoperability, industrial software and management service phantomization, digitalization of manufacturing processes and system equipment, and flexibility of manufacturing units and workshop factories. Furthermore, we should strengthen practical applications and effectively leverage the demonstrative role of typical application scenarios in new-type industrialization [20]. Secondly, we should accelerate the development and application of industrial large-scale models. Given the limitations of general-purpose large-scale models in vertical industry applications, it is crucial to increase investment in the research and development of vertical industry-specific large-scale models. We should expedite the exploration of knowledge representation, model training, and optimization techniques tailored to vertical domains. By delving deeply into the business processes, data characteristics, and requirements of specific industrial sectors, we can develop more targeted and practical vertical industry-specific large-scale models.

5.3. Accelerate Talent-Driven Development And Establish A Comprehensive Artificial Intelligence Talent Cultivation System

In the wave of new-type industrialization, the demand for high-caliber talent in the field of artificial intelligence (AI) has become increasingly prominent. However, the AI sector faces prominent issues such as a severe shortage of high-end interdisciplinary talent and a structural imbalance in the workforce. To effectively address these challenges, it is imperative to adopt a coordinated approach encompassing the improvement of the AI talent cultivation system [21], the enhancement of incentive mechanisms for AI talent, and the strengthening of deep integration among industry, academia, and research, thereby establishing a systematic talent supply guarantee system. Firstly, it is essential to cultivate core AI technical talent aligned with national strategic needs. Focusing on core AI technology areas such as chip research and development, general-purpose large-scale model development, and AI algorithm framework development, we should foster a cohort of internationally leading AI core technology research and development teams. Additionally, we should intensify the cultivation of professionals in basic research and core technology fields, constructing a multi-tiered talent cultivation system encompassing general education, applied foundational education, and

expert-level talent development. Secondly, it is crucial to establish a comprehensive AI talent education system. Courses covering fundamental knowledge, core technologies, application scenarios, and case studies should be developed at different levels for diverse audience groups, including management personnel, technical staff, students, and skilled workers. In light of the development needs of the AI industry, job-specific talent capability models, and key industrial technologies, educational institutions should be encouraged to formulate AI talent cultivation standards, upgrade AI teaching systems, and offer cross-college and cross-disciplinary AI technology courses.

5.4. Continuously Improve The Standard System And Laws And Regulations in the Field of Artificial Intelligence

With the rapid development of artificial intelligence (AI) technology, its application in the industrial sector has become a key enabler for advancing the process of new-type industrialization. However, the AI field faces issues such as lagging standard systems and laws and regulations. This lag has led to the disorderly development of AI technology, which in turn hinders industrial integration and the widespread adoption of technological applications. Therefore, establishing a comprehensive regulatory framework for AI has emerged as a crucial task for ensuring the healthy development of AI technology and promoting new-type industrialization. First, it is essential to establish and improve a standard system for AI technology. This system should encompass foundational technical specifications (such as algorithms, data structures, and processing methods), industry application standards, and safety guidelines to enhance technical interoperability, compatibility, and universal applicability, thereby preventing industrial fragmentation caused by the absence of standards. Meanwhile, a unified certification and evaluation mechanism should be implemented to ensure that AI products and services meet standard requirements, improve their market adaptability and cross-industry integration capabilities, provide clear technical guidance for enterprises, and promote the large-scale application of AI in new-type industrialization. Second, it is imperative to accelerate the enactment of dedicated AI legislation. Currently, legal gaps exist in cutting-edge fields such as autonomous driving and intelligent healthcare, severely constraining technological innovation and industrial implementation. There is a need to formulate an AI law that systematically regulates issues such as data usage, algorithm transparency, and the protection of privacy and intellectual property rights, providing a legal basis for technological research and application. Additionally, a dynamic legal revision mechanism should be established to regularly evaluate and adjust relevant regulations to keep pace with the rapid iteration and development needs of AI technology.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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