Research on Deepening the Construction of High-quality Industrial Development with New Quality Productivity from the Perspective of Artificial Intelligence

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Abstract: Amid China's strategic transition toward high-quality economic development, artificial intelligence (AI) has emerged as a pivotal enabler in catalyzing the formation of "new quality productive forces." This study investigates the mechanisms through which AI enhances total factor productivity — specifically via reallocation of production factors, transformation of innovation paradigms, and advancement of green manufacturing. Anchored in a theoretical framework centered on the triad of "data–computing power–algorithm," and illustrated through a case study in the chemical industry, the analysis delineates AI's tangible contributions to accelerating R&D cycles, enabling autonomous manufacturing systems, and facilitating low-carbon industrial transitions. Empirical evidence from a large-scale industrial park based in Guangzhou demonstrates measurable improvements: a 0.9% increase in product yield and a 6.7% reduction in unit energy consumption within one year of intelligent transformation. The findings underscore the necessity of robust digital infrastructure and refined data governance as foundational supports for scaling AI-driven high-quality industrial development.

***Keywords*:** artificial intelligence, new quality productive forces, high-quality development, industrial upgrading, total factor productivity, digital transformation

1. Introduction

The evolutionary history of industrialization is a chronicle of productivity leaps. Following three industrial revolutions — driven by steam power, electricity, and informatization — the fourth, centered on artificial intelligence, is now unfolding globally at an unprecedented pace. China's industrial sector, currently navigating a critical transformation period, faces multiple challenges: the traditional extensive development model has encountered the limits of resource and environmental constraints, the advantage of low labor costs is diminishing, and structural contradictions persist between excess low-end capacity and insufficient high-end supply. In response to this context, authorities including the National Development and Reform Commission have explicitly advocated for accelerating the development of "new quality productive forces" [3], stressing a fundamental shift from traditional growth models towards a leap in productivity quality through disruptive technological innovation. Globally, this sentiment resonates with initiatives like the EU's Industry 5.0 and the US's AI for Manufacturing programs, collectively highlighting AI's universal role in driving productivity leaps.

As a core engine for these new forces, artificial intelligence transcends being a mere technical tool; it is a general-purpose technology (GPT) characterized by permeability, substitutability, and synergy. As economists Acemoglu and Restrepo note, advancements in AI and robotics are reshaping capital-labor dynamics, propelling the economic structure towards higher value-added activities through automation and task reinterpretation [1]. This paper seeks to address the question of how AI, from a technological and mechanistic perspective, deepens the construction of new quality productive forces, thereby enabling industries to ascend the value chain and achieve genuine high-quality development.

2. Theoretical Logic: The Mechanism of AI-Driven Formation of New Quality Productive Forces

The formation of new quality productive forces hinges on enhancing total factor productivity and optimizing production relations. Within this process, AI technology acts simultaneously as a catalyst and an adhesive. It comprehensively reshapes the traditional trinity of production—labor, means of labor, and objects of labor—thereby triggering a chain reaction within the industrial system. Supporting this view, research by scholars such as Wang Futao indicates that digital transformation significantly propels manufacturing's high-quality development by optimizing resource allocation efficiency [7].

More concretely, AI has fundamentally altered the role and capabilities of the laborer. Where human roles in traditional industry were often constrained by physiological and cognitive limits, AI fosters a new norm of "human-machine collaboration." Intelligent algorithms now handle massive, high-dimensional datasets, assisting or even replacing humans in cognitive tasks ranging from high-throughput experimental screening to complex process optimization.

Simultaneously, data, emerging as a novel object of labor, has gained unprecedented value. Unlike exclusive and consumable traditional resources like minerals, data is non-competitive and reusable. Leveraging technologies like deep learning, AI extracts tacit knowledge from industrial processes, transforming once-discrete data into reusable digital assets. This "data + algorithm" paradigm holds the potential to counteract the diminishing marginal returns typical of traditional factors, a possibility underscored by digital economy research.Figure 1 presents our mechanism model for AI-driven new quality productive forces, illustrating how AI interacts with the three traditional production factors and, through the synergistic cycle of "data-computing power-algorithm," culminates in a leap towards high-technology, high-efficiency, and high-quality productivity.

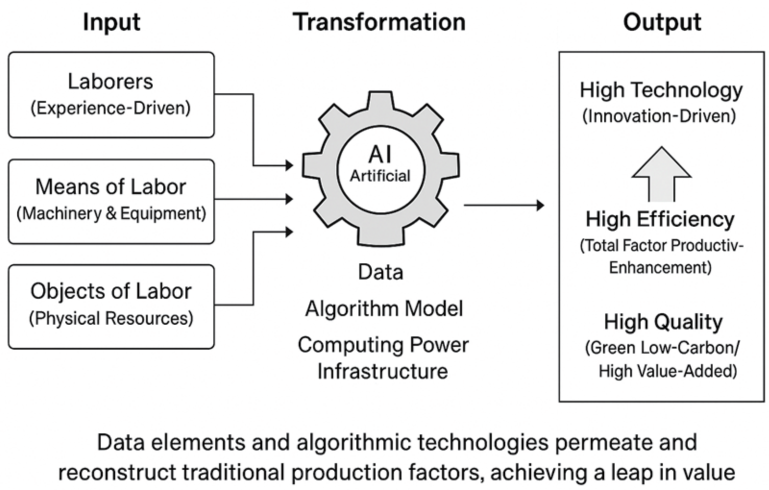

Figure 1. Mechanism Model Diagram of AI-Driven Formation of New Quality Productive Forces

3. Path Construction: Multi-Dimensional Scenarios of AI-Enabled High-Quality Development

Building upon this theoretical foundation, deepening new quality productive forces requires grounding in specific industrial practice. Taking the technology- and capital-intensive chemical industry as an exemplar, AI is forging a new landscape of high-quality development across three dimensions: R&D innovation, production manufacturing, and green, low-carbon development. As Venkatasubramanian's review underscores, AI applications in chemicals have evolved from early expert systems to big-data-driven deep learning, offering novel pathways for solving complex, nonlinear engineering problems [2].

3.1 R&D Paradigm Transformation: From "Trial-and-Error Experimentation" to "Computational Design"

The wellspring of high-quality industrial development is technological innovation, yet the high cost and long cycles of traditional R&D pose significant bottlenecks. The "AI for Science" paradigm is radically altering this landscape [4]. In new chemical materials, the traditional trial-and-error approach often entails prohibitive time and capital sink.

By constructing structure-activity relationship models via deep neural networks, researchers can perform reverse molecular design and high-throughput virtual screening across vast chemical spaces. As Zhang and Chen note, generative models (e.g., GANs, VAEs) can create novel molecular structures tailored for specific properties, such as high catalytic activity or thermal stability [6]. For instance, in catalyst development, AI models can predict the activity of millions of candidates within hours, boosting R&D efficiency by orders of magnitude. Figure 2 contrasts this shift: the traditional linear paradigm (literature → hypothesis → experiments) can span up to 36 months, whereas the AI-assisted, iterative paradigm (data training → generative screening → optimization) can compress the cycle to just 12 months, drastically cutting time and cost inputs, based on industry benchmarks

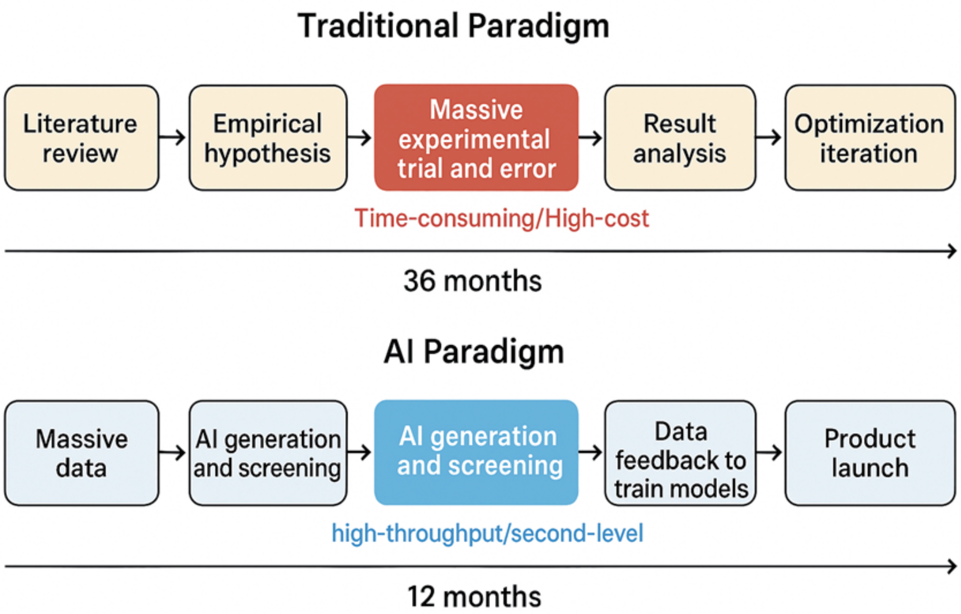

Figure 2. Process Comparison Between Traditional R&D Paradigm and AI-Assisted R&D Paradigm

3.2 Manufacturing System Reconstruction: From "Automation" to "Autonomous Intelligence"

The bedrock of high-quality development lies in manufacturing efficiency and stability. Achieving this demands manufacturing systems with closed-loop intelligence for perception, decision-making, and execution. Echoing this evolution, Porter and Heppelmann's concept of smart connected products outlines a progression from monitoring to autonomous optimization [5].

The next generation of industrial intelligent systems fuses mechanistic and data-driven models. Using reinforcement learning, intelligent agents can engage in trial-and-error within a digital twin environment, mastering optimal control strategies for complex equipment under diverse conditions. A case in point: Siemens' digital twin applications in chemical plants, utilizing reinforcement learning, have achieved 15-20% efficiency gains When deployed in physical plants, such systems can perceive real-time changes.across thousands of measurement points, dynamically adjusting parameters like temperature and material ratios to continuously operate at the optimal boundary of economic and safety performance.

3.3 Green and Low-Carbon Transformation: From "End-of-Pipe Governance" to "Global Optimization"

Integral to new quality productive forces is a green imperative. Under the strict "dual carbon" goals, high-energy-consumption industries face immense pressure. By enabling refined management of energy and material flows, AI offers a technical pathway for green transformation. Coupled with plant-level Energy Management Systems (EMS), AI algorithms can perform global optimization of utility networks, paving the way for decoupling industrial growth from carbon emissions.

4. Empirical Analysis: The Intelligent Leap of a Large-Scale Industrial Park

To ground our analysis in practice, this study examines a large-scale integrated chemical industrial park in Guangzhou The park undertook a comprehensive intelligent transformation project centered on an "Industrial Internet + AI" platform, which integrated heterogeneous systems into a unified industrial data lake.

After one year of operation monitoring, the data shows significant "new quality" characteristics. The equipment stability rate has been greatly improved, the yield of key products is close to the theoretical limit, and energy consumption has decreased significantly. Figure 3 demonstrates the comparative analysis of key performance indicators before and after intelligent transformation. Compared with the pre-renovation period, the product yield in each quarter after renovation continued to rise, and the unit energy consumption steadily decreased, ultimately achieving the dual results of a 0.9% increase in yield and a 6.7% reduction in energy consumption, fully confirming the empowering value of AI for high-quality industrial development.

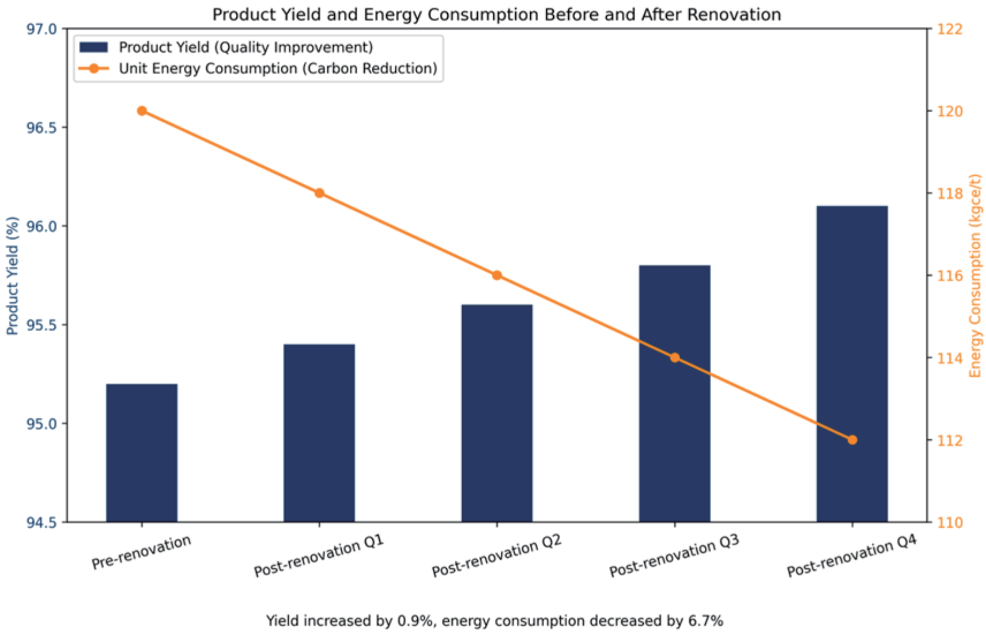

Figure 3. Comparative Analysis of Key Performance Indicators Before and After Intelligent Transformation

(Note: Product yield reflects the level of quality improvement, and unit energy consumption reflects the effect of carbon reduction)

This practice shows that artificial intelligence is not just a conceptual hype but possesses extremely strong real productivity transformation capabilities. It is a practical tool to promote the transformation of traditional industries towards high-end, intelligent, and green development.

5. Challenges and Countermeasure Suggestions

Despite its promise, deepening new quality productive forces with AI faces several entrenched challenges.

Data silos and governance difficulties remain primary hurdles. Industrial data's proprietary and heterogeneous nature often creates severe "data barriers" between and within enterprises. Furthermore, achieving effective integration between algorithmic outputs and established industrial mechanisms requires a fundamental breakthrough. The "black box" nature of deep learning clashes with industry's demand for certainty and safety. Compounding these issues is a structural shortage of interdisciplinary talent.

To address the above challenges, it is recommended to establish industry-level data exchange standards and trusted data spaces; vigorously promote the integrated research of "AI + mechanism" to build industrial large models with physical interpretability; and deepen industry-education integration to cultivate a new type of engineering talent team adapting to the intelligent era.

6. Conclusion

Deepening the construction of new quality productive forces constitutes a strategic imperative for high-quality economic development in the new era. Our analysis illustrates that AI, as a key variable, is profoundly reshaping industrial logic through technological permeation, factor restructuring, and process reengineering. From molecular design in R&D, to intelligent control in manufacturing, and lifecycle green governance, AI provides a novel framework for addressing traditional industry pain points. Moving forward, unleashing the full potential of new quality productive forces will depend on constructing a synergistic ecosystem where technology, data, talent, and policy co-evolve. Future research could empirically test the proposed model across diverse industries using econometric methods, particularly exploring AI's scalability in developing economies.

References

[1] Acemoglu, D., & Restrepo, P. The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. American Economic Review, 108(1), 1-48.

[2] Venkatasubramanian, V. The promise of artificial intelligence in chemical engineering: Is it here, finally? AIChE Journal, 65(2), 466-478.
[3] National Development and Reform Commission (NDRC). Report on the Development of New Quality Productivity in China. Beijing: People's Publishing House.
[4] Cui, Y., et al. AI for Science: A New Paradigm for Chemical Engineering. Engineering, 32(1), 12-25.
[5] Porter, M. E., & Heppelmann, J. E.How Smart, Connected Products Are Transforming Companies. Harvard Business Review, 93(10), 96-114.
[6] Zhang, L., & Chen, H. Deep Learning for Molecular Design: A Review. Chemical Engineering Journal, 450, 138-152.
[7] Wang, F., & Yuan, Y. Digital Transformation and High-Quality Development of Manufacturing Industry: Mechanism and Empirical Evidence. Journal of Management Sciences in China, 26(4), 22-35.