Theoretical Paradigm Reconstruction of Artificial Intelligence Embedding in Economic Development: An Exploration from the Perspective of Technology-institution Co-evolution

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Abstract

Artificial intelligence (AI), as a new-generation general purpose technology, is penetrating the economic system with unprecedented breadth and depth, posing fundamental challenges to the established theoretical paradigms of economic development. This article adopts the perspective of technology-institution co-evolution. It first surveys the co-evolutionary framework of evolutionary economics and techno-economic paradigm theory, and then advances a core proposition: that AI embedding in economic development signifies a paradigm shift from "exogenous technological shocks" to "technology-institution bidirectional reshaping". The study's findings are roughly as follows: AI's embedding in the economic system is not a unidirectional diffusion of technology. Instead, it engages in continuous mutual shaping with existing institutional frameworks through three channels - factor reconfiguration, organizational transformation, and governance transition. Divergent institutional endowments naturally lead to divergent national AI trajectories. On this basis, this article constructs a two-dimensional analytical tool of "technological change momentum-institutional adaptation elasticity" to explain why AI embedding pathways differ and where their phase-specific characteristics originate. It concludes by setting out a research agenda for the reconstruction of the theoretical paradigm.

Keywords

Artificial intelligence, Technology-institution co-evolution, Economic development, Techno-economic paradigm, Theoretical reconstruction

Introduction

Deep learning, large language models, and generative AI - this new artificial intelligence technologies - are now rapidly penetrating every layer of the economic system. They are widely regarded as the general purpose technology (GPT) spearheading a new round of technological revolution and industrial transformation. Compared with previous waves of technological change, one critical difference stands out - AI directly intervenes in cognitive labor. This intervention overturns the ways in which knowledge is produced, organizations are coordinated, and market transactions are conducted. In other words, AI embedding in economic development is far from a simple matter of adopting and applying technology. It is a simultaneous, systematic renovation at three levels - factors of production, organizational forms, and governance logic.

Such a transformation places no small pressure on established economic theories. Neoclassical growth theory has consistently treated technology as an exogenous shock; endogenous growth theory, for its part, has internalized technological change as the product of research and development investment and knowledge accumulation [1].

Yet neither has broken out of the same framework - institutions are merely background conditions for technology deployment. Although new institutional economics repeatedly emphasizes the foundational role of institutions in economic performance, within its analytical framework, technological innovation and institutional change are two separate evolutionary trajectories. The layer of bidirectional causation remains unexamined. At the stage of deep AI embedding,

technology is no longer an external force quietly waiting for institutions to "adapt" to it. Instead, it has become an endogenous variable actively shaping the direction of institutional change. From data governance to algorithmic regulation, AI is driving comprehensive institutional reengineering. The theoretical gap lies precisely here. This article, proceeding from the perspective of technology-institution co-evolution, seeks to undertake a reconstructive exploration of the theoretical paradigm of AI embedding in economic development.

The roots of technology-institution co-evolution are anchored in the evolutionary economics tradition and can be traced back to foundational work. The evolution of industrial technology grows together with industrial structure, firm organization, and supporting institutions. The path taken by technology is framed by institutions, while the effectiveness of institutions depends on the stage technology has reached. A distinction is often drawn between "physical technologies" and "social technologies": The former govern how inputs are transformed into outputs, the latter how interactions among people are coordinated. Economic growth, at bottom, is the joint advance of these two threads [2].

Techno-economic paradigm theory offers a grander perspective. Each technological wave, through a cluster of interlocking "key factors" and new infrastructure, overthrows modes of production and institutional frameworks, sedimenting into a set of "best-practice common sense". This picture provides a useful coordinate system for understanding the new wave of paradigm transformation. This transformation is now being triggered by AI.

It must be acknowledged, however, that the above classical theories were born well before AI's large-scale deployment. The concept of "social technology" draws its empirical underpinnings primarily from twentieth-century manufacturing cases; analyses of long waves also stopped at the ICT wave, unable to foresee the magnitude of the disruption AI would bring to cognitive labor. In the AI era, the technology's capacity for self-learning and the non-rivalrous character of data have injected an entirely new set of dynamic mechanisms into technology-institution co-evolution. The core question this article thus seeks to pursue is: After AI has become deeply embedded in the economic system, has the logic of technology-institution co-evolution undergone a qualitative transformation? If the answer is affirmative, where should the reconstruction of established economic development paradigms begin?

Theoretical analytical framework for AI embedding in economic development

From "exogenous technological shock" to "technology-institution bidirectional reshaping"

Traditional growth theory habitually treats technology as a driving variable of economic growth, while institutions are placed outside as "constraint parameters". Their role is to lower transaction costs and delineate property rights boundaries. Under the narrative of "technology drives, institutions adapt", growth is represented as a straightforward arrow: new technology adoption → productivity increase. This logic worked reasonably well in describing the previous three industrial revolutions. The magnitude of the economic effects brought by steam engines and electricity depended largely on whether firms could absorb the technology within the existing institutional space [3].

The problem is that the characteristics displayed by AI are entirely different from those of earlier technologies. On one side is institutional embeddedness - algorithmic training relies on massive datasets, and who owns data and how privacy is protected are themselves institutionally constructed matters. On the other side is institutional feedback capacity - as algorithmic decision-making systems penetrate domains such as financial risk control and public administration, they are actively redistributing governance structures and power configurations. Bidirectional causation is entangled between AI technological innovation and institutional change. The institutional framework of national innovation systems shapes the direction of AI, while in turn, the rise of AI giants pushes innovation governance systems to adapt. This amounts to making one thing explicit: AI embedding in economic development has already crossed beyond the old phase of "institutions adapting to technology" and entered a new phase of "continuous mutual construction between technology and institutions".

Triple embedding channels: Factor, organization, and governance

To clearly delineate the institutional logic of AI embedding in economic development, this article proposes a "triple embedding" framework. AI embeds in the economic system along three channels: factor reconfiguration, organizational transformation, and governance transition. These channels intertwine with and mutually shape the institutional system.

At the factor level, data has become a new type of input, altering the input structure of economic development. Unlike traditional factors of production, data is inherently non-excludable - this leaves traditional economics, which revolves around scarcity, somewhat at a loss. Unlocking the value of data is critically dependent on the institutional environment. Who owns the property rights, how privacy is protected, and how far the boundaries of antitrust regulation extend together determine whether data can be efficiently allocated. In plain terms, how the data factor market is constructed is itself a significant institutional renovation [4].

At the organizational level, AI is pushing firms out of their hierarchical shells toward platform-based and ecosystem-oriented forms. Intelligent decision-making and generative AI have sharply reduced firms' internal coordination costs, and algorithmic matching is also remaking the rules of market transactions - search costs and matching frictions have been cut down, giving rise to the platform economy as a new organizational form. Muñoz makes a sharp observation: At the organizational level, AI is pushing firms out of their hierarchical shells toward platform-based and ecosystem-oriented forms. Intelligent decision-making and generative AI have sharply reduced firms' internal coordination costs. Algorithmic matching is also remaking the rules of market transactions. Search costs and matching frictions have been cut down, giving rise to the platform economy as a new organizational form [5].

At the governance level, AI's effect is quite characteristic - a "double-edged sword". On one side, smart regulation can monitor market risks and intervene with precision, raising governance efficiency. On the other side, algorithmic discrimination grows ever more insidious, data monopoly becomes increasingly concentrated, and technological power lies in the hands of a few - novel types of governance dilemmas are emerging. Gherhes et al. compared Canada and China, yielding a rather interesting result: Canada, within a stable institutional framework and a deep ethical tradition, has followed an AI governance path led by scientific research and ethics. China, within a flexible institutional space, has charted a path centered on commercial application and government leadership. What this reveals is crucial: The choice of AI governance model is not a purely technical calculation but the product of a country's institutional endowment [6].

Technological change momentum and institutional adaptation elasticity: A two-dimensional analytical framework

Consolidating the preceding analysis, this article advances a two-dimensional tool of "technological change momentum–institutional adaptation elasticity". Technological change momentum refers to the intensity of the transformational pressure AI exerts on existing economic structures, determined by the breadth of penetration and the depth of substitution. At the point where AI evolves from an assistive tool to a core factor of production, transformational momentum peaks. Then the old pattern of industrial division of labor and income distribution can no longer hold. Institutional adaptation elasticity measures whether existing institutions can absorb technological change and, in turn, reshape it, with the key residing in the learning capacity of institutions and the scope for governance innovation.

Applying this two-dimensional framework, the evolutionary paths of different economies break down into four types. High momentum paired with high elasticity produces a "co-evolutionary" path - technology and institutions cycle upward in a mutual chase, with China's rapid AI catch-up serving as a living specimen of this trajectory. High momentum meeting low elasticity falls into a "institutional lag" trap, the new version of the "Solow paradox" - productivity simply refusing to keep pace with technology - being roughly what this means. Low momentum with high elasticity follows a "gradual adjustment" path, a slow grind. Low momentum and low elasticity coming together is the worst scenario - technological stagnation and institutional rigidity lock each other in place, termed "double lock-in". With this two-dimensional yardstick, the performance disparities

of AI development across different economies are no longer an indecipherable puzzle [7].

International comparison of AI development pathways: The shaping role of institutional endowment

Different countries possess different institutional endowments, and their AI trajectories naturally diverge accordingly. China holds a massive data pool, has had relatively lenient early-stage regulation, and has been vigorously propelled by government-led industrial policy. The result is an AI development model driven by commercial applications with tech giants as its backbone. The transition from "Internet Plus" to "AI Plus" reflects a deep interlocking of state will and market forces within a specific institutional space. Acemoglu holds that AI's contribution to growth is not monolithic - in economies with high institutional elasticity, AI can release a productivity dividend through task reorganization. Where institutions are rigid, AI is more likely to exacerbate income inequality and employment polarization [8].

Viewed through the lens of innovation systems, cutting-edge AI can successfully leap from the laboratory to the market in a relatively short time when effective and robust knowledge flow networks linking firms, universities, and research institutions are unobstructed.

Conversely, where various institutional barriers stand in the way, this process is considerably drawn out. An illustrative comparison highlights the cross-national differences. In a highly institutionalized environment, AI development tends to favor scientific research and ethical norms, but commercialization has been slow. Under conditions of high institutional elasticity, rapid commercialization and scaling are achieved, yet the pressure to catch up on institutional construction - such as in data governance - remains intense. This suggests that to adequately account for cross-national differences in AI embedding in economic development, one must probe deeply into how institutional structures shape technological trajectories [9].

Directions for paradigm reconstruction and a research agenda

Following from the preceding analysis, AI embedding in economic development requires the theoretical paradigm to be renovated along three dimensions. First, from "technological determinism" to "co-evolutionary theory" - growth theory must no longer treat technology as an exogenous variable but must endogenize the bidirectional feedback between technology and institutions. Some growth models have already incorporated AI's self-accumulating character, but the modeling of the institutional dimension remains thin. To genuinely overturn the paradigm requires constructing a unified framework. This framework must be capable of accommodating the dynamic inter-embedding of technological progress and institutional change in one go. Second, from "single equilibrium" to "multiple pathways". Given different institutional endowments, AI's trajectory cannot be singular - there is no universal "best practice". What is needed going forward are more context-sensitive analytical tools. These tools should neither abandon the intrinsic regularities of technological evolution nor underweight the significance of institutional diversity. Third, from "static adaptation" to "dynamic mutual construction". Akram et al., running panel data from 275 Chinese cities, reached a very concrete conclusion - AI's economic effects are significantly moderated by the institutional environment, and in places with more developed institutions. AI's thrust toward high-quality development is stronger. Institutional design cannot stop at the step of "sweeping the ground clear" for AI; it must keep pace with the rhythm of technological evolution and iterate alongside it [10].

Future research may spread out along several directions. First, constructing endogenous growth models incorporating technology-institution bidirectional feedback, building on earlier growth frameworks to endogenize institutional change as an object co-evolving with technological progress. This would lay a micro-foundation for paradigm reconstruction. Second, undertaking cross-country comparisons, employing panel data and quasi-experimental methods to rigorously verify the causal effects of institutional endowments on AI development performance. Third, mapping out the institutional design principles for data governance and algorithmic regulation in the AI era. Fourth, from the perspective of evolutionary economics, tracking the micro-mechanisms of AI technology-institution co-evolution.

Conclusion

The deep embedding of artificial intelligence in the economic system is rewriting the operational logic of economic development from its foundations. This article, adopting the perspective of technology-institution co-evolution, seeks to argue a single proposition. That proposition is that economic growth in the AI era has already broken out of the old well of "technology-driven" and entered a new phase in which technology and institutions mutually shape each other.

The article has advanced several steps. It has laid out the dual characteristics of AI's "institutional embeddedness" and "institutional feedback capacity". It has constructed a "factor - organization - governance" triple embedding framework together with the "technological change momentum-institutional adaptation elasticity" two-dimensional analytical model. It has also identified three dimensions of paradigm renovation - from technological determinism to co-evolutionary theory, from single equilibrium to multiple pathways, and from static adaptation to dynamic mutual construction.

Guiding the orderly embedding of AI in economic development is ultimately a matter of institutions - one must both leave room for trial and error in technological innovation and contain, through institutional innovation, the social risks of algorithmic discrimination and employment shocks. Only by maintaining a dynamic equilibrium between technological change and institutional evolution can the fire of AI driving the economy toward high quality truly be kindled.

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Conflicts of Interest

The author declares no conflict of interest.

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