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Analysis of the Synchrony between the Scientific Revolution and Changes in Social Structure

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Abstract

The scientific revolution, as a core force driving the expansion of human cognitive boundaries, has always maintained a profound interactive relationship with changes in social structure. Their synchronous evolution constitutes a crucial thread in the development of human civilization. This paper first traces the historical progression of the synchronous development between scientific revolutions and social structural changes, revealing the correspondence between scientific breakthroughs and transformations in social forms across different historical stages. It then analyzes the intrinsic mechanisms underlying the synchronicity of scientific revolutions and social structural changes from multiple dimensions, elucidating the dynamic relationships between scientific breakthroughs and societal needs, the cycles of scientific development and social transformation, as well as scientific innovation and societal resources. Against the backdrop of the contemporary technological revolution, this study proposes practical pathways to strengthen demand-oriented scientific research planning, improve institutional adaptation support systems, and promote public participation and collaborative mechanisms. These suggestions aim to provide theoretical reference and practical guidance for achieving efficient synchronization and adaptation between technological revolutions and social structures.

Keywords

scientific revolution; social structural changes; synchronicity; intrinsic mechanisms; demand orientation

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1. Introduction

Since humanity entered civilized society, science and society have always been in a dynamic relationship of mutual shaping. Changes in social structure give rise to new demands, new resources, and new institutions, which in turn provide the necessary soil and impetus for scientific revolutions. Scientific revolutions, meanwhile, are not merely disruptive reconstructions of knowledge systems—they also profoundly influence modes of production, ways of life, and even patterns of thought.

From Copernicus' heliocentric theory subverting the medieval theological cognitive system and promoting

the transformation of European society into the modern era[1], to Newton's classical mechanics system supporting the rise of the Industrial Revolution and facilitating the formation of an industrial society, and then to quantum mechanics and information technology triggering the modern scientific revolution and propelling human society into the information age, the synchronous characteristic of scientific revolutions and social structure changes has always run through the course of history.

Today, a new wave of technological revolution, represented by artificial intelligence, biotechnology, and new energy technologies, is vigorously unfolding. Social structure, in turn, is undergoing profound transformations: production factors are being reconfigured, class differentiation is accelerating, and governance models are evolving. However, disconnects also exist—between technological development and societal needs, and between the pace of innovation and the rhythm of institutional adaptation. These issues heighten the risk of asynchronous development between technology and society.

Against this backdrop, systematically examining the historical trajectory of synchronicity between scientific revolutions and social structural changes, analyzing their underlying mechanisms, and exploring pathways to achieve synchronization in the contemporary context carry significant theoretical value. Moreover, such efforts hold practical importance for enabling technology to empower social development and advancing the modernization of national governance systems and capabilities.

2. The Historical Evolution of the Synchronicity Between Scientific Revolution and Social Structural Change

2.1. The Modern Scientific Revolution and the Transformation of Pre-Industrial Social Structures

The modern scientific revolution of the 16th and 17th centuries was marked by the publication of Copernicus' On the Revolutions of the Celestial Spheres, the establishment of experimental science by Galileo, and the preliminary formation of Newtonian classical mechanics. This revolution brought about a fundamental breakthrough in humanity's understanding of nature, broke the medieval theological monopoly on knowledge, and propelled the transformation of European society from a feudal structure of the pre-industrial era to a modern social structure.

At the economic structure level, the modern scientific revolution gave rise to new production concepts and the germination of technologies. The Copernican astronomical revolution shook the feudal theological order supported by geocentrism, prompting people to approach natural laws with a rational perspective. This laid the cognitive foundation for the precision of calendars in agricultural production and the improvement of tools in handicraft production. Galileo's research on mechanical principles also contributed to the enhancement of simple machinery such as textile machines and water pumps, leading to increased production efficiency. The transition from a feudal natural economy to a commodity economy accelerated, and the emerging bourgeoisie gradually rose, becoming a core force driving changes in social structure.

At the level of social class structure, the rational spirit and emphasis on individual independent thinking advocated by the scientific revolution challenged the medieval hierarchical system centered on theology[1]. Scholars and technicians with scientific knowledge formed alliances with the emerging bourgeoisie to break the church and nobility's monopoly on knowledge and power[2]. As a result, channels for social mobility gradually opened, and a new class structure based on occupational specialization and wealth accumulation began to emerge.

2.2. The Classical Scientific Revolution and the Formation of Industrial Social Structure

The classical scientific revolution of the 18th and 19th centuries was characterized by the refinement of Newtonian classical mechanics, the discovery of thermodynamics laws, and the establishment of electromagnetic theory. This revolution constructed a complete system of classical physics, which not only provided a solid scientific foundation for the further advancement of the Industrial Revolution but also directly contributed to the ultimate formation of industrial social structures.

At the level of production structure, the achievements of the classical scientific revolution were directly translated into industrial production technologies. Newtonian mechanics elucidated the laws of mechanical motion, which facilitated the improvement and widespread adoption of steam engines. Consequently, production methods shifted from manual labor to machine-based manufacturing, with the factory system replacing traditional workshops. The characteristics of industrialization—scale and concentration—became increasingly pronounced[3]. Furthermore, breakthroughs in electromagnetic theory, such as Faraday's law of electromagnetic induction, gave rise to electrical equipment like generators and electric motors, ushering human society into the electrical age.

At the level of social life and governance structure, the concentration of industrial production drove mass migration from rural areas to cities. Urban centers expanded rapidly, gradually evolving into hubs of socioeconomic activity, and urbanization emerged as a defining feature of industrial society. Concurrently, the functions of government underwent a transformation, shifting from political domination to social management and public services [2]. To meet the demands of industrial production, education systems became increasingly universalized, with vocational education and basic education—aimed at cultivating technical workers and managers—developing rapidly[4]. Throughout this process, the governance structure and social service systems of industrial society were continuously refined and improved.

2.3. Modern Scientific Revolution and the Transformation of Information Society Structure

The modern scientific revolution since the 20th century began with the establishment of quantum mechanics and relativity, later extending to fields such as molecular biology, information technology, and artificial intelligence. It has constructed a brand new scientific knowledge system, driving the transition of human society from an industrial society to an information society. Social structures have also developed new characteristics of digitization, networking, and flattening.

At the level of economic structure, the modern scientific revolution has given rise to new industrial forms centered on information technology. Breakthroughs in quantum mechanics laid the foundation for the development of semiconductor and computer technologies. The invention of transistors and integrated circuits promoted the miniaturization and popularization of computers[5]. With the rise and development of internet technology, the temporal and spatial limitations of information dissemination were broken, giving birth to new formats such as e-commerce, online education, and telemedicine. The traditional industrial economy has gradually transitioned to a digital economy.

At the level of social structure, both the class structure and modes of interaction in the information society have undergone profound changes. The knowledge class and technical elites, who possess information technology and knowledge resources, have become the core forces driving social development. Social stratification has gradually shifted from being wealth-based to knowledge- and skill-based. With the increased convenience of information dissemination, civic consciousness has awakened, and channels for public participation in social governance have continuously expanded[6]. Social governance has shifted from government-led to multi-stakeholder collaboration, and the governance structure and social participation mechanisms of the information society are continuously being optimized.

3. The Intrinsic Mechanisms of Synchronicity Between Scientific Revolution and Social Structural Change

3.1. Goal Alignment: The Convergence of Scientific Breakthroughs and Societal Needs

The synchronicity between scientific revolution and changes in social structure primarily stems from the goal alignment between scientific breakthroughs and societal needs. Societal needs serve as the fundamental driving force for scientific development. When society encounters bottlenecks in areas such as production, daily life, and governance, it generates an urgent demand for new scientific knowledge and technologies. Scientific breakthroughs, in turn, provide the means to meet these needs[7]. This alignment of goals forms the premise for their synchronous evolution.

In early modern Europe, during the late feudal period, the development of a commodity economy required more accurate calendars to guide agricultural production and more efficient navigation technologies to support overseas trade. These societal needs drove advancements in astronomy and mechanics. While Copernicus' heliocentric theory initially emerged from rational exploration of cosmic understanding, its precise description of celestial motion indirectly fulfilled the demand for astronomical observations in navigation. The convergence of scientific breakthroughs and socioeconomic needs accelerated the transformation from pre-industrial to modern society.

In the contemporary era, challenges such as population aging have created demands for healthcare solutions, environmental degradation has spurred needs for ecological protection, and the pursuit of higher productivity has driven the demand for intelligent technologies. These needs have propelled developments in molecular biology, new energy technologies, and artificial intelligence. Breakthroughs in science and technology, in turn, address societal healthcare demands, promote the transformation of medical systems, and optimize social service structures[8], forming a virtuous cycle where needs drive science and science fulfills needs.

3.2. Rhythm Alignment: Synchronization of Scientific Development and Social Transformation Cycles

The synchronicity between scientific revolution and changes in social structure relies on the alignment of rhythms between scientific development and social transformation. Both scientific development and social structural change often exhibit cyclical patterns[9]. Achieving cyclical synchronization between the two ensures that the outcomes of scientific revolutions are timely integrated into social structural transformations.

The process of the classical scientific revolution and the formation of the industrial social structure fully demonstrates the characteristic of rhythm alignment. The establishment of Newtonian classical mechanics in the 17th century, Watt's improvement of the steam engine in the 18th century, and the widespread application of steam engines in textiles, mining, transportation, and other fields in the 19th century reflect a scientific development cycle spanning nearly 200 years. Meanwhile, the transformation of social structure—from the era of manual workshops to the factory system era, and then to the maturation of urbanization—underwent a similar cycle [3]. The theory-technology-application cycle of scientific development was highly synchronized with the germination-growth-maturation cycle of social transformation. This synchronization enabled steam engine technology to be applied at a stage when society's demand for large-scale production was most urgent, thereby accelerating the formation of the industrial social structure.

The rhythm alignment between the modern scientific revolution and the transformation of the information society is even more pronounced. From the establishment of quantum mechanics in the early 20th century, to the invention of semiconductor and computer technologies in the mid-20th century, and further to the popularization of internet technology in the late 20th century and the application of mobile internet and artificial intelligence in the early 21st century, the cycle of scientific development has been largely synchronized with the transformation cycle of the information society—from the infancy of technology to the rise of the digital economy, and then to the construction of a smart society. This rhythm alignment has enabled information technology to promptly respond to societal demands for information dissemination, productivity enhancement, and governance model optimization, thereby accelerating the transformation of the information social structure.

3.3. Dynamic Interaction: Two-Way Flow Between Scientific Innovation and Social Resources

The synchronicity between scientific revolution and changes in social structure hinges on the dynamic interaction between scientific innovation and social resources. Scientific innovation requires support from resources such as funding, talent, and institutional frameworks provided by society. Conversely, the outcomes of scientific innovation, by driving production development and enhancing social efficiency, generate additional resources for society[10]. This two-way flow creates a dynamic mechanism that continuously promotes the synchronous evolution of both.

On one hand, social resources provide the foundation

for scientific innovation. The conduct of scientific research relies heavily on financial investment. During the modern scientific revolution, scholars were funded by nobles and the church; in industrial society, enterprises invested R&D funds in scientific institutions[11]; and in the information society, governments use fiscal policies to support basic scientific research. Regardless of the era, financial resources have consistently served as a critical guarantee for scientific breakthroughs.

On the other hand, scientific innovation generates additional resources for society. Scientific breakthroughs drive technological progress, which in turn enhances production efficiency, creates more material wealth, and lays the groundwork for the accumulation of social resources. For instance, information technology, born from the modern scientific revolution, has propelled the development of the digital economy. This has not only created new employment opportunities but also opened up new channels for wealth growth, further expanding the total pool of social resources.

4. Contemporary Insights: Achieving Synchronous Adaptation Between Technological Revolution and Social Structure

4.1. Strengthening Demand-Oriented Scientific Research Planning

Against the backdrop of the contemporary technological revolution, achieving synchronous adaptation between technology and social structure requires strengthening demand-oriented scientific research planning. This ensures that technological development consistently addresses core societal needs and avoids disconnects between research and real-world demands.

On one hand, a linkage mechanism between societal needs and research project establishment should be established. Government research management departments should enhance communication with industries, social governance agencies, and the public. By regularly identifying core societal needs in areas such as economic development, livelihood security, ecological protection, and national security, a comprehensive list of societal demands can be formulated.

On the other hand, deeper integration among industry, academia, research, and application should be promoted. Enterprises should be encouraged to establish long-term collaboration mechanisms with universities and research institutions. Companies can propose technical challenges based on production and market demands, while universities and research institutions focus on addressing these challenges through basic and applied research. This creates a collaborative model where needs are identified by enterprises, research is conducted by academia, and outcomes are transformed by industry [4]. For example, in the field of artificial intelligence, enterprises can collaborate with universities to optimize algorithms and develop data processing technologies tailored to the needs of smart manufacturing and intelligent transportation[12]. This approach accelerates the practical application of AI technologies, meeting the demands of both societal production and daily life.

4.2. Improving the Institutional Adaptation Support System

Institutions serve as a critical bridge connecting technology and society, and their adaptability directly influences the synchronization efficiency between technological revolution and social structure. Therefore, it is essential to refine the institutional adaptation support system to provide institutional backing for technological development and social structural transformation.

In terms of social governance institutions, timely adjustments and improvements must be made to address new challenges arising from technological advancements[13]. For instance, policies and regulations should be updated to respond to ethical, security, and privacy issues brought about by emerging technologies such as artificial intelligence and biotechnology.

In the realm of scientific research management institutions, the evaluation system for research should be optimized. Traditional criteria that prioritize academic publications over practical applications must be reformed. Instead, metrics such as the effectiveness of achievement transformation and the degree to which societal needs are met should be incorporated into research evaluation indicators. This will incentivize researchers to focus on the practical application value of scientific and technological achievements.

Simultaneously, institutions should improve

the system for the transformation of scientific and technological achievements, simplify the transformation process, establish an achievement transformation and connection platform involving research institutions, enterprises, and the government, reduce the costs of transforming scientific and technological achievements, and promote the rapid integration of such achievements into social production and daily life.

4.3. Promoting a Collaborative Mechanism for Public Participation

The synchronous adaptation of the technological revolution and social structure requires the participation not only of governments, enterprises, and research institutions, but also the broad participation of all people, so as to form a multi-stakeholder collaborative promotion pattern[14].

On one hand, channels for public participation in technology and social governance must be expanded. This entails establishing mechanisms for public involvement in the demonstration of scientific research projects and the formulation of technology policies[15]. By collecting public opinions and suggestions on technological development directions and social governance through various means, it can be ensured that technological development and social structural transformation reflect public needs [5].

On the other hand, science popularization education must be strengthened to enhance public scientific literacy. Through school education, science museums, new media platforms, and other channels, scientific knowledge and technological development trends can be disseminated to the public. This helps cultivate scientific thinking and innovation awareness among the public, enabling them to understand the significance and impact of technological revolutions and proactively adapt to social structural changes.

5. Conclusion

The synchronicity between scientific revolution and changes in social structure is an objective law governing the development of human civilization. The two mutually support and shape each other, collectively driving the iterative upgrading of social forms. From the modern scientific revolution propelling the transformation of pre-industrial society, to the classical scientific revolution facilitating the formation of industrial society, and further to the modern scientific revolution guiding the transformation of the information society, historical practice has fully demonstrated that only through the goal alignment of scientific breakthroughs and societal needs, the rhythm adaptation of scientific development and social transformation, and the dynamic interaction between scientific innovation and social resources can the efficient synchronization between technological revolution and social structure be ensured.

In the future, as technology and society continue to evolve, the intrinsic mechanisms and implementation pathways of their synchronicity will undergo constant changes. This necessitates ongoing theoretical research and practical exploration to better grasp historical laws and promote high-quality social development.

Disclosure statement

The author declares no conflict of interest.

References

[1] Zhao M, Li H, 2024, The Evolution of Technological Science and an Examination of Human Subjectivity. Journal of Liaoning University (Philosophy and Social Sciences Edition), 52(6): 92–99.

[2] Li X, 2023, The Openness of the Modernization Process from the Perspective of World Historical Thought. Scientific Socialism, (5): 98–104.

[3] Xu H, 2023, The Dynamic Mechanism of Modernization and Historical Verification of Its Initial Formation. Journal of Nanjing University of Posts and Telecommunications: Social Sciences Edition, 25(1): 1–8.

[4] Xu X D, Chen L, 2021, The Transformation of the Modern "Empirical–Transcendental" Concept and the Scientific Revolution. Studies in Dialectics of Nature, (008): 037.

[5] Zhang J J, Lu N, 2024, Third Discussion on the Fourth Revolution in Anthropology: Research on the "Traditional–Modern" Transformation of Time-Honored Enterprises in the Internet Society from the Perspective of Enterprise Anthropology. Qinghai Journal of Ethnology, 35(2): 99–107.

[6] Shi Y, 2024, Technologically Driven Social Transformation and the Development of Sociology with Chinese Characteristics. The Journal of Humanities, (5): 101.

[7] Zhang C, 2019, Technology, Society, and the Reconstruction of Modernity in the Evolution of Civilization. Frontiers, (14): 51–57.

[8] Hao L, 2021, The Structured Process of Scientific Revolution. China Social Science Digest, 000(008): 45–46.

[9] Ma X, Ying X, 2022, Structure, Action, and History: The Origin and Development of Revolutionary Research from a Sociological Perspective. Social Sciences Digest, (9): 97–99.

[10] Li Z, 2023, Analysis of Social Structure Adjustment and Transformation in the Process of Chinese-Style Modernization. Journal of Hubei University of Economics: Humanities and Social Sciences Edition, 20(10): 4–10.

[11] Hu Q, Wang J, 2024, On Ideological Risks and Governance Under Disruptive Technology. Journal of China Emergency Management Science, (11): 198.

[12] Xiang X, Wan L, Cao J, 2021, The Governance Logic of the Scientific and Technological Revolution and the Path to Improving the Socialist Market Economy System. South China Economy, (09): 1–10.

[13] Zhou G P, Zou X H, 2022, Exploration of Achieving Common Prosperity Under the Background of the "New Industrial Revolution". Journal of Shijiazhuang Tiedao University: Social Sciences Edition, 16(4): 57–63.

[14] Tang X Y, 2022, The Impact of the Modern Scientific and Technological Revolution on Tourism Consumption. Tourism Tribune, (10): 002.

[15] Du M, 2024, The Evolution of the Structure of Scientific Revolution from the Perspective of Dialectics of Nature. Popular Art and Literature, (3): 187.