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Exploring the Paths and Insights for Regional Industrial Upgrading Based on HFS Model

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Abstract: - Given economic globalization and the advancement of information technology, traditional industries face the risk of hollowing out. The rise of de-globalization has challenged China's global economic activities and resulted in supply chain crises. To resolve the current industrial bottlenecks in the country, achieving industrial upgrading is the key. This article applies a HFS (Hardware-Firmware-Software) model inspired by processor systems to the production network framework. It investigates the activities driving industrial upgrading from the perspective of the labor division in value chains and proposes corresponding paths to the goal. By pursuing industrial upgrading, industrial reform can be conducted in areas with limited comparative advantages. This enables industries to move from relying on single advantages to leveraging their comprehensive strengths in competition..

Keywords:HFS model, regional industrial upgrading, path analysis.

I. INTRODUCTION

Industrial upgrading mainly refers to the improvement of the industrial structure within a region and the enhancement of industry quality and efficiency. This is an essential capability for regional economic entities to participate effectively in the global industrial value chain. A region's ability to add value to its industries can be demonstrated by its efficiency in processing the flow of products and information. Against the backdrop of economic globalization, the industrial systems have been established on a global scale, with industrial specialization and division of labor becoming clearer and more refined. The world is currently undergoing unprecedented changes. The international economic environment is now shaped by continuous advancements in information technology, accelerated integration between industries, and increasingly interconnected global production[1].

Regarding China's domestic economic reality, several internal factors, such as the disappearance of the demographic dividend, a substantial increase in labor costs, and changes in the labor structure, have greatly compromised the cost advantages of traditional manufacturing. This has led to a decline in international competitiveness, prompting either the relocation or partial migration of traditional industries. Ultimately, this has caused traditional industries to face the risk of hollowing out, significantly impacting economic stability. The competitive failure of the industries on the global stage will make it challenging for China to overcome the "middle-income trap[2]."

Structurally, a modern industrial system comprises traditional industries, emerging industries, and future industries, each with its unique characteristics and interdependent relationships. Traditional industries serve as the foundation of the modern industrial system, playing an indispensable role in the industrial and supply chains. They are characterized by large scale, diverse product offerings, high output value, and extensive employment opportunities. Therefore, many emerging and future industries cannot fully function without the support from traditional industries, even facing the risk of "chain breakages.[3]"

The development patterns of industrial structures in developed countries also offer valuable insights. It proves that mishandling the relationship between traditional and emerging industries can result in partial industrial hollowing. Excessive dependence on external sources for traditional industries significantly impacts employment and economic growth. If traditional industries fail to achieve transformation and upgrading, the entire industrial chain's supply side will be affected. This renders it out of the question to build a modern industrial system that is self-reliant, secure, reliable, and highly competitive[4-5].

Externally, China is confronting an increasingly tough and complex international environment. The backlash against globalization has presented numerous challenges to China's participation in global economic activities. It has also led to supply chain crises and significantly impacted corporate production. Additionally, frequent local conflicts have caused varying degrees of disruption in global industrial and supply chains, threatening the economic stability of many countries. Industrial upgrading is essential for the integration of international

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industries, thus boosting competitiveness. Actively adapting to and leading the new wave of technological and industrial revolution is necessary to build a robust and modern industrial system[6-7].

The trend of deglobalization compels China to expedite industrial upgrading to create competitive advantages, prevent decoupling from global markets, ascend in the value chain, and solidify its position as a major player in the global supply chain. Industrial upgrading is also of great importance for constructing a new development paradigm that prioritizes China's domestic economic cycle while the international economic cycle remains its extension and supplement[8].

II. THEORETICAL FOUNDATION

The rapid development of technology has strengthened the interconnections between various industries and economies. Production networks, which reflect the input-output relationships between sectors or industries, have gained massive traction from the academic community both domestically and abroad. Scholars have applied production networks to various fields such as economic growth, industrial upgrading, technological innovation, and trade. Its evolution has progressed from analyzing within a closed economic environment to an endogenous analytical framework, and then to an international production network framework suitable for developing economies. As academic research has deepened, this framework has incorporated factors such as endogenous decision-making, market distortions, and technology spillovers, gradually approximating production realities. Research in production networks continues to focus on the transmission effects across multiple sectors while maintaining the network attributes of the industrial chain. Studies on the mechanisms of applying production networks to industrial structure upgrading primarily revolve around driving factors such as production efficiency, input factors, and technological progress, emphasizing the technical aspects of the production process. To find out the paths for China’s industrial upgrading, this article introduces regional attributes into the production networks. It should be noted that specific regional production network nodes share similar market or technological environments, whereas different regional nodes possess distinct comparative advantages. Therefore, it is more effective to develop industrial upgrading paths tailored to a region's comparative advantage[9-10].

On the microscale, industrial upgrading is the aggregation of value-added activities initiated by market entities at production network nodes and transmitted to other production nodes. These represent individual behaviors of market entities during the industrial upgrading process. On the macro layer, industrial upgrading is manifested in the support or services provided by regional public service departments to enhance the value of production network nodes, aiming to alter the public attributes of production nodes within the region[11].

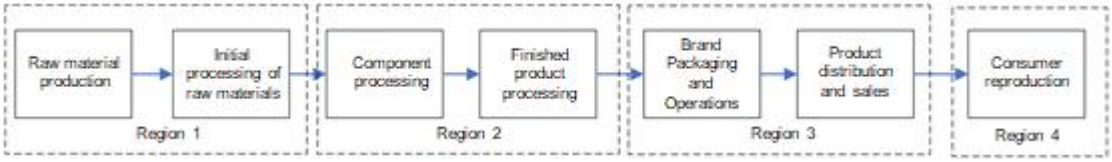


Figure 1, Production Network

Existing research on industrial upgrading based on the production network framework primarily explores the effects of technology spillover, market distortion, production network structure, and effective industrial policy. Inspired by the interplay of key elements of processor systems (hardware, firmware, and software), this article puts forward a HFS (Hardware-Firmware-Software) model and applies it to the production network. The aim is to identify core activities that contribute to industrial upgrading and provide corresponding paths from the perspective of the value chain division. Through industrial upgrading, industries with limited comparative advantages can be improved, thereby moving from relying on single advantages to possessing comprehensive strengths in competition.

The logical relationship diagram of the HFS model proposed in this article is shown below. The hardware layer is the foundation of industrial upgrading, representing the hard power of an industry. This layer is difficult to substitute, and its upgrading takes a long time. Once achieved, it offers a certain degree of scarcity, making it both the focus and the most difficult aspect of industrial upgrading. Without the capability upgrade at the hardware layer, any industrial upgrades at the firmware or software layers will be hard to implement. The software layer is primarily responsible for defining and introducing products, directly addressing user demands and managing customer resources. This layer is characterized by its wide application and diverse demand. The firmware layer facilitates the circulation and matching of resources between the supply and demand sides, aligning market needs with processing capabilities to find the most suitable solutions. It also provides the matching of production factors, such as financial support and talent backing. Moreover, the software and

firmware layers serve as windows that show the progress of industrial upgrading. They represent the soft power of an industry. Without the two layers, the sustainability of hardware upgrades cannot be ensured.

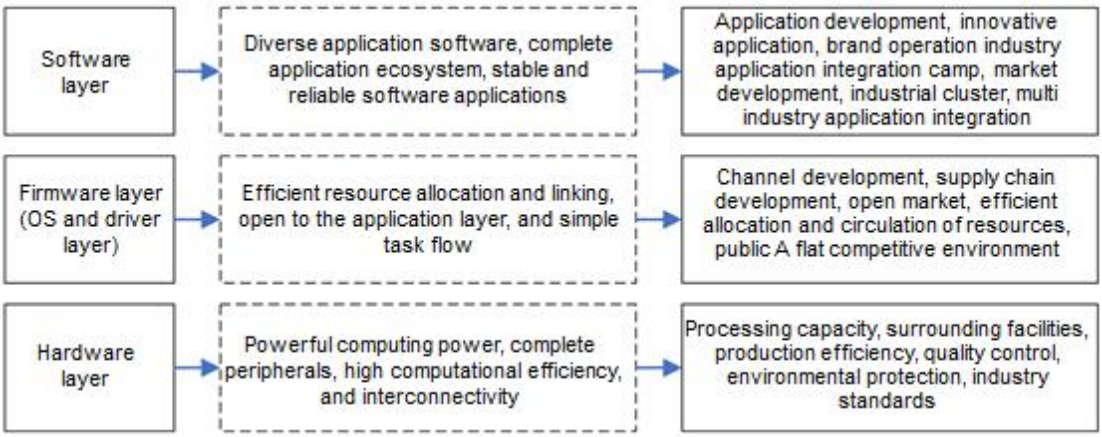
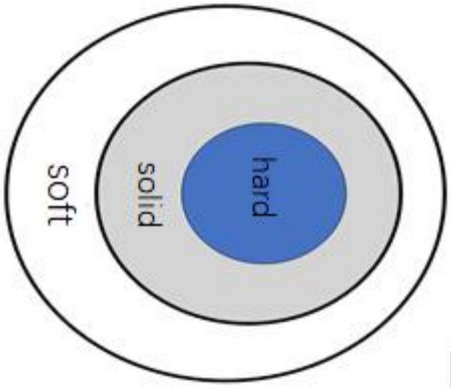


Figure 2: Relation diagram of hard soft solid three model

From the perspective of added value, high added value depends on the balance between the demand side and the supply side. When the industry is demand-driven, the software layer generates higher added value; when it is supply-driven, the hardware layer creates higher added value. The development and upgrading of industries occur through the continuous iteration and balancing between demand and supply. When a region claims advantage points of both the software and hardware, its industries can generate relatively high added value stably.



. Figure 3: Hard soft solid three model

III. PATH ANALYSIS

FBased on the theoretical foundation, the first step involves determining the regional attributes and global industrial positioning to identify current comparative advantages. Subsequently, each layer's industrial upgrading path can be proposed according to the HFS model.

A. Clarify Industrial Positioning and Identify Regional Comparative Advantages

In today's globalized economy, it is hard for a single region to cover all segments of an industry within its boundaries. Therefore, our industrial positioning must be clarified. For resource-exporting industries, it is essential to enhance the initial and deep processing of raw materials, improve the comprehensive utilization rate of resources, and ensure the circulation of raw materials. This involves leveraging regional technological advancements to find more eco-friendly alternative materials for sustainable development. Additionally, it is necessary to identify comparative advantages and, based on the region's factor endowments, select the advantageous industrial segments during the comparative advantage window period. This ensures a positive cycle of R&D investment and output.

B. Enhance Core Industrial Design and Manufacturing Capabilities, and Establish Robust Production Management and Quality Control Systems

The key to acquiring strong manufacturing capabilities lies in boosting industrial efficiency. This can be achieved through technological innovation, which can significantly increase production efficiency. R&D

investment is also necessary in that it can address critical industry challenges and enhance product competitiveness, thereby expanding application markets. Moreover, improvements in materials and processing technology can greatly increase product precision and reliability. Governments can support this by implementing policies that encourage companies to increase their R&D investment ratios and by offering financial rewards for technological breakthroughs and innovations. These measures can guide companies toward independent innovation, thus enhancing manufacturing efficiency and driving significant industry transformations, ultimately building globally competitive industries.

The effort should extend to developing an independent system for manufacturing machine tools. Despite China's strong manufacturing system established since the reform and opening up, most of the automation equipment and high-precision CNC machines used in industrial production are imported. Although this may not have an immediate impact on our manufacturing sector, as our industries advance to world-class layers, reliance on imported machine tools will become a critical bottleneck. The development of these machines and related technologies, which have cross-industry applicability, requires national-layer R&D investments.

Currently, many industries' design abilities and high-end manufacturing systems remain immature. As a crucial aspect of industrial upgrading, the enhancement of these core manufacturing capabilities must be achieved independently. Local governments should align their industrial upgrading plans with the establishment of fundamental research platforms and mechanisms to facilitate the integration of production and research.

Furthermore, standardized production management and quality control systems should be established. Over the past few decades, the introduction of foreign enterprises has enabled China to develop the world's most advanced industrial manufacturing systems. However, recent withdrawals of foreign capital have not only led to a loss of orders and production capacity but have also taken away sophisticated scientific management and quality control systems. These systems are critical soft power for industrial upgrading and are essential for building independent brands.

Another focus should be on integrating traditional manufacturing with emerging Industries. It includes employing automation and smart production to offset the surging labor costs. Digital technologies can also be used to enhance the efficiency of production management and quality control. Local governments should collaborate with leading enterprises to establish demonstration bases, promoting successful pilot experiences across or within industries.

C. Foster Sound Regional Industrial Ecosystem

A robust regional industrial ecosystem boosts overall industry competitiveness by fostering synergies among various production network nodes. If the upstream and downstream supply chains of the core industry nodes and extending segments operate within a region, resource sharing and optimal utilization can be achieved. This can lower the costs associated with product transfers, reduce resource waste, and facilitate centralized waste treatment to minimize environmental pollution.

D. Develop a More Open Market Economy and a Law-Based Business Environment

If the market cannot achieve optimal resource allocation, it impacts enterprises' ability to make innovative decisions, ultimately hindering industrial structural upgrading. In the product market, when market distortions in one sector of the production network change while remaining constant in others, these distortions directly influence that sector's product prices, subsequently affecting other segments' unit production costs. Market distortions in any segment can cause fluctuations in the equilibrium prices across the production network. Higher market distortions lead to increased equilibrium prices, raising production costs and reducing the set of production inputs enterprises can choose from, thereby discouraging innovation. Conversely, lower market distortions result in lower equilibrium prices, reducing production costs, expanding the set of production inputs, and motivating enterprises to invest more in innovations. This will enhance the overall innovation layer and impact industrial structural upgrading. f non-market entities provide production factors within a regional economy, it will inevitably affect the driving force and process of industrial upgrading.

The market economy forms the foundation of economic globalization, with the rule of law ensuring its rational operation. Marketization enables industrial enterprises to achieve optimal resource allocation on a global scale and the fair play of global competition. A law-based business environment ensures that enterprises can dedicate all their resources to production factors, thus fully stimulating the market vitality of private enterprises. Moreover, a highly market-oriented and law-based business environment attracts high-quality foreign enterprises to participate in industrial upgrading. This can drive China's industrial upgrades by leveraging external capital,

new industrial technologies, mature management experience, and product quality control systems brought by foreign investments.

E. Establish Industrial Clusters

Economies of scale can be achieved through the establishment of regional industrial clusters, thereby reducing marginal costs. Industrial clusters effectively share supply chain management, logistics, and marketing systems, further enhancing industry recognition. They address diverse customer needs and reduce the costs associated with meeting these demands. Clusters also create a public platform within the region that facilitates communicating market changes and trends, allowing for timely information sharing to inform design and production processes. In addition, clusters play a critical role in forming a consensus on innovation and development directions. This collective intelligence drives industrial development by transitioning from passively following industry demands to actively creating and guiding them.

IV. Strengthen Application Innovation and Product Definition

China has built a complete industrial system after decades of development. However, China remains a manufacturing hub in the global economy, functioning primarily as an OEM. Brands and sales channels are still controlled by other countries or regions, hence China's manufacturing yields low added value while branding and sales command high added value. Traditional industries mostly involve less complex production processes and are mainly demand-driven. For such industries, it is imperative to quickly establish proprietary brands. Our product definition capabilities and application innovation should be enhanced, extending our business directly to the market, building brands, and opening market channels. While building brands, industries must rigorously maintain quality systems to ensure a positive market cycle. Product definition and innovation, along with product quality control systems, constitute the soft power of industries and are essential for adding value at the application phase of production.

A. Create Leading Multi-Industry Application Integration

Most of China's manufacturing product upgrades are driven by the requirements of end users. They push for improvements in functionality or performance of products, gradually leading to industrial upgrading. In the absence of clear customers and orders, industrial enterprises lack clear targets and directions for improvement. They are also concerned about whether the costs of product upgrades will be compensated by market returns. This reduces their willingness to upgrade products. Without the demand for products that integrate multiple industries, many industrial enterprises will have to independently create application scenarios and conduct corresponding R&D. This slows the product upgrade process.

However, if there is a leading entity for multi-industry application integration, it possesses the capability to define product requirements, and its target products will integrate several industrial products. This entity can transmit technical needs downstream, driving product innovation and setting quality standards for downstream industries. Therefore, having a sufficient number of world-class application integrations capable of stimulating multi-industry product applications can quickly motivate a large portion of the industries to engage in innovative upgrades.

V. Implications for Policy Making

A. Actively Integrate into the Global Industrial Chain and Establish a Free Market Economy and Rule of Law.

Industry upgrading must target the globalized market, participating and integrating into global industrial segments to provide products or services. Analysis of China's dual circulation development model (external and internal) reveals that overreliance on internal circulation may require significant restructuring of the country's industrial system. Under internal circulation, industrial upgrading can only be driven by consumption upgrades. China's relatively centralized consumption patterns, limited purchasing power, and other issues significantly affect its industrial development. Only by shifting the targets to larger, multi-tiered, and large-capacity global consumer markets can industries receive better development. Therefore, actively integrating into the global industrial chain stands as the best choice. A free market economy and a well-established rule of law system are the basis and guarantee for globalization and integration of world economics.

B. Leverage University Research Platforms to Conduct Fundamental Research and Facilitate Technology Transfer.

Industry upgrading faces many challenges and issues. The machine tool industry that manufactures and processes tools for production has always been China's weak link. Additionally, relevant technological blockades by Western countries have made machine tools manufacturing and processing a focal point and a challenge for industrial upgrading. Machine tools are the products of basic technology-intensive industries, characterized by strong technological comprehensiveness, broad disciplinary span, small market scale, low general utility, high research and development cost, and long return cycles. This renders developing the tools in the private sector difficult. However, university research, with its research-oriented nature, is well-suited for fundamental technical research. For one thing, it provides a practical verification path for theoretical learning. For another, it offers platforms for cultivating students and serves as the primary driving force for social development. Government departments should establish mechanisms for cultivating and incubating the industrialization of basic technologies, ensuring that the outcomes of university research platforms can be rapidly transformed into productivity.

C. Make Leading Products and Enterprises Driving Industrial Development

The local governments should roll out policies to guide and support industries, focusing on several brand enterprises with comprehensive products to form the core nodes of the industry chain. This ensures the realization of the industry radiation while driving the development of related industries. Through multi-regional coordination, guided by high-tech, regional advantages can be utilized to create top-tier enterprises and products. A strategy of targeted breakthroughs and widespread development can also be employed to build a series of globally leading enterprise brands and products.

D. Foster More Talent in Basic Academic Disciplines and Improve Employment Mechanisms

Science and technology constitute a primary productive force, and talent is the source of technology and the main force of innovation. China should open wider for global talents to contribute their wisdom to its industries, activating the vitality, motivation, and creativity of talents through institutional design and market mechanisms.

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REFERENCES

[1]Chen, F., & Chen, A. (2021). Research on the development mechanism of the RCEP regional industrial chain and the upgrading path of China's industrial chain. Economist, (6), 70-80.

[2]Li J, Li S, Cheng L, et al. BSAS: A Blockchain-Based Trustworthy and Privacy-Preserving Speed Advisory System[J]. IEEE Transactions on Vehicular Technology, 2022, 71(11): 11421-11430

[3]Hong, J., & Shang, H. (2019). The conjoint circulation theory of China's open economy: Theory and augmentation. Chinese Social Sciences, (1), 42-64.

[4]Liu, Z., & Wu, F. (2018). The dual embedding of the global value chain under the Belt and Road Initiative. Chinese Social Sciences, (8), 17-32.

[5]Yu Z, Pei J, Zhu M, et al. Multi-attribute adaptive aggregation transformer for vehicle re-identification[J]. Information Processing & Management, 2022, 59(2): 102868.

[6]Wang, Y., Huang, Y., & Han, B. (2022). Research progress on production networks and vertical structure. Economic Perspectives, (3), 123-138.

[7]Wu, W., & Liu, J. (2020). Research on the mechanism and path of intelligent manufacturing promoting the transformation and upgrading of China's industry. Journal of Xi'an University of Finance and Economics, (3), 19-26.

[8]Zhong K, Wang Y, Pei J, et al. Super efficiency SBM-DEA and neural network for performance evaluation[J]. Information Processing & Management, 2021, 58(6): 102728.

[9]Xie, Q., & Jin, C. (2023). Industrial structural upgrading in the perspective of production networks:Logical deconstruction and realization path. Journal of Capital University of Economics and Business, (3), 32-42.

[10]Yeung, H. W.-c. (2021). Towards global economic geographies: Strategic Coupling and Global Production Networks Research: An editorial for Geographical Research "Special Issue on Global Production Networks and Strategic Coupling in China." Geographical Research, (12), 3253-3258.

[11] Jan N, Gwak J, Pei J, et al. Analysis of networks and digital systems by using the novel technique based on complex fuzzy soft information[J]. IEEE Transactions on Consumer Electronics, 2022, 69(2): 183-193.