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The Dynamic Evolution Mechanism of the Impact of Automation Technology on the Labor Market Structure

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Abstract: This article focuses on the dynamic evolution mechanism of the impact of automation technology on the structure of the labor market. By sorting out the development context of automation technology, it analyzes its substitution effect, productivity effect and employment creation effect on the structure of the labor market, and reveals the dynamic characteristics such as skill polarization, occupational reconfiguration and organizational form transformation. Research has found that through technological iteration and industry penetration, automation technology has driven the labor market to transform from a "pyramid" structure to a "pyramid-network" hybrid structure, forming an evolutionary trend of expanding skill premiums, the emergence of new occupations, and the networking of organizational collaboration. The research proposes countermeasures such as policy guidance, education system reform and the construction of lifelong learning mechanisms, providing theoretical support for promoting the high-quality development of the labor market.

Keywords: Automation technology; Labor market structure; Dynamic evolution mechanism; Skill polarization; Organizational form transformation

1. The Cyclical Characteristics of Capital Tides and the Paradox of Financialization

The evolution of automation technology was one of the core driving forces of the Industrial Revolution, profoundly transforming human production methods and the structure of the labor market [1]. From mechanization and electrification to digitalization and intelligence, the iteration of automation technology has

driven the reshaping of the global industrial landscape [2]. At present, the new generation of automation technologies represented by artificial intelligence, industrial robots and the Internet of Things are reshaping the supply and demand relationship, occupational distribution and organizational form of the labor market with "efficiency improvement" and "skill reconstruction" as the logical main lines. According to statistics, in 2022, approximately 40% of global jobs were exposed to the influence of automation technology, with this proportion reaching as high as 60% in advanced economies [3]. As the world's largest manufacturing country, China's application of industrial robots accounts for nearly 40% of the global total. The number of robots per 1,000 manufacturing employees in China has exceeded that of developed countries such as the UK and France (IFR, 2023). Against this backdrop, the impact of automation technology on the structure of the labor market has transcended simple job replacement and entered a stage of deep adjustment involving the differentiation of skill demands, the reconstruction of professional values, and the innovation of organizational models.

The impact of automation technology on the labor market is multi-dimensional. From a macro perspective, it promotes economic growth and industrial structure upgrading by enhancing production efficiency and reducing production costs. From a micro perspective, it influences individual career development and income distribution by altering the nature of work tasks and the structure of skill requirements [4]. However, most of the existing research focuses on the static impact of automation technology (such as the measurement of job replacement rate), or is limited to case studies in specific industries and regions, lacking systematic research on the dynamic interaction between technological iteration and market structure. This paper takes the perspective of dynamic evolution as the entry point and, by constructing an analytical framework of "technology iteration - industry penetration - structural adjustment", reveals the long-term impact mechanism of automation technology on the labor market structure, providing a theoretical basis for policy-making.

2. The Development Trajectory of Automation Technology and Its Impact Logic on the Labor Market

2.1 Historical Evolution and Core Characteristics of Automation Technology

The development of automation technology can be divided into four stages: The first stage (late 18th century - mid-19th century) was marked by mechanized production driven by steam engines, achieving the initial liberation of physical labor through the substitution of power [5]; The second stage (late 19th century - mid-20th century) focused on electrification and assembly line production, enhancing production efficiency through standardized processes [6]. The third stage (mid-20th century - early 21st century) made breakthroughs in computer control and numerical control technology to achieve digitalization and flexibility in the production process [7]. The fourth stage (from the 21st century to the present) takes artificial intelligence, industrial robots and the Internet of Things as the carriers, and promotes the intelligent transformation of production methods through intelligent decision-making and autonomous collaboration [8].

The core features of the new generation of automation technology are reflected in three aspects: First, intelligent decision-making capability. Based on deep learning and big data analysis, the automated system can independently optimize production parameters, predict equipment failures and adjust task allocation. Secondly, the human-machine collaboration mode. Through natural language processing and visual recognition technologies, robots can share workspaces with humans and complete high-precision operations and complex tasks. Thirdly, the ability to penetrate across fields. Automation technology has expanded from manufacturing to service sectors such as healthcare, education, and logistics, forming a technological ecosystem that covers the entire industrial chain.

2.2 The Logical Framework of How Automation Technology Affects the Labor Market

The impact of automation technology on the labor market follows the logical chain of "efficiency improvement - skill reconfiguration - structural adjustment". From the perspective of efficiency, automation reduces production costs, enhances product quality and production flexibility by replacing repetitive and procedural tasks. From the perspective of skills, the demand for labor in automation has shifted from "physical execution" to "technical operation" and "innovative management", driving the concentration of skill demands in high-value-added fields. From a structural perspective, automation triggers adjustments in the occupational distribution of the labor market, an expansion of income gaps, and changes in organizational forms through the interaction of substitution effects, productivity effects, and job creation effects.

Specifically, the substitution effect refers to the direct replacement of human labor by automation technology, resulting in a reduction in low-skilled positions. The productivity effect refers to the fact that automation expands the market size by enhancing production efficiency, indirectly increasing the demand for highly skilled labor and complementary positions. The employment creation effect refers to the fact that automation gives rise to emerging occupations such as new technology research and development, system maintenance and data analysis, forming new growth points for employment. The three factors work together to drive the transformation of the labor market from a "pyramid" structure to a "pyramid-network" hybrid structure.

3. The Dynamic Impact Mechanism of Automation Technology on the Labor Market Structure

3.1 Substitution Effect: The Continuous Contraction of Low-skilled Positions

The substitution effect of automation technology is concentrated in low-skilled and repetitive positions. According to the McKinsey Global Institute (MGI), by 2030, approximately 400 million workers worldwide (15% of the total workforce) may lose their jobs due to automation, with manufacturing, logistics, and administrative services being the most affected. In China, the rapid growth in the application of industrial robots has led to a significant decline in the number of traditional assembly, welding and handling positions. For instance,

after an international automotive manufacturing enterprise introduced automated welding robots, the number of welding positions decreased by 40%, but production efficiency increased by 60%.

The transmission mechanism of the substitution effect includes: First, cost-driven. The unit output cost of automated equipment is lower than that of labor. To reduce production costs, enterprises proactively adopt automation technology. Second, precision driven. The operational accuracy and stability of automated systems in repetitive tasks are superior to those of humans, which can reduce the defect rate of products. Thirdly, scale-driven. In large-scale production scenarios, the large-scale application of automation technology can significantly reduce marginal costs and drive enterprises to accelerate technological substitution.

3.2 Productivity Effect: Expansion of High-skilled Positions and Skill Premium

The productivity effect of automation technology is achieved through two paths: First, the direct effect. Automation enhances production efficiency, expands market scale, and indirectly increases the demand for highly skilled labor and complementary positions. For instance, after the application of industrial robots, enterprises need to recruit positions such as robot operators, system integration engineers and data analysts, which will drive up the proportion of highly skilled labor. Secondly, indirect effects. Automation enhances the competitiveness of enterprises by optimizing production processes, reducing inventory costs and shortening delivery cycles, prompting them to expand production scale and further increasing the demand for technical and management talents.

The productivity effect leads to an expansion of the skills premium. According to LinkedIn data, from 2020 to 2023, the demand for AI-related positions (such as machine learning engineers and data analysts) increased by 25%, with an average annual salary of over \$150,000. However, the salaries of low-skilled positions (such as retail cashiers and manufacturing assemblers) have stagnated or declined. The essence of the skills premium is the "screening effect" of automation technology on the labor market: highly skilled labor, due to their technical operation and innovation capabilities, become the "complements" of automation technology. Low-skilled labor, due to the lack of technical adaptability, has become a "substitute" for automation technology.

3.3 Employment Creation Effect: The Emergence of New Occupations and Occupational Restructuring

The employment creation effect of automation technology is concentrated in emerging occupations and job reconfiguration. First, emerging occupations. Automation has given rise to positions such as AI trainers, ethics auditors, and robot maintenance engineers. For instance, AI trainers need to label training data and optimize algorithm models, and their demand grows as the application scope of AI technology expands. Ethical auditors need to ensure the fairness of AI systems and avoid algorithmic biases in recruitment. Their professional value increases as AI ethical issues become more prominent. Second, career restructuring. Traditional occupations achieve skill upgrades through

technological empowerment. For instance, doctors use AI-assisted diagnostic tools to analyze CT scans, shifting their focus to the analysis of difficult cases and the optimization of treatment plans. Teachers utilize AI to generate personalized learning plans, shifting the focus of teaching towards creativity cultivation and emotional interaction.

The driving factors of the employment creation effect include: First, technological iteration. The rapid iteration of automation technology (such as the performance of the GPT series models being surpassed by 18 new models within a year) has given rise to a continuous demand for technical services. Second, industry penetration. Automation technology has expanded from manufacturing to fields such as healthcare, education, and finance, forming cross-industry technical application scenarios. Thirdly, policy guidance. The government promotes the research and development of automation technology through strategies such as "Made in China 2025" and "Industry 4.0", providing fertile ground for the development of emerging occupations.

4. Dynamic Evolution Characteristics of the Labor Market Structure

4.1 Skill Polarization: The Squeezing Out of Intermediate Skill Positions and the Differentiation of Skill Positions at Both Ends

Automation technology has led to a phenomenon of "skill polarization" in the labor market, that is, the proportion of intermediate-skilled positions (such as technical workers and administrative personnel) has declined, while the proportion of high-skilled positions (such as R&D engineers and data analysts) and low-skilled positions (such as basic service personnel) has increased. According to an OECD study, the proportion of high-skilled jobs will rise to 35% in 2025 (25% in 2020), while the proportion of intermediate-skilled jobs will further shrink.

The formation mechanism of skill polarization includes: First, the replacement of conventional cognitive tasks by automation. Intermediate skill positions often involve rule-based and procedural work (such as data entry and report processing), and are easily replaced by automation technology. Secondly, the complementarity of automation to unconventional cognitive tasks. High-skilled positions often involve innovative and decision-making work (such as algorithm design and strategic planning), complementing automation technology. Thirdly, the upgrading of service demands. Among low-skilled positions, some basic services (such as cleaning and security) are retained due to rigid demand, but the salary levels are relatively low.

4.2 Career Reconstruction: From "Physical Execution" to "Technical Operation" and "Innovation Management"

Automation technology drives occupational restructuring, transforming the workforce from "physical execution" to "technical operation" and "innovative management". In the manufacturing sector, traditional assemblers need to learn robot operation and maintenance skills and transform into robot system integration engineers. In the medical field, radiologists need to master the use of AI-assisted diagnostic tools and transform into experts in analyzing difficult

cases. In the field of education, teachers need to utilize AI to generate personalized courses and transform into creativity cultivation mentors.

The essence of career reconstruction is "re-pricing of human-machine capabilities" : automation takes on structured tasks (such as data organization and report generation), while humans focus on unstructured innovations (such as strategic decision-making and emotional interaction). This process requires workers to possess interdisciplinary capabilities (such as data + business analysis), critical thinking and continuous learning abilities, promoting the concentration of professional value in high-value-added fields.

4.3 Organizational Form Transformation: From "Bureaucracy" to "Networked Collaboration"

Automation technology drives the transformation of enterprise organizational forms from "hierarchical" to "networked collaboration". The traditional bureaucratic system is characterized by rigid hierarchies and fixed positions, while networked collaboration is marked by flexible teams, cross-functional collaboration and dynamic task allocation. For instance, data from Microsoft Teams platform shows that employees who use AI collaboration tools have seen a 45% increase in cross-departmental project engagement and a 30% improvement in team decision-making efficiency.

The driving factors of organizational form transformation include: First, the task decomposition ability of automation technology. AI can break down complex tasks into sub-tasks and assign them to teams with different skills. Secondly, data-driven decision optimization. AI supports dynamic resource allocation through real-time data analysis, enhancing organizational flexibility. Thirdly, there is a need for cross-disciplinary collaboration. The cross-industry application of automation technology requires organizations to have the ability to integrate multi-disciplinary knowledge, promoting the blurring of team boundaries.

5. Response Strategies and Policy Recommendations

5.1 Policy Guidance: Balancing Substitution Effects and Employment Creation Effects

The government needs to balance the substitution effect and job creation effect of automation technology through policy tools. First, establish a special skills training fund. In collaboration with vocational colleges and leading enterprises in the industry, we offer customized training courses to help low-skilled workers master new skills such as robot operation and basic programming, enabling them to transition to high-skilled positions. Second, introduce policies to encourage enterprises to adopt automation. Such as tax reduction and exemption, equipment subsidies, loan preferences, etc., to promote enterprises to enhance production efficiency, while requiring enterprises to hire the transformed workers in proportion. Thirdly, improve the social security system. Expand the coverage of unemployment insurance, strengthen re-employment training, and provide basic living security and skill improvement support for workers who have lost their jobs due to automation.

5.2 Education System Reform: Cultivate a Workforce Capable of Adapting to the Era of Automation

The education system needs to shift from "knowledge imparting" to "skills cultivation" and "innovation ability shaping". First, adjust the professional Settings. Add courses such as AI fundamentals, data analysis, and machine learning, and reduce the enrollment scale of traditional low-skill majors. Second, strengthen interdisciplinary education. Promote the cultivation model of compound talents such as "data science + Business Management" and "Artificial Intelligence + Medicine" to enhance the cross-disciplinary collaboration ability of workers. Thirdly, establish a lifelong learning mechanism. Continuous skill update courses are provided through online education platforms such as Coursera and edX to encourage workers to adapt to technological iterations.

5.3 Labor Relations Adjustment: Establishing a New Type of Contract for Human-machine Collaboration

Labor-capital relations need to shift from "opposition" to "collaboration", and a new type of contract featuring human-machine symbiosis should be established. First, implement a flexible employment model. Meet the short-term labor demands of enterprises through outsourcing, part-time work, temporary workers and other means, and reduce the impact of automation substitution on full-time employees. Second, establish a skills-oriented salary system. Link skill certification with salary levels to motivate workers to enhance their technical capabilities. Thirdly, improve the collective consultation mechanism. Through consultation between trade unions and enterprises, working hours, skills training and career development plans under the application of automation technology are formulated to safeguard the rights and interests of workers.

6. Conclusion

The impact of automation technology on the structure of the labor market is a dynamic evolution process. Through the interaction of substitution effect, productivity effect and employment creation effect, it promotes the transformation of the labor market from a "pyramid" structure to a "pyramid-network" mixed structure. During this process, skill polarization, career restructuring and organizational form transformation have become core features, which require policymakers, educational institutions and enterprises to respond in a coordinated manner. Through skills training, education system reform and labor relations adjustment, high-quality development of the labor market can be achieved.

Future research can further explore the following issues: First, the heterogeneous impact of the penetration differences of automation technology in different industries and regions on the structure of the labor market; Secondly, the impact mechanism of emerging issues such as artificial intelligence ethics and data security on the labor market; Thirdly, in the context of globalization, the international transfer of automation technology poses challenges and opportunities to the labor markets of developing countries. By deepening research in these fields, more comprehensive theoretical support can be

provided for constructing labor market policies that adapt to the era of automation.

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