The Implications of U.S. Industry Assessment Methods for China's Industrial Competitiveness Assessment

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Abstract—Competition and cooperation are the keynote of the future development of large countries, and building a solid industrial base and a resilient supply chain has become a key consideration for manufacturing powers to control industrial security and secure their competitive position. The U.S. approach to industrial base and supply chain assessment and risk identification has become a set of horizontal and vertical, point and surface combination of a more complete methodological system after years of development. Through the in-depth study of the U.S. industrial base assessment method, it provides a new inspiration for China to establish an industrial base and industrial competitiveness assessment system. Through the use of big data analysis model to establish industrial competitiveness assessment model and enterprise multi-attribute platform architecture, it provides a fully quantitative assessment tool for enterprises to realize the shortcomings of the industry and strengthen the advantages of the longcomings.

Keywords-industrial base; industrial competitiveness; assessment; multi-attribute analysis; big data analytics

1. Introduction

With the Russia-Ukraine war and secondary sanctions, the continuous evolution of the US strategic containment strategy against China, and the complex and severe situation of the global COVID-19 pandemic, the global economy is facing a high degree of uncertainty, and the restructuring of the industrial chain, supply chain and emerging technology competition is accelerating. The competition among major powers is fundamentally about the competition of industrial basic capabilities. Basic industrial capacity determines the overall quality, comprehensive strength and core competitiveness of a country or region's industries, and is the key support for the high-quality development of the manufacturing industry. In recent years, major developed countries in the world have implemented strategic measures aimed at improving the basic capability of national defense industry, constantly strengthening the assessment of basic capability and supply chain resilience, and strengthening the guidance of government industrial policies. Since the 1980s, the US has continuously carried out industrial assessment, aiming to build a secure and resilient supply chain system, control the international competitive advantage of key and emerging technologies, and accurately contain the industrial development of competitor countries. It is of great significance to win the battle to upgrade the industrial base and modernize the industrial chain under the current situation to study the US industrial evaluation practices, timely launch the investigation and evaluation of China's industrial com-

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petitiveness, identify the risks of key industrial chains and supply chains, and prevent systematic risks.

This paper mainly analyzes and summarizes the background of industrial assessment in the United States, the assessment measures and the effectiveness after the implementation of the assessment, and establishes the assessment model by taking the domestic manufacturing intelligent assessment as an example, divides the manufacturing enterprises into attributes by using the big data analysis model method, and facilitates the manufacturing enterprises to have a clear positioning and clear development goals for themselves through the user portrait method.

2. Background of U.S. industrial competitiveness assessment

2.1 The deindustrialization strategy of U.S. has a significant impact on its industrial base

The rise of manufacturing industry was the key driving force for the rapid development of the United States in the 20th century. After the baptism of the two world wars, the United States remained the world's largest manufacturing power, laying the industrial foundation for its hegemony in the world for a long time. Since the 1970s, due to the transformation of international competition pattern and the development of virtual economy such as service industry, the United States has moved toward the era of "deindustrialization". In the early 21st century, the proportion of manufacturing value added in the GDP of the United States has been declining year by year, to only 11% in 2019, and the proportion of employment has also been declining. Since 2014, the growth of labor productivity in the United States has stagnated, exacerbating the disadvantage of labor cost. With the rapid development of developed European countries and East Asian economies, the development of the US manufacturing industry is faced with domestic and foreign troubles, which has weakened the industrial base to a certain extent.

2.2 The rise of China and other developing countries is regarded by the United States as both military and economic threats

Since the 21st century, "China threat opinion", emerging markets in the United States from the Bush administration's "China is a competitor, is not a strategic partner", to the Obama administration to contain China "Asia-Pacific rebalancing strategy" for the purpose of, the government "all government" Trump "the whole society" containment policy toward China, and then to Joe Biden, the government actively promote the "five eyes alliance" groups such as confrontation, The US has positioned China as "a more powerful economic competitor than the Soviet Union during the Cold War". Released in 2021, the US national security strategy of interim guidelines ", made clear that China is the only potential comprehensive strength to challenge the existing international system of "main competitors", put forward only with a solid industrial foundation and emerging technologies to strengthen the competitive advantage, "speed up the response to China's growing multidisciplinary threat" has become the United States defense strategic objectives. Assessing the basic capability of the US defense industry against China is an important reference for the U.S. to come up with countermeasures against "threats".

2.3 The U.S. defense industrial base adequately reflects the majority of the U.S. industrial base

According to the U.S. National Defense Authorization Act definition, the defense industrial base for the United States, Canada, the United Kingdom, Australia and other developed countries with a high degree of synergy of industrial base capabilities in order to ensure that the United States has an absolute advantage in competition, deterrence, and victory in the technology and industrial base. U.S. defense industry output accounts for more than 1/3 of the manufacturing industry, and exports account for more than 1/3 of the global total. On the one hand, in terms of constituent elements, the defense industrial base includes six major elements of manufacturers, systems integrators, service providers, technology innovators, laboratories and research institutions, and other suppliers interconnected through regional, national, and global supply chains that provide superior tools, capabilities, and resources for U.S. warfighting. In addition, the U.S. has long promoted an integrated civil-military strategy, which has basically achieved a two-way transfer of dual-use technologies and resources to jointly support economic development and national defense construction. On the other hand, from the scope of the U.S. defense industry-based assessment in recent years, it has continuously strengthened the comprehensive assessment of the U.S. manufacturing industry, defense industry base and supply chain, and the assessment scope includes industrial mother machines, industrial software, new materials, basic components, electronic equipment and other basic industries, in addition to aviation, aerospace, ships, weapons and other narrowly defined military industries[1].

3. Major measures of U.S. industry competitiveness assessment

3.1 Upgrade industrial base and supply chain resilience assessment to state action by decree

At present, the US has formed an evaluation system dominated by the Department of Defense and coordinated by multiple government departments. In a sense, it is quite like the "nationwide system", which guarantees the objectivity, accuracy and sustainability of evaluation from the organizational and institutional aspects. Since the 1950s, the U.S. has enacted six acts to gradually elevate industrial base assessment to a national act, as shown in the timeline in **Fig. 1**.

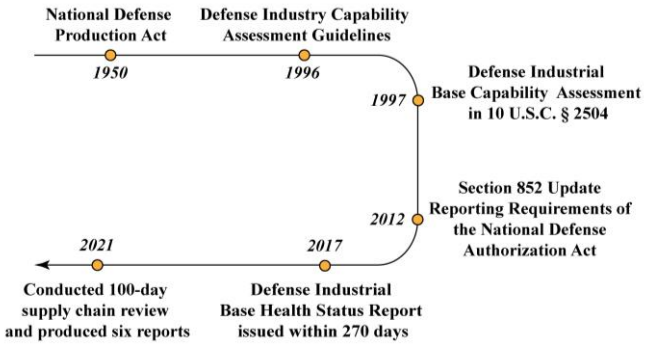

Fig. 1 Timeline of relevant U.S. laws and regulations

The 1950 National Defense Production Act authorized the US Department of Commerce to conduct industry and critical technology product evaluation, and required relevant parties to cooperate with the investigation and evaluation, or they would be punished. In 1996, the US Department of Defense issued the Defense Industry Capability Assessment Directive and the accompanying Defense Industry Capability Assessment Guidelines[2], which set the standards and procedures for the assessment. In 1997, the US Congress formally wrote the Defense industry Basic Capability Assessment into Article 2504 of Volume 10 of the United States Code, requiring the Department of Defense to submit the defense industry basic capability assessment report to the Congress before March 1 each year, and take it as an important basis for decision-making in formulating defense industry policies and preparing the budget for the next fiscal year[3]. Section 852 of the National Defense Authorization Act for Fiscal Year 2012 requires that the annual industrial base report should include an assessment of the status of the industrial base. In 2017, President Trump signed Executive Order 13806, which required departments to issue a report of the health of the defense industrial base within 270 days. In February 2021, Biden signed Executive Order 14017, directing seven departments - Defense, Commerce, Transportation, Energy, Agriculture, Health and Human Services, and Homeland Security - to conduct 100-day supply chain reviews and produce six reports on industries such as semiconductors, high-capacity batteries, mineral materials, and pharmaceuticals, with recommendations for evaluation every four years to support the long-term implementation of the U.S. supply chain strategy[4].

3.2 Extensive mobilization to establish a regular evaluation mechanism coordinated by multiple departments

Currently, the U.S. Department of Defense, Department of Commerce, and the U.S. Government Accountability Office are the primary departments conducting industrial base and supply chain security assessments. To date, the U.S. Department of Commerce and the Department of Defense have submitted more than one hundred industrial assessment reports to Congress.

The U.S. Department of Commerce's Industrial Base Assessment or Supply Chain Security Assessment reports are basically commissioned by the U.S. Congress, the U.S. Department of Defense and other military services. The U.S. Department of Commerce started the Defense Industrial Base Assessment in 1986, mainly carrying out assessments of the impact of imported key products on national security, critical technology assessments, and industrial base assessments of typical areas, covering more than 50 industry sectors or technology directions. supply chain security assessments began in 2015, all commissioned by the Department of Defense [5]. The Department of Defense's report is usually with the labor department, the Department of Energy and the Department of Homeland Security and the Ministry of Commerce, and with the Ministry of the Interior, Health and Human Services, Office of Management and Budget director, director of National Intelligence, national security affairs assistant to the President, assistant to the President of economic policy and trade negotiation and making policies such as assistant to the President. In the year since Executive Order 13806 was implemented, more than 300 different working groups have been involved in report preparation. At the same time, the National Defense Industry Association of the United States and the RAND Think Tank's defense think tank were commissioned to prepare the thematic evaluation report.

3.3 Constantly improve and expand the assessment elements and dimensions

The U.S. basic assessment of the defense industry has gone through stages of supply capability assessment for specific products or services, supplier-by-supplier assessment, industry assessment, and comprehensive assessment, reflecting the evolutionary development from point to surface to deep expansion, and from qualitative assessment to a combination of qualitative and quantitative assessment.

The U.S. Department of Commerce's Defense Industrial Base Assessment focuses on potential risks caused by foreign procurement and dependence on key products, identifying supply chain weaknesses, and measuring emergency response capabilities. The key time points of the assessment systems established by the U.S. Department of Defense over the last 20 years or so and the assessment methods used are shown in **table 1**.

Table 1 Key nodes in the assessment system established by the U.S. Department of Defense over the last 20 years

Step	***Years***	***Specific content***
1	1996	A system of assessment methods is defined
2	2017	Updated assessment methods in some areas
3	2020	For the first time, a comprehensive quantitative assessment method is proposed to show the risk level in a comprehensive index assessment
4	2022	A purely quantitative analytical assessment method was used

The U.S. Department of Commerce's Defense Industrial Base Assessment focuses on the potential risks posed by foreign procurement and reliance on critical products, identifying supply chain vulnerabilities, and measuring emergency response capabilities. The U.S. Department of Defense established a system of assessment methods in 1996 that focuses on criticality and supply chain vulnerability assessments. In 2017, the U.S. Department of Defense updated the assessment methodology based on risk management theory in four areas: risk identification, risk analysis, risk linkage, and risk monitoring. Since 2020, the National Defense Industrial Association (NDIA), commissioned by the U.S. Department of Defense, has proposed a comprehensive quantitative assessment methodology for the first time to demonstrate risk levels and trends in key industrial base areas in a comprehensive index assessment[6]. A special assessment of the industrial base in key areas such as quantum, commissioned by the U.S. Department of Defense through 2022 from RAND Intelligence, uses a purely quantitative analytical assessment approach.

3.4 Accurate benchmarking, the evaluation results as the reference basis for development strategy

In recent years, the U.S. Defense Industrial Base Capability Assessment has used China as a major competitor for comprehensive benchmarking. For example, in the 2018 U.S. Department of Defense Report 13806, the words "China" and "Beijing" appear 232 times, while "Russia" appears only once. In February 2022, the RAND Corporation proposed a common assessment methodology that could be applied to any country, first assessing China as re-

quired by the National Defense Authorization Act for Fiscal Year 2021, and releasing the reports "Assessment of Systemic Strengths and Weaknesses in China's Defense Industrial Base" and "Assessment of the U.S.-China Industrial Base for Quantum Technologies[7].

4. US assessment of implementation effectiveness

The US has long used the results of industrial evaluation as an important basis for making and adjusting industrial policies, including investment budgets and procurement decisions, so as to match industrial base capabilities with national defense needs.

In 2018, the US Department of Defense released a report titled "Assessing and Strengthening the US Manufacturing and Defense Industrial Base and Supply Chain Resilience", which clearly proposed measures such as "expanding investment in scarce defense industrial capabilities, manufacturing technology research and development, increasing direct investment in lower levels of the supply chain, and expanding local production capacity". Referring to the recommendations of the assessment report, Trump issued 14 presidential decisions in 2019, including advanced manufacturing technology and rare earths, to address supply issues in key areas[8]. In the same year, the US Department of Defense implemented the "Industrial Base Analysis and Maintenance" program to invest in a series of projects, including the naval propulsion plant casting project, in an effort to wean itself off foreign dependence.

In early 2022, the U.S. released "Progress on the First Anniversary of the U.S. Supply Chain Executive Order", a systematic summary of the effects of the implementation of Executive Order 14017. First, with reference to the results of the assessment of the industrial base and supply chain, the U.S. government established the Supply Chain Disruption Task Force (SCDTF) in June 2021 to lead departments to take a series of actions to strengthen the critical supply chain. Next, increase supply chain cooperation with allies, reduce dependence on competitors such as China for key products, and focus on supply chain resilience with key partners and allies through the Indo-Pacific Economic Framework. Next, advance competitiveness legislation across the board, such as the House-passed Creating American Manufacturing Opportunity, Technology Leadership, and Economic Strength (Competition) Act and the Senate-passed American Innovation and Competition Act, for strengthening America's world-leading R&D ecosystem and revitalizing a diverse industrial base. Then, mechanisms to identify long-term responses to supply chain disruptions are established, such as for the semiconductor industry, where the SCDTF has established a supply chain early warning system to monitor the risk of supply chain disruptions in the event of a forecasted epidemic. Subsequently, in a historic investment in maintaining long-term supply chain resilience, the House and Senate approved more than $50 billion for semiconductor manufacturing, effectively reducing the impact of the epidemic on the U.S. semiconductor industry and facilitating new supply chain partnerships between semiconductor companies and automakers. In terms of financial support in related areas, the Department of Energy invested $7 billion to support the battery supply chain and $60 billion to support the deployment of clean energy infrastructure, the Department of Defense invested $35 million in the reproduction and processing of rare earths, and the Treasury Department proposed more than $70 billion in loans and investments for manufacturing SMEs over the next decade. Investment from the private sector has been stimulated,

such as $80 billion in semiconductor manufacturing and $100 billion in batteries and electric vehicles.

Referring to the results of the industry assessment, the massive investment in key industrial supply chains has effectively stimulated a historic recovery in domestic production, resulting in the largest number of jobs in nearly 30 years, adding a significant number of manufacturing jobs and effectively contributing to GDP reaching pre-epidemic levels.

5. The Enlightenment for the Evaluation of China's Industrial Competitiveness

By analyzing the reasons for the formation of the U.S. Department of Defense's industrial assessment method system since 1996, the establishment of the assessment method and the effects after the assessment, it is aimed at providing formulated ideas for the development of the domestic manufacturing industry assessment. Through the continuous adjustment and revision of the industrial base assessment method in the United States, it is enough to reflect the importance of building a healthy and safe manufacturing industry system to the national economic development. No matter how the assessment method is adjusted, the adjustment direction is always around the improvement of the risk factors of the manufacturing industry. Therefore, for the development of China's manufacturing industry, while continuously promoting the development of manufacturing intelligence and digitalization, a sound industrial assessment system should be established, and the assessment of industrial risks should run through the main line of assessment. For the analysis of the above-mentioned American industrial competitiveness assessment method system, the following insights are available for the domestic manufacturing competitiveness assessment.

5.1 Establish a systematic industrial evaluation system method as soon as possible

Competition and cooperation are the keynote of the future development of large countries, and building a solid industrial base and a resilient supply chain has become a key consideration for each manufacturing power to control industrial security and secure their competitive position. The U.S. approach to the assessment and risk identification of its industrial base and supply chain has become a set of horizontal and vertical, point and surface combination of a more complete methodological system after years of development, and has begun to use quantitative assessment methods for China to carry out special assessments of the manufacturing industry. In today's increasingly complex international environment, instability and uncertainty are increasing, China's manufacturing industry has shown large and resilient, but the industrial base is still relatively weak, therefore, it is urgent to determine the weak position of manufacturing industry. Domestic industrial base and industrial competitiveness assessment system should be established as soon as possible, and special investigation and evaluation should be carried out for key industries and strategic resources related to national security, in order to help make up for the shortcomings of industries and strengthen the advantages of strengths, and deeply integrate into the ever-changing international division of labor pattern.

5.2 Establish a widely mobilized evaluation organization and mobilization mechanism

Throughout the years, the evolution and application practices of the defense industrial base and supply chain assessment methods in the United States have been based on relevant stat-

utes and national strategic requirements. With the Department of Defense as the main leader, various departments collaborated to conduct extensive enterprise surveys and literature analysis. It is suggested that relevant national departments should jointly establish a collaborative assessment mechanism, mobilize relevant think tanks and industry associations, establish an industrial competitiveness assessment expert committee, conduct systematic research on key enterprises in various industrial fields, and adopt a fully quantitative assessment method to obtain practical industrial and enterprise development data.

5.3 Carry out dynamic risk monitoring of industrial chain and supply chain

According to the above analysis, industry chain security and controllability are the core objectives of the U.S. industrial base assessment, and risk identification and assessment are key elements of the U.S. assessment methodology adjustment in recent years. Therefore, from the perspective of risk management, based on the assessment results of each industry, we will sort out the key risk points of the industrial chain, carry out dynamic monitoring and assessment and risk prediction, establish a global supplier backup network, and promote the matching of supply and demand in extreme situations.

5.4 Formulate response strategies based on the results of industry assessment

Carrying out industrial base and competitiveness assessment is urgently needed for national industrial development strategy, and the requirements for outputs should include, in addition to detailed assessment and analysis reports, trade countermeasures policy recommendations, backup supplier lists, technology product control list recommendations, industry chain supply chain key risk point lists, advantageous emerging technologies and long-board product lists, etc. The assessment results can be used to support the formulation of strategic planning for industrial development, industrial control policy reserves, the first set of major technology and equipment policy deepening, short board tackling and technological reform investment project establishment, science and technology innovation and investment guidance, etc.

6. Establishing an industrial competitiveness assessment model

In response to the above revelation, taking the development of manufacturing intelligent upgrade as an example, on the one hand, through the preliminary quantitative assessment of manufacturing enterprises gradually carried out the intelligent manufacturing maturity level assessment, grasping the development level of domestic manufacturing enterprises from the whole, and the government provides corresponding investment funds for intelligent manufacturing upgrade, promoting the development of enterprises in the direction of intelligence with incentive mechanism, enhancing the competitiveness of manufacturing industry, making the industrial The government will provide investment funds for upgrading intelligent manufacturing to promote the development of enterprises in the direction of intelligence, enhance the competitiveness of manufacturing industry, and make the industry move from low-end to high-end manufacturing. On the other hand, while upgrading the intelligence of manufacturing industry, it is also enhancing the ability of manufacturing industry chain system to fight against risks. Besides, in the process of upgrading, the manufacturing industry is also improving the competitiveness and stability of the manufacturing industry system.

6.1 Industrial competitiveness maturity evaluation process

In order to facilitate the quantitative assessment of the development of manufacturing enterprises, an industrial competitiveness assessment process is established as shown in **Fig. 2**. First, we collect data on the development of enterprises in the form of research or questionnaires, then establish a multi-dimensional industry assessment model based on the data, and finally form an industry maturity assessment report.

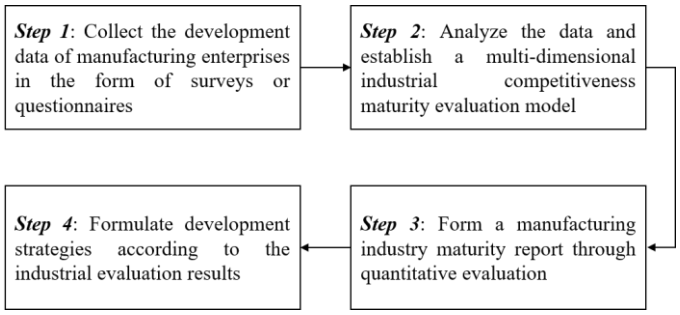

Fig. 2 Industry Competitiveness Assessment Steps

6.2 Establishing a multi-dimensional industry competitiveness assessment model

Regarding the establishment of the industrial competitiveness assessment model, it is realized based on the maturity model framework proposed by Schumacher et al[9], where the assessment of industrial competitiveness maturity is finally realized through a fully quantitative analysis and through a hierarchy, such as from 1-"not at all" to 5- " fully equipped" model to complete the assessment content. For different dimensions with different weights, the calculation model is not complicated, and the specific calculation model uses the following formula to complete the calculation of maturity level:

$$D_k = \frac{\sum_{i=1}^{n} D_{ki} \times \alpha_{ki}}{\sum_{i=1}^{n} \alpha_{ki}}$$

Where: $\boldsymbol{D_k}$- dimension; $\boldsymbol{D_{ki}}$- *i*-th item in this industry dimension; $\boldsymbol{\alpha}$- weighting coefficient; $\boldsymbol{n}$- number of items contained in the industry under this dimension.

Representing the final results obtained from industrial competitiveness in different dimensions on a radar chart makes the calculation results clear at a glance, and also facilitates the next step.

6.3 Building a multi-attribute analysis platform architecture for manufacturing companies

With the development of industrial Internet, big data analysis technology has been applied to various fields in order to achieve refined assessment and analysis. After the evaluation and analysis of manufacturing enterprises through the above model, due to the huge number of manufacturing enterprises and the huge amount of data generated, it is necessary to use some big data analysis methods to achieve accurate evaluation of enterprises, for example, to complete the user portrait of enterprises through multi-attribute analysis to realize the planning of personalized and customized development of high-quality enterprises.

The essence of user portrait modeling for enterprises is to "label" the enterprises, and there are three types of labeling methods, namely, statistical labeling, rule-based labeling and machine learning mining labeling. In the early stage, we collected relevant enterprise development data through enterprise research to establish a multi-attribute analysis platform architecture for manufacturing enterprises as shown in **Fig. 3**, which mainly contains data layer, technology layer and application layer. The proposed platform architecture is used to establish an effective manufacturing enterprise assessment service system, so as to realize the competitiveness assessment of manufacturing industry.

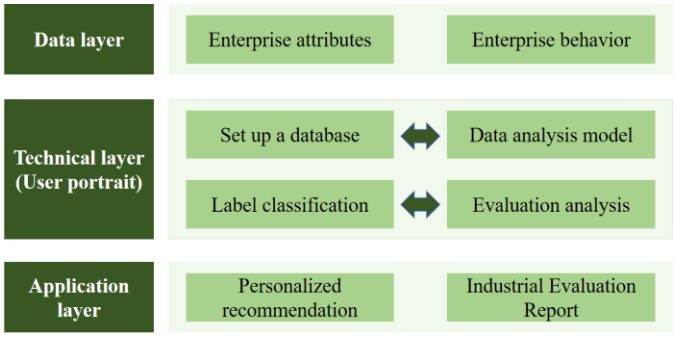

Fig. 3 Multi-attribute analysis platform architecture for manufacturing enterprises

The specific platform architecture is designed as follows.

(i) The data layer is the foundation for establishing a multi-attribute analysis platform, which is also shaped by a large amount of enterprise data, where the data source mainly contains enterprise attributes and enterprise behaviors. Enterprise attributes are objective data used for evaluation and labeling, and contain some basic and special attributes of enterprises. Enterprise behavior is subjective data, which can be used to reflect the correlation between enterprises. These data can provide the basis for establishing data analysis models.

(ii) The technical layer is the core of the platform architecture, using big data technology to establish a database of cleaned data and output labels after establishing mutual mapping relationships between the database and the data analysis model. Then the enterprises are classified according to the tags, and the tagged enterprises are evaluated and analyzed through different dimensions.

(iii) The application layer is to realize the application of evaluation and analysis results, mainly including personalized recommendation and output industry evaluation report. This layer is also the most intuitive layer to reflect the platform architecture functions, and the functions of the application layer can be used to realize the understanding of industry dynamics and more accurate access to enterprise development data.

7. Conclusion

A detailed analysis of the background of the assessment system of the industrial base and supply chain in the U.S., how it was established, the assessment measures, and the effectiveness of the implementation of the assessment is presented. Based on the results of the analysis, in order

to evaluate the competitiveness of China's industries, an industrial competitiveness assessment model and an enterprise multi-attribute analysis platform structure are established to evaluate the intelligence of existing industries. The next work plan will be to subdivide the assessment granularity and realize the application verification of enterprise assessment.

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