



# Modernization of Nonferrous Metals Industry Chain in Jiangxi Province: Achievements, Difficulties and Pathways

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**Abstract.** As the first pillar industry in Jiangxi province, the nonferrous metals industry faces the intense contradiction between economic growth and energy & environment constraints. Promoting the modernization of nonferrous metals industrial chain, especially rare earth, tungsten and copper, is an important measure and an inevitable requirement for ensuring the healthy development of Jiangxi's economy. In recent years, progress has been achieved, involving the construction of a complete industrial chain and chain leader-owner system. However, it faces a variety of problems including imbalance in industrial development, lack of professional and technical personnel and insufficient synergy of collaborative innovation. Consequently, policy support, technological innovation and green transformation should be put forward to foster the modernization of nonferrous metals industrial chain in Jiangxi province.

**Keywords:** Nonferrous Metals Industry, Industrial Chain Modernization, Jiangxi Province.

## 1 Introduction

As a fundamental raw material industry for national economic development, the non-ferrous metals industry is characterized by diversified products, extensive application and high industrial correlation. Jiangxi province is abundant in nonferrous metal resources, especially "seven golden flowers" of Jiangxi, such as copper, tungsten, uranium, tantalum, rare earth, gold and silver. Among them, copper, tungsten and rare earth are more characteristic, basically forming a systematic production from minerals, smelting products, processed materials to applied products, and gradually extending to the field of deep-processing, high-technology and high-value-added products<sup>[1]</sup>. According to the "1269" action plan in Jiangxi province, the nonferrous metals industry chain is the top two key manufacturing industrial chain whose annual main income should reach the trillion level.

The concept of the industrial chain can be traced back to discussions on the division of labor by classical mainstream economists in England represented by Adam Smith in the mid-to-late 17th century. Since then, a limited number of foreign studies

have explored the industrial chain, focusing on its conceptual definition<sup>[2]</sup>, the vertical control and expansion strategies employed by industrial chain manufacturers<sup>[3]</sup>, and the potential risks of industrial chain integration to the core competence of enterprises<sup>[4]</sup>.

A multitude of related studies in China have emerged since the concept of industrial chain modernization was put forward at the Fifth Meeting of the Central Finance and Economy Commission in 2019. Both theoretical and practical departments have delved into its connotation, development path and etc. As to the connotation of industrial chain modernization, a comprehensive definition means: (1) technological innovation reaches the global advance level and the core technologies of crucial links can be independently controlled; (2) the pillar industries in general move up to the middle and high end of the global value chain and make organic linkage between the industrial chain, technological chain, capital chain and talent chain; (3) the chain owner enterprise has a robust governance ability while enterprises have an in-depth division of labor but high synergy and strong resilience<sup>[5]</sup>. Moreover, there is a clear trend towards greening, ecology, digitalization, intelligence, and networking<sup>[6]</sup>. Certain scholars have further emphasized that the essence of industrial chain modernization lies in the modernization of the industry chain level, which includes the modernization process of industrial basic capacity enhancement, operation mode optimization, industry chain control enhancement and governance capacity enhancement, etc.<sup>[7]</sup>. Subsequently, scholars have expanded this concept to specific sectors such as the manufacturing industry<sup>[8,9]</sup>, digital culture industry<sup>[10]</sup>, sports industry<sup>[11]</sup> and agriculture<sup>[12]</sup>. Furthermore, the modernization of the industrial chain in Hubei province<sup>[13]</sup> and the manufacturing industry chain in Fujian province<sup>[14]</sup> have also been analyzed.

With regard to the development path of industrial chain modernization, the enhancement of the existing supply chain is crucial, whose four fundamental driving mechanisms are terminal demand, factor supply, regional industrial layout and integration into the global industrial division of labor system<sup>[15]</sup>. Concretely speaking, the objective of industrial chain modernization is to establish an autonomous and controllable modern industrial system. On the one hand, deploy the innovation chain in conjunction with the industrial chain and identify key technological breakthroughs within the industrial chain as sources of innovation. Thus, collaboration with industry, academia and research institutes is also crucial for constructing the industrial innovation chain and breaking new grounds in scientific and technological transformation pathways. On the other hand, design the industrial chain around the innovation chain, foster the industrial chain owner enterprise and promote open innovation so as to break through the existing industrial organization and external circulation modes<sup>[16]</sup>. In relation to China's non-ferrous metal industry, based on enhancing the safety net of the entire industrial chain and the realization of green development, it is imperative to consolidate the supply base of mineral resources and promote energy conservation, emissions reduction, cleaner production and recycling economy<sup>[17]</sup>.

With the trend of economic globalization and rapid technological advancement since the mid-to-late 20th century, the issue of industrial chain has become a new field and hot issue in modern industrial economics research. Researches on the connotation and pathway of industrial chain modernization primarily focuses on the en-

hancement of industrial basic capacities, optimization of operation modes, enhancement of industrial chain control and governance capacities, while the research object has expanded from the national level to specific regions, specific industries and specific industries within certain regions. However, the available literature is scarce, especially regarding the study of industrial chain modernization in Jiangxi province or the nonferrous metals industry. Promoting the modernization of the nonferrous metals industrial chain in Jiangxi province, especially rare earth, tungsten and copper, is an inevitable requirement for ensuring the high-quality development of Jiangxi's economy.

The rest of the paper is arranged as follows: Section 2 outlines the development achievements realized through the modernization of the nonferrous metals industrial chain in Jiangxi province; Section 3 describes the difficulties existed; Section 4 puts forward the realization pathways; and Section 5 concludes.

## **2 Development Achievements**

### **2.1 Complete Industrial Chain Construction**

Relying on the abundant nonferrous metal resources, Jiangxi province has become an important base for nonferrous metal mineral mining and production in China. With the expansions in scale and improvements in level, the nonferrous metals industry is not only a cornerstone of Jiangxi's manufacturing industry, but also the primary pillar industry in Jiangxi province. According to SCIO's news<sup>[18]</sup>, there are three facts:(1) Jiangxi's GDP increased from 1.28 trillion yuan in 2012 to 3.22 trillion yuan in 2023, with the nonferrous metals industry contributing significantly to this growth;(2) The industry's revenue approached 800 billion yuan in 2023, showing a strong growth momentum;(3) The province's industrial value-added output reached 1.12 trillion yuan in 2023, with the nonferrous metals sector being one of the key contributors.

The nonferrous metals industry in Jiangxi province has experienced significant transformation and growth, evolving from a singularly production-oriented enterprise aggregation to a complex cluster of enterprises involved in various aspects of the industrial chain. Upstream and downstream product supporting production enterprises, associated R&D centers of chemical raw materials and service industries have totally experienced rapid expansion. The growth has not been limited to e-commerce but extends to modern logistics, professional markets, research and development centers construction, product testing, technical research and design, as well as the establishment of entrepreneurial service centers and other supporting facilities. Consequently, a complete industry chain has been developed for mining and processing nonferrous metals in Jiangxi province.

### **2.2 Chain Owner Enterprises and Scientific Research Platforms**

The nonferrous metals industry chain in Jiangxi province is currently in a phase of continual improvement, focusing on industrial cluster development and leading enter-

prise cultivation. Owing to the positive role of chain owner enterprises, the construction of scientific research platforms has been improved, especially copper, tungsten and rare earth.

Jiangxi Copper Industry Group Co., Ltd., the largest copper product production base in China, has collaborated with universities and research institutes to establish the Jiangxi Provincial Copper Industry Science and Technology Innovation Consortium. The goal of this initiative is to foster open resource sharing and collaborative innovation in science and technology, ultimately aiming to overcome existing technological challenges. Jiangxi Tungsten Holding Group, as the chain owner enterprise, has established 6 national-level scientific research and innovation platforms and 19 provincial-level science and technology research and development innovation platforms to promote the standardization, modernization, and refinement of the tungsten industry. The Chinese Academy of Sciences and Jiangxi Province jointly established a national innovation platform dedicated to the research status, industrial layout and platform construction of the rare earth industry. The provincial ministry's collaborative innovation center for the development and utilization of rare earth resources aims to utilize resource advantages for collaborative innovation of high-end equipment and processes. Since its establishment in 2019, the center has achieved several internationally leading original results and has won the National Science and Technology Progress Award.

### **2.3 Chain Leader Institution and Carbon Emission Issue**

Ganzhou city, Jiangxi province is globally recognized as the "World's Tungsten Capital" and the "Rare Earth Kingdom," given that it produces 60% of the world's black tungsten and 70% of medium and heavy rare earth elements annually. Additionally, nationally, the capacity for smelting separation of medium and heavy rare earth elements and secondary resource recycling represents 50% and 60%, respectively. Meanwhile, the capacity for metal smelting and magnetic materials stands at 30% and 25%, respectively, while APT and tungsten powder & carbide tungsten powder account for 60% and 40%, respectively. For the nonferrous metals industry chain in Jiangxi province dominated by mining, separation and smelting activities, the issue of carbon emissions is of significant concern.

Since the implementation of the "chain leader institution" in the industrial chain in 2022, Jiangxi province has formed a tripartite environmental protection responsibility system involving the government, enterprises and society. In addition to enhancing product value and competitiveness, the issue of carbon emissions is also being effectively addressed. From the perspective of carbon emission of the nonferrous metals industry chain, more attention should be paid to the smelting and processing industry stage than the mining and selection stage, in which Jiangxi province shows a relatively effective in managing carbon emissions <sup>[19]</sup>.

### **3 Difficulties Exited**

#### **3.1 Imbalance in Industrial Development**

There is a certain scale in the upper and middle end of nonferrous metals industry chain in Jiangxi province, but with small proportion in the backend, which result in high resource consumption, low value-added products, short industry chain and prominent structural contradictions. On the one hand, the strength of nonferrous metals industry chain in Jiangxi province remains in the primary processing sector. The product structure of nonferrous metals industry chain in Jiangxi province is skewed towards primary products, with the front-end mining industry accounting for 30%. On the other hand, while the production of middle and lower end of nonferrous metals industry chain in Jiangxi province constitutes a significant portion of the national output, the representation of deeply processed products and their applications remains notably low. Furthermore, the majority of these products are categorized as middle or low quality, whose technological sophistication and value-addition exist a considerable disparity compared to domestic and foreign frontrunners.

#### **3.2 Lack of Professional and Technical Personnel**

The nonferrous metals industry is highly dependent on natural resources. At the early stage of development with low production technology, the human resource structure of nonferrous metals industry was dominated by a large number of labor populations and supplemented by a small number of technical, scientific research, and management personnel. In order to meet the development requirements of the new era, a series of industrial transformation policies are adopted in Jiangxi province, especially strengthening the construction of talent team in terms of core technology tackling and management model innovation. However, the fundamental and strategic role of human resources has not been fully realized. There is a notable deficiency in the overall quantity of talents, particularly in the realm of industrial talents required for major projects and critical sectors. Furthermore, there are evident shortcomings in the academic qualifications of enterprise operators in the nonferrous metals industry. The potential of talents in colleges, universities and scientific research institutions remains largely untapped.

#### **3.3 Insufficient Synergy of Collaborative Innovation**

Currently, higher education institutions and research institutes in Jiangxi Province have multiple national and provincial nonferrous metals industry innovation platforms. However, their scientific and technological investment as a proportion of GDP remains below the national and global averages. Additionally, there appears to be a lack of collaborative innovation synergy and adequate integration of innovative resources within these institutions. Firstly, the goal and direction of innovation remain unclear. The current planning for scientific and technological development lacks rele-

vance, failing to figure out the areas should be prioritized for development and technologies should focus on breakthroughs. Secondly, the total amount of investment in innovation is insufficient, with the focus not being prominent, hindering the creation of key common technologies and independent intellectual property rights. Despite the annual increase in investment in scientific and technological innovation in China, the total amount of investment is still insufficient compared to developed countries. Thirdly, the primary role of enterprises in innovation needs to be strengthened. The main role of enterprises in scientific and technological innovation has not yet been fully realized, with some enterprises showing a weak sense of innovation, insufficient investment in research and development and a weak ability to transform innovative achievements.

## **4 Realization Pathways**

### **4.1 Increasing Policy Support**

The chain leader should play the role of a bridge and bond, leveraging its own industry status and influence to promote policy measures that are more in line with the development needs of the industrial chain. Firstly, provide financial incentives to enterprises investing in technological innovation and green initiatives, such as subsidies, tax breaks, low-interest loans and etc. Secondly, create a supportive policy environment to foster the modernization of the nonferrous metals industry, which includes policies related to resource governance, environmental protection and technological innovation. Thirdly, invest in the development of infrastructure such as transportation, energy and communication networks to support the growth of the industry.

### **4.2 Deepening Technological Innovation**

Chain owner enterprises function as an initiator, promoter, integrator and practitioner of technological innovation. Firstly, allocate substantial resources towards R&D to incorporate advanced technologies in smelting, refining and recycling processes. This includes the use of system dynamics, dynamic material flow analysis and life cycle assessment to optimize the industry chain. Secondly, Foster robust partnerships with both local and international academic and research institutions to pioneer and execute cutting-edge technologies. For example, Jiangxi University of Science and Technology has been actively involved in research on the optimization of the nonferrous metals supply chain. Thirdly, encourage partnerships between industry players and academic institutions to facilitate the transfer of technology and knowledge through joint research projects, internships and training programs.

### **4.3 Accelerating Green Transformation**

The green transformation of the non-ferrous metal industry chain in Jiangxi Province must rely on the joint efforts of the chain leader, the chain owner enterprises and other

enterprises on the chain. Firstly, green initiatives should be implemented, including reducing carbon emissions through improved energy efficiency, adoption of renewable energy sources and enhanced resource recovery processes. Secondly, promote the recycling and reuse of materials within the industry to minimize waste and reduce the environmental footprint. Thirdly, strengthen environmental regulations and enforcement to ensure that all industry participants adapt to the energy consumption of "dual carbon" policies as soon as possible.

## 5 Conclusion

The modernization of the nonferrous metals industry chain in Jiangxi Province is crucial for achieving sustainable economic growth and environmental protection. By addressing the challenges through policy support, technological innovation and green transformation, Jiangxi can enhance the industry's competitiveness and contribute to the national goal of carbon peak and carbon neutrality.

## Acknowledgment

This study was supported by Youth Project of the Social Science Foundation of Jiangxi Province, China (Grant number 22YJ46).

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