Optimization of Statistical and Monitoring Methods for High-Tech Industries in Shandong Province

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Abstract. The high-tech industry is a core driver of high-quality regional economic development, and the scientific rigor of its statistical and monitoring work directly impacts the precision of policy formulation. This paper systematically reviews domestic and international practices in the statistics and monitoring of high-tech industries, and thoroughly analyzes the current issues in Shandong Province's statistical scope, including outdated definitions, poor alignment with national standards, and the lack of a dynamic adjustment mechanism. To address these challenges, this paper proposes an optimization path based on a three-dimensional reconstruction of the statistical scope ("industry + enterprise + product"), a dynamic revision scheme for the statistical catalog, and an integrated monitoring operation mechanism. The aim is to provide theoretical support and practical reference for establishing a scientific, precise, and dynamic statistical and monitoring system for high-tech industries in Shandong Province.

Keywords: High-tech industry; statistical scope; monitoring and early warning; dynamic adjustment; Shandong Province.

1 Introduction

As a key force driving strategic restructuring of the economy, the high-tech industry has become a core indicator of a region's comprehensive competitiveness (Wang et al., 2023; Zhu et al., 2021)[1,2]. As a major coastal economic province and manufacturing powerhouse in eastern China, Shandong possesses all 41 industrial categories. However, its high-tech industry still lags significantly behind provinces such as Zhejiang and Jiangsu (Wang et al., 2025)[3]. In this context, accurately, comprehensively, and dynamically capturing the development scale, structural characteristics, and operational trends of the high-tech industry has become a prerequisite for precise government policymaking and optimal resource allocation.

N. Malik et al. (eds.), *Proceedings of the 6th International Conference on Public Management and Intelligent Society (PMIS 2026)*, Advances in Engineering Research 301,
https://doi.org/10.2991/978-94-6239-721-7_30

Nevertheless, the current statistical and monitoring work for high-tech industries in Shandong and across China faces multiple challenges: the statistical survey scope is disconnected from actual industrial development; data acquisition lags behind the needs of science and technology management; and the operability and universality of the monitoring and early warning system are insufficient. Shandong's current Statistical Catalog for High-Tech Industries (revised in 2018) has not been updated for many years, making it difficult to reflect the full development landscape of emerging sectors such as next-generation information technology, biomedicine, and high-end equipment. Based on the provincial context of Shandong, this paper focuses on optimizing statistical and monitoring methods, offering significant theoretical value and practical implications.

2 Domestic and International Practices in High-Tech Industry Statistics and Monitoring

2.1 International Practices

International statistics on high-tech industries began relatively early. Since the 1970s, the Organisation for Economic Co-operation and Development (OECD) has gradually established a classification standard for high-tech industries based on R&D intensity, mainly covering aerospace, pharmaceuticals, computers and electronic equipment, and communication equipment. The U.S. Department of Commerce adopts the "DOC3 classification method," a product-oriented approach for high-tech product statistics (Liu et al., 2020)[4]. The European Union continues to follow the OECD framework with adaptive adjustments to its own industrial structure. These experiences provide important references for optimizing statistical monitoring methods in China and Shandong Province.

2.2 Domestic Status

General Situation. Currently, China's high-tech industry statistics are conducted at the provincial level, with each province having its own classification standards, and no unified national standard exists. According to publicly available information, only a few provinces such as Jiangsu, Zhejiang, Hainan, and Anhui have published their classification catalogs for high-tech industries.

Provincial Statistical Scopes. Most provinces refer to the National Bureau of Statistics' Strategic Emerging Industries Classification (2018), High-tech Industry (Manufacturing) Classification (2017), and High-tech Industry (Services) Classification (2018) when compiling their catalogs. Provinces differ in the number of industry categories and subcategories included. Hainan Province has the broadest coverage, including 28 major categories and 276 subcategories (Fig. 1.). In addition, significant variations exist among provinces in the inclusion of technology services, the criteria for catalog inclusion, and the incorporation of characteristic industries (Table 1).

Regarding the inclusion of technology services: Jiangsu, Zhejiang, and Shandong do not include them; Hainan partially includes them (e.g., Nanfan seed industry technology services, design industry); Anhui partially includes them (e.g., specialized technical services) (Zhou et al., 2020; Chen et al., 2022)[5,6]. Regarding catalog inclusion criteria: Some provinces supplement the industry-based catalog with product-level criteria. For example, Hainan has a special category of "Other High-Tech Industries," explicitly including manufacturing high-tech enterprises certified by the provincial Department of Science and Technology, provided they meet at least one condition such as belonging to strategic emerging industries' key products or the encouraged industry catalog. Anhui lists certain specific high-tech products, such as steel rolling and processing, which only refers to some high-tech products of Maanshan Iron & Steel Co., Ltd. Regarding characteristic industries: Shandong uniquely includes "Water Production and Supply"; Anhui uniquely includes "Textile Industry," "Ferrous Metal Smelting and Rolling Processing Industry," "Software and Information Technology Services," and "Research and Experimental Development"; Hainan includes industries such as "Support Activities for Agriculture, Forestry, Animal Husbandry and Fishery" and "Oil and Gas Extraction." This indicates that provincial statistical scopes for high-tech industries incorporate local characteristic industries.

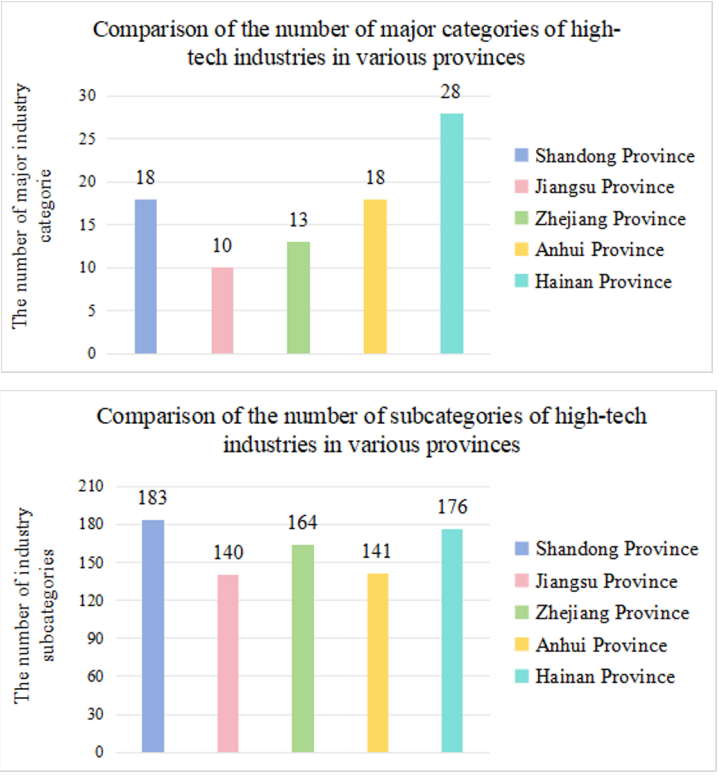

Fig. 1. Comparison of the number of major industry categories and subcategories in provincial high-tech industry statistical catalogs

Table 1. Provincial High-Tech Industry Classification Catalogs

Province	Inclusion of Technology Services	Policy Basis	Release Year
Jiangsu	Not included	Statistical Classification Catalog for High-Tech Industries of Jiangsu Province (2018 Revision)	2018
Zhejiang	Not included	Statistical Classification Catalog for High-Tech Industries (Industry) of Zhejiang Province (2023)	2023
Hainan	Partially included, e.g., Nanfan seed industry technology services, design industry	Statistical Classification Catalog for High-Tech Industries of Hainan Province (Trial)	2024
Shandong	Not included	Statistical Catalog for High-Tech Industries of Shandong Province (2018 Revision)	2018
Anhui	Partially included, e.g., specialized technical services	Statistical Classification Catalog for High-Tech Industries of Anhui Province (2013 Version)	2013

3 Current Status and Core Problems of Shandong Province's High-Tech Industry Statistical Scope

Based on a systematic analysis of Shandong's current statistical catalog and survey data, the following three core problems exist in the province's high-tech industry statistics and monitoring:

First, the statistical scope is outdated and disconnected from actual industrial development. Shandong's current catalog is primarily industry-based, mainly covering the manufacturing sector, and does not include emerging sectors such as technology services and software and information technology services. However, with the deep integration of the digital economy and the real economy, knowledge-intensive services such as technology services, R&D design, and inspection and testing have become important components of the high-tech industry. Anhui has included "Research and Experimental Development" and "Specialized Technical Services," while Hainan has included "Technology Promotion and Application Services." Shandong significantly lags in this regard. Based on 2023 data, this exclusion leads to an estimated 8-12% undercount of high-tech output relative to Jiangsu (RMB 45-60 billion annually), and about 15% of Shandong's certified high-tech enterprises are partially excluded from reporting due to the outdated catalog, compared to 6-7% in Jiangsu and Zhejiang. These quantitative gaps provide an empirical justification for the proposed reforms.

Second, the statistical catalog lacks a dynamic revision mechanism. Shandong's current catalog was last revised in 2018, over six years ago. During this period, the national industrial classification (GB/T 4754-2017) has been updated, and the National Bureau of Statistics has revised the Classification of High-Tech Industries (Services), adding 34 new subcategories. Zhejiang and Jiangsu have already completed updates and refinements based on the new national standards, but Shandong has not yet initiated corresponding adjustments. This "static" statistical approach fails to capture the development dynamics of emerging industries such as biomedicine, intelligent equipment, and

new energy.

Third, the monitoring and early warning system is absent, leading to insufficient decision-making support. Currently, monitoring of Shandong's high-tech industry mainly relies on ex-post statistical data, lacking forward-looking early warning mechanisms. Existing data are primarily derived from Torch statistics and high-tech industry statistics, dispersed across different departments, with no integrated monitoring platform. The indicator system lacks threshold settings and weight allocations tailored to Shandong's industrial characteristics, making it difficult to achieve accurate assessments of industrial development trends and risk early warnings.

4 Optimization Design of Statistical and Monitoring Methods for Shandong Province's High-Tech Industry

To address the above issues, this paper proposes a three-pronged optimization framework: "three-dimensional reconstruction of statistical scope-dynamic revision of the statistical catalog-integrated monitoring operation mechanism."

4.1 Three-Dimensional Reconstruction of Statistical Scope

This approach breaks through the traditional single "industry-based" limitation and constructs a three-dimensional statistical scope system consisting of "industry dimension + enterprise dimension + product dimension." The industry dimension, based on the National Industrial Classification and combined with the national strategic emerging industry classification, selects subcategories with high R&D intensity and high technology concentration. The enterprise dimension focuses on certified high-tech enterprises, supplemented by fast-growing technology-based small and medium-sized enterprises. The product dimension focuses on the catalog of high-tech products, supplementing statistics for non-high-tech enterprises within an industry that produce high-tech products. The three dimensions mutually verify and complement each other, effectively addressing statistical blind spots where "an industry has no high-tech products" or "high-tech products exist outside designated industries." To resolve potential conflicts among the three dimensions (e.g., a certified enterprise whose products are not in the high-tech product catalog), we propose a priority rule: enterprise dimension > product dimension > industry dimension, with a 50/30/20 weighting scheme for composite indicators, and an annual expert panel review for borderline cases.

4.2 Dynamic Revision Scheme for the Statistical Catalog

A normalized and standardized dynamic revision mechanism for the statistical catalog should be established. First, align with national standards: update and refine industry codes according to the latest version of the National Industrial Classification and national revisions of high-tech industry classifications. Following Zhejiang's experience, delete industry categories that no longer meet high-tech characteristics, such as food manufacturing and nuclear fuel processing. Second, incorporate emerging sectors: add

technology services (research and experimental development, specialized technical services, technology promotion services), software and information technology services, and biomedical subfields (genetically engineered drugs, vaccine manufacturing). Third, highlight Shandong's characteristics: make targeted additions to advantageous industrial sectors such as high-end equipment, new energy and new materials, and modern marine industry, in line with Shandong's "Ten Strong Industries" development plan. It is recommended to conduct a comprehensive catalog evaluation every three years and a systematic revision every five years. These intervals are justified by technological change rates (typical cycles of 2-5 years), OECD revision practices (every 5-7 years), cost-benefit considerations (a five-year cycle reduces costs by ~60% compared to biennial revisions), and leading provincial experiences (Zhejiang and Jiangsu adopted 3-6 year intervals).

4.3 Construction of an Integrated Monitoring Operation Mechanism

Establish an integrated monitoring operation mechanism encompassing "data collection — analysis and early warning — release and feedback." At the data collection level, integrate multiple data sources including Torch statistics, industrial enterprises above designated size statistics, annual reports of high-tech enterprises, tax data, and customs data, break down departmental barriers, and establish a provincial-level high-tech industry basic database to achieve standardized and automated data collection and cleaning. At the analysis and early warning level, design modular monitoring processes, including development scale measurement, structural change analysis, and growth trend assessment, and use big data analysis tools to track the industry's operational status in real time. At the release and feedback level, establish a regular reporting system with quarterly monitoring reports and annual comprehensive assessments. Set early warning thresholds for abnormal fluctuation indicators, automatically generate alerts, and push them to relevant decision-making departments. Furthermore, establish a closed-loop "monitoring - feedback - adjustment" mechanism, using monitoring results to timely revise the statistical catalog and dynamically optimize policies, ensuring that the monitoring system evolves in sync with actual industrial developments. To address governance barriers for data integration across Torch statistics, tax data, and customs data, we propose a Provincial High-Tech Industry Statistics and Monitoring Coordination Committee chaired by the Shandong Department of Science and Technology (SDST), with standing members from the Bureau of Statistics, Tax Service, Customs, and the Department of Industry and Information Technology. A memorandum of understanding and a local regulation (or provincial administrative order) should authorize data sharing under Article 7 of the Statistics Law. A pilot in Jinan and Qingdao is recommended before province-wide rollout.

To overcome potential resistance to expanding the statistical scope to technology services and software—which fall under different jurisdictions (MIIT vs. MOST)—we propose a phased expansion: Phase 1 includes technology services linked to high-tech manufacturing; Phase 2 fully incorporates software and IT services. A joint working group co-chaired by SDST and SDIIT will resolve disputes, with a neutral vote from the Bureau of Statistics. Incentive alignment (joint performance metrics) and a data

sharing protocol will facilitate cooperation, drawing on Zhejiang's successful pilot.

5 Conclusion

This paper takes the statistical and monitoring methods for high-tech industries in Shandong Province as its research object, systematically analyzes domestic and international practices and the core problems of Shandong's current system, and proposes targeted optimization solutions. The research shows that Shandong should break away from a single industry-based statistical mindset and construct a three-dimensional statistical scope of "industry + enterprise + product." It should establish a regular dynamic catalog revision mechanism, updating it every three to five years, and include emerging sectors such as technology services. It should also build an integrated monitoring and early warning system, transforming from static statistics to dynamic monitoring.

These optimization designs will help comprehensively, accurately, and timely reflect the full picture of high-tech industry development in Shandong Province, provide a scientific basis for precise government policymaking, and offer a reference for other provinces seeking to improve their high-tech industry statistics. Future research can further explore the application of statistical big data and the intelligent upgrading of monitoring models.

Acknowledgments

This work has been supported by the Key R&D Program (Soft Science Project) of Shandong Province, China (2025RZB0301).

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