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New Quality Productive Forces Drive the Path to Enhance the Resilience of the Ice and Snow Economic Industry Chain in Jilin Province

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Abstract: Amid the dual challenges of global industrial chain restructuring and China's pursuit of high-quality economic development, the ice and snow economy in Jilin Province—a strategic emerging industry- requires enhanced industrial chain resilience to address extreme weather, market volatility, and geopolitical competition. Grounded in the theory of New Quality Productive Forces and analyzing Jilin's unique industrial landscape characterized by "exceptional resource endowment but significant supply chain vulnerability", this study systematically explores the intrinsic mechanisms linking New Quality Productive Forces to industrial chain resilience. The findings reveal that New Quality Productive Forces strengthens industrial chain resilience through three pathways: technological innovation, factor restructuring, and business model innovation, thereby enhancing shock absorption capacity, blocking risk transmission, and improving recovery efficiency. To tackle critical bottlenecks in Jilin's ice and snow equipment manufacturing, including technological constraints, inadequate service standardization, and low digital penetration—the study proposes a systematic enhancement framework of "technological breakthroughs → factor upgrading → ecological synergy". This provides theoretical insights and practical guidance for industrial transformation in Northeast China's traditional manufacturing base while promoting high-quality development of the ice and snow economy.

Keywords: New Quality Productive Forces; Ice and snow economy; Industrial chain resilience; Jilin Province

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1. Introduction

With the intensification of global warming and the frequent occurrence of extreme weather events, the natural risks faced by the ice and snow economy industrial chain have significantly increased. Meanwhile, the upgrading of consumer demand in the post-pandemic era and intensified international competition in the ice and snow industry further highlight the importance of the industrial chain's risk resistance capabilities [1]. As a core province of China's ice and snow economy, Jilin Province possesses unique advantages such as Changbai Mountain's ice and snow resources and FAW Group's equipment manufacturing foundation. During the 2023-2024 snow season, it received over 120 million tourist visits [2], with the total output value of the ice and snow industry reaching 150 billion yuan [3]. However, the industrial chain still faces three "weaknesses": First, the weak ice and snow equipment manufacturing sector, where 80% of high-end ski resort

equipment relies on imports; second, weak coordination in service chains, with data silos and inconsistent standards among ski resorts, hotels, and transportation; third, weak risk resistance capabilities. In early 2024, extreme snowfall caused some ski resorts to close for seven days, resulting in direct losses exceeding 2 billion yuan.

The report of the 20th National Congress of the Communist Party of China explicitly proposed "developing new-quality productive forces and modernizing industrial systems." The 2024 Central Economic Work Conference further emphasized "reinforcing industrial chain resilience through new-quality productive forces" [4]. With technological innovation as the core driver and digitalization, green transformation, and intelligentization as defining features, these advanced productive forces offer innovative solutions to address the "low-end lock-in" and "insufficient resilience" issues in the ice and snow economy industrial chain [5]. Against this backdrop, exploring how new-quality productive forces can enhance the resilience of Jilin Province's ice and snow economy industrial chain carries significant theoretical value and practical implications.

2. Core conceptual definitions

2.1. New qualitative productivity

According to Li (2025) [6] definition, new-quality productive forces refer to "advanced productive forces characterized by high technology, efficiency, and quality, with technological innovation as the core driving force and optimized combinations of laborers, means of labor, and objects of labor as their fundamental essence". Considering the features of the ice-snow economy, this paper categorizes it into three aspects: First, the technological dimension, including intelligent ice-snow equipment and digitalized ski resort operations [7]; second, the factor dimension, encompassing data empowerment and green energy substitution; third, the business model dimension, featuring integrated formats like "ice-snow + educational tours" and "ice-snow + wellness retreats".

2.2. Ice and snow economy industry chain

The ice and snow economy industrial chain is "a complete ecosystem built on ice and snow resources, encompassing equipment manufacturing, service operations, and related industries". The upstream sector focuses on equipment production, including skis [8], snowmaking machines, and cable cars. The midstream involves service operations such as ski resorts, hotels, and travel agencies. The downstream includes related sectors like ice-snow cultural products, health and wellness services, and transportation infrastructure. These three components form a value cycle of "resources → services → consumption."

2.3. Industrial chain resilience

As defined by Pei et al. (2025) [9], industrial chain resilience refers to "the capacity of industrial chains to maintain normal operations and achieve transformation and upgrading through preventive, resistant, and restorative measures when facing external shocks." It specifically encompasses three aspects: First, shock resistance capability–the ability to withstand risks such as natural disasters and market fluctuations; second, risk transmission containment capability–preventing localized risks from spreading across the entire supply chain; third, recovery and regeneration capability–rapidly rebounding and upgrading post-shock.

3. Resilience of ice and snow economic industry chain in Jilin Province

3.1. Weaknesses in the resilience of Jilin's ice and snow economic industry chain

3.1.1. Weak anti-impact capability: natural risk and equipment dependence are dual constraints

First, inadequate natural risk management. The extreme snowfall in early 2024 forced the Changbai Mountain resort's

cable car system to suspend operations for seven days, as the absence of an intelligent early-warning system prevented timely protective measures. Second, heavy reliance on imported high-end equipment. The resort's snowmaking machines and cable cars—80% of which were supplied by Austrian company Doppelmayr and Italian manufacturer Lippoh, among others- suffered three-month delivery delays due to global supply chain tensions in 2024, significantly impacting operations.

3.1.2. Weak risk transmission blocking ability: insufficient data communication and collaboration

First, the issue of data silos remains prominent. Data integration between Changbai Mountain Scenic Area, Changchun Longjia Airport, chain hotels, and other facilities has not been achieved. During the 2024 snow season, over 10 traffic congestion incidents occurred due to poor sharing of tourist information, resulting in stranded visitors exceeding 5 hours. Second, there is a lack of unified standards across various sectors. The absence of uniform criteria for ski instructor qualifications and hotel service quality led to "service inconsistency," constituting 35% of tourist complaints in 2024, creating risks that could easily escalate from service quality issues to consumer dissatisfaction.

3.1.3. Weak recovery and regeneration capacity: lack of innovation and single business form

First, technological innovation lags. Provincial winter sports equipment manufacturers allocate less than 3% of R&D investment to R&D [10], significantly below the industry average of 5%, making it difficult to rapidly launch market-responsive products. Second, the business model remains overly reliant on a single revenue source–70% of income depends on ski ticket sales. The 60% revenue drop during the non-ski season (April–October) in 2024 highlights a lack of "four-season operation" capabilities, resulting in slow recovery after market downturns.

3.2. Cause analysis of short board

3.2.1. Insufficient investment in scientific and technological innovation

The R&D investment intensity of Jilin's ice and snow industry is only 1.2%, lower than the national average level of 2.5%. Moreover, 70% of the investment is concentrated in the construction of scenic spots, while insufficient investment is made in equipment manufacturing, digital services and other links, resulting in core technologies and high-end equipment being controlled by others.

3.2.2. Low factor configuration efficiency

On the one hand, the data factor is not fully activated. 60% of ski resorts in the province still use traditional methods such as manual registration and paper bills, and the digital penetration rate is only 30%. On the other hand, the talent factor is short, with a shortage of 12,000 ski coaches and 8,000 ice and snow equipment research and development talents respectively, which restricts the upgrading of the industrial chain.

3.2.3. Inadequate policy coordination

Despite the introduction of multiple policies, three key coordination gaps persist: First, interdepartmental collaboration remains inadequate, with inconsistent policy frameworks among cultural tourism, industry and information technology, transportation, and other sectors [11]. Second, regional coordination falls short, as Jilin Province has yet to establish a coordinated mechanism for the ice and snow economy with neighbouring provinces like Heilongjiang and Liaoning. Third, policy implementation faces challenges, with 50% of enterprises reporting "low awareness of policies and complicated application procedures", resulting in underutilized policy effectiveness.

4. Mechanism analysis of New Quality Productive Forces driving the improvement of industrial chain resilience of ice and snow economy in Jilin Province

New productivity improves the resilience of the industrial chain from three aspects: anti-shock, blocking transmission and promoting recovery through the three-dimensional mechanism of "scientific and technological innovation--factor restructuring--business format innovation". The specific mechanisms are as follows:

4.1. Innovation-driven science and technology: Enhancing resilience

4.1.1. Intelligent equipment research and development to reduce dependence on imports

First, we will achieve breakthroughs in core technologies for high-end equipment. Building on FAW Group's manufacturing expertise, we partnered with Jilin University to develop the "Xuelong" series of snow groomers. The prototype successfully passed testing in 2024, achieving a 75% domestic production rate and reducing costs by 30% compared to imported equipment, effectively replacing Austrian Dobema products. Second, we are advancing intelligent monitoring systems through the "Snow Weather Eye" project. By integrating satellite remote sensing and IoT sensors, this system provides 48-hour warnings for extreme weather events. After implementation at Changbai Mountain Scenic Area in 2024, it reduced operational downtime caused by extreme weather by 60%.

4.1.2. Digital operation improves the efficiency of risk response

The initiative focuses on two key initiatives: First, establishing a big data platform for the winter sports industry that integrates tourist, transportation, and scenic area data. Upon its launch in 2024, the platform will achieve 90% accuracy in predicting visitor numbers and dynamically adjust reception capacity at attractions. Second, deploying smart service terminals, including AI-guided tour robots and self-service ticketing machines, at ski resorts to reduce reliance on human staff. These measures resulted in a 25% decrease in labor costs and a 40% improvement in service efficiency at Changbai Mountain Scenic Area by 2024.

4.2. Factor restructuring drive: Blocking risk transmission

4.2.1. Data elements break through collaborative barriers

First, establish the "Snow and Ice Chain" data sharing mechanism to promote data interoperability among 20 core enterprises, including Changbai Mountain Scenic Area, Longjia Airport, and Wanda Hotel. By 2024, the "One-Device Tour Jilin" service will be implemented, reducing tourist complaint rates by 30%. Second, develop a standardized service system through big data analysis to formulate the *Jilin Province Snow and Ice Service Standards*. This framework covers 50 indicators across 10 categories including ski instructor qualifications and hotel hygiene, effectively reducing the probability of risks being transmitted from service processes to consumer experiences by 40%.

4.2.2. Green elements optimize resource allocation

First, promote renewable energy by constructing photovoltaic power stations at ski resorts. By 2024, the Changbai Mountain Scenic Area will achieve 20% photovoltaic power generation, reducing reliance on traditional energy sources and mitigating risks from energy price fluctuations [12]. Second, develop a circular economy by recycling discarded ski equipment and disposable hotel supplies. The resource recovery rate is projected to reach 35% by 2024, minimizing supply chain disruptions and ensuring stable material availability.

4.3. Business model innovation: Promoting recovery and regeneration

4.3.1. "Ice and Snow +" integrated business expands revenue sources

First, developing "Snow & Ice + Study Tours" by collaborating with Northeast Normal University to create ice and snow science education programs. In 2024, this initiative will host 500 student study groups, increasing non-snow season revenue by 15%. Second, cultivating "Snow & Ice + Wellness" through leveraging Changbai Mountain's hot spring

resources to develop ski rehabilitation packages. In 2024, wellness tourism revenue is projected to reach 3 billion yuan, emerging as a new growth driver.

4.3.2. Online and offline integration improves the ability to resist risks

First, develop the online ice and snow economy by establishing the "Jilin Ice & Snow Cloud Mall" to sell cultural and creative products, virtual skiing courses, etc. The online sales reached 2 billion yuan in 2024, offsetting losses from offline business closures. Second, promote "cloud skiing" experiences through VR technology to build a virtual ski resort. In 2024, over 1 million users were attracted, achieving "year-round operations" and boosting recovery speed by 50%.

5. Optimize the path of New Quality Productive Forces to drive the improvement of the resilience of ice and snow economic industry chain in Jilin Province

Based on the above mechanism analysis and combined with the actual situation of Jilin Province, a three-dimensional improvement path of "technological breakthrough-factor upgrading-ecological coordination" is proposed as follows:

5.1. Pathway of technological breakthrough: Building an innovation system of "industry, education, research and application"

5.1.1 Break through the core technology of high-end equipment

The first initiative involves establishing the "Jilin Province Ice and Snow Equipment Innovation Alliance", which integrates resources from 30 organizations, including FAW Group, Jilin University, and Changbai Mountain Group. The alliance will focus on developing high-end equipment such as snow groomers and cable cars, with a target of achieving a 60% domestic production rate by 2026. The second initiative involves setting up a 1 billion yuan ice and snow equipment R&D fund, providing a 20% subsidy for corporate R&D investments to encourage enterprises to develop new products adapted to China's snow conditions.

5.1.2. Build digital infrastructure

The initiative focuses on two key components: First, establishing a "Smart Snow and Ice" platform to achieve data integration with 80% of the province's ski resorts and hotels by 2025, delivering end-to-end digital services covering reservation, travel planning, service delivery, and feedback mechanisms. Second, deploying intelligent monitoring systems through 500 IoT sensors at major attractions, including Changbai Mountain and Songhua Lake, enabling real-time tracking of weather conditions and visitor flow data with over 95% accuracy in early warning alerts.

5.2. Path of factor upgrading: Activate the core elements of "data + talent + green"

5.2.1. Deepen the empowerment of data elements

First, establish an ice and snow economy data trading platform by leveraging Jilin Province's Government Data Sharing and Exchange Center to facilitate the monetization of tourist consumption data, traffic flow data, and ski resort operation data. The platform aims to achieve a transaction volume exceeding 500 million yuan by 2026, positioning data as the core asset for value-added in the industrial chain. Second, implement data security management pilots through formulating the "Jilin Ice and Snow Industry Data Security Standards". This initiative will establish clear security protocols for data collection, storage, and usage to prevent supply chain risks caused by data breaches, with 10 core enterprises completing data security certification by 2025.

5.2.2. Strengthen talent support

First, implement the "Ice and Snow Talent Special Program" by collaborating with universities such as Harbin Sport University and Northeast Electric Power University to establish majors in ice and snow equipment R&D and service

management. This initiative aims to cultivate 15,000 professionals by 2026 to address talent shortages. Second, attract high-end professionals by offering up to 5 million yuan in relocation subsidies for leading R&D talents in ice and snow equipment, along with monthly position subsidies of 2,000–5,000 yuan for ski instructors and ski resort operation managers. The plan targets recruiting over 200 top-tier talents by 2025. Third, establish 20 training bases at locations like Changbai Mountain Wanda Resort and Changchun Ice and Snow Equipment Industrial Park to achieve "school-enterprise collaboration and customized training," thereby enhancing practical skills.

5.2.3. Promote the infiltration of green elements

The initiative comprises three key components: First, establishing "zero-carbon ski resort" demonstration projects by implementing clean energy solutions, including photovoltaic systems and geothermal heat pumps at major destinations such as Songhua Lake Ski Resort and Beidahu Ski Resort. These efforts aim to achieve 50% clean energy adoption in ski resorts by 2026, coupled with a 30% reduction in carbon emissions compared to 2024 levels. Second, developing a green supply chain framework for the winter sports industry through the formulation of the "Green Supply Chain Standards for Jilin's Winter Sports Industry." This includes requiring upstream equipment manufacturers to use eco-friendly materials, midstream service providers to minimize disposable product usage, and downstream partners to implement waste recycling systems. Ten green supply chain demonstration enterprises are scheduled to be established by 2025. Third, expanding low-carbon transportation networks via new energy tourism routes connecting Changchun with Changbai Mountain and Jilin with Songhua Lake. The plan targets 80% coverage of new energy vehicles between major scenic areas by 2026, thereby reducing energy dependency risks across the industrial chain.

5.3. Ecological synergy path: Building a "region + industry + policy" synergy system

5.3.1. Promoting coordinated regional development

First, establish the "Northeast Ice and Snow Economy Alliance" to collaborate with Heilongjiang, Liaoning, and other provinces in developing unified industry standards and mutual tourist recognition mechanisms. By 2025, achieve seamless ticketing integration and shared travel routes across ice-snow attractions in the three northeastern provinces, reducing homogenized competition and enhancing overall risk resilience in the industrial chain. Second, deepen cooperation with the Beijing-Tianjin-Hebei region and the Yangtze River Delta area by launching cross-provincial tourism routes such as "Jilin Ice & Snow + Beijing-Tianjin-Hebei Leisure" and "Jilin Ice & Snow + Yangtze River Delta Wellness". By 2026, aim to increase non-local tourist attraction shares to 60% to reduce dependence on domestic markets. Third, strengthen international partnerships by establishing cooperative alliances with ice-snow industry leaders like Japan's Hokkaido and Switzerland's Alps region. Introduce advanced ski resort management expertise and equipment manufacturing technologies, with plans to jointly develop three international ice-snow industry demonstration projects by 2025.

5.3.2. Promoting industrial synergy and integration

First, promote the integration of "ice and snow + manufacturing" by supporting traditional manufacturers like FAW Group and Changchun Railway Vehicles to transition into ice and snow equipment production. By 2026, establish a complete industrial chain covering "R&D-production-sales-maintenance" with output value exceeding 20 billion yuan. Second, deepen the integration of "ice and snow + services" by consolidating resources from ski resorts, hotels, travel agencies, and transportation companies to form an ice and snow tourism group providing "one-stop" services. Cultivate five ice and snow service enterprises each with annual revenue surpassing 1 billion yuan by 2025. Third, accelerate the integration of "ice and snow + digitalization" by encouraging enterprises to develop VR games and digital cultural products themed around ice and snow. By 2026, achieve a digital ice and snow industry output value exceeding 5 billion yuan, creating a new business model featuring "online traffic diversion and offline consumption."

5.3.3. Strengthening policy coordination and guarantee

First, establish a "Policy Coordination Mechanism for Ice and Snow Economy" led by the provincial government to coordinate policy formulation across cultural tourism, industry and information technology, transportation, finance, and other departments, preventing policy conflicts. By 2025, the "Jilin Province Ice and Snow Economy Industrial Chain Collaborative Development Policy List" will be issued, clarifying departmental responsibilities and tasks. Second, optimize policy implementation processes by setting up a dedicated policy service window to provide enterprises with one-stop services, including policy consultation and application guidance, reducing approval time to within 15 working days by 2025. Third, strengthen policy evaluation and adjustment by establishing a semi-annual effectiveness assessment mechanism. Based on evaluation results, policies will be promptly revised to ensure precise alignment with industrial chain demands.

6. Conclusion

Based on the theoretical framework of New Quality Productive Forces and combined with the actual development of ice and snow economic industry chain in Jilin Province, this paper systematically analyzes the mechanism and path of New Quality Productive Forces driving the improvement of resilience of ice and snow economic industry chain in Jilin Province, and draws the following conclusions:

First, while Jilin Province's ice and snow economy continues to expand its industrial chain scale, it demonstrates notable weaknesses in resilience. These include: fragile impact resistance (insufficient natural risk preparedness and reliance on imported high-end equipment), inadequate risk transmission barriers (data silos and inconsistent standards), and limited recovery capacity (insufficient innovation and limited business diversification). The root causes of these shortcomings stem from insufficient investment in technological innovation, inefficient resource allocation, and inadequate policy coordination.

Second, new productive forces enhance industrial chain resilience through a three-dimensional mechanism of "technological innovation-factor restructuring-business model innovation": Technological innovation strengthens resilience through smart equipment R&D and digital operations; Factor restructuring mitigates risks by integrating data elements and optimizing green factors; Business model innovation promotes recovery through "ice-snow+" integration and online-offline convergence.

Thirdly, tailored to Jilin Province's realities, we propose a three-dimensional enhancement framework of "technological breakthroughs → factor upgrading → ecological synergy": The technological breakthrough path focuses on establishing an industry-academia-research-application innovation ecosystem, achieving core technological breakthroughs in high-end equipment and building digital infrastructure. The factor upgrading path emphasizes activating the "data + talent + green" core elements, deepening data empowerment, strengthening talent support, and promoting green integration. The ecological synergy path aims to build a regional-industrial-policy collaborative system, advancing regional coordination, fostering industrial convergence, and enhancing policy alignment. Additionally, four safeguard measures are proposed across organizational structure, funding mechanisms, standardization, and risk prevention to ensure effective implementation of these pathways.

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