

A DUAL-DRIVE MECHANISM OF TECHNOLOGICAL INNOVATION AND CULTURAL EMPOWERMENT: AN EMPIRICAL STUDY ON OVERCOMING SEASONAL BOTTLENECKS IN THE WINTER SPORTS INDUSTRY AND PROPOSED PATHWAYS

Zhang Ge

Assistant Lecturer

Graduate School of China Academy of Chinese Medical Sciences

Su Zhou, China

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Abstract

The winter sports industry serves as a vital pillar for China's economic transformation and the integrated development of culture, sports, and tourism. However, seasonal constraints have long hindered its high-quality growth. Drawing on the latest data and policy documents from 2025, this paper analyzes the current state of the industry and the characteristics of its seasonal constraints, elucidates the dual-drive logic of technological innovation and cultural empowerment, and proposes specific pathways to overcome these constraints through three key areas: technological breakthroughs, cultural exploration, and policy safeguards. The study finds that technological innovation can create year-round operational scenarios and digitally reconstruct the industrial chain, thereby resolving temporal and spatial constraints. Cultural empowerment can establish value recognition and extend consumption scenarios, enabling the industry to achieve year-round value appreciation. The combined effect of these two factors can propel the snow and ice industry from "seasonal dependence" to "year-round prosperity."

Keywords: Snow and ice industry, Seasonal bottlenecks, Technological innovation, Cultural empowerment, Integration of culture, sports, and tourism

I. Introduction

By 2025, the scale of China's winter sports industry had surpassed 1 trillion yuan. During the 2024–2025 winter season, related consumption reached 187.5 billion yuan, representing a year-on-year increase of over 25%¹. In the post-Winter Olympics era, China's winter sports economy continues to expand, shifting from scale expansion toward high-quality development. The Winter Olympics IP effect, industrial integration, technological empowerment, and capital investment have become the primary driving forces². The winter sports industry is highly dependent on cold-weather conditions, exhibiting the characteristic of being "booming in winter and quiet during the other three seasons." The supply side is constrained by time and space, while the demand side suffers from entrenched perceptions, creating a mutual lock-in. Winter snow and ice venues account for over 70% of annual visitor traffic and revenue, with most enterprises ceasing operations during the off-season. Coupled with issues such as seasonal mismatches in the industrial chain, facility idleness, and talent drain, this creates a vicious cycle of "off-season idleness—insufficient investment—lack of innovation—worsening off-season performance"³⁴.

This paper adopts a full-industry-chain perspective and draws on practical experiences from regions such as Heilongjiang, Jilin, Liaoning, Hebei, and Xinjiang to analyze the underlying logic and implementation pathways of a dual-drive model combining technological innovation and cultural empowerment, thereby providing theoretical references and practical models for the snow and ice industry to overcome seasonal constraints.

II. Current Status of the Snow and Ice Industry and Characteristics of Seasonal Constraints

China's winter sports industry is highly dependent on natural climate conditions. In northern regions,

winter temperatures are low, with snowfall concentrated between November and March of the following year. In southern regions, winter temperatures typically remain above 0°C, resulting in scarce natural snowfall and short snow seasons. When temperatures rise above 0°C, snow on outdoor winter sports venues melts rapidly, leading to significantly higher maintenance costs and, in some cases, rendering normal operations impossible.

A. Current Status of the Snow and Ice Industry

1) Parallel Expansion of Scale and Structural Upgrading

By 2025, China's winter sports industry is projected to reach a total output value of 1,005.3 billion yuan, with ski resort consumption amounting to 78.613 billion yuan, driving a 27.97% increase in consumption within a two-kilometer radius of these resorts¹. The consumer base has expanded from professional enthusiasts to include families with children and the elderly. The market has seen the emergence of differentiated products such as children's ski areas and night skiing. The industry structure has evolved from single-service tourism to a full industrial chain.

Upstream snow and ice equipment manufacturing has achieved technological breakthroughs. Midstream event operations have become more diversified. Leveraging the 15th National Winter Games, Liaoning has created an integrated model of "traveling to follow the events," driving the integration of event-driven economy with cultural and tourism consumption. Downstream, the "Snow and Ice Plus" model continues to innovate, with new business formats such as "Snow and Ice Plus Wellness" and "Snow and Ice Plus Educational Tours" increasing their share to 35%¹.

2) Policy Support and the Formation of Regional Patterns

The Chinese government has set a clear target of reaching a 1.5 trillion yuan winter sports economy by

2030, while local policies have provided targeted support to form a complementary framework. Regional development exhibits a pattern of “north-south coordination with distinct regional characteristics.” The Northeast and North China are leveraging natural resources to build world-class destinations, while Xinjiang is developing the “Third Pole of Winter Sports.” Indoor ski resorts in the south account for 18% of the nation’s annual visitor volume¹, and a comprehensive development trend is gradually taking shape.

3) Improvement of Hardware Facilities and Industrial Integration and Innovation

As of April 2025, China had 1,725 ice rinks and 79 indoor ski resorts, representing a 33.9% increase in numbers, and had established a product system comprising 15 major categories of winter sports equipment. The “Winter Sports Plus” model continues to expand its scope. Supporting facilities for “Ice and Snow + Tourism,” such as hotels and commercial streets, are becoming increasingly mature. “Ice and Snow + Culture” has created well-known IPs like the Harbin Ice and Snow World, and cultural and creative products from the Asian Winter Games have seen strong sales. “Ice and Snow + Wellness” combines hot spring therapy to develop distinctive products, while business formats such as ice and snow study tours and mountain sports continue to diversify. The north focuses primarily on ice and snow experiences, while the south holds greater advantages in equipment operation and maintenance, forming a complementary and synergistic development pattern.

B. Core Characteristics of Seasonal Constraints

The seasonal bottlenecks in China’s winter sports industry are not merely rigid constraints of time and space; they also stem from multiple deep-seated issues. Digital transformation is subject to path dependence, and traditional technological systems, management models, and industrial ecosystems—influenced by technology lock-in, structural rigidity, entrenched market structures, and stagnant capabilities—hinder year-round development³. The industrial chain lacks resilience; a weak industrial foundation, slow response to market changes, lagging safety measures, poor innovation commercialization, and insufficient cross-regional coordination further exacerbate seasonal fluctuations⁴. The integration of culture, sports, and tourism remains superficial; insufficient cultural empowerment, product homogenization, significant ecological pressure, and poor promotional effectiveness limit the industry’s value enhancement and year-round expansion⁵. The talent system does not align with industry needs, resulting in year-round talent shortages that exacerbate operational imbalances⁶. The legacy of major events such as the Winter Olympics and Asian Winter Games is underutilized, with poor conversion, shallow integration, and insufficient long-term support, making it difficult to sustain year-round operations⁷.

The seasonal bottlenecks in the winter sports industry are primarily manifested in three aspects: temporal and spatial constraints, mismatches in the industrial chain, and fragmented consumer demand. These factors intertwine to form a vicious cycle, hindering the industry’s high-quality development.

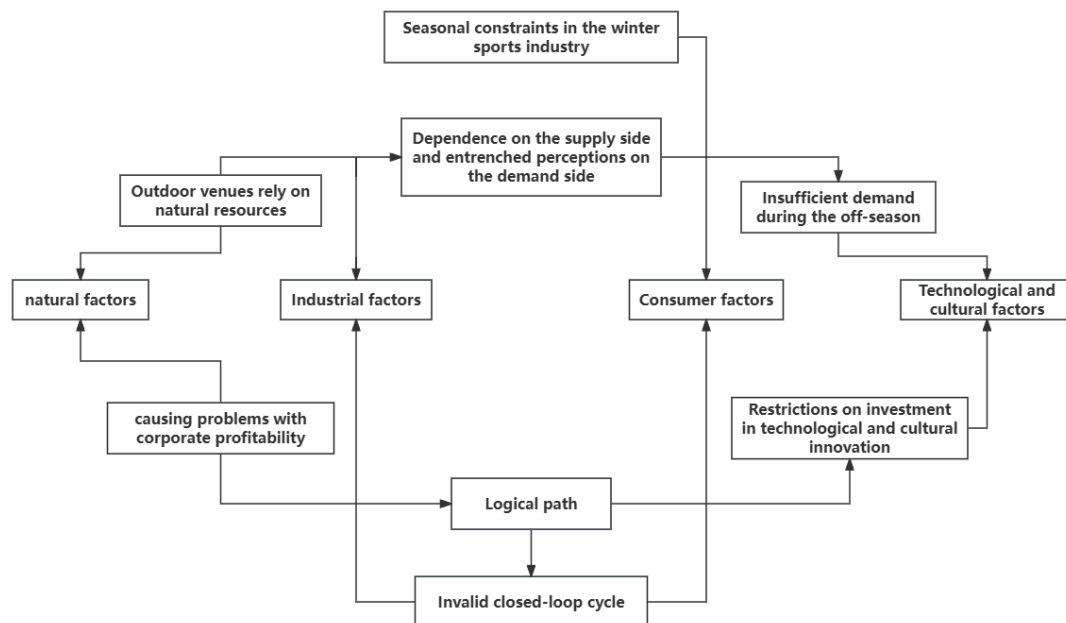


Figure 1 Diagram of the Causal Relationships Behind the Seasonal Bottlenecks in the Snow and Ice Industry

To break this cycle, it is necessary to address the spatiotemporal constraints on the supply side while simultaneously unlocking the year-round consumption potential on the demand side. Technological innovation can overcome physical limitations; through scenario transformation, digital reconstruction, and equipment upgrades, it fundamentally alleviates the constraints

that climate imposes on operations, thereby supporting year-round supply. Cultural empowerment focuses on the value dimension, tapping into regional culture, expanding consumption scenarios, and fostering year-round consumption awareness. This approach reconstructs the value identity of the snow and ice industry,

shifting consumption from a reliance on seasonality to a reliance on culture.

III. The Dual-Drive Logic of Technological Innovation and Cultural Empowerment

Technological innovation and cultural empowerment together constitute the core mechanism for overcoming seasonal bottlenecks. Rather than operating in isolation, they generate synergistic effects through a cycle of “platform support—value empowerment—feedback iteration.” Technological innovation addresses the question of “whether year-round operations are feasible,” providing the platforms and tools for cultural dissemination. Cultural empowerment addresses the question of “whether consumers are willing to engage year-round,” adding value and expanding the market for technological products. The two form a closed loop across three stages—scenario expansion, value enhancement, and demand activation—generating a “1+1>2” effect³⁸, driving the industry toward year-round prosperity.

From the perspective of new-quality productive forces, the high-quality development of the winter sports economy is premised on ecological conservation, led by technological innovation, and guided by integration and synergy, thereby achieving a more optimized industrial structure, higher efficiency, and

greater value⁹. Under the guidance of the “Two Mountains Theory,” the combination of technological empowerment and cultural enrichment can unify economic, ecological, and social benefits while avoiding homogenized competition and excessive ecological pressure⁷.

A. Scenario Expansion: Technological Innovation Creates a Year-Round Platform for Cultural Dissemination

Technological innovation enables the dissemination of snow and ice culture beyond winter settings, reducing temporal and spatial constraints as well as costs, and facilitating year-round implementation. Technologies such as VR/AR and 5G create immersive ice and snow cultural experience centers, transforming cultural content—including Northeast folk customs and intangible cultural heritage related to ice and snow—into virtual scenarios accessible year-round. Content such as Harbin’s ice sculpture craftsmanship and Xinjiang’s fur-lined ski-making techniques can transcend the limitations of winter viewing. Off-season visitor numbers account for 65% of the annual total, and technology has transformed ice and snow culture into a product that can be consumed year-round.

Table 2.

Proportion of Off-Season Sales of Altay Snow and Ice Intangible Cultural Heritage Creative Products Relative to Annual Total (2025, Unit: 10,000 yuan)

Category	Off-Season Sales	Winter Sales	Annual Share
Fur Ski Boards Handcrafted Souvenirs	2,100	900	70%
Snow and Ice Intangible Cultural Heritage Study Tours	1,800	200	90%
Snow and Ice-Themed Digital Collectibles	600	400	60%
Total	4,500	1,500	75%

Note: Data sourced from the Altay City Culture and Tourism Bureau’s 2025 intangible cultural heritage industry operational data; the non-snow season refers to April–October.

Advances in low-energy-consumption refrigeration technology for indoor ski resorts not only reduce operating costs for winter attractions in southern regions but also allow for the integration of local cultural elements. For example, Shenzhen Qianhai Ice and Snow World incorporates Lingnan water town culture,

avoiding the uniformity often seen in such venues and enabling indoor facilities to serve both as cultural hubs and consumer experience destinations. Technology provides year-round support for winter attractions, while culture helps these venues develop distinctive characteristics.

Table 3.

Growth Trends in the Number of Indoor Ski Resorts and Ski Visits Nationwide, 2020–2025 (Unit: 10,000 visits)

Year	Number of Indoor Ski Resorts (units)	Number of Indoor Skiing Visits (10,000)	Percentage of Total National Ski Visits
2020	36	269	12.9%
2022	48	385	16.7%
2024	60	488	20.2%
2025	66	563	21.61%

Note: Data source: 2024–2025 China Ski Industry White Paper. The statistical period runs from May 1 of each year to April 30 of the following year.

B. Value Enhancement: Cultural Empowerment Creates Value-Added Potential for Technological Products

Cultural empowerment redefines value, making technological innovations more competitive in the market and enabling the snow and ice industry to create value beyond seasonal constraints. Infusing technical

products with cultural significance transforms them from “functional tools” into “value-added products,” significantly increasing their added value and profit margins, thereby addressing the challenge of profitability during the off-season.

Harbin Qianmao Xuelong Sports Goods Co., Ltd. uses aerospace-grade composite materials to manufacture skis and incorporates local urban culture and intangible cultural heritage elements related to snow and ice to develop cultural and creative ski products, significantly enhancing product value-added and off-season sales performance (Heilongjiang Provincial Department of Industry and Information Technology, 2025). Cultural empowerment enables technical products to achieve year-round value appreciation.

C. Demand Activation Level: Fostering Year-Round Consumer Awareness Through Two-Way Synergy

Through the combined effects of technological innovation and cultural empowerment, efforts are made

from both the supply and demand sides to break the fixed perception that “snow and ice belong only to winter,” cultivate year-round demand for snow and ice consumption, and form a two-way cycle of supply and demand. Technological innovation has introduced products such as dryland snow and ice equipment and home ski simulators, providing consumers with avenues for participation during the off-season, lowering seasonal barriers, and creating consumption scenarios accessible year-round. Cultural empowerment, through short videos, commercial district exhibitions, and year-round winter sports festivals, continuously conveys the concept that “winter sports culture can be enjoyed year-round,” altering consumers’ seasonal perceptions and increasing their willingness to consume during the off-season. Together, these efforts drive winter sports consumption from a “seasonal experience” to a “regular habit,” forming a virtuous cycle where “new supply creates new demand, and new demand guides new supply.”

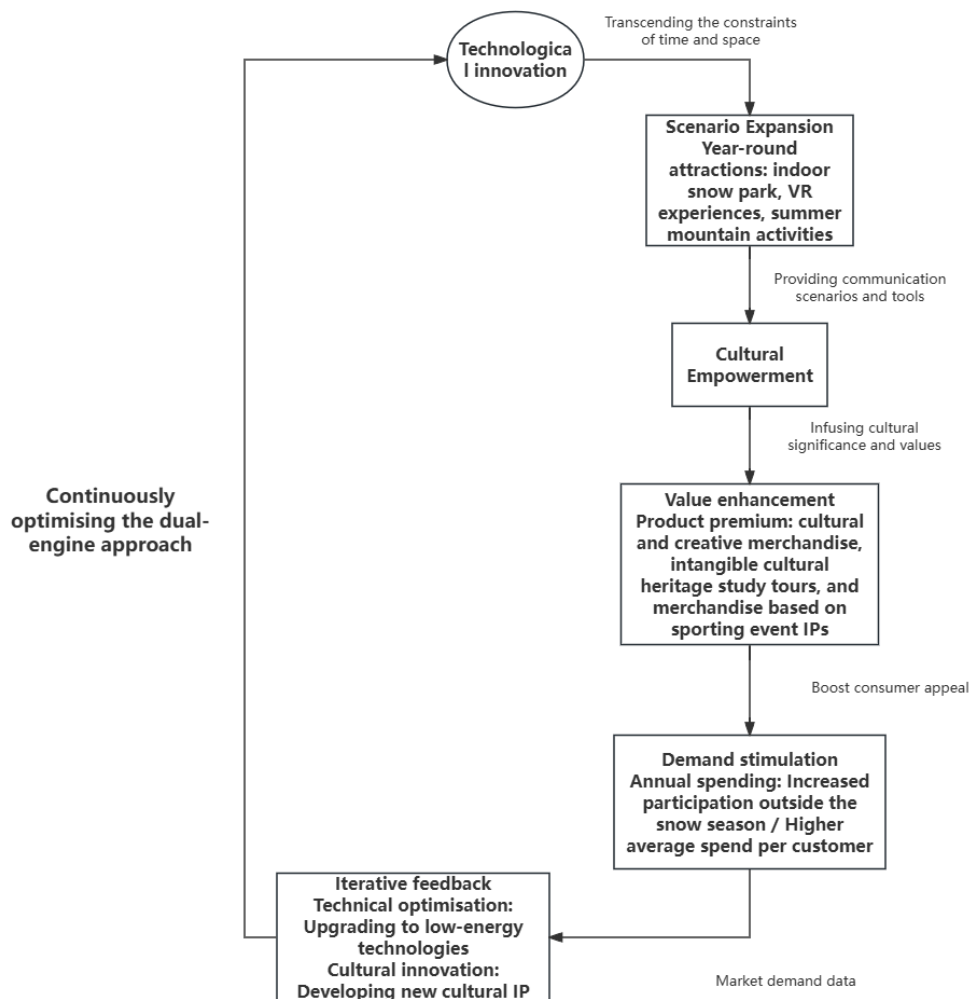


Figure 4. Model of the Synergy Mechanism Between Technological Innovation and Cultural Empowerment

The essence of the synergy mechanism between technological innovation and cultural empowerment is as follows: technological innovation addresses the issue of “the feasibility of year-round operations,” providing scenarios and tools for cultural dissemination. Cultural empowerment addresses the issue of “the appeal of year-round consumption,” endowing technological

products with value and market potential. Through a closed-loop interaction involving scenario expansion, value enhancement, and demand activation, the two achieve a synergistic effect where “1+1>2.”

IV. Pathways to Overcoming Seasonal Constraints Through Dual-Drive

This paper integrates the resource disparities between northern and southern regions in the winter sports industry, the need for industrial chain synergy, and the characteristics of the consumer market. The path design adheres to three principles: First, adapt to local conditions, respect regional differences, avoid a one-size-fits-all approach, and create differentiated year-round operation models. Second, match supply with demand, guided by year-round consumer needs, to meet the demands of groups such as families, educational tours, and seniors, and drive the transformation of supply toward year-round, personalized, and scenario-based offerings. Third, synergy and integration: Strengthen the interaction between technology and culture, allowing technology to serve as a vehicle for cultural dissemination and culture to enhance the value of technological applications.

At the same time, supported by policy safeguards, a "technology-culture-policy" trinity advancement mechanism is established to ensure the feasibility and sustainability of the implementation. This paper outlines specific pathways to overcome seasonal bottlenecks from three dimensions: technological innovation, cultural empowerment, and policy support. It also integrates policy safeguards to form a "technology-culture-policy" trinity of synergistic advancement mechanisms, ensuring the feasibility and sustainability of these pathways. From the three dimensions of technological innovation, cultural empowerment, and policy support, this paper elaborates on practical pathways to overcome seasonal bottlenecks.

A. Technological Innovation Dimension: Building a Technical Support System for Year-Round Operations

To break free from digital path dependence, it is necessary to establish an autonomous and controllable digital technology system, drive the digital transformation of management systems, break down barriers in traditional industrial ecosystems, and foster a culture of innovation³. Leveraging new-quality productive forces, we must accelerate the application of digital technologies and enhance the efficiency of data resource allocation. By renovating outdoor venues for year-round use, upgrading low-energy-consumption cooling technologies, building VR/AR virtual scenarios, establishing digital middleware platforms, and developing flexible equipment, we can reconstruct year-round consumption scenarios, improve the efficiency of industrial chain resource allocation, and achieve peak-shifting production, cross-seasonal workforce deployment, and stable capacity utilization³⁴⁹.

1) Technological Breakthroughs in Scenario-Based Development: Reconstructing Year-Round Consumer Experiences

Promote the year-round transformation of outdoor venues. Support key ski resorts such as Chongli and Beidahu in developing summer activities including hiking and forest trekking, and build supporting ice and snow cultural exhibition halls and smart experience zones, so as to realize the model of "skiing in winter and diversified experiences in summer". thereby revitalizing idle resources. Develop low-energy artificial refrigeration technologies to reduce costs for indoor ski

resorts in southern regions, while integrating local culture to avoid homogenization. Expand the scale of indoor ski resorts in southern regions to establish a year-round consumption ecosystem that complements northern and southern markets. Utilize VR/AR and 5G technologies to build online snow and ice theme parks and digital snow and ice museums, breaking through spatial and temporal constraints to form a year-round "online + offline" consumption loop.

2) Restructuring the Digital Industrial

Chain to Enhance Resource Allocation Efficiency

Build a digital middle platform for the snow and ice industry to integrate data across the entire industrial chain—including equipment manufacturing, scenic area operations, and cultural tourism consumption—thereby breaking down information barriers and enabling off-peak production and cross-seasonal staffing. Equipment manufacturers should adjust their plans based on year-round consumption data, allocating approximately 30% of their production capacity to the production of cultural and creative products during the off-season to resolve idle capacity issues. Scenic areas should use big data to forecast visitor flows and pre-recruit service staff for the off-season to alleviate mismatches between labor supply and demand.

Promote the digital transformation of winter sports equipment manufacturing to enhance flexible production capabilities and meet year-round demand for personalized customization. The Harbin Winter Sports Equipment Industrial Park has achieved a closed-loop "R&D–Manufacturing–Application" system, with cultural and creative equipment accounting for 40% of its output value during the off-season. Digital transformation makes the winter sports industry chain more modern and efficient.

3) Equipment Technology Innovation to

Expand Sports Consumption Scenarios

Increase R&D efforts for summer training equipment and dryland winter sports gear to transition winter sports from a "winter-only professional activity" to a "year-round mass participation" activity. Promote dryland curling, land hockey, and similar sports by introducing them into schools and communities to popularize winter sports. Develop portable ski simulators for use in homes and commercial districts, making winter sports a year-round recreational option. This will expand consumption scenarios and stimulate year-round winter sports consumption among the general public.

B. Cultural Empowerment Dimension: Building a Cultural Value System with Year-Round Value

The integration of the snow and ice industry with the tourism sector is driven by four core factors: infrastructure development, government planning and management, the improvement of service systems, and innovation in "Snow and Ice Plus" business models³. We must deeply explore local snow and ice culture, create a year-round IP matrix, and promote the deep integration of "snow and ice + intangible cultural heritage + educational tours + wellness + digital cultural creativity." By pursuing a path of differentiated development, we will transform cultural resources into year-round consumer products⁴. At the same time, we will activate

the legacy value of sporting events and, through three mechanisms—resource integration, industrial convergence, and brand building—convert the short-term benefits of events into long-term industrial value⁹.

1) Deeply Explore Regional Snow and Ice Culture to Build a Year-Round IP Matrix

Systematically organize cultural resources such as Northeast folk customs, Xinjiang's snow-region culture, and Northern ice-play traditions, transforming them into experiential and consumable products to build a year-round winter sports and culture IP matrix. Harbin has extended the "Ice and Snow World" IP into a year-round cultural and creative brand, developing products such as ice and snow blind boxes and replicas of intangible cultural heritage ice sculptures, making the IP a vehicle for year-round consumption. Liaoning, centered on the "Creative Winter + Fun in Liaoning" brand, hosts seasonal ice and snow cultural festivals—featuring competitions in winter, cultural and creative exhibitions in summer, and educational tours in spring and autumn—using IP operations to achieve year-round dissemination and consumption of ice and snow culture.

2) Promoting the Integration of "Snow and Ice + Culture" Business Models to Extend the Consumption Chain

Deepening the integration of "Ice and Snow + Intangible Cultural Heritage," "Ice and Snow + Educational Tours," and "Ice and Snow + Wellness," we combine ice and snow culture with diverse business models to free ice and snow cultural consumption from seasonal constraints. We transform intangible cultural heritage projects such as fur-lined skiing and ice sculpture making into year-round educational tour courses, creating a year-round "Culture + Education" business model. Combine with hot spring wellness to launch "summer retreat + snow and ice cultural experience" packages, achieving the integration of "culture + wellness."

Encourage the integration of snow and ice culture with digital cultural and creative industries, launching snow and ice-themed digital collectibles and virtual brand ambassadors to create new growth points for online consumption. Cultural empowerment shifts snow and ice consumption from "scene-dependent" to "value-driven." Even without actual winter snow and ice settings, people can add value to the industry through intangible cultural heritage experiences and cultural and creative consumption, driving the deep integration of snow and ice culture and the tourism industry.

3) Strengthen Cultural Communication to Foster Year-Round Consumption Awareness

Utilize short videos, offline experiential exhibitions, and pre-event hype for competitions to break the entrenched perception that "snow and ice = winter." For example, host snow and ice culture exhibitions in commercial districts during the summer to showcase the history of ski equipment development and intangible cultural heritage techniques related to snow and ice, allowing consumers to engage with snow and ice culture up close. Leverage key events such as competitions and festivals to continuously promote the concept of

"snow and ice all year round," fostering year-round consumption habits. Regular and diverse cultural outreach can reshape consumer perceptions, increase willingness to spend during non-ski seasons, and support year-round operations of the winter sports industry from the demand side.

C. Policy Support Dimension: Establishing a Dual-Drive Institutional Framework

We should refine the policy framework for year-round operations, strengthen incentives for technological innovation, and promote regional coordinated development to form a "technology-culture-policy" trinity mechanism. This will provide institutional safeguards for the implementation of the dual-drive strategy, helping the snow and ice industry overcome seasonal constraints and achieve high-quality development.

Implement Jilin's "Jilin Ice and Snow All Year Round" talent policy, provide cross-season employment subsidies, address year-round talent shortages, and provide human resources support for year-round operations. Offer tax breaks and energy consumption subsidies to snow and ice enterprises operating during the off-season to reduce operational costs and boost their enthusiasm for year-round operations.

Strengthen incentives for technological innovation by establishing a special fund for winter sports equipment R&D, rewarding technological achievements that overcome seasonal constraints, and encouraging enterprises to pursue core technology development. Promote regional coordination by leveraging transportation routes such as National Highway G331 and the Shenyang-Baicheng High-Speed Railway to integrate winter sports resources from Northeast and North China, creating cross-regional, year-round winter tourism routes. This will reduce the seasonal dependence of individual regions and foster coordinated regional development of the winter sports industry.

V. Conclusions and Outlook

In the future, with the deepening application of technologies such as 5G and AI, as well as the continuous exploration of the cultural value of winter sports, the industry will further integrate technology and culture, achieving the year-round transformation of "cold resources" into a "hot industry." The realization of the 2030 target of a 1.5 trillion yuan winter sports economy will no longer rely solely on the contribution of the winter season.

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