Journal of Economics and Management Sciences; Vol. 8, No. 4; 2025
ISSN 2576-3008 E-ISSN 2576-3016
https://doi.org/10.30560/jems.v8n4p59

Research on the Digital Transformation Path of Ice and Snow Venues in Hebei Province

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Received: July 20, 2025; Accepted: August 2, 2025; Published: August 3, 2025

Abstract

Since the successful co-hosting of the Winter Olympics by Beijing and Zhangjiakou, China's ice and snow venues have experienced rapid development under the dual impetus of policy support and market demand. Leveraging its geographical and strategic advantages, Hebei Province has actively improved its venue infrastructure and competitiveness. However, in the context of the digital era, traditional operational models face increasing challenges. This study, using literature review and logical analysis, examines the current situation of Hebei's ice and snow venues and explores digital transformation strategies in areas such as intelligent decision-making, service innovation, and operational optimization. Targeting issues like outdated infrastructure and limited data sharing, the paper offers practical solutions to support the high-quality and sustainable development of the regional winter sports sector.

Keywords: Hebei Province, ice and snow venues, digital transformation, advantages, optimization path

1. Introduction

1.1 Introduce the Problem

On July 31, 2015, China successfully secured the hosting rights for the 24th Winter Olympics in 2022. The successful bid ignited a wave of enthusiasm for developing winter sports projects. In 2018, China issued the "Implementation Outline for Engaging 300 Million People in Winter Sports (2018-2022)", which further encouraged private capital investment and accelerated the rapid development of the winter sports industry[1]. As core facilities, ice and snow venues play a vital role in both sporting events and leisure services. In the post-pandemic era following 2022, digitalization has emerged as a transformative force in global value chains, serving as a key driver of economic growth worldwide. Traditional operational models of these venues now face numerous challenges, making it imperative to explore digital transformation pathways that align with China's national conditions.

(1) Development status of Hebei Ice and Snow Pavilion

Since Beijing and Zhangjiakou jointly secured the bid for the Winter Olympics, Hebei Province has seized opportunities by issuing the "Hebei Ice and Snow Industry Development Plan (2018-2025)". The province has actively planned venue layouts, accelerated the construction of ice and snow sports facilities, and implemented post-Olympic venue renovations. It mandates that each city build at least one standard public skating rink spanning 1,830 square meters, while encouraging regional development of seasonal ice rinks, demonstrating strong commitment to ice and snow industry growth[2]. By 2024, Hebei had established 213 indoor ice rinks–the highest in China, with 100 real ice rinks and 28 standard ice rinks exceeding 1,830 square meters; along with 55 ski resorts, ranking third nationally[3] (Table 1). According to data released by the Hebei Provincial Sports Bureau and Statistics Bureau, the industry's total output reached 240 billion yuan in 2023, marking a 15% year-on-year increase. However, some local ice rinks continue to upgrade their facilities, updating equipment to meet international standards for a top-tier skiing experience.

Table 1. Distribution of Ice and Snow Venues in Hebei Province

city	quantity	proportion
Baoding	43	16.045
Shijiazhuang	38	14.179
Zhangjiakou	34	12.687
Xingtai	28	10.448
Tangshan	25	9.328
Cangzhou	21	7.836
Hengshui	18	6.716
Qinhuangdao	16	5.970
Chengteh	16	5.970
Langfang	15	5.597
Handan	14	5.224
Total	268	100

The key challenge lies in transforming the Winter Olympics' fleeting ice and snow craze into a sustainable development momentum. Confronted with both the challenges and opportunities brought by the Games, Hebei Ice and Snow Venue should seize the digital transformation opportunity to establish a scientific venue system that meets market demands, develop a distinctive industrial chain, and ensure healthy, sustainable growth for the facility.

2. Advantages of the Digital Economy in Promoting High-Quality Development of Hebei Ice and Snow Venue

(1) Big Data Information Circulation and Industry Sharing

The rise of digitalization has driven profound transformations in the winter sports industry. By leveraging big data platforms, fragmented services including ticketing, equipment rentals, accommodation, and reservations are now integrated into a unified management system, delivering convenient and efficient online experiences for travelers. The advancement of big data technology has merged previously separate systems such as ticketing, ski equipment rentals, hotel bookings, and instructor scheduling, providing enhanced service convenience. These digital platforms have broken down information silos by consolidating operational data into a single platform[4]. This integration enables seamless communication between venue staff and visitors, while allowing real-time updates on facility operations and fare adjustments. Cross-venue sharing of instructors and equipment resources enhances coordination between events and activities. Through data analytics, venues gain precise insights into market trends and operational status, driving digital upgrades, expanding revenue streams, and boosting overall efficiency and transformation momentum.

(2) Precise Supply and Personalized Services of Cloud Computing

The operation of ice and snow facilities is complex. Cloud computing enables centralized resource management and intelligent monitoring, enhancing efficiency while reducing energy consumption. The platform builds user profiles based on visitor behavior and historical data, delivering personalized course recommendations, equipment selections, and venue services to optimize supply-demand matching. Cloud services create customized resource recommendations and service plans[5] using visitors' historical data. When tourists wish to experience different attractions, the platform promptly provides comprehensive data across venues. Venue staff continuously monitor visitor feedback and evolving needs, making ongoing improvements to services. Managers can track real-time crowd dynamics through the platform, dynamically adjusting staffing and operational strategies—enhancing scheduling during peak hours and attracting visitors with seasonal events during off-peak periods. The cloud platform also supports real-time monitoring of equipment and environmental conditions, enabling precise regulation and service optimization to comprehensively improve visitor experiences and resource utilization efficiency.

(3) Intelligent Technology Innovation and User Experience

The intelligent technological innovation has not only enhanced the operational efficiency of the venue but also significantly improved visitor experiences. The facility actively incorporates VR/AR technologies to create immersive educational environments. Visitors can simulate skiing and skating scenarios in virtual settings, experiencing tracks of varying difficulty levels. During VR instruction, the system promptly corrects visitors' improper movements, helping them learn proper techniques and postures. Wearable devices and sensors within

the venue collect real-time data on participants' speed, heart rate, and calorie expenditure during activities. An intelligent monitoring system identifies ice surface cracks or dangerous behaviors, issuing alerts to ensure visitor safety. Meanwhile, smart environmental systems continuously monitor and regulate temperature, humidity, and air quality, providing visitors with a more comfortable and secure sports environment.

3. Problems faced by Hebei Ice and Snow Venue in digital transformation

(1) The Shackles of Management Concepts and Technical Thinking

Many ice and snow venue operators lack a clear understanding of digital transformation, still relying on traditional management models—a phenomenon particularly prominent in Hebei Province's ice and snow facilities. A survey of 50 venues in the province revealed that approximately 40% of operators view digital transformation merely as computer system upgrades (Table 2), without strategically planning for it.

Table 2. Operators' awareness of digital transformation in Hebei Ice and Snow Venue

city know	Computer system upgrade	Introduce smart devices	It is not clear what the digital transformation entails	A comprehensive and correct understanding
Baoding	2	2	1	1
Shijiazhuang	3	2	1	1
Zhangjiakou	3	1	1	0
Tangshan	1	2	1	1
Cangzhou	2	1	0	0
Hengshui	1	0	1	1
Qinhuangdao	2	1	1	1
Chengde	1	1	1	0
Langfang	2	1	0	1
Handan	1	1	1	0
Xingtai	1	2	1	1
Total	19	14	9	7

As evidenced by the table, cognitive biases have indirectly contributed to the lack of systematic and forward-looking approaches in digital transformation for cultural venues. Digital transformation is not merely about isolated technological upgrades, but rather a comprehensive overhaul encompassing business process restructuring, organizational innovation, and service model optimization. Due to limited understanding, some venues mistakenly view digitalization as mere technical upgrades while neglecting process reengineering and system integration, which results in operational coordination gaps. Although ticketing systems have been implemented, critical links like ticket sales, validation, and visitor guidance remain disconnected, creating fragmented experiences. The failure to effectively integrate cutting-edge technologies, such as big data and cloud computing, has hindered precise marketing and intelligent services, causing venues to gradually lose competitiveness and struggle to meet digital-era demands. Traditional operational models fail to accurately reach target customer groups, severely limiting market influence. This narrow perspective has significantly constrained the deepening of digital transformation in ice and snow sports venues, causing them to lose their competitive edge in increasingly fierce market competition and struggle to adapt to the evolving needs of the digital age.

(2) Technical Application and Business Process Constraints

Most ski resorts are situated in mountainous areas with complex terrain, where inadequate network coverage and severe signal attenuation hinder real-time data transmission for equipment management and visitor tracking systems. This infrastructure limitation impedes the smooth operation of digital service platforms. Furthermore, generic solutions from some digital service providers struggle to adapt to the diverse operational workflows required by these venues. Particularly in critical areas like slope monitoring and resource allocation, these systems often fail to meet practical needs. This mismatch not only reduces operational efficiency and increases costs but also delays digital transformation efforts, ultimately placing the resorts at a competitive disadvantage in the market.

(3) Infrastructure Construction Lags Behind

The digital transformation of Hebei Provincial Ice and Snow Venues faces challenges stemming from outdated infrastructure, particularly in both hardware and software systems. Many venues are located in remote areas with weak network coverage and insufficient bandwidth, leading to frequent congestion during peak tourist seasons. This results in limited functions like ticketing, live streaming, and remote operations, while smart turnstiles frequently malfunction, affecting entry efficiency and visitor satisfaction. Most venues lack unified service platforms and online features such as apps or mini-programs, relying instead on manual operations. The fragmented systems and data silos further hinder connectivity. The absence of temperature/humidity sensors and air quality monitoring equipment has led to delayed maintenance responses, significantly reducing operational efficiency and service quality–critical bottlenecks constraining the digital transformation process.

(4) Security and Reliability are Challenged

During the digital transformation of ice and snow venues, security concerns have become increasingly prominent, directly impacting visitor experiences and operational stability. On one hand, ticketing systems, membership management, and equipment networks face cyber-attack risks. If hacked, this could not only lead to visitor data leaks and tampered ticketing records but also trigger trust crises. On the other hand, aging facilities and cracked ice surfaces require urgent maintenance. The absence of intelligent early-warning systems exacerbates safety hazards. Moreover, the venue's digital emergency response mechanisms remain underdeveloped. Current emergency alarm and rescue systems operate under separate departments with inefficient coordination, making timely responses to emergencies difficult. The lack of digital emergency drills and staff unfamiliarity with operations further weaken emergency response capabilities and system reliability, becoming major obstacles to realizing the benefits of digital transformation.

(5) Dual Pressure of Market Demand and Consumption Experience

With the advancement of the digital era, consumers' demand for digital Ice and Snow Venues has shown a rapid growth trend. Through a questionnaire survey of 105 people, it can be seen that consumers have great demand for digitalization, and their demand for ice and snow sports is no longer limited to simple entertainment, but has expanded to fitness, competition, social interaction, and other fields (Table 3).

Table 3. Digital demand survey form for tourists of Hebei Ice and Snow Venue

Category of needs	non-essential	same as	need	need	Very much needed	Total
Convenience ticketing service	12	6	53	23	11	105
Venue tour APP	2	21	31	46	5	105
Introduction to Electronic Projects	0	2	31	28	44	105
Interactive experience (VR/AR)	4	35	22	38	6	105
personalized service	13	15	39	20	18	105
Real-time information	0	25	37	29	14	105
Customer support	0	12	39	42	12	105
Zero failure payment method	2	6	27	37	33	105
Safety Warnings and Protection Measures	0	1	15	54	35	105
Membership services	21	14	27	31	12	105
Smart fitness equipment	4	8	34	53	6	105
Digitalization of competition	18	37	15	30	5	105
Exclusive social platform	24	17	31	22	11	105

With the diversification of consumer demands, ice and snow venues urgently need to respond swiftly to market needs by offering more personalized and differentiated services. However, constrained by traditional operational models and technical capabilities, most venues struggle to accurately identify consumer preferences and market trends, leading to delayed service responses. The substantial investments required for technological upgrades and system maintenance during digital transformation make it difficult to achieve significant short-term benefits. Compounded by users' unclear willingness to pay for digital services, operational uncertainties are further exacerbated. In terms of data collection and application, most venues remain at a basic level, only able to obtain fundamental information like ticket purchases and reservations. Lacking professional analytical teams, they fail to

mine user behavior patterns or deliver targeted service recommendations, resulting in underutilized data value. With rapid growth in regional ice and snow venues and intensifying market competition, coupled with insufficient talent reserves, some venues have halted their digitalization efforts at the experience optimization stage, lacking the momentum and support for deeper transformation.

(6) Digital Dilemma Caused by the Absence of Industry Standards and Norms

Industry standards and regulations are crucial for advancing the digital transformation of ice and snow venues. Currently, the lack of a unified technical standard system has led to significant disparities in system architecture, data formats, and interface specifications across venues, resulting in interoperability challenges and prominent information silos. Some facilities adopt cost-cutting low-end systems, while others invest heavily in advanced infrastructure. However, due to the absence of unified standards, effective collaboration remains difficult. Processes such as ticketing, membership management, and equipment maintenance lack standardized protocols, with chaotic service rules hindering cross-venue consumption experiences and resource allocation efficiency. The insufficient regulatory oversight by industry associations has resulted in fragmented digital development, which has become a critical bottleneck constraining high-quality growth in ice and snow venue sectors.

4. Optimal Path to Realize the Digital Transformation and Development of Hebei Ice and Snow Venue

(1) Reshaping Management Cognition and Technical Thinking Paradigm

The organization will conduct specialized workshops for ice and snow venue operators on digital transformation, inviting experts to analyze successful and failed cases of digitization in domestic and international venues. Through detailed data analysis and multidimensional insights, the program aims to help operators understand that digital transformation is not merely about upgrading computer systems, but a comprehensive overhaul encompassing strategic positioning, business processes, organizational structures, and service models. Building on this foundation, the program will guide venues in formulating 3-5 year digital development strategies with clear phased objectives, implementation paths, and performance metrics to ensure well-defined transformation directions and orderly progress. Focusing on end-to-end visitor experiences, the program will employ process analysis techniques to map out all stages from online reservations to exit feedback, identifying process breakpoints and inefficient nodes for digital reinvention. By eliminating redundant processes and optimizing inefficient links through digital solutions, the program will also break down data barriers between operational departments to achieve efficient information flow and collaborative operations, thereby enhancing operational efficiency and service quality. Continuous optimization of processes based on visitor feedback will establish closed-loop management mechanisms.Operators are encouraged to actively participate in global forums, academic seminars, and industry summits to stay updated on innovative applications of cutting-edge technologies like big data, artificial intelligence, and blockchain in winter sports scenarios. Professional advisory teams will be introduced to conduct venue diagnostics, develop tailored technical solutions according to actual needs, and facilitate seamless integration of technology with business operations to drive effective digital transformation.

(2) Break Through the Dilemma of Technology Application and Business Adaptation

Several ice and snow venues in Hebei Province, located in remote mountainous areas, face challenges in network communication. To address this, venue operators have established cooperation mechanisms with telecom service providers. By leveraging Geographic Information Systems (GIS) and signal simulation technologies, comprehensive topographic mapping and coverage analysis are conducted to optimize base station placement and signal transmission routes, thereby enhancing network strength and stability. A diversified and reliable communication infrastructure is being developed to ensure stable operation of smart devices and real-time data transmission, providing solid support for digital transformation. Digital service providers must conduct thorough multi-level business research during system implementation. Using various modeling methods, they analyze core operational processes including ski slope management, equipment leasing, visitor safety, and event organization, identifying process logic, data requirements, and business rules. Based on these analyses, customized management systems tailored to the venues' unique needs are developed. A trial-and-feedback optimization mechanism is established[6]. Comprehensive technical and operational training programs are implemented for all staff, covering multiple dimensions. Regular technical exchange sessions and innovation competitions encourage employees to share digital technology solutions for operational challenges, fostering organizational innovation and boosting digital transformation capabilities.

(3) Promoting Iterative Upgrading of Infrastructure Construction

To address the network infrastructure challenges in remote venues, substantial funding and policy support should be prioritized. The adoption of cutting-edge technologies, including fiber-optic communication, 5G networks, and

wireless local area networks (WLAN), will enable the development of high-speed, stable broadband systems. Signal amplifiers should be deployed to eliminate coverage gaps, ensuring smooth network performance during peak tourist seasons and supporting online ticketing, live event streaming, and remote control functions. Simultaneously, smart turnstiles and self-service terminals must maintain operational reliability to enhance admission efficiency and visitor experience, providing robust support for digital transformation. Leveraging mobile internet and cloud computing technologies, integrated service platforms (including apps, official accounts, and mini-programs) should be developed to combine ticket purchasing, event reservations, live streaming, educational resources, equipment rentals, and social interactions. A province-wide unified platform should be established to facilitate venue information sharing, cross-venue planning comparisons, and collaborative marketing strategies, thereby elevating overall service quality and fostering an open, shared, and mutually beneficial digital ecosystem. Smart sensors monitoring temperature, humidity, air quality, and facility wear will be installed at venues, creating dynamic environmental monitoring systems. Through IoT platforms, real-time data collection and analysis will establish predictive maintenance models and early-warning mechanisms, enabling intelligent equipment management. Additionally, precise adjustments to venue conditions will ensure operational safety and visitor comfort, providing reliable sensory support for digital operations.

(4) Build a Security and Reliability Guarantee System

In accordance with national cybersecurity regulations, we have established comprehensive data management systems and privacy policies. Dedicated personnel oversee sensitive data collection, storage, and access processes to ensure traceable operations and clear authority boundaries. High-strength encryption algorithms protect sensitive information, such as tourist ID numbers and bank details, while a multi-region backup mechanism ensures regular reviews of backup data security and integrity. A professional technical team conducts round-the-clock network monitoring to enhance emergency response capabilities against cyberattacks and data breaches, fully safeguarding tourist information and venue digital assets. The ice rink has implemented an emergency alarm system and rescue response network, utilizing integrated information technology to establish a unified command platform. This integrated emergency command system enables rapid alarm transmission, real-time resource allocation, and GIS-based precise positioning support. By incorporating VR technologies, we have developed digital emergency plans specifying departmental responsibilities, collaborative procedures, and operational protocols. Regular drills strengthen staff emergency response and coordination capabilities, effectively ensuring visitor safety and stable venue operations.Through a full lifecycle management system, we monitor and manage ice-making equipment, ski lifts, snowmaking systems, and safety devices in real time. Sensors installed at critical equipment points collect operational status data, while data analysis enables predictive models for equipment failure risk assessment, allowing us to formulate scientific maintenance plans. Through professional training, the skills and safety awareness of operation and maintenance personnel are improved. With the intelligent reminder system, inspection, maintenance, and replacement tasks are implemented to ensure that the equipment always runs stably and creates a safe and comfortable playing environment for tourists.

(5) Alleviating the Tension Between Market Demand and Consumption Experience

Establish a market research team comprising analysts, industry experts, and survey specialists. Utilize comprehensive methodologies, including questionnaires, in-depth interviews, focus group discussions, big data analytics, and user behavior tracking, to fully understand consumers' diverse needs across fitness, competitive sports, and social engagement. Develop a consumer demand database for in-depth analysis and modeling, identifying latent needs and consumption patterns to provide precise data support for venue service design. Optimize facility offerings based on market insights by introducing personalized winter sports packages, themed social events, and competitive sports services to better align supply with market demands. Create a scientific ROI analysis framework for digital transformation, applying project management and financial strategies to allocate resources rationally for technological upgrades, system maintenance, and talent development. Implement dynamic monitoring mechanisms with regular benefit evaluations to prioritize key projects that significantly enhance user experience and revenue. Explore diversified profit models through third-party collaborations to boost commercial value while mitigating operational risks. Strengthen partnerships with universities and vocational institutions to develop digital operation curricula and training platforms, co-conduct research projects, and cultivate interdisciplinary professionals with both digital literacy and operational expertise. Collaborate with training organizations to deliver tiered programs: frontline staff focusing on system operations, and managers prioritizing strategic planning and data-driven decision-making. Establish project bonus and innovation incentive mechanisms to enhance the attractiveness and stability of talent and provide intellectual support and talent guarantees for the digital transformation of stadiums.

(6) Establish and Improve the System of Industry Standards and Norms

To drive coordinated efforts among industry associations, research institutions, service providers, and operators in establishing unified standards for digital systems in ice and snow venues, a specialized technical committee will be formed to standardize key technical elements and clarify construction specifications and compatibility requirements for different venue types. All venues will be guided to strictly implement standardized system selection and deployment protocols, ensuring seamless connectivity, data sharing, and collaborative operations across platforms. This initiative aims to break down information silos and enhance the industry's overall digitalization level and resource integration efficiency. Through process analysis technology, core business processes of ice and snow venues will be systematically organized to establish standardized operational guidelines. Unified mechanisms for cross-venue ticketing settlements, membership benefits, and points systems will be implemented, while equipment procurement, maintenance, and event organization procedures will be regulated to build a comprehensive standardization framework covering the entire business chain. The implementation of these standards will improve operational efficiency and service consistency, optimize cross-venue consumption experiences, and promote industry-wide standardization and scaling. Leveraging industry associations, a unified regulatory and evaluation system will be established with detailed implementation rules and performance metrics. Regular inspections, random checks, and third-party assessments will comprehensively monitor digital infrastructure development and operational quality. Digital model venues will be recognized to share best practices, fostering internal benchmarking and collaborative improvements, ultimately advancing the standardized development of digital capabilities across Hebei Province's ice and snow venues.

5. Conclusions

Driven by policy guidance and market demand, Hebei Province's ice and snow venues have achieved rapid development. However, challenges persist in digital transformation, including inadequate infrastructure, poor system compatibility, and restricted data sharing. This paper analyzes the multiple advantages of digital transformation in service optimization, operational management, and resource allocation, while proposing solutions such as platform construction, process restructuring, and governance mechanisms. As a typical regional case, Hebei's digital transformation of ice and snow venues holds demonstrative significance for China's high-quality development of the winter sports industry. Future efforts should focus on improving institutional safeguards, advancing technological implementation, and enhancing the effectiveness of the transition.

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