

EXPLORING THE EFFECTS OF TECHNOLOGY INVESTMENT, INTELLIGENT INFRASTRUCTURE, AND TECHNOLOGY INTEGRATION ON USER SATISFACTION IN HARBIN'S SMART SPORTS VENUES

ANALISANDO OS EFEITOS DO INVESTIMENTO EM TECNOLOGIA, DA INFRAESTRUTURA INTELIGENTE E DA INTEGRAÇÃO TECNOLÓGICA NA SATISFAÇÃO DOS USUÁRIOS NAS INSTALAÇÕES ESPORTIVAS INTELIGENTES DE HARBIN

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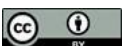
The authors declare that there is no conflict of interest

Abstract

This study focuses on the influence of technology investment, intelligent infrastructure, and technology integration on user satisfaction in Harbin's smart sports venues. A structural equation model was constructed using quantitative research methods to explore the mechanism of these factors on user satisfaction. A total of 240 questionnaires were distributed, and data were analyzed using descriptive statistics, reliability analysis, confirmatory factor analysis, and structural equation modeling. The study aims to: 1) investigate the current status of technology investment perception, intelligent infrastructure experience, and technology integration among users of Harbin's smart sports venues; 2) analyze the impact paths of various factors on user satisfaction; 3) propose strategies to enhance user satisfaction. The findings show that technology investment and intelligent infrastructure both have significant positive impacts on user satisfaction. Technology integration directly and positively affects user satisfaction and acts as a mediator in the relationship between technology investment, intelligent infrastructure, and user satisfaction. This study provides a theoretical basis for the operation and management of

Resumo

Este estudo enfoca a influência do investimento em tecnologia, da infraestrutura inteligente e da integração tecnológica na satisfação dos usuários nas instalações esportivas inteligentes de Harbin. Foi construído um modelo de equações estruturais utilizando métodos de pesquisa quantitativa para explorar o mecanismo de ação desses fatores sobre a satisfação dos usuários. Foram distribuídos 240 questionários, e os dados foram analisados por meio de estatística descritiva, análise de confiabilidade, análise fatorial confirmatória e modelagem de equações estruturais. O estudo tem como objetivo: 1) investigar a situação atual da percepção do investimento em tecnologia, da experiência com infraestrutura inteligente e da integração tecnológica entre os usuários das instalações esportivas inteligentes de Harbin; 2) analisar as vias de impacto de vários fatores sobre a satisfação do usuário; 3) propor estratégias para aumentar a satisfação do usuário. Os resultados mostram que tanto o investimento em tecnologia quanto a infraestrutura inteligente têm impactos positivos significativos sobre a satisfação do usuário. A integração tecnológica afeta direta e positivamente a satisfação dos usuários e atua



smart sports venues, suggesting that optimizing technology investment direction, strengthening intelligent infrastructure construction, and improving technology integration efficiency can continuously enhance user experience and satisfaction.

Keywords: Smart Sports Venues. Technology Investment. Intelligent Infrastructure. Technology Integration. User Satisfaction.

como mediadora na relação entre investimento em tecnologia, infraestrutura inteligente e satisfação dos usuários. Este estudo fornece uma base teórica para a operação e gestão de instalações esportivas inteligentes, sugerindo que otimizar a direção do investimento em tecnologia, fortalecer a construção de infraestrutura inteligente e melhorar a eficiência da integração tecnológica pode aprimorar continuamente a experiência e a satisfação dos usuários.

Palavras-chave: Instalações Esportivas Inteligentes. Investimento em Tecnologia. Infraestrutura Inteligente. Integração Tecnológica. Satisfação dos Usuários.

1 INTRODUCTION

With the rapid development of information technology, smart sports venues have become a new trend in the sports industry. Harbin, as an important city for ice and snow sports in China, has attracted significant attention for the construction and operation of its smart sports venues. However, the specific mechanisms through which technology investment, intelligent infrastructure, and technology integration affect user satisfaction remain unclear (Fu, 2023). Understanding the impact paths of these factors is of great theoretical and practical significance for improving venue service quality and optimizing user experience.

This study takes Harbin's smart sports venues as the research object and systematically analyzes the direct and indirect impacts of technology investment, intelligent infrastructure, and technology integration on user satisfaction by constructing a structural equation model. It aims to provide scientific decision-making basis for venue managers and promote the sustainable development of Harbin's smart sports venue industry.

2 LITERATURE REVIEW

2.1 The concept and development of smart sports venues

Smart sports venues refer to a new type of venue that uses new-generation information technologies such as the Internet of Things (IoT), big data, and artificial intelligence (AI) to achieve intelligent management and service upgrading of venue resources (Yu, 2022). Their core goal is to enhance user experience and optimize operational efficiency through technological applications. Existing studies have shown that the development of smart venues faces challenges such as insufficient technology integration and low user need matching (Stanković *et al.*, 2023).

2.2 Technology investment and user satisfaction

Technology investment refers to resource input in technology procurement, development, and maintenance, including intelligent access control, sports data monitoring, and other technologies (Basu, 2023). Studies indicate that reasonable technology investment can directly improve user satisfaction by enhancing service efficiency and optimizing facility functions (Rashid, 2017). For example, upgrading online ticketing systems can reduce user queuing time and enhance experience convenience.

2.3 The role of intelligent infrastructure

Intelligent infrastructure covers physical and digital components such as high-speed networks and sensor-embedded devices (Fernandez Molanes, 2018). High-quality intelligent infrastructure (e.g., intelligent lighting and environmental control systems) can create a comfortable sports environment for users, thereby improving satisfaction (Kim, 2020).

2.4 The mediating effect of technology integration

Technology integration is the process of organically integrating various technologies and infrastructure to form a seamless user experience (Yu , 2020). Research has shown that the level of technology integration directly affects users' perception of venue services and acts as a mediator between technology investment, intelligent infrastructure, and user satisfaction (Nguyen, 2023).

3 RESEARCH HYPOTHESES

H1: Technology investment has a significant positive impact on user satisfaction in Harbin's smart sports venues.

H2: Intelligent infrastructure has a significant positive impact on user satisfaction in Harbin's smart sports venues.

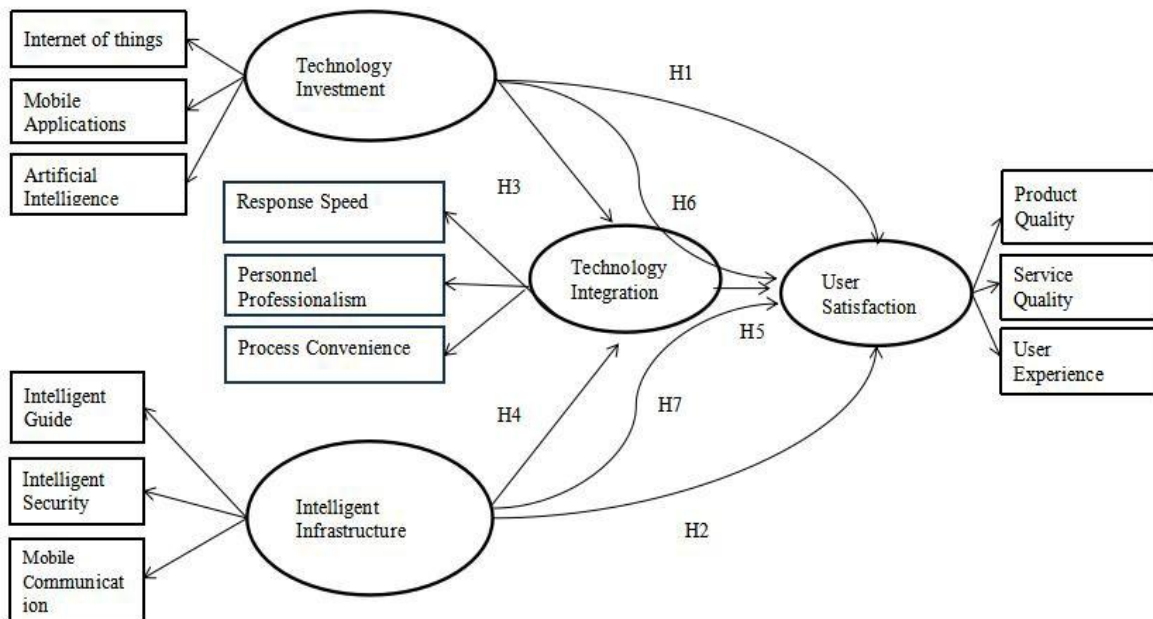
H3: Technology investment has a significant positive impact on the level of technology integration in Harbin's smart sports venues.

H4: Intelligent infrastructure has a significant positive impact on the level of technology integration in Harbin's smart sports venues.

H5: Technology integration has a significant positive impact on user satisfaction in Harbin's smart sports venues.

H6: Technology integration plays a mediating role in the relationship between technology investment and user satisfaction.

H7: Technology integration plays a mediating role in the relationship between intelligent infrastructure and user satisfaction.

Figure 1*Variable structure diagram*

4 RESEARCH METHODOLOGY

4.1 Research design

A mixed research method was adopted, combining quantitative questionnaire surveys and qualitative focus group interviews. The quantitative research targeted users of Harbin's smart sports venues, while the qualitative research invited industry experts and user representatives to participate in discussions.

4.2 Sample and data collection

A total of 240 questionnaires were distributed in the quantitative research, and 240 valid questionnaires were recovered, with an effective recovery rate of 100%. The sample covered multiple smart sports venues in Harbin, including ice and snow sports venues and comprehensive sports centers. The questionnaire used a 5-point Likert scale (1 = "strongly disagree", 5 = "strongly agree") to measure variables such as technology investment, intelligent infrastructure, technology integration, and user satisfaction.

4.3 Variable measurement

Technology Investment: Including three dimensions: IoT technology, mobile applications, and artificial intelligence.

Intelligent Infrastructure: Covering three dimensions: intelligent navigation, intelligent security, and mobile communication.

Technology Integration: Including three dimensions: response speed, personnel professionalism, and process convenience.

User Satisfaction: Comprising three dimensions: product quality, service quality, and user experience.

4.4 Data analysis methods

SPSS 26.0 and AMOS 26.0 were used for data analysis, including the following steps: Descriptive statistics and reliability-validity analysis;

Confirmatory factor analysis (CFA) to test the goodness-of-fit of the measurement model; Structural equation modeling (SEM) to test the path relationships between variables;

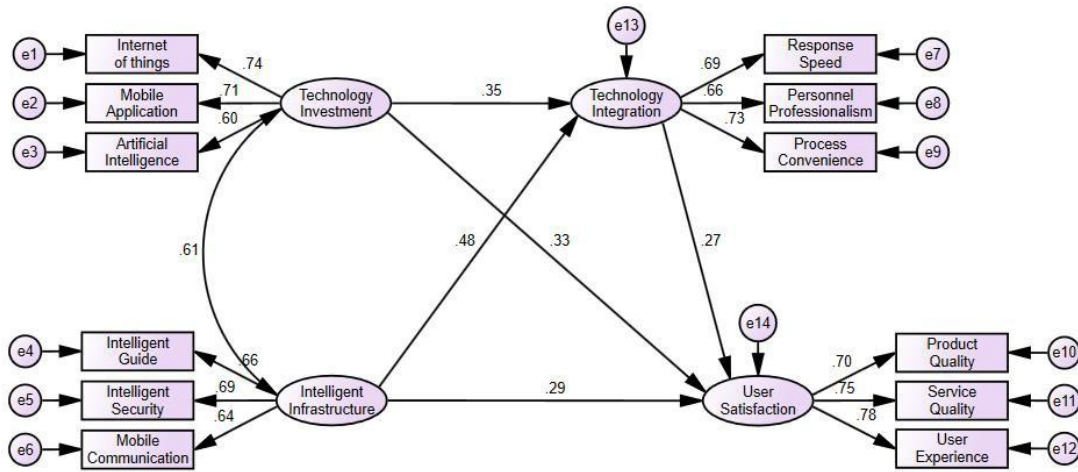
Bootstrap method to test the mediating effect (5000 repeated samplings).

5 STRUCTURAL EQUATION MODELLING

Based on the correlation analysis between variables and previous assumptions, this study constructed the correlation path between structural equation model and independent variables. After data fitting by AMOS 26 software, the following results were obtained:

Figure 2

Operating results of structural equation model diagram (standardized)



The figure shows a structural equation model involving variables such as digital engagement, perceived value, experience event and attention behavior.

The data analysis from Table 1 shows that the χ^2/df value is 1.312, which is less than 3; the RMSEA value is 0.036, below the 0.08 threshold, indicating a good model fit; the GFI value is 0.956, the IFI value is 0.984, and the CFI value is 0.983, all meeting acceptable standards. All goodness-of-fit indicators meet general standards, indicating a good model fit.

Table 1

Model fitting index

Indicator	X2/df	GFI	AGFI	IFI	CFI	RMSEA
Statistic Value	1.312	0.956	0.928	0.984	0.983	0.036
Reference Value	<5	>0.8	>0.8	>0.8	>0.8	<0.08
Achievement Status	Mees Standard	Mees Standard	Mees Standard	Mees Standard	Mees Standard	Mees Standard

As shown in Table 2, Regarding the relationships between variables, technology investment and intelligent infrastructure directly influence technology integration, which in turn directly impacts user satisfaction. Additionally, technology investment, intelligent infrastructure, and technology integration also directly affect user satisfaction.

Technology integration acts as a partial mediator, with each path coefficient reflecting the degree of mutual influence among the variables.

Table 2

Path Coefficients Between Variables

Regression Paths		Estimate	S.E.	C.R.	P	Std.Estimate		
Technology Integration	<---	Technology Investment	0.313	0.102	3.069	0.002	0.351	H3
Technology	<---	Intelligent	0.534	0.138	3.878	***	0.476	H4
Integration		Infrastructure						
User Satisfaction	<---	Technology Integration	0.255	0.119	2.146	0.032	0.271	H5
User Satisfaction	<---	Technology Investment	0.279	0.093	2.999	0.003	0.333	H1
User Satisfaction	<---	Intelligent Infrastructure	0.307	0.131	2.339	0.019	0.292	H2

6 MEDIATED EFFECTS TEST

The Bootstrap method can directly test the existence of mediating effects. The hypothesis for direct testing is $H_0: ab=0$. If the confidence interval obtained from the test results contains 0, it indicates that there is no mediating effect.

Based on the results of path analysis, the hypothesis test is valid. In order to explore whether there is a mediating effect in these significant paths, we ran the Bootstrap method on AMOS 26.0, and bias correction method for testing.

Table 3*Mediation Effect*

Regression Paths	Decomposition of Effects	Estimate	Lower	Upper	P
Technology Investment=>Technology Integration=>User Satisfaction	direct effect	0.279	0.091	0.569	0.006
	indigo effect	0.08	0.003	0.253	0.04
	gross effect	0.359	0.162	0.636	0.001
Intelligent Infrastructure=>Technology Integration=>User Satisfaction		0.307	0.004	0.67	0.048
	direct effect	0.136	0.012	0.423	0.033
	indigo effect	0.443	0.195	0.745	0.001
	gross effect				

As shown in Table 3, The indirect effect of technology integration between technology investment and user satisfaction was 0.080 (95% CI: 0.003~0.253), excluding 0, supporting H6.

The indirect effect of technology integration between intelligent infrastructure and user satisfaction was 0.136 (95% CI: 0.012~0.423), excluding 0, supporting H7.

7 CONCLUSION

This study focuses on the Harbin Intelligent Sports Venue, employing a combination of qualitative and quantitative research methods to evaluate the technical investment, intelligent infrastructure, technology integration, and user satisfaction of the venue. Through qualitative research, we aim to explore how technical investment, intelligent infrastructure, and technology integration affect user satisfaction in the Harbin Intelligent Sports Venue, laying the groundwork for subsequent quantitative studies.

The study used quantitative methods for surveys and data collection. Descriptive statistics, exploratory and confirmatory factor analysis, and correlation analyses were conducted on the data from 240 valid questionnaires. The model indicates that technical investment, intelligent infrastructure, and technology integration significantly impact user satisfaction in the Harbin Intelligent Sports Venue. Ultimately, the study concludes: Technology investment significantly enhances user satisfaction. Intelligent

infrastructure has a significant positive impact on user satisfaction. Technology integration also positively influences user satisfaction. Technology investment significantly promotes technology integration. Intelligent infrastructure similarly has a significant positive impact on technology integration. Technology integration acts as a mediator between technology investment and user satisfaction. Additionally, technology integration serves as a mediator between intelligent infrastructure and user satisfaction.

8 SUGGESTIONS FOR FURTHER RESEARCH

Future research can expand the scope to explore the demand differences among different user groups (e.g., professional athletes and ordinary fitness enthusiasts) or introduce moderating variables such as user behavior habits to further refine the study of influence mechanisms.

REFERENCES

- Adamides, E., & Karacapilidis, N. (2020). Information technology for supporting the development and maintenance of open innovation capabilities. *Journal of Innovation & Knowledge*, 5(1), 29–38.
- Basu, B. (2023). Perspectives on the intersection between sports and technology. In *Sports management in an uncertain environment* (pp. 143–168). Springer.
- Deng, X., Jiang, P., Peng, X., & Mi, C. (2018). An intelligent outlier detection method with one class support tucker machine and genetic algorithm toward big sensor data in internet of things. *IEEE Transactions on Industrial Electronics*, 66(6), 4672–4683.
- Elnour, M., Fadli, F., Himeur, Y., Petri, I., Rezgui, Y., Meskin, N., & Ahmad, A. M. (2022). Performance and energy optimization of building automation and management systems: Towards smart sustainable carbon-neutral sports facilities. *Renewable and Sustainable Energy Reviews*, 162, Article 112401.
- Glebova, E., & Brasier, E. (2020). Définir la réalité étendue dans les sports: Limitations, facteurs et opportunités. In M. Desbordes & C. Hautbois (Eds.), *Management du sport* (3rd ed.). [Editora não identificada — recomenda-se completar]
- Ha, J.-P., Kang, S. J., & Kim, Y. (2017). Sport fans in a "smart sport" (SS) age: Drivers of smartphone use for sport consumption. *International Journal of Sports Marketing and Sponsorship*, 18(3), 281–297.

- Kumar, S., Raut, R. D., & Narkhede, B. E. (2020). A proposed collaborative framework by using artificial intelligence-internet of things (AI-IoT) in COVID-19 pandemic situation for healthcare workers. *International Journal of Healthcare Management*, 13(4), 337–345.
- Mahdi, M. J., Aljuboori, A. F., & Hussein, A. (2021). Smart stadium using cloud computing and Internet of Things (IoT): Existing and new models. *International Journal of Computer Applications Technology and Research*, 10(5), 111–118.
- Navandar, R. K., Hasan, S. H., Jadhav, N., Singh, K. U., Monisha, R., & Venkatram, N. (2025). Modernizing sports an intelligent strategy for entertainment through internet of things in sports. *Entertainment Computing*, 52, Article 100804.
- Panchanathan, S., McDaniel, T., Tadayon, R., Rukkila, A., & Venkateswara, H. (2019). Smart stadia as testbeds for smart cities: Enriching fan experiences and improving accessibility. In *Proceedings of the 2019 International Conference on Computing, Networking and Communications (ICNC)*.
- Zheng, B., Mei, Z., Hou, L., & Qiu, S. (2021). Application of internet of things and edge computing technology in sports tourism services [Retracted]. *Security and Communication Networks*, 2021, Article 9980375.
- Zhongxue, C. (2017). Research on the development path of the transformation and upgrading of China's stadium services in the era of "Internet+." *Journal of Nanjing Institute of Physical Education (Social Science Edition)*, 88–92.

Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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