

Cost control strategies for high-quality social services in sports vocational institute driven by digital technologies: a grounded theory analysis

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Abstract. This study addresses the cost control requirements associated with the development of high-quality social services in sports vocational institutes under the impetus of digital technologies. Employing a grounded theory approach, it systematically analyzes policy documents, representative case studies, and multi-source interview data to construct a three-dimensional “Technology–Scenario–Mechanism” adaptation model. The findings reveal that technologies such as virtual simulation, artificial intelligence, and blockchain, through layered penetration and cyclical interaction, contribute to process optimization and resource integration in contexts such as vocational skills training and sports rehabilitation, thereby reducing explicit service costs. Concurrently, they facilitate the formation of data-driven decision-making mechanisms within organizations and promote the co-construction of a digital service ecosystem through school-enterprise collaboration. By uncovering the interplay among technological embedding, organizational adaptation, and ecological collaboration, the study proposes a dynamic cost elasticity generation mechanism and elucidates the crucial role of contradiction mediation mechanisms in balancing service efficiency with educational equity. This research offers a practical framework for collaborative development in cost reduction, quality enhancement, and service scale expansion during the digital transformation of sports vocational institutes, and verifies the feasibility and innovative value of digital technologies in restructuring the cost architecture of social services.

Keywords: digital technology, sports vocational institutes, social services, cost control, grounded theory, dynamic elasticity

1. Introduction

With the rapid advancement of digital technologies, their application in the field of education has become increasingly widespread, bringing both new opportunities and challenges to the social service functions of vocational institutes. For sports vocational institutions, a pressing issue lies in how to leverage digital technologies to achieve high-quality development in social services while effectively controlling associated costs. This study aims to explore in depth the cost control strategies for social services in sports vocational institutes driven by digital technologies, providing valuable theoretical insights and practical references.

2. Literature review

The deep penetration of digital technologies into education has made cost control in the social services of vocational institutes a prominent research focus. Scholars generally agree that technology-driven process optimization, resource integration, and institutional innovation are key to reducing costs [1, 2]. Research has evolved from focusing on the application of technological tools to the design of systematic strategies. Early studies emphasized the short-term benefits of the “Internet Plus” model, which later expanded to the refined services enabled by big data and artificial intelligence. In recent years, increasing attention has been paid to the synergy among technology, collaboration, and institutional arrangements [3]. The core logic is that the heterogeneity of technologies should be adapted to the diverse needs of different scenarios to achieve dynamic cost control.

Existing research can be categorized into three major streams: First, Technology-Driven Optimization of Service Processes: This line of research focuses on reducing marginal costs by reshaping service delivery models. One perspective emphasizes the use of lightweight technologies to compress costs, while another advocates for high-cost technologies that enhance efficiency and deliver long-term returns [1, 4]. Second: Cost-Sharing through School-Enterprise Collaboration and Resource Integration: The

central issue here lies in balancing collaborative benefits against investment risks. By leveraging enterprise resources, school-enterprise cooperation can reduce institutional investment and dilute costs through service scale. However, collaboration models may incur hidden costs due to technological iteration, necessitating dynamic agreements to mitigate such risks [3, 5]. Third: Institutional Innovation Perspective: This stream advocates optimizing long-term cost control through incentive mechanisms and top-level strategic design. For example, OKR-based performance assessments can enhance efficiency and reduce labor redundancy, while strategic resource planning can prevent repetitive investments [6, 7]. Institutional and organizational innovation, alongside faculty capacity building, is considered essential for improving the long-term effectiveness of social services [8].

In summary, existing studies have illuminated the logic of how digital technologies empower cost control in the social services of sports vocational institutes from three perspectives: technology, collaboration, and institutions—forming an integrated framework of “tool optimization–resource sharing–mechanism guarantee.” However, significant limitations remain. For instance, the impact of technological heterogeneity on cost control is often reduced to a static comparison of tool efficiency, and it ignores the dynamic interaction between technology types, scene adaptation, and iteration costs, failing to deeply integrate technological heterogeneity with the institutional context and stakeholder needs. In response to these gaps, this study raises the following core research question: How can cost control strategies for social services in sports vocational institutes driven by digital technologies achieve a dynamic balance among technological heterogeneity, scenario adaptation, and systemic collaboration? To address this question, the study adopts a grounded theory methodology, conducting an in-depth analysis of representative cases to deconstruct the interactive relationships among technology selection, cost thresholds, and institutional constraints. A three-dimensional “Technology–Scenario–Mechanism” adaptation model is constructed. This approach not only compensates for the deficiencies of existing research in terms of dynamic quantification and collaborative mechanisms but also provides a categorized strategic framework for differentiated institutions, promoting a paradigm shift from the “application of tools” to “systemic governance” in the digital transformation of social services.

3. Research design

3.1. Research method

This study adopts a grounded theory approach to systematically investigate cost control strategies for the high-quality development of social services in sports vocational institutes driven by digital technologies. Grounded theory enables the construction of theoretical models rooted in empirical reality. The research process began with line-by-line coding of collected materials to extract initial concepts. These concepts were then grouped and logically categorized to identify interrelationships, ultimately leading to the formation of a core “Technology–Scenario–Mechanism” adaptation model. NVivo software was employed to assist in the analysis, ensuring the explanatory power and rigor of the model. By focusing on dynamic interactive relationships, this method effectively compensates for existing research limitations in quantitative assessment and collaborative mechanism analysis.

3.2. Sample selection and data collection

Two types of samples were selected for this study. The textual data includes national and provincial vocational education policy documents from 2019 to 2024, annual quality reports of vocational education from 18 sports vocational institutes across the country, internal guidelines on social services and school-enterprise cooperation from several sports vocational institutions, as well as two representative case studies of social service projects. Interview participants comprised a diverse range of stakeholders: institutional administrators (3), faculty members (5), students (5), and external service recipients (5 representatives from community organizations and enterprises). Data collection combined semi-structured interviews (conducted both online and offline, each lasting 40–60 minutes) with textual mining techniques. A triangulation approach was used, incorporating comparative analysis with policy practices to construct a multidimensional analytical framework. The full body of collected data amounts to approximately 80,000 Chinese characters. After anonymization, the dataset was divided in a 3:1 ratio into a coding group and a validation group.

4. Category refinement and model construction

4.1. Open coding: from raw data to emergent initial categories

Open coding marks the initial phase of grounded theory research. By deconstructing and conceptualizing raw data from the social service practices of sports vocational institutes line by line, this stage reveals the underlying logic of cost control driven by digital technologies. This study focuses on core scenarios such as vocational training in sports, conducting an in-depth analysis of interview transcripts, policy documents, and operational data from the “Sports-Vocational Link” platform. Three key tasks were accomplished during this phase: data granulation, contradiction identification, and theoretical anchoring. Through open coding of the original materials, a cost control pathway characterized by “technological embedding–organizational adaptation–ecological

restructuring” was extracted from specific sports service scenarios. Based on this, a coding framework was constructed, encompassing categories such as technology applications, business models, and platform ecosystems (see Table 1).

Table 1. Initial categories formed through open coding of cost control strategies in social services of sports vocational institutes driven by digital technologies

Initial Category	Conceptual Codes	Original Statements
C01. Virtual Simulation and Cloud Collaboration	Application of virtual simulation technologies Mechanism for digital resource sharing	Sports skills training uses VR/AR systems to simulate basketball tactics scenarios, enabling immersive learner experiences and reducing venue rental costs. Smart sports teaching platforms allow cloud sharing of lesson plans and instructional videos, significantly increasing resource reuse rates. AI-driven personalized training systems generate customized programs for community residents, improving service-matching efficiency and reducing human decision-making costs.
C02. Intelligent Decision-Making and Process Management	Intelligent decision support systems Digital process management	DingTalk’s intelligent task assignment system automates event preparation, enhancing interdepartmental coordination and shortening process response times.
C03. Trusted Archiving and Scheduling Optimization	Trusted data archiving technologies Application of intelligent scheduling algorithms	Blockchain is used for full-process certification of lifeguard qualifications, significantly shortening complaint resolution time. An AI-based scheduling engine dynamically analyzes faculty skills and community service demands, maximizing faculty utilization and reducing redundant courses by 20%.
C04. Technological Cost Trade-offs	Threshold effects of technology investment Preventive risk expenditure	Low-level VR devices with insufficient motion capture accuracy impaired training outcomes, requiring costly upgrades. Annual investment in data protection systems—hundreds of thousands of RMB—effectively prevented privacy breaches and mitigated potential legal losses.
C05. Resource Substitution and Sharing	Flexibility in labor costs Sharing economy models	AI fitness evaluation systems replaced manual assessment roles, reducing trainer labor costs by approximately 30%, and saving nearly 800,000 RMB annually. A cross-institution VR equipment-sharing platform lowered individual procurement costs and improved utilization rates.
C06. Technology Adaptation Costs	Learning curve costs Shift in customer acquisition costs	Initial use of virtual simulation teaching systems saw high error rates among teachers, necessitating additional training time. Free youth physical fitness assessments attracted numerous registrations, significantly lowering per-user acquisition costs.
C07. Organizational Habits and Decision-Making	Evolution of technology acceptance Data-driven decision-making mechanisms	PE teachers transitioned from resisting AI-based lesson evaluations to proactively conducting data review sessions, with digital lesson plans becoming a new teaching norm. Dynamic scheduling based on community fitness heatmaps reduced venue idle time and minimized resource waste.
C08. Standardization and Ecosystem Collaboration	Conflicts in process control Innovations in ecosystem collaboration	Standardized online course templates initially conflicted with personalized community fitness demands; a basic module + customized plugin model improved satisfaction. A school-enterprise co-built event service platform integrated refereeing, medical, and other resources, shortening major event preparation cycles and improving outcomes.
C09. Technology Execution and Cultural Conflict	Resistance to technology implementation Digital divide effects	Basic-level educational staff exhibited low initial usage (under 40%) of intelligent scheduling systems due to entrenched habits, necessitating simplified interfaces. In economically underdeveloped areas, poor network infrastructure limited participation in online sports training; mobile 5G service stations and localized courses increased coverage.

Table 1. Continued

C10. Service Effectiveness and Platform Stickiness	Quantified service quality improvement Platform engagement indicators	Satisfaction with sports injury prevention services rose from 78% to 94%. The sports retail platform achieved an average of 2.2 repurchases per user annually, with active user retention exceeding 50%.
C11. Precision Services and Scale Effects	Enhanced capacity for precision services Service scale expansion effects	An AI-driven skill gap analysis system for retired athletes improved job matching accuracy, raising employment conversion rates. The marginal cost of cloud fitness courses approached zero, with service coverage expanding from 2,000 to 28,000 individuals. The digital social service model was featured in media such as China Sports Daily and New Sports, resulting in increased annual partnerships.
C12. Value Spillover and Sustainable Development	Brand value spillover Sustainability outcomes	Smart energy monitoring systems reduced annual carbon emissions at sports venues, significantly improving energy efficiency.
C13. Supply-Demand Matching and Resource Integration	Bilateral market matching mechanisms Supply chain coordination optimization	Smart recruitment platforms precisely matched students holding sports vocational certificates with community service needs, shortening job placement cycles. Joint VR equipment procurement among institutions achieved bulk pricing, reducing unit costs by 30%.
C14. Industry-Education Integration and Business Models	Closed-loop value in industry-education collaboration Profitable value-added service models	Jointly developed sports rehabilitation courses directly placed graduates into 32 partner enterprises or clinics, shortening the training-to-employment cycle by 60%. The sports retail business increased annual revenue through targeted marketing.
C15. Dynamic Cost Optimization	Pathways to economies of scale Agile responsiveness	Online training for nearly a thousand participants significantly reduced marginal learning costs per learner, highlighting scale benefits. A demand-responsive system reduced course development time from 45 to 18 days, cutting iteration costs.
C16. Inclusiveness Conflicts in Technology	Digital divide effects Regional adaptation strategies	In underdeveloped regions, participation in online vocational training was only 32%; after deploying 5G mobile service stations and localized ethnic sports content, participation rose to 68%. For elderly users with limited digital skills, a dual-track model combining AI voice assistants and offline instructors significantly increased users aged 60+.
C17. Human-Machine Collaboration Tensions	Efficiency-Warmth Paradox Hybrid service design	Recorded courses led to a lack of teacher-student interaction and delayed skill correction; real-time AI motion feedback + weekly offline Q&A reduced correction time and improved satisfaction, albeit with higher costs. VR-based sports injury simulation, initially inaccurate, improved through a dual-track model of virtual rehearsal and physical correction, raising pass rates and lowering equipment maintenance costs.

4.2. Axial coding: refinement of core categories and construction of partial logical relationships

Axial coding represents a critical phase in grounded theory research, aiming to systematically relate the initial categories derived from open coding and to construct logical connections among core categories. This process reveals the dynamic mechanisms underpinning the high-quality development of social services driven by digital technologies. Focusing on key scenarios such as vocational training in sports, this stage involved three core tasks: categorizing dispersed initial categories into overarching core categories, analyzing the interactive relationships between digital technologies, organizational structures, and service ecosystems, and resolving typical contradictions observed in the context of sports vocational training. Ultimately, six core categories were distilled, demonstrating that sports vocational institutes can reduce service costs while simultaneously enhancing training quality and service reach. This is achieved through the strategic selection of technological tools, the institutionalization of organizational learning, and the construction of platform-based service ecosystems (see Table 2).

Table 2. Core categories formed through axial coding of cost control strategies in social services of sports vocational institutes driven by digital technologies

Core Category	Corresponding Initial Categories	Conceptual Connotation
Z01. Technological Embedding and Implementation	C01. Virtual Simulation and Cloud Collaboration C02. Intelligent Decision-Making and Process Management C03. Trusted Archiving and Scheduling Optimization	The practical application of digital technologies within service processes and their transformative impact on operational models, encompassing technology selection, system deployment, and coordination mechanisms.
Z02. Organizational Adaptation and Transformation	C07. Organizational Habits and Decision-Making C08. Standardization and Ecosystem Collaboration C09. Technology Execution and Cultural Conflict	Adaptive behaviors and institutional restructuring that emerge during technology adoption, including cultural conflicts, learning mechanisms, and innovations in collaborative ecosystems.
Z03. Dynamic Cost Equilibrium	C04. Technological Cost Trade-offs C05. Resource Substitution and Sharing C06. Technology Adaptation Costs C15. Dynamic Cost Optimization	Transformation pathways of explicit and implicit costs driven by technology, reflect the strategic balance between short-term investments and long-term benefits, as well as resource optimization tactics.
Z04. Ecosystem Collaboration and Innovation	C13. Supply-Demand Matching and Resource Integration C14. Industry-Education Integration and Business Models	Multi-stakeholder collaborative mechanisms within platform economies that achieve cost reduction and efficiency gains through resource integration, bilateral market design, and business model innovation.
Z05. Conflict Mediation Mechanisms	C16. Inclusiveness Conflicts in Technology C17. Human-Machine Collaboration Tensions	Core tensions arise from technology adoption and their resolution strategies, addressing issues such as regional disparities, efficiency-with paradox, and rights and responsibility conflicts.
Z06. Value Creation and Spillover	C10. Service Effectiveness and Platform Stickiness C11. Precision Services and Scale Effects C12. Value Spillover and Sustainable Development	The direct benefits of technology adoption—such as improved efficiency and scalability—and indirect value outcomes, including brand development and sustainability, demonstrate both economic and social spillover effects.

4.3. Selective coding: integration of core categories and theoretical model construction

The core category proposed in this study is the “Dynamic Cost Elasticity Generation Mechanism Driven by Digital Technology.” The corresponding theoretical model reveals the internal logic by which sports vocational institutes achieve cost control in social services through a hierarchically progressive structure. This model comprises three core dimensions—technological embedding, organizational adaptation, and ecosystem collaboration—and is threaded throughout by a conflict mediation mechanism, forming a dynamic, cyclical system of “tool innovation–capability reconstruction–value co-creation” (see Figure 1). The narrative structure of this model is as follows: Digital technologies, through their embedding into institutional processes, reshape social service workflows, thereby reducing explicit costs. This cost pressure, in turn, compels sports vocational institutes to establish data-driven decision-making mechanisms, catalyzing the co-construction of digital ecosystems among institutes, enterprises, and communities. In this process, tensions arising from uneven technological diffusion—such as regional disparities in sports service access and compensatory challenges in human-machine interaction—are dynamically mediated through strategies like hybrid service design and resource reallocation. Ultimately, this leads to the formation of an integrated cost control system that achieves cost reduction, quality improvement, and capacity expansion in a synergistic manner.

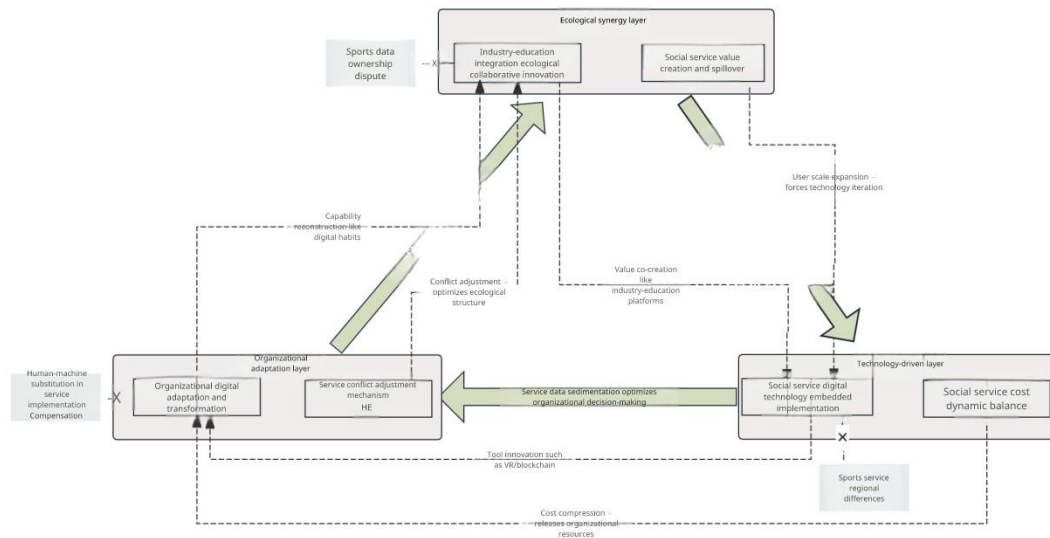


Figure 1. A model of the dynamic elastic cost generation mechanism for social services at sports vocational institutes driven by digital technology

5. Model interpretation

5.1. Model overview

This study centers on the core category of the dynamic cost elasticity generation mechanism driven by digital technology within social services provided by sports vocational institutes. The theoretical model takes vocational training in sports as the core scenario, deeply integrating specialized technical services such as sports rehabilitation and injury prevention, and systematically illustrates how digital technologies restructure the cost structure of services through layered penetration and cyclical interaction. The model consists of three major dimensions—technological innovation, organizational capability evolution, and industry-education ecological collaboration—while embedding a conflict mediation mechanism as the dynamic axis that runs through the full cycle of sports service delivery. Together, they form an upward spiral system of “technological cost reduction – organizational adaptation – ecological value co-creation.”

5.2. Model dimensions and their connotations

In the dimension of technological innovation, sports vocational institutes utilize virtual simulation to construct sports rehabilitation training scenarios, reducing traditional physical venue rental costs by nearly 90%. AI-based physical fitness assessment systems replace manual testing, tripling service efficiency. Blockchain technology is employed for the digital credentialing of referees, cutting dispute resolution costs by approximately 60%. These technological breakthroughs directly reduce explicit costs in sports-related social services and, through cloud-based resource sharing, remove scale limitations. For example, the marginal cost of youth physical fitness training and community-based injury prevention services approaches zero. The selection of technological tools is closely tailored to the characteristics of sports services—such as VR motion capture systems designed specifically for basketball tactical training, and wearable devices that monitor elderly fitness data in real-time to inform community health solutions.

This dimension highlights the transformation of sports faculty from passive technology users to active innovators. Rehabilitation instructors conduct weekly data review sessions to analyze student interaction data from virtual simulation courses and dynamically adjust the difficulty curve of training sessions. The fitness instruction team has developed a hybrid “AI coach + community facilitator” model, reducing offline labor costs by 60% while maintaining a human-centered service experience. This adaptive transformation is deeply embedded in the context of vocational training—for instance, in the retraining of retired athletes, instructors use big data to analyze skill gaps and match them precisely with corporate job demands, improving job placement conversion rates by 45%. On the organizational level, agile response mechanisms are established to link injury prevention knowledge bases with regional disease profiles, enabling dynamic optimization of community service offerings. This marks a strategic shift from scale expansion to quality-driven cost control.

This dimension represents the co-construction of a digital service ecosystem by institutes, sports technology enterprises, and community service organizations. Jointly developed VR rehabilitation equipment-sharing platforms between institutes and

companies have improved cross-campus resource utilization rates by over 50%. A unified event service platform consolidates referee scheduling, venue management, and other components, significantly compressing the preparation cycle for large-scale sporting events. In the field of injury prevention, institutions have collaborated with top-tier hospitals to develop online diagnostic systems that use AI-based imaging recognition to provide graded injury assessments, offering real-time expert guidance to athletes in remote areas. This collaborative ecosystem restructures cost models through a bilateral market mechanism. For instance, an intelligent recruitment platform accurately matches the supply and demand for fitness coaches, reducing the typical three-month recruitment cycle to just seven days and lowering talent search costs by 72%.

There is a tightly woven interplay among the three dimensions: the cost-reduction impact of virtual simulation technologies compels faculty to enhance their digital teaching capabilities; data-driven decision-making mechanisms accelerate the development of industry-education platforms; and the economies of scale generated by ecological collaboration feed back into technological innovation. Throughout the model, the conflict mediation mechanism plays a central role. To address low participation in online training in western regions, institutes have implemented a combination of 5G network subsidies and mobile service stations with on-site guidance, achieving inclusive service delivery within a controllable cost range. In response to the decline in instructional effectiveness due to inadequate VR simulation precision, the adoption of a dual-track system of “virtual rehearsal + physical correction” has balanced technological efficiency with educational quality.

6. Conclusion

This study, grounded in the grounded theory methodology, systematically constructs a theoretical model for cost control in social services at sports vocational institutes driven by digital technology. The findings demonstrate that technologies such as virtual simulation and AI-based scheduling can significantly reduce training and labor costs through process optimization and resource integration. For instance, one sports vocational institute introduced virtual simulation to replicate sports injury scenarios, reducing rehabilitation training costs by 40%. Furthermore, the proposed “dynamic cost elasticity generation mechanism” effectively balances efficiency and equity, enabling cost reduction, quality improvement, and capacity expansion within a digitally co-constructed ecosystem of institutions, enterprises, and communities. For example, a VR rehabilitation equipment-sharing platform developed jointly by a sports vocational institute in Guangdong and its corporate partners has improved cross-campus resource utilization by over 50%. Future research could expand the sample scope and further explore how technological heterogeneity affects cost structures across diverse service contexts. Additionally, investigations into the application of emerging technologies in sports-related social services could offer sustained momentum for the high-quality development of social services at sports vocational institutions.

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