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HOW DOES DIGITAL TECHNOLOGY IMPACT TOTAL FACTOR PRODUCTIVITY OF CHINESE SPORTS ENTERPRISES*

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Abstract. The contemporary concept of quality productive forces is predicated on scientific and technological innovation, thereby promoting high-quality development through technological breakthroughs and factor recombination. Digital technology is indisputably pivotal in the development of new quality productive forces, thereby engendering an increase in the total factor productivity (TFP) in various domains. In the context of the sports manufacturing industry and the sports service industry, digital empowerment is primarily manifested through the integration of digital production factors and traditional production factors. Digital technology has been fully integrated into manufacturing, management, operation, and supply-demand analysis, resulting in the reshaping of production and operation models, the innovation of product (service) functions, and the optimisation of supply-demand linkages. The present paper is founded upon the TFP theory and employs this as a basis to construct a new econometric model. The present study selects sports enterprises from China's A-share market and the National Equities Exchange and Quotations (NEEQ) from 2015 to 2024 as research samples, and examines the impact of digital transformation on the TFP of sports enterprises. The research findings indicate that the extent of digital transformation exerts a favourable influence on the TFP of sports enterprises, with the configuration of human capital and enterprise R&D functions serving as mediating factors in this relationship. The heterogeneity test demonstrated that the digital transformation level (DTL) exerted a significant positive influence on the total factor productivity (TFP) of both sports manufacturing enterprises and service enterprises. Concurrently, the impact of the structure of human capital and enterprise R&D on sports manufacturing enterprises and sports service enterprises varies considerably. In light of the aforementioned points, it is recommended that efforts be made to strengthen R&D investment and the cultivation of digital-related talents. Furthermore, it is advised that the transformation of sports data resources into data assets and data capital be promoted, and that the business models of the sports manufacturing industry and the sports service industry be further explored following digital transformation. These measures are expected to contribute to an enhancement in the TFP of sports enterprises.

Keywords: digital economy, enterprise total factor productivity, sports service industry, sports manufacturing industry.

JEL Classification: O32, O40

1. Introduction

In China, sports have evolved from rudimentary physical activities to competitive disciplines, and ultimately, to a hallmark of healthy lifestyles. The sports industry has become an increasingly vital component of national economic and social development.

In 2019, the State Council of the People's Republic of China (PRC) published the "Outline for Building a Leading Sports Nation", a document which explicitly calls for the accelerated integration of internet technologies, big data, and artificial intelligence with the sports sector, with the aim of driving its digital

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transformation. In the subsequent year of 2021, the State Council's "Circular of National Fitness (2021-2025)" and the General Administration of Sport, PRC's "14th Five-Year Plan for Sports Development" both emphasised the advancement of the digital transformation of China's sports industry, with particular focus on innovating the application of core elements such as data within the sector.

It is evident that China's substantial population, pervasive health consciousness, and high participation rates in sporting activities have precipitated a series of innovations in the integration of digital technology with the sports industry. The Chinese sports industry is currently experiencing a period of rapid innovation, with new products, business models and formats emerging in a variety of forms. These developments include the use of technology by athletes and coaches to analyse match strategies, the digital broadcasting of sporting events, online ticket management systems and smart fitness apps. The sports manufacturing and service industries are now demonstrating an increasing inclination towards digital transformation and intelligent development.

This study is based on the theory of total factor productivity (TFP), with the digital transformation level (DTL) serving as the core explanatory variable. By controlling for variables such as firm size, age, the debt-to-asset ratio, equity concentration, financing constraints and government support, this study investigates the influence of various input factors on TFP in sports enterprises through digital technology empowerment. It also examines the mediating roles of innovation capability and human capital. Based on this framework, the research analyses actionable strategies to enhance TFP across different operational dimensions.

2. Literature Review and Research Hypothesis

In academic studies of the impact of digital technology on the sports industry, scholars such as Ren Bo & Huang Haiyan (2021) and Shen Keyin, Lin Shuting & Dong Qinqin (2022) argue that the digital economy introduces data as a new production factor, thereby enhancing internal resource allocation efficiency in enterprises. The optimisation of supply chain management and production processes has been demonstrated to reduce operational costs (Ren & Huang, 2021; Shen, Lin & Dong, 2022). Deng Rui and Fang Chunni (2022) utilised a range of econometric models to ascertain the favourable impact of the digital economy on the advancement of the sports industry. Their findings demonstrated that the digital economy can indirectly foster the growth of the sports industry through the optimisation of a rational industrial structure. Using the "core drive-intrinsic effect-realisation path" framework, Wei Yuan, Cheng Chuanyin and Han Xue (2021) investigated the mechanism of industrial structure upgrading after the integration of digital technology into sports industries. In their seminal study, Shao Jiping, Ni Yanzhen and Wu Sheng (2024) sought to analyse the positive influence of digital transformation on business performance. To this end, the authors examined sports enterprises in the concept section of the Shanghai and Shenzhen Stock Exchanges from 2010 to 2021. As highlighted by Feng Bing (2011) and Ye Haibo (2021), the digital economy has been shown to foster operational efficiency in sports industries. This is achieved by strengthening inter-industrial linkages and indirectly influencing other production factors. Existing research indicates that digital technology introduces data as a new production factor and transforms traditional elements, thereby improving the efficiency with which sports enterprises and industries allocate resources. Furthermore, integrating digital technologies into production operations and organisational management effectively optimises operational efficiency across sports enterprises and sectors.

A variety of research methodologies have been employed by scholars in China and abroad in order to investigate the determinants of changes in the TFP of the sports industry. For instance, Porter et al. (2008) utilised input-output models to analyse the economic impacts of the Olympics on host countries, thereby establishing the foundation for TFP studies in sports. In 2016, Ren Bei applied the Malmquist Index method from data envelopment analysis. They compared total annual industrial expenditure and the number of coaches with annual revenue and athlete performance metrics in order to examine total factor productivity (TFP) variations across China, the United States, and Russia from 2005 to 2013. Tang Peng and Zhan Zhaolei (2016) used the Malmquist Index to demonstrate that technological advancement was the main driver of significant total factor productivity (TFP) improvements in China's sports manufacturing industry across 15 provinces from 2004 to 2013. Fu Kaixin et al. (2024) analysed how the digital economy empowers sports manufacturing, examining the mediating effects of innovation capabilities and TFP. Chen Huijuan (2023) emphasised that the digital economy enhances the TFP of the sports industry by alleviating financing constraints, boosting R&D investment and increasing labour efficiency.

Productive forces consist of three elements: labourers, the means of labour and the objects of labour. Labourers represent the human resource component, while the means and objects of labour constitute the material factors. Integrating digital technology with the sports industry has transformed all components of productive forces. The empowerment of digital technology in the sports industry has given rise to three "digital + sports" models, which foster new, high-quality

productive forces centred on data as a core production factor and innovation as a foundation:

First is digital industrialisation. Digital technologies have empowered data to become the core element in the production process, expanding the objects of labour in the sports industry. Meanwhile, combining data with traditional objects continuously generates innovative sports products and services (digital industrialisation). For example, with the support of 5G, VR, AI and IoT technologies, the sports manufacturing industry can produce smart sports facilities and athletic gear. Sports service industries use internet-based transmission networks to create a wide range of digital sports content, significantly improving the efficiency with which supply and demand are aligned.

Second is industrial digitalisation. Digital technology itself serves as an intangible means of labour (tools), thereby providing foundational support for the digitisation, networking and intelligentisation of other physical or non-physical labour resources. Technologies such as big data, AI, blockchain and the Internet of Things (IoT) are gradually permeating these sectors, becoming powerful drivers for transforming the processes of management in both sports manufacturing and services. Convolutional neural networks and motion recognition/tracking in artificial intelligence, for instance, have been demonstrated to enable athletes and coaches to monitor physical status and movement during training or competitions. It is evident that these innovations play a pivotal role in the optimisation of sports talent development and the enhancement of tactical strategies. This development has the potential to enhance collaborative efficiency throughout the sports industry chain, whilst concurrently giving rise to novel business models through the integration of digital sports products and services.

Third, the advent of digital technology has precipitated a paradigm shift in the capabilities of the workforce. Digital literacy and skills are the cornerstones of technological innovation, facilitating rapid adaptation to advanced technologies and high-end equipment. By leveraging digitised labour resources and objects, they achieve a significant increase in the volume of products and services, establish efficient operational frameworks, and notably accelerate the conversion of sports digital products/services into digital assets through blockchain and NFTs. It is evident that, under the protection of electronic copyrights and transactions, these assets evolve into digital capital, thereby generating new value-added processes that achieve digital valorisation within the sports industry.

The following hypotheses are hereby proposed:

H1: Digital transformation enhances the TFP of sports enterprises.

H2: The innovation capability plays a mediating role in the impact of digital transformation on the TFP of sports enterprises.

H3: The optimisation of the structure of human capital plays a mediating role in the impact of digital transformation on the TFP of sports enterprises.

3. The Impact of Digital Technology on the TFP of Sports Enterprises

3.1. The Mechanism of Digital Transformation Empowering Sports Enterprises' TFP

The digitalisation and transformation of the sports manufacturing industry can be understood through two key lenses. Firstly, the integration of digital elements with traditional manufacturing processes enables precise tracking of data collection, production, and energy consumption, whilst generating efficient consumer behaviour analysis. This, in turn, has the potential to reshape production models and enhance efficiency. Secondly, the digital empowerment of consumers has been demonstrated to drive product innovation through functional upgrades and design innovations. This, in turn, has resulted in the opening of new markets for sports and the optimisation of supply-demand alignment. Intelligent products have emerged across sectors, including fitness-for-all, competitive sports, and public sports facilities, thanks to the use of interactive hardware, AI technologies, VR/AR applications, and other digital solutions. From a fitness perspective, innovations include wearable devices such as smart bands and cycling gear, as well as fitness equipment like spinning bikes, rowing machines, and jump ropes. There are also VR applications, including smart mirrors and VR games. In competitive sports, advancements include smart timing systems, scoring judgement devices and training tools such as AI fitness trainers and rehabilitation robots that address musculoskeletal pain, sports injuries, spinal adjustments and postoperative recovery. In terms of public sports facilities, innovations include digital stadiums, smart swimming pools and outdoor amenities such as community walking trails, running tracks and smart fitness centres.

Firstly, regarding the digitalisation of the sports service industry, smart management systems for sports events and facilities provide a basis for big data analysis, enabling service providers to achieve precise supply-demand matching and improve management efficiency in the upstream business. Secondly, in terms of the midstream sector, the integration of sports with content industries has enabled the global dissemination of content, free from time and location constraints, through digital technologies. Emerging technologies such as AR/VR, AI and NFTs have provided audiences with unprecedented engagement through immersive experiences and real-time access to detailed match and player information. For downstream businesses such as online ticketing and the integration of sports with

fitness, tourism and leisure, digital empowerment has optimised input factors, innovated service forms and provided consumers with more valuable experiences and satisfaction.

Digital technologies empower one to transform the three major production factors – labourers (skill upgrading), labour objects (the foundation of digital products and services) and labour means (intelligent tools) – driving the reconstruction and optimisation of production and operational processes, as well as service methods, in sports manufacturing and service industries (e.g., service-oriented new products and multi-modal interactive services). This substantially enriches the supply, ensuring precise and efficient matching between supply and demand. This significantly improves the total factor productivity (TFP) of sports enterprises.

3.2. Model Construction

Traditionally, total factor productivity (TFP) was estimated using the Cobb–Douglas function (C-D function). However, this approach is subject to simultaneous and sample selection bias. Various correction methods have been proposed to address these issues, with the Olley-Pakes (OP) method and the Levinsohn-Petrin (LP) method gaining widespread acceptance (Lu & Lian, 2012). The OP method addresses simultaneous bias by treating firms' current investments as a proxy variable. This requires that actual investments are positive. This constraint may result in certain companies being excluded from this study. By contrast, the LP method, which employs intermediate inputs as proxies, is better suited to this research. The utilisation of the LP method facilitates the estimation of the TFP of sports enterprises that have been empowered by digital technologies. The establishment of the following benchmark OLS regression model is thus achieved:

$$TFP_{i,t} = a_0 + a_1 Digital_{i,t} + a_4 Controls_{i,t} + Firm + Year + e_{i,t} \quad (1)$$

In addition, the mediation effect model developed in this study is employed to elucidate the mechanism underlying the discrepancy between "DTL of enterprises" and "TFP of enterprises".

$$Digital_{i,t} = b_0 + b_1 Mediator_{i,t} + b_2 Controls_{i,t} + Firm + Year + e_{i,t} \quad (2)$$

$$TFP_{i,t} = c_0 + c_1 Digital_{i,t} + c_2 Mediator_{i,t} + c_3 Controls_{i,t} + Firm + Year + e_{i,t} \quad (3)$$

In this study, the dependent variable is the TFP of sports enterprises, while the core explanatory variable is the DTL (variable name: Digital), which measures the extent of digital transformation in these enterprises. Controls denote a set of independent variables affecting the TFP, including: enterprise size, enterprise age, asset-liability ratio, ownership concentration, financing

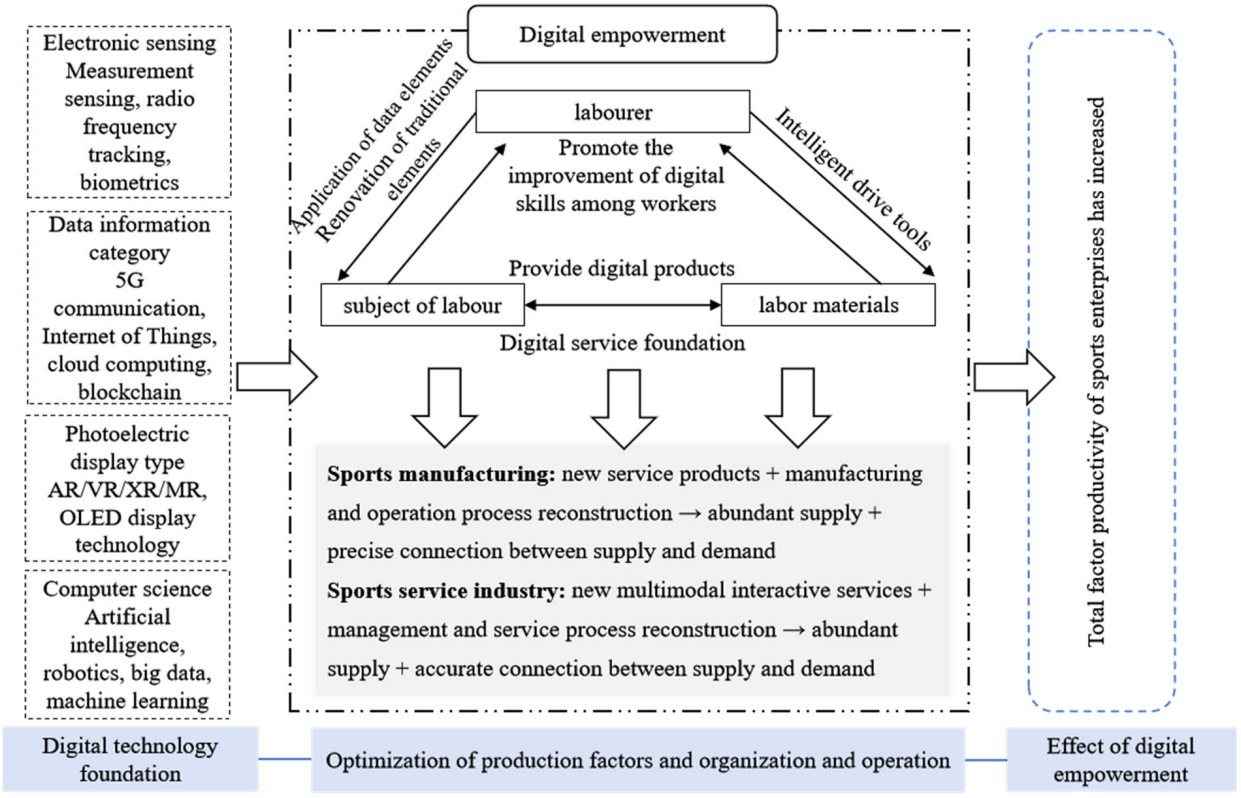

Figure 1. Mechanism of digital transformation on total factor productivity of sports enterprises

Source: developed by the authors

constraints, and government support. Mediator refers to the mediating variable. From the perspective of innovation ability and human capital of sports enterprises, this study explains the feasibility of its mediating path between digital transformation and the TFP of sports enterprises.

The index (i) represents the unique identification code (stock symbol) of each listed enterprise, t denotes the year of business data statistics, and e is the model's random error term. Variable descriptions are detailed in Table 1. To eliminate the impact of extreme values on research conclusions, continuous variables in this study have undergone 1% upper/lower truncation.

Previous studies have primarily measured the DTL of different enterprises using two methods: distributing questionnaires and analysing the frequency of keywords in annual reports (Matt et al., 2016; Meng & Zhao, 2018; He & Liu, 2019; Wu et al., 2021). However, since annual reports serve both as a summary of the previous year's operations and as a plan for future development, the information they contain is forward-looking and does not fully reflect DT progress. In order to overcome the limitations of relying solely on keyword frequency analysis, this study employs a hybrid methodology that combines text analysis with expert scoring. This approach is based on the research of Yang Deming and Liu Yongwen (2018) and is used to develop an index for evaluating the DTL of sports enterprises.

Firstly, a comprehensive comparison of China's digital economy policy documents was conducted, resulting in the identification of five dimensions of digital technology and a foundational keyword database. The present study built upon the extant literature by systematically analysing the practical experiences of the digital transformation of several sports enterprises. The analysis generated specific sub-keywords from two aspects: internal informatisation and the digitalisation of production and operation processes. The study ultimately constructed a specialised keyword corpus related to sports enterprises (see Table 2). Secondly, the jieba function in Python was employed to conduct word segmentation for enterprise annual reports, with the objective of analysing keyword frequency. The preliminary indicator for DT was calculated as the ratio of an enterprise's annual keyword frequency to the total keyword frequency of all enterprises in that particular year. Thirdly, drawing inspiration from the expert scoring method developed by scholars including Yang Deming & Liu Yongwen (2018), Zhao Can et al. (2020), and Zhao Chenyu, Wang Wenchun & Li Xuesong (2021), the DTLs in listed companies were evaluated based on disclosed content in their annual reports (see Table 3). In conclusion, the Digital Transformation Index for enterprises was derived in this study through the equal weighting of results from both text analysis and expert scoring methods.

3.3. Sample Selection and Data Source

In the section on sample selection, this study first considered factors such as enterprise information disclosure standards and organisational management systems. Ultimately, it was decided that the research subjects would be sports enterprises listed on the A-share markets and the NEEQ. As the sports industry spans both the secondary and tertiary sectors, it exhibits strong inter-industrial linkages and expansion potential in its upstream and downstream links. Some sports enterprises act as both manufacturers and service providers. Different studies have adopted various criteria for selecting samples of sports enterprises. This paper screens research enterprises according

Table 1
All variables and their definitions

Class	Variable name	Symbol	Variable definition
Explained variable	Enterprises' total factors productivity	TFP_LP	TFP of enterprises calculated by LP method
		TFP_FE	TFP of enterprises calculated by FE method
Core explanatory variables	The digital transformation level of enterprises (DTL)	Digital	Measures of the degree of digital transformation contained in corporate annual reports
Controlled variable	Scale	Size	The natural logarithm of the total number of employees
	Enterprise age	Age	Ln (year of year-year of establishment +1)
	Asset-liability ratio	Debt	Total liabilities/total assets
	Equity concentration	Share	Shareholding ratio of the largest shareholder
	Financing constraints	Fin_cost	Financing constraints measured by the SA index
	Government support	Gov	The proportion of cultural, sports and media expenditure in government expenditure in the previous year
Mediator	R&D	R&D	Ln (R&D expenditure +1)
	Human capital	Labour	The proportion of employees with a bachelor's degree or above

Source: the variable comes from the model setting

Table 2
Keywords of digital transformation level for sports enterprises

Project	Keyword		Sub-keywords
Digitisation of production and operation process	Internet technology	Internet, 5G	Digital technology, digital communication, digital networks, digital terminals, digital intelligence, digital marketing, digital retail, digitization, digital sports, digital events, mobile internet, industrial internet, internet models, e-commerce, live streaming, live streaming platforms, new media, apps, mini-programs, micro-malls, online sales, O2O, B2B, C2C, B2C, C2B, Internet
	Big data technology	Big data, virtual reality, augmented reality	Data management, data mining, data network, data center, digital control, virtual reality (VR), augmented reality (AR), mixed reality (MR), virtual, virtualization, virtual manufacturing, DCS, EDA, Oracle, SAP, U9, ERP
	Cloud computing technology	Internet of Things, cloud computing technology	Cloud, cloud computing, cloud storage, cloud platform, cloud fitness, cloud service, cloud networking, intelligent logistics, intelligent warehousing, intelligent factory, SaaS, PaaS, IoT
	Artificial Intelligence technology	Artificial intelligence, business intelligence, intelligence	Artificial intelligence, robotics, intelligent, intelligent venues, intelligent manufacturing, intelligent equipment, intelligent control, intelligent terminals, intelligent factories, intelligent warehousing, intelligent technology, intelligent equipment, intelligent production, intelligent networking, numerical control, integration, integration, integrated control, integrated system, future factory, intelligent fault diagnosis, PLM
	Blockchain technology	blockchain	Decentralization, digital collectibles, NFT, digital currency, smart contracts
Enterprise internal information construction	Information network		Information sharing, information management, information integration, information software, information system, information network, information terminal, information center, information technology, informatization, networking, knowledge management, mobile office, intelligent office, online office, 5G, OA

Source: constructed by the authors based on Chinese digital economy policy documents and practical cases of sports enterprises

Table 3
Content and score of expert scoring method

Content evaluation	Value
The investment direction of sports enterprises for the next year is primarily digital.	3
Digital technology has been fully integrated into the main production and operational processes of sports enterprises.	3
Digitalisation is mentioned in sports enterprise investment plans (though not as the main investment focus for this or the following year).	2
The core business of sports enterprises has begun to undergo digital transformation, but it has not yet been deeply integrated with digitalisation.	2
Sports enterprises are engaged in digitalisation outside their core business activities.	1
Digitalisation is included in the future development plans of sports enterprises.	1
There is no mention of digitalisation in the business or development plans of sports enterprises.	0

Source: adapted from Yang Deming & Liu Yongwen (2018) and Zhao Can et al. (2020), and customised for sports enterprises by the authors

to the following two standards: 1) they conform to the definition of a sports enterprise specified in the "Classification of Sports Industry Statistics (2019)" issued by the Chinese State Council in 2019; and 2) to ensure accuracy, enterprises that went bankrupt, closed down, or were classified as ST, PT, S*ST or SST by the A-share market during the sample period are excluded.

The present study examines the period from 2015 to 2024, with a focus on selected enterprises based on predefined criteria. A total of 50 qualified companies were identified, including 34 that are listed on the Shanghai (.SH), Beijing (.BJ) and Shenzhen (.SZ) A-shares markets, and 16 on the NEEQ (.NQ) (see Table 4). During the selection process, enterprises with no sports-related core businesses were excluded. The data was collected from three distinct sources: the Wind database, Juchao Information Network, and the official websites of the respective enterprises. This process ultimately resulted in the collection of 417 valid sample records.

3.4. Descriptive Statistics of Samples

3.4.1. Descriptive Analysis of TFP and Digital Transformation Degree of Sports Enterprises

From 2015 to 2024, the digital transformation level (DTL) of enterprises and the total factor productivity (TFP_LP) of China's sports enterprises showed an overall moderate upward trend. Digital transformation

Table 4
List of sample enterprises

Code	Code	Code	Code	Code
000558.SZ	002899.SZ	300729.SZ	605099.SH	834425.NQ
000639.SZ	300005.SZ	300979.SZ	605299.SH	835282.NQ
001300.SZ	300043.SZ	600158.SH	688207.SH	839446.NQ
001368.SZ	300651.SZ	600679.SH	833429.BJ	871549.NQ
002105.SZ	002639.SZ	603081.SH	837226.NQ	871721.NQ
002181.SZ	002701.SZ	603099.SH	830877.NQ	430756.NQ
002395.SZ	002768.SZ	603129.SH	832655.NQ	870841.NQ
002486.SZ	002780.SZ	603558.SH	834274.NQ	871641.NQ
002489.SZ	002832.SZ	603908.SH	870749.NQ	831326.NQ
002870.SZ	002858.SZ	605080.SH	837720.NQ	832875.NQ

Source: curated by the authors from publicly listed enterprise data (Shanghai /Beijing/ Shenzhen A-shares and NEEQ), filtered via criteria detailed in Section 3.2. Raw data sourced from Wind Database, Juchao Information Network, and official websites of enterprises

accelerated significantly from 2016 onwards due to policies such as the "National Fitness-for-All Program (2016–2020)", with continuous increases in investment in smart equipment manufacturing and online service platforms confirming the industry's systematic embrace of digital technology. Although the pandemic caused a significant decline in TFP, especially for sports service enterprises that relied on offline scenarios, overall TFP showed strong resilience and quickly returned to an upward trajectory later on. In the manufacturing industry, digitalisation has been shown to focus on supply-side upgrades (intelligent production processes, flexible supply chains), thereby supporting the stability of its TFP. In the service industry, digitalisation has been shown to focus on demand-side innovation (VR event live broadcasts, AI personal training, community operations), which has resulted in a TFP that is more vulnerable to external shocks (such as event suspensions and gym closures caused by the pandemic), yet more resilient in rebound.

3.4.2. Descriptive Statistical Analysis

This study analyses data from listed sports enterprises from 2015 to 2024. Descriptive statistics for key variables are presented in Table 5. The TFP_LP shows an average of 7.898, ranging from a minimum of 0 to a maximum of 10.725, and has a standard deviation (SD) of 1.675. The metrics indicate significant disparities in productivity among Chinese sports enterprises during the research period. With regard to the DTL of enterprises (variable name: Digital), it was found that the maximum reached 1.599, while the minimum remained at 0. This finding indicates significant variations in the digitalisation of the sports industry in China.

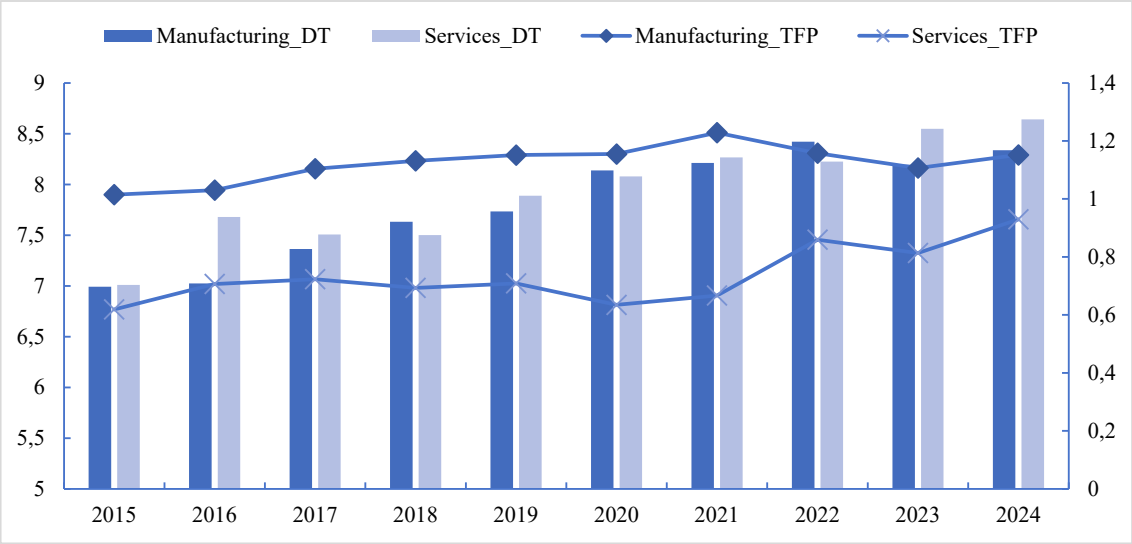

Figure 2. TFPs and DTLs of sample enterprises

Source: generated by the authors based on sample data from Wind database and other sources

Table 5

Descriptive statistics

Variable	Observed value	Average	Standard deviation	Min	Max
TFP_LP	417	7.898	1.675	0.000	10.725
Digital	417	1.026	0.477	0.000	1.599
Size	417	6.460	1.888	0.693	12.087
Age	417	2.870	0.364	1.609	3.638
Debt	417	0.409	0.219	0.028	1.665
Share	417	0.425	0.186	0.078	0.900
Fin_cost	417	2.859	2.099	-1.926	6.758
Gov	417	0.021	0.006	0.009	0.038
R&D	417	10.760	8.369	0.000	20.749
Labour	417	0.217	0. 206	0.000	0.885

Source: descriptive statistics calculated by the authors based on data from Wind database, Juchao Information Network, and official websites of sports enterprises

3.5. Correlation Test

Prior to conducting regression analysis of the primary model, this study performed correlation analysis on key variables to address issues of multicollinearity. The findings indicated a substantial positive correlation between the DTL and the TFP, with a coefficient of 0.238 at the 1% significance level. This finding suggests that digital transformation in sports enterprises has the potential to substantially enhance their TFP. All other variables demonstrated correlation values below 0.6, and the Variance Inflation Factor (VIF) test score of 2.52 (average) remained well below the threshold of 10, indicating minimal multicollinearity among variables.

3.6. Analysis of Benchmark Empirical Results

3.6.1. Benchmark Regression and Robustness Test

As illustrated in Table 6, Column (1), the results of the benchmark regression utilise a two-way fixed effects model. This model serves as the primary validation of the relationship between digital transformation and the TFP in sports enterprises. The empirical findings demonstrate that when a sport enterprise's DTL increases by one unit, its TFP rises by 0.547 units, generating a statistically significant positive impact at the 1% level of significance.

In order to ensure the reliability of the empirical results, the TFP measured by LP method was replaced by the TFP measured by FE method. The results are displayed in column (2). The findings of this study demonstrate that the degree of digital transformation exerts a substantial positive influence on the TFP, with a 1% significance level, as indicated by the regression coefficient of 0.629.

Meanwhile, column (1) also demonstrates the impact of control variables on a firm's TFP. The analysis reveals that firm size, age, debt-to-asset ratio, and equity concentration all pass significance tests. Specifically, the findings indicate a positive correlation between firm size and the TFP at the 5% significance level. The evidence suggests that larger firms demonstrate stronger resource integration capabilities and greater economies of scale, thereby enhancing overall productivity. Conversely, firm age has a negative effect on TFP at the same level of significance, as prolonged operation leads to organisational rigidity and reduced innovative capacity, ultimately reducing efficiency. The debt-to-asset ratio reflects a firm's ability to utilise external financing and shows a positive correlation with TFP at the 1% significance level. This suggests that lower financial leverage reduces access to external funding, thereby limiting expansion through external financing or technological innovation and consequently constraining productivity growth. Equity concentration notably exhibits a negative correlation with TFP at the 10% significance level. Excessive concentration enables major shareholders to interfere too much in management, which undermines the efficiency of corporate governance and hinders productivity improvement.

3.6.2. Endogeneity Test

As enterprises with higher production efficiency are more likely to proactively pursue digital transformation, the empirical analysis in this study may encounter endogeneity issues arising from reverse causality. In order to address this issue, the following approach has been implemented: firstly, in consideration of the potential time lag effect on the TFP caused by digital transformation, first-period lagging was applied to the core explanatory variable (Digital) and regression analyses were reconducted. As demonstrated in Column (1) of Table 7, the coefficient for digital transformation maintains a substantial positive association at the 1% significance level.

Table 6
Digital transformation and the TFP of sports enterprises

Variable	(1)	(2)
	TFP_LP	TFP_FE
Digital	0.547***(3.84)	0.629***(3.76)
Size	0.139**(1.97)	0.242**(2.13)
Age	-0.671**(-2.11)	-0.729**(-1.99)
Debt	1.787***(5.16)	2.259***(5.56)
Share	-1.639*(-1.74)	-2.125*(-1.92)
Fin_cost	0.030(0.21)	0.054(0.32)
Gov	0.056(0.11)	0.354(0.19)
Constant term	8.288***(5.10)	9.671***(5.07)
Observed value	417	417
Observed individuals	50	50
R^2	0.540	0.461
Individual fixation	Control	Control
The timing is fixed	Control	Control

Source: Levinsohn-Petrin (LP) method framework (Lu & Lian, 2012), addressing simultaneity bias in productivity estimation. Control variables (firm size, liquidity, etc.) follow established econometric specifications. Fixed effects (firm/year) mitigate unobserved heterogeneity

Note: ***, **, and * indicate significance at the 1%,5%, and 10% significance levels, respectively

Secondly, following the methodology of Wang Bo & Kang Qi (2023), a one-period lagged core explanatory variable (V1) and the internet penetration rate in different provinces in the previous year (V2) were employed as instrumental variables for endogeneity testing. In the initial stage of regression analysis (see Table 7), both instrumental variables exhibited statistically significant positive coefficients for the endogenous explanatory variable (Digital, V1: 0.391, p<0.01; V2: 0.963, p<0.01). The initial F-value of 36.04 was found to be significantly higher than the Stock-Yogo 10% threshold of 19.93, thereby rejecting the weak instrument hypothesis. The Kleibergen-Paap rank sum LM statistic for under-identification reached 12.74 (p=0.002), thereby invalidating the null hypothesis that "instrument variables are uncorrelated with endogenous variables". The Hansen J statistic for excessive identification (p=0.341) did not reject the exogeneity hypothesis of instrument variables. The second-stage regression revealed that the coefficient of digitalization (digital transformation) on total factor productivity (TFP_LP2) was 0.812 (z=2.73, p=0.000), showing statistically significant positive effects at the 1% level of significance. This finding suggests that even when endogeneity issues are controlled for, digital transformation continues to significantly enhance the TFP of enterprises.

3.7. Test of Mediation Effect

In the context of sports enterprise development, digital transformation has been shown to enhance the

Table 7
Results of endogeneity test

Variable	(1)	(3)	(4)
	TFP_LP	Digital	TFP_LP
DT	0.557*** (3.28)		0.812*** (2.73)
V1		0.391*** (5.67)	
V2		0.963*** (3.03)	
Controlled variable	Control		Control
Observed value	365		365
Kleibergen-Paap RK LM statistics			12.74***
Kleibergen-Paap, Wald F, and statistics			36.04***

Source: reference is made to the instrumental variables for enterprise digital transformation constructed by Wang Bo and Kang Qi (2023) to conduct endogeneity tests

Note: ***, **, and * indicate significance at the 1%,5%, and 10% significance levels, respectively

TFP by restructuring corporate elements. Innovation capabilities (R&D) and human capital (labour) have been identified as crucial mediating factors in this process. In order to verify this hypothesis, a mediation effect model was constructed for analysis in this study (see Table 8).

In terms of innovation capacity, digital transformation provides sports enterprises with data support, collaboration platforms, and a low-cost trial environment for R&D activities, thereby significantly enhancing innovation output. Digital technology has been demonstrated to facilitate the accurate capture of market demands, the reduction of R&D cycles, and the minimisation of failure risks. Conversely, digital platforms have been demonstrated to enhance knowledge spillovers and technology sharing, thereby reducing R&D costs and risks. As demonstrated in Column (1) of Table 8, digital transformation exerts a statistically significant positive influence on corporate innovation capacity.

In terms of human capital, digital transformation increases the demand for highly skilled labour and optimises the human capital structure through online training and remote collaboration. The widespread adoption of digital tools has prompted enterprises to reduce their reliance on low-skilled roles, attracting more versatile talent and stimulating knowledge spillover and collaborative innovation. As shown in Table 8, Column (2), digital transformation has a positive impact on human capital at the 1% significance level. This indicates that greater digitalisation in sports industries is associated with a higher proportion of high-quality professionals within organisations.

As illustrated in Table 8, Column (3), the empirical findings following the introduction of a mediating variable indicate the substantial mediating roles of innovation capability (R&D) and human capital in augmenting the TFP through digital transformation. The contribution ratio of innovation capability to the total effect is 13.1%, with a Bootstrap 95% confidence interval [0.007, 0.068], while the ratio of human capital to the total effect is 14.7%, with a Bootstrap 95% confidence interval [0.019, 0.044]. The introduction and optimisation of high-quality talent has been demonstrated to directly improve the operational efficiency of enterprises. In addition, due to their ability to learn, apply and disseminate new technologies, these individuals can become a key hub for transforming the effectiveness of digital transformation into actual production value. This forms a virtuous cycle of "technological R&D – knowledge transformation – value creation". This has been demonstrated to enhance factor allocation efficiency and management effectiveness, thereby driving the leap in productivity of sports enterprises.

3.8. Heterogeneity Test

The benchmark regression framework is utilised as a foundation, with sports enterprises categorised into two distinct groups: sports service providers and manufacturers. This classification is based on the primary business activities of each entity, and separate regression analyses are conducted to evaluate the performance of these groups. The regression results presented in Tables 9(1) and 9(2) demonstrate that digital transformation significantly enhances the TFP in both two sectors. However, the underlying mechanisms of this effect demonstrate notable industry-specific heterogeneity.

The findings indicate that the impact of digital transformation in the sports service industry (coefficient = 0.583, at the 5% significance level) surpasses that in the sports manufacturing industry (coefficient = 0.479, at the 1% significance level). This finding suggests that service industries, being

Table 8
Results of mediation test

Variable	(1)	(2)	(3)
	R&D	Labour	TFP_LP
Digital	6.079***(7.54)	0.850***(3.87)	0.590***(4.16)
R&D			0.012***(3.69)
Labour			0.102***(5.06)
Controlled variable	Control	Control	Control
Constant term	11.209***(27.21)	0.935***(19.14)	3.00***(4.12)
Observed value	417	417	417
Observing individuals	50	50	50
R^2	0.430	0.495	0.502
Individual fixation	Control	Control	Control
The timing is fixed	Control	Control	Control

Source: the regression results explain the mediating role of enterprise innovation ability and human capital structure in formulas (2) and (3) in model 3.2 construction.

Note: ***, **, and * indicate significance at the 1%,5%, and 10% significance levels, respectively

inherently closer to consumer terminals and data application scenarios, can more efficiently convert digital investments into productivity gains. The sports service sector significantly boosts productivity through the mediating role of corporate innovation capabilities (R&D) (coefficient = 0.047, significant at 5%), highlighting how digital technologies directly empower the iteration of products and optimisation of user interaction. In contrast, the sports manufacturing sector exhibits longer technology adoption cycles and a greater focus on equipment intelligence, showing no significant impact from innovation capabilities. There are also distinct differences in the labour structure: optimised human capital in sports manufacturing significantly enhances production efficiency (coefficient = 0.069 at a 1% significance level), which confirms the manufacturing sector's strong reliance on highly skilled digital talent. This talent is required for technological integration and process reengineering. However, the labour coefficient in the service sector does not pass significance tests, which suggests that improvements in its efficiency rely more on model innovation than on upgrading the workforce.

4. Conclusions and Recommendations

4.1. Research Conclusions

Empirical analysis demonstrates that the integration of digital technologies with the sports industry generally generates positive impacts on sports enterprises, enhancing their TFP and fostering the development of new quality productive forces. It is evident from empirical findings and current practical developments that the sports manufacturing sector and service sector face distinct challenges and opportunities during their digital transformation processes.

This study analysed data from sports enterprises listed on the A-share market and the NEEQ between 2015 and 2024. The findings demonstrated that digital transformation significantly enhances the TFP in the sports industry. This effect remained statistically significant when subjected to robustness tests and endogeneity control, thus highlighting digital technology's role as a driving force of new quality productive forces. Further analysis of the mediating variables revealed that digital transformation does not directly or linearly improve the TFP, but rather exerts its effects through two paths: innovation capability and human capital development.

However, an analysis of industry heterogeneity reveals a significant divergence in digitalisation trajectories between the sports service and manufacturing sectors. The sports service sector has demonstrated a higher level of digital transformation, owing to its technology application scenarios being closer to consumer terminals. These enable efficient conversion of digital investments into productivity gains. It has been demonstrated that R&D investments (e.g., immersive sports event broadcasts, e-sports competitions, and fitness apps) drive service model iterations and user experience enhancements, with human capital playing a less significant role. This underscores the efficacy of their strategic enhancements, which prioritise organisational innovation over talent restructuring. Conversely, the manufacturing sector evinces comparatively diminished returns, chiefly reliant on human capital optimisation (e.g., augmenting the proportion of high-skilled professionals) as a pivotal mediator to facilitate technology integration and process reengineering. However, the statistical insignificance of R&D investment suggests that the benefits of intelligent upgrades to sports equipment do not manifest immediately.

This discrepancy underscores the divergent pathways between the "technology embedded" approach of manufacturing and the "service innovation" approach of services.

Table 9
Heterogeneity test

Variable	(1)	(2)
	Sports manufacturing	Sports services
Digital	0.479***(2.79)	0.583**(2.16)
R&D	0.138(1.65)	0.047**(1.99)
Labour	0.069***(3.12)	0.021(0.62)
Controlled variable	Control	Control
Constant term	10.933***	1.750***
Observed value	270	147
Observing individuals	33	17
R^2	0.474	0.562
Individual fixation	Control	Control
The timing is fixed	Control	Control

Source: according to the definition of the sports industry in the "Statistical Classification of the Sports Industry" issued by China in 2019, the sample enterprises are divided into manufacturing and service industries based on their main business, and regression analyses are conducted respectively

Note: ***, **, and * indicate significance at the 1%,5%, and 10% significance levels, respectively

4.2. Research Suggestions

This study is predicated on the findings of a comprehensive empirical analysis and the development experience of the sports manufacturing and service industry. The study puts forward the following three suggestions, with the aim of providing a reference point for the integrated development of the sports industry and digital technology in the future.

1. Focus on "labour objects + labour materials" and strengthen digital research and development investment

The empirical findings indicate that innovation capacity (R&D) and human capital (Labour) play significant mediating roles in the process of enhancing enterprises' TFP through digital transformation (the contribution of innovation capacity to the total effect accounts for 13.1%, Bootstrap 95% CI [0.007, 0.068]; human capital accounts for 14.7% of the total effect, Bootstrap 95% CI [0.019, 0.044]). However, a heterogeneity analysis reveals that R&D investment significantly promotes TFP in the sports service industry, while its effect is not statistically significant in the sports manufacturing industry. In contrast, the influence of human capital is more evident in the sports manufacturing industry than in the sports service industry. Consequently, irrespective of the industry, the prioritisation of enhancing objects of labour and means of labour through augmented R&D investment and enhanced enterprise innovation capabilities is more efficacious in elevating TFP.

Sports manufacturing enterprises should align their strategies with market demands by focusing on consumers' need for interactivity and immersion. They should increase investment in R&D to develop intelligent, personalised sports and fitness facilities, equipment and related products. They should also enhance their analysis of feedback data, deriving actionable insights from the sales and usage processes of intelligent, personalised products in order to continuously upgrade their offerings and deliver intelligent, interactive services.

For the sports service industry, R&D investment should prioritise expanding and extending the sports industry chain. Efforts should focus on integrated areas such as "sports + entertainment", "sports + tourism", and "sports + cultural dissemination". Enterprises should enrich the content and services provided by sports apps and online platforms, innovate business models, stimulate latent consumer demand and improve digital transformation efficiency.

2. Build a closed loop of "enterprise strategy-matrix training-multiple applications" to cultivate digital human resources capabilities

Firstly, sports companies should incorporate digital literacy and capabilities into their human resources and core competitiveness indicators. This could include the proportion of digital talent, relevant training implementation and the application and effects of digital skills in the KPI assessment of senior management and departments. This would enhance digital transformation achievements, forming a closed loop from strategy to training to application and enabling people – the most dynamic factor of productivity – to play a role in digital empowerment.

Secondly, it is recommended that the collaborative strengths of the government, industry, academia and research institutions be leveraged in order to develop training initiatives. On February 25, 2020, the Ministry of Human Resources and Social Security officially released 16 new in-demand occupations to the public, in collaboration with the State Administration for Market Regulation and the National Bureau of Statistics. These include intelligent manufacturing engineers, VR engineering technicians, AI trainers, and all media operators. At the same time, vocational training and certification programmes for these roles were launched quickly, with many local governments providing financial subsidies to support related training. Meanwhile, universities and research institutions have developed relevant courses. Peking University's "Digital Sports" elective course, for example, which was launched in 2024, integrates AI smart grading with dialect recognition, personalised path recommendations and foundational Python programming alongside Tableau visualisation training. Listed sports companies can expand their collaborations with governments and research institutes to build a multidimensional matrix for cultivating digital competency in human resources, addressing management, technical, operational and service levels.

Ultimately, putting knowledge into practice is the key to transforming digital literacy into business competitiveness. This involves two key dimensions. First, collaboration with academic institutions through joint laboratories and R&D centres facilitates the sharing of emerging digital technologies and knowledge, driving innovation in new products and services. Second, employees are motivated to implement training outcomes in sports training, event operations and related services. A cutting-edge example is the "Digital Twin Fan Community" pilot programme in the Chinese Super League (CSL), in which staff developed skills such as Unity engine programming and blockchain-based ticket distribution, achieving tangible commercial success. In order to comprehensively enhance the digital competence of employees and cultivate professionals capable of providing technical support, application-level design, platform operation, and management for sports digital transformation, it is necessary to integrate dynamic production factors with other elements. Only through this approach can the efficiency and effectiveness of digital technology be fully leveraged.

3. Promote the transformation of "digital resources-digital assets-data capital" and release the value of sports data

The analysis of sports data has become a fundamental element in the production process, driving innovation in the sports industry, enhancing competitive performance, and optimising public fitness experiences. Enterprises operating within the sports manufacturing and service sectors are capable of collecting and integrating fragmented sports data related to their operations across various fields. This can be achieved by establishing data platforms through cost-effective cloud computing solutions such as Huawei Cloud and Alibaba Cloud-Sports Cloud. By standardising data, they prepare it for further analysis, completing the full data lifecycle from "collection to storage to analysis". Currently, NBA teams use sensors embedded in players' jerseys to collect over 100 metrics, including jump height and movement speed, in real time. This provides them with the information they need to make tactical adjustments. Meanwhile, Chinese sports service providers use user profiling (including exercise preferences and consumption habits) to offer personalised services such as workout course recommendations and equipment shopping guides.

In contrast, data in the sports industry is transformed into assets through processes such as cleaning, categorisation, integration and rights confirmation. These assets can only be termed data capital once they have generated value through operations and transactions. The transition from data resources to data assets, and subsequently to data capital, is contingent upon the interplay between novel forms of labour, instruments of labour (tools), and objects of labour within the sports industry. This transformation is precipitated by the influence of emergent productive forces. The utilisation of technologies such as AI algorithms, XR, and blockchain facilitates the conversion of data into diverse forms of sports content products and services, thereby establishing the foundation for the circulation and appreciation of data capital. The high added value and liquidity of data capital will result in a significant expansion of the scope of labour objects in the sports sector, enabling its application across various sports economic activities. In prioritising data governance and privacy protection, the conversion of sports industry data resources into data assets and capital will greatly enhance the generation of sports data value, driving industrial innovation and growth.

References:

Chen Huijuan (陈慧娟). (2023). 数字经济对体育企业全要素生产率的影响 *Shuzijingji dui tiyu qiye quan yuansu shengchanlv de yingxiang* ["The Impact of Digital Economy on the Total Factor Productivity of Sports Enterprises"]. *Journal of Shandong Sport University, 39*(3), 53–62.

Deng Rui (邓瑞), & Fang Chunni (方春妮). (2022). 数字经济对体育产业发展的影响研究——基于长江经济带沿线11省市的实证考察 *Shuzijingji dui tiyuchanye fazhan de yingxiang yanjiu—ji yu Changjiang Jingji Dai yanxian 11 shengshi de shizheng kaocha* ["The Impact of Digital Economy on Sports Industry Development: An Empirical Study of 11 Provinces and Municipalities along the Yangtze River Economic Belt"]. *Journal of Physical Education, 38*(5), 22–29.

Feng B. (2011). Study on Development Path of Shandong Sports Industry from the Perspective of Low-carbon Economy. *Energy Procedia, 5*, 879–883.

Fu Kaixin (伏开鑫), Chen Po (陈颇), Yi Xiaolang (易小琅), Chen Zhenyu (陈震宇), & Liu Congzhong (刘从众). (2024). 数字经济赋能中国体育用品制造业转型升级的效应测度与实现路径 *Shuzijingji funeng Zhongguo tiyu yongpin zhizaoye zhuanxing shengji de xiaoying cedu yu shixian lujing* ["The Effect Measurement and Realization Path of the Transformation and Upgrading of China's Sports Manufacturing Industry Empowered by Digital Economy"]. *Journal of Tianjin University of Sport, 4*, 427–434.

He Fan (何帆), & Liu Hongxia (刘红霞). (2019). 数字经济视角下实体企业数字化变革的业绩提升效应评估 *Shuzijingji shijiao xia shitiqiye shuzihua biange de yeji tisheng xiaoying pinggu* ["Assessment of the Effect of Performance Improvement of Real Enterprises under Digital Transformation: from the Perspective of Digital Economy"]. *Reform, 4*, 137–148.

Lu Xiaodong (鲁晓东), & Lian Yujun (连玉君). (2012). 中国工业企业全要素生产率估计: 1999—2007 *Zhongguo gongye qiye quan yuansu shengchanlv guji: 1999–2007* ["Estimation of Total Factor Productivity of Chinese Industrial Enterprises: 1999–2007"]. *China Economic Quarterly, 11*(02), 541–558.

Matt, Ch., Hess, T., Benlian, A., & Wiesbock, F. (2016). Options for Formulating a Digital Transformation Strategy. *MIS Quarterly Executive, 15*(2), article 6, 123–139.

Meng Fensheng (孟凡生), & Zhao Gang (赵刚). (2018). 传统制造向智能制造发展影响因素研究 *Chuantong zhizao xiang zhineng zhizao fazhan yingxiang yinsu yanjiu* ["Influencing Factors of the Transformation from Traditional Manufacturing to Intelligent Manufacturing"]. *Science & Technology Progress and Policy, 35*(01), 66–72.

Porter, P. K., Fletcher, D., Dwyer, L., & Fredline, L. (2008). The Economic Impact of the Olympic Games: Ex-ante Predictions and Ex-poste Reality. *Journal of Sport Management, 22*(4), 470–486.

Ren Bei (任蓓). (2016). 全要素生产率视角下中外体育产业的动态实证分析——基于DEA-Malmquist指数模型 *Quan yuansu shengchanlv shijiaoxia zhongwai tiyuchanye de dongtai shizheng fenxi—ji yu DEA-Malmquist*

zhishu moxing ["Dynamic Empirical Analysis of Sports Industry in China and Abroad from the Perspective of Total Factor Productivity: Based on DEA-Malmquist Index Model"]. *Jiang-huai Tribune, 2*, 20–25.

Ren Bo (任波), & Huang Haiyan (黄海燕). (2021). 数字经济驱动体育产业高质量发展的理论逻辑、现实困境与实施路径 *Shuzijingji qudong tiyuchanye gaozhiliang fazhan de lilun luoji xianshi kunjing yu shishi lujing* ["Theoretical Logic, Practical Difficulties, and Implementation Path of the High-quality Development of Sports Industry Empowered by Digital Economy"]. *Journal of Shanghai University of Sport, 45*(07), 22–34+66.

Shao Jiping (邵继萍), Ni Yanzhen (倪艳珍), & Wu Sheng (吴晟). (2024). 我国体育产业数字化转型：作用机制与经营绩效评估 *Woguo tiyuchanye shuzihua zhuanxing: zuoyong jizhi yu jingying xiaoguo pinggu* ["Digital Transformation of China's Sports Industry: Mechanism and Performance Evaluation"]. *Journal of Beijing Sport University, 47*(1), 35–49.

Shen Keyin (沈克印), Lin Shuting (林舒婷), & Dong Qinqin (董芹芹). (2022). 我国体育产业数字化转型的现实要求、发展困境与实践策略 *Woguo tiyuchanye shuzihua zhuanxing de xianshi yaoqiu fazhan kunjing yu shiji celve* ["The Real Requirements, Development Difficulties, and Practical Strategies of Digital Transformation in China's Sports Industry"]. *Journal of Wuhan Sports University, 56*(08), 51–59.

Tang Peng (唐鹏), & Zhan Zhaolei (战炤磊). (2016). 体育用品制造业空间集聚与全要素生产率变化——理论机理与实证检验 *Tiyu yongpin zhizaoye kongjian jiju yu quan yaosu shengchanlv bianhua—lilun jili yu shizheng jianyan* ["The Spatial Concertration of Sports Manufacturing Industry and the Change of Total Factor Productivity: Theoretical Mechanism and Empirical Test"]. *Journal of Hohai University (Philosophy and Social Sciences), 18*(05), 26–31+90.

Wang Bo (王博), & Kang Qi (康琦). (2023). 数字化转型与企业可持续发展绩效 *Shuzihua zhuanxing yu qiye kechixu fazhan xiaoguo* ["Digital Transformation and the Sustainable Development Performance of Enterprises"]. *Business and Management Journal, 45*(06), 161–176.

Wei Yuan (魏源), Cheng Chuanyin (程传银), & Han Xue (韩雪). (2021). 数字经济驱动体育产业结构升级的内在作用、现实困境与破解路径 *Shuzijingji qudong tiyuchanye jiegou shengji de neizai zuoyong xianshi kunjing yu pojie lujing* ["The Internal Role, Practical Difficulties, and Solutions of the upgrades of Sports Industry Structure Empowered by Digitial Economy"]. *Sports Culture Guide, 9*, 73–78+85.

Wu Fei (吴非), Hu Huizhi (胡慧芷), Lin Huiyan (林慧妍), & Ren Xiaoyi (任晓怡). (2021). 企业数字化转型与资本市场表现——来自股票流动性的经验证据 *Qiye shuzihua zhuanxing yu ziben shichang biaoxian—laizi gupiao liudongxing de jingyan zhengju* ["Digital Transformation of Enterprises and Capital Market Performance: Empirical Evidence from Stock Liquidity"]. *Management World, 37*(07), 130–144+10.

Yang Deming (杨德明), & Liu Yongwen (刘泳文). (2018). "互联网+"为什么加出了业绩 *"Hulianwang +" weishenme jiachule yeji* ["Why can the "Internet+" Blueprint Boost the Performance of Enterprises"]. *China Industrial Economics, 5*, 80–98.

Ye Haibo (叶海波). (2021). 新发展阶段数字经济驱动体育产业高质量发展研究 *Xinfazhanjieduan shuzijingji qudong tiyu chanye gaozhiliang fazhan yanjiu* ["High-quality Development of Sports Industry Empowered by the Digital Economy in the New Development Stage"]. *Journal of Sports Research, 35*(5), 9–18.

Zhao Can (赵璨), Cao Wei (曹伟), Yao Zhenye (姚振晔), & Wang Zhuquan (王竹泉). (2020). "互联网+"有利于降低企业成本粘性吗？ *Hulianwang +" youli yu jiangdi qiye chengben nianxing ma?* ["Can 'Internet+' Blueprint Help Reduce the Stickiness of Cost of Enterprises? "]. *Journal of Finance and Economics, 46*(04), 33–47.

Zhao Chenyu (赵宸宇), Wang Wenchun (王文春), & Li Xuesong (李雪松). (2021). 数字化转型如何影响企业全要素生产率 *Shuzihua zhuanxing ruhe yingxiang qiye quan yuansu shengchanlv* ["How does Digital Transformation Influence the Total Factor Productivity of Enterprises"]. *Finance & Trade Economics, 42*(07), 114–129.

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