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The Role of Digital Economy in Enhancing the Sports Industry to Attain Sustainable Development

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Abstract: The digital economy system is an essential driving force that promotes the development of the sports industry, aligning with Sustainable Development Goals (SDGs), including Goal 9 (Industry, Innovation, and Infrastructure), Goal 8 (Decent Work and Economic Growth), and Goal 11 (Sustainable Cities and Communities). This paper aims to provide a comprehensive understanding of the roles of the digital economy in enhancing the sustainable high-quality development of the sports industry in China. This study utilizes panel data from 17 provinces in China, spanning the period from 2014 to 2020. The level of high-quality development in both China's digital economy and sports industry is calculated using the entropy method. To examine the empirical relationship between the digital economy and the sports industry's high-quality development, this study employs benchmark regression, mediation models, and spatial analysis and conducts robustness tests. The findings of this study indicate that the digital economy not only directly and significantly contributes to the development of the sports industry but also drives it indirectly through the transformative effects of technological innovation. This study reveals that the impacts of the digital economy on the sports industry's high-quality development exhibit nonlinear characteristics, with an initial period of rapid growth followed by a diminishing growth rate and spatial spillover effects. By recognizing this dynamic relationship, stakeholders could better strategize and allocate resources in their efforts to achieve SDGs. To advance the development of the sports industry and contribute to the SDGs, it is crucial to accelerate the construction of digital infrastructure in China, nurture a diverse pool of talent in sports science and technology, and develop region-specific strategies that consider sustainability and inclusivity.

Keywords: digital economy; sports industry; technology innovation; threshold effect; space spillover effect; sustainable development; China

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1. Introduction

The deep integration between the digital economy (DE) [1–7] and the sports industry (SI) [7–12] plays a crucial role in stimulating sports consumption and driving the transformation and advancement of the sporting sector. Moreover, it facilitates the enhancement of quality and efficiency in the SI, promotes the digital transformation of the SI, and acts as a "new engine" for driving China's economy toward rapidly effective development [13–15]. Consequently, there is an urgent need for systematic research to explore effective strategies that harness the potential of the DE to drive SI growth, addressing a pressing practical challenge [16,17].

Regarding enhancing SI, research primarily focuses on three aspects. First, scholars have examined the conceptual landscape of sports industry growth, reaching a consensus that it encompasses "innovation, coordination, green practices, openness, and sharing". This involves leveraging elements of innovation to boost SI growth and optimize its economic structure and efficiency. Second, efforts have been made to establish evaluation systems to measure the efficiency of the SI. Scholars have constructed evaluation index systems considering dimensions, such as power, efficiency, and quality. For instance, Wang and Man [18] developed an index to measure SI efficiency in China. Similarly, Kang and Haiyan [19] also created an index based on industrial structure, production efficiency, industrial efficiency, development impetus, industrial foundation, and industrial scale, testing its effectiveness using benchmark regression and spatial measurement models. Finally, theoretical research has analyzed the challenges and opportunities for SI growth in China. Researchers such as Ren and Dai [20] and Hua [21] have explored the issues of quality and efficiency, as well as the path to rapid growth from a global value-chain point of view.

Although scholars [22–25] have conducted extensive research on the growth of the DE and the SI, some limitations persist. Existing studies often lack representative indicators to effectively measure the rapid growth of these sectors. Furthermore, there is a lack of a unified analytical framework and relevant empirical data, potentially impacting the accuracy of research findings. The primary objective of this study is to fill the gaps in understanding the role of the DE in promoting sustainable development within China's sports industry (SI). The research is original and contributes significantly in two main aspects. First, it develops an approach for assessing DE development, encompassing dimensions, such as development carriers and the environment, digital infrastructure, and industry digitalization. This overcomes the limitations of previous research that relied on single-dimensional evaluation indices. Second, this study analyzes the intrinsic mechanisms of efficacy DE development in the SI by following a benchmark regression-mechanism test-space spillover analysis path. The empirical relationship between the DE and the development of SI is examined by employing benchmark regression, mediation models, spatial analysis, the fixed-effect model, the spatial Durbin model (SDM), and conducting robustness tests in this study. This deepens the understanding of the spatial relevance associated with DE development [22–25].

The integration between the DE and the SI, as explored in this research, aligns with several sustainable development goals (SDGs) [26]. It directly supports SDG 8 (Decent Work and Economic Growth) by driving economic development and promoting employment opportunities within the SI [27]. Additionally, it contributes to SDG 9 (Industry, Innovation, and Infrastructure) by fostering innovation and advancing technological transformations [28–31]. The research findings [32–36] also have implications for SDG 11 (Sustainable Cities and Communities), as they address the need for sustainable urban development and the promotion of inclusive and safe public spaces through the digitalization of the SI.

The paper has the following structure: literature review—analysis of the theoretical background on the link between DE and the SI to justify the research hypotheses; methodology—describing the data, instruments, and methods to check the research hypotheses; results—exploring the findings of the investigations; and conclusions—summarizing results and policy implications considering findings, limitations and further directions for investigations.

2. Literature Review

2.1. Research on the DE

There have been studies on DE from theory and demonstration. In terms of theory, scholars define the connotation of DE from different perspectives. From a broad perspective, DE is a new economic development model [37]. From a narrow point of view, DE is a new economic development model with data elements as the key information carrier to promote economic efficiency. Empirically, there have been studies focusing on measuring the development level of the DE. At the international level, the OECD and the United States proposed measurement systems for DE in 2015 and 2019, respectively. From the domestic perspective, some scholars focus on the measurement of the scale of DE and its added value [38], while others measure the DE development index from multiple dimensions, such as digital industrialization [39], the internal and external environment of DE development [40], and the integrated application of DE [41]. In summary, the above studies lack comprehensive dimensions and provincial-level measurements of DE, and coupled with differences in statistical caliber and indicator system leads to great differences in the development level of China's DE.

2.2. Research on the Development of SI

Research on the high-quality development of SI focuses on two aspects: evaluation index systems and theory. First, we consider the evaluation system for enhancing the SI. Wang Chenxi constructed a high-quality evaluation index system for China's sports industry from the perspectives of power, efficiency, and quality [18]. Kang Lu constructed the high-quality development index system of the sports industry [19] from the perspectives of industrial structure, production efficiency, industrial benefit, development power, industrial base, and industrial scale and empirically tested the validity of the index by using the methods of benchmark regression and a spatial econometric model [42]. Second, there is theoretical research on the high-quality development of the sports industry. Ren Bo analyzed the dilemma of high-quality development of China's sports industry from the perspective of quality and benefit [20]. From the perspective of the global value chain, Hua Kai analyzed the path of high-quality development in China's sports industry [21]. In general, there have been abundant studies on enhancing SI but are limited by the availability of sports industry data and the differences in the selection of indicators by different scholars; the rigor and universality of the existing evaluation index system for enhancing SI have been reduced.

2.3. Research on DE Enabling SI Development

Research on DE enabling SI development mainly focuses on the theoretical level. First, from a micro perspective, on the one hand, digital technology enables the enhancement of SI by accelerating the digital transformation process of the sporting goods manufacturing industry [43]. On the other hand, DE promotes the structural upgrading of the industrial chain and supply chain of the sports service industry to help enhance SI [44,45]. Second, from the perspective of the medium, the DE promotes the enhancement of SI through digital platforms to carry out sports digital business, transform the development mode of sports enterprises, and reshape the market structure of the sports industry [46]. Third, from a macro perspective, the DE improves the production efficiency of the sports industry through the input of new factors, thus promoting the enhancement of SI [47]. In short, the existing results provide abundant support for the development of this study but are limited by the support of empirical research; the "mechanism black box" of how the DE affects the enhancement of SI still exists.

In summary, scholars have conducted a wealth of research on the DE and enhancement of SI, but there are also certain limitations. First, the existing research lacks scientific and accurate DE and a high-quality development evaluation index system for the sports industry. Second, existing studies lack a unified analytical framework in analyzing the relationship between the DE and the enhancement of SI and lack the evidence of relevant empirical data, which may reduce the accuracy of existing research results. Third, there is a lack of research on the impact of DE on the development of the sports industry from a spatial perspective in the existing studies, and it is impossible to draw conclusions about the spatial correlation of the sports industry. Therefore, this study selects high-quality development data of DE and the sports industry in 17 provinces of China from 2014 to 2020 and uses a variety of econometric models to test the empowering effect of DE on the high-quality development of the sports industry. The innovation and marginal contribution of this study are mainly reflected in the following two aspects. First, in terms of research indicators, a relatively comprehensive index system for measuring the development level of DE is constructed from four dimensions: carrier of DE development, DE development environment, digital industrialization, and industrial digitalization, overcoming the shortcomings of single evaluation indicators and insufficient dimensions of existing studies. Second, in terms of research content, this study follows the research idea of benchmark regression, mechanism testing, threshold regression analysis and space overflow analysis, explores the mechanism of DE enabling high-quality development of the sports industry, and deepens the understanding of the spatial correlation of DE.

3. Theoretical Analysis and Research Hypothesis

3.1. Direct and Indirect Role of the DE in Enhancing SI

DE can be endowed with high growth, high technology, high diffusion, high synergy, and strong penetration by accelerating information interaction [16,46–48] to drive SI growth by innovation. First, from the perspective of cost reduction, the application of digital technology in the SI not only reduces the product design costs of sports enterprises in the research and development stage but also reduces the resource mismatch costs in the production stage [49–52]. At the same time, the service costs of various departments of sports enterprises are reduced through the rapid development of digital logistics. Second, from the perspective of creating benefits, on the one hand, the DE can encourage sports enterprises to carry out digital, information and intelligent transformation in the production stage [53] and improve the total factor productivity of sports enterprises [54] to bring higher economic benefits to the enterprises themselves [53,54]. On the other hand, the DE can promote the structural transformation of the regional SI through the demonstration effect formed by the digital platform to increase the proportion in the regional sports service industry and bring more economic benefits to the SI [16,46]. Third, from the spillover effect, digital technology in the SI in each niche application not only creates common technology sharing to create richer, higher quality sports products but also brings more sports service jobs [55–58] to promote sports employment, stimulate sports consumption, and boost SI growth.

DE promotes the enhancement of SI mainly in the following three aspects. First, thanks to the strong technical characteristics of the DE, digital infrastructure, such as long-distance optical cables and Internet communication base stations drives the transformation and updating of traditional sports industry equipment and supports the new development model of the sports industry. Second, relying on the strong penetration characteristics of the DE, through large-scale application of high-tech digital technologies, such as big data, the Internet of Things, and the Internet in the sports industry product design, manufacturing, product sales, and other links, the formation of a strong technical empowerment effect improves the production efficiency of the sports industry. Third, relying on the high diffusion characteristics of the DE, through the communication and interaction of digital elements in different locations, the limitation of the geographical location of the sports industry is broken; the timely transmission of information technology across regions is realized, and the economies-of-scale of the sports industry are promoted. Based on the above analysis, Hypothesis 1 is proposed as follows:

H1. *DE positively affects the enhancement of the SI.*

The indirect effect of the DE on the SI is mainly reflected in the enabling effect of technological innovation [55]. First, from the perspective of product innovation [46], technological innovation enables the digital meaning of traditional sports products and promotes sports enterprises to produce a higher added value and derivative value of sports products to provide an inexhaustible power for product innovation and value appreciation of sports enterprises. Second, from the form of innovation, the strong diffusion of the DE broke the boundary between sports manufacturing and sports service industries [57,59]. Thus, general technology in the sports manufacturing industry and sports services diffusion penetration promotes the integration of the sports manufacturing industry and sports service industry development to produce more value creation, value-added, and return. Third, from the perspective of a business model innovation [17], emerging business models, such as network broadcasting and e-commerce that benefit from digital technology innovation, continue to empower the sales of traditional sports services and promote the innovative development of traditional sports service sales business models. Fourth, from the perspective of the innovation environment [60,61], the demand-oriented innovation created by the DE links the industrial end, the innovation end, and the consumer end and realizes the interactive innovation of the industrial chain and value chain, thus forming a more open innovation environment. The open innovation environment accelerates the penetration and diffusion of digital technology to the physical enterprises of the SI [62] to reduce the innovation costs of enterprises, form the regional scale effect, lead to a wider range of technological innovation, and promote SI growth.

Technological innovation is the indirect mechanism of DE affecting the high-quality development of the sports industry. First, DE can effectively reduce the cost of technological innovations in the sports industry. The extensive application of new-generation digital technologies, such as artificial intelligence and big data in the sports industry, has driven the digital transformation of production elements of the sports industry, greatly improved the efficiency of the industrial chain and supply chain, and reduced the production cost of the sports industry [63]. Second, DE helps to enhance the technological innovation ability of the sports industry. The sports industry can expand its knowledge through integration, absorb the knowledge of other industries or other countries with innovative value, seek continuous breakthroughs in the technical level of its own industry, and promote research and development activities to extend to the most cutting-edge technical fields to accelerate the transformation of technological achievements. In summary, DE promotes the digital and technological transformation of the sports industry through technological innovation, forms a new format for the development of the sports industry, and enhances SI.

Based on the above analysis, Hypothesis 2 is proposed in this paper.

H2. *DE positively affects enhancing SI through technological innovation.*

3.2. Nonlinear Effect of the DE on Enhancing SI

In accordance with Metcalfe's law [64], the DE weakened the SI boundary in various fields of economic activity. There is a closer connection between different innovation subjects, which will bring about a decline in the cost of information, prompting more innovation subjects to be involved in the construction of SI development quality and leading to the development of the SI quality dynamic spillover effect of evolution. The presentation of this dynamic evolution result is not only the effect of the linkage between the innovation subjects of the SI but also the embodiment of the empowerment of the DE [65]. On the one hand, existing studies [66,67] have shown that the DE has a nonlinear feature of a marginal increase in economic development. This is because the DE not only improves the operation efficiency of the industry itself but also reduces the marginal costs between various departments [49,52]. On the other hand, Chen et al. [68] show that there is a U-shaped relationship between the development of the DE and the income gap between urban and rural residents. This indicates that the impact of the DE on the SI increases first, and then decreases in the increasing dynamic evolution trend, which is also a nonlinear feature, in essence [67]. In addition, in the early stages of the development of the DE, the investment in digital technology is huge and the return is low, which also limits SI development [49,52]. However, with the deepening of the digital transformation of SI, digital technology will improve the productivity and market competitiveness of the subindustries of SI, accelerate the pace of structural adjustment within SI, and increase the marginal income in SI. In the mature period of the DE, the digital technology infrastructure is fully developed and its role in promoting SI growth will be weakened. On the whole, the DE presents a nonlinear feature to the SI growth. Based on the above analysis, Hypothesis 3 is proposed.

H3. *The DE nonlinear effect on enhancing SI.*

3.3. Spatial Spillover Effect of the DE on Enhancing the SI

DE has the capability to reduce spatial and temporal barriers by improving the efficiency of information transmission. This, in turn, expands the scope and depth of connections between regional activities in the SI, consequently fostering SI growth [60]. A previous study [68,69] showed that the spatial spillover effect of the DE in the regional economy is mainly reflected in two aspects of the data elements and digital platforms. First, as far as data elements are concerned, data break through geographical spatial limitations due to their low cost and fast transmission characteristics, reflecting a strong geospatial spillover effect [70]. By sharing open data, the regional SI can improve the utilization rate of data elements of each subindustry near the geographical location to drive coordinated growth in the production efficiency of the regional SI. Second, in terms of digital platforms, digital platforms not only provide a collaborative allocation of data resources and information access channels for SI innovation but also provide conditions for online communication, field research, offline research, building entity platforms, innovative business models, and SI innovation ecosystems [71,72]. On this basis, Cui et al. [71] verified the spatial spillover effect of Internet development with panel data from 30 provinces and cities in China, and Yang and Jiang [72] also verified the spatial spillover effect of DE on regional total factor productivity. Therefore, while promoting the SI in this province, the DE can also have a spillover effect on enhancing the SI in other provinces through the high liquidity of data elements and the online synergistic effect of digital platforms. Based on the above analysis, Hypothesis 4 in this paper is proposed.

H4. *The DE spatial spillover effect on the enhancing SI.*

4. Materials and Methods

4.1. Model Setting

To verify whether the DE promotes the enhancement of the SI, this paper constructs the following benchmark regression model:

$$Quality_{it} = \alpha_0 + \alpha_1 Digital_{it} + \alpha_2 X_{it} + \nu_i + \delta_t + \mu_{it} \quad (1)$$

where $Quality_{it}$—the SI development in year t of province i (the explained variable); α_0—the constant item; $Digital_{it}$—the DE growth in year t; α_1, α_2—the regression coefficients; X_{it}—the control variable; ν_i—the province fixed effect of province i; ν_t—the time fixed effect of year t; and μ_{it}—the random disturbance term.

To verify whether the development of DE promotes the enhancement of the SI through technological innovation, the following intermediary effect test model is set:

$$Innovation_{it} = \beta_0 + \beta_1 Digital_{it} + \beta_2 X_{it} + \nu_i + \delta_t + \mu_{it} \quad (2)$$

$$Quality_{it} = \gamma_0 + \gamma_1 Digital_{it} + \gamma_2 Innovation_{it} + \gamma_3 X_{it} + \nu_i + \delta_t + \mu_{it} \quad (3)$$

where $Innovation_{it}$ is the technical innovation level of province i in year t.

The test procedure for the intermediary effect can be outlined as follows.

1. In the first step, we examine whether there is a positive impact of the DE on enhancing the SI. This involves testing the significance of α_1 in Equation (1).
2. In the second step, once the positive effect in Equation (1) is confirmed, this study investigates whether DE promotes the intermediary variables. This entails testing the significance of β_1 in Equation (2).
3. In the third step, after confirming the relationship in Equation (2), we include both the DE and mediation variables in the same model to examine the existence of a mediation effect. If γ_1 and γ_2 are statistically significant in Equation (3), it indicates partial mediation by the mediation variable. If γ_1 and γ_2 are not significant, it suggests complete mediation by the mediation variable. In cases where γ_2 is not significant, it implies that the mediation variable does not have a mediation conduction effect.
4. Finally, in the fourth step, we employ the Sobel test to assess the presence of a mediation effect.

To test whether DE affects SI growth with nonlinear characteristics, a threshold regression model with DE as the threshold variable is constructed based on model (1), and Hypothesis 3 is tested. The specific model is shown as follows:

$$Quality_{it} = \alpha_0 \quad +\alpha_1 Digital_{it} \times \mathrm{I}(Digital_{it} < \theta_1) + \alpha_2 Digital_{it} \times \mathrm{I}(\theta_1 < Digital_{it} < \theta_2) \\ +\alpha_3 Digital_{it} \times \mathrm{I}(Digital_{it} \geq \theta_2) + \alpha_c X_{it} + \nu_i + \delta_t + \mu_{it} \quad (4)$$

where $Digital_{it}$ is the threshold variable; θ_1 and θ_2 are different threshold values; and $\mathrm{I}(\cdot)$ is utilized to assign a value of 1 when the conditions specified within the parentheses are satisfied. Conversely, when these conditions are not met, the indicator function assigns a value of 0; $\alpha_0 \cdots \alpha_c$ is the relevant regression coefficient.

To discuss the spatial spillover effect of the DE on the enhancing SI, the spatial interaction term is introduced in Equation (1), and it is further expanded into the spatial Durbin model (SDM). The spatial correlation between the DE and the SI should be tested. If there is spatial correlation, the spatial measurement method can be used.

The interaction relationships between regions are introduced into the model by considering different spatial effects. To obtain the best fitting effect, the spatial Durbin model (SDM) is constructed. The specific formula is as follows:

$$Quality_{it} = \sigma_0 + \rho W \times Quality_{it} + \sigma_1 Digital_{it} + \sigma_2 W \times Digital_{it} + \sigma_3 X_{it} + \nu_i + \delta_t + \mu_{it} \quad (5)$$

where W is the spatial weight matrix, $W \times Quality_{it}$ is the spatial lag term of the SI growth in each province, ρ is the spatial autocorrelation coefficient, and $W \times Digital_{it}t$ is the spatial lag term of the DE in each province.

To test the stability of the empirical results, four methods are mainly used to test the robustness. First, the robustness test was performed by replacing the core explanatory variables. Second, it was tested for robustness using the quantile regression method. Third, the robustness test was performed using lag phase one and lag phase two of the core explanatory variables. Fourth, the robustness test is based on the endogeneity problem.

4.2. Variable Selection

Explained variable. The SI growth (Sh) is measured by the indicators shown in Table 1. It should be noted that all indicators are stimulators.

Table 1. Variables for assessment of the SI.

Index	Subindex
Economic Benefit	
1. Industry scale	The share of added value from SI in GDP The share of SI in GDP Total output of SI Added value of SI Sports manufacturing industry accounts for the share of SI The share of added value of sports manufacturing industry in SI
2. Finance support	Local fiscal expenditures for culture, sports and media Year-on-year growth rate of fixed asset investment in culture, sports and entertainment
3. Wage income	Total salaries of persons employed in the cultural, sports and entertainment industries in urban units Average wages of persons employed in the cultural, sports and entertainment industries in urban units Culture, sports and entertainment industry Average wage of employed persons in urban private units
Social Benefit	
4. Employment absorption	Persons employed in cultural, sports and entertainment industries in urban units Number of cultural, sports and entertainment legal persons
Harmonious Development	
5. The industrial structure is advanced	Sports service industry accounts for the proportion of SI Proportion of added value of sports service industry in added value of SI

Explanatory variable. DE development (Sc) is measured by traditional and new infrastructures, R&D investment, intellectual support, communication services, software and information technology services scale, industry digitization, and digital finance (Table 2).

Table 2. Variable for assessment of the DE.

Index	Subindex
Carrier of DE development	
1. Traditional infrastructure	Number of broadband Internet access ports Internet domain name number Cable length
2. New infrastructure	Number of cell phone base stations Mobile phone penetration Number of Internet users
DE development environment	
3. R&D Investment	R&D personnel of industrial enterprises above designated size are equivalent to full-time equivalent R&D expenditure of industrial enterprises above designated size Number of R&D projects (projects) of industrial enterprises above designated size
4. Intellectual support	Number of institutions of higher learning Number of students enrolled in regular institutions of higher learning Number of employees in information service industry
Digital industrialization	
5. Communication service	Online mobile payment level
6. Software and information technology services scale	Software revenue Output value of information service industry Telecommunication traffic volume Total amount of technical contract transactions
Industry digitization	
7. Digital finance	Coverage of digital finance Depth of use of digital finance Digital finance digitization degree

The development of China's DE and SI is calculated by the entropy method [73,74].

Metavariable. Technological innovation (Inn) plays an important role in mediating the relationship between DE and SI growth [16,47,49]. Scholars [65,68] express technological innovations according to the number of patent applications or patent grants in each province, and some scholars [62,75] measure technological innovation by the full-time equivalent of R&D personnel. Considering data availability, this paper uses provincial R&D expenditure as an alternative indicator for technological innovation.

Controlled variables are added to the regression model to improve the accuracy of the SI growth on the regression of the DE. This paper sets the following six control variables: population density (Per, measured by the total population at the end of the year divided by the regional area); infrastructure (Inf, measured by expressed by highway mileage; degree of government intervention (Gov, divided by regional GDP in the general budget of local finance); economic openness (Ope, measured by the ratio of the total import and export of each province and the GDP of the region); economic development level (GDP, the ratio of regional GDP to the total regional population); and employment density (Emp, measured by the number of employed persons divided by the administrative area).

4.3. Data Sources and Descriptive Statistics

Data from 17 provinces in China (Beijing, Tianjin, Hebei, Inner Mongolia, Liaoning, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Shandong, Henan, Hunan, Guangdong, Chongqing, Sichuan and Guizhou) were selected for the years 2014–2020. Based on the availability of sports industry data, the statistical data system of China's sports industry is still in the process of improvement at this stage. Therefore, sports industry data can only be collected from the websites of sports bureaus and statistics bureaus of the 17 provinces and cities.

The data are processed as follows: first, the true data are interpolated or compared; second, the proportion of some indicators is calculated on the basis of the original indicators. Digital economic indicators mainly come from the EPS database, China's economic and social big data research platform, China Statistical Yearbook, China Education Statistical Yearbook, China Science and Technology Statistical Yearbook, China Population and Employment Statistical Yearbook, and Digital Inclusive Finance Index of Peking University.

The data indicators of SI development are obtained from the official websites of provincial sports bureaus and statistics bureaus, statistical yearbooks of provinces, conference minutes, the official website of Australia Star and the "12th Five-Year Plan" and "13th Five-Year Plan" of provincial sports. Table 3 shows the descriptive statistical results for the core variables.

Table 3. Descriptive statistical results.

Variable	Mean	Sta	Min	Max	VIF
Sh	0.263	0.107	0.099	0.585	5.15
Sc	0.240	0.149	0.023	0.806	2.40
Inn	6.474	1. 030	4.016	8.155	3.45
Per	8.501	0.607	7.232	9.443	4.57
Inf	11.718	0.975	9.466	12.885	1.05
Gov	0.204	0.057	0.119	0.382	2.87
Ope	0.349	0.297	0.027	1.215	2.57
Gdp	1.546	0.998	0.589	4.712	1.25
Emp	0.041	0.048	0.001	0.217	3.36

The results show that the average value of SI development is 0.263, the maximum value is 0.585 and the minimum value is 0.099; the average value of DE development is 0.240, the maximum value is 0.806, and the minimum value is 0.023. At the interprovincial level, the results are consistent with the national conditions of the unbalanced development of China. The average VIF value is 2.96, the VIF value is less than 5, and the VIF value of a single variable is less than 10, indicating that there is no multicollinearity between variables.

5. Results

The findings in Table 4 confirm that the DE has a direct effect on the enhancement of the provincial SI.

Among them, the estimation coefficient of the DE listed from (1) to (3) on enhancing the provincial SI is significantly positive. This indicates that DE promotes SI development at the provincial level. Columns (4) to (6) are the regression results of the addition of time and province fixed effects and control variables. Column (6) shows that the influence coefficient of DE on enhancing the SI is 0.460 and passes the significance test (at the 1% level). This shows that the DE significantly affects the enhancing SI. At the same time, there is an insignificant negative correlation between Per and Ope and SI development. This confirms that while improving the level of urbanization and expansion, the development of the SI has not been effectively improved. Infrastructure is negatively associated with enhancing the SI and passed the significance test at the level of 10%. This shows that the increase in highway mileage in each province did not affect the enhancement of the SI. The government intervention degree, GDP and Emp are positive, but none of them pass the significance test at the 10% level. These results prove that with the increase in government participation, the improvement in economic growth and the increase in the employed population, the development quality of the provincial SI has not been effectively improved. The above empirical results support Hypothesis 1.

Table 4. The direct effect of the DE on enhancing the SI.

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Sc	0.635 *** (0.030)	0.617 *** (0.039)	0.558 *** (0.049)	0.568 *** (0.058)	0.465 *** (0.080)	0.460 *** (0.078)
Per		−0.025 (0.015)	−0.030 (0.020)		0.120 (0.193)	−0.052 (0.198)
Inf		−0.006 (0.008)	0.013 (0.018)		−0.207 ** (0.0545)	−0.176 * (0.053)
Gov		−0.392 *** (0.089)	−0.390 *** (0.095)		0.022 (0.103)	0.118 (0.133)
Ope			0.045 (0.031)			−0.054 (0.042)
Gdp			0.011 (0.011)			0.011 (0.022)
Emp			−0.086 (0.189)			1.913 (0.963)
constant	0.110 *** (0.087)	0.489 *** (0.075)	0.293 * (0.143)	0.161 *** (0.011)	1.178 (1.414)	1.817 (1.394)
fixed time	NO	NO	NO	YES	YES	YES
Provincial fixation	NO	NO	NO	YES	YES	YES
sample size	119	119	119	119	119	119
Adj-R^2	0.782	0.831	0.833	0.967	0.971	0.973

Note: ***, ** and * indicate that the regression coefficients are significant at 1%, 5% and 10% significance levels, respectively, with standard error in parentheses.

The findings in Table 5, column (2), indicate a strong and statistically significant positive association between the DE and the mediation variables. This significance is observed at the 1% level.

Table 5. Indirect effects of the DE on the enhancing SI.

Variable	Sh	Inn	Sh
Sc	0.558 *** (0.049)	2.875 *** (0.286)	0.691 *** (0.066)
Inn			0.046 ** (0.159)
con	YES	YES	YES
constant	0.293 * (0.143)	4.090 *** (1.434)	0.481 ** (0.152)
fixed time	YES	YES	YES
Provincial fixation	YES	YES	YES
sample size	119	119	119
Adj-R^2	0.833	0.921	0.844
Ind_eff test	−1.48	0.003	[−0.110, −0.015]
Dir-eff test	0.51	0.000	[0.029, 0.091]
Sobel test	0.132 *** (0.0474)		
Goodman-1 (Aroian)	0.132 *** (0.048)		
Mediating effect coefficient	0.132 *** (0.047)		
Direct effect coefficient	0.691 *** (0.66)		
Proportion of mediating effect to total effect	0.237		

Note: ***, ** and * indicate that the regression coefficients are significant at 1%, 5% and 10% significance levels, respectively, with standard error in parentheses.

Based on the benchmark regression model, the regression results after adding intermediary variables are shown in column (3) of Table 5. The promotional effect of digital economic and intermediary variables on enhancing the interprovincial SI is still significant at the 1% level. Compared with the benchmark regression model, the results of the model after adding intermediary variables show that the influence coefficient of DE on enhancing the interprovincial SI has been improved, indicating that technological innovation is an important intermediary variable for DE to promote the interprovincial SI. The empirical results support Hypothesis 2. A bootstrap test was further conducted to verify the mediating role of technological innovation in promoting the enhancement of SI in DE. As shown in Table 5, the indirect and direct effects of technological innovation are significant, indicating that the effects of technological innovations play a partial mediating role in the process of promoting the enhancement of SI in DE. To further explain the proportion of the partial mediating role of technological innovation, the Sobel test is used. As shown in Table 5 the Sobel test significantly rejects the hypothesis that there is no intermediary effect in the model. The indirect effect of DE on improving the high-quality development of the interprovincial sports industry through technological innovation is 0.132, accounting for 23.7% of the total effect. As shown in Table 5, the Sobel test significantly rejected the hypothesis that there is no mediation effect in the model. The indirect effect of DE on improving interprovincial SI development through technological innovation was 0.132, accounting for 23.7% of the total effect.

To further explore whether there is a nonlinear feature in the promoting effect of the DE on the enhancing SI, this paper first refers to the practice of Hansen and tests the existence of a panel threshold on the basis of 1000 repeated samplings using the "self-help method" (bootsrap). Considering the findings in Table 6, the digital economic threshold variables passed the double threshold test and were significant at the 5% level, and the threshold values were 0.119 and 0.177, respectively, which did not pass the triple threshold test.

Table 6. The findings of the threshold effect test for DE development.

Threshold Model	Threshold Value	F Value	*p* Value	Critical Values of Different Significance Levels		
				10%	5%	1%
Single threshold	0.119	25.610	0.028	19.903	22.944	30.431
Double threshold	0.177	22.730	0.035	17.878	21.568	27.415
Triple threshold	0.281	12.980	0.398	30.4231	36.4082	51.429

The findings show that the DE has a threshold effect on enhancing SI. This means there is a nonlinear influence relationship between the analyzed variables. The regression results of the DE on SI development after adding the panel threshold model are shown in Table 7.

Table 7. The empirical results of the threshold regression.

Variable	Coefficient	SE	t Value	*p* Value
Per	−0.542	0.168	−3.220	0.002
Inf	0.020	0.041	0.490	0.623
Gov	0.310	0.123	2.530	0.013
Ope	−0.008	0.033	−0.250	−0.730
Gdp	0.048	0.021	2.310	0.023
Emp	1.225	0.862	1.420	0.159
$Sc \leq 0.119$	0.736	0.041	17.150	0.000
$0.119 < Sc \leq 0.177$	0.791	0.048	16.430	0.000
$Sc > 0.177$	0.538	0.045	11.900	0.000
constant	4.380	1.414	3.100	0.003
sample size		119		
fixed time		YES		
Provincial fixation		YES		
Adj-R^2		0.899		

The results presented in Table 7 demonstrate that the impact of the DE on the enhancement of the SI exhibits distinct nonlinear characteristics. Specifically, when DE is below 0.119, the coefficient for DE is 0.736, showing statistical significance at the 1% level. As the DE grows and reaches a range between 0.119 and 0.177, the development level of the DE increases to 0.791, still maintaining significance at 1%. However, when the DE surpasses 0.177, the development level of the DE decreases to 0.538, yet it remains significant at the 1% level. These findings indicate that the relationship between DE growth and SI development follows an inverted U-shaped curve, where it first increases and then decreases. This pattern reflects the nonlinear influence of DE development on the SI and confirms the validity of Hypothesis 3.

Table 8 presents the results obtained from employing Moran's I index to calculate the spatial effect of DE on SI in China between 2014 and 2020.

Table 8. Global Moran's I index.

Year	Adjacent Space Matrix				Economic Spatial Matrix				Economic Geography Nested Matrix			
	Sh		Sc		Sh		Sc		Sh		Sc	
	I	Z	I	Z	I	Z	I	Z	I	Z	I	Z
2014	0.205 **	1.409	0.157 **	1.578	0.312 **	2.315	0.295 **	1.231	0.133 **	1.275	0.276 **	1.263
2015	0.267 **	1.738	0.241 **	1.984	0.357 ***	2.605	0.363 **	2.524	0.203 **	1.732	0.254 **	1.649
2016	0.329 **	2.071	0.379 **	2.566	0.427 ***	3.045	0.467 ***	3.119	0.253 **	2.065	0.335 **	2.172
2017	0.389 **	2.394	0.396 **	2.798	0.456 ***	3.239	0.479 ***	3.140	0.287 **	2.296	0.361 **	2.465
2018	0.366 **	2.292	0.421 **	3.107	0.434 ***	3.129	0.547 **	3.883	0.262 **	2.149	0.389 **	2.781
2019	0.349 **	2.211	0.457 **	3.201	0.424 ***	3.072	0.575 **	4.126	0.242 **	2.027	0.414 **	3.121
2020	0.340 **	2.131	0.342 **	2.99	0.390 ***	2.818	0.495 ***	3.535	0.228 **	1.904	0.421 **	3.356

Note: *** and ** indicate that the regression coefficients are significant at 1% and 5% significance levels, respectively, with the standard error in parentheses, I—Moran's I, Z—Z value.

Across all types of spatial matrices, including economic space, adjacent spatial, and economic geography nested matrices, Moran's I index reveals a statistically significant spatial agglomeration for the development of the DE and the SI in China from 2014 to 2020, reaching a 5% significance level. These findings are presented in Table 8.

To delve deeper into the spatial correlation of individual provinces, the local Moran index was calculated for both the DE and the SI. The results of these calculations can be found in Tables 9 and 10.

Table 9. Index distribution of the local Moran index for the SI.

Quadrant	Spatial Correlation Model	Area	Quantity
One	H-H gather	Fujian, Guangdong, Zhejiang, Shanghai, Jiangsu	5
Two	L-H gather	Inner Mongolia, Tianjin	2
Three	L-L gather	Liaoning, Guizhou, Chongqing, Anhui, Hunan, Henan, Hebei, Sichuan	8
Four	H-L gather	Beijing, Shandong	2

Table 10. Moreland Index distribution of the DE Bureau.

Quadrant	Spatial Correlation Model	Area	Quantity
One	H-H gather	Fujian, Guangdong, Zhejiang, Shanghai, Jiangsu	5
Two	L-H gather	Inner Mongolia, Tianjin, Anhui	3
Three	L-L gather	Liaoning, Guizhou, Chongqing, Hunan, Hebei, Henan	6
Four	H-L gather	Beijing, Shandong, Sichuan	3

Observing Table 9 reveals that the majority of points corresponding to the Moran index for the DE and SI among provinces are located in the first and third quadrants. This pattern indicates a robust spatial correlation between the variables in local areas, aligning with the findings of the global Moran index. Consequently, the significant presence of local spatial positive correlation underscores the importance of considering spatial factors and selecting an appropriate spatial measurement model. The spatial autocorrelation test establishes a significant correlation between the development of the SI and the DE. To achieve more accurate regression results, it is crucial to determine the specific form of the spatial econometric model through a series of tests prior to analyzing the model.

Based on the results presented in Table 11, the null hypothesis is rejected for all four LM tests. This outcome indicates that the selected samples exhibit both spatial lag and spatial error autocorrelation effects, which are encompassed in the general form of the spatial measurement model. Consequently, selecting the spatial Durbin model is a reasonable choice.

Table 11. The empirical results for the LM test.

LM Test	LM Value	*p* Value
LM-error	0.198	0.016
Robust LM-error	4.701	0.030
LM-lag	38.029	0.000
Robust LM-lag	42.532	0.000

The results in Table 12 reject the null hypothesis of the SDM and SEM and accept the SDM.

Table 12. The empirical results for the Wald test.

Wald Test	LM Value	*p* Value
SEM	56.12	0.000
SAR	55.69	0.000

Hausman tests were conducted to choose a fixed effect or a random effect. Table 13 results show a value of 126.66 and passed the 1% significance test, indicating that the SDM model should be analyzed with fixed effects.

Table 13. The findings of the regression results for the analyzed models SAR, SEM and SDM.

Variable	(1) SAR	(2) SEM	(3) SDM
Sc	0.486 *** (7.33)	0.568 *** (5.87)	0.799 *** (9.753)
Per	−0.147 (−0.87)	−0.115 (−0.64)	−0.507 *** (−2.950)
Inf	−0.139 *** (−2.96)	−0.165 *** (−3.63)	−0.022 (−0.489)
Gov	0.113 (1.02)	0.185 * (1.65)	0.076 (0.744)
Ope	−0.038 (−1.06)	−0.062 * (−1.87)	−0.038 (−1.101)
Gdp	0.014 (0.78)	0.006 (0.32)	−0.001 (−0.033)
Emp	1.968 ** (2.46)	2.493 *** (3.01)	2.809 *** (3.720)
W × Sc			0.854 *** (4.819)
W × Per			−0.754 * (−1.918)
W × Inf			−0.037 (−0.343)
W × Gov			1.009 *** (3.169)

Table 13. *Cont.*

Variable	(1) SAR	(2) SEM	(3) SDM
W × Ope			0.016 (0.301)
W × Gdp			0.053 (1.213)
W × Emp			1.760 (0.818)
Adj-R^2	0.846	0.852	0.924
Log-L	332.533	332.411	356.590
σ^2	0.0003 *** (7.87)	0.0004 *** (7.40)	0.0002 *** (7.45)
Hausman			126.66 ***
LR test	48.11 ***	48.36 ***	
N	119	119	119

Note: ***, ** and * indicate that the regression coefficients are significant at 1%, 5% and 10% significance levels, respectively, with standard error in parentheses.

To investigate the impacts of the DE on the enhancement of the SI, it is recommended to employ the fixed-effect model. The regression results presented in Table 13 indicate that the SDM exhibits a goodness of fit of 0.924, and the Log-L values surpass those of the other models. According to the SDM, the coefficient for the DE is 0.779, and the hypothesis test reveals a significance level of 1%. This implies that provinces with higher levels of DE experience greater development in the SI. Additionally, the coefficient for the spatial interaction term of DE in the SDM model, $W \times Sc$, is significantly positive. This suggests that the DE of a province has a positive and significant spillover effect on the development of the SI in both the province itself and neighboring provinces. These findings provide confirmation of Hypothesis 4.

Since the spatial Durbin model solely explains the spatial economic correlation between provinces, the parameter estimation results do not directly reflect the direct effect, spatial spillover effect, and actual effect. Considering the study [76], this paper utilizes the partial differential method to decompose the coefficient of SI development into direct effects, indirect effects, and total effects. As demonstrated in Table 14, the direct effect, indirect effect, and total effect coefficients for the DE are all positively significant at the 1% level.

Table 14. The empirical results of spatial effect decomposition.

Variable	Direct Effect	Indirect Effect	Gross Effect
Sc	0.763 *** (9.728)	0.560 *** (3.609)	1.323 *** (6.432)
Per	−0.480 *** (−2.815)	−0.522 (−1.498)	−1.002 ** (−2.421)
Inf	−0.014 (−0.307)	−0.027 (−0.284)	−0.040 (−0.440)
Gov	0.011 (0.097)	0.865 *** (3.116)	0.876 *** (3.372)
Ope	−0.040 (−1.131)	0.024 (0.504)	−0.016 (−0.328)
Gdp	−0.004 (−0.230)	0.047 (1.274)	0.043 (1.090)
Emp	2.746 *** (3.199)	0.938 (0.492)	3.684 ** (2.178)

Note: *** and ** indicate that the regression coefficients are significant at 1% and 5% significance levels, respectively.

The results of the robustness test are shown in Table 15. To test the stability of the empirical results in this paper, four methods are used to test the robustness. First, a robustness test is performed by replacing core explanatory variables. Second, quantile regression is used to test robustness. Third, the robustness of the core explanatory variables is tested by the lag phase. Fourth, the robustness test is based on the endogeneity problem.

Table 15. Empirical results of the robustness test.

Variable	**(1) Replace Sc**	**(2) Sc 25%**	**(3) Sc 50%**	**(4) Sc 75%**	**(5) Lag-one-sc**	**(6) Lag-two-sc**	**(7) 2SLS**
new_ Sc	0.272 ***						
	(0.023)						
Sc		0.451 **	0.670 **	0.640 ***	0.511 ***	0.551 ***	0.555 ***
		(0.184)	(0.181)	(0.205)	(0.092)	(0.104)	(0.137)
constant	−2.491	1.147	3.279	3.743	1.769	0.707	2.844
	(1.404)	(2.300)	(2.219)	(2.699)	(1.517)	(1.630)	(1.481)
control variable	YES	YES	YES	YES	YES	YES	YES
control variable	NO	YES	YES	YES	YES	YES	YES
control variable	YES	YES	YES	YES	YES	YES	YES
sample size	119	119	119	119	119	119	119
Adj-R^2	0.961	0.968	0.881	0.890	0.980	0.987	0.986

Note: *** and ** indicate that the regression coefficients are significant at 1% and 5% significance levels, respectively.

The core explanatory variable of this paper is the level of DE development at the provincial level. The DE evaluation index and the robustness test are conducted as a proxy variable to measure the development degree of China's DE, and the results are listed in column (1) of chronology 15. The promotional effect of DE on the enhancement of SI is significant at the 1% level, which is consistent with the empirical conclusions above.

To explore the impact of DE on the enhancement of SI, regression was carried out with three subpoints at 25%, 50%, and 75%, and the results are shown in columns (2), (3) and (4) of Table 15. It can be seen from Table 15 that, from the perspective of coefficient significance, the DE is significant at the 5% level regardless of the 25th, 50th, and 75th marks, which proves that the baseline regression is robust. Furthermore, it can be seen from columns (2), (3), and (4) of Table 15 that the marginal impact of DE on the enhancement of SI is 0.451, 0.670, and 0.640, respectively, indicating that the promotion effect of DE on the enhancement of SI shows a trend of first increasing, and then decreasing.

The endogeneity test results are shown in Table 16. On the one hand, the DE can promote the enhancement of SI; on the other hand, the enhancement of SI can also promote the development of the DE. Therefore, there may be endogeneity problems caused by two-way causality in the model. In addition, there may be missing variables in the model, which may bias the results. Therefore, this paper draws on Huang Qunhui's practice [77] and selects the number of landline telephones per 100 people at the provincial level in 1984 as the instrumental variable. On the one hand, the historical telecommunications foundation will affect the early access and popularization of the local Internet, and then affect the level of digital technology. On the other hand, compared with the rapid development of current digital technology, the impact of traditional fixed telephones on the upgrading of industrial structures is gradually diminishing and can be ignored. Considering that the number of fixed telephones selected is a cross-section data and panel analysis cannot be carried out, this paper, referring to the processing method of Nunn and Qian [78], introduces the number of Internet users in China in the previous year and forms an interaction term with the number of fixed telephones per million people in 1984 as the final instrumental variable. The results are shown in Table 16(1)–(3). The coefficient symbols and significance of the benchmark regression model, the intermediary effect model, and the spatial econometric model have not changed significantly, which proves that the research conclusions in this paper are credible.

Table 16. Results of endogeneity test.

Variable	(1) Reference Model	(2) Mediator Model	(3) Spatial Model
Sc	0.811 ***	0.954 ***	0.353 ***
	(16.59)	(11.55)	(2.839)
Inn		0.061 ***	
		(−3.13)	
Per	−0.739 ***	−0.683 ***	0.770 ***
	(−4.08)	(−3.43)	(5.003)
Inf	−0.136 ***	−0.038	−0.356 ***
	(−3.34)	(−0.77)	(−7.307)
Gov	−0.061	−0.105	0.269 **
	(−0.47)	(−0.73)	(2.142)
Ope	−0.001	0.019	−0.049
	(−0.03)	(0.47)	(−1.096)
Gdp	−0.002	0.018	0.019
	(−0.09)	(0.69)	(0.969)
Emp	3.361 ***	3.465 ***	1.230
	(3.96)	(3.48)	(1.372)
W× sc			0.546 ***
			(2.806)
W × per			1.633 ***
			(2.646)
W × inf			−0.171
			(−1.215)
W × gov			1.187 ***
			(4.308)
W × ope			0.086
			(0.602)
W × gdp			−0.027
			(−0.405)
W × emp			0.955
			(0.254)
Stage one F number			22.617
Adj-R^2	0.974	0.970	0.570
σ^2			0.000 ***
			(7.712)
N	119	119	119
Kleibergen–Paap rk	16.91	17.35	
LM	[0.000]	[0.000]	
Kleibergen–Paap rk	51.96	29.07	
Wald F	{16.38}	{16.38}	
Cons	6.893 ***	5.788 ***	
	(4.76)	(4.04)	
Fixed time	YES	YES	
Provincial fixation	YES	YES	

Note: *** and ** indicate that the regression coefficients are significant at 1% and 5% significance levels, respectively.

The findings of the robustness test confirm the stability of the empirical results obtained above.

6. Discussion

The findings of this study regarding the role of DE in enhancing sustainable development in the sports industry align with previous investigations in the field [11,15]. Our research confirms that the integration of digital technology into the sports industry's development process plays a pivotal role in advancing sustainable development, consistent with prior studies. This alignment underscores the significance of the DE's impact on sustainable development outcomes in the sports sector.

Comparative analysis with previous studies further strengthens the importance of considering the implications of DE for sustainable development in the sports industry. Scholars have emphasized the relationship between DE and sustainable development [5,13,64], indicating that these two aspects are intrinsically linked. It is essential for policymakers and industry stakeholders to recognize the interplay between DE and sustainable development when formulating strategies and policies for the sports industry's growth. This study highlights the critical need to consider the multifaceted dimensions of the DE's impact on sustainable development in the sports industry. Scholars have also echoed this sentiment [9,14,23,24], emphasizing the complex nature of this relationship. The realization of sustainable development goals within the sports industry requires a comprehensive approach that takes into account various factors influenced by the DE. Policymakers should prioritize and tailor strategies that leverage the full potential of the DE while addressing specific challenges and opportunities in the sports sector.

The empirical results show a positive association between DE and sustainable development in the sports industry, corroborating previous research [18,45,49]. This study indicates that the DE directly promotes economic growth and job opportunities within the sports sector, aligning with Sustainable Development Goal 8. Moreover, it indirectly stimulates the sports industry through technological innovation, supporting Sustainable Development Goal 9. These results underscore the importance of harnessing the potential of the DE to advance sustainable development goals within the sports sector. However, it is essential to recognize that the integration of the DE and sustainable development is not without challenges. Considering the studies [67,74], this study echoes the need to address potential hurdles and limitations associated with digital technology adoption in the sports industry. Scholars [9,14,23] have outlined the importance of comprehensive strategies and policies that proactively tackle these challenges while maximizing the benefits of digital technologies in achieving sustainable development goals within the sports sector. This study significantly contributes to the existing knowledge on the role of DE in enhancing sustainable development in the sports industry. Insights from this study, coupled with the findings of past research [5,13,62], provide a robust foundation for policymakers and practitioners involved in shaping policies and strategies for sustainable development in the sports sector. By considering the implications of the DE and drawing from collective knowledge in this field, stakeholders can make informed decisions and implement effective measures that promote sustainable development in the sports industry. This interdisciplinary understanding will be crucial in guiding the sports industry toward a more sustainable and prosperous future.

7. Conclusions

In the era of DE, the integration of digital technology into the SI development process has led to the emergence of a new model for China's SI, aligning with Sustainable Development Goal 9 (Industry, Innovation, and Infrastructure) and Sustainable Development Goal 8 (Decent Work and Economic Growth). Based on panel data from 17 provinces spanning 2014 to 2020, the research findings reveal that DE directly promotes SI, contributing to Sustainable Development Goal 8 by fostering economic growth and job opportunities within the sports sector. Moreover, it indirectly stimulates the SI through technological innovations, with an intermediary effect of 23.7%, thus supporting Sustainable Development Goal 9 by promoting innovation and advancements in industry and infrastructure.

Additionally, the impact of digital economic development on the enhancement of the SI exhibits a nonlinear pattern of initial growth followed by a decrease, which necessitates continuous efforts to maintain progress and aligns with Sustainable Development Goal 9, Target 9.2, to promote inclusive and sustainable industrialization and foster innovation. Furthermore, the DE's significant spatial spillover effects on the SI in neighboring provinces underscores the importance of regional cooperation and partnerships to achieve Sustainable Development Goal 11 (Sustainable Cities and Communities) and Sustainable Development Goal 17 (Partnerships for the Goals). By fostering regional collaboration and digital integration, provinces can collectively enhance their SI while working toward more sustainable and inclusive communities.

Considering the conclusions of this study, the following policy suggestions are proposed, which are in line with various Sustainable Development Goals:

1. Accelerate the construction of a digital China and foster deep integration between the DE and the SI. This approach supports Sustainable Development Goal 9, Target 9.3, by increasing access to information and communication technologies and promoting innovation. Additionally, it aligns with Sustainable Development Goal 8, Target 8.2, by promoting sustained and inclusive economic growth, as well as Target 8.5, by encouraging entrepreneurship, creativity, and technological innovation within the sports sector.
2. Increase investment in education and technological innovation to nurture multitalented sports science and technology professionals, thereby supporting Sustainable Development Goal 4 (Quality Education) and Sustainable Development Goal 9, Target 9.5, which emphasizes enhancing scientific research, upgrading the technological capabilities of industrial sectors, and encouraging innovation.
3. Formulate regional differentiated development strategies to promote coordinated SI growth in the eastern, central, and western regions. This approach aligns with Sustainable Development Goal 11, Target 11.3, by enhancing the capacity for sustainable urbanization and integrated policies for sustainable resource management. Moreover, it supports Sustainable Development Goal 17 by fostering partnerships and collaborative efforts among provinces to achieve common sustainable development objectives.

Despite the valuable findings, this study has a few limitations that should be incorporated into further investigations. Thus, it is important to extend the object of this investigation by adding other Asian and European countries. It allows us to generalize the recommendation for boosting the sports industry. In addition, considering prior studies [25–29,56,79], the healthcare system and SI are closely related to each other, which should be considered in future research.

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