



Research article

Research on the impact of green finance on the high quality development of the sports industry based on statistical models

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Abstract: The significant impact of high levels of green finance penetration on the development of the sports industry is evident, contributing to its comprehensive and high-quality growth across multiple dimensions. After analyzing the current state of the sports industry in China, data from 31 provincial-level administrative regions between 2008 and 2021 were carefully selected. An evaluation index system was established to assess the development of green finance and the high-quality development of the sports industry. The entropy method was applied to measure the levels of green finance and the quality of sports industry development in different regions. Empirical research demonstrates a statistically significant and positive relationship between green finance and the high-quality development of the sports industry, reaching a significance level of 1%. Nonetheless, there are still several challenges and areas for improvement within the realm of green finance and the sports industry's high-quality development. To propel the sports industry's growth under the umbrella of green finance, efforts should be focused on expediting the enhancement and construction of green finance, utilizing it effectively to empower the sports industry, staying attuned to the trends and dynamics of green finance development, as well as fostering a congenial environment for its further advancement.

Keywords: China interprovincial; green finance; sports industry; high quality development

Mathematics Subject Classification: 60K40, 62P05

1. Introduction

The sports industry has emerged as a significant growth driver within national economies, offering comprehensive development effects encompassing social, economic and ecological domains. In September 2019, the “Opinions on Promoting National Fitness and Sports Consumption to Promote the High-quality Development of the Sports Industry” [1] were issued by the General Office of the State Council of China, setting the strategic direction for the industry’s high-quality development at the policy level. Notably, data from the General Administration of Sports of China reveals an impressive growth trajectory, with the total scale of the sports industry increasing more than doubled between 2015 and 2019, surpassing the annual GDP growth rate of 1.14% during the same period. As a result, the industry’s added value has exceeded one trillion yuan, accounting for more than 1% of the nation's GDP, signifying the increasing significance of the sports industry within the national economy. Recognizing the imperative of bolstering financial support for sports industry development and fostering a deep integration of the sports and finance sectors, Fumin Liu, deputy director of the State Sports General Administration, emphasizes the fundamental role of these efforts in enhancing industry quality, efficiency and sustained rapid growth, ultimately contributing to the establishment of a sporting powerhouse and a healthier China [2].

China’s sports industry exhibits distinctive characteristics such as a large sports population, numerous investment channels, strong financial support and far-reaching social effects. However, with the diversification of sports industry models and the gradual reduction of government financial backing, traditional financing models are no longer adequate to meet the high-quality development requirements of the modern sports industry. In this context, green finance, an emerging field within the contemporary financial system, has garnered increasing attention from investors due to its exceptional features, including ecological sustainability and environmentally friendly resources. Given the imperative of conducting sustainable sports events over extended periods, it becomes crucial to leverage emerging technologies to promote green finance and drive the high-quality development of the sports industry. Nevertheless, the sports industry supported by green finance encounters several structural challenges. These include the difficulty in implementing green innovation within sports industry projects and the relatively low degree of compliance with existing green financial regulations [3]. Moreover, the actual promotion and application of green finance remain limited, posing challenges for relevant sports enterprises and investment institutions to effectively utilize standardized financial tools. Consequently, urgent research efforts are required to explore the mechanisms by which green finance can facilitate the high-quality development of the sports industry and identify effective pathways to leverage its potential.

The relationship between finance and the high-quality development of the sports industry has been extensively studied by scholars, focusing on two main aspects: theoretical research and the mutual influence between the two. At the theoretical level, Hou [4] demonstrated the positive impact of green finance on resource allocation efficiency, thereby facilitating the structural upgrading of the sports industry. Ma [5] utilized logical analysis to establish the necessity of stable and sustainable financial support for the high-quality development of the sports industry, emphasizing the role of green finance in promoting innovation and growth within the industry. Examining both the supply and demand sides, Chen [6] and colleagues elucidated the optimization path and financial support mechanisms for the sports industry in the context of the new development pattern, highlighting green finance as an endogenous driving force for innovation. Chen et al. [7] investigated the influence of digital inclusive finance on the sports industry, particularly regarding the living standards of rural Chinese residents. Their findings confirmed that leveraging the advantages of green financial tools, such as digitization

and precision, can enhance residents' consumption structure and foster positive development in the sports industry. Liu et al. [8] demonstrated that green finance has the potential to enhance digital transformation and sustainable development in the sports industry, alleviate financial challenges and inject new momentum into high-quality development.

While abundant research exists on the topic, there are still certain limitations. Most studies focus solely on the benefits of green finance in the sports industry without delving into the underlying mechanisms between the two. Moreover, few analyses explore the application of green finance in the sports industry across different regions, making it difficult to explain regional disparities. To address these gaps, this study utilizes panel data from 31 provinces spanning the years 2008 to 2021, employing fixed effect and random effect models. The objective is to investigate the impact mechanism of green finance on the high-quality development of the sports industry, thus providing a theoretical foundation for relevant policy formulation and implementation.

2. Theoretical analysis

Green finance encompasses four main aspects: digital green credit, green investment, green funds and green insurance. Building upon this framework, this paper investigates the relationship between green finance and the high-quality development of the sports industry. It further explores how green finance can facilitate the advancement of the sports industry from the following perspectives.

2.1. Green credit and the sports industry

Green credit refers to financial instruments and mechanisms designed to support environmentally friendly and sustainable projects. On the other hand, the sports industry encompasses various sports-related activities, including sustainable infrastructure, energy efficiency, renewable energy, sustainable event management, sponsorship, and marketing, among others. Green credits offer financial support and incentives to sports organizations, aiding them in achieving sustainable development goals. This, in turn, leads to a reduction in environmental impact, enhancement of brand value and long-term cost savings [9]. Simultaneously, the influence and visibility of the sports industry contribute to raising public awareness and promoting sustainable practices, thereby expanding the reach and impact of green credit initiatives. Based on the aforementioned analysis, the following hypothesis is proposed:

Hypothesis 1: Green credit has a positive impact on the high-quality development of the sports industry.

2.2. Green investment and the sports industry

Green investments exert a profound influence on the sports industry by supporting sustainable infrastructure, promoting renewable energy adoption, facilitating sustainable event management, fostering technological innovation and enhancing branding and public engagement. By allocating financial resources toward environmental initiatives, the sports industry assumes a pivotal role in addressing climate change, reducing environmental impact and promoting sustainable development to a broad audience. Based on the above analysis [10], the following hypothesis is proposed:

Hypothesis 2: Green investment has a positive impact on the high-quality development of the sports industry.

2.3. Green funds and the sports industry

Green funds contribute positively to the sports industry by providing financial resources for sustainable sports infrastructure, endorsing eco-friendly operations, supporting sustainable events, driving innovation, enhancing brand value and fostering sustainability awareness. By combining financial investment with environmental and social considerations, green funds facilitate the transition of the sports industry towards a more sustainable and responsible future. Based on the above analysis [11], the following hypothesis is proposed:

Hypothesis 3: Green funds have a positive impact on the high-quality development of the sports industry.

2.4. Green insurance and the sports industry

Green insurance encompasses risk mitigation for sustainable infrastructure, climate change and natural disaster defense, carbon liability insurance, environmental liability insurance and the promotion of sustainability reports, among other elements. Green insurance provides the sports industry with risk mitigation, financial protection and incentives to adopt sustainable infrastructure, mitigate environmental risks and promote eco-friendly practices. By integrating insurance products with environmental considerations, green insurance supports the transition to a more sustainable and resilient sports industry. Based on the above analysis [12], the following hypothesis is proposed:

Hypothesis 4: Green insurance has a positive impact on the high-quality development of the sports industry.

3. Data sources and indicator construction

3.1. Data sources

The time interval of the data used in the research of this paper is from 2008 to 2021. Due to the limited accessibility of the data, incomplete statistics of the sports industry related data in some regions, untimely data release, etc., the data are supplemented by using the index smoothing method and interpolation method. The data indicators for the high-quality development of the sports industry mainly come from the statistical yearbook of each province, the official website of the sports bureau of each province, the statistical bureau of each province and the China Sports Statistical Yearbook.

3.2. Index construction

3.2.1. Explanatory variables

In this paper, the green financial indicators follow the analytical methods employed in the literature by Xiao et al. [13], Zhao et al. [14], Xie et al. [15] and Zhang [3]. The specific details of each indicator are as follows:

Green credit: Proportion of credit allocated to environmental protection projects—total credits for environmental protection projects divided by the total credits for the province.

Green insurance: Degree of promotion of environmental pollution liability insurance—income from environmental pollution liability insurance divided by the total premium income.

Green funds: Proportion of green funds—total market value of green funds divided by the total market value of all funds.

Green investment: Proportion of environmental pollution control investment in GDP—environmental pollution control investment divided by GDP.

3.2.2. Dependent variables

The construction of the evaluation index for the high-quality development level of the sports industry refers to the research findings of Ruan [16], Zhong [17], Su [18] and others [19–23]. The specific index system is presented in Figure 1.

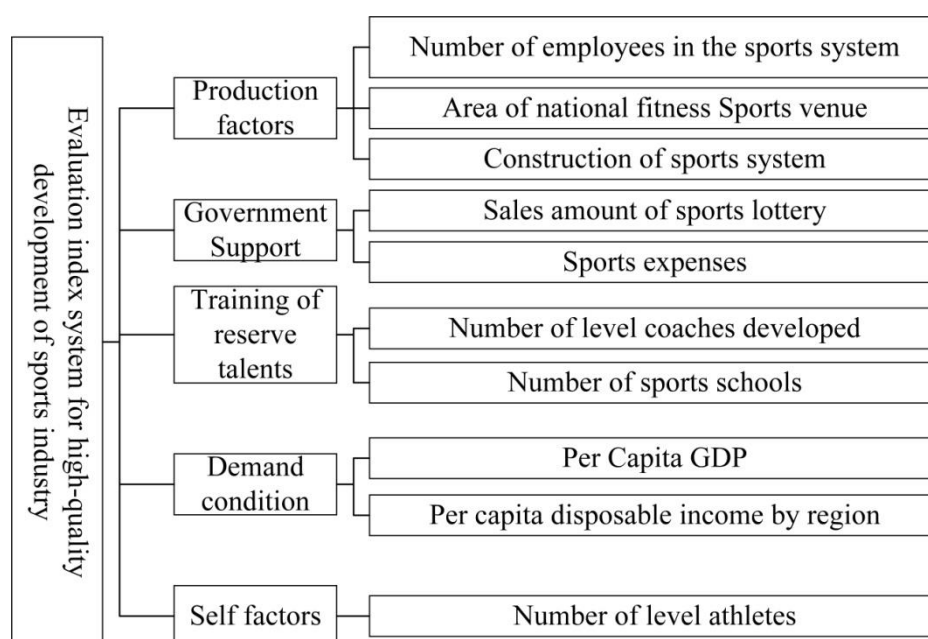


Figure 1. Evaluation index system for the development level of the sports industry.

3.2.3. Control variables

In this paper, the level of economic development of each region (Ingdp) is expressed by logging the GDP of each region; the level of government participation (gov) is expressed as the ratio of local fiscal expenditure to regional GDP; the rate of economic change rate (gdprate) is expressed as the rate of change of the GDP of each region; corporate science and technology expenditure (sci) is expressed as the R&D research investment of sports enterprises; and the level of residential consumption (Inconsum) is expressed as the logarithm of the disposable income of residents.

3.2.4. Measurements of indicators based on improved entropy method

Explanation of the indicator: n is the year span, m is the number of cities and d is the indicator volume.

Standardised treatment:

$$X'_{\theta ij} = \frac{X_{\theta ij}}{X_{\theta ijmax}}, \text{ indicator } j \text{ is a positive indicator.} \quad (1)$$

Since the entropy value method calculates the ratio of a certain indicator of each program to the sum of the values of the same indicator, there is no influence of the scale, and standardization is not required; if there is a negative number in the data, non-negativity of the data is required. In addition, in order to avoid the meaninglessness of the logarithm when seeking the entropy value, it is necessary to carry out data translation.

Determine the entropy value of the indicator:

$$H_j = -k \sum_{\theta=1}^n \sum_{i=1}^m [Y_{\theta ij} \ln Y_{\theta ij}], \quad k = \frac{1}{\ln (dn)}, \quad Y_{\theta ij} = \frac{X'_{\theta ij}}{\sum_{\theta=1}^n \sum_{i=1}^m X'_{\theta ij}}. \quad (2)$$

Calculation of valid values for indicator information:

$$G_j = 1 - H_j. \quad (3)$$

Calculating indicator weights:

$$W_j = \frac{G_j}{\sum_{j=1}^d G_j}. \quad (4)$$

Calculating the overall score:

$$Z_{\theta i} = \sum_{j=1}^d (W_j X'_{\theta ij}). \quad (5)$$

3.2.5. Description of the measurement results

The results of the improved entropy method are shown in Table 1: In terms of the overall national trend, China's Green Finance Index shows a gradual increase from 2008 to 2021. It increases from 0.524 in 2008 to 0.816 in 2021, a growth rate of 52.2%. Based on the above results, the development stages of green finance in China are divided into the following three, as follows:

Initial stage (2007~2015): This stage is the initial stage of green finance development in China. In 2007, China issued the "Guidance on the Establishment of Green Credit Policy", marking the first clear government support for green finance. Subsequently, China Construction Bank issued the country's first green bond in 2012, further promoting the development of green finance.

Rapid growth phase (2016~2018): This phase is a period of rapid growth for green finance in China. In 2016, China issued the Internet+Green Finance Action Plan to promote the integration and development of green finance and internet finance. In the same year, China issued the Guidelines for the Development of Green Bond Market, which provided guidance for the standardised development of the green bond market. With the support of government policies and increased market demand, the green bond market has risen rapidly.

Innovative development phase (2019~present): This phase is a period of innovative development of green finance in China. 2019 saw further development of China's green bond market, with China becoming the world's largest issuer of green bonds by the end of 2019. In addition, China has introduced the integration of financial technology with environmental protection and encouraged the exploration of green financial technology innovation.

Table 1. Green finance composite score.

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Beijing | 0.665 | 0.624 | 0.629 | 0.715 | 0.716 | 0.758 | 0.742 | 0.802 | 0.842 | 0.829 | 0.884 | 0.976 | 1.031 | 0.938 |
| Tianjin | 0.705 | 0.686 | 0.712 | 0.748 | 0.846 | 0.791 | 0.854 | 0.894 | 0.816 | 0.991 | 0.958 | 0.94 | 0.932 | 0.945 |
| Hebei | 0.512 | 0.583 | 0.578 | 0.619 | 0.666 | 0.723 | 0.673 | 0.713 | 0.757 | 0.787 | 0.866 | 0.848 | 0.760 | 0.424 |
| Shanxi | 0.565 | 0.562 | 0.632 | 0.624 | 0.646 | 0.641 | 0.765 | 0.683 | 0.723 | 0.797 | 0.855 | 0.782 | 0.842 | 0.391 |
| Inner Mongolia | 0.541 | 0.570 | 0.603 | 0.585 | 0.646 | 0.693 | 0.673 | 0.738 | 0.694 | 0.839 | 0.814 | 0.818 | 0.853 | 0.409 |
| Liaoning | 0.539 | 0.577 | 0.590 | 0.590 | 0.598 | 0.673 | 0.655 | 0.746 | 0.797 | 0.799 | 0.781 | 0.884 | 0.904 | 0.442 |
| Jilin | 0.532 | 0.528 | 0.586 | 0.579 | 0.646 | 0.699 | 0.734 | 0.701 | 0.733 | 0.826 | 0.790 | 0.852 | 0.806 | 0.426 |
| Heilongjiang | 0.510 | 0.583 | 0.544 | 0.612 | 0.630 | 0.713 | 0.720 | 0.683 | 0.787 | 0.818 | 0.800 | 0.839 | 0.846 | 0.419 |
| Shanghai | 0.651 | 0.741 | 0.7 | 0.738 | 0.763 | 0.779 | 0.846 | 0.957 | 0.998 | 0.974 | 1.082 | 1.104 | 1.046 | 0.964 |
| Jiangsu | 0.731 | 0.698 | 0.762 | 0.725 | 0.765 | 0.78 | 0.877 | 0.895 | 0.939 | 0.909 | 0.98 | 0.932 | 0.954 | 0.977 |
| Zhejiang | 0.638 | 0.685 | 0.7 | 0.767 | 0.8 | 0.824 | 0.789 | 0.82 | 0.874 | 0.835 | 0.835 | 0.943 | 0.996 | 0.935 |
| Anhui | 0.495 | 0.517 | 0.597 | 0.586 | 0.677 | 0.660 | 0.666 | 0.703 | 0.759 | 0.750 | 0.860 | 0.780 | 0.937 | 0.390 |
| Fujian | 0.506 | 0.583 | 0.618 | 0.581 | 0.640 | 0.651 | 0.686 | 0.687 | 0.717 | 0.730 | 0.838 | 0.871 | 0.864 | 0.435 |
| Jiangxi | 0.574 | 0.615 | 0.533 | 0.617 | 0.645 | 0.705 | 0.689 | 0.775 | 0.783 | 0.795 | 0.816 | 0.830 | 0.831 | 0.415 |
| Shandong | 0.519 | 0.586 | 0.619 | 0.629 | 0.648 | 0.709 | 0.688 | 0.707 | 0.792 | 0.733 | 0.769 | 0.863 | 0.884 | 0.432 |
| Henan | 0.529 | 0.599 | 0.558 | 0.586 | 0.626 | 0.633 | 0.659 | 0.706 | 0.746 | 0.757 | 0.771 | 0.863 | 0.801 | 0.432 |
| Hubei | 0.506 | 0.550 | 0.641 | 0.636 | 0.609 | 0.630 | 0.693 | 0.682 | 0.743 | 0.779 | 0.835 | 0.844 | 0.916 | 0.422 |
| Hunan | 0.535 | 0.513 | 0.546 | 0.608 | 0.605 | 0.702 | 0.682 | 0.694 | 0.782 | 0.842 | 0.816 | 0.830 | 0.845 | 0.415 |
| Guangdong | 0.502 | 0.553 | 0.528 | 0.631 | 0.642 | 0.645 | 0.693 | 0.709 | 0.801 | 0.845 | 0.846 | 0.876 | 0.848 | 0.438 |
| Guangxi | 0.509 | 0.589 | 0.614 | 0.594 | 0.597 | 0.656 | 0.686 | 0.755 | 0.743 | 0.810 | 0.862 | 0.854 | 0.811 | 0.427 |
| Hainan | 0.509 | 0.542 | 0.575 | 0.612 | 0.615 | 0.648 | 0.710 | 0.720 | 0.718 | 0.763 | 0.744 | 0.881 | 0.852 | 0.441 |
| Chongqing | 0.537 | 0.579 | 0.615 | 0.594 | 0.672 | 0.663 | 0.683 | 0.728 | 0.718 | 0.780 | 0.820 | 0.832 | 0.858 | 0.416 |
| Sichuan | 0.554 | 0.541 | 0.617 | 0.671 | 0.662 | 0.659 | 0.722 | 0.723 | 0.785 | 0.762 | 0.825 | 0.882 | 0.868 | 0.441 |
| Guizhou | 0.549 | 0.585 | 0.560 | 0.571 | 0.596 | 0.713 | 0.708 | 0.655 | 0.776 | 0.761 | 0.768 | 0.868 | 0.872 | 0.434 |
| Yunnan | 0.503 | 0.547 | 0.549 | 0.646 | 0.631 | 0.678 | 0.640 | 0.779 | 0.651 | 0.550 | 0.497 | 0.527 | 0.530 | 0.398 |
| Xizang | 0.563 | 0.494 | 0.585 | 0.602 | 0.683 | 0.694 | 0.705 | 0.680 | 0.766 | 0.793 | 0.771 | 0.811 | 0.889 | 0.405 |
| Shaanxi | 0.551 | 0.564 | 0.609 | 0.588 | 0.646 | 0.698 | 0.686 | 0.778 | 0.749 | 0.807 | 0.813 | 0.840 | 0.831 | 0.420 |
| Gansu | 0.490 | 0.592 | 0.551 | 0.580 | 0.638 | 0.697 | 0.741 | 0.691 | 0.796 | 0.777 | 0.827 | 0.824 | 0.897 | 0.412 |
| Qinghai | 0.529 | 0.582 | 0.545 | 0.582 | 0.669 | 0.621 | 0.546 | 0.419 | 0.648 | 0.634 | 0.656 | 0.709 | 0.720 | 0.735 |
| Ningxia | 0.514 | 0.569 | 0.593 | 0.617 | 0.633 | 0.706 | 0.666 | 0.651 | 0.677 | 0.513 | 0.541 | 0.521 | 0.510 | 0.261 |
| Xinjiang | 0.393 | 0.456 | 0.468 | 0.487 | 0.475 | 0.508 | 0.599 | 0.560 | 0.553 | 0.543 | 0.513 | 0.454 | 0.302 | 0.283 |
| National | 0.524 | 0.558 | 0.576 | 0.601 | 0.633 | 0.666 | 0.683 | 0.701 | 0.741 | 0.756 | 0.784 | 0.806 | 0.811 | 0.816 |

According to the data in Table 1, the top 5 green finance indexes in China's provinces and autonomous regions are now Shanghai, Jiangsu, Zhejiang, Tianjin and Beijing. It is clearly evident that the green finance index is higher in the eastern region, and the reasons for this are found to be the following four main reasons:

(1) Higher level of economic development in the eastern region: The eastern region is the core region of China's economic development and has a more developed market and industrial base. The

strong economic strength provides good support for green finance and attracts more green finance investments and projects.

(2) Strong innovation drive in the East: The eastern region has higher strengths and resources in technology, innovation and enterprise development. These advantages provide favorable conditions for the innovation and promotion of green financial products and services.

(3) Stronger policy support in the eastern region: Governments in the eastern region have actively introduced and implemented a series of policies to encourage the development of green finance. For example, measures such as supporting the issuance of green bonds, setting up green funds and providing tax incentives have contributed to the prosperity of green finance.

(4) Environmental awareness: The eastern region is facing more problems of environmental pollution and need for ecological protection, and has a relatively high awareness of green development and sustainable development. This environmental awareness has also prompted local governments, enterprises and residents to pay more attention to the development of green finance, promoting the formation and growth of a green financial market.

While the eastern region has a high level of green finance development, the central and western regions are also gradually strengthening their green finance power. With the further expansion of policies and markets, the development of green finance in the central and western regions will gradually improve and achieve a more balanced development.

3.3. Regression model analysis

The analysis shows that green finance will be used to accelerate the improvement of the sports financial system and promote the high-quality development of the sports industry. This paper focuses on the impact of green finance on the high-quality development of the sports industry, using the level of development of the sports industry as the response variable and the level of green finance development as the explanatory variable, controlling for the size of the economy, government expenditure and total imports and exports. The following model is constructed:

$$quality_{it} = \alpha_0 + \alpha_1 GC_{it} + \alpha_2 lngdp_{it} + \alpha_3 gdprate_{it} + \alpha_4 lnconsum_{it} + \alpha_5 gov_{it} + \alpha_6 sci_{it} + \omega_{it},$$

$$quality_{it} = \alpha_0 + \alpha_1 GF_{it} + \alpha_2 lngdp_{it} + \alpha_3 gdprate_{it} + \alpha_4 lnconsum_{it} + \alpha_5 gov_{it} + \alpha_6 sci_{it} + \omega_{it},$$

$$quality_{it} = \alpha_0 + \alpha_1 GI_{1it} + \alpha_2 lngdp_{it} + \alpha_3 gdprate_{it} + \alpha_4 lnconsum_{it} + \alpha_5 gov_{it} + \alpha_6 sci_{it} + \omega_{it},$$

$$quality_{it} = \alpha_0 + \alpha_1 GI_{2it} + \alpha_2 lngdp_{it} + \alpha_3 gdprate_{it} + \alpha_4 lnconsum_{it} + \alpha_5 gov_{it} + \alpha_6 sci_{it} + \omega_{it},$$

where $quality_{it}$ is the level of development of the sports industry, $lngdp$ is the logarithm of regional GDP, $gdprate$ is the rate of economic change, sci is the R&D investment of enterprises, $lnconsum$ is the logarithm of disposable income of the population, gov is the ratio of government fiscal expenditure to GDP, GC is the green credit index, GF is the green fund index, GI_1 is the green investment index, GI_2 is the green insurance index, α_0 is the constant term, ω is the random error term, i denotes region and t denotes year.

4. Empirical analysis

4.1. Model regression analysis

As the data collected in this paper differed significantly in the time dimension and the cross-sectional dimension, it was judged that the data were first regressed using a random effects model and a fixed effects model. According to the Hausman test [24], $P=0.5539$, so the regression analysis using the random effects model is the best estimate. Table 2 shows the results of the regression analysis of the composite score of green finance on the composite score of high-quality development of the sports industry. Using the random effects model and fixed effects model, the coefficient of the effect of green finance on the development of the sports industry is 0.046 at the 1% level of significance, which is positive.

According to the analysis of the results of the random effects model, the regression coefficient of government financial expenditure is 0.012, at the 1% significance level, indicating that the sports industry achieves a level of upgrading with strong support from government expenditure. The reason for this is that increased government investment accelerates the speed of sports infrastructure construction even more, promotes the process of high-tech research and development and provides stable support for the upgrading China's sports industry.

The coefficient of disposable income of the population is 0.005, at a significance level of 1%. As residents' disposable income increases, people's spending power in the sports sector also increases. They may be more willing to buy sporting goods, participate in fitness activities, watch matches, etc., thus contributing to the prosperity and growth of the sports market. They may be more inclined to invest a portion of their capital in the sports industry, such as investing in sports equipment production, stadium construction, sports and entertainment companies, etc. Such investments help to improve the technology level and service quality of the sports industry.

Looking at the four sub-indicators of green finance:

(1) An increase of 1 in the green credit index and an increase of 10.6% in the quality development of the sports industry, i.e., hypothesis one holds, i.e., green credit provides financial support and incentives for sports organizations to achieve sustainable development and promotes the quality development of the sports industry.

(2) An increase of 1 in green investment and 17.4% in quality development of the sports industry, i.e., hypothesis two holds. Green investments can have a profound impact on the sports industry by supporting sustainable infrastructure, renewable energy adoption, sustainable event management, technological innovation, branding and public engagement.

(3) The green fund increased by 1 and the quality development of the sports industry increased by 17.2%, i.e., hypothesis three holds. The green fund can provide financial resources for sustainable sports infrastructure, promote eco-friendly operations, support sustainable events, drive innovation, enhance brand value and raise sustainability awareness.

(4) Green insurance increases by one and quality development of the sports industry increases by 14.1%, i.e., hypothesis four holds. Green insurance can provide risk mitigation, financial protection and incentives for the sports industry to adopt sustainable infrastructure, mitigate environmental risks and promote eco-friendly practices.

Table 2. Regression analysis.

| | M-RE quality | FE quality | M2-RE quality | M3-RE quality | M4-RE quality | M5-RE quality |
|-----------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <i>GI</i> | 0.046*** -0.002 | 0.027*** -0.003 | | | | |
| <i>GC</i> | | | 0.106*** -0.008 | | | |
| <i>GI₁</i> | | | | 0.174*** -0.015 | | |
| <i>GF</i> | | | | | 0.172*** -0.012 | |
| <i>GI₂</i> | | | | | | 0.141*** -0.016 |
| <i>gov</i> | 0.012*** -0.002 | 0 -0.017 | 0.025*** -0.003 | 0.004 -0.004 | 0.012*** -0.005 | 0.019*** -0.006 |
| <i>sci</i> | -0.000*** 0 | 0 0 | 0 0 | 0 0 | 0 0 | 0 0 |
| <i>gdprate</i> | 0 0 | 0 -0.002 | 0 0 | 0 0 | 0 0 | 0 0 |
| <i>lnconsum</i> | 0.005*** -0.001 | 0.002 -0.002 | 0.002* -0.002 | 0.004* -0.002 | 0.001*** -0.001 | 0.003 -0.001 |
| <i>lngdp</i> | 0 -0.002 | 0 -0.001 | 0 -0.001 | 0 -0.002 | 0 -0.002 | 0 -0.002 |
| <i>-cons</i> | -0.024* -0.015 | -0.03 -0.018 | -0.043** -0.019 | -0.047** -0.03 | -0.049** -0.02 | -0.032** -0.02 |
| <i>N</i> | 434 | 434 | 434 | 434 | 434 | 434 |
| <i>year</i> | yes | yes | yes | yes | yes | yes |
| <i>province</i> | yes | yes | yes | yes | yes | yes |

Note: standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.2. Robustness tests

To ensure the credibility of the analysis, this study adopts Li's [25] approach to select the "Green Finance Development Level Index (GFDLI)" as a representative indicator of the green finance index. Additionally, robustness testing is conducted by using alternative explanatory variables to examine the relationship between green finance and the high-quality development of the sports industry. The findings indicate a significant and positive impact of green finance on the high-quality development of the sports industry, with a significance level of 1%. These empirical results provide strong support for the reliability of this study. Furthermore, the robustness of the obtained results is demonstrated in Table 3.

Table 3. Robustness tests for replacement indicators.

| | <i>re</i> |
|----------------|----------------------|
| | <i>quality</i> |
| <i>GFDLI</i> | -0.000*** (0.000) |
| <i>gov</i> | 0.002 (0.010) |
| <i>sci</i> | 0.000*** (0.000) |
| <i>gdprate</i> | -0.001*** (0.001) |
| <i>lngdp</i> | -0.000 (0.002) |
| <i>consum</i> | 0.004*** (0.001) |
| <i>_cons</i> | -0.017 (0.017) |
| <i>N</i> | 434 |

Note: standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Theoretical contributions and discussion

5.1. Theoretical contributions

This study makes a valuable contribution to existing literature by conducting a provincial-level regression analysis between green finance and the sports industry. Previous studies have primarily focused on analyzing individual aspects of finance and the sports industry, with limited regression analysis on the relationship between green finance and the sports industry. In this study, we assess the level of high-quality development in the sports industry through indicators relating to production factors, government support, talent training, demand conditions and industry elements. Additionally, we analyze green finance encompassing green credit, green investment, green funds and green insurance, utilizing indicator data to evaluate the development level of green finance. This comprehensive quantitative research provides valuable insights into the impact of green finance on the sports industry.

5.2. Discussion

5.2.1. Green credit promotes the high-quality development of the sports industry

The introduction of green credit has expanded the financing channels available to the sports industry, attracting increased participation from financial institutions, funds and investors. This provides sports companies with additional resources and support, facilitating high-quality development and market expansion. Green credit offers financial assistance for technological innovation, equipment upgrades and venue construction in the sports industry, leading to improvements in facilities and equipment quality and promoting high-end and intelligent development. By providing financial support, driving innovation, advocating for environmental protection and expanding the market, green credit creates essential conditions and incentives for the sports industry to move towards sustainable and high-quality development.

5.2.2. Green investment promotes the high-quality development of the sports industry

Green investment provides financial support to the sports industry, encouraging sports companies to invest in sustainable and environmentally friendly projects. This enhances the quality and standards of sports facilities, equipment and technology, fostering the industry's development in a healthier, lower-carbon and sustainable direction. Moreover, it improves the environmental image and brand value of enterprises, especially those emphasizing environmental protection and sustainable development. With the support of green investment, sports industry enterprises are more likely to gain public attention and recognition, thereby expanding their market share and enhancing competitiveness. Green investment also promotes innovation in the sports industry by fostering the development of sports technology, digital technology and sustainable projects. By investing in research and development and promoting the application of eco-friendly and energy-efficient technologies, green investment facilitates high-quality, innovation-driven development in the sports industry.

5.2.3. Green funds promote the high-quality development of the sports industry

Green funds facilitate cooperation and exchanges within and outside the sports industry, creating a platform for win-win collaborations among sports companies. Through activities such as green forums, seminars and project partnerships, knowledge sharing and experience exchanges are encouraged, strengthening cooperation across the entire industry chain. This, in turn, improves the overall development quality and sustainability of the industry. Green funds provide financial support for the sustainable development of the sports industry by financing projects that meet green standards and prioritize environmental friendliness. This encourages sports companies to invest in green technology innovation, energy conservation, emission reduction and renewable energy utilization, thereby enhancing the industry's level of environmental protection and resource utilization efficiency. Green funds also stimulate innovation and support technological research and development, as well as business model innovation in the sports industry. By funding projects related to technological innovation, digital technology and sustainable development, green funds promote higher levels of technological innovation, management and operational efficiency in the sports industry, ultimately enhancing competitiveness and market influence.

5.2.4. Green insurance promotes the high-quality development of the sports industry

Green insurance plays a crucial role in providing risk management and guarantee services to the sports industry. The sports industry faces various potential risks, such as natural disasters, athlete injuries and game cancellations, which can negatively impact business operations and development. Green insurance offers tailored insurance solutions to address these specific risks, reducing corporate vulnerabilities and providing corresponding compensation protection to ensure the industry's stability. In the event of a disaster or risk event, green insurance supports the swift reconstruction of the sports industry [26]. It facilitates prompt claims settlement and financial assistance when natural disasters or accidents result in damage to sports facilities or losses for enterprises. By aiding quick business recovery, it minimizes economic losses and helps maintain the industry's continuity and sustainability. Green insurance also promotes environmental responsibility within the sports industry and encourages environmental protection actions. Through the establishment of environmental incentive mechanisms or collaboration with eco-friendly projects, green insurance motivates companies to undertake proactive environmental protection measures, including carbon emissions reduction, energy

conservation and resource recycling. These actions not only enhance corporate image and social identity but also establish a solid foundation for the industry's long-term sustainable development.

6. Conclusions and policy recommendations

6.1. Conclusions

This study employs regression analysis, utilizing fixed effect and random effect models, to examine the relationship between green finance and the sports industry. The analysis yields the following conclusions:

(1) Financial support: Green finance plays a vital role in providing financing for sustainable development and environmental protection. The sports industry requires substantial capital investments for activities such as constructing sports venues, upgrading equipment and promoting research and development innovation. By offering green loans and green bonds, green financial institutions can provide long-term and cost-effective financial support, facilitating the industry's sustainable development.

(2) Environmental responsibility: Green finance encourages the sports industry to fulfill its environmental responsibilities. Green financial institutions typically impose specific environmental standards and guidelines on borrowing companies or projects. This compels the sports industry to adopt environmentally friendly practices related to resource utilization, energy consumption and carbon emissions. These measures contribute to minimizing the industry's environmental impact, reducing ecological damage and enhancing its reputation and social standing.

(3) Technological innovation: Green finance drives technological innovation within the sports industry. To achieve environmental protection goals, the industry must continuously promote technological advancements and adopt energy-efficient, environmentally friendly and sustainable technologies and products. Green financial institutions can provide dedicated funds to support technological innovation, research and development and facilitate the industry's transition toward a low-carbon and clean trajectory, thereby enhancing its competitiveness.

(4) Brand value: Green finance contributes to enhancing the brand value of the sports industry. Increasingly, consumers prefer environmentally conscious and sustainable industries. With the support of green finance, the sports industry can strengthen the connection between its brand image and green concepts, thereby increasing brand influence and market competitiveness. This not only promotes long-term enterprise development but also aligns with growing consumer environmental awareness and preferences.

6.2. Policy recommendations

(1) Develop guidance documents on green finance for relevant industries: The government should establish or update laws and regulations to provide clear guidance and policy measures for implementing green finance in the sports industry. These documents should include provisions for lower interest rates on green loans, tax incentives and other incentives to encourage financial institutions to invest more in green sports projects.

(2) Create dedicated funds: The government or financial institutions should establish specialized funds to support innovation, transformation and upgrading initiatives focused on environmental protection within the sports sector. These funds can provide low-interest loans, risk guarantees, project support and other forms of assistance to facilitate the implementation of green technology innovation

and sustainable development projects by sports companies.

(3) Encourage green bond issuance: Efforts should be made to incentivize sports companies to issue green bonds, attracting capital market investments for green sports projects. The government can introduce supportive policies, streamline green bond issuance procedures, offer interest discounts or other incentives and enhance the attractiveness of green bonds to investors.

(4) Establish a green finance evaluation system: Promote the establishment of a sports industry-specific green financial evaluation index system that assesses and certifies green sports projects. This system will enhance the transparency and credibility of green finance, attracting more financial institutions to invest in environmentally friendly initiatives.

(5) Foster collaboration mechanisms: Create collaborative mechanisms involving the government, financial institutions and sports enterprises to foster information exchange and synergy. Regular convening of green finance summits, symposiums and similar events can facilitate sharing experiences and case studies among all stakeholders. These platforms can also address challenges and issues related to the green development of the sports industry.

(6) Promote innovative research and development: Encourage sports enterprises to pursue breakthroughs in green technology innovation and the development of environmentally friendly products through incentive systems or financial support. Establish innovative research and development centers and demonstration projects, provide research subsidies, ensure intellectual property protection and offer other forms of support. These measures will provide continuous momentum for the green advancement of the sports industry.

These policy recommendations aim to foster collaboration among financial institutions, enterprises and government departments to create a favorable environment for green finance in the sports industry. By directing funds and offering policy support, the transition towards sustainability and green development in the sports industry can be accelerated, leading to high-quality growth.

Data sources

The data utilized in this study spans from 2008 to 2021. Due to limited data accessibility, there are instances where sports industry-related data for certain regions are incomplete or delayed in their release. The indicators for measuring the high-quality development of the sports industry are primarily obtained from provincial statistical yearbooks, official websites of provincial sports bureaus, provincial statistical bureaus and the China Sports Statistical Yearbook. The relevant indicators for green finance are primarily sourced from the “China Statistical Yearbook” and “Peking University Digital Financial Inclusion Index”.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare that they have no competing interests.

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