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Correlation Analysis on Social Psychological Adjustment, Sports Cultural Products Consumption, and Sports Cultural Industry Development

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Abstract: The society today advocates the prosperity of cultural undertakings and cultural industries, and pursues the enhancement of cultural soft power. Sports development is closely connected with economic development. The complementarity between the two is the inevitable trend of our society. However, there are relatively few studies on sports cultural products consumption (SCPC) and sports cultural industry development (SCID). Besides, the influence of social psychological adjustment (SPA) on the entire sports cultural industry is largely overlooked. Therefore, this paper explores the correlations between SPA, SCPC, and SCID. Firstly, the relationship between SCPC and SCID was modeled, and the action mechanism of SCPC on SCID was detailed. Next, the dynamic correlation between SCPC and SCID was analyzed. After that, SPA was introduced to discuss the associations between SPA, SCPC, and SCID from the perspective of correlations. The Augment Dickey-Fuller (ADF) unit root test and Johansen cointegration test were carried out to verify whether SPA, SCPC, and SCID are stationary, and have long-term equilibrium relationships in the long run. Finally, experiments were carried out to estimate the correlations between the three, using three-stage least squares (LS) method, and obtain the results of ADF and Johansen tests. The study on the interaction mechanism between SPA, SCPC, and SCID clarifies their interactive paths, and helps policymakers to roll out favorable policies on the following issues: designing institutional incentives of SCPC, enhancing the fundamental role of SCPC in SCID, and promoting the high-quality regional economy development under SPA.

Keywords: social psychological adjustment (SPA); sports cultural products consumption (SCPC); sports cultural industry development (SCID); correlation analysis

Introduction

Sports development is closely connected with economic development (Gong, 2011; Guo, 2017; Lin, 2015; Liu, 2020; Qiu et al., 2013; Xu and Wang, 2012; Wei, 2017; Wu and Lei, 2011; Zhai et al., 2021;). The complementarity between the two is the inevitable trend of our society: the prosperity of cultural undertakings and cultural industries, and the enhancement of cultural soft power (Gao, 2014; Gu, 2015; Jiang and Liang, 2014; Xiang; 2014; Xiao, 2014; Xu, 2014 Wang, 2014;). The development and formation of sports cultural industry begin with the manufacturing of sports cultural products. The growing demand for various sports cultural products and services stimulates the boom of sports cultural industry, and drives the development of relevant cultural industries (Chen, 2019; Li, 2021; Wang and Lv, 2019; Xin and Lei, 2017). In fact, the manufacturing of sports cultural products has an immense potential in guiding social sports consumption, and adjusting social sports structure (Zhang and Zhang, 2021; Zhou et al., 2017).

The rising income and living standards boost people's demand for sports fitness and entertainment (Du and Gao, 2014). Using input-output model, Du and Gao (2014) quantified the rate and change law of the sports industry's contribution to economic growth, and presented policy recommendations. From the angle of economic environment, Miao (2013) expounded on the necessities and concerns of scale development of sports industry, and carried out a development-oriented analysis on the economic environment of the market scale for sports industry, providing a meaningful reference for managers and decision-makers. Popescu et al., (2017) highlighted the effects of gross domestic product (GDP), sports investment, and government on sports advertising and media, and clarified the associations between sports investment, health and tourism departments, and sports industry. Huang (2011) identified the main industries of China's economic development after 2008 Beijing Olympiad (sports goods industry, sports tourism industry, leisure sports industry, sports consumption, etc.), discovered the promoting effect of the Olympic game on the formation and development of sports industry chain, and predicted that the Olympic industry formed by the sports industry will greatly promote China's economic development.

Sports cultural creative industry stems from the in-depth development of sports products and cultural industrialization

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(Yu, 2020). Yu (2020) emphasized the obvious social, economic, cultural and sports functions of sports cultural creative industry, and held that the development of the industry is propelled by both external and internal factors. From the perspective of data mining, Yang (2020) analyzed the feasibility of predicting the growth of sports cultural industry based on big data theory, proposed a growth prediction model for sports cultural industry based on genetic neural network, and forecasted the growth law of sports cultural industry in the context of big data. Through questionnaire survey, mathematical statistics, and strength, weakness, opportunity, and threat (SWOT) analysis, Li and Li (2014) summarized the merits, defects, chances, and threats of sports cultural industry.

To sum up, most studies have explored the relationship between the structure of sports cultural industry and the upgrading of sports cultural products consumption (SCPC), but rarely discussed their mutual influence under the same mechanism. On influence direction, the research emphasis lies in the promoting effect of SCPC upgrading on the structure of sports cultural industry. Few scholars have investigated how the supply structure variation induced by social psychological adjustment (SPA) on SCPC demand.

The main contents of this work are as follows: (1) Modeling the relationship between SCPC and sports cultural industry development (SCID), and detailing the action mechanism of SCPC on SCID; (2) Analyzing the dynamic correlation between SCPC and SCID; (3) Introducing SPA to the problem, and discussing the associations between SPA, SCPC, and SCID from the perspective of correlations; (4) Conducting Augment Dickey-Fuller (ADF) unit root test and Johansen cointegration test to verify whether SPA, SCPC, and SCID are stationary, and have long-term equilibrium relationships in the long run; (5) Setting up simultaneous equations to estimate the correlations between the three, using three-stage least squares (LS) method, and obtain the results of ADF and Johansen tests.

SCPC-SCID Relationship Model

This paper mainly discusses the relationship between SCPC and SCID. Therefore, only enterprises and consumers need to be considered in a completely closed regional economy. It is assumed that the total demand is the superposition between SCPC demand XF and sports cultural industry investment demand TZ. The SCPC demand XF can be further divided into potential consumer demand XF^R and actual consumer demand XF^S. Different classes of sports cultural industry and periods are denoted by subscripts i and τ, respectively. Let $B^{\varepsilon}_{i-\tau}$ be the total demand of class i sports cultural sectors (hereinafter referred to as sectors) in period τ; $XF^S_{i-\tau}$ be actual consumption; $TZ_{i-\tau}$ be total investment. Then, the total demand of the sports cultural market in that period can be given by:

$$B^{\varepsilon}_{i-\tau} = XF^S_{i-\tau} + TZ_{i-\tau} \quad (1)$$

Let $B^o_{i-\tau}$ be class i sectors; PJ, CA, and WD be the mean technical level, capital, and labor input of the sectors, respectively. Then, a Cobb–Douglas production function can be established as:

$$B^o_{i-\tau} = PJ_i \cdot CA^{\gamma}_{i-\tau} \cdot WD^{\phi}_{i-\tau} \quad (2)$$

where, $\gamma>0$; $\varphi<1$; $\gamma+\varphi=1$. Suppose PJ is fixed, and the ratio of CA to WD is fixed, i.e., $CA_{i-\tau}/WD_{i-\tau}$ is a constant, then the products in different classes of sectors are not mutually replaceable.

In formulas (1) and (2), the SCPC structure is reflected by the proportionality between the consumptions XF^S_i of class i sectors. The proportion of the consumptions of class i sectors in total consumption can be described by $XF^S_i/\Sigma^m_{j=1}XF^S_i$. The structure of sports cultural industry is reflected by the proportionality between the outputs B^o_τ of class i sectors. The proportion of the outputs of class i sectors in total output can be described by $B^o_j/\Sigma^m_{j=1}B^o_j$.

Taking the logarithm of formula (1) and then finding the partial derivative relative to τ:

$$\frac{1}{B^{\varepsilon}_i}\frac{dB^{\varepsilon}_i}{d\tau} = \frac{1}{b^S_i+TZ_i}\left(\frac{dXF^S_i}{d\tau}+\frac{dTZ_i}{d\tau}\right) \quad (3)$$

Taking the logarithm of formula (2) and then finding the partial derivative relative to τ:

$$\frac{1}{B^o_i}\frac{dB^o_i}{d\tau} = \frac{1}{CA^{\gamma}_i}\frac{dCA^{\gamma}_i}{d\tau}+\frac{1}{WD^{\phi}_i}\frac{dWD^{\phi}_i}{d\tau} \quad (4)$$

Figure 1 illustrates the relationship between SCPC and SCID. Suppose the investment $TZ_{i-\tau}$ in a class of sectors remains at the mean TZ'_i in period τ, i.e., $TZ_{i-\tau}=TZ'_i$. Then, there are three possible scenarios for the relationship between residents' potential SCPC demand, actual consumption of sports cultural products, and output of sports cultural industry:

(1) If $XF^p_{i-t}>B^s_{i-\tau}-TZ'_i$, class i sectors are short supplied, the output is entirely transformed into actual SCPC, and the consumer demand is excessive.

(2) If $XF^R_{i-\tau}=B^o_{i-\tau}-TZ'_i$, class i sectors are balanced in supply and demand, and the output is entirely transformed into actual SCPC, and the consumer demand is not excessive. This is the ideal market state for SPA.

(3) If $XF^R_{i-\tau}<B^o_{i-\tau}-TZ'_i$, class i sectors are over supplied, the output is partially transformed into actual SCPC, and the production capacity is excessive. In this case, $XF^R_{i-\tau}=XF^S_{i-\tau}-TZ'_i$.

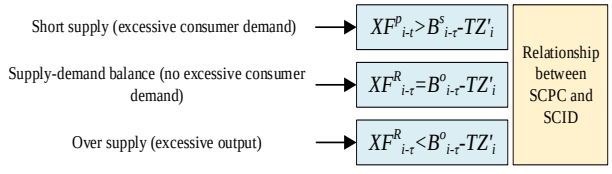

Figure 1. Relationship between SCPC and SCID

Under the assumption that the investment in class *i* sectors remains constant, the relationship between $XF^R_{i\text{-}\tau}$ and $B^o_{i\text{-}\tau}$ directly determines the equilibrium state of the market. For any class *i* sectors, if $XF^R_{i\text{-}\tau}=XF^S_{i\text{-}\tau}$ and $XF^R_{i\text{-}\tau}+TZ'_i=B^o_{i\text{-}\tau}$, that is, the total output of regional sports cultural industry is used for residents' SCPC, except for the parts used to increase the number of enterprises in the industry, or to adjust the capital and asset expenditures of the industry, then:

$$\sum_{i=1}^{m}\left(XF_{i,t}^{S}+TZ_i^{'}\right)=\sum_{i=1}^{m}B_{i,\tau}^{o} \quad (5)$$

Because the products in different classes of sectors are not mutually replaceable, when $XF^R_{i\text{-}\tau}\neq B^o_{i\text{-}\tau}\text{-}TZ'_i$, some classes of sectors might face over supply or short supply, tilting the equilibrium of the whole market.

The market equilibrium between the output and consumption of sports cultural products is an ideal dynamic state from nonequilibrium to equilibrium. This ideal equilibrium state changes constantly, due to the variation in SCPC demand and the structure of sports cultural industry.

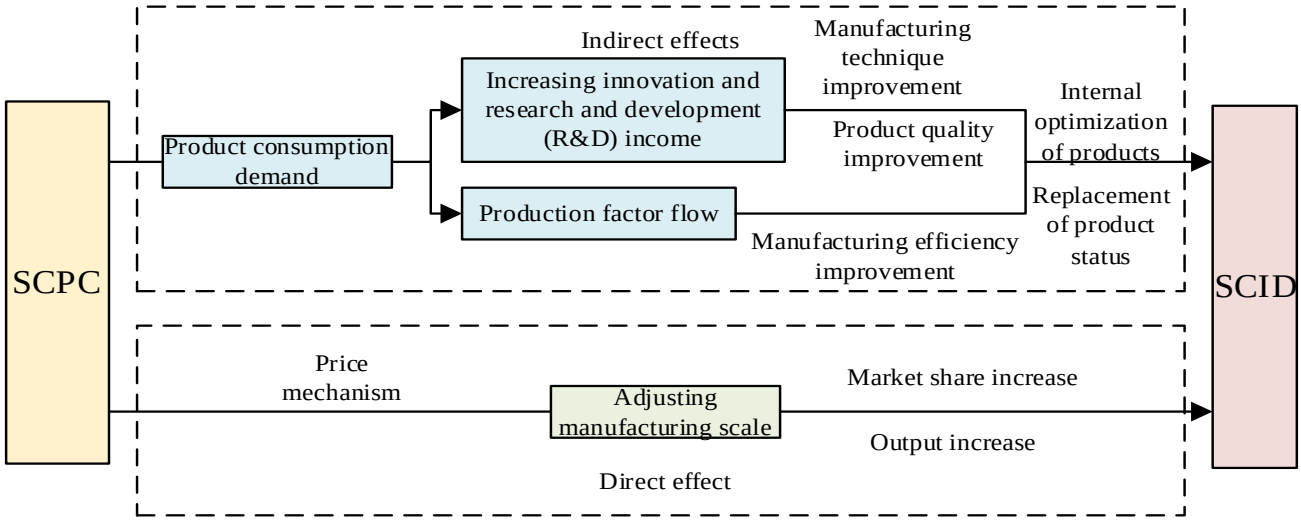

Figure 2. Action mechanism of SCPC on SCID

Figure 2 shows the action mechanism of SCPC on SCID. Judging by the influence paths, the SCPC structure exerts both direct and indirect effects on the structure of sports cultural industry. When consumers purchase the products of different classes of sectors, the corresponding enterprises obtain the profits, and will pursue expanded reproduction by reinvesting and redistributing production factors. The market share of these enterprises will thus be improved. Due to the structural changes of SCPC demand, the classes of sectors with a high demand are relatively fast in scale expansion.

In period τ-*k*, the residents' potential consumer demand for class *i* sectors is denoted as $XF^R_{i\text{-}(\tau\text{-}1)}$, and their potential consumer demand for class *j* sectors is denoted as $XF^R_{i\text{-}(\tau\text{-}1)}$; the outputs of classes *i* and *j* sectors are denoted as $B_{i\text{-}(\tau\text{-}1)}$ and $B_{j\text{-}(\tau\text{-}1)}$, respectively. Then, $XF^R_{i\text{-}(\tau\text{-}1)}=B_{i\text{-}(\tau\text{-}1)}$, $XF^R_{j\text{-}(\tau\text{-}1)}=B_{j\text{-}(\tau\text{-}1)}$. In this case, the markets for the two classes of sectors are both in equilibrium state.

It is assumed that in period τ, the residents have greater potential consumer demands for classes *i* and *j* sectors, and the potential demand for the products in class *i* sectors increases faster than that for the products in class *j* sectors, then $(XF^R_{i\text{-}\tau}\text{-}XF^R_{i\text{-}(\tau\text{-}1)})/(XF^R_{i\text{-}(\tau\text{-}1)}>(XF^R_{j\text{-}\tau}\text{-}XF^R_{j\text{-}(\tau\text{-}1)})/XF^R_{j\text{-}(\tau\text{-}1)}$.

It can be seen that $\Delta XF^R_{i\text{-}\tau}/XF^R_{i\text{-}(\tau\text{-}1)}>\Delta XF^R_{j\text{-}\tau}/XF^R_{j\text{-}(\tau\text{-}1)}$.

Owing to the price conducting mechanism, the residents' potential demand for the products of class i sectors grows faster than that for the products of class j sectors. Because the market supply-demand does not change, the product price of class i sectors will rise faster than that of class j sectors. That is, there exists $\Delta RU_{i\text{-}\tau}/RU_{i\text{-}(\tau\text{-}1)}>\Delta RU_{j\text{-}\tau}/RU_{j\text{-}(\tau\text{-}1)}$. Thanks to the price hike of sports cultural products, the products of the corresponding class i sectors will yield a high profit in the short term. The production factors like capital *CA* and labor *WD* will flow in to help enterprises pursue expanded reproduction. The production factors in these sectors will grow faster than those in class j sectors.

Suppose the proportions of *CA* and *WD* are fixed. Then, the two parameters will change in accordance with: $\Delta CA_{i\text{-}\tau}/CA_{i\text{-}(\tau\text{-}1)}>\Delta CA_{j\text{-}\tau}/CA_{j\text{-}(\tau\text{-}1)}$ and $\Delta WD_{i\text{-}\tau}/WD_{i\text{-}(\tau\text{-}1)}>\Delta WD_{j\text{-}\tau}/WD_{j\text{-}(\tau\text{-}1)}$. Without considering the variation in technical factors of corporate production, the production of sports cultural industry can be described by Cobb–Douglas production function, and the outputs of classes i and j sectors are denoted as $B_{i\text{-}\tau}$ and $B_{j\text{-}\tau}$, respectively. Finding the partial derivative of the production function relative to τ:

$$\frac{1}{B_n^o}\frac{dB_m^o}{d\tau}=\frac{1}{CA_m^{\gamma}}\frac{dCA_m^{\gamma}}{d\tau}+\frac{1}{WD_m^{\phi}}\frac{dWD_m^{\phi}}{d\tau},m=i,j \quad (6)$$

Formula (6) can be simplified as:

$$\frac{dB_m^o}{B_m^o} = \frac{dCA_m^\gamma}{CA_m^\gamma} + \frac{dWD_m^\phi}{WD_m^\phi}, m = i, j \quad (7)$$

Formula (7) shows that, without considering other factors, the output growth rate of regional sports cultural industry equals the sum of the growth rate of capital *CA* and that of labor *WD*. Since class i sectors are faster than class j sectors in the growth of *CA* and *WD*, the output of class i sectors will increase faster than that of class j sectors: $dB_{i\text{-}\tau}/B_{i\text{-}(\tau\text{-}1)} > dB_{j\text{-}\tau}/B_{j\text{-}(\tau\text{-}1)}$. It can also be understood as $\Delta B_{i\text{-}\tau}/B_{i\text{-}(\tau\text{-}1)} > \Delta B_{j\text{-}\tau}/B_{j\text{-}(\tau\text{-}1)}$.

From the above process, it can be inferred that the residents' changing consumer demand for the products in different classes of sectors eventually drives up the outputs of different classes of sectors by affecting the flow of production factors like *CA* and *WD* and the market price mechanism. Structurally speaking, the variation in residents' SCPC structure will influence the structure of sports cultural industry, and the industrial structure can be characterized by the SCPC demand variation function.

From the perspective of structural changes of sports cultural industry, the outputs of classes i and j sectors in period τ-1 are denoted as $B_{i\text{-}(\tau\text{-}1)}$ and $B_{j\text{-}(\tau\text{-}1)}$, respectively; the potential consumer demands for products of classes i and j sectors in that period are denoted as $XF^R_{i\text{-}(\tau\text{-}1)}$ and $XF^R_{j\text{-}(\tau\text{-}1)}$, respectively. Both $B_{i\text{-}(\tau\text{-}1)}$ and $B_{j\text{-}(\tau\text{-}1)}$ are smaller than the potential consumer demand of the market for sports cultural products. Therefore, the actual SCPCs in the markets of classes i and j sectors satisfy $XF^S_{i\text{-}(\tau\text{-}1)} < XF^R_{i\text{-}(\tau\text{-}1)}$ and $XF^S_{j\text{-}(\tau\text{-}1)} < XF^R_{j\text{-}(\tau\text{-}1)}$, i.e., the two markets face excessive SCPC demands.

Suppose the market operations tend to be equilibrium in period τ, and the potential SCPC demand does not change. Accordingly, classes i and j sectors will improve outputs by stepping up the inputs of production factors like *CA* and *WD*. It is assumed that the production techniques of products remain the same, and the *CA* and *WD* in class i sectors grow faster than those in class j sectors. According to the previous analysis, the following situation will occur: $\Delta B_{i\text{-}\tau}/B_{i\text{-}(\tau\text{-}1)} > \Delta B_{j\text{-}\tau}/B_{j\text{-}(\tau\text{-}1)}$, i.e., class i sectors will grow faster than class j sectors. Since the supply of sports cultural products in both markets falls short of the potential consumer demand for the products, the output increment of sports cultural products will be transformed into actual SCPC, with $\Delta XF^S_{i\text{-}\tau}/XF^S_{i\text{-}(\tau\text{-}1)} > \Delta XF^S_{j\text{-}\tau}/XF^S_{j\text{-}(\tau\text{-}1)}$. This process will continue until $XF^S_{i\text{-}\tau} = XF^R_{i\text{-}\tau}$, i.e., the products of class i sectors fully satisfy the potential consumer demand. To sum up, the output changes in different sectors, i.e., the structural changes of sports cultural industry, will affect the actual SCPC in the corresponding markets, reshaping the SCPC structure. The structure of SCPC can also be characterized by the structural variation function of sports cultural industry.

Dynamic Associations Between SCPC and SCID

The economic growth of sports cultural product market in line with SPA is featured by the transformation and upgrading of the structure of sports cultural industry. Here, the structure supererogation of sports cultural industry is defined as the weighted product of the proportionality between sectors and the labor productivity of sports cultural industry. Different regions and years are denoted by subscripts *n* and τ, respectively; the primary, secondary, and tertiary sectors of sports cultural industry are denoted by subscripts *n*; the added value of class i sectors of region n in period τ as a proportion of regional GDP is denoted as $b_{i\text{-}n\text{-}\tau}$; the labor productivity of class i sectors of region n in period τ is denoted as $\eta_{i\text{-}n\text{-}\tau}$. Then, we have:

$$HIS_{i,\tau} = \sum_{n=1}^{3} b_{i-n-\tau} \times \eta_{i-n-\tau}, n = 1,2,3 \quad (8)$$

where, $\eta_{i\text{-}n\text{-}\tau}$ can be calculated by:

$$\eta_{i-n-\tau} = B_{i-n-\tau}/EP_{i-n-\tau} \quad (9)$$

Suppose the added value of class i sectors of region n in period τ is $b_{i\text{-}n\text{-}\tau}$, and the corresponding employed personnel is $EP_{i\text{-}n\text{-}\tau}$.

The structure of sports cultural industry will be gradually rationalized, as the coordination and association between sectors continue to strengthen. In a sense, the dynamic process is a measurement of the coupling between the structure of input factors like *CA* and *WD* and the output structure of sports cultural products. To a certain extent, this process mirrors the allocation of *CA* and *WD* between different classes of sectors. This paper introduces Theil index to characterize the structural rationalization of sports cultural industry. Let $\omega_{i\text{-}n\text{-}\tau}$ be the personnel employed in class i sectors of region n in period τ as a proportion of the total number of employees in the region. Then, we have:

$$TI_{i-\tau} = \sum_{n=1}^{3} b_{i-n-\tau} \ln(b_{i-n-\tau}/\omega_{i-n-\tau}), n = 1,2,3 \quad (10)$$

If *TI*=0, then the sports cultural industry has reached a structural equilibrium. The smaller the TI value, the more equilibrium the industrial structure, and the more reasonable the allocation of the market shares and production factors among sectors. Otherwise, the structure of sports cultural industry deviates further away from the equilibrium state.

The structural transformation of sports cultural industry interacts with SCPC upgrading. If the interaction is estimated directly by a singe function model, the regression coefficients will be distorted by endogeneity problem. To prevent the problem, this paper sets up a model of

simultaneous functions for both the structural transformation of sports cultural industry and SCPC upgrading. The established model consists of two parts: the sub-model *IS*1 about the influence of the structural transformation of sports cultural industry on SCPC upgrading, and the sub-model *IS*2 about the influence of SCPC upgrading on the structural transformation of sports cultural industry. Different regions and years are denoted by subscripts n and τ, respectively; intercept terms are denoted by γ_0 and φ_0; random disturbance terms are denoted by λ and u; the core estimation parameters are denoted by γ_1 and φ_1; the control variable vector is denoted by A; the corresponding coefficient matrices are denoted by ψ and υ, respectively. Then, sub-models *IS*1 and *IS*2 satisfy:

$$IS1_{i-\tau} = \gamma_0 + \gamma_1 IS2_{i-\tau} + \psi A_{i-\tau} + \lambda_{i-\tau} \quad (11)$$

$$IS2_{i,t} = \phi_0 + \phi_1 IS1_{i,t} + \upsilon X_{i,t} + u_{i,t} \quad (12)$$

SPA-Based Association Analysis

After discussing the relationship between SCPC and SCID, SPA was introduced to expound on the associations between SPA, SCPC, and SCID from the perspective of correlations. Since SPA always has a lag period, the correlation changes were observed by gradually accumulating the time-delay terms. The ADF unit root test and Johansen cointegration test were carried out to verify whether SPA, SCPC, and SCID are stationary, and have long-term equilibrium relationships in the long run.

Depending on the presence/absence of intercept term and trend term, three models are available for ADF unit root test. Let PV_τ be the predictor variable; g_0 be the intercept term; δ be the autocorrelation coefficient; $g_1\tau$ be the trend term; $\Sigma^T_{i=2}\xi_i QB_{\tau-i+1}$ be the time-delay term of the explained variable; T be the lag period; σ_i be the residual. Then, the model without intercept and trend terms can be given by:

$$dPV_\tau = \delta PV_{(\tau-1)} + \sum_{i=2}^{R} \xi_i dPV_{(\tau-i+1)} + \sigma_i \quad (13)$$

The model with intercept and without trend terms can be given by:

$$dPV_\tau = g_0 + \delta PV_{(\tau-1)} + \sum_{i=2}^{R} \xi_i dPV_{(\tau-i+1)} + \sigma_i \quad (14)$$

The model with intercept and trend terms can be given by:

$$dPV_\tau = g_0 + \delta PV_{(\tau-1)} + \delta_1 \tau + \sum_{i=2}^{R} \xi_i dPV_{(\tau-i+1)} + \sigma_i \quad (15)$$

When the time series of SCPC data and SCID data are nonstationary, direct regression on them will become spurious. The traditional solution is to carry out differencing on the original time series. But this solution overlooks the long-term relationship between variables. To explore this relationship, the traditional solution can be replaced with a cointegration test capable of determining the number of cointegration vectors and cointegration coefficients.

This paper selects the Johansen cointegration test, which can preserve the information of the original data to the maximum extent. This test method mainly performs the first-order differencing of formula (15). Let $EV_{\tau-T}$ be the endogenous variables of SPA with a lag period of T; g_T be the coefficient of the variable; $\sigma_{i\tau}$ be the error term. Then, we have:

$$EV_\tau = g_1 EV_{(\tau-1)} + g_2 EV_{(\tau-2)} + \ldots + g_T EV_{(\tau-T)} + \sigma_\tau (i = 1,2,3,\ldots,T) \quad (16)$$

Let G_j be the regression coefficient matrix; H be the cointegration coefficient matrix; $\sigma_{j\tau}$ be the residual term. Then, the first-order differencing of EV_τ can be described by:

$$dEV_\tau = H \cdot B_{(\tau-T)} + \sum_{j=1}^{T-1} G_j dEV_{(\tau-j)} + \sigma_\tau \quad (17)$$

Johansen cointegration test measures the long-term equilibrium relationship of EV_τ with cointegration coefficient matrix H. The rank Z of matrix H could follow one of the following cases:

(1) If $Z(H)=T$, then all endogenous variables of EV_τ are stationary;

(2) If $Z(H)=0$, then the endogenous variables of EV_τ do not have cointegration relationship;

(3) If $0<Z(H)=z<T$, then EV_τ has z cointegration vectors.

There are two methods of Johansen cointegration test: characteristic root trace test and maximum eigenvalue test. For characteristic root trace test, if formula (17) has z maximum characteristic roots, then EV_τ has z cointegration vectors. The characteristic root μ_{z+1} of the remaining T-z non-cointegration combinations equals zero. The null hypothesis and alternative hypothesis of characteristic root trace test can be expressed as:

$$E_0: \mu_{z+1} = 0 \quad E_1: \mu_{z+1} > 0 \quad z = 0,1,2,\ldots,T-1 \quad (18)$$

Let ρ_z be characteristic root trace statistic; α be the number of observations. The test statistic can be calculated by:

$$\rho_z = -\alpha \sum_{i=z+1}^{T} \ln(1-\mu_i) \quad z = 0,1,2,\ldots,T-1 \quad (19)$$

Formula (19) shows, if ρ_0 is insignificant, there is no cointegration relationship between the variables, and the null hypothesis in formula (18) is accepted; If ρ_0 is significant, there is at least 1 cointegration vector between the variables, and the null hypothesis in formula (18) is rejected. The next step is to test the significance of ρ_1. If ρ_1 is insignificant, there is 1 cointegration vector between the variables, and the null hypothesis in formula (18) is accepted. The rest is deduced by analogy until ρ_z is insignificant.

The null hypothesis and alternative hypothesis of maximum eigenvalue test can be given by:

$$E_0: \mu_{z+1} = 0 \quad E_1: \mu_{z+1} > 0 \quad z = 0,1,2,\ldots,T-1 \quad (20)$$

The statistic test is carried out based on the maximum eigenvalue. Let β_z be maximum eigenvalue statistic; α be the number of observations. Then, we have:

$\beta_z = -\alpha \sum_{i=z+1}^{T} ln(1-\mu_i) \qquad z = 0,1,2,\ldots,T-1 \qquad (21)$

Formula (20) shows, if β_0 is insignificant, there is 1 cointegration vector between the variables, and the null hypothesis in formula (20) is accepted; if β_0 is significant, there is no cointegration relationship between the variables, and the null hypothesis in formula (20) is rejected. The next step is to test the significance of β_1. If β_1 is insignificant, there is 1 cointegration vector between the variables, and the null hypothesis in formula (20) is accepted; if β_1 is significant, there are 2 cointegration vectors between the variables, and the null hypothesis in formula (20) is rejected. The rest is deduced by analogy until β_z is insignificant.

Experiments and Results Analysis

Through the above three sections, this paper proposes a theoretical model of the interaction between structural transformation of sports cultural industry and SCPC upgrading, and analyzes the interaction between the two. The regression effect of variables was tested to verify the mutual influence mechanism between structural transformation of sports cultural industry and SCPC upgrading, thereby confirming the rationality of our analysis.

SCID and SCPC have a cooperative and interactive two-way causal relationship. To prevent the interference of the endogeneity problem between variables, this paper constructs simultaneous equations, and makes estimations by the three-stage least squares (LS) method. Table 1 shows the regression results of the simultaneous equations under different models.

Table 1

Basic regression results of simultaneous equations

	R1	R2	R3	R4
Industrial structure supererogation	3.072** (0.179)			
Consumption structure		0.513** (0.035)		-1.571** (0.218)
Industrial structure rationalization			0.513*** (0.045)	
Unemployment rate	-0.005** (0.001)		-0.013** (0.006)	
Human capital level	0.015** (0.007)		0.067** (0.008)	
Urbanization level	0.135** (0.026)		0.269** (0.036)	
Resident income	0.049** (0.015)		-0.152** (0.023)	
Government spending		-0.023** (0.007)		0.408** (0.035)
Technical innovation		0.006** (0.003)		-0.123** (0.009)
Investment demand		0.007** (0.003)		-0.118** (0.019)
Constant term	0.235** (0.012)	-0.056** (0.011)	0.098** (0.023)	-0.324** (0.056)
N	625	625	625	625
Overidentifying restrictions test	1.726	*P*=0.1927	1.554	*P*=0.1652
R^2	0.356	0.427	0.418	0.089

Note: R1 and R2 are the regression results of the simultaneous equations for sub-model *IS*1; R3 and R4 are the regression results of the simultaneous equations for sub-model *IS*2.

The regression results of R1 show that the coefficient for the influence of structure supererogation of sports cultural industry over SCPC structure was 3.072. In other words, the structural index of sports cultural products increases by 3.072 units for every unit of increase of the structure supererogation of sports cultural industry. During the structural development of sports cultural industry, the supply structure needs to be adjusted and optimized to upgrade the consumption of sports cultural products, and further realize the mutual transformation between supply and demand, in order to continuously upgrade SCPC demand.

The regression results of R2 show that the coefficient for the influence of SCPC structural upgrading over the structure supererogation of sports cultural industry was significantly positive. The structure supererogation of sports cultural industry increases by 0.513 unit for every unit of increase of the SCPC upgrading index. With the rising level of residential consumption, the demand for spiritual and health consumptions in SCPC is on the rise, which promotes the development of multi-class sectors, including sports cultural services.

The regression results of R3 show that the structure

rationalization of sports cultural industry has a positive impact on SCPC structure. Here, the industrial structure rationalization is measured by Theil index. It can be seen that, following the current trend of production factor shift, the growth of the structure rationalization index of sports cultural industry, to a certain extent, benefits SCPC structural upgrading.

The regression results of R4 show that the coefficient of the influence of structural upgrading of SCPC over the structure rationalization of sports cultural industry was -1.571. The structure rationalization index of sports cultural industry decreases by 1.571 units for every unit of increase of SCPC structural index. Hence, SCPC structural upgrading can effectively promote the structural rationalization of sports cultural industry, that is, SCPC upgrading can effectively promote the rational allocation of production factors like *CA* and *WD*, while guiding SCID.

Table 2

Regression results of simultaneous equations after changing consumer demands

	R5	R6	R7	R8
Industrial structure supererogation	1.145**			
	(0.121)			
Consumption structure		0.262**		-0.935*
		(0.152)		(0.795)
Industrial structure rationalization			0.152**	
			(0.029)	
N	625	625	625	625
Control variable	Yes	Yes	Yes	Yes
R^2	0.472	0.536	0.347	0.275

To test model robustness, this paper adjusts the consumer demands for sports cultural products from basic demands like clothing and gears to pleasurable demands like tourism and health care. Table 2 lists the regression results of simultaneous equations after changing consumer demands. Despite the adjustment of consumer demands, the significance of different coefficients did not change greatly. The structure rationalization of sports cultural industry still interacts with SCPC upgrading: SCPC upgrading promotes the structure rationalization of sports cultural industry, while the latter negatively affects the former.

Considering the lag in the influence of SPA on SCID and SCPC, SPA time-delay term was introduced to the regression of simultaneous equations. The results in Table 3 show that, after the introduction of time-delay term, the influence coefficient of SCPC upgrading over structure transformation of sports cultural industry became insignificant, suggesting that the obtained regression results are relatively robust. In the short term, the interaction intensifies between structural transformation of sports cultural industry and SCPC upgrading; in the long run, the correlation and interaction between the two will weaken.

Table 3

Regression results of simultaneous equations after introducing time-delay term

	R9	R10	R11	R12
Industrial structure supererogation	2.153**			
	(0.076)			
Consumption structure		0.352**		-0.453*
		(0.016)		(0.095)
Industrial structure rationalization			0.316**	
			(0.019)	
N	610	610	610	610
Control variable	Yes	Yes	Yes	Yes
R^2	0.562	0.572	0.617	0.136

Table 4 shows the regression results of simultaneous equations after introducing disturbance term covariance matrix (DTCM). It can be observed that the test results before and after introducing DTCM were consistent with the basic regression results in Table 1: SPCP structural upgrading can effectively promote the structure supererogation and renationalization of sports cultural industry, and the structure supererogation of the industry can promote SPCP structural upgrading.

Table 4

Regression results of simultaneous equations after introducing DTCM

		Before introducing DTCM				Our algorithm			
		R13	R14	R15	R16	R17	R18	R19	R20
After introducing time-delay term	Industrial structure supererogation						1.035** (0.016)		
	Consumption structure					0.935** (0.025)		0.316** (0.019)	
	Industrial structure rationalization								0.927** (0.095)
Before introducing time-delay term	Industrial structure supererogation	2.975* (0.095)				0.165* (0.063)			
	Consumption structure		0.552* (0.095)		-1.029* (0.231)		0.017* (0.006)		-0.127** (0.032)
	Industrial structure rationalization			0.539* (0.045)				0.059* (0.016)	
	N	605	605	605	605	605	605	605	605
	Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	R^2	0.435	0.372	0.398	0.121	-	-	-	-

Based on the classification of time series correlation of SCID, this paper calculates the weights of the internal relationships in different classes of sector under the effect of SPA.

Table 5

Features of different classes of SCID

Class	Fitness and recreation	Competition and performance	Venue service	Sports brokerage	Sports brokerage
Number of enterprises	7	8	7	12	5
Expected weight	0.19	0.25	0.17	0.34	0.12
Actual weight	0.25	0.23	0.11	0.27	0.09
Development feature	Main beneficiary	Bidirectional overflow	Mediator	Net beneficiary	Mediator

Table 5 lists the features of five classes of SCID: fitness and recreation, competition and performance, venue service, sports brokerage, and sports training. Fitness and recreation had an actual weight of 0.25, 0.06 above the expected weight (0.19). Thus, this class is the primary beneficiary among the five major sectors. The SCID of fitness and recreation is characterized by the transmission and reception of external relationships. The reception of external relationships is more prominent than the transmission. The enterprises in this class are greatly affected by the other classes of SCID, and, to some degrees, drive the SCID of other regions. These enterprises also mutually affect each other. Figure 3 reports the depth changes of different classes of SCID.

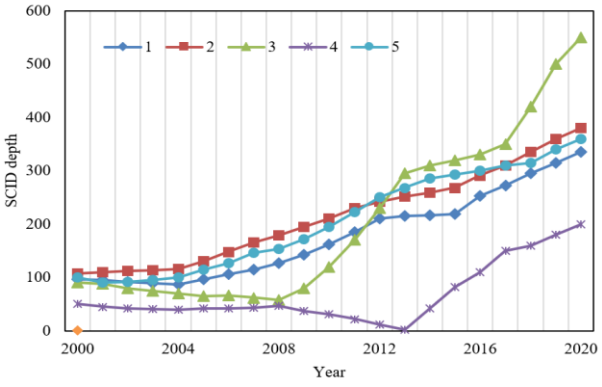

Figure 3. Depth changes of different classes of SCID

Table 6

Descriptive statistics on SCPC, SCID, and SPA

Month-on-month data	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
SCPC	2.367541	2.000000	8.90000	-1.700000	2.324394	0.617529	3.658623
SCID	17.64213	15.70000	28.76000	10.30000	3.846243	1.752964	5.074561
SPA	21.85123	24.00653	56.39785	2.654512	9.785438	0.285426	3.09785

Before further analysis, the descriptive statistics of variables SCPC, SCID, and SPA were given (Table 6). The month-on-month data show that the skewness of all three parameters was greater than 0, and the kurtosis of them was greater than 3, indicating that the three parameters oscillate violently. SCPC is negatively correlated with SPA, and positively with SCID. Meanwhile, the correlation coefficient between SPA and SCPC was relatively large. It can be understood as SPA affects the growth of SCID by impacting the growth of SCPC.

Table 7

ADF test results

Variable	SCPC	SCID	SPA
1%	-2.6329	-2.6281	-2.6735
5%	-1.8724	-1.8724	-1.8724
t-statistic	-1.2573	-0.5934	0.4783
p-value	0.1862	0.4853	0.3612

Table 7 presents the ADF unit root test results on SCPC, SCID, and SPA. The p-values of all variables were insignificant at the levels of 1% and 5%. Thus, the null hypotheses should be accepted: under the effect of SPA, the original time series of SCPC and SCID are nonstationary time series. Table 8 shows the ADF test results after first-order differencing. This time, the p-values of all variables were significant at the levels of 1% and 5%, indicating that the null hypothesis should be rejected: the original time series are stationary. Figure 4 shows the trend of each original time series after first-order differencing. It can be learned that the time series changed more stably after first-order differencing.

Table 8

ADF test results after first-order differencing

Variables	SCPC	SCID	SPA
1%	-3.7612	-3.7612	-3.7612
5%	-2.8555	-2.8555	-2.8556
t-statistic	-4.3574	-3.6725	-5.1734
p-value	0.0003	0.0019	0.0000

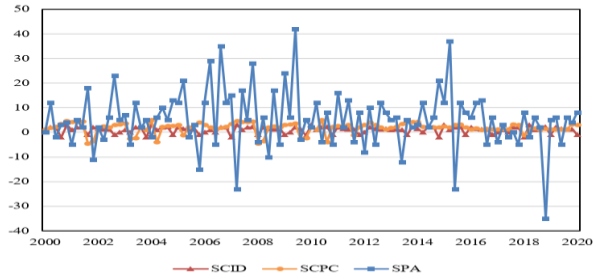

Figure 4. Trend of each of the three parameters after first-order differencing

This paper also summarizes the Johansen cointegration test results on SCPC, SCID, and SPA. The test statistics of characteristic root trace test and maximum eigenvalue test are recorded in Tables 9 and 10, respectively. By either test method, the null hypothesis was rejected, i.e., there is 1 cointegration vector between the three parameters. Table 11 shows the normalized cointegration coefficients of the three parameters.

Table 9

Test statistics of characteristic root trace test

Number of cointegration vectors	0	1	2
Characteristic root	0.127534	0.039513	0.003584
Trace statistic	30.08751	6.015666	0.572561
p-value	0.0472	0.6852	0.4892

Table 10

Test statistics of maximum eigenvalue test

Number of cointegration vectors	0	1	2
Characteristic root	0.127534	0.039513	0.003584
Maximum eigenvalue	25.09523	5.475203	0.578523
p-value	0.0175	0.6759	0.4759

Table 11

Normalized cointegration coefficients of the three parameters

CPI_RATE	M2_RATE	INV_RATE
1.000000	-0.312542	0.057523

The above results show that SCPC, SCID, and SPA have equilibrium relationships in the long term, because there is only 1 cointegration vector between them.

Conclusions

This paper explores the correlations between SPA, SCPC, and SCID. Firstly, the relationship between SCPC and SCID was modeled, the action mechanism of SCPC on SCID was detailed, and the dynamic correlation between SCPC and SCID was analyzed. Through comprehensive consideration of SPA, the authors then discussed the associations between SPA, SCPC, and SCID from the perspective of correlations. Coupled with experiments, estimations were made with proposed simultaneous equations, using three-stage LS method. The regression results of simultaneous equations were obtained under different models. Next, the authors analyzed the regression results of these equations after changing the classes of consumer demands, and after introducing the DTCM. The regression results were found consistent with the results of basic regression (Table 1). In addition, the features of five classes of SCID, namely, fitness and recreation, competition and performance, venue service, sports brokerage, and sports training, were analyzed, and the results of ADF unit root test and Johansen cointegration test were obtained for SCPC, SCID, and SPA.

In previous studies, SCPC upgrading has attracted more and more attention. Based on the work of predecessors, this paper attempts to clarify the interactive relationships between SPA, SCPC, and SCID. However, there are several aspects of the manuscript to be further explored and improved:

(1) Due to data availability, this paper mostly measures structural transformation of sports cultural industry and SCPC upgrading, and their relationship with macro structural indices, lacking the support from micro data. To reflect micro influences, it is suggested to design a brand-new city-level SCPC upgrading evaluation system/

(2) The other interactive paths between structural transformation of sports cultural industry and SCPC upgrading should be further investigated, both theoretically and empirically.

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