Zhang D & Li H (2025) DEVELOPMENT PATH INNOVATION OF DIGITAL SPORT INDUSTRY UNDER INTERNET ENVIRONMENT. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 25 (99) pp. 75-89.
DOI: https://doi.org/10.15366/rimcafd2025.99.006

ORIGINAL

DEVELOPMENT PATH INNOVATION OF DIGITAL SPORT INDUSTRY UNDER INTERNET ENVIRONMENT

Dongsheng Zhang, Huijun Li*

School of Physical Education of Inner Mogolia University, Hohhot, 010021, Inner Mongolia Autonomous Region, China.
E-mail: zhangdongsheng693280@126.com

Recibido 07 de Marzo de 2024 **Received** March 07, 2024
Aceptado 10 de Octubre de 2024 **Accepted** October 10, 2024

ABSTRACT

The Chinese government and relevant departments have attached great importance to and supported the development of digital Sport industry. Digital communication technology has transformed the traditional sport, leading to the birth of digital newspapers, digital radio and digital TV, and making the traditional sport industry glow with new vitality. This research focuses on the development path innovation of digital Sport industry based on big data in the Internet environment. In order to study the cost warning situation of digital Sport industry and know the future development trend of cost warning situation, this paper will combine SVM (support vector machine) and AC (Analog Complexing) methods to establish an early warning model. Through qualitative analysis of the factors that affect the cost of digital Sport industry, the initial cost early warning index system is established, and then the grey correlation method is used to calculate the correlation degree between warning indicators and warning indicators, and the index with larger correlation degree is selected, and the final cost early warning index system is established through quantitative and qualitative analysis. The results show that the weighted frequent item sets generated by this algorithm take much less time than SVM algorithm, and the time cost of this algorithm is reduced by 8.681% compared with SVM algorithm. It is verified that the model has good stability, simple use and high efficiency, and can be used as a conventional analysis and processing method in this field.

KEYWORDS: Internet; Big Data; Digital Sport Industry; Data Mining.

1. INTRODUCTION

Digital sports leverage modern technology to enhance the sports

experience, including online live streaming, virtual reality and esports. At the same time, it helps athletes and enthusiasts optimize performance and exercise through data analytics and fitness apps, enhancing interaction with the audience. With the popularity of social media, digital sports are redefining the way sports are engaged and consumed. Digital Sport design industry combines the most popular digital technology and culture and art, and forms a close cooperative relationship with other industries in China at present, which has great development value and prospects. Based on digital technology and combining culture and art, the digital Sport industry has become the hottest, most promising and valuable emerging industry. In the era of big data, internet plus has penetrated into all walks of life. Nowadays, digital technology has exerted the greatest revolutionary influence on the sport. Its application in the sport industry and the all-round development of society influences and promote each other, and there is a close interactive relationship between them. Digital communication technology has brought a brand-new sport platform, which has brought many challenges to newspapers, radio and television. Digital communication technology has transformed the traditional sport, leading to the birth of digital newspapers, digital radio and digital TV, and making the traditional sport industry glow with new vitality (Gor, 2019). The problem of cultural shaping and value expression of digital Sport has not only become an important bottleneck that puzzles the development of digital Sport, but also makes people constantly bear the unprepared cultural doubts and even the social and cultural psychological harm brought by it when they accept the new feelings of digital Sport (Wsilliam, 2018). However, it can't be denied that China's digital Sport design industry chain has just begun to take shape. Chinese government and relevant departments have attached great importance to the development of digital Sport industry and given all-round support, for example, establishing digital Sport industry base and providing financial support for related digital sport technology research and development. The decisive influence of technology on enhancing communication effect is the consensus of people in the industry. The application of digital technology has an obvious influence on the birth of new sport such as Internet, digital broadcasting, digital TV, digital mobile communication terminals and their communication content, form and effect. Through the investigation of the development of regional digital Sport industry, it is of certain reference significance to further guide the development of the whole digital sport industry by examining the interaction between digital sport and the overall development of the region.

1.1 Research Innovation

(1) This study investigates the development of digital sport industry in typical regions, and examines its impact on the overall development of local society, which can provide detailed reference for further guiding and promoting the development of digital sport industry.

(2) In this paper, DM is used to innovatively explore the development path of digital Sport industry, and on this basis, some countermeasures and suggestions are put forward, hoping to have a certain guiding role for the development of digital Sport industry.

The main contents of this paper include: The first chapter introduces the background work of the research. The second chapter mainly introduces the present situation of this research. The third chapter puts forward the DM model of digital Sport industry development path based on big data. The fourth chapter verifies the performance of the model studied in this paper. The fifth chapter is the conclusion.

2. Related Work

2.1 Research on Digital Sport Industry

Lee et al.' s research on "the development of sport industry", the changes of sport system under the background of digitalization, including the relationship between government and sport, the path and mode of development; The industrial structure refers to the proportional relationship and integration pattern between different old and new sport (Lee & Lee, 2019). Nortvig et al., through a comprehensive analysis of the development of digital sport industry in representative counties, deeply discussed many topics such as format change, performance integration, domain expansion and industrial integration of digital sport in the digital age, and provided theoretical suggestions for the development mode and management policy of digital sport (Carmen, 2021; Nortvig et al., 2020). In the economy, the most important component is the industrial structure and employment structure, which are important components of the economic structure. If we want to complete the economic development and social progress, we must know how much the employment structure and industrial structure have influenced the multi-economy. Viardot et al. revealed the distribution and transfer law of labor force in three major industries with the development of economy, and also pointed out that the reason for the change of labor force distribution structure is the relative income gap between industries (Viardot et al., 2021). Park et al. compared the actual structure produced by the change of industrial structure with the standard structure, and the data obtained from the comparison provided a reference for measuring the development of industrial structure and employment structure (Park & Vasudevan, 2021; Vaughn & Leon, 2021).

2.2 Research Status of DM

Knowledge discovery and DM (data mining) is one of the most important topics in the field of database. The explanation of data warehouse put forward by Artieri et al. is that data warehouse is a data set, and its main features are subject-oriented, time-varying, integrated and effective set for supporting

decision (Boccia Artieri & Gemini, 2019). Khedr et al. have made remarkable achievements in dealing with whether they are suitable suppliers by statistical methods (Khedr et al., 2020). Su et al. think that industrial alliance is a collection of contracts. Although they are both alliances, the property rights of alliance members are independent (Su et al., 2019). Different enterprises in the same supply chain produce the same or different products in different regions. Shao et al. Used earned value method to jointly monitor the progress and cost, and effectively monitored and warned the cost and progress in the project implementation process through the constructed performance analysis prediction model (Shao et al., 2018). Zhang et al., using labor cost theory and statistical analysis methods, established an elastic index system and an early warning model of labor cost control, and discussed the methods and countermeasures of labor cost control, which promoted the establishment of self-restraint mechanism of labor cost (Zhang et al., 2019). Wang et al. used association rule algorithm to determine the interdependence of cost drivers in the cost accounting based on activity-based costing, that is, after one or more cost drivers are known, they can estimate other cost drivers that are difficult to determine (Wang Fang et al., 2018). Xu et al. put forward a logistics cost prediction model based on neural network, which is optimized by genetic algorithm. The empirical results show that the prediction model is stable and accurate, which provides reference value for stimulating domestic demand and expanding consumption (Xu & Luo, 2021).

3. Methodology

3.1 The Role of Industry in Promoting Digital Sport Technology

Every era will have new sport belonging to that era. The reason for sport renewal may come from external technical conditions, and the artistic texts created in this free space will also have a free atmosphere. At the same time, it is also free to accept or appreciate any kind of digital artistic texts, and this freedom almost exceeds the limitations of time and space, reality and virtual. At this time, the digital artistic texts have both social and cultural values. Traditional art is limited by material, technology and other factors, so the form of expression is single. In the era of pan-sport, pure art should conform to the trend and adapt to the new requirements of the times through pan-sport. With the emergence of new sport and other network means, digitalization has brought cross-border and diversity to artistic creation, which makes sensory content richer and more comprehensive than before (Basciftci et al., 2018; Qiao et al., 2020). The influence of inter-regional economic relations on regional markets is directly reflected in regional market division and market network layout. And reasonable interregional relations can promote the formulation and implementation of reasonable interregional economic policies and industrial policies. It can be seen that when studying the economic development of a region, we must never ignore the inter-regional relationship, and we must

rationally plan the economic development of this region from a higher angle and a broader vision. Figure 1 shows the Digital Sports Industry development structure.

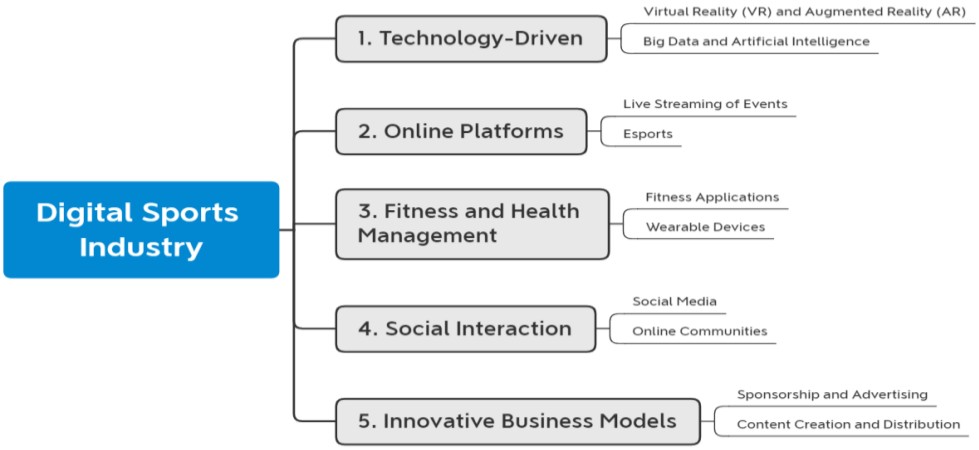

Figure 1: Digital Sports Industry development structure

According to the theory of product life cycle, any industrial product has a certain life cycle, that is, with the development of production and technology, the technology intensity of products will decrease, and with the change of technology intensity of products, the production of products will shift from region to region, and the expansion stage is the period when the production technology of products gradually matures and the market demand is expanding. The most important influencing factors of product production at this stage are management and capital. Maturity and the later stage of maturity are the periods of product market saturation and technology stagnation. The most critical factor affecting the production of products at this stage is cheap and simple labor. Backward areas have a large number of cheap labor, so the production of products at this stage will be transferred to the backward areas. At present, the film and television industry is in a pluralistic era, and globalization has intensified the blending of film and television cultures. While China's film and television industry is gradually in line with international standards, its traditional cultural characteristics have also been ignored. China's digital Sport industry is also beginning to face a full-scale collision with foreign digital Sport industries. The mature experience of foreign countries is worth learning for the construction and operation of China's digital Sport industry. Let the cultural industry develop freely according to the needs of the market, but at the same time, the comments and reviews of organizations such as associations spontaneously set up by relevant cultural enterprises are very objective and authoritative, so that the legality and artistry of cultural products can be guaranteed to the greatest extent.

3.2 DM of Digital Sport Industry Development Path Based on Big Data

In daily life, people are surrounded by various sport, which affect our

cultural orientation, our judging standards and right and wrong angles. With the vigorous development of multisport technology, people's concept of cultural consumption has also undergone tremendous changes, and only works with true feelings in plays can impress the audience and be generally recognized by people. Movies and cartoons in different countries reflect the cultural history, customs, political traditions and cultural heritage of different countries, and people's sense of identity and belonging to their own culture. People can appreciate the diversity of the world culture and experience the unique experience of harmony and difference while watching movies and cartoons. The application and popularization of information technology such as computer network and other related intelligent technologies have become an important strategy for national development, so as to comprehensively improve the economic operation efficiency, labor productivity, enterprise competitiveness and people's living standards. If you want to enjoy such a rich and colorful tourism culture, you need enough time, expense and energy. Even so, you may not be able to enjoy it completely. It is a good choice to browse the tourism cultures around the world through film and television works. DM is an effective and potentially valuable information processing technology that extracts from a large number of fuzzy, unreal, redundant and complex data sources. From the perspective of economic benefits, DM is a new technical means to achieve enterprise profits. It can extract and process valuable data from the complicated business of enterprises, so as to make data support for business judgment. It is also a criterion for finding the dependency conditions between data (Schack et al., 2018). In this paper, Apriori algorithm in clustering mode and correlation mode is selected to mine the development path of digital Sport industry, so as to obtain the selection result of industrial development. SVM (support vector machine) is a machine learning method based on statistical theory, which has been well applied to classification, regression and face recognition. The purpose of linear SVM regression is to find the functional relationship between independent variables and dependent variables. If a suitable functional relationship can be found to minimize the loss function, it can be used as the regression equation of SVM. It is assumed that the linear function can fit all the training samples, namely:

$$min\frac{1}{2}\|w^2\|, \rightleftarrows s.t.\begin{cases} w\cdot x_i + b - y_i \le \varepsilon \\ y_i - w\cdot x_i - b_i \le \varepsilon \end{cases} (i = 1,2,\cdots,n) \quad (1)$$

Therefore, the regression function is:

$$f(x) = \sum_{i=1}^{n}(a_i - a_i^*)\,k(x_i\cdot x) + b^* \quad (2)$$

Factor analysis is used to determine the relationship between variables and reduce subsequent analysis variables. These linear combinations are called principal components, and their dimension reduction data can be used for further analysis (Zhong et al., 2018). Calculate the correlation coefficient of

the sample correlation matrix:

$$r(x,y) = \frac{k(x,y)}{\sigma_x^* \cdot \sigma_y^*} = \frac{\sum n_{xy} xy - x^* y^*}{n\sigma_x^* \cdot \sigma_y^*} \quad (3)$$

Clustering analysis is an unsupervised DM method, which only groups data according to the information describing objects and their relationships. Its goal is that the objects within a group have the greatest similarity to each other and the objects between groups have the smallest similarity (Huang et al., 2018). Let Nrepresent the number of observations, and x_i represents the ith observation $i - 1,2,\cdots,N$; Let K represent the number of categories, $C_i(l = 1,2,\cdots,K)$ represents the set of serial numbers of observations belonging to the l -th category, and $C_i(i)(l = 1,2,\cdots,N)$ represents the serial number of the category to which observation i belongs. The commonly used distance measure in K-means clustering method is Minowski distance:

$$d(x,y) = \left[\sum_{r=1}^{p} |x_r - y_r|^m\right]^{1/m} \quad (4)$$

$m = 2$ by default (that is, the default distance is European). In order to study the cost alert of digital Sport industry and know the future development trend of cost alert, this paper will combine SVM and AC (Analog Complexing) to establish an early warning model and study the cost alert of digital Sport industry. See Figure 2 for the construction ideas of the specific cost early warning model.

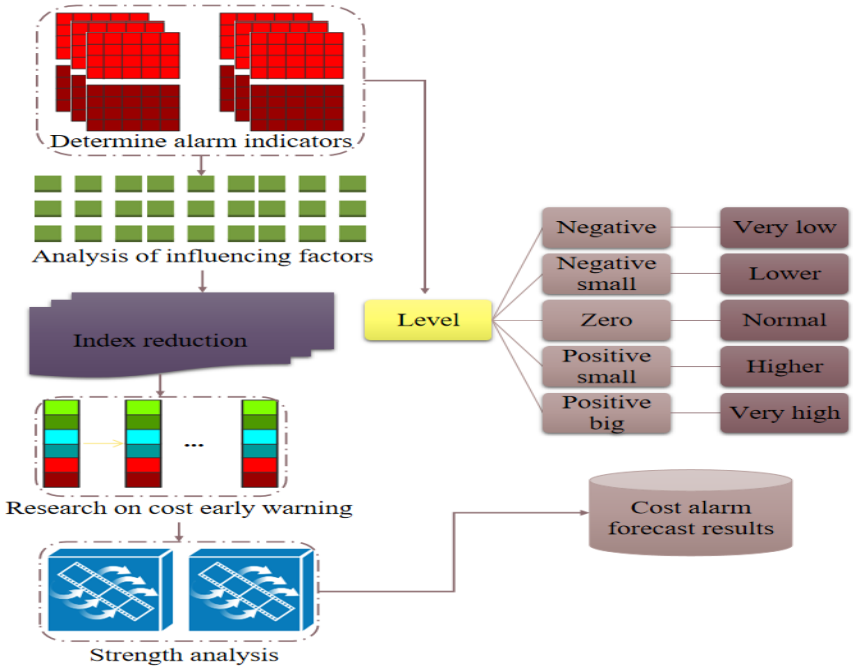

Figure 2: Build a cost pre-popularization model

The AC algorithm combines the self-organizing DM method with the

advanced screening program, thus improving the application performance. Different from other parametric models, it predicts variables from local patterns by looking for patterns similar to local ones. To measure the similarity between the reference pattern P^R and the transformed candidate pattern $P_k(i)$, it is necessary to calculate the distance between the$i$th candidate pattern and the reference pattern, namely:

$$d = \frac{1}{k+1}\sum_{j=0}^{k-1}\sqrt{\sum_{r=1}^{m}\left(x_{r,i+j} - x_{r,N-k+j+1}\right)^2} \quad (5)$$

Therefore, the similarity $s_i = 1/d_i$ between the two patterns shows that the similarity and the distance have opposite effects, and the larger the distance, the smaller the similarity of the patterns. We take $\{g_j\}$ as the equal weight andg_j as the weight coefficient of the combined model, namely:

$$y_{N+1} = \sum_{j=1}^{F} g_j y_{j+k+i-l} \quad (6)$$

Among them, the prediction range is $\tau, i = 1,2,\cdots,\tau$; The extension of variables to be predicted in reference mode and similar mode are $y_{N+1}, y_{j+k+i-l}$, respectively. Then the prediction can be obtained from the combination of Fsimilar patterns. For each non-empty subset s of l, if,

$$\frac{Support\_count(l)}{Support\_count(s)} \geq min \geq conf \quad (7)$$

Output rules$s \Rightarrow (l-s)$. Where $min \geq conf$ is the minimum confidence threshold. Let I be the set of all items, Y be q - item set $q < k$, and remember that the first $k-q$item with the largest weight in item set $I-Y$ is $\{w_{r1}, w_{r2}, \cdots, w_{r(k-q)}\}$. Then the maximum possible weight of any k - itemset containing itemset Y is:

$$W(Y,k) = \sum_{i_j \in Y} w_j + \sum_{j=1}^{k-q} w_{r_j} \quad (8)$$

The first sum formula is the sum of the weights of q items in q - item set Y, and the second sum formula is the sum of the top $k-q$ maximum weights of the remaining items. Convert the indicators into isolated comprehensive indicators, and extract representative and valuable evaluation indicators. At the same time, save the information of the initial data. Indices are isolated and unconnected individuals, thus reducing the redundancy of information. The variance contribution rate of the k principal component is:

$$a_k = \lambda_k \sum_{i=1}^{p} \lambda_i \quad (9)$$

The cumulative variance contribution rate of the first k principal components $y_1, y_2, \cdots, y_k$ is:

$$a(k) = \frac{\sum_{j=1}^{k} \lambda_j}{\sum_{i=1}^{p} \lambda_i} \tag{10}$$

The index system should avoid the repetition of the same or similar variables, so it should be concise, general and representative. If the number of variables with the largest possible number is smaller, take the smallest possible number.

4. Experiment and Results

Considering the availability and continuity of sample data, the warning time of this empirical analysis is based on years, and the data of warning indicators and warning indicators are collected in each year. Among them, the total cost of warning indicators is calculated by the collected data of cost profit rate and total profit. The grey correlation analysis method is used to calculate the correlation degree between warning indicators and warning indicators. A larger correlation degree indicates that the warning indicators and warning indicators are closely related, so the warning indicators are selected as the research variables, and the final cost early warning index system is determined. Cluster analysis is used to try to classify the risk factors and explore the clustering situation of each risk. SPSS 26.0 software is used to process the data of experts' scoring, and factor analysis is used to further explore the common relationship of various risk indicators and explore the common factors of various risk indicators. Cluster analysis results are as follows: Figure 3 and Figure 4:

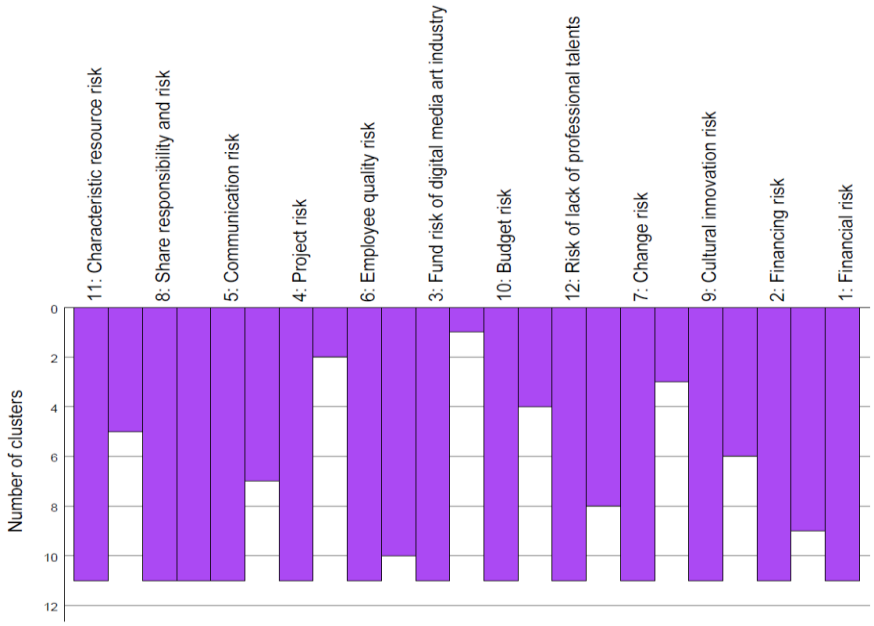

Figure 3: Icicle diagram of risk variable cluster analysis

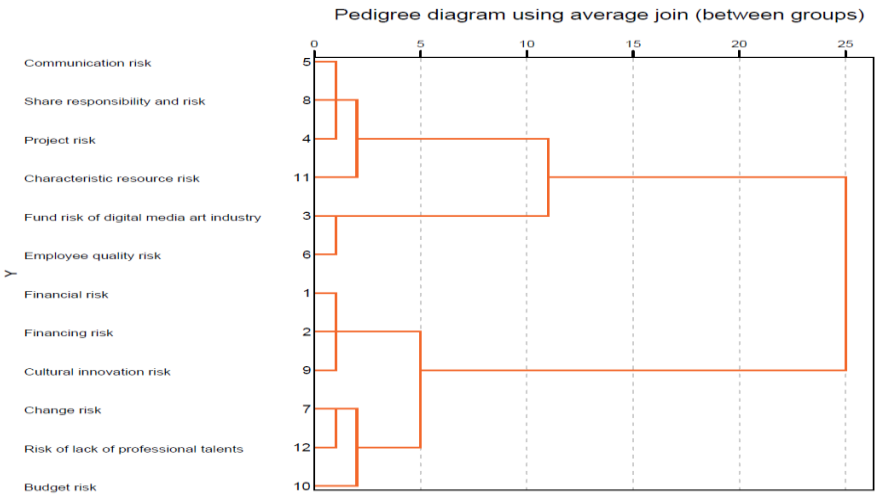

Figure 4: Cluster pedigree diagram of risk variables

From the systematic cluster pedigree diagram and icicle diagram of risk indicators, it can be seen that the obvious cluster groups are 2, 3 and 4, 5 and 6, 1 and 7 and 12, 8, 9 and 1. Financial risk, financing risk and digital Sport industry fund are grouped together, project design and communication risk are grouped together, decision-making change risk and liability risk are grouped together, budget risk and characteristic resource risk are grouped together, and professional talent shortage risk and employee quality risk are grouped together respectively. As can be seen from Table 1 and Figure 5, from 6.52% in 2010 to 3.49% in 2021, the proportion of fixed assets investment in the secondary and tertiary industries fluctuates, which shows that although the industrial structure in the research area tends to be reasonable gradually, more and more attention is paid to the tertiary industry.

Table 1: Study the fixed assets investment structure of the whole society in the region

YEAR	INVESTMENT IN FIXED ASSETS OF TERTIARY INDUSTRY		
	PROPORTION OF PRIMARY INDUSTRY (%)	PROPORTION OF SECONDARY INDUSTRY (%)	PROPORTION OF TERTIARY INDUSTRY (%)
2010	6.502	49.68	41.811
2011	6.614	45.962	50.957
2012	6.61	54.018	43.567
2013	5.111	47.338	41.593
2014	5.679	48.643	41.627
2015	4.214	50.464	52.785
2016	4.71	49.345	41.541
2017	4.044	44.876	48.22
2018	3.041	43.011	40.712
2019	3.55	42.722	54.112
2020	3.011	44.276	51.036

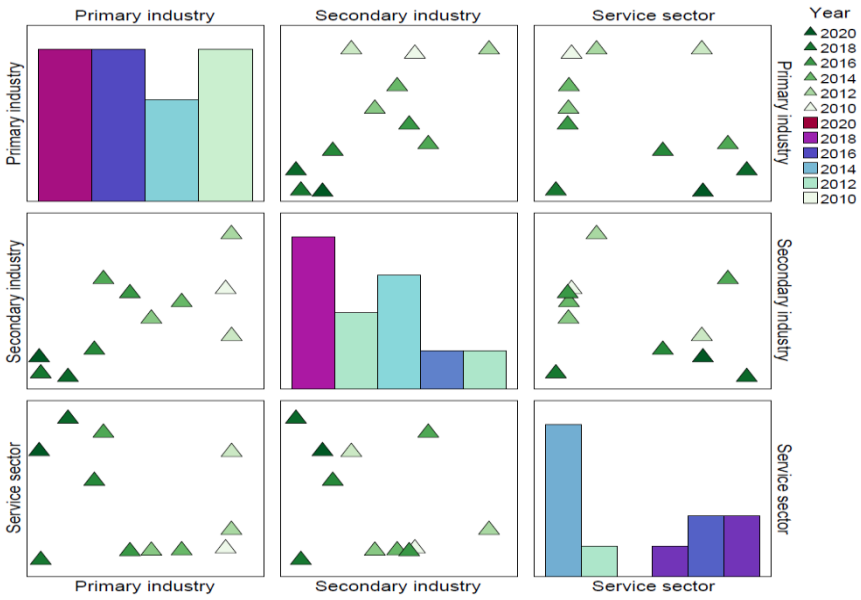

Figure 5: Distribution map of investment structure of all social fixed assets

Take the total cost of warning indicators from 2010 to 2020 as the reference sequence, and the original 10 warning indicators as the comparison sequence; Then, the initialization method is used to make the data sample dimensionless. The resolution coefficient is set to 0.5, which is realized by matlab programming, and the correlation degree of each warning indicator in Table 2 is obtained.

Table 2: Correlation degree of warning signs

WARNING INDICATOR	DEGREE OF ASSOCIATION	WARNING INDICATOR	DEGREE OF ASSOCIATION
GDP	0.95955	Number of business units	0.9309
GROSS OUTPUT VALUE OF SECONDARY INDUSTRY	0.9335	Total assets	0.92288
RESIDENTS' CONSUMPTION LEVEL	0.94351	Turnover times of current assets	0.92245
UNEMPLOYMENT RATE	0.96113	Accumulated depreciation	0.90324
RMB EXCHANGE RATE	0.93116	Total liabilities	0.92039

The economic attribute research method is similar to the natural attribute research method, and it starts from each sub-index belonging to the economic attribute. If the index dimension is large, the principal component analysis method is used to reduce the dimension first, and all components with cumulative contribution rate greater than 85% are selected for clustering. Fiscal revenue and expenditure are closely related, so this paper puts two three-level indicators (fiscal expenditure and fiscal revenue) together for analysis, so as to

facilitate the next step of correlation analysis. The fiscal revenue and expenditure of each region affect the financial situation of each province. The clustering results of fiscal revenue and expenditure of each region are shown in Figure 6.

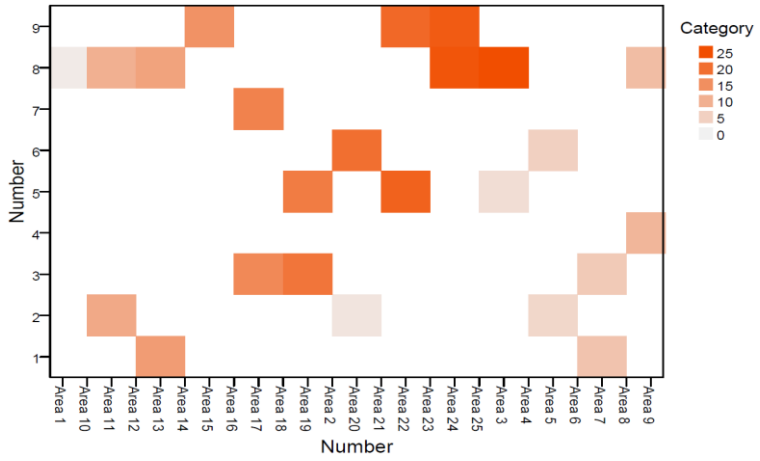

Figure 6: Cluster results of fiscal revenue and expenditure in different regions

From the cluster results, it can be seen that the infrastructure construction and management of cities in economically developed areas are at a high level, similar to economic attributes and fiscal revenue attributes. At the same time, similar conclusions are drawn with statistical research methods: it is found that capital strength (investment in fixed assets and the balance of residents' savings at the end of the year) has a great impact on GDP, which undoubtedly has a direct impact on urban infrastructure. In order to show the superiority of SVM_AC algorithm over SVM algorithm in performance, this section will test the performance of SVM_AC algorithm and SVM algorithm, and compare and evaluate their test results. Because the real transaction database file is not easy to get, the database used in the test is a simulated transaction database file, in which a transaction is stored as a line. Figure 7 shows the time taken by the two algorithms to generate weighted frequent item sets under different support thresholds.

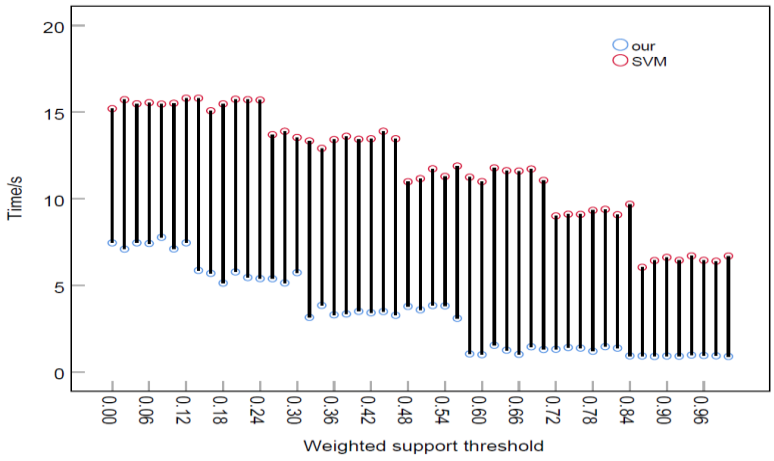

Figure 7: Time taken to generate weighted frequent item sets

It can be seen that the weighted frequent item sets generated by this algorithm take much less time than SVM algorithm, and the time cost of this algorithm is reduced by 8.681% compared with SVM algorithm. This is mainly because the weighted frequent item sets generated by this algorithm have less redundancy, which is more interesting to decision makers. From the above two tables, we can see that this algorithm has much better performance than SVM algorithm. Through the application of the above example, it is proved that the application model of DM technology in the innovation research of digital Sport industry can play a good role in the research of long-term macroeconomic or short-term policy efficiency. The model is stable, easy to use and efficient, and can be used as a conventional analysis and processing method in this field.

5. Conclusions

The digital sports industry has emerged as a vital sector, driven by technological advancements and the growing influence of big data. This research highlights the importance of establishing a robust cost warning model that combines Support Vector Machine (SVM) and Analog Complexing (AC) methods. Such a model not only enhances the efficiency of cost management but also provides valuable insights into future trends, thereby supporting strategic decision-making in an increasingly competitive environment. However, while this study contributes significantly to the understanding of cost dynamics within the digital sports sector, it also acknowledges certain limitations. The reliance on specific algorithms may restrict the model's adaptability to varying contexts or unforeseen market changes. Furthermore, qualitative factors influencing costs may require deeper exploration to fully capture the complexities of the industry. Looking ahead, the digital sports industry is poised for remarkable growth and innovation. The ongoing integration of artificial intelligence, machine learning, and blockchain technology is expected to revolutionize fan interactions and operational processes. Additionally, as consumer preferences continue to evolve, there will be a greater emphasis on personalized experiences and data-driven insights. With sustained support from government bodies and industry stakeholders, the digital sports sector will not only redefine traditional sports but also open new avenues for economic development and societal engagement in the years to come.

Acknowledgements

Fund Project: General Project of the National Social Science Fund of China in 2023: Research on the Relationship Mechanism and Implementation Path of Deep Integration of Culture, Sports, and Tourism in Inner Mongolia from the Perspective of embodied experience (Fund No.: 23BTY030).

REFERENCE

Basciftci, B., Ahmed, S., Gebraeel, N. Z., & Yildirim, M. (2018). Stochastic

optimization of maintenance and operations schedules under unexpected failures. *IEEE Transactions on Power Systems*, *33*(6), 6755-6765.

Boccia Artieri, G., & Gemini, L. (2019). Mass media and the web in the light of Luhmann's media system. *Current Sociology*, *67*(4), 563-578.

Carmen, J. (2021). Makerspaces: combining information literacy with pattern design for fiber art through digital images. *Library trends*, *69*(3), 585-611.

Gor, A. (2019). Reimagining the iconic in new media art: mobile digital screens and chôra as interactive space. *Theory, Culture & Society*, *36*(7-8), 109-133.

Huang, S., Gu, X., Zhou, H., & Chen, Y. (2018). Two-dimensional optimization mechanism and method for on-demand supply of manufacturing cloud service. *Computers & Industrial Engineering*, *117*, 47-59.

Khedr, A. M., Osamy, W., Salim, A., & Abbas, S. (2020). A novel association rule-based data mining approach for internet of things based wireless sensor networks. *IEEE access*, *8*, 151574-151588.

Lee, J. W., & Lee, S. H. (2019). User participation and valuation in digital art platforms: the case of Saatchi Art. *European Journal of Marketing*, *53*(6), 1125-1151.

Nortvig, A.-M., Petersen, A. K., Helsinghof, H., & Brænder, B. (2020). Digital expansions of physical learning spaces in practice-based subjects-blended learning in Art and Craft & Design in teacher education. *Computers & Education*, *159*, 104020.

Park, A., & Vasudevan, L. (2021). Remaking Community With Art. *Journal of Adolescent & Adult Literacy*, *64*(5), 589-593.

Qiao, B., Jiang, S., & Zhang, J. (2020). Stereoscopic optimization of industrial structure of the equipment manufacturing industry from the perspective of collaborative emissions reduction: Evidence from China. *Plos one*, *15*(4), e0232293.

Schack, D., Rihko-Struckmann, L., & Sundmacher, K. (2018). Linear programming approach for structure optimization of renewable-to-chemicals (R2Chem) production networks. *Industrial & Engineering Chemistry Research*, *57*(30), 9889-9902.

Shao, Y., Liu, B., Wang, S., & Li, G. (2018). A novel software defect prediction based on atomic class-association rule mining. *Expert Systems with Applications*, *114*, 237-254.

Su, T., Xu, H., & Zhou, X. (2019). Particle swarm optimization-based association rule mining in big data environment. *IEEE access*, *7*, 161008-161016.

Vaughn, M. P., & Leon, D. (2021). The personal is political art: using digital storytelling to teach sociology of sexualities. *Teaching Sociology*, *49*(3), 245-255.

Viardot, E., Mccarthy, I. P., & Chen, J. (2021). Standardization in a digital and global world: State-of-the-art and future perspectives. *IEEE Transactions*

On Engineering Management, *68*(1), 11-17.

Wang Fang, W. F., Xia LiHua, X. L., Chen ZhiBin, C. Z., Cui WenJun, C. W., Liu ZhiGen, L. Z., & Pan CuiHong, P. C. (2018). Remote sensing identification of coastal zone mariculture modes based on association-rules object-oriented method.

Wsilliam, D. (2018). Book review: Virtual Memory: Time-Based Art and the Dream of Digitality. In: SAGE Publications Sage UK: London, England.

Xu, R., & Luo, F. (2021). Risk prediction and early warning for air traffic controllers' unsafe acts using association rule mining and random forest. *Safety science*, *135*, 105125.

Zhang, R., Chen, W., Hsu, T.-C., Yang, H., & Chung, Y.-C. (2019). ANG: a combination of Apriori and graph computing techniques for frequent itemsets mining. *The Journal of Supercomputing*, *75*, 646-661.

Zhong, W., Liu, S., Wan, F., & Li, Z. (2018). Equipment selection knowledge base system for industrial styrene process. *Chinese Journal of Chemical Engineering*, *26*(8), 1707-1712.