Application of factor analysis in risk evaluation of basketball arena project construction

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Abstract

In basketball arena project construction, the project safety is an important topic. Aimed at the current situation of basketball arena project construction, the risk factors in the project construction are evaluated from the aspect of factor analysis method and the data in the process are processed according to relevant theory of factor analysis method and by virtue of SAPP software, so as to verify the scientific reasonableness of the method. In addition, in the process of evaluation, the subjectivity is linked with the objectivity in combination with the reality to provide main basis for the safety risk problems in the basketball arena project construction, which is beneficial for the safety management in the project construction. The application of factor analysis method in the basketball arena project construction can provide some new thoughts for other analysis methods, so as to enhance the theoretical research basis for the factor analysis method.

Keywords: Factor analysis method, Basketball arena, Project construction risk, Evaluation

1 Introduction

The concept of factor analysis originated from the intelligent test statistical analysis experiment of Karl Pearson and Charles Spearmen etc. [1]. In recent decades, with the rapid development of computer network, factor analysis method has been widely applied in various fields, so as to further enrich the theory and method of factor analysis [2]. Factor analysis method is a model analysis method to find out the relevant public factors, which is to construct several public factors with clear significance on the basis of main components, and to analyze and explain the original variables based on these public factors, so as to get the relation with the original variables [3].

With the continuous deepening of the reform and opening up, more and more basketball arenas are required, and the project construction of basketball arena has also welcomed infinite vitality, developing at an unprecedented scale and speed [4]. However, in recent years, the project construction has become "the disaster area of corruption", with a lot of risk safety crisis, mainly reflected in the following two aspects: first in the risk management of project construction, the construction unit selects staff with low quality and skill level, the machinery and equipment are operated unreasonably and there is an improper management for the material purchase and quality; second, the supervisors do not strengthen supervision to the project, with cheating on workmanship and materials [5-6]. Therefore, the researching and analysis on the risk problems in the basketball arena project construction and effectively finding out a risk control approach have been increasingly emphasized by the academic circle and political circle [7]. In order to construct the project construction better, it is required to strength the research on the risk evaluation problem of basketball arena project construction [8]. In order to comprehensively evaluate the basketball arena project construction, we research and discuss from different theories, so as to introduce the application of factor analysis method in the risk evaluation of basketball arena project construction [9].

Factor analysis method is a multi-variable statistical analysis method of including a lot of variables with complicated relations into several comprehensive factors by starting from the research on the dependence of internal correlation [10]. Its key is to detect and classify the correlation between variables and finally use a public factor to express the original variable, and it is widely used for limited unforeseeable invisible variables to explain the correlation between the original variables [11]. Factor analysis method is one of the important methods in the academic circle to analyse a lot of problems. In this research, the factor analysis method is used to comprehensively evaluate the risk problems of basketball arena project construction, so as to further discuss the application of factor analysis method.

2 Overview of factor analysis method

The main purpose of factor analysis method is to use a few factors to describe more indicators and analyze the correlation among these factors, and include several variables with close relation into the same category, each category of variable is one of the factors (because it is not the specific variable, and cannot be observed), and use a few factor to reflect most of the information of the things evaluated.

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Using this research method, we can analyze and solve a lot of problems better conveniently.

2.1 BASIC MODEL OF FACTOR ANALYSIS METHOD

The basic model of factor analysis method is described as follows:

(1) $X = (X_1, X_2, \ldots, X_P)$, in which X is an observable random vector, with mean factor $E(X) = 0$, covariance matrix $Cov(X) = \sum$, and the covariance matrix $\sum$ is equal to relevant matrix R (the variable should be standardized to achieve equality of the two).

(2) $F = (F_1, F_2, \ldots F_m)$, in which $F(m < p)$ is an unobservable vector, with mean factor $E(F) = 0$, covariance matrix $Cov(F) = I$, and at this moment, each component is mutually independent.

(3) $e = (e_1, e_2, \ldots, e_p)$, in which e and F are mutually independent, and $E(e) = 0$, e is the covariance matrix $\sum$, which is a diagonal matrix, and at this moment, each component e is also mutually independent, so the matrix can be expressed as:

$$
\begin{aligned}
X_1 &= A_{11}F_1 + A_{12}F_2 + \ldots + A_{1m}F_m + e_1 \\
X_2 &= A_{21}F_1 + A_{22}F_2 + \ldots + A_{2m}F_m + e_2 \\
&\ldots \\
X_P &= A_{p1}F_1 + A_{p2}F_2 + \ldots + A_{pm}F_m + e_p
\end{aligned}
$$

It is called factor analysis model, this model is aimed at the variable for calculation, and each factor is mutually orthogonal, so it is also called R-type orthogonal factor model.

Its model matrix form is $x = A_F + e$

Where, X, A, F, e are the known correlatives.

Here,

(1) m is unequal to p;

(2) $Cov(F, 0) = 0$, i.e. F is unrelated to e;

(3) $D(F) = I_m$, i.e. $F_1, F_2, \ldots, F_m$ are unrelated and their variance is 1;

The quadratic sum of each element of column $j(j = 1, 2, \ldots, m)$ of the factor load matrix A is recorded as g_{j2}, called the variance of the public factor F_j to X. g_{j2} is the sum of variance provided by the j_{th} public factor F_j to each component $X_i (i = 1, 2, \ldots, p)$ of X, which is an important factor to weigh the public factor. The more g_{j2} is, the more contribution of the public factor F_j to X will be, or the larger influence on X will be. If we calculate all $g_{j2} (j = 1, 2, \ldots, m)$ of the factor load matrix A, and sort them in order of size, finally we can get the most influential public factor based on this.

2.2 BASIC CALCULATION STEP OF FACTOR ANALYSIS METHOD

During research and analysis on the factor analysis method, the main problem faced is to reasonably construct the factor variable and name and interpret the factor variable, and the general steps are:

(1) Input the raw data, detects their reasonable correlation, calculate the sample covariance and carry out standardized processing;

(2) Calculate the sample correlation coefficient matrix R;

(3) Calculate the characteristic root $\lambda_i (\lambda_1, \lambda_2, \lambda_3 \cdots \succ 0)$ of correlation coefficient matrix, and the characteristic vector.

(4) Determine the number of public factor, and calculate its communality variance;

(5) Rotate the load matrix, so as to better explain the public factor;

(6) Have a special explanation on the public factor;

(5) Calculate the final score with the variance contribution rate weight of each factor.

3 Application of factor analysis method in risk evaluation of basketball arena project construction

In the research on the fire accident in gymnasium, evaluation and assessment on the warn of fire disaster risk is an inseparable link in our daily warning. With the development of society, the assessment systems and methods for the fire risk warning have been diversified increasingly, but most of them are limited to the investtigation and analysis stage, and there is seldom further analysis and affirmation from theory. According to the above situation, we establish the fire risk system of main component analysis method and add the scientific component of mathematical model to the subjective analysis, so as to realize the transformation from qualitative analysis to the accurate quantitative analysis.

3.1 SELECTION OF RISK EVALUATION INDICATORS IN BASKETBALL ARENA PROJECT CONSTRUCTION

The factor analysis method is applied to consider the comprehensive factors in the project construction in recent 10 years, from the initial construction to the later completion of the basketball arena, including many risks, 10 specific risk manifestation indicators are selected as the raw data, see Table 1;

TABLE 1 Risk manifestation indicators

Raw data indicator	
X_1	Personnel physical quality risk
X_2	Personnel professional skill risk
X_3	Personnel knowledge and common sense risk
X_4	Mechanical technology risk
X_5	Project design risk
X_6	Material technology risk
X_7	Project supervision risk
X_8	Artificial environment risk
X_9	Natural condition risk
X_{10}	Geographical condition risk

TABLE 2 KMO detection result

Bartlett and KMO detection		
Sufficient sampling through KMO weighing		0.708
Bartlett's test of sphericity	About Chi-square	253.875
	Degree of freedom	120
	Examination value of difference significance	0.000

3.2 PROCESS ANALYSIS IN RISK EVALUATION OF BASKETBALL ARENA PROJECT CONSTRUCTION

With the popularization of computer and its use in various aspects, in the process SAPP data analysis software can be used for the factor analysis method.

(1) Analyse whether the selection of evaluation indicator in basketball arena project construction is appropriate for the factor analysis. Bartlett's test of sphericity and KMO detection are used for detection and SPSS software is used for the calculation to obtain the raw data correlation examination, as shown in Table 2.

KMO detection value ranges from 0 to 1, the more KMO value indicates that there are more communities among variables and it is more appropriate for factor analysis. Generally, when the detection value is more than 0.5, factor analysis is appropriate, whole not appropriate when less than 0.5. The result in Table 1 sows that the KMO value is 0.708, Bartlett examination value is 0.00, less than 1%, indicating that the evaluation indicator is appropriate for the factor analysis, but there is a correlation among the variables.

(2) Carry out standardization processing to the primitive matrix, the standardization expression formula is $Zi = \frac{Xj - \bar{X}j}{Sj}$ in which X_j is the j_{th} risk evaluation indicator of the i_{th} basketball arena, S_j is the mean value and sample covariance of X_j, so as to calculate the relevant coefficient matrix of the standardization data and get the characteristic value.

TABLE 3 Factor variance contribution rate

Explanation on all variables						
	Initial characteristic value			*Factor rotation load*		
Component	Component characteristic value	Percentage of factor variance in total variance /%	Accumulative percentage of factor variance in total variance/ %	Component characteristic value	Percentage of factor variance in total variance /%	Accumulative percentage of factor variance in total variance/ %
1	4.467	27.921	27.921	3.92	24.502	24.502
2	2.078	12.99	40.911	1.968	12.302	36.804
3	1.399	8.741	49.652	1.757	10.98	47.784
4	1.240	7.752	57.404	1.312	8.190	55.983
5	1.066	6.664	64.067	1.293	8.084	64.067
6	0.935	5.845	69.913			
7	0.867	5.422	75.334			
8	0.722	4.511	79.846			
9	0.669	4.182	84.028			
10	0.624	3.9	87.928			

TABLE 4 Rotated factor load matrix

	Component				
	1	*2*	*3*	*4*	*5*
X_1	0.709	0.14	0.039	0.092	-0.073
X_2	0.697	0.11	-0.308	0.166	-0.091
X_3	0.826	0.149	0.04	0.054	0.071
X_4	0.102	-0.454	-0.147	0.089	0.213
X_5	0.395	0.602	-0.278	-0.31	0.031
X_6	-0.2	0.694	0.09	-0.018	0.099
X_7	0.048	0.168	-0.782	-0.148	0.196
X_8	0.125	-0.191	0.14	0.974	0.083
X_9	0.183	0.151	-0.043	-0.849	0.053
X10	0.026	0.6	0.118	0.068	0.706

Generally, according to the calculation of variance contribution rate and the accumulative variance contribution rate, the total variance contribution rate should be above 80%.

(3) Rotate and determine the factors. Imagine F_1, F_2, …, F_m are m factors, the first n factors with accumulative variance contribution rate above 80% are obtained, and these n factors can represent all information volume. The actual significance of these n factors cannot be determined clearly, so they are often rotated to obtain the significant actual meaning.

TABLE 6 Factor scoring coefficient matrix

	Component				
	1	*2*	*3*	*4*	*5*
X1	-0.098	0.495	-0.073	0.092	-0.081
X2	0.187	-0.011	-0.178	0.2	-0.12
X3	-0.002	0.104	-0.128	0.69	0.058
X4	0.205	-0.137	-0.049	0.11	0.121
X5	0.189	-0.095	-0.071	-0.192	-0.025
X6	-0.025	0.002	0.473	-0.143	0.082
X7	-0.081	0.086	-0.053	-0.095	0.627
X8	0.038	-0.158	0.066	0.202	0.539
X9	-0.014	0.099	-0.224	-0.21	0.031
X10	-0.063	0.301	0.279	-0.157	0.064

The factor matrix is rotated with orthogonal rotation method, the results obtained show that the first factor has a large load in X_1, X_2 and X_3, i.e. the influential factors represent these aspects; the second one has a relatively large load in X_4, X_5 and X_6; the third one has a large load in X_7, the fourth one has a large load in X_8 and X_9, the fourth factor has a large load in X_8 and X_9 and the fifth one has a relatively large load in X_{10}. The first factor represents the staff, the second one the influence of project construction machinery, facilities and materials, the third one the influence of construction site, the fourth factor the influence of environmental conditions, and the fifth factor the influence of geology selected for the project construction, so it is concluded that the variables represented by the factors are as shown in Table 5 below, consistent with the actual condition.

TABLE 5 Factor structure

Factor	Raw data	Variable
F_1	X_1 X_2 X_3	Staff physical condition: disease, emotion, attitude Staff skills: Proficiency, mastering degree of professional knowledge Staff knowledge: special and hazardous work, equipment safety, electrical power, open fire operation site, construction technology, protective goods, mastering and defect of protection technology.
F_2	X_4 X_5 X_6	Machinery: obsolete or problematic machinery, overloading operation, mixed operation of personnel and machinery. Facilities: setup, overloading operation Materials: transmission method, ordering degree of stacking, use of nonconforming materials, storage of special materials, use of members, accessories and factor prefabricated members.
F_3	X_7	Site: size of working face, whether work platform or not, arrangement of construction site, whether protective facilities or not, overhead operation or deep foundation pit operation, clearing of construction site.
F_4	X_8 X_9	Condition: special environment (oxygen deficit, toxic gas, smoke, noise, vibration), on-site lighting and obstacle influencing vision etc. Climate: severe natural environment
F_5	X_{10}	Geology: stratum, water quality, construction

(4) Calculate comprehensive score: carry out linear combination with raw indicator data, so as to get the weight of covariance contribution rate of each factor, the comprehensive evaluation of the linear combination of factor indicator is expressed as: $F=\omega_1 F_1+\omega_2 F_2+\omega_3 F_3+\cdots+\omega_m F_m$, in which ω_m represents the covariance contribution weight of the rotated factor.

The score of each factor can be calculated according to the formula $F=\omega_1 F_1+\omega_2 F_2+\omega_3 F_3+\cdots+\omega_m F_m$.

$$\begin{cases} F_1 = -0.098X_1+0.187X_2-0.002X_3+\cdots-0.063X_{10} \\ F_2 = 0.495X_1-0.011X_2+0.104X_3+\cdots+0.301X_{10} \\ F_3 = -0.073X_1-0.178X_2-0.128X_3+\cdots+0.279X_{10} \\ F_4 = 0.092X_1+0.200X_2-0.690X_3+\cdots-0.157X_{10} \\ F_5 = -0.081X_1-0.120X_2-0.058X_3+\cdots+0.064X_{10} \end{cases}$$

Then SPSS is used to calculate the function scoring result based on the above matrix formula, and the scores of the 5 factors are converted into new variables, then the covariance contribution rate weight of each factor is calculated, and finally it is concluded that the comprehensive situation of the risk evaluation of project ball arena project construction is:

$$F=0.179F_l+0.230F_2+0.187F_3+0.078F_4+O.067F_5$$

3.3 RESULT ANALYSIS OF RISK EVALUATION OF BASKETBALL ARENA PROJECT CONSTRUCTION

The comprehensive score of each factor can be obtained according to the covariance contribution rate of the rotated factor, so as to analyze the influence of the factors on the risk evaluation of basketball area project construction according to the score. The result shows that the second factor has the highest score, with coefficient 0.230, followed by the third factor 0.180, and then successively the first one 0.179, the fourth one 0.078 and the fifth one 0.067. As the second factor represents the machinery (obsolete or problematic machinery, overloading operation, mixed operation of personnel and machinery), facilities (setup, overloading operation) and materials (transmission method, ordering degree of stacking, use of nonconforming materials, storage of special materials, use of members, accessories and factory prefabricated units), which are the skeleton of basketball arena construction in actual application and play a vital important role for the project safety; the third factor site (size of working face, weather work platform or not, arrangement of construction site, whether protective facilities or not, overhead operation or deep foundation pit operation and clearing of construction site) also directly concerns the safety in project construction, while the objective factors such as geology and environmental condition have a small risk influence on the project construction.

Therefore, in the basketball area project construction, first, strictly control the quality and operation of machinery, equipment and raw materials, when supervising the project, relevant departments must detect the project strictly according to the national regulations and systems; second, the project construction personnel should have professional technical level and basic occupational moral quality, prevent cheating in craftsmanship and materials and illegal operation. Finally, in the basketball area project construction, it is also required to pay attention to the selection of geological condition, and select the high-quality geographical environment as far as possible.

4 Conclusions

The factor analysis method has a simple principle, with relatively complicated calculation process. With the wide application of computer, using SAPP to process and analyze the step calculation process greatly reduces the work amount of data calculation and improves the accuracy, so factor analysis method had been gradually applied in various fields. It is possible to objectively analyze the safety of basketball arena project construction, discover the potential risks timely and overcome the adverse factors unfavorable for the project construction by using factor analysis method to comprehensively evaluate the basketball arena project construction risks, carrying standardization processing to the raw data and rotating the factor to get the comprehensive score of each factor, so as to promote the normal, healthy and continuous development of the basketball arena project construction. Besides, this evaluation and analysis method is to used data for statistical processing via computer, the influences of subjective factors are overcome in the process of evaluation and the result obtained is more objective, conforming to the actual project construction condition more. The application of factor analysis method researched in this paper in the risk evaluation of basketball arena project construction provides some new thoughts for other analysis methods in a certain extent, increasing the theoretical research basis for the factor analysis method and providing some reference values for the further research.

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