Journal of Computers Vol. 34 No. 4, August 2023, pp. 111-118
doi: 10.53106/199115992023083404009

Structure and Analysis of the Smart Court Construction Evaluation Index Based on Principal Component Analysis for Different Regions

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Received 1 July 2023; Revised 20 July 2023; Accepted 25 July 2023

Abstract. In this paper, the principal component analysis method is mainly used to analyze that the construction level of Smart Court in different regions. The construction level of Smart Court consists of three main components. The result of Smart Court construction level in different regions is calculated. It is concluded that the construction level of Smart Court varies in different regions. It is necessary to make great efforts to solve the problem of unbalanced regional development. It is suggested that the construction of Smart Court in the future should focus on the publicity business such as online cases. And more and more new generation information technology such as artificial intelligence should be applied.

Keywords: Smart Court construction, evaluation index, principal component analysis

1 Introduction

The construction of Smart Court characterized by networking, publicity, and intelligence as their characteristics, which has effectively propelled the modernization of the judicial system and judicial capabilities [1]. In 2017, the concept of smart courts has been proposed, which marked the comprehensive launch of Smart Court construction throughout the country. Smart Court is a new form of judicial information construction that better meets the needs of judicial business in the networked, digitized, and intelligent era. The proposed Smart Court characterized by networking, publicity, and intelligence for all businesses online, full-process information disclosure, and comprehensive information services have opened up a new phase in the construction of judicial informatization. Informatization evaluation has always been an important part of "plan, construction, use, and evaluation" closed-loop process. Currently, various regions throughout the country are vigorously promoting the construction of Smart Court. However, due to the influence of policy environment, economic environment, development funds, and talent quality in different regions, there are some differences in the level of Smart Court construction. Therefore, it is necessary to establish a scientific index system, conduct evaluations of Smart Court construction, accurately analyze the differences and problems in Smart Court construction in different regions, and promote the balanced development of Smart Court. This is a problem that needs to be considered and solved at the current stage of Smart Court development.

2 Research Status

Currently, there are evaluations on the construction of Smart Court or the informatization of courts both domestically and internationally. Since 2003, the World Bank has compiled the *Doing Business Report* to assess objective measures of business regulations and their enforcement in various economies [2]. In *Doing Business 2020*, China ranked 31st out of 190 economies globally, becoming one of the economies with the greatest improvement in the business environment [3]. The World Bank assessment includes an "Automation Index of the Judiciary",

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which consists of four parts: whether the initial complaint can be submitted electronically through a dedicated platform within the jurisdictional court; whether the complaint can be served electronically to the defendant through a dedicated system or email, fax, or messaging service; whether litigation fees can be paid electronically through a dedicated platform or online banking; and whether judgments of local courts are made available to the public through official gazettes, newspapers, or the internet [4]. All four parts are core businesses of electronic litigation in Smart Court, namely online filing, electronic service, online payment of fees, and public access to judicial documents. The World Bank's annual evaluation collects a limited number of indexes and only uses indexes from several cities to represent the automation level of Chinese courts.

Domestically, relevant assessments mainly include *Smart Court Construction Evaluation Report* released annually by the Information Center of the Supreme People's Court since 2017. The report covers six dimensions, including planning and guidance, basic support, networked application effectiveness, public application effectiveness, intelligent construction effectiveness, and comprehensive support, with a total of 68 evaluation indexes. This assessment mainly takes place within the national court system, evaluating both business results and management implementation. The China Academy of Social Sciences Institute of Law releases the *Annual Report on Informatization of Chinese Courts* [5]. The 2018 report covers 46 evaluation indexes in four dimensions, including intelligent trial, efficient execution, automated management, and quality service. This assessment mainly takes a third-party perspective to evaluate the development of court informatization nationwide from a societal viewpoint.

3 Research Principles

3.1 Research Principles for Evaluation of Smart Court Construction

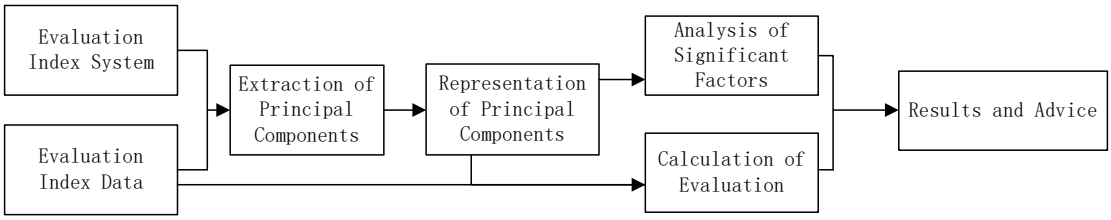

Fig. 1. Research principles for evaluation of Smart Court construction

The research principles for evaluation of Smart Court construction are shown in Fig. 1. Establish the Smart Court construction evaluation index system first, gather the required data for evaluation, and then use principal component analysis to extract the key elements of the evaluation. On the basis of the main components, develop a Smart Court construction level evaluation model and outline the constituent parts of the primary factors. Examine the elements that significantly affect the quality of Smart Court construction. Lastly, evaluate the outcomes of the Smart Court construction based on regional attributes and propose relevant policy recommendations.

3.2 The Basic Principle of Principal Component Analysis Method

Principal component analysis method [6] solves the characteristic equation of the correlation matrix of observed variables to obtain the corresponding eigenvalues and eigenvectors. The eigenvalues are then sorted in descending order and represent the variance of the observed variables. The use of principal component analysis method has the following advantages: First, it can eliminate the correlation among evaluation indexes and transform them into relatively independent principal components. Second, it can reduce the workload of indexes selection and select relatively simple indexes. Third, it can improve computational efficiency. Only the principal components with large variance contribution are used to calculate evaluation results, simplifying the calculation process

and improving efficiency.

The process of principal component analysis method in evaluation [7] is as follows: First, standardize the original index data to transform it into standardized data with a mean of 0 and variance of 1; Second, conduct a KMO test on the data. The KMO value is between 0 and 1, and values less than 0.6 are unsuitable, values between 0.6 and 0.7 are marginally suitable, values between 0.7 and 0.9 are suitable, and values above 0.9 are very suitable; Third, conduct principal component analysis, calculate the variance contribution rate, determine the main components where the cumulative variance reaches 85% or more, and rotate the main component factors to form a model; Fourth, calculate the evaluation results.

The Smart Court evaluation model based on principal components is as follows:

$$\mathrm{F} = \sum_{i=1}^{n} \alpha_i F_i \,. \tag{1}$$

In which F_i represents the i-th principal component, n is the number of principal components, and α_i is the contribution rate of the principal component.

The principal component factor model is as follows:

$$F_i = \sum_{j=1}^{m} \beta_{ij} x_{ij} \,. \tag{2}$$

Where x_{ij} represents the j-th factor in the i-th principal component, m is the number of factors in the principal component, and β_{ij} is the factor loading.

4 Construction of Evaluation Index System for Smart Court Construction

4.1 Construction Method of Informatization Evaluation Index

Since the 1960s, many domestic and foreign scholars have evaluated informatization. A.-L. Jiang [8] summarized and analyzed eight informatization level measurement methods such as the Machlup method, the Porat method, and the informatization index method. In 1965, Japanese economist Komatsuzaki Seisuke proposed the informatization index method, mainly used to examine the development level of national informatization, involving four elements: information amount, information equipment rate, communication subject level, and information coefficient in industries such as postal, broadcasting, and television [9]. The construction method of the informatization index has been widely applied to informatization evaluation in various fields such as countries, regions, governments, and industries. In 1995, the International Telecommunication Union proposed a set of evaluation index systems for the informatization development status of the seven Western countries with the theme of "information society," including six groups of indices: telephone trunk lines, cellular phones, ISDN, cable TV, computers, and optical fiber [10]. In 2001, the Ministry of Information Industry of China published the *Structural Scheme of the National Informatization Quotient* [11], designing 20 informatization level measurement indexes. In 2011, the National Bureau of Statistics issued the *Informatization Development Index Optimizes Research Report* [12], which explicitly stated that the Informatization Development Index (IDI) is a comprehensive index for evaluating the level of national economic and social development, and can be used to measure the ability of society to create, acquire, use, and share information and knowledge using information and communication technology, as well as the promoting role of information development in social and economic development.

4.2 Design Principles of the Informatization Evaluation Index System

The principle of targeting. The informatization evaluation is usually aimed at promoting the level and application effectiveness of information system, examining the smoothness of the running connection of various elements, and enhancing the level and capacity of information business. At the same time, the informatization evaluation index design should be carried out based on the principles of overall planning, intensive utilization, scientificity, and pragmatism.

The principle of scientificity. In general, there is unevenness in the level of information system construction and application among different evaluation objects. Informatization evaluation needs to have general adaptability and practicality, and pay attention to scientificity in index design. The differences between different evaluation objects should be considered comprehensively and fully. A scientific and reasonable evaluation algorithm and model is adopted to prevent the occurrence of evaluation results biased due to unreasonable index design.

The principle of forward-looking. The new generation of information technologies represented by big data, cloud computing, and artificial intelligence are increasingly widely used in various industries and will drive greater changes in social development. In the evaluation process, it is necessary to fully consider the forward-looking nature of system construction and the breadth and depth of information technology development. The evaluation work can be carried out continuously for 3-5 years.

The principle of operability. The evaluation method and process should be simple and practical, with clear evaluation subjects, objects, and content, and strong operability. Quantitative evaluation is generally used as the main method, supplemented by some qualitative evaluation. Each index should have specific algorithms, design easily accessible and accurate data items for ease of data collection and analysis.

4.3 Evaluation Index System for Smart Court

The evaluation of Smart Court is proposed in order to quantitatively reflect the overall level of informatization of courts nationwide, especially to evaluate the effectiveness of informatization in enhancing the core business support of courts. Based on the principle of combining rationality, scientificity, purposefulness and operability, the evaluation index system of Smart Court construction is constructed according to the method of constructing informatization evaluation indexes, with reference to the *Annual Report on Informatization of Chinese Courts* [5], which consists of three primary indexes of networking indexes, publicity indexes, intelligence indexes, and 14 secondary indexes. The networking indexes primarily cover the technology court and the litigation service venue, etc. The publicity indexes primarily cover the trail openness and the judgment documents openness, etc. The intelligence indexes primarily cover e-files and the clerical support, etc. The specific indexes system is shown in Table 1:

Table 1. Evaluation index system of Smart Court

Number	Primary indexes	Secondary indexes
1	Networking	Technology Court
2		Litigation Service Venue
3		Electronic Signature
4		Total-to-Total Search and Control
5	Publicity	Trial Openness
6		Judgment Documents Openness
7		Online Filing
8		Online Payment
9		Online Evidence Exchange
10		Online Mediation
11		Online Trial
12	Intelligence	E-Files
13		Clerical Support
14		Courtroom Speech Recognition

5 Empirical Principal Component Analysis of the Smart Court Construction Level

5.1 Index Data Collection

Based on the design of evaluation indexes for Smart Court construction, this article selects 68 cities nationwide as evaluation objects and conducted research on the relevant situations of Smart Court. By distributing questionnaires, specific court data for the period from January 1 to December 31, 2018, were collected for all 68 cities, and all questionnaires were valid. China is divided into seven geographical regions: A, B, C, D, E, F and G. Of the 68 cities, 5 are in the A region, 13 in the B region, 12 in the C region, 15 in the D region, 13 in the E region, 5 in the F region, and 5 in the G region.

5.2 Data Standardization and KMO Test

Because the data for each evaluation index varied significantly, all index data is first standardized before analysis using Stata 16 software. To investigate the variables, the KMO value isas calculated. The KMO value is 0.611, greater than 0.6, which is indicating that there is a correlation between variables. The principal factor extraction could be extracted. Principal component analysis is suitable.

5.3 Principal Component Analysis

Principal component analysis is performed with Stata16, and the scree plot is shown in Fig. 2, which shows that the first three principal components have a large contribution.

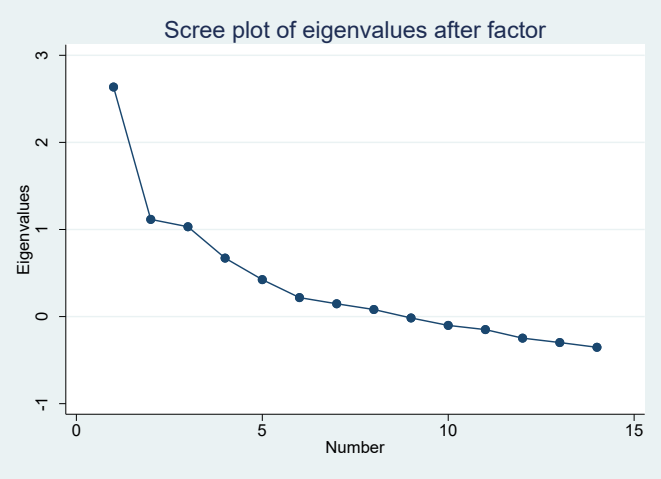

Fig. 2. Scree plot for principal component analysis

The principal component variance contribution analysis is shown in Table 2:

Table 2. Analysis of variance contribution rates for principal components

Component	Eigenvalue	Variance	Variance contribution rate	Cumulative contribution rate
F1	2.63583	1.51973	0.5107	0.5107
F2	1.1161	0.08449	0.2162	0.7269
F3	1.03161	0.3601	0.1999	0.9268
F4	0.67151	0.2471	0.1301	1.0569
F5	0.42441	0.20642	0.0822	1.1391
F6	0.21799	0.07074	0.0422	1.1813
F7	0.14726	0.06615	0.0285	1.2098
F8	0.08111	0.09698	0.0157	1.2256
F9	-0.01587	0.0853	-0.0031	1.2225
F10	-0.10117	0.04809	-0.0196	1.2029
F11	-0.14926	0.09818	-0.0289	1.174
F12	-0.24744	0.05049	-0.0479	1.126
F13	-0.29793	0.05464	-0.0577	1.0683
F14	-0.35257	.	-0.0683	1

From the above table, it can be seen that the eigenvalues of the three principal components F1, F2 and F3 are greater than 1, and their cumulative contribution rate reaches 92.68%, and the level of Smart Court construction can be expressed as:

$$F = 0.5107F1 + 0.2162F2 + 0.1999F3 . \quad \textbf{(3)}$$

The principal component loading matrix is shown in Table 3:

Table 3. Matrix of factor loading for principal components

Variables	F1	F2	F3
x1	0.148	0.1193	0.1348
x2	0.4067	0.1084	0.2579
x3	-0.0021	0.4108	0.1285
x4	0.0064	-0.5778	-0.0514
x5	0.0612	-0.0517	-0.0065
x6	0.0651	-0.3523	0.0331
x7	0.7967	-0.1226	-0.0104
x8	0.0387	0.135	0.5386
x9	0.8751	-0.1089	-0.0651
x10	0.304	-0.062	0.5246
x11	0.8523	-0.0972	-0.086
x12	0.3935	0.2934	-0.318
x13	0.0707	0.1245	-0.4975
x14	0.2447	0.5483	-0.0308

From the results, it can be seen that F1 has very high loadings on three indexes: x7 online filing, x9 online evidence exchange, and x11 online trial. F2 has a high loading on x14 courtroom speech recognition, and F3 has high loadings on x8 online payment and x10 online mediation. It can be concluded that improving the effectiveness of transparent applications such as online filing, online payment, online evidence exchange, online mediation, and online trial will greatly promote the overall level of Smart Court construction. This is a key direction that should be focused on in the future Smart Court construction.

5.4 Results of Smart Court Construction Evaluation

Through the principal component analysis method, the results of the evaluation of Smart Court construction in different regions are calculated and the results of each principal component and the total result are shown in Table 4:

Table 4. Results of principal component analysis for Smart Court in different regions

Region	F1	F2	F3	F
A	-0.6143	-0.6352	-0.7563	-0.6022
B	0.6261	0.5321	0.3046	0.4957
C	3.5887	0.8245	-0.6923	1.8726
D	-0.8826	-0.5056	-0.9454	-0.7491
E	-1.3605	-0.8091	1.1031	-0.6492
F	-0.6607	0.7766	-0.4801	-0.2655
G	-1.6835	-0.5388	-0.9428	-1.1647

From the above table, it can be seen that the highest F1 value is 3.5887 in the C region, and the lowest value is -1.6835 in the G region; the highest F2 value is 0.8245 in the C region, and the lowest value is -0.8091 in the E region; the highest F3 value is 1.1031 in the E region, and the lowest value is -0.9454 in the D region; the highest F value is 1.8726 in the C region, and the lowest value is -1.1647 in the G region.

6 Analysis of Results and Suggestions for Countermeasures

The development of Smart Court in China is uneven across different regions, with the best in the C region and A region in need of strong support. From the evaluation results of the "F value" of Smart Court construction in seven regions across the country, the highest score is 1.8726 in the C region, and the lowest is -1.1647 in the G region. The evaluation results of these two regions are significantly different from the other five regions, indicating that there is a significant regional development imbalance in the construction of Smart Court across the country. Especially in the G region, the construction of Smart Court has been influenced by various factors such as regional economic development, scientific and technological level, and talent quality. It urgently needs attention and support to coordinate and promote it.

The publicity application has become the key direction of Smart Court construction. From the situation of principal component analysis, the load of transparent application of Smart Court such as online filing, online payment, online evidence exchange, online mediation and online trial is larger and has a significant impact on the evaluation bureau of Smart Court construction, and the courtroom speech recognition in intelligent application also has a certain impact, and other indexes, especially the networking indexes, have little impact on the evaluation results, indicating that the gap between the networked construction and application levels of courts at all levels is not large and has reached a more balanced level. Therefore, the improvement of the overall level of Smart Court construction relies on vigorously promoting the application of publicity business such as online filing, online payment, online evidence exchange, online mediation and online trial.

Increase the application of new generation technologies such as big data and artificial intelligence. The current national Smart Court has gradually involved the use of big data, artificial intelligence and other new generation information technology, but the scope of application is not extensive enough, mainly in the generation of documents and intelligent voice. From the principal component analysis, the highest F2 value is in the C region, the main influencing factor is the courtroom speech recognition index, analysis of the reasons may be due to the dialect of the C region is the closest to Mandarin, intelligent voice recognition technology is better applied, other regions with stronger dialects may receive the limitation of technical level and the application effect is not ideal. Therefore, further improving the level of big data, artificial intelligence and other technologies, and increasing the application of new technologies in the construction of Smart Court will drive the level of intelligent court construction to achieve leaps and bounds.

Acknowledgement

This paper is partly supported by the National Key Reseach and Development Plan (2018YFC0831605).

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