Research on Audit Index System of "Special Bonds + PPP" Based on FAHP

Qianru Fang

Wenzhou Polytechnic, Wenzhou 325000, Zhejiang, China

Abstract

This paper starts from the angle of life-cycle audit coverage, and builds the whole-process audit index system of the "special bonds + PPP" public infrastructure construction model project (hereinafter referred to as "special bonds + PPP"). Firstly, through literature research and interviews with institutional experts, the audit index system is built in accordance with the three dimensions: including early project approval decision, medium-term administration as well as later handover evaluation; secondly, the fuzzy analytic hierarchy process(FAHP) is introduced to sequence and assign values to various indexes, and build judgment matrices; In the end, on the basis of the questionnaire information data of importance order of evaluation index system filled in by experts, the weight value is calculated with the MATLAB program; It makes the audit index system scientific and operable.

Keywords

Special bonds + PPP; Audit index; FAHP.

1. Introduction

Public-Private Partnership (PPP) has been fully applied to China's infrastructure construction since 2014, in order to resolve the defect of the increasingly prominent financing difficulties, local governments have issued special bonds in combination with projects, the "special bond + PPP" public infrastructure construction model project (hereinafter referred to as "special bond + PPP") has become an important promoter of our country's infrastructure construction. At present, there are few theoretical research results in "special bonds + PPP" whole-process tracking audit index system, practical results lack systematic summary, audit development lacks scientific basis; a scientific and fitting audit index system need to be built to make audit work well-founded, and this has important implications to ensure the operating legality of such projects and achieve the expected benefits.

2. Building of the Whole-Process Tracking Audit Index System of "Special Bonds + PPP"

2.1. Audit Dimensions and Key Identification of PPP Project

PPP projects have the characteristics of long cooperation period, numerous participating subjects and different interests and appeals of all parties, scholars have done extensive research on the identification of reasonable and effective audit dimensions and audit priorities. This paper analyzes the audit dimensions and key identification established by various scholars based on literature research, as shown in Table 1.

Table 1. Research on audit dimensions and key identification of PPP project

scholar	audit dimension	identification of audit priorities
Yan Xiaojian [1]	(1) results and benefits (2) execution process	(1) products and services; (2) public satisfaction; (3) bidding procedures; (4) contract management; (5) risk allocation; (6) performance evaluation; (7) audit environment
Lu Xinyi[2]	(1) early project approval (2) medium-term construction (3) later assessment	(1) project screening; (2) feasibility report; (3) contract terms of franchise; (4) project design; (5) assessment and argument; (6) cooperation way; (7) commercial contracts; (8) risk share; (9) project quality; (10) capital estimation
Shi Xian[3]	(1) project cost (2) project management (3) investment performance	(1) investment estimation; (2) design estimation; (3) partner selection methods and procedures; (4) cooperation contracts; (5) quality and progress management; (6) budget and final account execution; (7) project construction procedures ; (8) bid procedures; (9) contract management; (10) risk management; (11) economic benefits; (12) construction effects; (13) public service capability
Wang Liguo, Zhang Ying[4]	(1) policy implementation (2) project approval (3) process operation (4) investment performance	(1) policy implementation; (2) institutional measure; (3) policy strategy system; (4) feasibility study; (5) construction procedures; (6) bid; (7) quality and progress management; (8) environmental protection; (9) budget and final accounts execution; (10) mechanism construction; (11) management effect; (12) financial performance; (13) comprehensive benefits
Fang Jun, Ren Suping, Huang Juntian[5]	(1) project approval decision (2) administration (3) handover evaluation	(1) project development procedures; (2) relevant procedures and documents; (3) applicability of models; (4) governmental investment decisions; (5) governmental administration functions; (6) project financing; (7) fund management and use; (8) project handover procedure; (9) evaluation of good value for money
Zhao Chong, Gao Yun[6]	(1) project decision (2) project implementation (3) project operation and maintenance	(1) approval procedure; (2) feasibility study report; (3) environmental assessment; (4) demolition assessment; (5) bid procedure; (6) project design; (7) quality and progress management; (8) funds management; (9) contract management; (10) project settlement; (11) economic benefits; (12) social benefits; (13) environmental benefits
Ye Xiaosu, Zhang Deqin, Shi Shiying[7]	(1) audit main body (2) audit time sequence (3) audit execution	(1) project planning and approval; (2) franchise; (3) risk allocation; (4) financing risk; (5) governmental gap fund subsidy; (6) pricing standard/user charges; (7) total project cost (tpc); (8) bid; (9) project construction procedures; (10) supervision of project construction activities; (11) commercial development; (12) operation, maintenance, development and revenue; (13) good value for money (3e); (14) pv; (15) asset valuation
Huang Wanyi, Lu Yongsong[8]	(1) project identification (2) project preparation (3) project purchase (4) project execution (5) project handover	(1) identification process; (2) investment estimation; (3) good value for money; (4) financial affordability argument; (5) implementation plan; (6) contract system; (7) organizational structure; (8) operation cost; (9) investment return mechanism; (10) approval process; (11) bid procedure; (12) financing plan; (13) construction management; (14) asset evaluation; (15) performance testing; (16) performance evaluation
Sun Lingzhi, Jia Hongjun, Ren Renxin[9]	(1) implementation process (2) management elements (3) participating body	(1) feasibility study report; (2) approval documents; (3) approval process; (4) environmental assessment; (5) undertaker selection; (6) bid procedure; (7) project design; (8) investment control; (9) quality and progress management; (10) contract management; (11) good value for money; (12) functional evaluation; (13) operational costs; (14) organizational structure
Jiao Sheng[10]	(1) project identification (2) project preparation (3) project purchase (4) project execution (5) project handover	(1) project initiation and screening; (2) approval process; (3) good value for money; (4) financial affordability; (5) environmental impact assessment; (6) feasibility study report; (7) evaluation of good value for money (8) bidding procedures; (9) contract management; (10) quality and progress management; (11) project construction cost; (12) performance evaluation; (13) asset value assessment

2.2. Key Identification of Special Bonds

The government issues special bonds for public infrastructure construction projects of the PPP mode, takes advantage of the short issuance cycle and low financing interest rate of special bonds, thereby improving the performance of PPP projects. After the introduction of special bonds, the financing model and implementation process of PPP projects have changed, and new

audit priorities should be added. This paper summarizes the audit priorities of special bond through literature review and interviews with institutional experts, as shown in Table 2.

Table 2. Research on key identification of special bonds

scholar or institution	identification of audit priorities
Wen Laicheng, Diao Weitao, Chen Baodong[11]	(1) use progress of funds; (2) intensity of information disclosure; (3) investment direction and use of funds
Chai Yunlong[12]	(1) issuance ways; (2) issuance life; (3) repay capital with interest
Xu Bo, Yang Wei[13]	(1) rights and liabilities of the issuer; (2) scale and structure; (3) project selection; (4) utilization efficiency of funds; (5) source of debt paying funds
Wangqing County Audit Bureau	(1) bond raising; (2) bond distribution; (3) bond release; (4) bond issuance; (5) bond management and use
21st Century Business Herald	(1) utilization rate of special bond funds; (2) investment direction of special bond funds; (3) solvency of principal and interest of debt
Liang Jiang New Area Audit Bureau	(1) whether the investment direction of bond funds is accurate; (2) whether the use of bond funds is standard; (3) whether the use of bond funds is efficient
Qingdao Chengyang District Audit Bureau	(1) bond borrowing; (2) bond use; (3) bond repayment; (4) responsibility monitoring

2.3. Building Principles of Index System

(1) Quantitative and qualitative principle, the introduction of qualitative index can prevent audit from only being superficial on the data, and the combination of quantitative index can effectively avoid the excessive influence of subjective factors.

(2) Layering principle. After the PPP project is combined with the special bonds, the number of participating main body and audit priorities increase, the method of layering construction is adopted to identify the audit priorities, and the indexes are layered to make the layers clear and easy to evaluate.

(3) Crucial and overall principle, the short-term benefits and long-term benefits of PPP projects are combined, the importance and relevance of indexes are fully considered, avoid the important and dwell on the trivial, and reduce the difficulty within a reasonable range.

(4) Scientific and operable principle, the indexes are scientifically set, in order to achieve the effect of full coverage and operability, and help the collection and analysis of evaluation results.

2.4. Building of Index System

According to the research and analysis of Table.1 and Table.2, it is found that the current PPP project audit dimensions are divided into the following kinds: firstly, according to the full life cycle theory of the project, they are divided into audit of early project approval decision stage, audit of medium-term administration stage, and audit of the later handover evaluation stage; secondly, according to the work flow, they are divided into five stages: project identification, preparation, purchase, execution, and handover; thirdly, according to the key points of project management and control, they are divided into the implementation process, management elements, and participating main body, all of which starts from the audit idea before, during and after the event. Combining the audit priorities proposed by the above experts and scholars based on different dimensions and perspectives, in order to achieve full coverage of audit and

fit the actual process of project application and use, and follow the building principle of index, this paper extracts the specific indexes of the whole-process tracking audit of "special bonds + PPP" in accordance with the three dimensions: early project approval decision, middle-term administration and later handover evaluation, it builds the whole-process tracking audit index system including 3 first-level indexes (represented by P), 23 second-level indexes (represented by S), and 68 third-level indexes (represented by T). The specific index names and index connotations are shown in Table 3.

Table 3. The whole-process tracking audit index system of "special bonds + PPP"

first-level index	second-level index	third-level index	index connotation
early project approval decision P_1	project identification procedure S_1	project initiation, screening procedure T_1	according to the Ministry of Finance's No.76 document [2014] and relevant laws and regulations, evaluate the legality of procedure
		complete procedures and documents T_2	compliant approval procedures, complete and correct documents
	investment estimation S_2	approval procedure T_3	according to the "Administrative Measures of the Franchise of Infrastructure and Public Utilities" issued by the National Development and Reform Commission [2014] No. 2724, evaluate the compliance of approval procedure
		evaluation procedure T_4	open and transparent project evaluation procedure
		compilation basis T_5	the compilation basis for investment estimation is correct, reasonable and sufficient, and should be combined with the project proposal and the final account data of the completion of similar projects
		estimation accuracy T_6	the accuracy of investment estimation, rationality of errors
	preliminary implementation plan S_3	compilation basis for plan T_7	the correctness of plan compilation basis should include relevant laws, regulations and documents in the fields of purchase, investment and financing, PPP and special bonds, etc.
		signing of franchise contract T_8	according to No. 25 document of Six Ministries and Commissions "Administrative Measures for Franchise of Infrastructure and Public Utilities", evaluate the compliance, legality and practicality of the terms of the contract
		cooperation way T_9	the rationality of project cooperation way, compliance degree with actual situation of project
		contract system T_{10}	according to the relevant provisions of the "Contract Law", evaluate the integrity of the commercial contract system, and the clarity of the assignment main body and core terms, etc.
		return on investment mechanism T_{11}	the correctness of calculation method of governmental payment or feasibility gap subsidy, the rationality of the return source and payment mechanism, the legality, compliance and flexibility of the incentive mechanism
	good value for money report S_4	good value for money report T_{12}	the integrity of good value for money report should cover seven major contents, namely project survey, background, significance, operation mode; definition of good value for money, qualitative and quantitative analysis and evaluation; attached list.
		qualitative analysis content T_{13}	the pertinence of qualitative analysis of good value for money, including the discussion of the proposed PPP project from the aspects of increasing public supply, optimizing risk allocation, financing, and feasibility during the concession period, etc.
		quantitative calculation T_{14}	the correctness of quantitative calculation, including PSC value, PPPs value and annual discount rate calculation
		annual discount rate T_{15}	the accuracy of the annual discount rate is determined based on the Ministry of Finance's No.113 document [2014] and the local financial subsidy expenditure year basis and refer to the return of local government bonds in the same period
	financial affordability argument S_5	argument report T_{16}	the integrity of the general financial affordability evaluation report should include six parts, namely project survey, implementation significance, operation mode, governmental financial situation analysis, responsibility identification of governmental project, and assessment of governmental financial capacity
		relevant calculation T_{17}	the accuracy of relevant calculation, including the reasonable profit rate of social capital, annual operating costs, governmental operating subsidy expenditure, and general public budget expenditure
		responsibility identification of financial expenditure T_{18}	the responsibility identification rationality of financial expenditure
	risk sharing S_6	risk balance configuration T_{19}	the rationality of basic framework of risk allocation

		combination of governmental resources and social capital T_{20}	review the effectiveness of combination of governmental resources and social capital
		get governmental support T_{21}	according to [2014] No. 2724 "Administrative Measures of Franchise of Infrastructure and Public Utilities", evaluate the compliance of the project's practical operation and whether it has excessively obtained governmental support
	purchase procedure S_7	purchase document T_{22}	the integrity of the purchase document compilation, contents should include purchase invitations, instructions to bidders, PPP project contract (draft), project purchase requirements, evaluation methods, format of bidding documents, qualification documents, and project implementation plans proposed by bidders, etc.
		transparency of information disclosure T_{23}	the timeliness and transparency of relevant information disclosure and announcement in the purchase procedure
		response document review T_{24}	according to the "Government Purchase Law of the People's Republic of China" and "Bid Law of the People's Republic of China", evaluate and review legality and compliance
		contract signing T_{25}	the legality of the contract signing procedure, the integrity of the terms and the consistency of the bid document
	application procedure of special bonds S_8	application procedure T_{26}	according to the "Interim Measures of the Issuance Administration of Special Bonds of Local Governments", evaluate the integrity of the application procedure
		budget compilation T_{27}	according to the relevant provisions of the Ministry of Finance's ''Administrative Measures of Budgets of Special Debt of Local Governments'' No.155 [2016], evaluate the rationality of budget compilation
		bond accounting T_{28}	according to "Views on Strengthening the Management of Local Government Debts" (the State Council [2014] No. 43) and "Administrative Measures of the Budget Management of Special Bonds of Local Governments in 2015" (the Ministry of Finance [2015] No. 32), evaluate the accounting accuracy of special bonds
	project income solvency S_9	balance receipts and payment capacity T_{29}	project income and financing are balance
		solvency analysis T_{30}	combining the special income and government gap subsidy repayment during the operation period, evaluate the accuracy of the solvency calculation and the correctness of the governmental understanding of the solvency
middle-term administration P_2	fulfilment of governmental administrative functions S_{10}	government administration T_{31}	effective administration of project construction and operation of the government, financial departments and industry authorities
		administration of special bond funds T_{32}	effectiveness, timeliness and risk prevention capacity of administration of special bond funds
		legal attainments of staff T_{33}	familiarity of government departments, industry bodies, project leaders, auditors and finance professionals with policies and regulations of special bonds
	rationality of project financing S_{11}	financing structure T_{34}	according to the "Implementation Views on Promoting the Standardized Development of Cooperation between Government and Social Capital" (the Ministry of Finance [2019] No.10), evaluate the rationality of the financing structure.
		financing plan T_{35}	the economy of financing plans includes the comparison of various plans and the correctness of plan compilation
		calculation results T_{36}	calculation accuracy related to financing plan
	use rationality of special bonds S_{12}	idle rate of funds T_{37}	whether the special bonds are idle, the funds are useless, and the interest is paid in vain
		connection between funds and project T_{38}	the connection condition between the application and use of special funds and the progress of the project, ensures that the bond funds are issued, used and effective as soon as possible
		return period and bond period T_{39}	the matching degree between the project income period and the bond period should meet the conditions that the project income period covers the bond period, and guarantee the solvency condition of the project
		fund information T_{40}	all information in the use of special funds is open and transparent
	legality of construction procedure S_{13}	plan decision T_{41}	the rationality of project plan and decision, take into account the quality, cost and construction period
		construction procedure T_{42}	according to the relevant documents of the Ministry of Finance and the National Development and Reform Commission on the implementation of the PPP model, evaluate the perfection and compliance of the construction procedures
	fulfilment degree of project company S_{14}	cooperation agreement T_{43}	the execution degree of cooperation agreement, including the consistency between the results achieved by the project at various stages of construction and operation and the expected goals

		quality safety and progress management T_{44}	the quality of construction and operation, the deviation degree of the construction progress in comparison with the expected plan, and the reliability of the actual quality of the project
		project cost T_{45}	reduction rate of project cost = (incurred cost of current PPP project-incurred cost of current similar traditional project) / incurred cost of current similar traditional project
	evaluation quality of middle-term performance S_{15}	performance system T_{46}	review the rationality of the performance system, the evaluation index system should be built in accordance with the evaluated objectives
		incentive effect of plan T_{47}	whether the compiled incentive plan can achieve the expected incentive goals
	payment condition of project completion S_{16}	settlement price T_{48}	the settlement price is reasonable and consistent with the contract or market price
		completion settlement T_{49}	correctness of completion settlement compilation, including compilation basis, project quantity change, claim, other inspection and calculation correctness
		final account compilation of completion T_{50}	the final account rationality of completion, including the compilation basis and the correctness of the contents of the final accounts
	gap subsidy condition of government feasibility S_{17}	pricing and subsidies T_{51}	pricing rationality of operating income, including subsidies in line with actual conditions and contract agreements
		subsidy funds T_{52}	the calculated correctness of subsidy funds, gap subsidy of government feasibility = availability return annuity + operation and maintenance return of the year - user fee income of the year
	financial and operational situation S_{18}	account book, accounting statement T_{53}	the authenticity and effectiveness of the account book and accounting statement, including the authenticity of the accounts and the compilation correctness of the cash flow statement
		project operation T_{54}	openness and transparency of various businesses and operating income during the project operation period
		user fee T_{55}	the rationality of fee standard, including practicality, reasonable pricing, and compliance in the operation process
later handover evaluation P_3	compliance of project handover S_{19}	handover procedure T_{56}	procedure compliance, including integrity of handover object, legal transfer and management rights
		handover content T_{57}	content integrity, including that the handover content meets the terms of the contract.
		achievement rate of handover standard T_{58}	the standard achievement rate, including the equipment integrity rate, the shortest service life, and deviation degree set by other indexes
	economy of handover subsidy amount S_{20}	asset evaluation procedure T_{59}	asset evaluation procedure is in place and legal
		asset evaluation plan T_{60}	the asset evaluation plan include that the transfer working group and the social capital confirm the transfer situation and compensation method, and the rationality and pertinence of the asset evaluation plan
	effectiveness of performance test S_{21}	performance test program T_{61}	overall normativeness of performance test program
		performance test plan T_{62}	the performance test plan includes the feature pertinence and rationality of the project to be handed over
	repayment degree of principal and interest of special bonds S_{22}	repayment rate of principal and interest T_{63}	repayment of principal and interest of special bonds, repayment rate = principal and interest repaid / principal and interest to be repaid
		repayment coverage rate of special income T_{64}	whether the special income fully covers the repayment of the principal and interest of the special bonds, achieve return self-balance, and whether the special operating income repays the principal and interest of the special bonds in time
	rationality final performance evaluation S_{23}	public goods or service efficiency T_{65}	the fulfilment condition of the functions of the "special bonds + PPP" project, and the efficiency and practicality of the public products or services provided
		public satisfaction T_{66}	the public satisfaction with project outcome
		environmental impact rate T_{67}	the degree of environmental impact on society, economy and ecology after the project is completed
		reduction rate of project investment T_{68}	the construction economy of final investment of the project in comparison with the traditional modes

3. Weight Determination of the Whole-Process Tracking Audit Index System of "Special Bonds + PPP"

3.1. Determination of the Weight Calculation Method

Each index in the index system built above has a different impact on the project, for scientific evaluation, the weight of each index needs to be determined. At present, the weight determination methods mainly include subjective weighting method, objective weighting

method and subjective and objective comprehensive integrated weighting method. After fully studying the advantages and disadvantages of various weighting methods, combining the features of "special bonds + PPP" and the conditions at this stage, this paper initially considers using the analytic hierarchy process (AHP) to calculate the weight. AHP can quantify the qualitative judgments made by decision makers based on subjective experience, which not only fully considers experts' experience and avoids being separated from reality, but also quantifies the decision process and avoids subjective arbitrarinesa and AHP can complete the determination of weights without huge sample data. However, the traditional AHP requires experts to make "comparison in pairs" on indexes, in the case of a large number of audit indexes in this paper, repeated "comparison in pairs" will easily affect the consistency of experts' thinking, thereby affecting the accuracy of the final judgment results. In order to avoid the defects caused by AHP, finally, this paper decided to introduce the improved AHP, changed the "comparison in pairs" to order assignment, namely the fuzzy analytic hierarchy process (FAHP), which optimized based on retaining the advantages of traditional methods, and effectively improved the efficiency and capacity of AHP to solve problems.

3.2. Building of FAHP Model

(1) Building of hierarchical structure model

A hierarchical structure model is built, and complex problems are decomposed into factors with logical relationships through the model, and the lower layer of factors is the subdivision of the upper layer of factors.

(2) Factor sorting and assignment

Expertise is used to sort the factors in the hierarchical structure, assign the most important factor as 10, the least influential factor as 1, and the other factor assignments are calculated as follows:

$$u_k = 1 + \frac{10-1}{n-1}(k-1)$$

In the formula: k is the serial number of the influencing factors after the influencing factors are sorted in ascending order by severity; u_k is the value assigned to k-th factor; n is the number of influencing factors, $n \geq 2$.

(3) Building of the judgment matrix

The positive and negative judgment matrix $A\left(A = \left(a_{ij}\right) n \times n\right)$ is built, and the element a_{ij} of the matrix take the value in accordance with the following formula.

$$a_{ij} = \begin{cases} u_i - u_j, u_i - u_j > 0 \\ 1, \quad u_i - u_j = 0 \\ \dfrac{1}{\left|u_i - u_j\right|}, u_i - u_j < 0 \end{cases}$$

In the formula: a_{ij} is the elements of the judgment matrix, u_i and u_j are the assignments of the factors i and j, i、$j = 1,2\ldots,$ n. a_{ij} has the following properties:(1) $0 < a_{ij} < 1$; (2) $a_{ij} \cdot a_{ij} = 1$; (3) $a_{ij} = 1$; thus building the following judgment matrix A.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

(4) Calculation of Weights

1) Column vector normalization, namely, normalize each column of the judgment matrix.

$$a'_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}$$

In the formula: a'_{ij} ——the matrix element obtained after the column vector is normalized. $i 、 j = 1,2 ..., \; n$.

2) Each row of vector after normalization is added up to get the column vector a,

$$a_i = \sum_{j=1}^{n} a'_{ij} \quad ; a = (a_1, a_2, ..., a_n,)^T$$

In the formula: a'_{ij} is the value after the addition of i−th row, $i 、 j = 1,2 ..., \; n$;.

3) After the vector a is normalized, the matrix eigenvector W is obtained

$$w_i = \frac{a_i}{\sum_{i=1}^{n} a_i} \quad ; \quad W = (w_1, w_2, ..., w_n,)^T$$

In the formula: W ——eigenvector; w_i ——the value of i−th row in w , $i = 1,2 ..., \; n$

4) Calculation of the eigenvalue λ_max

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(Aw)}{nw_i}$$

In the formula:

$\lambda_{\max}$—— maximum eigenvalue w_i—— eigenvector; A—— judgment matrix.

3.3. 3. Data Source and Application

Taking the three-level index T1-T68 in Table.3 in this paper as content, the questionnaire of sorting the importance of the audit index system was set up, 36 questionnaires are distributed to the audit bureau, design institute, project management company and relevant professional teachers in colleges and universities, and people with practical experience through the WJX APP, and 31 valid questionnaires were recovered. The above-mentioned FAHP model is used to calculate the weight of each index.

(1) Building of judgment matrix

This paper selects the No. 5 expert questionnaire to compare the information in two layers, assigns values to each index factor, and obtains the judgment matrix of each level, the comparison logic of the hierarchy of the judgment matrix P1—P3,S1—S9,S10—S18,S19—S23,T1—T2,T3—T6,T7—T1,T7—T11,T16—T18,T19—T21,T22—T25,26—T28,T29 —T30,T31 —T33,T34—T36,T37—T40, T41 —T42,T43 —T45,T46 —T47, T48 —T50, T51—T52,T53 —T55, T56 —T58,T59—T60,61—T62,T63 —T64,T65 —T68. Due to a large number of judgment matrices and a large amount of data, this paper extracts some matrices for display, as shown in Table.4-9:

Table 4. P1-P3 index judgment matrix

P	P_1	P_2	P_3
P_1	1	9	4.5
P_2	0.11	1	0.22
P_3	0.22	4.5	1

Table 5. S1-S9 index judgment matrix

S_{1-9}	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
S_1	1	3.375	4.5	9	2.25	7.875	1.125	6.75	5.625
S_2	0.296	1	1.125	5.625	0.889	4.5	0.444	3.375	2.25
S_3	0.222	0.889	1	4.5	0.444	3.375	0.296	2.25	1.125
S_4	0.11	0.178	0.222	1	0.148	0.889	0.127	0.444	0.296
S_5	0.444	1.125	2.25	6.75	1	5.625	0.889	4.5	3.375
S_6	0.127	0.222	0.296	1.125	0.178	1	0.148	0.889	0.444
S_7	0.889	2.25	3.375	7.875	1.125	6.75	1	5.625	4.5
S_8	0.148	0.296	0.444	2.25	0.222	1.125	0.178	1	0.889
S_9	0.178	0.444	0.889	3.375	0.296	2.25	0.222	1.125	1

Table 6. T1-T2 index judgment matrix

T_{1-2}	T_1	T_2
T_1	1	9
T_2	0.11	1

Table 7. T3-T6 index judgment matrix

T_{3-6}	T_3	T_4	T_5	T_6
T_3	1	9	3	6
T_4	0.11	1	0.167	0.333
T_5	0.333	6	1	3
T_6	0.167	3	0.333	1

Table 8. T63-T64 index judgment matrix

T_{63-64}	T_{63}	T_{64}
T_{63}	1	9
T_{64}	0.11	1

Table 9. T65-T68 index judgment matrix

T_{65-68}	T_{65}	T_{66}	T_{67}	T_{68}
T_{65}	1	9	3	6
T_{66}	0.11	1	0.167	0.333
T_{67}	0.333	6	1	3
T_{68}	0.167	3	0.333	1

(2) Calculation of index weight

According to the corresponding judgment matrix sorted out, MATLAB program is used to solve the weight vector and maximum eigenvalue of each judgment matrix, on the basis of the information of the No.5 expert questionnaire, the weight of each audit index calculated to the importance of the whole index system is obtained, for details, see the data of "Expert No.5" in Table.10.

(3) Calculation of the overall average index weight

3. data source was adopted and (1) and (2) steps were applied, 31 valid questionnaires were analyzed and calculated, respectively, and then the corresponding index weights were averaged, and finally the average weight of each index relative to the importance of the whole index system was obtained, for details, see the "average" data in Table.10.

Table 10. The calculation results of whole-process tracking audit index system weight of "special bonds + PPP"

first-level index	index weight		second-level index	index weight		third-level index	index weight	
	No.5 expert	average		No.5 expert	average		No.5 expert	average
P_1	0.7276	0.4879	S_1	(0.2864)0.2084	0.1705)0.0832	T_1	(0.9000) 0.1876	(0.5129) 0.0427
						T_2	(0.1000) 0.0208	(0.4871) 0.0405
			S_2	(0.1127)0.0820	(0.1265)0.0617	T_3	(0.5913) 0.0485	(0.235) 0.0145
						T_4	(0.0465) 0.0038	(0.2324) 0.0143
						T_5	(0.2570) 0.0211	(0.2713) 0.0167
						T_6	(0.1052) 0.0086	(0.2613) 0.0162
			S_3	(0.0789)0.0574	(0.1189)0.058	T_7	(0.0378) 0.0022	(0.1727) 0.01
						T_8	(0.4928) 0.0283	(0.2145) 0.0124
						T_9	(0.2662) 0.0153	(0.2149) 0.0125
						T_{10}	(0.1352) 0.0077	(0.1707) 0.0099
						T_{11}	(0.0680) 0.0039	(0.2272) 0.0132
			S_4	(0.0220)0.0160	(0.0819)0.0399	T_{12}	(0.5913) 0.0095	(0.2917) 0.0116
						T_{13}	(0.1052) 0.0017	(0.2517) 0.0100
						T_{14}	(0.2570) 0.0041	(0.2312) 0.0093
						T_{15}	(0.0465) 0.0007	(0.2254) 0.0090

P			S			T		
			S_5	(0.1589)0.1156	(0.0771)0.0376	T_{16}	(0.7276) 0.0841	(0.3461) 0.0130
						T_{17}	(0.2112) 0.0244	(0.3891) 0.0146
						T_{18}	(0.0613) 0.0071	(0.2648) 0.0100
			S_6	(0.0282)0.0205	(0.1123)0.0548	T_{19}	(0.0613) 0.0013	(0.3246) 0.0178
						T_{20}	(0.7276) 0.0149	(0.3031) 0.0166
						T_{21}	(0.2112) 0.0043	(0.3723) 0.0204
			S_7	(0.2191)0.1594	(0.0863)0.0421	T_{22}	(0.2570) 0.0410	(0.2517) 0.0106
						T_{23}	(0.5913) 0.0943	(0.2498) 0.0105
						T_{24}	(0.1052) 0.0167	(0.2615) 0.0110
						T_{25}	(0.0465) 0.0074	(0.2371) 0.0100
			S_8	(0.0387)0.0282	(0.1337)0.0653	T_{26}	(0.7276) 0.0205	(0.3842) 0.0251
						T_{27}	(0.2112) 0.0060	(0.3175) 0.0207
						T_{28}	(0.0613) 0.0017	(0.2983) 0.0195
			S_9	(0.0551)0.0401	(0.0928)0.0453	T_{29}	(0.1000) 0.0040	(0.4613) 0.0209
						T_{30}	(0.9000) 0.0361	(0.5387) 0.0244
			S_{10}	(0.2863)0.0176	(0.1814)0.0553	T_{31}	(0.0613) 0.0011	(0.3676) 0.0203
						T_{32}	(0.7276) 0.0128	(0.3246) 0.0179
						T_{33}	(0.2112) 0.0037	(0.3078) 0.0170
			S_{11}	(0.1127) 0.0069	(0.1011) 0.0308	T_{34}	(0.2112) 0.0015	(0.3079) 0.0095
						T_{35}	(0.7276) 0.0050	(0.3197) 0.0098
						T_{36}	(0.0613) 0.0004	(0.3724) 0.0115
			S_{12}	(0.1589) 0.0097	(0.1278) 0.0389	T_{37}	(0.2570) 0.0025	(0.2575) 0.0100
						T_{38}	(0.5913) 0.0057	(0.2578) 0.0100
P_2	0.0613	0.3046				T_{39}	(0.1052) 0.0010	(0.2517) 0.0098
						T_{40}	(0.0465) 0.0005	(0.2331) 0.0091
			S_{13}	(0.2190)00135	(0.1379) 0.042	T_{41}	(0.9000) 0.0122	(0.5645) 0.0237
						T_{42}	(0.1000) 0.0013	(0.4355) 0.0183
			S_{14}	(0.0220) 0.0013	(0.1033) 0.0315	T_{43}	(0.7276) 0.0009	(0.3198) 0.0101
						T_{44}	(0.2112) 0.0003	(0.3342) 0.0105
						T_{45}	(0.0613) 0.0001	(0.3461) 0.0109
			S_{15}	(0.0387) 0.0024	(0.0641) 0.0195	T_{46}	(0.1000) 0.0002	(0.5645) 0.0110
						T_{47}	(0.9000) 0.0022	(0.4355) 0.0085
			S_{16}	(0.0284) 0.0017	(0.0964) 0.0294	T_{48}	(0.2112) 0.0004	(0.4057) 0.0119

						T_{49}	(0.7276) 0.0012	(0.2795) 0.0082
						T_{50}	(0.0613) 0.0001	(0.3148) 0.0093
			S_{17}	(0.0789) 0.0048	(0.0649) 0.0197	T_{51}	(0.1000) 0.0005	(0.5903) 0.0116
						T_{52}	(0.9000) 0.0043	(0.4097) 0.0081
			S_{18}	(0.0551) 0.0034	(0.1231) 0.0375	T_{53}	(0.0613) 0.0002	(0.3343) 0.0125
						T_{54}	(0.7276) 0.0025	(0.4009) 0.0150
						T_{55}	(0.2112) 0.0007	(0.2648) 0.0099
			S_{19}	(0.1352) 0.0285	(0.2187) 0.0454	T_{56}	(0.0613) 0.0017	(0.2053) 0.0093
						T_{57}	(0.7276) 0.0207	(0.3294) 0.0150
						T_{58}	(0.2112) 0.0061	(0.4653) 0.0211
			S_{20}	(0.2662) 0.0562	(0.2317)0.0482	T_{59}	(0.9000) 0.0506	(0.5645) 0.0272
						T_{60}	(0.1000) 0.0056	(0.4355) 0.0210
P_3	0.2111	0.2075	S_{21}	(0.4928) 0.1040	(0.2398) 0.0496	T_{61}	(0.1000) 0.0104	(0.6677) 0.0331
						T_{62}	(0.9000) 0.0936	(0.3323) 0.0165
			S_{22}	(0.0680) 0.0144	(0.1727) 0.0358	T_{63}	(0.1000) 0.0014	(0.6161) 0.0221
						T_{64}	(0.9000) 0.0130	(0.3839) 0.0137
			S_{23}	(0.0378) 0.0080	(0.1371) 0.0285	T_{65}	(0.2570) 0.0021	(0.2664) 0.0076
						T_{66}	(0.5913) 0.0047	(0.2750) 0.0078
						T_{67}	(0.1052) 0.0008	(0.2233) 0.0064
						T_{68}	(0.0465) 0.0004	(0.2353) 0.0067

Note: there are weights for the upper-level indexes in bracket, and there are weights for the whole index system outside the bracket.

4. Conclusion

(1) Through literature research and interviews with institutional experts, the reasonable dimensions and important content identification of the whole-process tracking audit of "special bonds + PPP" were analyzed, according to the three dimensions: early project approval decision, middle-term administration, and later handover evaluation, the evaluation index system including 3 first-level indexes, 23 second-level indexes and 68 third-level indexes were built, the audit work covered the whole life cycle of the project, and ensured the legal operation of the project and achieve the expected benefits.

(2) The questionnaire information is based on the importance sorting of the evaluation index system filled in by experts, in order to avoid the shortcomings of the traditional AHP, namely, there are many indexes in this paper, and it is difficult to determine the weight of each index by "comparison in pairs", so the FAHP is introduced, the factor sorting and assignment are made to each index, the judgment matrix is built, and MATLAB program is used to obtain the mean value of weight, which makes the audit index system scientific and operable.

This paper focused on the building contents of the whole-process tracking audit index system of "special bonds + PPP" and the weight of each index, and made the audit work well-founded.

In the future research, we will further study the audit prediction model matching this index system, and provide theoretical and practical support for the project audit activities of government departments.

Acknowledgments

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