Research on the Hidden Quality Cost Control of Construction Project Based on Bayesian Network

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Abstract

At present, the hidden quality cost of construction projects in China is too high. If it is not controlled, a "benefit funnel" will inevitably occur. This paper uses Bayesian network to construct the control model of implicit quality cost of construction project. Combined with the prior knowledge obtained and the evidence found, through the causal reasoning and diagnostic reasoning of the model, we can grasp the status of implicit quality cost in the construction process in time and find out the key influencing factors, so as to take targeted control measures It can improve the pertinence and effectiveness of comprehensive and dynamic management of implicit quality cost in the construction process.

Keywords

Hidden cost , Construction Project, Bayesian Network.

1. Introduction

In recent years, engineering quality accidents have frequently occurred, and the losses caused by them each year exceed 100 billion. 20% of the projects do not meet the mandatory quality standards set by the state [1]. The resulting quality costs have caused the construction industry and Wide concern of society. In the process of comprehensive cost management, there are two levels of quality cost, explicit and implicit [2]. Among them, the explicit quality cost contained in the accounting account is relatively transparent, which is easy to be counted and calculated. [3] The hidden quality cost outside the accounting account is easy to be ignored due to its hidden and difficult to quantify characteristics. Uncontrolled will inevitably form a "benefit funnel", which is not conducive to the overall management of project costs [4]. As far as academic research is concerned, China's exploration in this field started relatively late [5]. Liu Yongxin applied lean thinking to the control of hidden quality costs during construction [6]; Zhou Jichun and Deng Xuefen explored ways to control hidden quality costs through total quality management [7]. These studies mainly focus on the establishment of qualitative control measures, which are obviously insufficient for quantitative data analysis. Therefore, this paper aims to establish the hidden problems of building construction projects based on the characteristics of hidden quality cost and many uncertain factors, and the Bayesian Network (Bayesian Network) (BN) advantages of uncertainty reasoning, to build hidden hidden dangers of construction projects. Based on the acquired prior knowledge and observed evidence, causal reasoning and diagnostic reasoning are implemented to realize the dynamic and holistic control of hidden quality costs of construction projects.

2. Analysis of hidden quality cost control process of construction projects based on BN

Based on the analysis of the components and control elements of hidden cost of construction resources in construction projects, the optimization and dynamic control model of construction resources based on BIM and genetic algorithm is constructed, as shown in Figure 2.

2.1 Bayesian Network

The Bayesian network includes a directed acyclic graph G = <N, E> and a set of probability distributions P [8-11]. It can effectively combine probability theory with graph theory, and has the

advantages of both. Therefore, in terms of the essential properties of the Bayesian network, it has unique advantages when it is used in the study of hidden costs.

2.2 Hidden quality cost control process of construction project

Using Bayesian Networks to Hidden Quality of Construction Projects. This control includes 4 steps.

(1) Identification and analysis of influencing factors

First, by looking at historical data, expert experience, and in-depth field surveys, find out the factors that affect the hidden quality cost of a construction project as comprehensively as possible, and then select the main influencing factors through expert discussions.

(2) Construction of Bayesian network model. First, the main influencing factors obtained in the first step are the event nodes, and the causal relationship between the influencing factors is given by expert decision to determine the topology of the Bayesian network. Secondly, the probability of the parent node and the conditional probability of each child node are obtained through historical data collection and expert investigation, so as to obtain the parameter values of the model.

(3) Uncertainty reasoning. When researching the hidden quality cost control process of construction projects, the causal reasoning and diagnostic reasoning of the model are mainly used to infer the probability of hidden quality costs of construction projects, and then determine the key influencing factors.

(4) Implement effective control. Aiming at the key factors that affect the hidden quality cost of a construction project, we take targeted control measures to avoid the occurrence or further expansion of hidden quality cost of a construction project.

3. Empirical analysis

3.1 Influencing factor identification

Due to the large differences between construction projects, when performing hidden quality cost control analysis for different projects, it is necessary to establish a corresponding BN model and obtain corresponding parameter values for analysis. This paper analyzes the hidden quality cost of a construction project in Wenzhou.

By consulting the literature and engineering background information, according to the recommendations given by the experts, and combining the practical experience obtained by the research team at the construction site, the hidden quality of the construction project is summarized from the four aspects of personnel, technology, materials and equipment, and the environment The 18 main factors that influence cost are shown in Table 1.

Tab.1 Major influencing factors of hidden quality cost

Number	Factor category	Main factor of influence	Code
1	Personnel factor	Owner is irresponsible	P1
2		Supervisor failure	P2
3		Lack of training for laborers	P3
4		Poor quality of construction management staff	P4
5	Technical factors	Construction organization design is unscientific	T1
6		Rushing schedules and neglecting quality issues	T2
7		Backward process	T3
8		Quality inspection is not serious	T4
9		Defective survey and design documents	T5
10		Blindly reducing costs and sacrificing quality	T6
11		Lagging quality standards	T7
12	Material and equipment factors	Quality of building materials is not up to standard	M1
13		Equipment maintenance is not in place	M2

14		Degraded use of materials	M3
15	Envirnmental factor	Constrained by natural conditions	E1
16		Force majeure	E2
17		Environmental impact	E3
18		Market and policy implications	E4

3.2 Construction of Control Model Based on Bayesian Network

In the process of identifying and analyzing the hidden quality cost influencing factors of building construction projects, it is necessary to judge the causal relationship between each influencing factor. Due to the large number of nodes and the complex causality, it is limited to space reasons. This article only introduces examples. For example, due to the irresponsibility of the supervision engineer, the lack of review of the defective construction organization design led to the backwardness of the process methods used in the construction process, which led to quality problems and hidden quality costs (P 2 → T1 → T 3 → T); due to the owner's irresponsibility, blindly requesting the construction period and neglecting quality issues, resulting in the occurrence of hidden quality costs (P 1 → T 2 → T); due to the low quality of construction managers, in order to pursue profits, blind Reducing costs and sacrificing quality leads to substandard quality of the project, which leads to rework, repairs, claims, and hidden quality costs (P 4 → T 6 → T). According to the causal relationship between the various influencing factors, the hidden quality cost Bayesian network topology structure of the construction project can be constructed with the help of Genie 2.0 software, as shown in Figure 1.

In this paper, questionnaires are used to obtain relevant data. In order to ensure the reasonableness of the obtained data, 50 experienced experts in the fields of design, engineering, cost, contract, and senior management were surveyed, and the statistical results After conducting a comparative analysis and repeated corrections, the prior probability of the root node in Figure 2 can be finally determined, as shown in Table 2. Due to the large amount of conditional probability data of each child node, only the conditional probability of node J1 is listed here, as shown in Table 3.

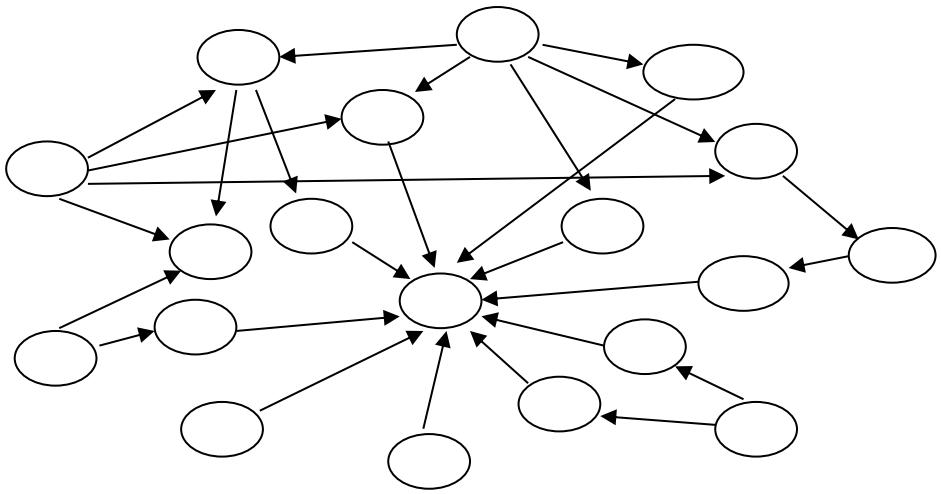

Fig.1 Bayesian network topology

Tab.2 Priori probability of the root nodes

Factors	P1		P2		P4		E1		E4		T7	
	Y		N		Y		N		Y		N	
Priori probability/%	8.24	91.76	5.65	94.35	3.50	96.5	1.19	98.81	1.21	98.79	2,24	97.76

Tab.3 Conditional probability of the node T1

Factors	P2	Y		P4	
	P4	Y	N	Y	N
	Y	52.34	32.03	39.24	0

Conditional probability of the node T1/%	N	47.66	67.97	60.76	1

3.3 Uncertainty reasoning

(1) Causal reasoning

After the model is constructed, the obtained parameter values are input into the model, and the probability will propagate forward along the layer-to-layer relationship in the Bayesian network. Finally, the hidden information of the construction project under the given parameter conditions can be obtained. The probability that the sexual quality cost will occur, and the probability of the hidden quality cost is predicted. The parameter input and causal reasoning process of this paper are implemented in Genie 2.0 software. After reasoning, the probability of the hidden quality cost of the construction project is 27%, as shown in Figure 3. After comparison, the probability of the hidden quality cost of the construction project is greater than the safety threshold, and diagnostic reasoning should be performed to determine the key influencing factors.

When there is evidence, it is input into the Bayesian network and causal reasoning is performed again. Because the number of nodes is too large, this article only conducts experiments on the root nodes, and assuming that the status of each root node is "Y", the probability of hidden quality costs for the construction project is inferred.

The results show that the probability of the hidden quality cost of the construction project rises when each root node event occurs. This conclusion is consistent with the actual situation and also proves the rationality and scientificity of the model from another level.

(2) Diagnostic Reasoning

When the hidden quality cost of a construction project is observed or the probability of its occurrence is high, the probability value of each influencing factor at that time can be inferred through the inverse principle of the Bayesian network model.

3.4 Determine control measures

Sort the probability of occurrence of each influencing factor (see Table 5)

It can be seen that when the hidden quality cost occurs, the event T5 has the highest probability, that is, the event T5 is most likely to cause the hidden quality cost. Therefore, after the hidden quality cost of a construction project is known to occur, this factor should be considered first, and it should be investigated to find remedial measures. If the event is found to be occurring, it will be controlled in time. In the process of effective control, new evidences P (T = Y) = 1 and P (T5 =Y) = 1 need to be re-entered into the system to calculate the probability of other relevant nodes. According to the calculation results, the impact events are investigated one by one to find the highest probability event, and according to the results of the investigation, targeted control measures are implemented. According to this procedure, the evidence input and re-inference are continuously performed, and the influencing factors are investigated and controlled one by one until the hidden quality cost of the construction project is fully controlled.

It can be seen from Table 4 that among the top ten influencing factors, four are technical factors, three are personnel factors, two are materials and equipment factors, and one is environmental factors. According to this, it can be known that for this project, the environmental factors have little effect on the hidden quality cost of the construction project. The control of the hidden quality cost of the construction project mainly starts from the three aspects of technology, personnel, materials and equipment.

(1) Technical aspects: During the construction process, try to use new technologies and methods as much as possible; optimize the design unit to ensure the design quality; strengthen quality inspection to eliminate hidden quality risks.

(2) In terms of personnel: the owner shall strictly perform its due obligations and select qualified supervision units; the construction party shall select labor subcontracting units and strengthen technical training of labor personnel.

(3) Material and equipment: Establish an effective mechanism for the repair and maintenance of construction machinery, strictly abide by the operating rules of construction machinery, and strictly prohibit illegal operation; strictly select and optimize material suppliers, strictly implement inspection procedures for material quality, and prohibit the application of unqualified materials Into the project.

Tab.4 Sequence of probability of factors

Code	Main factor of influence	Probability/%	Sort
T5	Defective survey and design documents		1
P3	Lack of training for laborers		2
M2	Equipment maintenance is not in place		3
M1	Quality of building materials is not up to standard		4
T3	Backward process		5
P1	Owner is irresponsible		6
E4	Market and policy implications		7
T7	Lagging quality standards		8
T2	Rushing schedules and neglecting quality issues		9
P2	Supervisor failure		10
T4	Quality inspection is not serious		11
M3	Degraded use of materials		12
T1	Construction organization design is unscientific		13
P4	Poor quality of construction management staff		14
E1	Constrained by natural conditions		15
T6	Blindly reducing costs and sacrificing quality		16
E3	Environmental impact		17
E2	Force majeure		18

4. Conclusion

Based on the research of hidden quality costs of construction projects, this article draws the following conclusions:

(1) Establish the hidden quality cost control model of construction projects by using Bayesian network; it has good objectivity and rationality.

(2) The causal reasoning of the model can predict the probability of the hidden quality cost of the construction project, which is convenient for the manager to grasp the status of the hidden quality cost of the construction project in time.

(3) The diagnostic reasoning of this model can find out the key influencing factors that affect the hidden quality cost of construction projects, which is helpful for managers to control the hidden quality cost of construction projects in a targeted manner.

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References

[1] LIU Xiaowei.Quality control of building construction process[J] .Construction Materials & Decoration, 2014 (36): 61- 62

[2] HAN Yanwei.Study of hidden quality cost of exter -nalization [D].Shanghai: Tongji University, 2007.

[3] SHAO Bilin, WANG Yin , LIN Seng.Hidden cost factors of the duration based on Bayesian Network[J] .Friends of Accounting, 2013 (4): 34- 37.

[4] Xu Haifeng. An analysis of the recessive cost of enterprises, Journal of Information Technology in Civil Engineering and Architecture, 2017. 13(6):234-245.

[5] HU Yu, XU Xiaolong.Hidden cost of quality review[J] .Journal of Nantong Vocational College, 2010(2): 35- 37.

[6] SHAO Binlin, WU Jieqiong, CHEN Zhuo.Recessive quality cost estimation model of construction projectbased on activity- based costing[J] .Construction Econ -omy, 2012 (10):38-42.

[7] LIU Yongxin, CHEN Bingjun.Hidden quality cost control of construction projects based on lean construction [J].Construction Technology, 2013 (4): 112– 115.

[8] ZHOU Jichun, DENG Xuefen , HUANG Gong xun.Discussion on ways of reducing the implicit cost of quality [J].China Business & Trade, 2012 (3):236- 237.

[9] TENG Lihua, WEI Jun.Analysis of environmental impact factors of eco- industrial parkbased on Bayesian network [J]. Industrial Technology & Economy, 2008(12):78 - 80.

[10] JIANG Liangxiao, LI Chaoqun.Bayesian network clas sifier : algorithms and applications [M] .Wuhan : China University of Geosciences Press,2015.

[11] WU Xianguo DING Baojun.Risk management of sub way construction based on bayesian network [J] .China Safety Science Journal, 2014 (1):85- 89.