Economic Incentive Policy Making Plan of Green Buildings Based on BIM

Li XUE[1], Yimin JIN[2]

[1]*Department of Management,* Shenyang Jianzhu University, Shenyang, 110168, China
[2]*Department of Civil Engineering,* Shenyang Jianzhu University, Sheyang, 110168, China

***Abstract* —A BIM, Buildings Information Modelling, project cost analysis algorithm using Bayesian collaborative decision-making based on mutual belief model is proposed in this paper in order to improve the reliability and scientific value of cost analysis of green buildings project. Firstly, BIM model is utilized to establish the quantitative index of the project evaluation result and establish judgment and comparison matrix of hierarchical structure so as to provide decision making analysis with model basis; secondly, similarity evaluation on the project cost index is conducted with the D-S evidence theory and the collaborative decision-making model is established in combination with the Bayesian algorithm based on mutual belief model to achieve the scientific analysis of BIM project cost. Finally the experiment verifies the effectiveness of the methods proposed.**

Keywords - mutual belief model; bayes; bim project; cost analysis; D-s evidence

I. INTRODUCTION

BIM refers to building information modeling (Building Information Modeling) and due to past relatively slow development of science and technology, traditional green building design focuses on two-dimensional drawings, and although it also focuses on the accuracy and preciseness necessary for the design, it is short of visual and simple expression form; the specific information about the engineering project is inputted through the BIM technology to establish a green building model for the project, and therefore, it is not only more visual, but also accordingly changes in case of any design change so as to avoid unnecessary design mistakes and enhance the design accuracy and preciseness [1-2].

Research analysis of components related to green building cost is conducted in Literature [3] by using BIM model to form a form-simplified green building component. The evaluation on the green building project cost is conducted in Literature [4] by using the BIM model. Evaluation system is established for the life cycle of the green building and research on the environmental disturbance of the green building of life cycle is also conducted in Literature [5]. A green building evaluation model of green building under cost influence is established based on the cost evaluation model of green building in Literature [6] to obtain the environmental disturbance factors of the green building examples. The model building mode of green building based on BIM with relatively obvious advantages is widely used on the evaluation application scenario of the green building. Currently, for relevant researches on the cost model of green model, the application of 3D model evaluation framework of project BIM technology is a practical mode to influence the cost factors [7-8].

The model relationship between green building material and BIM elements is established in this Thesis with the Bayesian collaborative decision-making based on mutual belief model from the perspective of cost analysis of construction project to form a systematic evaluation method for quantitative components of green building so as to improve the reliability of the cost evaluation.

II. DEFINITION OF REFINEMENT ENGINEERING COST

A. *Definition Description*

Refined management of cost refers to the detailed management of all project phases to achieve the phased intensive management of the cost. Optimal allocation will be carried out for resources at all phases of project implementation to effectively the phenomenon of “three excesses”. The management links for refinement engineering cost mainly includes: five phases of design, decision making, construction, bid and tender and completion and the cost management and relevant subjects related to these five phases are shown in Fig. 1.

The cost management of refinement engineering is the precondition for the determination and control of reasonable cost. Firstly it is necessary to ensure it within the control limit of the total cost in order to achieve the reasonable evaluation of investment. In particular, at the cost evaluation phase of design, it is necessary to ensure that the cost evaluation value is more reasonable than that at the investment phase and is under the influence of the cost estimation at investment phase. For the cost estimation at the construction drawing design phase, it is necessary to conduct deep and detailed evaluation based on the design thinking of construction drawing and materials. The management of interim and advance payment for the progress construction project needs to be combined with two key links of construction practice and early phase design of scheme. For the final account and settlement management links of green building project, the summary of actual engineering cost is not only needed, but also the cost control at the engineering phase is necessary.

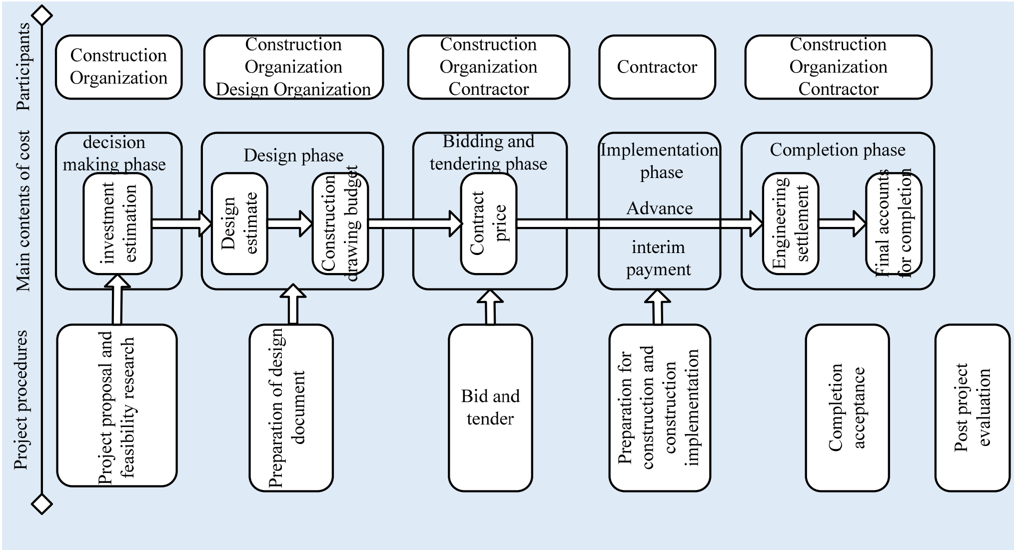

Figure 1. Engineering cost management of green building

B. BIM Quantitative Evaluation Model

The cost management process of scientific research building construction project of certain university in China is taken as a research object herein and the cost analysis of cost management process of the construction project as research object is conducted. Upon determination of cost evaluation section, it is necessary to establish the model relationship between green building material and BIM elements and specific types of green building material as shown in Table 1.

TABLE 1. BIM-TALLY CORRESPONDENCE

SI No.	Material name	Name of model family	Volume
1	FA_concrete-fine stone concrete	100+150	74.168
2	FA_concrete-reinforcement	100+150	18.532
3	FA_concrete-fine stone concrete	100+200	19.918
4	FA_concrete-reinforcement	100+200	5.974
5	FA_concrete-reinforcement	150	0.218
6	FA_concrete-reinforcement	FW-150	118.156
7	FA_concrete-reinforcement	JT-150	15.142
8	FA_concrete-reinforcement	SH-150	290.128

Upon determination of green building material of concrete reinforcement, the cost influence of green building material on the green building project can be calculated. It mainly includes three phases as follows:

(1) Project construction phase. In the progress of project construction, the cost influence factors of various green buildings are sorted by size; due to the proportion of consumption of primary energy and non-renewable energy for green building more than 80% of the total engineering cost at the construction phase, the reinforcement and fine stone of concrete and such materials of lower cost are selected to help to reduce the process cost of the whole project. (2) Project maintenance and operation phase. The recycle recovery and reuse of waste water and such raw materials during the project construction shall be strengthened at this phase so as to further reduce the engineering project cost. (3) Recovery phase of green building material. This process mainly includes the steel scrap recycling and reasonable recovery of floor waste for new green building construction, which is significant for the reduction of engineering cost.

C. Model Evaluation Indexes

Main evaluation indexes of engineering construction project cost include: three indexes of technology, environment and cost. A uniqueness correlation model for the indexes and subsystem may be established based on said factor characteristics to establish the hierarchical structure evaluation model of cost management with multiple complex factors for the engineering project, and the model is totally divided into three different levels: (1) comprehensive influence parameters of environment; (2) economic index, engineering index and environmental index; (3) specific evaluation indexes are shown in Table 2.

Complete cost evaluation process generally includes three phases of production, operation construction and maintenance and eight groups of unit members for floor production shown in Table 1 are taken as basis to evaluate their influence on the cost evaluation during production. The solution result of relevant indexes relate to the economic index, that is, the environmental governance input and construction material price, and these two factors are set as variables and remaining indexes are calculated by using BIM model.

TABLE 2. COST EVALUATION INDEXES OF CONSTRUCTION PROJECT

Target level	Second-level index	Third-level index
	Engineering attribute D_1	Surface of structural component I_1
Comprehensive environmental influence factor Z		Volume of structural component I_2
	Economic index D_2	Material price of structural component I_3
		Environmental governance input I_4
		Primary energy demand I_5
	Environmental index D_3	Non-renewable energy consumption I_6
		Renewable energy consumption I_7

III. ANALYSIS OF COLLABORATIVE DECISION MAKING PROBLEM

A. *Description of Collaborative Decision Making Problem*

Collaborative decision making problem about the green building design can be abstracted as $m = f(M;W)$, where, W is the collaborative decision making parameter. D—S evidences combination rule implements the function mapping from M to m in case of W as a empty set, and under the green building design background, it can be written as:

$$\begin{cases} m = f(M) = m_1 \oplus m_2 \oplus \cdots \oplus m_n \\ m_i \oplus m_j = [m_{i\oplus j}(1), m_{i\oplus j}(2), \cdots, m_{i\oplus j}(k)]^T \\ m_{i\oplus j}(t) = (1-k)^{-l} m_{it}, m_{jt} \\ k = \sum_{s,t=1,s\neq t}^{s,t=k} m_{is} m_{jt} \end{cases} \quad (1)$$

The focus is the correlation between evidences and the weight of current evidence at one evidence fusion is determined by analyzing the supporting degree of other evidences for the current one, which enables the fusion result to get close to one set of evidences with “similar opinions” in the majority of the evidence combination, implying the idea of “the obedience of minority”.

When cost evaluation of green building is conducted by using BIM, this method may be used to fuse the identification result of target classification for various BIM cost analyses; however, this method is of obvious deficiencies-due to certain error probability of BIM analysis, the error result of one point will be intensified on account of the support of other error results of BIM cost analysis, especially it is much easy to intensify the error result under the condition of larger error probability of various cost analyses; from another point of view, when measuring the reliability of one evidence, in addition to the consideration of the support of other evidences, the historical representation of the BIM analysis for this evidence also needs to be taken into consideration, and hence, the collaborative decision making parameters can be expressed as:

$$W = [W_1, W_2], w_1 = [w_{11}, w_{12}, \cdots, w_{1n}]^T \quad (2)$$

Equation (1) shows mutual support degree of evidences, reflecting the mutual belief degrees of them.

$$W_2 = [w_{21}, w_{22}, \cdots, w_{2n}]^T \quad (3)$$

The reliability of BIM cost analysis has been measured from the perspective of historical representation of BIM cost analysis, reflecting the credibility of evidences.

B. *Quantitative model of mutual belief degree*

In the analysis of correlation between evidences, using following method to measure the distance between evidences, the distance between evidence m_i and evidence m_j is defined as:

$$d(m_i, m_j) = \sqrt{\left(\|m_i\|^2 + \|m_j\|^2 - 2\langle m_i, m_j\rangle\right)/2} \quad (4)$$

Where, $(m_i, m_j) = \sum_{t=l}^{k} m_{it} m_{jt}$. The similarity of evidences is measured again and the similarity between evidence m_i and evidence m_j is as follows:

$$sim(m_i, m_j) = 1 - d(m_i, m_j) \quad (5)$$

Then the support degree obtained by evidence m_i from other evidences can be defined as:

$$\sup(m_i) = \sum_{j=1, j\neq i}^{n} sim(m_i, m_j) \quad (6)$$

The total belief of mutual support between evidences is defined as 1 and normalization operation is conducted for $\sup(m_i)$ to obtain the mutual belief degree of evidence m_i :

$$w_{1i} = \sup(m_i) / \sum_{i=1}^{n} \sup(m_i) \quad (7)$$

Thus, the mutual belief degree of BIM cost analysis is obtained:

$$w_1 = [w_{11}, w_{12}, \cdots, w_{1n}] \quad (8)$$

C. *Collaborative Decision Making Process*

From the perspective of belief assignment and probability, the system S divides the belief into n parts based on the BIM cost analysis result and in one decision making process, the mutual belief degree W_1 of BIM cost analysis shows the belief assignment in S , which is a prior probability, namely, $\omega_{1i} = P(S_i)$. In case it is expressed as x (correct target classification identification) and the creditability W_2 shows the class conditional probability, namely, $\omega_{2i} = P(x|S_i)$; once there is prior probability and class conditional probability, it is possible to use Bayes formula to calculate the posterior probability $\omega_{1i} = P(S_i)$. Once there is prior probability and class conditional probability, it is possible to use Bayes formula to calculate the posterior probability:

$$P(S_i \mid x) = \frac{P(x \mid S_i)P(S_i)}{\sum_{i=1}^{n} P(x \mid S_i)P(S_i)} = w_{2i}w_{1i} / \sum_{i=1}^{n} w_{2i}w_{1i} \quad (9)$$

$P(S_i \mid x)$ shows the correction of class conditional probability $P(x|S_i)$ for the prior probability $P(S_i)$, which is a better belief assignment method. Therefore, after the mutual belief degree W_1 and creditability W_2 of the BIM cost analysis are obtained, it is possible to use Bayes formula to conduct fusion operation for W_1 and W_2 and then obtain the reliability measurement of BIM cost analysis $\omega = [\omega_1, \omega_2, \cdots, \omega_n]^T$. Where, $\omega_i = P(S_i \mid x)$; and then M is weighed by using ω to obtain the weighted mean basic belief assignment function:

$$m_w = \sum_{i=1}^{n} \omega_i m_j \quad (10)$$

Then, conduct $n-1$ times of fusion for m_w to obtain the final decision making result m. Based on said analysis, the steps of collaborative decision making algorithm are as follows:

Step 1: initialize system training set S_T and calculate initial W_2;

Step 2: obtain the information processing result M of various BIM cost analyses;

Step 3: utilize M to calculate the mutual belief degree W_1 of BIM cost analysis;

Step 4: utilize Equation (9) to fuse W_1 and W_2 to obtain the reliability measurement ω of BIM cost analysis;

Step 5: utilize ω to weigh M based on Equation (10) to obtain the weighed belief function m_w;

Step 6: substitute all basic belief assignment function m_i in M with m_w and utilize D—S combination rule to fuse for $n-1$ times to obtain the decision making result m;

Step 7: record the decision making result m in the system training set S_T and update W_2;

Step 8: return to Step 2 and conduct the next collaborative decision making.

IV. EXPERIMENTAL ANALYSIS

Three BIM engineering cost software of Thsware, Glodon and Luban are selected as the basic modeling software and the indexes analysis is conducted in combination with the algorithm proposed in this Thesis, and the evaluation indexes are selected as follows: software installation, safety evaluation and function universality. By comparison of decision making algorithm, algorithm in Literature [11] is selected.

Based on the need of decision making process, the evaluation criterion is divided into five grades of “very poor”, “poor”, “fair”, “good” and “very good” and based on it, the comment set can be obtained: $V = \{v_1, v_2, v_3, v_4, v_5\} =$ {very poor, poor, fair, good and very good}. For the worst grade v_1, its assignment is 50 points and for the best grade v_5, its assignment is 100 points and then the quantitative grade vector can be obtained:

$$B = \{50, 60, 80, 90, 100\} \quad (11)$$

TABLE 3. FUZZY EVALUATION

Evaluation index	Software	Algorithm	Value
Software installation	Glodon	Algorithm herein	91.2
		Literature [11]	89.8
	Thsware	Algorithm herein	89.7
		Literature [11]	88.6
	Luban	Algorithm herein	88.3
		Literature [11]	86.2
Safety evaluation	Glodon	Algorithm herein	82.36
		Literature [11]	80.1
	Thsware	Algorithm herein	89.4
		Literature [11]	86.3
	Luban	Algorithm herein	92.7
		Literature [11]	89.2
Function applicability	Glodon	Algorithm herein	86.9
		Literature [11]	84.3
	Thsware	Algorithm herein	88.2
		Literature [11]	85.4
	Luban	Algorithm herein	89.9
		Literature [11]	86.7
Comprehensive evaluation	Luban	Algorithm herein	88.2
		Literature [11]	84.9
	Glodon	Algorithm herein	89.4
		Literature [11]	86.2
	Thsware	Algorithm herein	89.5
		Literature [11]	84.3

Engineering cost analysis is conducted based on the expert evaluation mode in Literature [11] and firstly expert evaluation is conducted based on the grades defined in the comment and the statistical analysis of evaluation data is implemented based on mathematical statistics to obtain its value of membership degree. For instance, experts from ten different fields evaluate the engineering cost indexes, and in case there is no one selecting the V_1 and V_2 evaluation grade, there are two experts selecting V_3 evaluation grade and five ones selecting V_4 evaluation grade, three ones selecting V_5

DOI 10.5013/ IJSSST.a.17.40.12

ISSN: 1473-804x online, 1473-8031 print

evaluation grade, then the fuzzy evaluation value of the cost software index is (0,0,0.2,0.5,0.3).

The fuzzy evaluation values of indexes of algorithm herein + (Thsware, Glodon and Luban) and Literature [11] + (Thsware, Glodon and Luban) are shown in Table 3.

Data in Table 3 shows that in various evaluation indexes, the evaluation value obtained by mode of algorithm herein + (Thsware, Glodon and Luban) is superior to that of the Literature [11] + (Thsware, Glodon and Luban), reflecting the effectiveness of the algorithm proposed herein. At the same time, for those three BIM software of Thsware, Glodon and Luban, the grade of Glodon is lowest and the grade groups of Thsware and Luban is better, which shows that the cost quality of Thsware and Luban is better.

Standardized and integrated weighted analysis is conducted for the economic index based on the result shown in the algorithm model herein, and under the condition of set price variable P, the cost influence evaluation result of 1-8 members shown in Table 3 can be obtained:

$D_1 = 0.132P_1 + 0.0213$, $D_2 = 0.132P_1 + 0.0216$

$D_3 = 0.132P_1 + 0.0173$, $D_4 = 0.132P_1 + 0.0068$

$D_5 = 0.132P_1 + 0.0007$, $D_6 = 0.132P_1 + 0.1876$

$D_7 = 0.132P_1 + 0.0246$, $D_8 = 0.132P_1 + 0.4876$

Said analysis result shows that the eighth group of members among eight groups of members has the greatest influence on the corresponding cost due to its member structure greater than that of other members. For members 2, 3 and 7, their influences on the cost are close, showing the influence difference on the cost evaluation for the difference in green building material selection. In addition, attention shall be paid to the environmental influence factor based on said analysis result to further refine the calculation difference of different member elements.

V. CONCLUSIONS

A BIM project cost analysis algorithm of Bayesian collaborative decision-making based on mutual belief model is proposed in this Thesis and BIM model is utilized to establish the quantitative index of the project evaluation result to establish judgment and comparison matrix of hierarchical structure and then the collaborative decision-making model of BIM project cost for green building is established based on D-S evidence theory and Bayesian algorithm in accordance with mutual belief model to achieve the scientific rationality of decision making.

REFERENCES

[1] Puthalakath H, O'Reilly L A, Gunn P, et al. ER Stress Triggers Apoptosis by Activating BH3-Only Protein Bim[J]. Cell, 2007, 129(7):1337-49.

[2] Puthalakath H, Huang D C S, O'Reilly L A, et al. The Proapoptotic Activity of the Bcl-2 Family Member Bim Is Regulated by Interaction with the Dynein Motor Complex[J]. Molecular Cell, 1999, 3(3):287-96.

[3] O'Connor L, Strasser A, O'Reilly L A, et al. Bim: a novel member of the Bcl - 2 family that promotes apoptosis[J]. Embo Journal, 1998, 17(2):384-395.

[4] Bouillet P, Strasser A. Proapoptotic Bcl-2 relative Bim required for certain apoptotic responses, leukocyte homeostasis, and to preclude autoimmunity.[J]. Science, 1999, 286(286):1735-8.

[5] Jinyu Hu and Zhiwei Gao. Distinction immune genes of hepatitis-induced heptatocellular carcinoma[J]. Bioinformatics, 2012, 28(24): 3191-3194.

[6] Liu, Y., Yang, J., Meng, Q., Lv, Z., Song, Z., & Gao, Z. (2016). Stereoscopic image quality assessment method based on binocular combination saliency model. Signal Processing, 125, 237-248.

[7] Jinyu Hu, Zhiwei Gao and Weisen Pan. Multiangle Social Network Recommendation Algorithms and Similarity Network Evaluation[J]. Journal of Applied Mathematics, 2013 (2013).

[8] Yishuang Geng, Jin Chen, Ruijun Fu, Guanqun Bao, Kaveh Pahlavan, Enlighten wearable physiological monitoring systems: On-body rf characteristics based human motion classification using a support vector machine, IEEE transactions on mobile computing, 1(1), 1-15, Apr. 2015

[9] Lv, Z., Halawani, A., Feng, S., Ur Réhman, S., & Li, H. (2015). Touch-less interactive augmented reality game on vision-based wearable device. Personal and Ubiquitous Computing, 19(3-4), 551-567.

[10] Jinyu Hu and Zhiwei Gao. Modules identification in gene positive networks of hepatocellular carcinoma using Pearson agglomerative method and Pearson cohesion coupling modularity[J]. Journal of Applied Mathematics, 2012 (2012).

[11] Jiang, D., Ying, X., Han, Y., & Lv, Z. (2016). Collaborative multi-hop routing in cognitive wireless networks. Wireless personal communications, 86(2), 901-923.

[12] Hildeman D A, Zhu Y, Mitchell T C, et al. Activated T Cell Death In Vivo Mediated by Proapoptotic Bcl-2 Family Member Bim[J]. Immunity, 2002, 16(6):759-67.

[13] Whitfield J, Neame S J, Paquet L, et al. Dominant-Negative c-Jun Promotes Neuronal Survival by Reducing BIM Expression and Inhibiting Mitochondrial Cytochrome c Release[J]. Neuron, 2001, 29(3):629-43.

[14] Yadav R K, Lee G H, Lee H Y, et al. TMBIM6 (transmembrane BAX inhibitor motif containing 6) enhances autophagy and reduces renal dysfunction in a cyclosporine A-induced nephrotoxicity model.[J]. Autophagy, 2015, 11(10):1760-74.

[15] Wagner T, Pöthig A, Augenstein H M S, et al. From Simple Ligands to Complex Structures: Structural Diversity of Silver(I) Complexes Bearing Tetradentate (alkylenebimpy) NHC Ligands[J]. Organometallics, 2015, 68(2):122-127.

[16] Jing D, Bhadri V A, Beck D, et al. Opposing regulation of BIM and BCL2 controls glucocorticoid-induced apoptosis of pediatric acute lymphoblastic leukemia cells.[J]. Blood, 2015, 125(2):273-83.

[17] Karan E P, Irizarry J. Extending BIM interoperability to preconstruction operations using geospatial analyses and semantic web services[J]. Automation in Construction, 2015, 53:1-12.

[18] Gianniou C, Dirani A, Jang L, et al. REFRACTORY INTRARETINAL OR SUBRETINAL FLUID IN NEOVASCULAR AGE-RELATED MACULAR DEGENERATION TREATED WITH INTRAVITREAL RANIZUBIMAB: Functional and Structural Outcome.[J]. Retina, 2015, 35(6):1195-201.

[19] Haschka M D, Soratroi C, Kirschnek S, et al. The NOXA-MCL1-BIM axis defines lifespan on extended mitotic arrest.[J]. Nature Communications, 2015, 6.

[20] Liu, Y., Yang, J., Meng, Q., Lv, Z., Song, Z., & Gao, Z. (2016). Stereoscopic image quality assessment method based on binocular combination saliency model. Signal Processing, 125, 237-248.

[21] Yang, J., Xu, R., Lv, Z., & Song, H. (2016). Analysis of Camera Arrays Applicable to the Internet of Things. Sensors, 16(3), 421.

[22] Lv, Z., Penades, V., Blasco, S., Chirivella, J., & Gagliardo, P. (2016). Evaluation of Kinect2 based balance measurement. Neurocomputing.