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Analysis and Evaluation of Project Cost Risk Based on BP Algorithm

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Abstract

Standing at the perspective of the project management, this thesis, from the relation between schedule, quality and cost, analyzes how the project cost was influenced by the schedule risk and quality risk, assesses the total cost risk of the project with artificial neural network BP algorithm, and determines the most sensitive factors of the project cost risk, which could provide reference for the project managers to control the project cost risk.

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Keywords: project; cost; risk; BP algorithm;

Part One: Analysis of Project Cost Risk

1. Introduction

The main contents of project management can be summarized as "three controls, two managements and one coordination" .The "three controls" refers to the progress control, quality control and cost control, which constitute the overall project management of the unity of opposites. In the progress of the project construction, schedule risk and quality risk often result in an exorbitant actual cost and give rise to the cost risk, which will lead to target profit none-achieved. Therefore, it is important for us to study the total project cost risk, systematically analyze and control the formation of the factors leading to risk and effectively prevent and early warn the formation of the cost risks on the theory and practice of project management.

2. Influencing Factors of Project Cost Risk

Project cost risk is the possibility that actual cost exceeds the established target cost during the project construction,

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caused by the project schedule risk and quality risk. There are many factors leading to project cost risk. Mainly based on the relation between schedule, quality and cost, this thesis analyzes how schedule risk and quality risk lead to the increase of the project actual cost.

2.1 Influence of Schedule Risk

Relevant data shows that: In the UK 4000 project records, only a handful of the projects did not schedule delays, and in Australia only 1 / 8 project construction in the planed period can be completed on time .[1] So the progress delayed in project construction is its widespread. The delayed progress of the project will inevitably generate the actual costs that exceed the target cost, causing the formation of the cost risk. From the perspective of schedule risk, the factors that affect the cost of the project are: the weather and geology, engineering changes, the owner, the contractor and other reasons. [2]

2.1.1 Weather and Geological

Summer in China, the average temperature always is 33-37 ℃, workers' inefficiency slow down the schedule of the project. Winter's weather is cold so that concrete construction and maintenance are much more difficult and need additional labour force, materials and machinery to help complete the concrete pouring and curing; some places, or simply does not meet construction condition, fail to reach the pouring of the concrete strength requirements. All of these will lead to rising of labour cost, mechanical use of cost and cost of materials, which will affect the efficiency of management, increase administrative costs and ultimately lead to the formation of the cost of risk.

Geological conditions\ also greatly impacts for the cost of the project. Strange terrain and geological conditions maybe did not meet the construction requirements, which increase the difficulties of the plan, large machinery and equipment going into the site, and the construction. All of these will reduce the efficiency of construction and increase labour costs, mechanical use of cost, measures project fees and management measures expenses.

2.1.2 Engineering Change

Because of the complexity of the technical and project management, the engineering change is inevitable. The errors of survey and design will lead to the increasing amount of the project, which will disrupt construction plans, lead to idle labour, machinery and equipment rented, increase labour costs, mechanical use of cost and management fees, thus increasing the cost of the project and forming the project cost risk. Meanwhile engineering change often results in re-purchasing new materials and replacing machinery and equipment. Procurement of new materials and replacement of equipment will be faced with the risk of price increasing and have to pay more for materials and mechanical. These expenses will undoubtedly increase the project cost, and form the risk of project cost.

2.1.3 Owners

The owner of the project is the investor who is in a dominant position, so the owners' behaviour will have a direct impact on the costs of the project. If the work-yard is not supplied on time by the owner, and if the contractor has already been ready for construction this will make them wait for starting and result in personnel and equipment idling, schedule delaying, increasing the direct project costs. If the owners provide construction conditions less than the design requirements of internal and external transportation condition, which will increase the machinery and equipment depreciation costs and the failure rate, the formation of the cost risk. In addition, the contract price of the deferred payments would also increase the project costs. Progress payments are not in place and the contractor suspended will make downtime losses and increase the project cost; if after consultation the two sides agreed to postpone payment for work, in order to ensure the smooth construction, the contractor had to mat endowment for construction, even higher than the interest on bank loans to raise funds, which would increase the financial costs and debt burden of the contractor, and ultimately increase the cost of the project, the formation of the cost of risk.

2.1.4 Contractors

Contractor directly participants in the construction of the project and its project management's level directly affects the progress and cost of the project. If project cost management system of the contractors did not form a sound cost management system, it will result in a lack of mutual cooperation and support of various sectors and will inevitably increase the cost of project; if project managers can not conduct a reasonable construction design, personnel and mechanical equipment will collaborate, labour force will be idled, and mechanical equipment use will be unreasonable, which will result in manual and mechanical use of cost and management fees increasing; failure of construction graphic design will lead to irrational use of labour and equipment , which will increase costs of direct costs and secondary transportation ; materials management systems do not take effect ,which generate an unreasonable use of materials and sending and receiving seriously waste. Thereby this will increase costs of materials, storage costs and ultimately increase the procurement cost of the project, the formation of project risks.

2.2 Impact of the Quality Risk

Construction quality is the most basic requirement and it is also a hard target. Project quality risk will inevitably lead to the formation of the cost of risk. From the quality point of view of risk, the cost risk factors are: design reasons, the reasons for failure of building materials, construction management is not in place of the causes and reasons for dereliction of duty supervisors[3].

2.2.1 Design

It is obvious that the qualities of design directly impact on the quality and the cost of the project. Although the design costs account for a small proportion of project costs, but the quality of design will enormously influence the about 75% to 95% of project cost [3]. Therefore, the design will have a significant impact on the actual cost of the project. On one hand, design ignored the cost factor. When designing, the owners often require "high, big, new, odd" designs. However, if the shape of the construction is too complex, the difficulties of project management and construction methods will be increased, which will reduce the efficiency of the workers, increase the amount of labour force and investment in machinery and equipment , leading to direct project costs and management costs. On the other hand, the design quality is too rough. There are many contradictions or has unclear or wrong place in the design, which will definitely affect the quality of the project, lead to the increases of rejection and repair rate and labour input. At last it will add costs of materials and machinery to increase the project cost, the formation of the cost of risk.

2.2.2 Disqualification of Building Materials

Because of the increasing in the price of materials, some of the contractors purchase substandard materials in order to reduce the project cost, which will augment the number of scrap loss and rework and increase project cost. For example, concrete that is damp or expired does not meet the strength requirements; failure of steel chemical ingredient and of welding steel can not be used. Substandard materials will reduce the quality of the project, resulting in materials, labour force and machinery costs of waste. Re-purchase of new materials will also face the risk of rising prices resulting in higher procurement costs, and ultimately increase the cost of the project, the formation of cost risk.

2.2.3 Level of Project Management

Contractor is the direct participant of the construction and build reality buildings according to the design. Thus the quality of project management is an important factor affecting the cost of the project. So the unreasonable sequences and inappropriate construction methods and construction organizations will result in the quality problems of the project and increasing of project costs, the formation of construction cost risk.

First, the irrational construction sequences will increase the idle time of labour force and machinery, which can not achieve continuous construction, leading to unit quantity of project requiring additional loabour force, machinery and equipment. All of these will result in labour costs and machinery use fees increase; Secondly, inappropriate choice of construction methods will result in machinery and labour cost increase, increase labour inputs, construction materials, and then lead consumption to exceed the planning; again, inappropriate construction organization can not coordinate construction worker and construction machinery, which will reduce the labour and mechanical efficiency, and result in labour costs and machinery use fees increasing, and ultimately increase the cost of the project, the formation of the cost of risk.

2.2.4 Negligence of Supervisors

Supervision of staff supervises closely the whole process of project implementation, coordination and collaboration with parties to the contract. Supervisors supervise the details of each process of the construction site in accordance with the "Construction Standards" requirements. The supervisors’ poor sense of responsibility will have an impact on the cost of the project. For example, part of the supervising engineers, until the bar on-site installation complete, finishes acceptance of the quality of steel process. If it will not meet the requirements, reworking the production will be needed. The result is material waste and labour costs increase. Besides supervisors must coordinate the conflict parties to the contract, if coordination is not in place, the owners, in order to put into use for the project as soon as possible, blindly reduce the time which will disrupt the original construction design of the contractor, increase labour and machinery inputs, result in direct costs, the formation of the cost of risk.

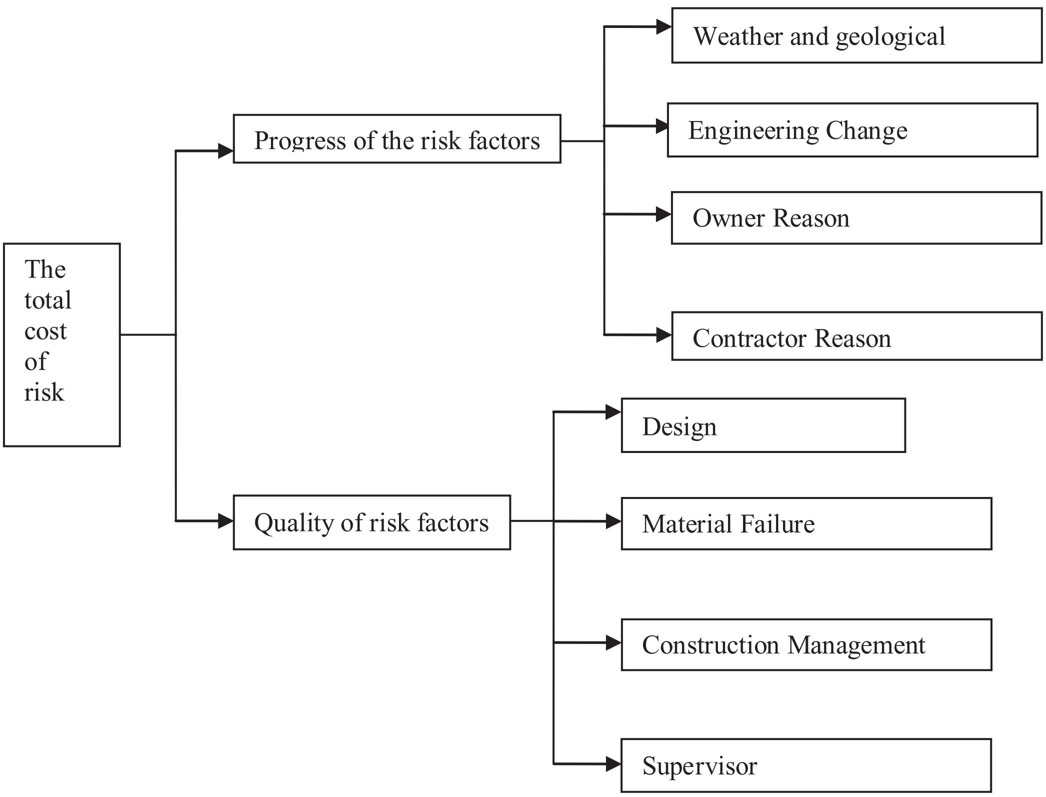
Part Two: Project Cost Risk Assessment

1. Introduction to Artificial Neural Network BP Algorithm

BP network in risk evaluation, investment decision-making, automatic control and other fields have a very wide range of applications. The network was invented in 1986 by Rumelhart and Mc. Celland who led team of scientists proposed an algorithm by error back propagation trained multilayer feed-forward network. BP network can learn and store a lot of input - output model mapping, and its learning rule is to use the steepest descent method, by back-propagation network to continuously adjust the weights and thresholds, the minimum error of the network. BP network topology structures include input layer, hidden layer and output layer.

2. Risk Evaluation Index System

According to risk factors under the analysis of project cost, we use BP algorithm to establish the project risk evaluation index system (shown below), to assess the cost of the project risk.

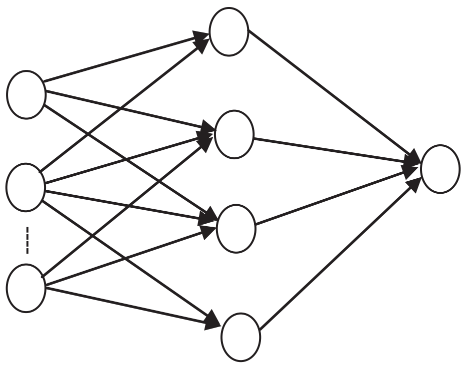


3. Assessment Model of Project Cost Risk

3.1 Design of Artificial Neural Network BP Model

Previous studies and applications show that a reasonable number of network layers and layers determine the number of neurons, which is the key factors of successful application of BP neural network model .G. Cybenyo, who proved that the neural network with an hidden layer could express any continuous function with arbitrary accuracy, while

the practice indicates that more than two hidden layers and of no use. [4] Therefore, the model constructed with only one layer of hidden layer set.
1. Selection of the Input Node. According to the index system established, make the weather and geology, engineering change, owner, contractor, design, materials failure, construction management and supervision of staff 8 BP model of risk factors as input nodes.
2. Choice of Hidden Layer Nodes. Selection of the number of hidden layer nodes is a very complex issue. According to various considerations, the model selected four hidden layer nodes.
3. Output Node corresponds to the evaluation results. In this model, the end result is a comprehensive evaluation value, and represents a different degree of risk. Therefore, the output node is 1.
In summary, this thesis builds the neural network model is 8 * 4 * 1 layer network model. As shown below:



3.2 The Neural Network Learning

BP algorithm is a kind of learning ability and storage capacity of the algorithm, BP algorithm's learning process can be described as the forward propagation and back propagation. In the forward propagation process, the information that was input processed from the input layer to hidden layer, and transmitted to the output layer. If the output layer are not the desired output, then transferred back propagation, the error signal back along the original connection channel, by modifying the weights of neurons in each layer, making the smallest error signal.
According to the network structure is established, we make each node input layer as a_i, hidden layer nodes as b_r, the output layer has only one point, so make it as c. Between the right and then make the value as w_{ir}, the threshold as T_r; between the right and then between make value as v_{rj}, the threshold as θ_j. This function is used Sihmoid layers of output functions. That is:

$$f(x) = \frac{1}{1+e^{-x}} \quad (1)$$

(1) For each layer weights and thresholds with a random number added to the layers, namely w_{ir} ,T_r , v_{rj} , θ_j =

Random (s) (s∈(0,1)).
(2) Input x, a sample, to the network orderly, to start training the neural network, and then the network automatically adjusts the weight and threshold between nodes and node.
(3) The output of each node in the hidden layer is:

$$b_r = f\left(\sum_{i=1}^{8} w_{ir} a_i - T_r\right) \quad (r=1,2,3,4); \quad (2)$$

$$C = f\left(\sum_{j=1}^{1} v_{rj} b_r - \theta_j\right) \quad (j=1); \quad (3)$$

(4) Calculate the error between the output value of the output layer and the expected value c', so that:

$$d_j = c(1-c)(c'-c); \tag{4}$$

(5) If the calculated error does not meet accuracy requirements, then calculate the reverse distribution of error of hidden layer nodes, so that

$$e_r = b_r(1-b_r)\left(\sum_{j=1}^{1} v_{rj} d_j\right); \tag{5}$$

(6) to adjust weights and thresholds between the hidden layer nodes and the output layer:

$$v_{rj} = v_{rj} + \alpha\, b_r\, d_j; \tag{6}$$

$$\theta_j = \theta_j + \alpha\, e_r \quad ; \tag{7}$$

(7) to adjust weights and threshold between input layer and hidden layer :

$$w_{ir} = w_{ir} + \alpha\, a_i\, e_r; \tag{8}$$

$$T_r = T_r + \alpha\, e_r \quad ; \tag{9}$$

(8) Repeat steps (3) until the calculated to meet the schedule requirements, complete the network learning. Output c.

3.3 Empirical Study

First, Design Institute, the owners, contractors, and supervision of experts were invited to evaluate the cost risk factors of the project. The results of the evaluation according to the front index system by experts were obtained as follows:

Weather and geological	Engineering Change	Owner Reason	Contractor Reason	Design	Material Failure	Construction Management	Supervisor
0.5808	0.5432	0.478	0.5726	0.498	0.513	0.6314	0.568

Input these data into the trained neural network model, assisted by computer program, to calculate the result of the comprehensive risk assessment valuation .The result is 0.5492. Then, through the establishment of the neural network model of individual risk factors, evaluate the sensitivity analysis of cost risk. When changes in the various risk factors were +10% and -10%, applying neural network model, changes can be calculated after the value of a comprehensive risk assessment. (as Table 1 shows)

We can be seen from Table 1: the level of contractors' management and the use of substandard materials for the project cost risk are the most sensitive. Therefore, in the implementation of project cost risk control, the level of project management and qualified materials procurement are the most sensitive factors and must be paid more attention to.

4. Conclusion

Based on the evaluation by experts, the relative sensitive factors of project cost risk could be gained; by artificial neural network BP algorithm, comprehensive risk valuation and the risk sensitivity can be calculated. Then we can ultimately establish most sensitive factors of the project cost risk, from the relation between schedule, quality and cost, and provide useful reference for the project managers to control the risk of project cost and improve the level of the project management, which can ensure a successful project.

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[5] China Association of Construction Project Cost Management Life cycle cost control theory and method [M], China Planning Press;

Table 1:

	Basic items	The Rate of Change	Evaluation value after the changes	Value of comprehensive evaluation	Deviation
Risk Factors	Weather and geological	10%	0.6389	0.5794	0.0302
		-10%	0.5227	0.5205	-0.0287
	Engineering Change	10%	0.5975	0.5575	0.0083
		-10%	0.4889	0.5335	-0.0157
	Owner Reason	10%	0.5258	0.5787	0.0295
		-10%	0.4302	0.51909	-0.03011
	Contractor Reason	10%	0.6299	0.5807	0.0315
		-10%	0.5153	0.5097	-0.0395
	Design	10%	0.5478	0.5639	0.0147
		-10%	0.4482	0.5397	-0.0095
	Material Failure	10%	0.5643	0.5804	0.0312
		-10%	0.4617	0.5159	-0.0333
	Construction Management	10%	0.6945	0.5842	0.035
		-10%	0.5683	0.5072	-0.042
	Supervisor	10%	0.6248	0.5741	0.0249
		-10%	0.5112	0.5231	-0.0261