Cost risk management of key chain in engineering construction project

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Abstract. In the process of construction project, it is always appearing that some budget overruns and abuse problems about costs happen, which mainly due to the overall planning and prediction of cost risk for project managers is not science or unreasonable. Based on the characteristics of the chain effect of cost risk, we establish the key chain of costs, then, take the cost risk quantity as the buffer of a key chain, in order to achieve the cost risk warning and help project managers master the cost risk from the overall situation, so that the project manager can make the scientific and reasonable cost risk measures.

Introduction

In the implementation process of engineering construction project, it involves a large number of complex factors such as economic, social, market, manpower, resources, and natural disasters, which make the project produce a lot of uncertainty about the risk [1]. The implementation of construction project has irreversibility, and will not change once the money has been shifted to a project entity, as a result, the management of cost risk is the key to risk management, it is involving that the whole life cycle and each process of the engineering project, so we should consider it from the viewpoints of both global and local, at the same time, combine with other resources which limit cost, so that can accurately estimate cost risk [2].

Recently, we always use the analytic hierarchy process to evaluate the risk of project, but the application of AHP has some limitation, and the premise is that the various factors among all the levels are independent of each other, this method can only make the static analysis of independent risk of each process, but the engineering construction projects are interconnected among each working procedures, cost of each working procedure and resources also restrict each other [3]. Based on the chain effect of schedule management of construction projects, project risk management will be considering the risk dynamic and relevance [6], therefore, in different stages of the project cost risk is with the chain effect [4].

The distinct advantage of the critical chain has been widely applied to project management, but it has been only used in the schedule risk and cost control, the cost control in different stages of the research is aimed at independent, therefore, this study apply critical chain to cost risk management, in combination with the characteristics of the chain effect of cost risk, and make early warning for cost risk through the establishment of critical chain and risk buffer, as well as a more effective approach for the cost of project management, so that can help us effectively relieve the phenomenon of project costs in excess and cost abuses [5].

Construct cost key chain

In the engineering construction project, there are many factors which can affect the cost risk of project and some internal risk factors of the project, for example, economical and political environment, each relevant units of the project risk, technical mistakes occurring in the process of project, construction management and associated process error and so on, at the same time, the same as the chain effect of schedule risk management [6], the chain effect of risk in the engineering construction project is also applied to the cost risk.

So, the cost risk of each process should be determined by the following variables, namely the last working procedure of cost risk, the system cost risk of this phase, absorptive capacity of this stage cost risk procedure, the contribution rate of the system cost risk to the cost risk of this stage, random perturbation terms of the process [7]. Due to the transmission of risk is unidirectional and irreversible, so the cost of each process can be expressed as:

$$R_t = \beta_t * Y_t + W_t * R_{t-1} + \varepsilon_t$$

R_t : t the activity expenses risk of stage process,

Y_t : exogenous variables , the system cost risk of t phase,

β_t : the contribution of the system cost risk to the activity cost risk of this stage,

W_t ;the risk transfer coefficient of cost risk from last procedure to a stage process of t,

ε_t : the random disturbance

the system cost risk of the process Y_t = the probability of occurrence of a risk*the costs of beyond the plan* the effect of emergency measures , t the probability of procedure cost risk occurs:

$$P_t = P(x_t > x_o) = 1 - P(x_t \le x_o) = \int_{x_o}^{\infty} f(x)dx$$,

x_0 : the cost risks of the activity can withstand , x_t : the excess of cost risk actually ,

W_{ij} : the correlation coefficient of the cost risk of the adjacent process, the function of these is

$$f(R_i, W_{ij}, R_j) = 0$$

The effectiveness of the emergency measures α_t associated with the content and nature of the process, but also with project managers and project implementers strain capacity and practical ability [8].

According to the cost risk of chain effect to calculate the cost risk of each process, establish work node network diagram, each working procedure node in the network has a attribute is composed of five elements $\left(\mathrm{X}, Y_t, W_{it}, \mathrm{R}_t, \varepsilon_t\right)$, X says the time in the process, Y_t shows cost risk of the system in the activity process, W_{ij} means the transfer coefficient of the cost risk between the working procedure i the working procedure j, R_t means the amount of cost risk in the activities process, ε_t says the disturbance of the process, then, determine the path of the greatest risk for cost key chain.

The warning and optimization to the key chain of cost

Set the buffer.

According to the critical chain theory, we build the cost risk buffer, and take 50% of the sum of the amount of the safety cost risk in each process on the key chain as the project buffer, then, take 50% of the sum of the amount of security cost risk in each process on the non-critical chain as the input buffer [9],

Amount of cost risk = amount of the system cost risk + transfer coefficient of risk * amount of cost risk on last stage, amount of system cost risk = probability of risk* excess of cost * the effectiveness of emergency measures.

The warning of cost risk.

Monitoring cost risk is mainly to manage the amount of cost risk on buffer, make managers master the situation of project cost and the amount of cost risk on the buffer whether is to achieve acceptable line or not, then, due to the warning of buffer to judge whether the phase should take some related measures to control risk [10].

This study uses the methods of three color partition to warn the buffer, and divides the buffer into three regions, namely green, yellow and red. The green says that the present situation of cost using is ideal, and in the planned scope of the consumption on the cost buffer that amount of cost risk is acceptable. Yellow means not very ideal, namely there is a smaller range between the planed cost usage and the cost of consumption in fact, but in this range, it has produced a little impact on the whole project cost risk, and the excess of the cost buffer is smaller that the cost risk is acceptable. Red means a lot of problems, namely there is the larger gap between the planed cost usage and the cost of consumption in fact which produces a large impact on the project cost risk, we cannot accept this situation, and should take appropriate remedial measures immediately to avoid problems continue to deteriorate.

The measures of adjustment.

Due to the warning of buffer, we can know that the situation of the cost of consumption on the critical chain risk, and judge the current amount of cost risk whether is to influence the whole project implementation or not on the basis of the three colors of buffer, if exceed the amount of risk that can be withstood, we should take some corresponding measures timely to reduce the probability of occurrence of a risk or loss of risk.

If the amount of cost risk buffer at the present stage is shown in green area, we don't need to adopt measures to control risk. If in yellow area, it produces the cost risk, although the cost risk is in an acceptable range, we also take certain measures to remedy, if in the red areas, namely it has serious influence on the whole project cost risk, and the scope of cost risk has been achieved unacceptable that there are serious problems in the process of project, in addition to the remedial measures in the yellow area, we make a analysis of comprehensive range of the construction project in the present stage to find out the principal causes of cost risk, and remedy in time, then, we make the project plan again on the basis of the construction of the project in the present stage , supervise the accomplish of construction strictly, and make statistical analysis of the improvement of cost risk in the process of construction, if it does not make the improvement, we need further adjustment plan, in a word, we make some measures as much as possible to reduce the risk of cost, the project can go smoothly and cost risk can be controlled at the same time, so that the benefit can achieve to maximization.

The analysis of case.

Here is a simple example, firstly, we set up the network diagram of work node, each working procedure node in the network has a attribute is composed of five elements $\left(X, Y_t, W_{it}, R_t, \varepsilon_t\right)$, X says the time in the process, Y_t shows cost risk of the system in the activity process, W_{ij} means the transfer coefficient of the cost risk between the working procedure i and the working procedure j, R_t means the amount of cost risk in the activities process, ε_t says the disturbance of the process, as shown in fig 1 as the work node network diagram, and according to the above formula to calculate of the amount of cost risk of the activity in each process, the red thick line is a chain of the most cost risk, namely the key chain of cost risk.

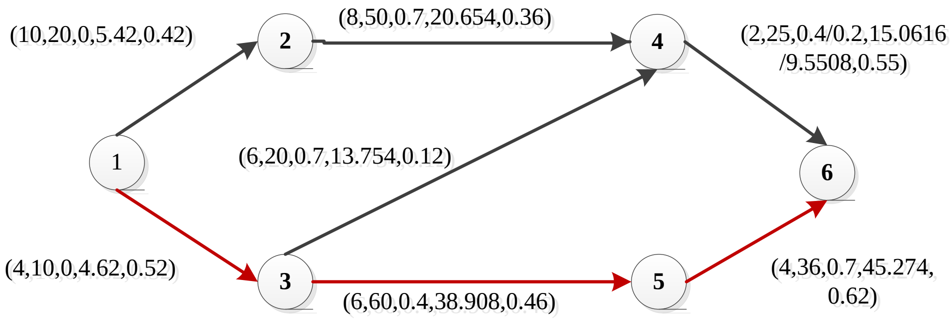

Fig 1. The network diagram of work node

After establishing the network diagram of work node, determine the key chain of cost for the 1-3-5-6, then, reduce half of the amount of cost risk in each process to narrow value of cost risk, and reduce duplication of safety cost in order to realize the maximization of the benefit. As shown in fig 2.

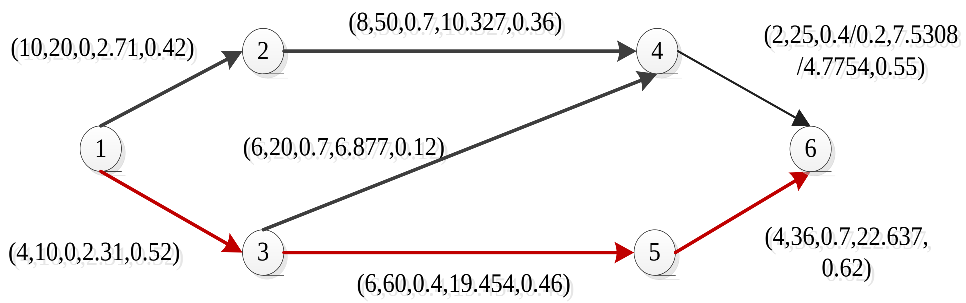

Fig 2. The shortened network diagram

According to the content and nature of each process, we can analysis whether the excess of the process actually and cost risk can be acceptable or not, thus, we can use the following formula to compute the probability of cost risk P_t,

$$P_t = P(x_t > x_o) = 1 - P(x_t \le x_o) = \int_{x_o}^{\infty} f(x)dx$$

At the same time, make the analysis of controlled risk ability of project manager and the actual operation processing ability of project implementers after the risk is produced, then, we can analysis the effectiveness of the different emergency measures for different degrees of risk, finally, it can be concluded that the effectiveness of emergency measures of each process. We randomly take the excess of each process for example, through the formula of system risk cost, we can know that its specific data as shown in table 1,

Table 1. The system cost risk of each process Y_t

process	1-2	13	2-4	3-4	3-5	4-6	5-6
the probability of a risk	0.1	0.5	0.25	0.4	0.15	0.125	0.12
the excess	500	200	1000	500	1000	1000	3000
effective of emergency measures	0.4	0.1	0.2	0.1	0.4	0.2	0.1
cost risk of system process	20	10	50	20	60	25	36

According to the activity cost risk is produced by the effect of chain, its process of calculation is shown in table 2 below:

Table 2. The amount of cost risk of each process

process	1-2	1-3	2-4	3-4	3-5	4-6	5-6
system cost risk of each process Y_t	20	10	50	20	60	25	36
Transfer coefficient W_{it}	0	0	0.7	0.7	0.4	0.4/0.2	0.7
Contribution β_t	0.25	0.41	0.33	0.52	0.61	0.25	0.31
the random disturbance ε_t	0.42	0.52	0.36	0.12	0.46	0.55	0.62
The activity cost risk R_t	5.42	4.62	20.65	13.75	38.9	15.19.55	45.27

As mentioned above, the key chain of cost risk is the 1-3-5-6, the maximum amount of cost risk is 45.27, and can be shorten to 22.64, which is the weakest process chain of the project cost management in the critical chain, it is very important that make the reasonable management of the cost risk on the key chain to the overall operation of the project.

To set the buffer, the amount of the cost risk of the project buffer PB is (2.31 + 19.454 + 22.637) * 50% = 22.2, the cost risk of the output buffer on the key chain FB1 is (2.71 + 10.327 + 7.5308) * 50% = 20.57, FB2 is (2.31 + 6.877 + 4.7754) * 50% = 6.98, as shown in fig 3,

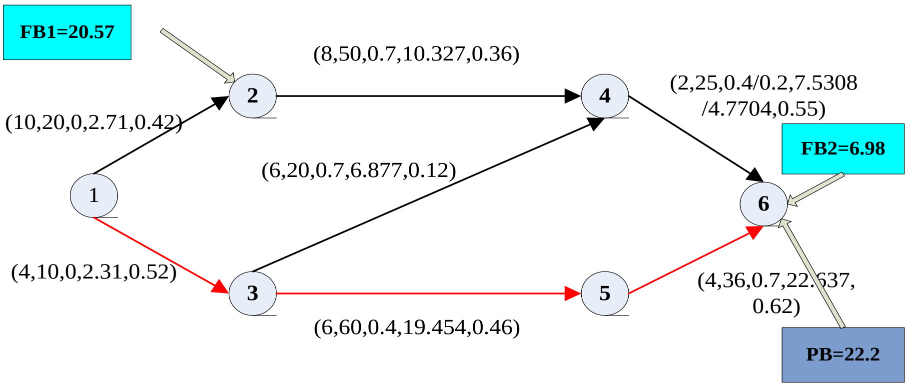

Fig 3. Set the buffer

We take the project buffer PB, input buffer FB1 and FB2 as warning zone to warn project management of the cost risk. According to the different nature and the content of the project, we separate the amount of cost risk can be withheld on the buffer into three, then, set up the amount of cost risk in the green areas for 7 and the amount of cost risk in the yellow area is 8.2 and the amount in the red areas is 7, as shown in figure 4, in the project, the amount of cost risk between 0 ~ 7 is in the green zone which the project is very well, the amount of cost risk between 7 to 15.2 is in the yellow area which the project is not very ideal, and the amount of cost risk between 15.2 ~ 22.2 is the red areas means the project produce the bigger problems, we need to immediately take effective measures to remedy, so that can be in the controllable range.

Summary

The critical chain theory is applied to the cost risk of construction project, first of all, due to the project risk has the characteristics of the chain effect, we calculate for cost risk of each working procedure, thus establish the critical chain and the buffer, we can determine the position of the buffer in the present stage through the amount of the cost risk, then judge whether the amount of cost risk is acceptable or not, so that can help project managers to eliminate the uncertainty of the project, then, can make project managers better control the cost risk of the whole project and timely take corresponding measures to remedy, so that can make the project successfully completed.

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