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The risk element transmission theory research of multi-objective risk-time-cost trade-off☆

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ABSTRACT

Risk management project is an important aspect of general project risk element transmission theory. To solve the multi-objective time-cost trade-off problem considering the risk elements effectively, this paper establishes an analytical model for multi-objective risk-time-cost trade-off problem based on general project risk element transmission theory. We divide risk elements into discrete model and continuous model to be discussed separately, and the two models for multi-objective risk-time-cost trade-off problem are established by taking Markov dynamic PERT network into classical PERT network. Thus, we combine Radial Basis Function (RBF) neural network to solve the discrete model of the problem. Finally, a practical example illustrates the effectiveness of the algorithm.

1. Introduction

The time-cost trade-off problem (TCTP) is the most important content in the project management. Although many scholars did a lot of research on the problem and got many achievements, the TCTP considering the risk elements has not been solved effectively. In the TCTP, the objective is to determine the duration of each activity in order to achieve the minimum total costs of the project. Studies on TCTP have been done using various kinds of cost functions such as linear [1, 2], discrete [3], convex [4,5], and concave [6] and so on. From the above we can see, they all concerned the complex time planning, but comparing with the real situation, there are two main problems. First, there are no model considering the risk elements on TCTP; Second, how to get the optimization about the risk-time-cost when the network is random.

In order to resolve the above problems, this paper improved the model in the paper [9] based on the general project risk element transmission theory [7,8] and get the multi-objective risk-time-cost trade-off problem(MRTCTP) model when risk elements considering in dynamic PERT network. Thus, this paper gets the relationship of the resource allocation and the risk elements by combining the RBF neural networks and putting the multi-objective risk-time-cost programming problem into the multi-objective cost, expectation, variance, risk-time probability programming.

The paper is organized as follows. Section 2 presents the analytical model of the multi-objective risk-time-cost trade-off problem (MRTCTP), and gives the definition of the Markov dynamic PERT network. Section 3 presents the neural network analytical algorithm of MRTCTP. An empirical example is presented in Section 4. Finally, Section 5 concludes the paper.

2. The model of multi-objective risk-time-cost trade-off problem

2.1. Raising multi-objective risk-time-cost trade-off problem

In this section, we combine multi-objective time-cost trade-off problem and raise the risk-time-cost trade-off problems considering risk element. In practical projects, We use CPM, PERT [10] network technology to get the project completion

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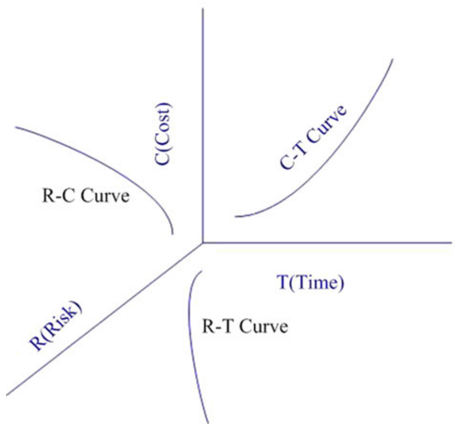

Fig. 1. The three-dimensional structural model of multi-objective risk-time-cost trade-off problem.

time and the corresponding costs. And there are the following balance problems: the cost of the project is not least or within expected expenditures when seeking to the shortest period. when the cost within expected expenditures, the time is not within expected time. The mathematical expression of the problem expresses as follows:

T is the completion time, T^* is the shortest completion time, the corresponding cost is C'. C is the total completion costs of project, C^* is the least completion costs, the corresponding completion time is T', then we can get:

When $C' \le C$, T^* must be the best solution, that is the shortest completion time.

When $C' > C$, set $\Delta C = C' - C$, when ΔC becomes smaller, T^* becomes closer to the best solution.

In actual project, we often encounter the $C' > C$ situation. Therefore, our aim is to enable ΔC decreases, and getting the entire project satisfactory solution.

We can understand the risk-time-cost trade-off problems well with the introducing of the multi-objective time-cost trade-off problems. That is time-cost trade-off considering the influence of risk element. Here he risk element is random variables, its distribution can be discrete or continuous. We build the three-dimensional structural model of risk-time-cost trade-off problems referencing the three-dimensional structural model of general project risk element transmission theory. As shown in Fig. 1.

From the figure we can see that risk time and cost are increasing mutual functions relations. According to the actual project, project resource allocations will affect the time and the cost. Allocations and the time are decreasing functions. Allocations and the cost are increasing functions. In this way we can take the risk impaction of time and cost into the allocation of resources impaction of time and cost. Eventually we can get the analytical model of multi-objective risk-time-cost trade-off problem combining the literature [9].

2.2. Definition of Markov dynamic PERT network

Dynamic PERT network can be described as a queuing system network. Each network will be built as a function of the corresponding service. From queuing theory, arrival rate of the service subjects to the parameters of a Poisson distribution. The desk assumption is that the number of systems in each service is limited or one and the service time is exponentially distributed. Thus, for each joint activities, it forms a queuing system ($M/M/..Model$), and Azaron et al. [9,11] take this dynamic PERT network into classical PERT network. Concrete steps are as follows :

Step 1. Compute the density function of the time spent in each service station.

Step 1.1. If there is one server in the service station settled in the ith node,then the density function of time spent in this $(M/M/1)$ queuing system is $w_i(t) = (\mu_i - \lambda)e^{-(\mu_i-\lambda)t}$, $t > 0$, where λ and μ_i are the generation rate of new projects and the service rate of this queuing system, respectively. Therefore, the distribution of time spent in this service station would be exponential with parameter $\mu_i - \lambda$.

Step 1.2. If there are infinite number of servers in the service station settled in the ith node, then the time spent in this $(M/M/\infty)$queuing system would be exponentially distributed with parameter μ_i, because there is no queue.

Step 2. Transform the dynamic PERT network into an equivalent classical PERT network.

Step 2.1. Replace each node with a stochastic arc (activity) whose length is equal to the time spent in the particular service station.

Let us explain how to replace node k in the network of queues with a stochastic activity. Assume that $b_1, b_2, \dots, b_m$ are the incoming arcs to this node and $d_1, d_2, \dots, d_n$ are the outgoing arcs from it. Then, we substitute this node by activity k', k'', whose length is equal to the time spent in the corresponding queuing system. Furthermore, all arcs b_i for $i = 1, 2, \dots, n$ end up with k' while all arcs d_j for $j = 1, 2, \dots, m$ start from node k''.The indicated process is opposite of the absorption an edge, see [12] for more details.