Solving the equilibrium problem of time, cost, resource and quality of project network by using expanded fuzzy logic set

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Abstract

Nowadays the requests of managers and other persons who benefited by such projects for drop total project's cost have increased considerably. Besides, the amount of changes exert on this factors can result to variation in initial estimation of them. In this way, however; by observing this types of changes in different circumstances, the ideal quality for projects is going to be considered. Moreover, generally in realty world, either falling in time consuming or the amount usage of resources for a task could not lead to decline of task quality. As a result, assigning fixed and deterministic values for assessing ideal quality leading to unpredictable outcomes. I this study, fuzzy logic developed remarkably to measure the quality for wide range of tasks and activities in various variation circumstances. At last, the presented model apply to real case study and the obtained values have proved the efficiency of proposed model in comparison to others in deterministic situations**.**

Keywords:

Fuzzy Logic, Quality of Project, Deterministic Model, Expenditure and Cost of Project

1. Introduction

Every project consist of set of executive tasks which some of them could be in both independent in parallel position and dependent series positions that they can be done in sequence order by considering priority and delay. Furthermore, there are different way to use but also, they have differences in time, cost, resources and performance quality. As a result, to do a project which is consist of different executive tasks from start to finish, it is possible to exert various methods with relevant characteristics of mentioned factors. Total time of project obtain from one of the functional method and it contain of cumulative time in critical path. In majority of proposed model in related to equilibrium of time-cost, reduction of task's time has linear relationship with escalation of cost and in addition the main goal is minimizing the total cost and total cost simultaneously. Presumably, to solve such a mentioned model, different methods were applied [1, 2, 3, 4] and various approaches for cost function were cited as well [5, 6]. In real world, however, different few approaches were applied it related to time-cost equilibrium in concrete circumstances accordingly in concrete condition, the estimation of cost, duration, resources and quality are argued [7]. Also, precise and deterministic methods for solving DTCTP 1 problem for big size have not enough efficiency [8, 9, 10]. In reality, DTCTP problem belong to NP-Hard problems which need to utilize different meta-heuristic methods [11, 12, 13, 14]. The important fact is the total quality of project is

[1] Discrete Time-cost Trade-off Problem

affected by compacting the project network. Therefore it is necessary to consider quality as a crucial factor in time-cost equilibrium problem in concrete conditions. In previous researches in this issue [16] factors such as time, cost and quality have been investigated in different moods for doing special task in project network and for solve such this problem, therefore, a meta heuristic algorithm called [2]NHGA has been applied which is more effective rather than other fame algorithm such as genetic algorithm.

In this study, the obtained quality level of performing tasks of project has been considered in fuzzy number set due to the assigning fixed and deterministic parameter for quality were not appropriate enough. Because of the variations in different moods had not linear relationship with quality. In forward, the proposed model apply in real case example. Finally, the obtained outcomes have proved the efficiency and affectivity of proposed model rather than previous one.

2. Proposed model for DTCQTP problem

Initially, parameters and criteria, decision variables and membership function is presented.

Table 1 Criteria of proposed model

Criteria	
t	Task duration index $t = 1,...,\bar{T}$
i	Network task index $i = 0,...,n$
m	Executive mood index for performing tasks i $m = 1,...,\mathrm{M}_i$
l	Technical characteristic index for task
b	Renewable resources index $b = 1,...,B$

[2] New Hybrid Genetic Algorithm

Table2 Parameters of proposed model

Parameters	
C	Indirect costs for each time unit
M_i	Total summation of functionality mode available for task i
C_{im}	Direct cost of task i when mode m apply
t_{im}	Duration for task i when mode m apply
q_{ilm}	Quality for task i when mode m apply
x_{imt}	Decision variable will be 1 if task i in mode m in time t perform otherwise 0
w_i	Quality weight of task i while $\sum_{i=1}^{n-1} W_i = 1$
w'_{il}	Affection of technical specification i in comparison with total technical specification L while $\sum_{i=1}^{L_i} W'_{il} = 1$
Q_{allow}	Accepted quality lower limit of total project
$T_{cpm}^{\bar{m}}$	Total time of project while all tasks are performed in executive mood set $\bar{m}$
$(U_{qilm}, P_{qilm}, L_{qilm})$	Upper limit, baseline limit and lower limit of quality for task i when mode m is performed
r_{imb}	The amount of renewable source type b for task i when mode m is performed
U_b	Maximum source of renewable source type b
d_{im}	Duration of task i when mode m is applied
$\bar{T}$	Predicted time for finishing overall project (Deadline)

Table 3 variables of proposed model

Variables	
C_T	Total cost consist of both direct and indirect costs
T_t	Finishing time of overall project

$$\mu_{qilm}=\begin{cases}1 & if \quad P_{qilm}\le\sum_{m=1}^{M_i}q_{ilm}\sum_{t=EST_i}^{LST_i}x_{imt}\le U_{qilm}\\ 0 & if \quad \sum_{m=1}^{M_i}q_{ilm}\sum_{t=EST_i}^{LST_i}x_{imt}\le L_{qilm}\\ \dfrac{U_{qilm}-\sum_{m=1}^{M_i}q_{ilm}\sum_{t=EST_i}^{LST_i}x_{imt}}{U_{qilm}-P_{qilm}} & if \quad L_{qilm}\le\sum_{m=1}^{M_i}q_{ilm}\sum_{t=EST_i}^{LST_i}x_{imt}\le P_{qjlk}\end{cases}$$

With presenting covariate λ which show the total satisfaction level [15] proposed model was has been turned linear and as a result this model has gained.

maximize λ

St:

$$\lambda\le\mu_{qilm} \tag{1}$$

$$C_T=(\sum_{i=1}^{n-1}\sum_{m=1}^{M_i}C_{im}\sum_{t=EST_i}^{LST_i}x_{imt})+C*T_{cpm}^{\bar{m}} \tag{2}$$

$$T_t=T_{cpm}^{\bar{m}} \tag{3}$$

$$\sum_{i=1}^{n-1}W_i\sum_{l=1}^{L_i}W_{il}'\sum_{m=1}^{M_i}q_{ilm}\sum_{t=EST_i}^{LST_i}x_{imt}\ge Q_{allow} \tag{4}$$

$$\sum_{m=1}^{M_i}\sum_{t=EST_i}^{LST_i}x_{imt}=1\ , \qquad \forall\ i\in n \tag{5}$$

$$\sum_{m=1}^{M_i}\sum_{i=1}^{n-1}t*x_{imt}+d_{im}\le\sum_{i=1}^{M_i}\sum_{t=EST_i}^{LST_i}t*x_{imt}\ , \qquad \forall\ i\in n \tag{6}$$

$$\sum_{i=1}^{n-1}\sum_{m=1}^{M_i}r_{imb}\sum_{q=\max\{t-d_{im},EST_i\}}^{\min\{t-1,LST_i\}}x_{imq}\le U_b\ , \quad \forall\ b\in B\ \ \&\ \forall\ t\in\bar{T} \tag{7}$$

$$T_{cpm}^{\bar{m}}=\sum_{t=EST_n}^{LST_n}tx_{nt}\le\bar{T} \tag{8}$$

In this propose model, however; the goal function is the maximizing total satisfaction level. The constrains of model are divided into two main category which the first section is satisfaction of membership function and the next section is deterministic limitation of model. Constraint number (1) is related to persuade satisfaction level by membership function in each step. Constraint number (2) is corresponded to both direct and indirect total cost of the given project. The first phrase calculate the summation of overall direct cost due to every task and next phrase shows the indirect cost related to finishing time of total project. Constraint number (3) is related to completing the total project and constraint number (4) ensure the minimum quality level of project. Constraint number (5) is the obligation for performing task exactly in earliest and latest time interval. Constraint number (6) present the prerequisite relationship between deferent tasks .Constraint number (7) explain the maximum availability of renewable resources in each time period and finally, Constraint number (8) illustrate the maximum possible time to complete total project tasks.

3. Applying propose model

In real case study a segment of structural project with 10 tasks has been selected. Additionally, the prerequisite network of given example are shown as bellow:

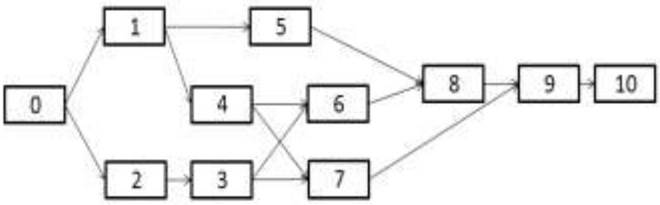

Fig 1 prerequisite network of given project

In this project, presume that each task j has $M_j$mode which performing the each task in related mode consist of duration, fuzzy quality and special cost. Also, requested resource in each mode is variable for each task. It seems natural that by increasing the cost due to decline of duration of task. A particular salient example is when a new technology be used quality boom as result of duration fall. But in this case assume that resource replacement is not allowed and decrease in duration time is possible whether resource number with more cost is available. I this case, related obtained quality of process cannot be illustrated with parameter by fixed values. The number of functional modes for tasks and specification of cost, quality, resources and estimated duration are shown in table 4:

Table4 The number of functional modes

Tasks		1	2	3	4	5	6	7	8	9
1	T	7	8	8	10	14	8	11	11	11
	C	160	140	110	100	160	130	150	140	150
	Q	90	85	90	95	92	85	90	91	90
	r_1	3	4	2	2	2	5	4	3	3
	r_2	6	7	5	4	6	7	7	8	7
2	T	6	7	7	9	13	7	10	10	10
	C	180	150	120	130	170	140	180	150	170
	Q	85	82	85	90	90	82	80	88	88
	r_1	4	5	2	2	3	6	5	4	4
	r_2	7	8	6	6	7	8	8	9	8
3	T	5	6	6	8	12	6	9	9	9
	C	190	170	140	140	180	160	190	160	180
	Q	80	80	84	85	86	80	75	85	85
	r_1	5	6	3	4	5	7	5	5	5
	r_2	8	9	7	6	8	8	8	10	9
4	T	4	5	5	6	11	5	8	8	8
	C	200	180	150	150	200	170	200	170	200
	Q	70	75	80	75	70	78	70	75	80
	r_1	5	7	3	4	5	8	6	6	6
	r_2	8	10	8	8	8	9	9	11	10
5	T	3	4	4	6	10	4		7	
	C	230	200	170	165	220	190		265	
	Q	67	70	76	72	68	75		70	
	r_1	6	8	4	5	6	9		8	
	r_2	9	11	8	9	9	11		12	
w_i		0.09	0.11	0.14	0.11	0.13	0.15	0.09	0.11	0.07

This type on data are equivalent with the volume application of resources to reach target quality goal. Thus, by vary the volume usage of resources, durations and costs estimated. Therefore, by exerting the proposed approach, the outlines for resources in different positions of duration and cost are calculated in special in optimum time. The obtained results are shown in figure 2:

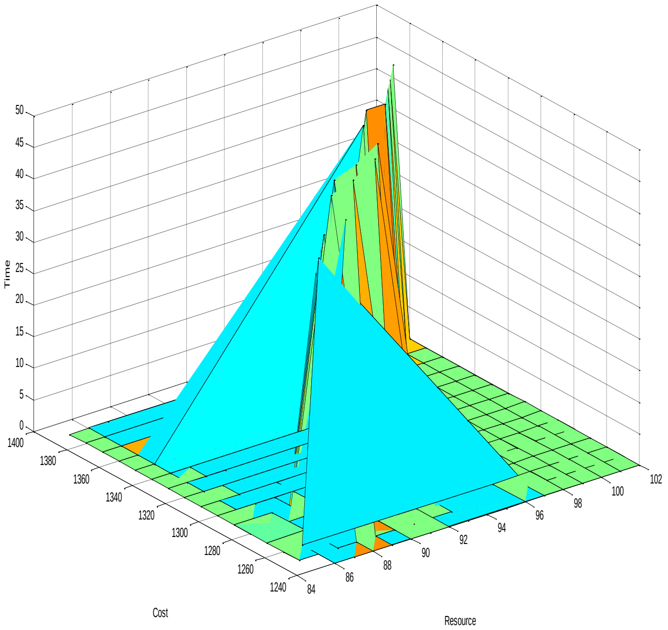

Fig 2 result for proposed approach in different mode

Moreover, based on fuzzy ideal quality the optimum duration is presented as bellow with corresponding to performing project tasks step by step.

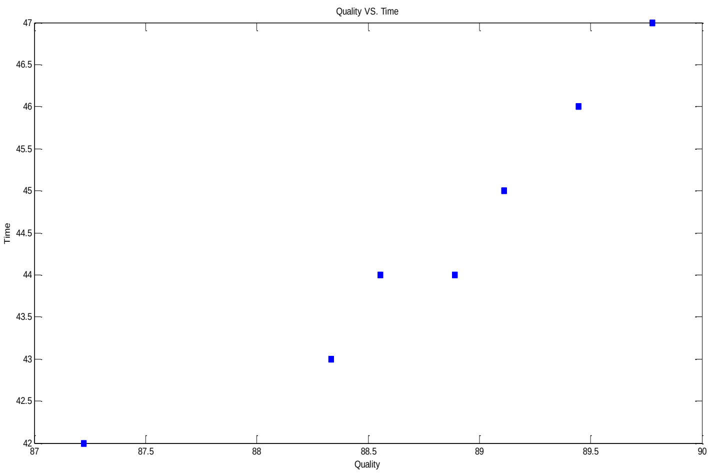

Fig 3 ideal quality in optimum duration

All in all, the proposed approach in this study has more flexibility in corresponding to other deterministic methods particularly in real circumstances. In this way, however; by applying the presented model, there are more controls over the deterministic situations and management of fundamental factors.

4. conclusion

In this study, the obtained quality level from performing the project in different modes are considered in fuzzy number set. Due to assigning deterministic parameter for quality in not appropriate enough when variations are planning to do for cost, durations and available resources. For more explanation, there is not linear relationship between quality and variations in modes.

In the other hand, by using the proposed approach, estimation of crucial parameters and critical path are predictable for future variations in related to quality level. For future research, to have more control in uncertainty environment, identification of new parameter in lack of certainty circumstances and mixed methods of “stochastic – fuzzy”, it is possible to close to real environment. By this way, it is accessible to control uncertainty when variations exist.

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