Considering the time value of money for modeling the risk assessment of cost and time components in construction projects

Abbas Mahmoudabadi
Department of Industrial Engineering, MehrAstan University, Gilan, Iran
mahmoudabadi@mehrastan.ac.ir

RoghayeMousazade
MSc. in Construction Engineering and Management, Islamic AzadUniversity, Branch of South Tehran, Tehran, Iran
rmousazade@yahoo.com

Abstract
The present paper focuses on developing a cost-risk evaluation model in order to evaluate the risk of cost that may happen in project stages. Since, it is important to detect risk factors which may cause cost overrun for different activities and stages of various projects; the main objective is to provide an evaluation method in order to determine the current value of cost risks in construction projects. Risk cost may occur in different stages of construction and the time value of money is different over the construction time, it is necessary to have a detailed assessment between the risk categories. For this purpose, the project is broken to stages and activities and the cost of activities, cost risk factors, activity cost risk,stage cost risk, total value of project cost riskand so onare determined. Eventually, the present value of cost risk, the value of different risk groups are calculated and comparedto three pre-defined risk categories.

Keywords
Project Management, Time, Cost, Risk, Time value of money

1. Introduction
Risk is used in many different ways and words, such as Hazard or Uncertainty. There is perhaps no consistent use of this word. Every activity may be characterized by the presence of risk. Risk can be defined in many fields such as safety, social, business, investment, military, political and etc. The riskier activity may happen costlier the consequences if the wrong decision is made(Jannadi& Almishari, 2003). Construction projects are considered to have a high level of risk due to numerous stakeholders, long project duration and open production system(Taroun, 2014).The construction process is inherently prone to risks. Risk management is an essential and integral part of project management on virtually all construction projects. Risk analysis is the main component of risk management that enables professionals to quantify and analyze risks those may pose potential threats to project performance in terms of cost, quality, safety, and time (Choudhry et al., 2014).They usually have extensive durations with varying uncertainties and complex relationships among the participants.Identifying and analyzing potential risks that could occur on a project as early as possible can enhance successful completion of the project(Taroun, 2014). Time, cost and risk are three criticalconcerns of construction project management (Choudhry et al., 2014). The effect of cost overrun and schedule overrun not only influence the construction industry but the overall economy as well (El-Karim et al., 2015). In the construction industry, where the main aim is to minimize the costs of construction work, as well as to gradually decrease the prices for construction work, procuring an offer for construction work is very difficult. Construction companies are usually interested in maximizing the profit in order to secure funds for new investments, and cover possible expenses associated with the occurrence of risk factors during construction (Dziadosza et al., 2015).

Using the Gray Decision Making Trial and Evaluation Laboratory (GDEMATEL) method for prioritizing sources of project risk within a multi-criteria decision making (MCDM) framework, resulted thatTechnology which is applied in the project-based construction firms should be considered as one of the crucial sources of risks in projects and must be chosen appropriately in order to lower the effects of "Technical" risks.It is Also revealed that "External" risks are very significant and can bring about many drawbacks for effective project accomplishment such as inflation rate and environmental factors although these components are not under control of the project manager's authority but they cause a broad range of issues and managers should be vigilant to decrease their negative effects.. (Vafadar nikjooet al., 2015)

Despite its importance to the success of project management,risk management is rarely approached with the same rigor as other project management processes such as project scope and scheduling. A process of risk management has involved risk identification, risk assessment and risk mitigation. The identification and assessment of project risk are the critical procedures for projecting success.Many construction project risk assessment techniques are currently used in the construction industry but insufficient attention has been paid by researchers to a select suitable risk assessment model (Karimi Azari et al., 2011).

A deterministic approach to project management that has preset parameters of time and cost and in whichdecisions are taken based on the independent analysis of time or cost,even if they are interrelated,has a low likelihood to be successful.Construction projects are typically confronted with delay and additional cost, which reduce a company's profit and can lead to its bankruptcy. Therefore, a more efficient approach should take into account the risk events, the uncertainties and resources limitation parameters (Purnus & Bodea, 2014).

In project management sophisticated monitoring techniques and analytical models which are employed for earned valuemanagement, optimization tools and decision support systems, but not for thecontinuous risk monitoring system. Although some of the employed risk management methods focus on advancedmathematical tools, they leave out either the ownership approach from the criteria, or the applicability of continuoususage.A formalized, integrated risk management model based on a value-based risk management approach that includes the concept of owner's valueand provides the mathematical background of the phenomenon of time-varying risks based on an algorithm tofacilitate continuous risk monitoring,describes the ratherpragmatic phenomenon of the decrease of risk as time passes, while the applicability of the process is maintained. It is believed that providing the mathematical context of time-varying application of riskmonitoring process will help further clarify the concept of business project risks (Toth & Sebestyen, 2015).

Nowadays, production and delivery time, price, risk andquality are considered as the most important competitive advantages in industries. Hence, in the recent years,examining the relationship between competitiveadvantages in the leading industries and industrializedcountries are still under discussion. Every year, a large number of companies spend large sums on the research anddevelopment about the most optimum combination ofproduction or the most optimum function and feature oftheir products and services. The impact ofpoor quality on the price of products and organization earnings and the amount of cost should be paid for highquality has raised many important issues affectingcost accounting, quality control, repairs andmaintenance, supply chain, production management,stores, safety and health, education and improvement andso forth. Project managers and management accountants perform crashing with the aim of reducing the total cost, time and risk along with maximizing the total quality. It isnot admirable to say that the balance between variouscomponents of survival pyramid,Time, Cost, Quality, Risk are not only interesting toproduction and operational activities, but such a balancemay guarantee the long-term success of organization inservice and support activities affecting the amount ofincrease and decrease in cost and achieving success. It isinteresting to note that new business strategies are formed based on the above mentioned factors (Rezaian, 2011).

Since, the time value of money is one of the fundamental concepts of engineering economics, reviewing the literature and research on construction project risk assessment show that less attention has been paid to the concept of money time value and the cost risk which are determined regardless of the variable value of money in different periods.So in this paper,a model of cost risk assessment due to the time value of money has been developed. This paper is organized into five sections. After introduction, a clear discussion on the proposed procedure is made consisting of the present value of project risk cost and risk group evaluation. The last section is to briefly discuss what has been done in this research work.

2. Proposing Procedure

To determine the present value of cost risk, a construction project is divided into several stages in which each stage is divided to relevant activities.The cost of any activity and cost risk factors are determined through filling out questionnaires.To determine the impact of risky factors on the project,cost risk calculated for each factor related to each activity followed by calculatinga cumulative cost risk for each activity.The present value of cost risk for each activity is obtained by cash-flow equation and finally present value of stage cost risk is the sum of present value of related activities cost risk. All the above notes can be described as the below steps:

1.Select the construction project.

2.Break the project to construction stagesbased on project properties and activities. Stagesmay be defined as annual, seasonal,monthly.
3. Determine the activities and their related costs for each stage of the project.
4. Determine risk factors which may lead to cost overrun.
5. Determinethe probability of occurrence and severity of impact for each risk factor. (The effect of each factor on activity cost,cost risk, the productof (activity cost × risk severity × risk probability) is calculated.
7. Calculate the total risk cost per activity as the sum of cost risk (activity cost × risk severity × risk probability)
8. Convert the value of activity cost risk to present value of cost risk using cash flow formula.
9. Calculate the present value of stage cost risk as the sum of cost risks for the related activities of that stage.
Figure 1 shows all steps which have been defined in the proposed procedureas well as parameters and their definition arealso described as below:

Index	*Definition*
J	*Stage index*
I	*Activity index*
m	*The number of activities in each stage*
n	*The number of project stages*
o	*The number of risk factors for each activity*
r	*Risk index*
C_{ij}	*The cost of activity (i) in stage (j)*
P^r_{ij}	*The probability of risk (r) related to activity(i) in stage (j)*
S^r_{ij}	*The severity of risk (r) related to activity(i) in stage (j)*
C^r_{ij}	*The cost risk (r) related to activity(i) in stage (j)*
F_{ij}	*The total value of cost risks related to activity(i) in stage (j)*
P_{ij}	*The present value of cost risks related to activity(i) in stage (j)*
P_j	*The present value of cost risks may happen in stage (j)*
ir	*Rate of interest*

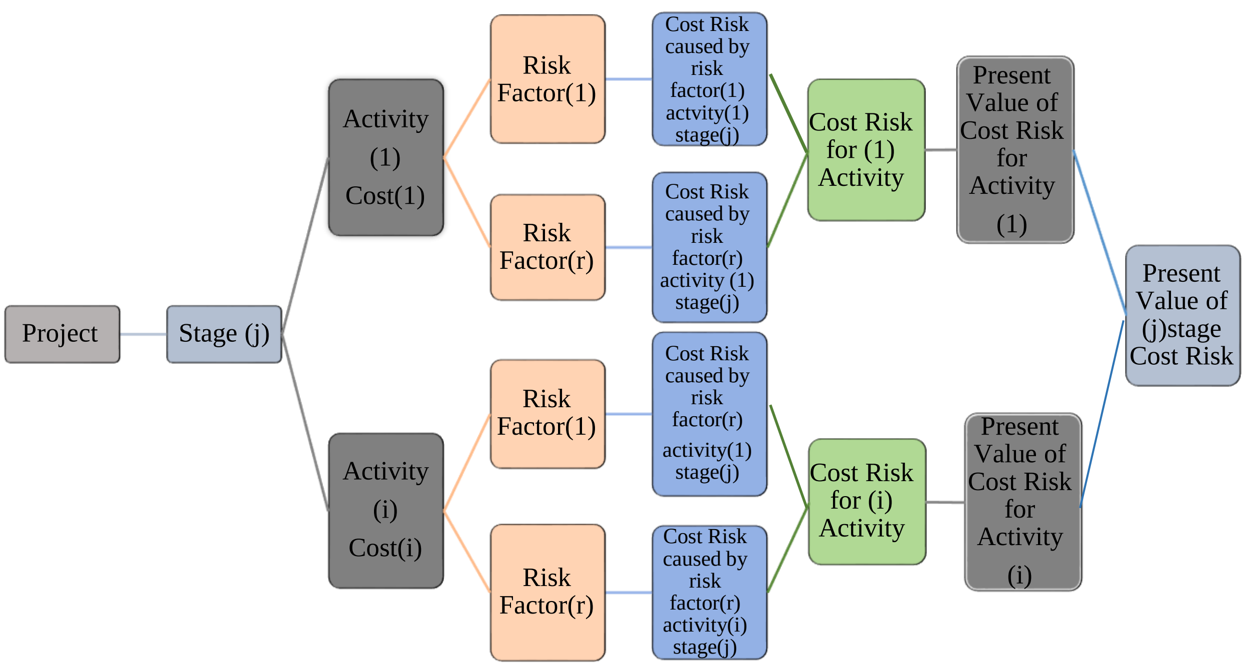

Figure1. Determine the present value of stage cost risk

3. Proposed sequential procedure

After dividingthe project into (j) stages and determining the (i) an activity of each stage, the cost of activity (i) is defined by C_{ij} in stage (j).following that (r) risk factors is defined for each activity in step (3), and the probability of risk (r) related to activity(i) in stage (j) is defined as P^r_{ij}. The severity of risk (r) related to activity(i) in stage (j), is also defined by symbol S^r_{ij} in step(3). The cost risk (r) corresponding to each activity(i) in stage (j), C^r_{ij}, is calculated by equation (1) in step (4). Afterward, in step (5), the total value of cost risks related to activity(i) in stage (j), F_{ij}, is calculated by equation (2). The present value of cost risks assigned to activity(i) in stage (j) defined as P_{ij}, calculated by equation (4) in step (6). At the final step (7), the present value of cost risks may happen in stage (j) shown as P_j, is calculated by equation (5).

The cost risk is used to determine the effect of each risk factor related to the activity. For this purpose, the activity cost is affected by risk severity and probability, so for each activity the value of cost risk per each factor iscalculated by equation (1) where C^r_{ij} is Cost of risk (r) for activity (i) at stage (j), S^r_{ij} is severity of risk factor(r), P^r_{ij} is the probability of risk factor(r) and C_{ij} is cost of activity (i) at stage (j).

$$C_{ij}^{r} = S_{ij}^{r} \times P_{ij}^{r} \times C_{ij} \tag{1}$$

To determine the total effect of cost risks for each activity, total value of cost risks is calculated by equation (2), where F_{ij} is total cost risk of activity (i) at stage (j) and $C^r_{ij}$is the total cost risk of activity (i) at stage (j).

$$F_{ij} = \sum_{r=1}^{o} C_{ij}^{r} \qquad \forall i = 1, \dots, m \in N \ \& \ \forall j = 1, \dots, n \in N \ \& \ \forall r = 1, \dots, o \in N \tag{2}$$

In order to convert the value from their real-time occurrence to the beginning time of the project, the cash flow formula is used where P is present value, F is future value, p/f is present-future worth ratio, ir% is rate of interest.

$$P = F \times F(p/f\ , \%ir\ , j) \tag{3}$$

By replacing the value of stage cost risks (F_{ij}) in cash flow formula, the present value of cost (P_{ij}) risks for each stage is calculated by equation (4).

$$P_{ij} = F_{ij} \times F(P/F\ , \%i\ , j) \tag{4}$$

The present value of cost risks for each stage is the sum of the present value of the activities of that stage and defined by equation (5). A sequence of using the above parameters is tabulated in Table 1.

$$P_j = \sum_{i=1}^{m} P_{ij} \ \forall j = 1, \dots, m \in N \tag{5}$$

Table 1.Determine the present value of project cost risk

Project stages (J)	Stage activities (I)	Activity cost (C_{ij})	risk factor (r)	Factor probability (P_{ij})	Factor severity (S^r_{ij})	value of cost risk (C^r_{ij})	Total value of activity cost risks (Fij)	present value of activity cost risks (P_{ij})	Present Value of Cost Risk related to Stage (P_j)
1	1	C_{11}	1	P^1_{11}	S^1_{11}	C^1_{11}	F_{11}	P_{11}	P_1
			r	P^r_{11}	S^r_{11}	C^r_{11}			
	i	C_{i1}	1	P^1_{i1}	S^1_{i1}	C^1_{i1}	F_{i1}	P_{i1}	
			r	P^r_{i1}	S^r_{i1}	C^r_{i1}			
j	1	C_{1j}	1	P^1_{1j}	S^1_{1j}	C^1_{1j}	F_{1j}	P_{1j}	P_j
			r	P^r_{1j}	S^r_{1j}	C^r_{1j}			
	i	C_{ij}	1	P^1_{ij}	S^1_{ij}	C^1_{ij}	F_{ij}	P_{ij}	
			r	P^r_{ij}	S^r_{ij}	C^r_{ij}			

4.Risk group evaluation

In order to have an evaluation between different risk categories,risks that construction projects may be encountered in implementation process divided into three groups ofcost risks, national-regional risks and technical ones. Two parameters of the weight(importance) and magnitude(score) of risks are also defined to rate the risks. For technical and national-regional ones, parameters are independent of time like as the weight of cost risks but the magnitude of cost risk isconsidered to be variable for different stages. The parameters are shown in a table like Table 2.The mentioned amountcould be extracted through questionnaires completed by experts. The values for technical and national-regional risks are fuzzy numbers,but the magnitudes of cost risk are in non-fuzzy format, so it is necessary to normalize the values for cost risk over the interval [1-5].

Table2. Risk categories parameters

Project Stage	Risk Categories					
	Cost Risks		TechnicalRisks		National-RegionalRisks	
	Weight [0-1]	Magnitude [1-5]	Weight [0-1]	Magnitude [1-5]	Weight [0-1]	Magnitude [1-5]
1	W_C	M_{C1}	W_T	M_T	W_N	M_N
2		M_{C2}				
j		M_{Cj}				

Using the process the cost risk value will convert the values to fuzzy forms and the following formula is applied:

$$M_{C_j} = \frac{(P_j - P_{j_{min}})}{(P_{j_{max}} - P_{j_{min}})} \times (5-1) + 1 \qquad (6)$$

M_{C_j}: The fuzzy presenet value(magnitude) for cost risk over the interval $[1-5]$

$P_{j_{min}}$: The lowest amount of present value of stage cost risks over the project time

$P_{j_{max}}$: The maximum amount of present value of stage cost risks over the project time

The sum of cost risks for project (M_C) over the interval [1-5], is obtained by equation (7).

$$M_C = \frac{\left[\sum_{j=1}^{n} M_{C_j}\right]}{n} \qquad (7)$$

And in continue,

$$V_T = (M_T \times W_T) \qquad (8)$$

Where, V_T is the value of project technical risks, M_T is the magnitude of project technical risks and W_T is the weight of project technical risks.

$$V_N = (M_N \times W_N) \qquad (9)$$

Where V_N is the value of project national-regional risks, M_N is the magnitude of project national-regional risks and W_N is the weight of project national-regional risks.

$$V_C = (M_C \times W_C) \qquad (10)$$

Where V_C is the value of project cost risks, M_C is the magnitude of project cost risks and W_C is the weight of project cost risks, So the total value of project risk is the sum of technical and national-regional risks with the cost risks considering the time value of money:

$$Vs = V_T + V_N + V_C$$

$$Vs = \sum_{k=T,N,F} V_k \qquad (11)$$

So the rank for each category isdetermined:

$$R_{T_C} = \frac{V_C}{V_S} \times (5-1) + 1 \qquad (12)$$

$$R_{T_M} = \frac{V_M}{V_S} \times (5-1) + 1 \qquad (13)$$

$$R_{T_T} = \frac{V_T}{V_S} \times (5-1) + 1 \qquad (14)$$

Using the rank of risk groups, we can determine the importance of the threats posed by the different risk groups. We can make decision about the project cost risk and finally can talk about how to deal with these risks to reduce, accept or transfer them to others and reduce project cost risks and consequently reduce the project cost.

5. Summary and Conclusion

The study was presented a cost risk assessment model.Considering the time value of money in the calculation of these risks, is the special feature of this method. For this purpose, the project was broken down into specific steps,related activities and risk factors with their parameters. Present value of activities and stages cost risks were calculated by presented formulas. Then based on the data derived from the questionnaires, the weight and value of the three risk categories are defined for the project, to asses risk categories values. The values ofrisk categories weredetermined in the form of fuzzy numbers; finally, the rating was determined for risk groups.

Set construction project cost risk taking into account the time value of money, leads to bettercomparison between different risk categories, because the impact of variability in the value of money and the cost risks on the project

implementation process is considered, so we can evaluate the risks of project at various times for different groups to make decisions and reactions for dealing with them at the right time.
It is recommended for future studies; the construction project cost risk is reviewed and evaluated considering the cost-benefit ratio. It seems that use the combination of these two concepts, a more comprehensive assessment of project cost and benefit would be done. So with comparison the cost and benefit risks during the project implementation and operation period, decisions on feasibility and economic viability of the project would be possible.

References

Choudhry, R.M., Aslam, M.A., Hinze, J.W., Arain, F. M., Cost and Schedule Risk Analysis of Bridge Construction in Pakistan: Establishing Risk Guidelines, DOI: 10.1061/(ASCE)CO.1943-7862.0000857, American Society of Civil Engineers, 2014.

Dziadosza, A., Tomczykb, A., Kaplińskic,O., Financial risk estimation in construction contracts, Operational Research in Sustainable Development and Civil Engineering - EURO working group meeting and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015),2015.

El-Karim, M.S.B., El Nawawy, O.A.M., Abdel-Alim, A.M., Identification and assessment of risk factors affecting construction projects, HBRC Journal, 2015.

Jannadi, O.A., Almishari, S., Risk Assessment in Construction, 10.1061/(ASCE)0733-9364, 129:5(492), 2003.

KarimiAzari, A.R., Mousavi, N., Mousavi, S.F., Hosseini,, S.B., Risk assessment model selection in construction industry, Expert Systems with Applications 38, Pages 9105–9111, 2011.

Purnus, A., Bodea, C.N., Correlation between time and cost in quantitative risk analysis of construction projects, Creative Construction Conference, 2014.

Rezaian, A, Time Cost Quality Risk Of Construction And Development Projects Or Investment", Middle-East Journal of Scientific Research 10 (2), Pages 218-223, 2011.

Taroun, A. Towards a better modelling and assessment of construction risk: Insights from a literature review, International Journal of Project Management 32, Pages 101–115, 2014.

Toth, T., Sebestyen, Z., Time-varying risks of construction projects, Creative Construction Conference 2015.

Vafadarnikjoo, A., Mobin, M.s., Salmon, C. ,Nikbakhsh, J.,An Integrated Gray-Fuzzy Cause and EffectApproach toDetermine the Most Significant Categories of Project Risks, Proceedings of the 2015 Industrialand Engineering Research Conference S. Cetinkaya and J. K. Ryan, eds, 2015.

Biography

Abbas Mahmoudabadicorresponding author (mahmoudabadi@mehrastan.ac.ir), Ph.D. in Industrial Engineering, is the director of Master Program in Industrial Engineering at MehrAstan University, Gilan, Iran and deputy of Planning and Coordination in Transport and Fuel Management Centre, at Road Maintenance and Transport Organization, Tehran, Iran. He achieved his Ph.D. degree in January 2014 in the field of optimization in Hazmat transportation and received Thesis Dissertation Award from IEOM society in March 2015, Dubai, UAE. He has published near 60 journal or international conference papers and one book chapter published in the field of industrial engineering, transportation, and trafficand road safety. He is a professor and teaches transport and industrial engineering courses at universities and has around 24 years of executive experiences on traffic and road safety planning in developing countries. He has strong cooperation with national and international agencies on traffic safety and more with international agencies in the field of industrial engineering. Some national transportation projects have been implemented under his supervisory responsibilities with the results of fatality reduction in intercity transportation.

RoghayeMousazadeholds a Bachelor of Science degree in Civil Engineering from Amirkabir University of Technology and iscurrently master student in construction engineering and management in AzadUniversity,South Tehran Branch. She spent ten years as atechnical expert in the technical office of the Organization for Development, Renovation and equipping schools of Tehran Province.She has done the structural design of more than 100 different schools,related buildings, sport halls .Since 2008,she has been a member of the Engineering Organization of Tehran Province, during this time,structural design and supervision over 10,000 square meter residential building served.