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Presentation of the Economical Evaluation Model of Delay Cost in Civil Projects: An Iran Railway Case Study

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Abstract: Successful implementation of a civil construction project is highly affected by time and cost framework of a project. Delay in completion of civil projects will cause significant cost for all beneficiaries of the project. Furthermore, completion of the project will not be economically reasonable if the delay continues. Therefore, presentation of a model for evaluating these expenses is essential. The research methods used in this study are modeling and analysis method (based on Fundamentals of Engineering Economics), case study method and field study method. In this study, 3 models for economical evaluation of delay costs in civil projects are presented. Using these models which are based on engineering economics, a case study of IRI railway construction has been discussed. The outputs indicate that in a civil project, the rate of return and net present worth are reduced according with delay period. The results also indicate the maximum tolerable delay period for a project.

Key words: Civil projects, railway, delay, economic appraisal model of delay, projects

INTRODUCTION

Delay in civil projects results in increase of the project construction time which is undesirable for all beneficiaries; they all will experience lost, the employer because of the lost profit, contractors because of the increase in costs and occupation of resources and people because of unavailability of social benefits of the project. Construction delay is considered to be one of the most recurring problems in the construction industry and it has an adverse effect on project success in terms of cost, time, quality and safety. There are several factors that cause delay in construction. Delay may be caused by clients, users, consultants, designers, owners, contractors and suppliers. A questionnaire survey was conducted to determine the causes of delay from owners, consultants and contractors of large building construction projects. About 70 respondents participated in the survey. Using the importance index analysis, the study identified 10 most important causes of delay from a list of 30 different causes. Ten most important causes were:

- Lack of experienced construction manager
- Lowest bidder selection
- Funding shortage by owner
- Lack of proper management
- Improper planning and scheduling
- Lack of skilled workers
- Site constraints
- Contractors' cash flow problems during construction,
- scalation of resources price
- Contractors' excessive workload

The more delay the project experience the less economically appealing the project will be and if the delay continues, the project might not be economically feasible anymore. Therefore, a model is needed to evaluate the economic costs imposed by delay in civil projects (Oskoonejad, 2014). Ahadi and Sepahi (2013a) in a research have presented a model for evaluating economic costs of delays.

As the execution time of railway construction project increases, the following financial changes happen in the project: increase in materials and facilities cost due to inflation; increase in current expenses of the project (workers payments, equipment or locations rent, energy, contract and agreement extensions and insurance), for example, if a supposedly 5 year project is executed in 10 years, workers payments should be paid for 120 months instead of 60 months. This payment also increases with inflation.

Delay in project income: Economic losses due to delay in execution of a project (DED) considering the cases in Eq. 1:

$$DED = NPV_d - NPV_0 \quad (1)$$

Where:

PW_0 = The net Present Worth without delay
NPW_d = The Net Present Worth with 'd' years delay

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This research clearly reveals delay costs in a civil project, however, the outputs of this model do not reveal the relationship between the amount of delay and the amount of economic losses and more importantly how many delay years is allowed economically in execution of a project. To study the delay case, it is necessary to focus more on economic justification studies in civil projects (Ahadi and Sepahi, 2013b).

For example, in execution of Kansas USA Railway Project, civil costs, operation costs and execution incomes were addressed more and its justification plan (economic and financial evaluation) is based on this but delay costs are not included.

In development of justification plan of South Suburban Commuter Rail Project, costs and incomes of this project were included but what costs will be imposed on the country in case of delay and for how many years of delay this project will be economically feasible, were not mentioned.

In the literature, delay and changes in project life cycle, often has been mention under sensitivity analysis, sensitivity is, in fact, a review to an economic evaluation. With this question that whether initial estimates can perfectly represent future conditions that affect the project? Sensitivity analysis is to help decision makers to decide, thus if the initial parameters change and the initial results don't, it will be promising for the investors and they would feel more hopeful.

Sensitivity analysis applies Net Present Worth and Rate of Return methods and using financial procedures can be executed before or after taxes. Sensitivity analysis can also be used for evaluating any involved elements and then show the results on geometrical graph as percent of changes in primary elements. To summarize, sensitivity analysis includes the repeat of calculations of a financial process along changing primary elements and comparing the results with initial data. In the initial Feasibility study report of Chabahar Railway, the sensitivity of the project is evaluated in terms of some effective parameters in profitability. The results are showed in Table 1.

Table 1: Chabahar railway project sensitivity analysis

Analysis	Net present worth (Billion rial)	Rate of return (%)
Change in charge[1]		
Minimum (20% decrease)	681	8.0
Realistic	1093	8.6
Maximum (20% increase)	1506	9.2
Construction time[2]		
Minimum (3 year)	-	8.0
Realistic (5 year)	-	8.6
Maximum (7 year)	-	6.9
Inflation rate[3]		
Minimum (20% decrease)	654	12.5
Realistic (13%)	1093	10.0
Maximum (20% increase)	-45	7.5

[1]Analysis of sensitivity to change in passenger and cargo transportation charge; [2]Analysis of sensitivity to change in construction time; [3]Analysis of sensitivity to change in inflation rate

In sensitivity analysis, some changes are made in a parameter and the resulting changes in rate of return and net present worth are calculated and the results are shown on diagrams; however, it does not mention that 1% change in time parameter causes how much change in costs parameter precisely or how much increase in time is allowed in execution of the project.

Considering above, it is necessary to present a comprehensive model for economic evaluation of delay costs and to answer these questions: how much will the rate of return and net present worth change for each percent change in project execution time. And basically, how much delay is allowed for the project to be still economically feasible? The three models of economic evaluation of delay costs in civil projects which are presented here, study delay in three different ways to answer these questions. In this study, to evaluate results from models, execution project of Miane-Ardebil Railway is considered as a case study.

MATERIALS AND METHODS

Engineering economic fundamentals and the concept of inflation: The Future value (F) of a present investment (F) is:

$$F = P(1+i)^n \tag{2}$$

In this Eq. 2, i represents interest rate of investment. In a financial and economic calculation, they often shift all costs and incomes to present time. And the summation of these numbers is called Net Present Worth (NPW).

In calculating net present worth if interest rate is used, which will turn NPW to zero; this interest rate is called Rate of Return (ROR). Increase in prices and decrease in purchasing power in time is called inflation. If P is the present worth of a property and F_t^* is the future value of this property with inflation impact for t years, the present worth of the property is calculated as following:

$$F_t^* = P\left((1+f)^t(1+i)^t\right) \tag{3}$$

Equation 3 can also be written as:

$$F_t^* = P(1+if)^t \tag{4}$$

By Eq. 5 and 6, we can write:

$$(1+ \text{if})^t = (1+i)^t (1+f)^t \tag{5}$$

So:

$$\text{if} = i + f + i \times f \tag{6}$$

CST increase due to delay in civil projects: Delay in execution of civil projects will cause increases in following costs:

- Execution delay costs and lost profits
- Costs due to inflation (increase in material and execution costs)
- Increase in labor force and equipment costs
- Cost increase due to extension of contracts and agreements
- Increase in input investment interest cost
- Losing the competitive market
- Cost increase due to decrease in government incomes and social welfare
- Cost increase due to losses in substitution projects
- Increase in environmental costs of the substitution projects
- Cost increase due to economic and political instability

Parameters and rates of economic evaluation model of delay costs in civil projects: The following parameters and rates are used in presented models:

- Material Cost (MC)
- Service and rent Cost (SC) during construction: includes work labor payment (professional or non-professional), equipment, land and building rent, license and contract cost and other similar costs in construction phase
- Investment Cost (IC) of the project: is the summation of Material Cost (MC) and Service Cost (SC)
- Annual Cost (AC) of the execution period: such as energy costs, repair and maintenance costs and personnel salary
- Direct Income (DI): the income earned through selling the products, or services
- Social, environmental, economic and general benefits (SB)
- The minimum attraction rate of the geographic zone (i_r) which is considered the same as interest rate
- Inflation rate (F): this rate is declared by the Central Bank
- Inflation rate of the service index (f_S)
- Investment factor (α): the ratio of material cost to investment cost:

$$\alpha = MC/IC \tag{7}$$

- Construction period of the civil project (n_1)
- Execution period of the civil project (n_2)
- Delay in construction of the civil project (d)

It is necessary that n_1, n_2 and ‘d’ have the same unit. In civil projects, these parameters are usually in year unit.

- Percent of Delay (PD): is equal to delay time divided by initial construction time
- Percent of Rate of Return (PROR): is equal the difference of delay Rate of Return (ROR_d) and rate of return without delay ROR_0 divided by Rate of Return (ROR_0) without delay
- Percent of Net Present Worth (PNPW): is equal to difference of delay net present worth NPW_d and net present worth without delay divided by net present worth without delay NPW_0:

$$PNPW = \frac{(NPW_d - NPW_0)}{NPW_0 \times 100} \tag{8}$$

RESULTS AND DISCUSSION

First model; economic evaluation of delay costs in civil projects absent inflation: When inflation in costs and incomes is the same, it can simply be ignored (Sabzeh, 2014). The following stages are presented for using (absent inflation model).

Determining interest rate and alpha rate (investment factor): if material cost, payment cost and services are not available individually, they can be calculated using alpha rate.

Calculation and development of cash flow table for different years (material cost, payment and services cost, direct income, social and national benefits, annual profit or loss). It should be noticed that all these calculations are based on economics engineering equations and time value of money.

In Miane-Ardebil Railway Project, interest rate is 7%, investment factor is 0.7, construction time is 6 year and execution period is 20 year.

Calculation of present net value and rate of return of the project: considering the 7% interest rate, the present net value is 1482 billion rials and the rate of return is 11.64%. Therefore, the project is economically feasible without delay and inflation.

Updating the project cash flow table in case of ‘d’ years delay: in this case, the construction period will be n_1+d years but the execution period will remain n_2 years. Because, the amount of material used in a certain project is fixed, if we ignore inflation, as the construction time increases, material costs will not change but will be

Table 2: Cash flow of Miane-Ardebil Railway Project with 3 years delay in construction

Years	Passenger ticket time	Cargo income	Social benefit	Investment cost	Utilization and maintenance cost	Cash flow
1383	0	0	0	400652	0	-400652
1384	0	0	0	343416	0	-343416
1385	0	0	0	421882	0	-421882
1386	0	0	0	287186	0	-287186
1387	0	0	0	59549	0	-59549
1388	0	0	0	11603	0	-11603
1389	18496	246365	146236	992800	130349	-712051
-	-	-	-	-	-	-
1407	44513	610879	361493	102325	198754	715806
1408	46738	3343860	381148	120250	205207	3446289

distributed on the new construction period. However, because payment and services cost (such as labor salary, equipment and building rent, contract extensions, etc.) are directly related to construction period, they must be paid during the new construction period. Thus, in case of 'd' years delay in construction, present worth of every year's material cost is determined by the total present worth of material cost divided by the new construction period (n_1+d). Then each year's material cost is determined by present worth of material cost multiplied by $(1+i)^n$. Labor payment cost in 'd' years delay is also calculated based on previous procedures. Direct income and social benefits of the project in delay years are zero. Income and benefit in the first new execution year or (n_1+d)th year is equal to those of (n_1+d)th year in without delay execution period. Similarly, these parameters in each year of the new execution period are equal to those in the same year of without delay execution period. Income and benefits in the last 'd' years of the new execution period are determined through procedure analysis of the previous years. The same way, cash flow table for different values of 'd' are developed. For example, cash flow table of the project for 3 years is shown in Table 2.

Recalculating the rate of return and net present worth and developing outputs of the first model: Rate of return and net present worth are calculated for different delays. However, these calculations can also be used for negative delay (sooner in utilization) in constructing the project. Therefore, PNPW and PROR graphs are plotted in terms of Pd then the three outputs of the model are determined. These three are: percent of change in net present worth of the project for 1% delay, percent of change in rate of return for 1% delay and maximum allowed delay. These graphs for Miane-Ardebil project are shown in Fig. 1 and 2. Correlation of the first graph is 0.9993 which indicates the linear relationship between percent of change in net present worth and percent of delay.

Line equation of the first graph is PNPW = -0.59, Pd, therefore, 1% delay in project will decrease the net present worth of the project by 0.59%. About 1% sooner in execution of the project will also increase the net present worth of the project by 0.59%.

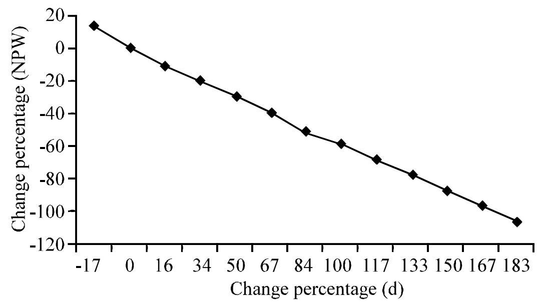

Fig. 1: Change in NPW graphs for Miane-Ardebil Project

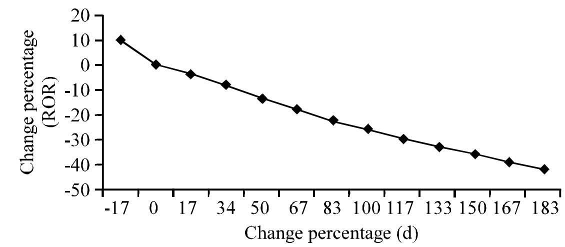

Fig. 2: Change in ROR graphs for Miane-Ardebil Project

The line equation of second graph indicates that 1% delay will cause a 0.24% decrease in rate of return. Maximum allowed delay in a project is the amount of delay that results in zero net present worth. Based on the first model calculations, the maximum allowed delay for the project is 10 years (167% delay).

Second model; economic evaluation of delay costs in civil projects considering inflation: This model is generally similar to first model; the only difference is that in this model inflation is applied to costs and incomes. In Iran, inflation rate of the country is declared by the central bank. Inflation rate of food and non-edible goods and services and the inflation rate of the total index are also declared by Iran statistics center (Assaf, 2015).

In the second model, just like the first model, a cash flow table absent inflation and delay and a cash flow table absent inflation and considering delay are calculated and developed. Then, all cost and income items are inflated proportional to the base year. As material, services and execution cost is a function of economic conditions of the society, it is inflated by the total inflation rate of the country but direct income and social benefits of the project are inflated by non-edible goods and services index inflation rate. Because tariffs for national civil project incomes increase based on non-edible goods and services index. Outputs of the second model are the same as the first model: percent of change in net present worth of the project for 1% delay, percent of change in rate of return for 1% delay and maximum allowed delay.

Outputs of the second model for Miane-Ardebil Railway Projects are: 2% decrease in net present worth and 0.3% decrease in rate of return for 1% delay in execution of the project and maximum allowed delay: 2 year (33%) (Ahadi and Sepahi, 2013a, b).

A different delay and inflation analysis: In a case where there is a delay in a civil project execution, especially for national scale ones, by mostly-government employers, this is not definitely undesirable having destructive effects. This claim can be verified only when the government, during executing a project, faces a much more important project with higher priority, profit and more socially beneficial, thus reduces financial resources of the current project to start the new project. Although, the delay might cause the current project to be more expensive but often the resulting benefits of the new project are much more than losses in the current project. On the other hand, generally speaking, in managing employer and government project basket (portfolio) discussion, it is necessary to check that whether the losses of stop or delay in the current project are more than the benefits of the new project or not. Using this criterion in portfolio management can prevent a lot of economic losses.

But, if financial resources of the project are supplied by the employer adequately and in time, in other words delay in execution is merely because of technical problems and project management, economic losses, in this case, will be considerable. Another important thing is the difference between economic and accounting approaches. Consider the case where because of passing of time and time value of money, P sum of money invested this year will be equal to P(1+i) money unit next year. Based on engineering economics and according to equilibrium principle, these two sums are equal. But in accounting, the next year's sum is Pi more than the current sum.

In a project which is delayed, whenever all expenses are increased because of time value, interest rate (i) and inflation rate (f), in accounting point of view, total cost is more than the predicted number but the truth is that these costs are increased by apparent interest rate (i_f), the present worth is also calculated using the same rate and according to equilibrium principle, these two expenses are the same, therefore delay in execution of a project does not necessarily result in economic loss.

A delayed project has some lost profit. And it might seem like economic loss at first sight. But, it is necessary to notice that if for example, Miane-Ardebil Railway Project, is constructed in 8 year instead of 5 year construction and 30 year utilization, the utilization period would still be 30 year. Therefore, 3 year delay does not mean losing the profit for 3 year but this profit is delayed for 3 year. It is obvious that considering the 3 year delay, these incomes are increased by $(1+i_f)^3$ and in accounting point of view, the income of the project is increased but again due to equilibrium principle, this delayed income is equal to the initial income. When the economic life of the project ends, reconstructing the project will repeat investment cost, utilization income and, etc. Therefore, delay apparently does not increase any cost or eliminates any income but as we study more, we conclude that two of costs and incomes change economically and must be evaluated and calculated. These two costs and incomes which are the fundamentals of the third model are:

Social benefits of the project during delay time: In a project which is executed with 'd' years delay, direct incomes of the execution period are not eliminated but merely postponed. If a project which is supposed to be exploited for 30 year is repaired or rebuilt after each life time, cargo and passenger profit and social benefits are repeated constantly for eternity. If utilization or direct income is delayed, it can proved that the present worth of these incomes do not change but the society will not experience the social, environmental and fuel and oil saving benefits of the project for 'd' years. Thus, the lost social benefits in 'd' year delay are the first economic loss.

Services, payments, equipment and workshop rent costs in 'd' year delay: Services and labor power payment costs, equipment and workshop rent cost, extension of contracts and permissions cost and so on, are directly related to project execution time and are repeated for delay years. Present worth of these costs should also be calculated and considered as economic loss. It must be noticed that service cost of a project is calculated independently or through α factor:

$$SC = (1-\alpha)\, IC \quad (9)$$

Where:

SC = Service Cost
IC = Investment Cost

Alpha factor is an investment coefficient which can be determined via Eq. 7. It should also be noted that in case of delay, Material Cost (MC) is distributed on the new construction period (n_1+d) and its present worth to which the apparent interest rate is applied, is not much different comparing to the absent delay case.

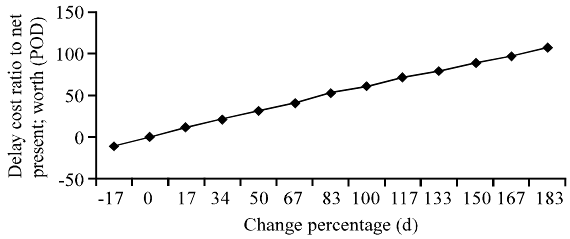

Fig. 3: Delay cost ratio to net present worth of the project (POD) in terms of percent of delay (pd)

Third model; economic evaluation of delay costs in civil projects based on lost social benefits and service cost increase: Based on explanations in study, third model is presented in the following:

$$COD = \Sigma(SB_n + SC_n)(1+i)^n \quad (10)$$

Where:

COD = The Cost due to Delay

Sb_n = The lost Social benefit during 'd' year delay

Sc_n = Services and payments cost during 'd' year delay

In this Eq. 10, n can change from n1 to (n_1+d-1). Result of the third model is interpretable as following:

$$POD = COD/NPV_0 \times 100 \quad (11)$$

Percent of Delay (POD) is equal to the ratio of delay cost to the net present worth of the project absent delay. Changing delay time from zero to 'd' years, COD and POD can be calculated and their tables and graphs can be presented as outputs of the third model.

Figure 3 shows the graph of delay cost ratio to net present worth of the Project (POD) in terms of percent of delay (pd). According to this graph which has a Correlation of 0.9993, the following line equation can be easily derived: 1% change in execution time of the project results in 0.59% decrease in net present worth of the project. If 10 year delay occurs in execution of the project, POD index will be 98% and in the future years, it will surpass 100%. Therefore, we can say that the maximum allowed delay in execution of this project is 9 year.

CONCLUSION

As mentioned above, there is a specific relationship between delay and the costs imposed by delay. In this study, three models are presented to evaluate these costs. The inputs of these models are costs and incomes and cash flow of the project during its life time absent delay. The outputs indicate that 1% change in delay causes how much decrease in net present worth and rate of return. Furthermore, it also shows that how much delay is allowed in this project. In all three models, decrease rate is used to apply time value of money.

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