Investigating the impact of industrial mega-projects life cycle on the changes of strategic key resources in the project critical path

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Abstract

Project as a temporary effort is a function of time, resources and costs and two essential factors of lead time and profitability are the final determinants of success of failure of it. But other factors such as quality and customer satisfaction are also influential in assessing the project.

The common method of industrial engineers in planning and investigation of projects is operational planning. In this method of planning, the activities or work packages are the main core and project constraints (resources, cost, scope and risk) are defined for each project. From this viewpoint there are two essential challenges. First that the resources shall be divided among the activities by a method and second that if the change is intended, it shall be considered for all activities. This difficulty causes specially in mega-projects which are consisted of thousands of activities or work packages, assigning the project constraints to the activities do not happen or it is conducted merely without analysis.

From one hand the large industrial project which are known as mega-projects to have unique behaviors that differentiate them from the projects such as research and development and have behaviors like production projects. This feature enables us to simulate these projects in terms of behavior and performance.

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With regards to the above mentioned points, in this paper the possibility of large project modeling in viewpoint of strategic resources influential in project are investigated.

Keywords: Strategic key resources, Project life cycle, Mega-project, Project critical path.

1- Introduction

Project has a history of more than 4500 years and maybe the Egyptian Pyramids or Mayan temples can be mentioned as the first mega-projects (Rossi, 2003). During the ages with regards to the role and importance of projects in the progress of human society, it has gotten a scientific framework and now there are several standards in this field. Two main features, transform an activity to a project. First it is a single and temporary effort and has specific beginning and end and second it is defined in order to reach certain objective or objectives (PMI, 2012).

If the project is regarded as a system, from the subcontractors' viewpoint, the output is profit which can be tangible such as financial profit or it can be intangible such as good reputation or tangible and intangible together (Sterman, 2000). Various tangible and intangible factors can be regarded as the input of the project. All the inputs and project body shall be in the direction of maximum output of the project. Multiple method in sciences related to project management are present in this regard form with the dynamic analysis of inputs and their impact on the outputs can be effective in maximizing the profit. The main purpose of this paper is presenting a method for maximizing the profit.

2- Project modeling

2-1- Project function

In the case the project is regarded as a mathematical function, this function has six factors in the input which are known as project constraints and scope, time and cost are the three first constraints and resources, risk and quality of project are the second three constraints (PMI, 2013).

$$ProjectRevenue = ProjectFunction(Scope.Time.Cost.Resource.Risk.Quality)$$
(Relation-1)

The output of this function as it was mentioned in the introduction is the project profit. The six constraints are not dependent from each other and for example the resources are a function of the time.

From the six constraints with regards to the temporary and time-dependents of the project, the time can be regarded as the main constrain. When the time is regarded as the main constraint, the concept of dynamics comes to mind. The project critical path which is the series of activities in the longest path in the project and indicated the minimum time for the project (PMI, 2012) changes its meaning with the word "dynamic". (Warren, 2002).

Based on this in the dynamic state the relation 1 is presented as follows:

$$ProjectRevenue/_{dt} = ProjectFunction\left(Scope/_{dt} . Time/_{dt} . Cost/_{dt} . Resource/_{dt} . Risk/_{dt} . Quality/_{dt}\right)$$

(Relation-2)

The output of the above relation is (x, y) → (Time, Revenue). The above equation is in fact the project dynamic equation which shall be investigated with regards to the complexity of mega-projects.

2-2- The necessity and reason for project modeling

In the common industrial projects, when the project is advised from the employer to the contractor, based on the organizational structure of contractor and the contract type, different procedures are employed. Providing the project charter or project management program is from the arbitrary procedures. In contrast provision of scheduled operational program is definitely in the contractors' agenda for all the projects.

The operational program based on the project type and its span is provided for different levels but finally in the last level these programs lead to activities or work packages. Each work package in terms of activity and financial has certain weight against the total weight of the project. Therefore, the providing team of project schedule in the course of providing this schedule which is in the beginning and the first step of the project, shall make relation between the work packages or activities with the mentioned constraints for the project. When the name of mega-project is mentioned it means that the activities are more than several thousands and therefore resource allocation, quality of work of each resource for each activity, projected risks and their impact on the resources influencing the activity and these kinds of issues is very difficult with the micro view to the macro operational planning and it can be said that they are often superficial and unreliable (Li, 1993). From the other hand in the case of change in one of the main resources in the course of the project, employment of this change to a set of activities and the impact extent on each activity is very difficult and with low accuracy. Again it shall be emphasized that mega-projects which sometimes take the form of a portfolio of the projects make this difficulty multiple times harder.

Therefore, it seems that the top-down method leading to the activities is not appropriate for general investigation of project dynamics and its function and makes it impossible to assess the impact of some of the constraints. So for resolving this deficiency in the method of investigation of project function dynamics, the project shall be modeled in terms of strategic resources and constraints (Penrose, 1959). The core of this modeling is not activities but is the strategic resources influencing the project so from this viewpoint the issue shall be entered in the change management and investigating the project dynamics. In this conditions it can be predicted that the impact of constraints change on the project function and its output is easily observable and receivable.

2-3- The method of referencing in mega-projects

Although the project is a temporary and unique effort but for some mega-projects with the purpose of optimizing the costs and reducing the reworks, lower primary investment, reducing the lead time, faster presentation more easily, enhancing the quality and reducing the risk are done similarly and with reference designs (Siemens AG, 2008).

In fact, with this method the project features change from unique to similar and become like production plans.

Acquiring this policy that the projects are conducted typical and similar to a reference plan has an important advantage. In the case that according to the explanations of the previous section the provision of project model is in agenda and is employed in the conditions of the reference project, it is only enough to provide the model with the elements of the project implementation with different structures. In Iran these kind of projects repeat tens of times in the electricity, oil, gas and petrochemical industries. For instance, in the electricity industry of Iran a power plant reference model with the name of project “NYAM” is there with the company of power plant projects management in Iran for engineering, procurement and implementation of combined cycle power plants which in the recent years with annual production of more than 5 thousand megawatt has the third rank in the world. In the oil, gas and petrochemical industry also in the biggest gas field of the world in the Southern Pars in Iran, the defined projects by the Petro Pars company as the project owner is conducted by multiple contractors in various steps but in terms of project generals much of the engineering work is executed alike.

Based on the dynamic attitude in relation to the mega-projects, although it is possible for the primary modeling, but with regards to the repeat of the project it is usable for numerous times and with the valuable output this attitude can be useful in the strategic resources management and finally the output of the project is increasing profitability. In the following in order to investigate this attitude and its outcomes the general model of project “NYAM” from the company of power plant projects management of Iran (MAPNA) is represented for sample.

3- Sample project modeling

There are multiple softwares in relation to modeling the dynamic systems. Among these softwares, AnyLogic software in a powerful one for modeling the dynamic systems. This Russian software with the Java programming capability provides a wide range of facilities for the researcher. From one hand reputable companies such as

Caterpillar, HP, IBM, GM, Panasonic and NASA have used this software for reference modeling therefore the reliability of this software is quite high. From the various versions of the software, the version 7.0.2 is employed in this research.

The purpose of presenting a model for mega-project as sample is giving solution and method for modeling the similar projects by the reader of this article. The mentioned mega-project is in the MAPNA group company in form of engineering, procurement, execution and implementation. This group has project with its own investment and with investments from outside the group and the contracts shall be signed with the groups inside the company. Therefore, with regards to the fact the profitability of the project as the main outcome is intended (according to the relation 1), the first step is to identify the contracts. The main contract between the main contractor with the project owner is called parent contract and the lower contracts also shall be identified. In the software the modeling of contract sums is regarded as the table function in the dynamic modeling section. In this project 10 downstream contract from the main one are in the group.

In the second step each contract shall be modeled separately. IF the contracts have several sections based on the cost breakdown structure, for example engineering and supply contracts it is better that each part is modeled separately and the division by this method is intended.

In the third step each contract shall be divided in terms of the resources. In the engineering contract, from the tangible strategic resources the number of assigned human resource, human resource cost and the general engineering documents can be mentioned and form the intangible strategic resource, the skills of human resource and organizational knowledge can be named. These strategic elements can be connected together with the logical chain. For instance, statistically the average of documented produced by each individual is existent in the MAPNA group engineering companies as the normalizer coefficient in MONENCO company. The cost of each individual for the subsidiary is a function of the person’s experience and can be regarded as a function of producing the engineering documents. As the organizational knowledge and the people’s experience is higher the probability of not approving the engineering documents by the owner’s consultant decreases although the cost of producing the engineering documents increases. In relation to the intangible resources it is proposed that with using the statistical methods as a coefficient between zero and one it will be regarded in the model quantitively.

In the supply contracts also the tangible strategic resources such as the capacity of factory manufacturing and from the intangible resources the political test of customs clearance can be mentioned. The costs shall be regarded in the model completely and be deducted from the income. In the case that all the cost including the product manufacturing costs, transportation and clearance costs are not included in the foreign costs the final analysis has error. Therefore, enough accuracy here is needed. With regards to the different costs of production of equipment the cost breakdown structure rate shall be employed in form of a table function. Another important point in this regards is proper employment of resources in the modeling. The best choice for representation in the equipment is using the source.

In the execution section usually the building and installment costs are separate. Therefore, based on the first and second steps it is suggested that the financial flow of these contracts will be represented separately. In addition to this, separating the models to activity island and set of related activities can prevent the model designer from committing error in the algorithm and modeling logic. From the tangible strategic resources in the building contracts the human resource, machinery and raw material shall be mentioned and from the intangible resources the human resource skills which shows itself in the verification coefficients of building laboratory activities can be mentioned. Form important variables in this section are the work volume and the costs of activities which shall be regarded with correct logic. It is suggested that in cost breakdown structure in fixed price contracts a table function will be employed in order to facilitate the change of values in different conditions of the project.

In the executive contracts for installment, from the tangible resources the work groups, machinery and consuming material and from the intangible resources the rate of equipment non-compliance shall be mentioned. The non-compliance coefficient of equipment can be regarded as engineering or returned building and as a reducer coefficient in the model. The algorithmic relation between the supplied equipment and installed ones can be regarded as well. In the projects which are implantation in the work scope of the contractor, the work group and their cost shall also be included in the model.

As an example some parts of different contracts are presented in the model.

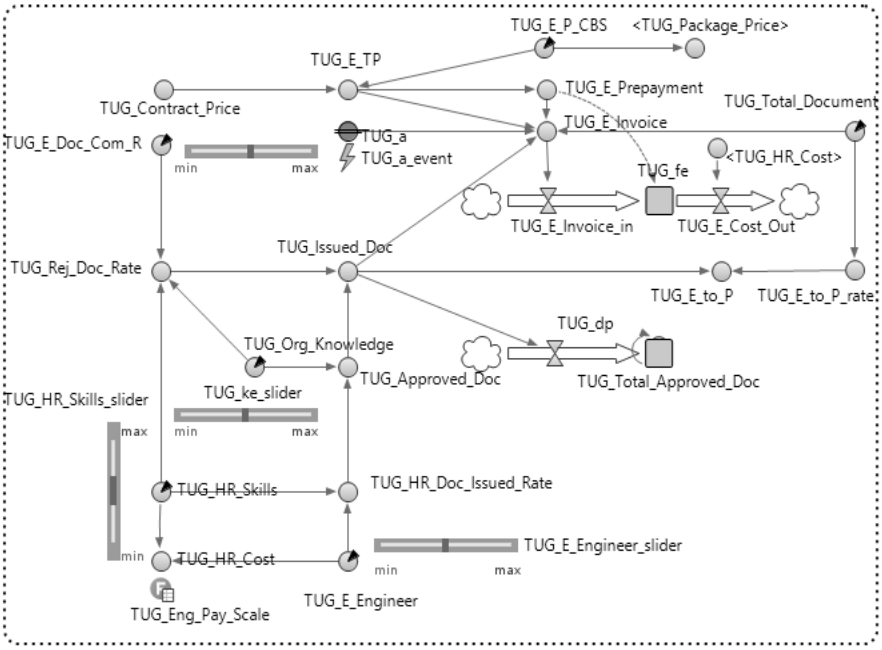


Figure 1-Sample of engineering model

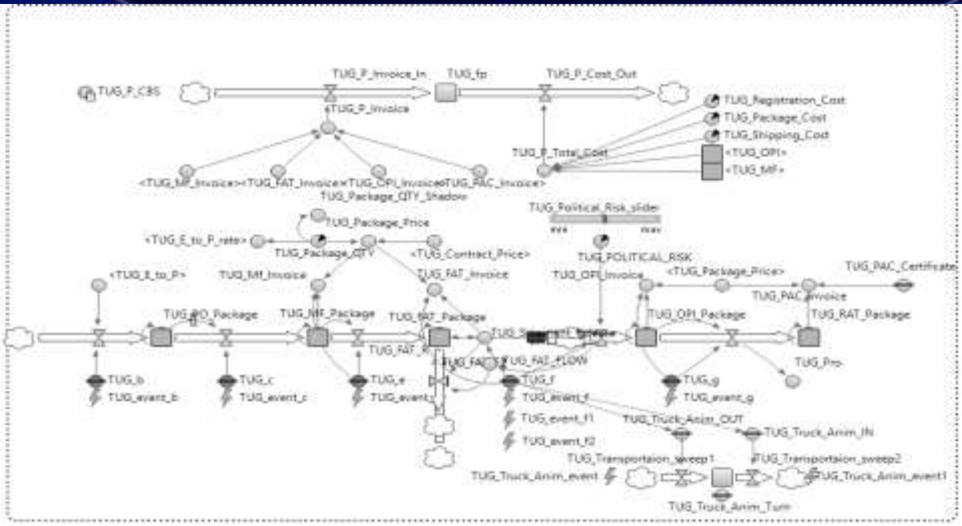


Figure 4-Sample of procurement model

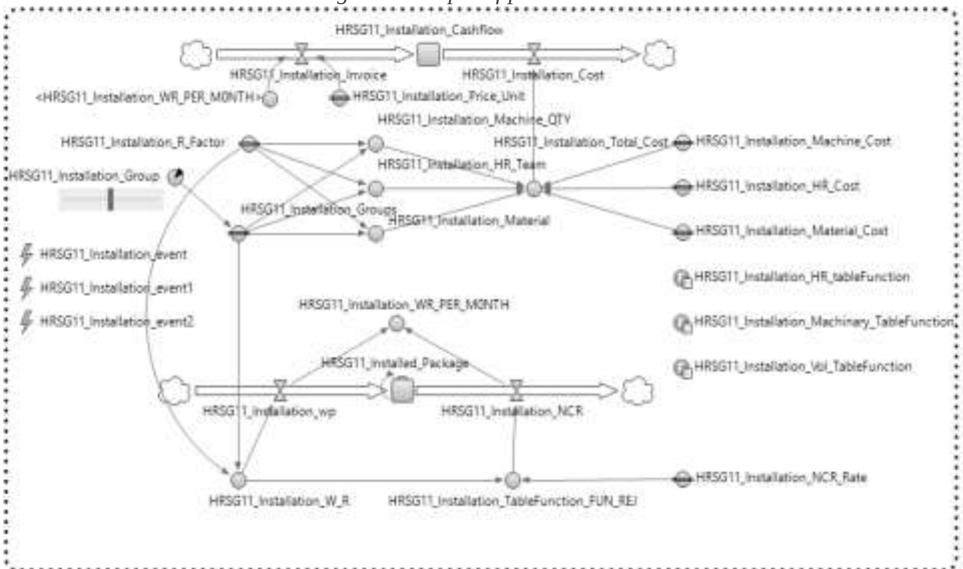


Figure 3- Sample of construction model

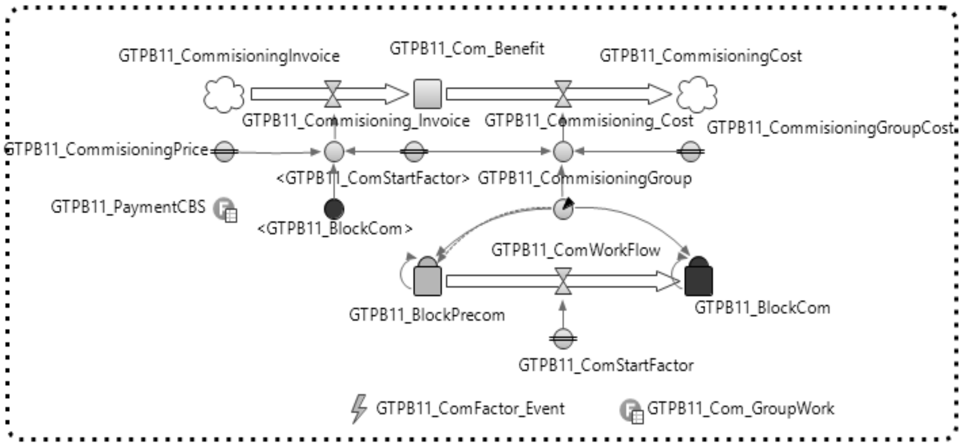


Figure 3-Sample of commisioning model

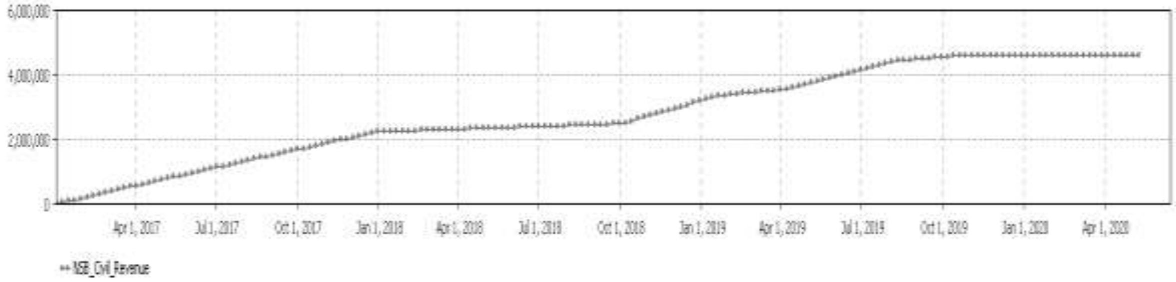
4- Projects model data entry and analysis:

If the provided model has enough accuracy and includes all strategic resources and parameters can be influential on the project. After providing the model the first essential question is the numbering method and getting the outcome from the model. In the response it shall be said that a selected set of mega-projects have the normal conditions that is repeating in the execution. The parameters of these conditions are called normal parameter. From the other hand from the six constrains of the projects including time, scope, cost, quality, risk and resources except the first constraint which is the dynamic concept of the main variable, 5 other constraints can be fluctuating in the contracts in the contractual and normal scope. For example, the rise of project scope for approximate 20 percent decrease of increase is a probable issue. The changes in risk and quality has also probable minimum and maximum. This set of changes create a fluctuating scope that each of them are independent and the combined probability of simultaneous occurrence of the events can determine the analysis conditions. In relation to the selected project also the situation is similar. A table from the probable conditions can be formed and be number in the model and the outcome of each contract is the profit will we compared with the normal state(n). Then in the next step the selected states of each contract are combined and the optimum state is acquired with effort and error.

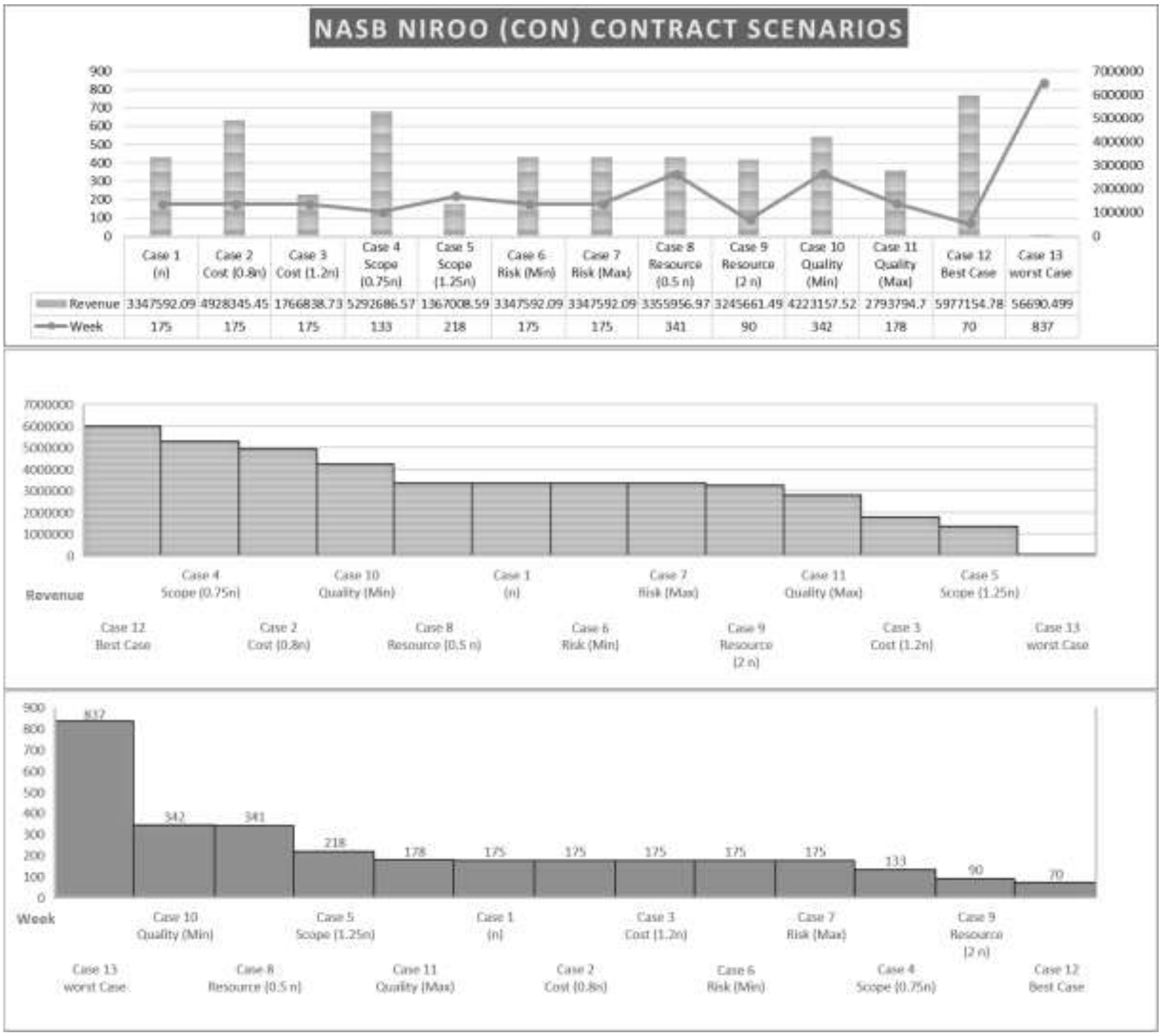
The below table represents the states of the 2 variable and accumulated variable states in relation to the provided model.

Table 1-Probable concoction of variables

5 Variables	2 Variables
Scope, Risk, Resource, Quality→(0.75n, Min, 2n, Max), (n, n, n, n),(1.25n,Max, 0.5n,Max)	Scope→0.75n,n,1.25n
	Risk→Min, n, Max
	Resource→0.5n,n,2n
	Quality→Min, n, Max



Graph 1-Time- Revenue curve of construction contract in one concoction of analysis (Sample)



Graph 2- Probable analysis of construction contract (Sample)

5- Conclusion

In the analysis of the selected model in form of the 14 states of analysis with outcome of 154 diagram of profit to the time form the downstream and parent contracts, 13 comparative diagram are resulted that the significant results in relation to the project are presented:

- Increasing the resources (human resource and machinery) for the parent contract increases the profitability but it decreases the profit of the contractors especially the engineering contracts. Therefore, the project owners expect that the contractors provide more force and equipment in the project site with the same payment that is time profit and financial profit at the same time but does not compensate the contractors' cost. Therefore, based on the common routine the contractors expect that with medium resources they get the maximum profitability and always face the resistance of the contracts for incasing the resources.
- The second subject which is important for the final analysis and is often neglected is the impact of quality on the project. In the general view increasing the quality is regarded time consuming form one hand and from the other hand is considered costly. Based on the engineering contracts model, the quality of engineering documents is function of the human resource skills. Increasing the skills of the engineering force also causes increase in payment. Therefore, in the primary viewpoint the two subjects of increasing time and cost seem right but the results of the model indicate that increasing the quality leads to profitability and decreasing the time in the EP contracts. The main reason for this issue is the decrease of rework. From the other hand this issue has the direct effect on the decrease of non-compliance in the installation time.

The two above results and the extent of their impact on the project are investigated in form of the model with multiple numbering. The other several items are concluded from this analysis method that is not possible to present them in the concise structure of this paper. At the end it shall be mentioned again that using this method in the repeatable mega-projects leads to utilizing the valuable tool for resource management, in the replan enhancement of project operational programs and for maximum profitability of the project through intelligent management.

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