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A Systems Dynamics Model for Project Management systems of Project-Based Organization

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Abstract

This study aimed to determine the relation between quantum management skills and It is obvious that the success of a project-based organization is dependent on its projects. A variety of tools such as the project excellence model, project management maturity models, the earned value method, have been developed in this regard, but there are still delays in projects because the projects have dynamic nature with non-linear relationships and feedback processes during the project life cycle. In this paper, we study the factors affecting the project management system in a project-based organization through system dynamics methodology and investigate the causal relations between them as well as the average cost and time variation of organizational projects during the time period. According to the analyses, the increase in each of the project quality or human resource efficiency is insufficient by raising the level of project management maturity or leadership maturity, but their concurrent increase and created synergy have a significant impact on the cost and time variation control. Furthermore, this research is contrary to the public perceptions under which the progress of projects depends on their funding. It is probably due to the maturity level of project management and the maturity of its leadership who takes measures for better management of costs and delays

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Introduction

Projects always have complex and dynamic factors and consist of feedback processes and non-linear relationships. Despite the fact that the problems of project implementation are essentially dynamic, they have been statically considered as the parts of the project. According to the obtained results, the schedule delays and additional costs in the project have become normal and usual despite the advances in project management techniques (Park M. a.-M., 2003). The network-based tools such as the critical path method, program review and evaluation technique, Earned Value method, and project management maturity models have been widely in the management of constructional and industrial projects. Although these tools may create the unrealistic estimations for users due to the application of static approach, they reject the non-linear relationships and multiple processes and ignore encountering them because of their inability (Flood, 2003). According to recent studies, more than 50 percent of large projects cannot achieve their goals in terms of cost and time. However, other studies indicate that the variatin of 40% to 200% is common (Invotan, 1996). Delays and then changes in program forces the project manager to manage the project in a dynamic space. Despite the fact that the traditional tools are seeking to combine the dynamics of the project with the initial program through the reception of new data and program variation, they cannot encourage the managers to analyze the feedback loops which play the project dynamics roles.

One of the predictive approaches in dynamic systems is the use of computer simulation systems. (Shakibayifar, Hassannayebi, & Mirzahossein, 2018) It has become a widely recognized and flexible cause and effect methodology for modeling and simulating the dynamic environment of projects via the analysis of delay and disruption in the system [(Gholizad, Ahmadi, & Hassannayebi, 2017). SD modeling approach is capable of analyzing the rework and error feedback loops involved in projects (Sayyadi & Awasthi, 2017)].

According to this discussion, the traditional tools of project management and planning are not trivial, but the system dynamics should complete the project interaction with the organization and the environment as a complementary tool for traditional methods of project scheduling and management. Traditional tools are appropriate for dealing with combined complexity of complex projects including the multiple parallel activities, but the system dynamics is useful for dealing with dynamic complexity which is caused by interdependencies, feedback, time delay, and nonlinearities in large projects (Ford D. J., 2007). This research aims at investigating the project management system dynamics in a project-based organization in order to study the non-linear relationships and interaction of organizational factors affecting the project and their dynamics during the studied period.

The first project management model was introduced by Roberts in 1964 and he examined the basic dynamics of research and development projects and introduced the concepts of perceived progress and real progress for the first time. Cooper's developed model in Pav-Roberts Company in 1980 was the first important practical application of system dynamics in project management. Ford, Lyneis (Ford D. J., 2007) have studied the minimization of costs in project management, and Lyneis and Ford (Lyneis, 2007.)have investigated the dynamic project management model and reviewed the conducted studies in this field and have concluded that three basic measures, which are taken to improve the real performance gap by prediction in most of the models, are as follows: 1) Employment of additional labor, 2) working overtime, 3) speeding up the works.

Bishwas (Bishwas, 2011)described the key issues in the growth and success of the organization through system dynamics modeling. Howick (Howick, 2003)has investigated the delay and stop project modeling based on the system dynamics approach and suggested that this approach is able to model the systems associated with project management and analysis of delay in implementation of projects. Yaghootkar and Gil (Yaghootkar, 2012)have modeled the project management system with regard to the shared resources for various projects and based on the system dynamics method.

Despite the importance of projects and numerous studies in this field, there are a few projects with full success; and the projects usually fail partially or completely. According to a research conducted on 365 companies, the main causes of project failure are studied and three key factors are mentioned for project failure as follows:

1. Poor communication
2. Poor project management processes
3. the Improper structure of project team which are more important than any other factors.

All mentioned items analyze the project dynamics and investigate its key factors, but they have not studied the roles of organizational factors such as the leadership, project management maturity level, and the interaction of key factors in the project-based organizations from the perspective of system dynamics. In this research, we utilize the previous research on the determination of key factors and causal model of organization and investigate the individual and simultaneous changes in key variables over time through system dynamics method. It has been proved today that other linear and unilateral approaches are not efficient and that it is necessary to have a dynamic simulation tool for understanding the complexity of the systems [(Olafsdottir, Sverdrup , & Stefansson, 2019;26(2))].

Material and methods

Research methodology is based on the overall step of system dynamics approach. The system dynamics was introduced by Jay W. Forrester from Massachusetts Institute of Technology (MIT). System dynamics method has an ability to model various aspects of the issue and is considered as an effective method in the analysis of system and issues through computer simulation and helps to understand complex systems. Different scenarios can be evaluated by the help of this approach through the systemic vision. There are some applications of this methodology in complex problem modeling such as mobile banking adoption simulation (Abbasi, 2016), Banking Risk Management (Bastan M. M., 2016), Sustainable Development (Bastan M. e., 2016), Organizational Demographics (Akbarpour, 2016).

(Shafieezadeh & Kalantar, 2019) showed that The result of the SD model demonstrates its capability to control the disruptive effects of changes, reworks and errors on time and cost performance indicators. According to the obtained results it can be seen that the predictive change management poli- cies in large projects have a significant role and can have a positive or negative effect on the success of the project.

This approach provides the opportunity for the decision maker to test his proposed solutions in simulation model before application in the actual system and study its consequences in the long term. The problem solution is performed through system dynamics methodology at five stages:

1. Identification and definition of problem
2. Drawing the causal diagrams
3. Construction of mathematical model (Stock and flow)

4. Simulation and validation of model
5. Definition of different scenarios; evaluation, selection, and implementation of appropriate solution

Model Dynamic Hypothesis and Causal Model

In project-based specialized parent organizations, the levels of relationship between parent organization as the employer with executives, and the amount of delegated authority for them in performing the projects, and the internal structures of work, and financial and strategic controls play significant roles in efficiency of executive organizations and timely implementation of projects within the framework of target objectives. The types of relations and methods of parent organization evaluation and control are among the key factors in this regard. The implementation of a project is usually evaluated based on four factors namely the time, cost, quality and scope of the project. This evaluation is based on the difference between these factors from their planned value. The organization and project management take efforts to reduce to minimize the differences. To do this, there are two solutions: 1- Increasing the performance level, for instance, through overtime working, 2- Reducing the desired value and objectives of the project (change in scope). The above-mentioned can be achieved through control loops (Figure 1). The project implementation process can be accelerated by increasing the resources, overtime working, or increasing the working hours and workload schedule on staff, but this speed should not be at the expense of its quality.

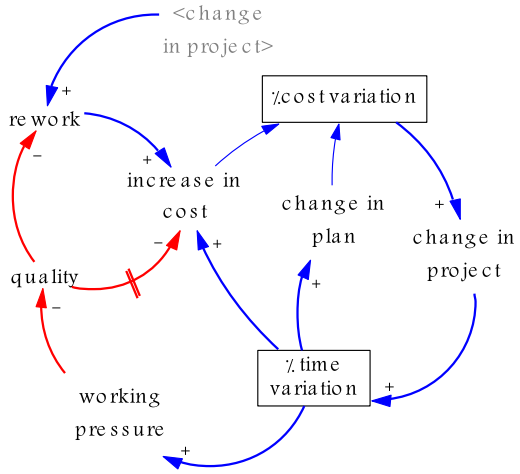

Figure 1. Causal loop of project reworks

The outcome of projects is important for project managers and also the faculty members and managers in the organizations. The outcome of each project is manifested in three key factors namely the project cost, quality and it's time variation from which the time variation and project costs are the most important factors and have been always taken into account by managers in their reports. The quality product can be ensured through the establishment and precise control of quality assurance system because, in the case of low quality, its result will be manifested in defined tests during the project life. Therefore, we can determine the time and cost variation of projects in target model by the relative

confidence of state variables. Therefore, the state variables of our dynamic model in this regard include the project time and cost variations which are presented in Percentage.

Stock and flow Model

We first analyze the dynamics of changes in project management system in order to achieve a full project management model. Any changes within the project scope will lead to changes in the overall project, and this affects the changes in the project schedule. The increased changes in project scheduling will lead to the increase in costs and rework in addition to increased changes in the project process. This, in turn, will increase the costs and variation in the overall cost of projects, and it will change the project portfolio in the case of too much variation.

The organizational project management maturity affects the stability of scope and also the project planning in addition to the quality of activities in projects. The more the organizational project management maturity is increased, the more the projects are stable in planning and range of activities and goals and are qualified in performing the activities and output of the project. On the other hand, the low project management maturity will lead to too much variation in project cost and time because the instability and low quality of activities and project deliverables are the factors which intensify the changes in projects and rework, and thus increase the project cost and time variation. Figures 4 and 5 show the flow charts of model by adding the project management maturity factor to the previous model and its results in time and cost variation of organizational projects.

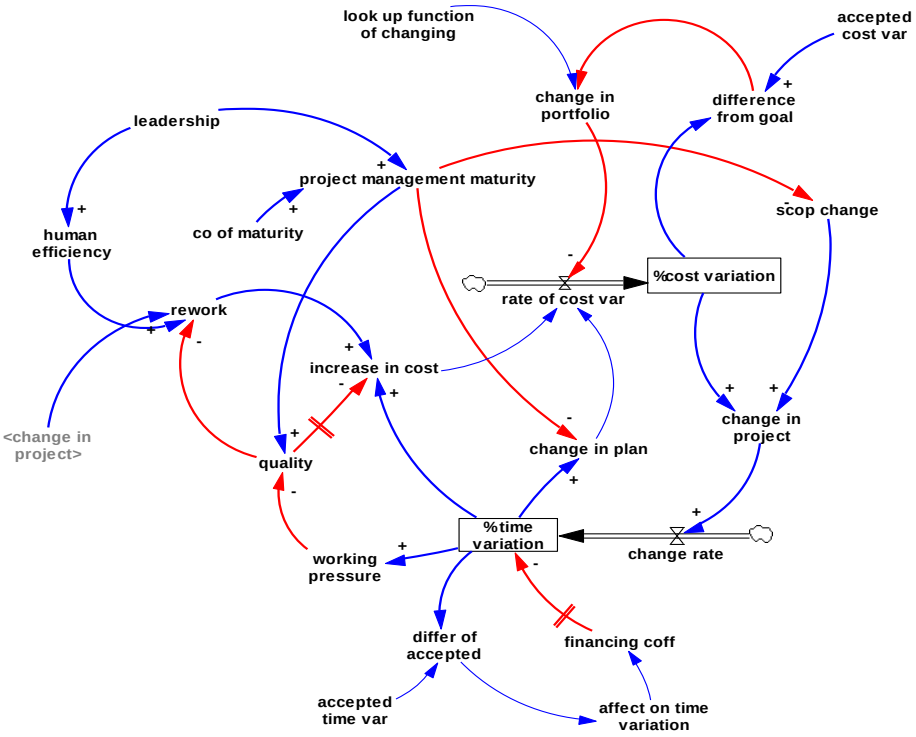

Figure 2. Stock and Flow Model

Validation analysis

Befor scenario designing and simulation the result of model must be qualified and we must be sure of validity. For this purpose We compare the result of model to historicl data. We use three hypothsis tests in spss and the result shows that they fits in 95% confidence level :

Equality of mean test

Good of fitness test

F test for equality of variation

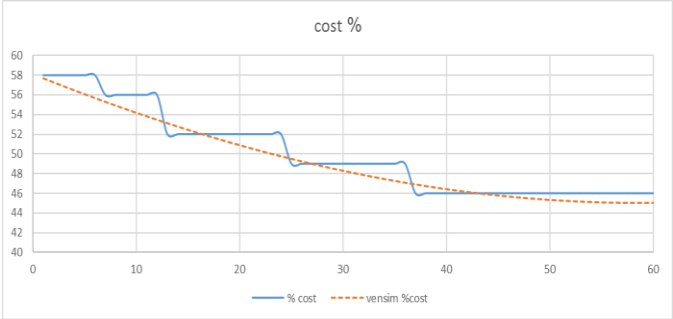

Figure 2- compare of cost variation

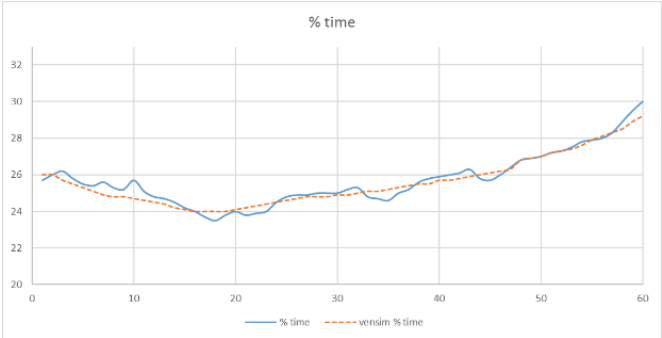

Figure 3- compare of time variation

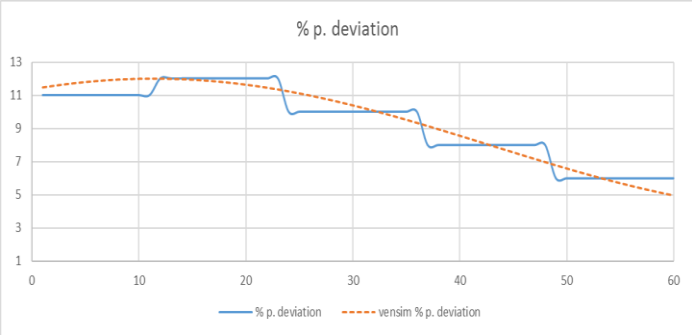

Figure 4- compre of change in projects

Scenario Making and Simulation

Scenario 1: Continuation of the current status: The current situation of the organization is studied in the first scenario, and then the time and cost variation charts of organizational projects are drawn according to the continued current trend. In this case, the time and

cost variations are above the acceptable levels, and thus the cost and time of projects will be dramatically increased.

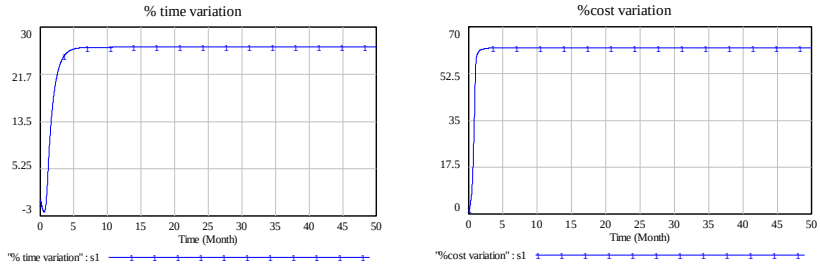

Figure 3- Cost and time variation in Scenario 1 (S1)

Scenario 2: Increase in the quality by increasing the project management maturity: in this scenario, we attempt to increase the Organizational Project Management Maturity and measures its changes over time based on the variations. Therefore, the variation is reduced in this case, but it is not favorable and is above the acceptable level.

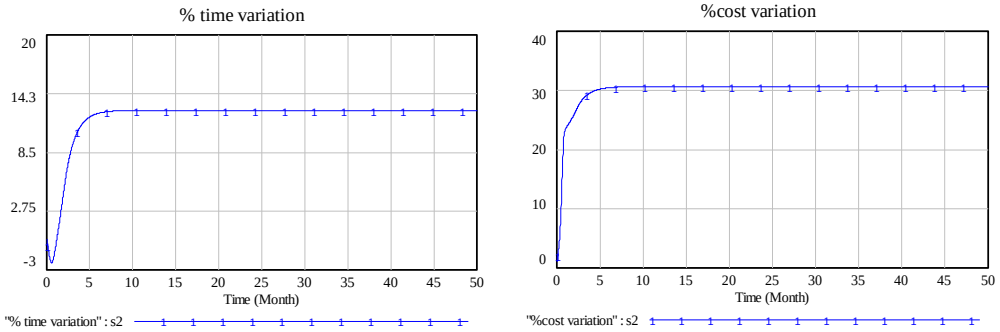

Figure 4. Cost and time variation in Scenario 2 (S2)

Scenario 3: Increase in human resources efficiency and reduction of rework: The increased in human resources efficiency through increased job satisfaction is another method for increasing the efficiency in the organizations and it is as determining factor. In this scenario, we have only studied the increase in this factor according to other factors and then investigated its results in a reduction of variation

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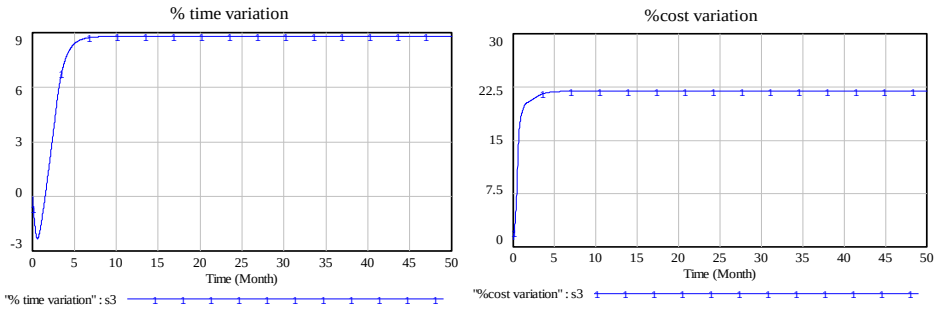

Figure 5- Cost and time variation in Scenario 3 (S3)

Scenario 4: Concurrent increase in human resource satisfaction and job quality: In this case, we analyze the variation through the implementation of concurrent programs which focus on increasing the job satisfaction and quality. In other words, we analyze the concurrent implementation of scenarios 2 and 3 in this section, and thus we achieve the additional results and reduction in the variation.

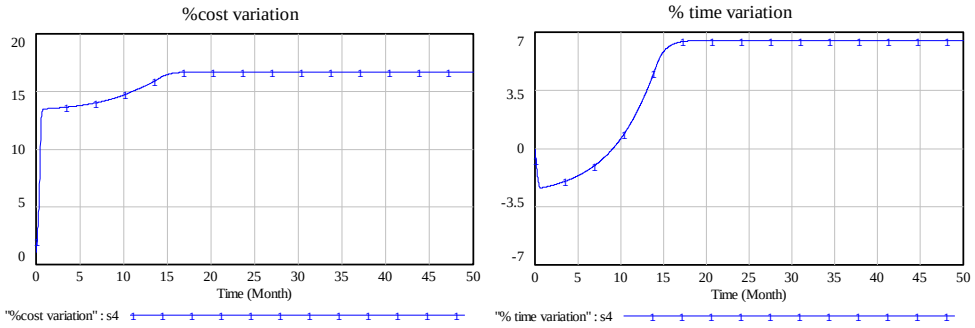

Figure 6- Cost and time variation in Scenario 4 (S4)

Scenario 5: of sensitivity Analysis to funding rate: The changes in cost and time variations of projects are separately shown in a chart according to the constant or increased rates of financial sources in the project. In these charts, the Scenario 4 (S4) refers to data of S4 as previously mentioned; and S5, S6, and S7 are the Scenarios with an increase in funding rates and constant other factors in S4. It is observed that there are not any significant changes in increased cost and time variations.

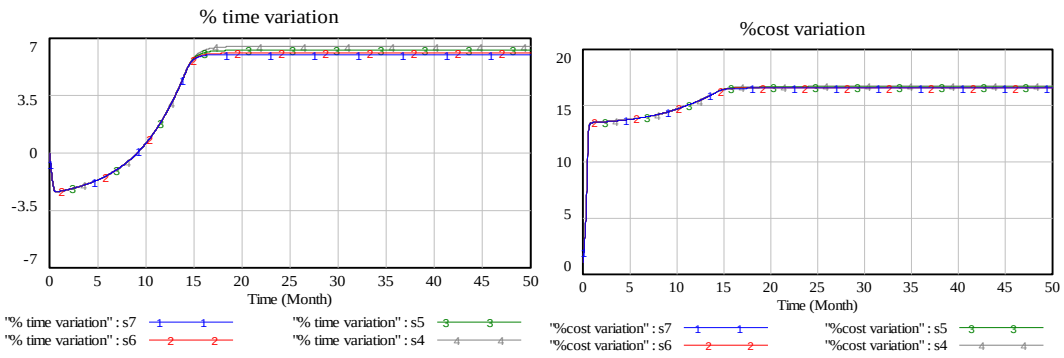

Figure 7- Cost and time variation in Scenario 5 (S5)

Analyses shows that, there is a less impact of funding rate under favorable conditions for other parameters. In other words, the less time and cost variations occur due to the maturity of project management level as well as the leadership level and its interaction with subsidiaries. This is probably due to the project management maturity level in better management of costs and also the high level of leadership tasks in the organization as he prevents the financial and cost variation of organizational sources. However, if these cases are not ideal, the system sensitivity to funding will be significantly increased, and thus the progress of projects will be largely depended on funding.

According to the charts of different scenarios, the cost and time variations remain constant after the increased time due to the activated control loops; and these conditions are preserved in various scenarios. Furthermore, both these variations are increasing in the first months of modeling due to the existence of primary conditions and inactivated control conditions for time and cost variations. This increase will be activated for cost variation in different scenarios from the seventh to fifteenth months. The concurrent advent of balance conditions in time and cost variations of different scenarios is another reason for model creditability. For instance, the balance mode of time of cost starts from the eighth month for the second scenario; but it starts from the 15th months in the fourth scenario, and this concurrence indicates the dependence of time and cost variations in the model as it is the same as the real world

Results and Conclusion

In this research, we first introduced the project-based organization and then identified the key factors in success and excellence of the organization. Afterward, we analyzed the effect and cause diagram for these factors in project management system dynamics model of organization, and drew the chart of the model and mentioned the relevant equations based on the types of relationships between the variables. Four different scenarios were analyzed for the model and it was found that the mere increase in quality or human resource efficiency through increasing the project management maturity or leadership maturity was insufficient, but their concurrent increase and created synergy had a significant effect on controlling the cost and time variations. Furthermore, contrary to the public who consider the project progress dependent on its funding, the scenarios 5, 6 and 7

and their comparison with scenario 4 indicate that it will not have any significant effect on controlling the time and cost variations of projects. The possible factors and risk can be included in the model in order to complete the model, and thus the simulation results will become more complete. This is suggested as the subject for future studies.we conclude from the scenario analysis that we must plan and axecute two or more program simultaneously to enhance maturity of project management get better reslt of project management system.

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