

System Dynamics in The Management of Power Plant EPC Projects

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Abstract- Project management is a unique discipline with its own tools and techniques such as WBS, Gantt, PERT/CPM and etc. However, because these tools inherently use a static approach, they may provide users with unrealistic estimates and may also ignore the feedback processes and nonlinear relationships of a project or the challenge of today's dynamic projects. The purpose of this article is to coordinate and improve the quality in project management for project-oriented companies in the power plant industry. Also, this research focuses on EPC power plant projects, but the model is ready for implement in other industries with minor modifications. Relationships in EPC projects are complex and dynamic in nature. As a result, a stronger understanding of their dynamics facilitates their management and creates a source of competitive advantage. In addition, the dynamics of relationships can create effective management philosophies and principles to achieve organizational benefits. This research provides a comprehensive and integrated model for managing power plant projects using different management functions. Dynamic hypotheses were developed through interviews with experts and field specialists. After that, a simulated model was formulated using system dynamics modeling. The model was quantitatively and qualitatively validated using a real project. Finally, several policies were examined through extensive simulation to analyze their effects.

Keywords- project management, simulation, system dynamics, Vensim

Introduction

Many competitive factors such as competition, fragmented markets and diverse and changing technologies make great companies, including companies related to power plant affairs, consider improving project management as a necessity in this competition. These factors have increased the complexity and uncertainty of projects. Project management processes and organizations that were created for relatively stable, long-term markets and technology-based competition are often no longer able to survive in this competition. Therefore, improving the performance of projects is not simple. The problems of societies and organizations are becoming more complex day by day and solving them requires better thinking. There are many cases where the efforts of managers and officials to solve a problem only alleviated it, and after a short period of time, the situation returned to the same or led to the creation of bigger and worse problems (Nayini, 2007). In the last decade, the trend of uncertainty in projects has been increasing and all internal and external factors have been dynamic and relatively unstable. Changes that occur during a project may have significant and often unpredictable effects on the organization and its management. In these cases, changes are essentially unplanned disturbances that disrupt work progress and can have a very negative impact on the project

management system. Project managers do their utmost to achieve the goals of the stakeholders and prevent deviations in the projects; However, completion of the project, the errors that were made earlier are discovered and expensive rework, overtime, schedule slippage or reduction in the quality of the project occur. Therefore, project managers must react appropriately to "change" and understand how changes can affect the behavior of the project system (Khosravi & Samsami, 2015). Then changes can be effectively managed. For example, project-oriented organizations consist of team members from different organizations that form a single project at different times to form a multi-purpose organization temporarily or ephemerally. Relationships between team members are formalized by contract but often supplemented and adjusted to cope with unforeseen problems by informal understandings and protocols that have evolved over time. Several studies have identified these uncertainties. The nature of relationships in the project team is one of those that is uncertain about its characteristics. Many unpredictable effects and uncertainties arise very quickly during the project life cycle and lead project to delays and additional costs (Khosravi & Samsami, 2015). The characteristics and effects of static or review on one or two dimensions of project dimensions have been widely researched in project management. On the other hand, project

management is effectively with dynamic elements of project structures and considering more dimensions, less understood and used and applied in project management. Dynamic features include feedback systems, time delays, and nonlinear cause-and-effect relationships between variables. These features combine to make project systems behave in complex ways, which are difficult to understand and predict and they are difficult to manage. System dynamics modeling is based on cause and effect relationships. These cause and effect relationships continuously interact when running the model on the computer and simulate the dynamic interactions of a system. The most powerful feature of system dynamics modeling is realized when several cause and effect relationships are connected and a circular relationship, which is known as a feedback loop. The feedback loop concept shows that each actor in a system is ultimately affected by its performance (Khosravi & Samsami, 2015). In this paper, project management is investigated using the simulation method (system dynamics) and we seek to answer the question whether there is a relationship between the use of systems thinking and system dynamics in solving problems that arise during power plant projects. There is a simple model to express the dynamics of the system and analyze using this approach. Finally, after describing the structure of the model, it is simulated with the help of Vensim software.

Theoretical framework and research background

Theoretical background

The problems of human societies and organizations is becoming more complex day by day and their solution requires better thinking. There are many cases where the efforts of managers and officials to solve a problem only alleviated it, and after a short period of time, the situation returned to the same as before or led to the creation of bigger and worse problems. The problems of cost and time in projects have been persisting for decades, despite numerous advances in the field of project management. In the 1950s, static modeling approaches such as PERT and CPM critical path method were developed. These methods have grown with the addition of probabilistic parameter estimates and integration with resource assessments. Despite these advances in tools and techniques, projects often fail (Nayini, 2007). Some experts believe that the reason for the failure of projects is that, despite those projects are basically complex dynamic systems, many project management concepts and tools look at the project statically, or provide an incomplete and limited view to managers, which often leads to Managers' mental modeling is necessary to overcome

the complexity. Static modeling approaches determine how a change in the time required to complete a step, such as engineering drawing, may affect the total time to complete a project, but the analyst can adjust the schedule by changing the time. Re-estimate the requirement for the small number of individual steps directly affected by the change and re-calculate the critical path and time required for completion. Of course, the implicit assumption is that the time which required to perform all other steps remains unchanged, and it means that all other interactions are ignored. Therefore, many issues and problems that arise during the project are caused by unforeseen effects of past performance. Also, often all these policies that are used to solve important issues fail and cause wrong solutions or new issues and problems (Bazazian, 2011). A complex system includes several interactive feedback processes. Feedback processes are essential elements in the dynamics of managerial, technical and other systems. Traditional methods of time and cost planning, such as the critical path method, do not adequately consider feedback effects. Unless a project manager or an analyst anticipates all these feedbacks and interactions and changes, the critical path method will often significantly underestimate the impact of changes (Nayini, 2007). In general, classical approaches consider the project as a set of consecutive or parallel works that must be done at a certain cost and in a certain time. Therefore, they make detailed plans for all the steps and try to control and implement the plans with various tools. On the other hand, project management is one of the successful applications of SD. This approach provides a holistic view of the project by explaining the role of project variables and examining their effects. In this way, it tries to provide effective management strategies in different situations (Shahrabi Farahani, 2013). System dynamics is a simulation method that helps to understand problems in complex and dynamic systems by modeling. As mentioned, the main application of the system dynamics method is to find and show the feedback processes, with the structures of stock and flow and time delays, determine the dynamic behavior of the system (Nasirzadeh, 2011). Stocks and flows are the main variables of the SD method and show the interaction between the variables in the complex system. The values of the inputs are definite in the SD method, while in the traditional method they are considered probabilistically and with the information in the database. When a complex system is modeled, the system dynamics method can be used at higher and strategic levels, considering that it has a more detailed

look, at the interactions between different variables of the system. This method can show interactions qualitatively and is closely related to problem solving structure and impact diagrams. In contrast, the discrete event simulation method is mainly used at the operational levels to solve specific problems such as optimization or increasing the productivity of the user process (Moradi, 2011). Foster believes that systems dynamics is a set of conceptual tools that give us the ability to understand the structure and dynamics of complex systems, and finally, with accurate modeling and computer simulation, they will be able to design more effective policies. Given the dynamic nature of project problems, it is not surprising that SD has been used to understand and improve the behavior of complex projects.

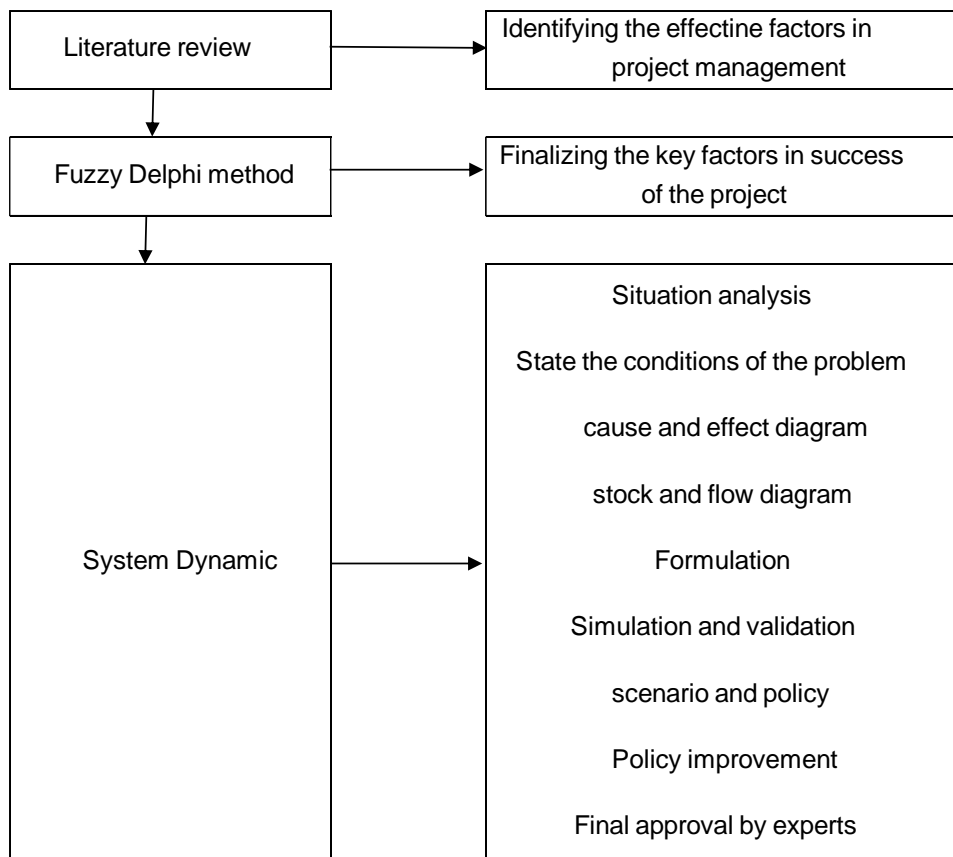
Experimental background

(Xu, X., & Zou, 2021, 17-31) in their research, addressed the analytical modeling approach of system dynamics for the management of construction projects. The findings showed that SD is effective in a wide range of research topics including (1) sustainable construction, (2) design error, rework and change management, (3) risk management, (4) resource management, (5) decision making, (6) hybrid modeling, (7) safety management and (8) effective performance. (Shafieezadeh, Hormozi, Nayebi, Soleymani & Gholizad, 2020, 201-216) in their paper addressed a system dynamics simulation model to evaluate project planning policies. The results of research showed that resource allocation can be optimized to improve project performance indicators. The developed decision model can be considered as a flexible and predictive tool in the construction industry with the aim of explaining the dynamic behavior of a project. (Ecem Yildiz, Dikmen & Talat Birgonul, 2020) stated in a research that dynamic systems can be used to improve strategic decision-making by evaluating the impact of strategies on performance measures under different scenarios, taking into account changes in internal processes as well as conditions. The research results showed that SD models have certain advantages, the problems of generalization, validity may limit their application to a significant extent and leave for further improvements. (Kim, Chang & Castro-Lacouture, 2020) in research called dynamic modeling to analyze the effects of

skilled labor shortage on construction project management, they created five scenarios to simulate construction project shortages and behaviors, and in the suggestions section they stated that the applicability of this model should be investigated in the future through testing and adjusting different cases to adapt the different conditions presented by the construction industry. (Nasir & Hadikusumo, 2019) in research entitled System Dynamics Model in contractual relations between owner and contractor in construction projects, several individual policies and various combinations through extensive simulation to analyze their effects on the dynamics of the relationship. The results showed that, in general, combining policies produced better results than individual policies, and future research can be extended to analyze the evolution of O/C relationships by combining the interactions of activities in both preconstruction and construction phases. Due to the unique nature of the construction industry, future studies could also be based on other types of construction projects and different methods. (Franco, Guzmán Cortés & González Rodríguez, 2020) in a study of collaborative logistics strategies with system dynamics and project management and stated that the system is defined by identifying the network of activities, actors and resources and a definition of logistics strategy with They provided some definitions of project management. It is determined using a dynamic model that integrates network activities of the system and the supply chain to determine possible impacts. Future research could use optimization models to select beneficiaries and the type of assistance and resources needed to minimize operation costs. Consider the project. (Etemadinia & Tavakolan, 2021, 93-112) The use of hybrid system dynamics and interpretive structural modeling for risk analysis in the design phase of construction projects was investigated and they came to the conclusion that considering related structures and overall risk of the project can help managers to accurately estimate project goals such as cost and completion time. They also suggested that this approach be applied to modeling the interfaces of different phases of a construction project such as design, procurement, construction, operation, etc.

Conceptual Model

Figure 1. Research conceptual model



Methodology

Purpose of research

The purpose of the current research is to determine the appropriate scenarios for the improvement and development of project management based on system dynamics in power plant projects that are carried out as EPC project.

Research tools

In this research, a questionnaire was used as a research tool and provided to the experts. It should be noted that in the process of conducting the present research, first by studying the literature related to each variable, and the literature on the formation of project management, a model has been selected for the research variables, since the model used in this research is system dynamics, after extracting the cause and effect diagram, the model was reviewed by industry and university experts and approved after modification, the required information was obtained from interviews with experts and library study of available statistics and documents, and finally, the outputs of Vensim software were approved by experts.

Research Methodology:

The current research is practical and seeks to discover new knowledge that has a specific affect in this

process. Also, the current research is considered a "cross-sectional" type of research since it examines data related to a period of time. The method used in this research is analytical survey. In order to collect combination of information, library and research methods have been used. The library method will be used to study the literature of the subject and review the research history. Then, with other methods, information and surveys are collected, and finally, the necessary checks are done with the help of Vensim software. In this research, by determining the variables as well as the relationships between them and presenting a conceptual model, some dimensions of factors affecting the management of power plant EPC projects have been identified, which can clarify the causes of the problems in it.

Variables

In this research, by reviewing the studies conducted in the field of project management, it has been tried to include the variables considered in these studies in the questionnaire, which gives a relatively comprehensive coverage to the effective factors.

The most important limitation in identifying as many variables as possible in the management of power plant EPC projects is related to the inadequacy of the studies conducted in this field. Therefore, this research is in the field of applying previous experiences and modeling factors affecting the

management of power plant EPC projects. Therefore, reaching the results can help improving the efficiency and management by using modeling techniques and the organizing them by the researcher.

As it was mentioned, the examination and use of the most important variables that were discussed in previous studies and the use of the fuzzy Delphi method have helped to design the conceptual model of the formation of power plant EPC project management. The different dimensions used in this model are in accordance with the subject literature

and expert's opinion. Considering the system dynamics model and the fact that this model is a set of independent and dependent variables, the variables of this research were extracted from the research literature and expert's opinions through the fuzzy Delphi process. The variables and indicators of project management include: risk, quality, supervision, cooperation, conflict, communication, plans and strategies of the organization, and other variables make a relationship between these indicators.

Table 1. The average of expert's opinion

variable	expert 1	expert 2	expert 3	expert 4	expert 5	expert 6	expert 7	expert 8	L	M	U	FAVE
risk	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.75 و 1)	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	0.53125	0.78125	0.9375	0.75
chart	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	0.15625	0.40625	0.71875	0.427083333
resource	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	0.125	0.375	0.625	0.375
quality	(0.75 و 1)	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	0.59375	0.84375	0.96875	0.802083333
supervision	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	0.5625	0.8125	0.96875	0.78125
integration	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	0.09375	0.34375	0.59375	0.34375
scope	(0 و 0.25)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	0.0625	0.28125	0.53125	0.291666667
cooperation	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.75 و 1)	(0.75 و 1)	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	0.65625	0.90625	1	0.854166667
conflict	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	(0.75 و 1)	0.5	0.75	0.9375	0.729166667
time schedule	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	0.125	0.375	0.625	0.375
communication	(0.5 و 0.75)	(0.75 و 1)	(0.75 و 1)	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	(0.5 و 0.75)	(0.75 و 1)	0.625	0.875	1	0.833333333
planning	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	0.21875	0.46875	0.71875	0.46875

Table 2. The difference in opinion of experts in the first and second stage

variable	expert 1	expert 2	expert 3	expert 4	expert 5	expert 6	expert 7	expert 8
risk	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.75 و 1)	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)
chart	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)
resource	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)
quality	(0.75 و 1)	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)
supervision	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)
integration	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)
scope	(0 و 0.25)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)
cooperation	(0.75 و 1)	(0.5 و 0.75)	(0.75 و 1)	(0.75 و 1)	(0.75 و 1)	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)
conflict	(0.25 و 0.5 و 0.75)	(0.5 و 0.75)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	(0.75 و 1)
time schedule	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)
communication	(0.5 و 0.75)	(0.75 و 1)	(0.75 و 1)	(0.75 و 1)	(0.5 و 0.75)	(0.5 و 0.75)	(0.5 و 0.75)	(0.75 و 1)
planning	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0 و 0.25 و 0.5)	(0.25 و 0.5 و 0.75)	(0 و 0.25 و 0.5)	(0.5 و 0.75)	(0.25 و 0.5 و 0.75)

Data analysis
A causal loop diagram

A causal diagram is a tool for showing causal relationships within a system, which is divided into two general types: reinforcing loops and balancing loops. Reinforcing loops are positive feedback systems that keep pace with initial change. Balancing

loops, contrary to the behavior of reinforcing loops, will take opposite to the initial change.

In the following figures, the cause and effect loops related to the proposed dynamic hypotheses are presented.

According to Figure 2, it can be seen that the rate of access to raw materials and technology decreases with the increase of sanctions. Limited choices lead to

a decrease in management ability, and with a decrease in management ability, communication and planning also decrease. The reduction of these variables has caused the project to become more complex, and due to the increase in complexity, the fields of implementing the necessary standards to increase the quality have been lost, and as a result, the security variable is also reduced.

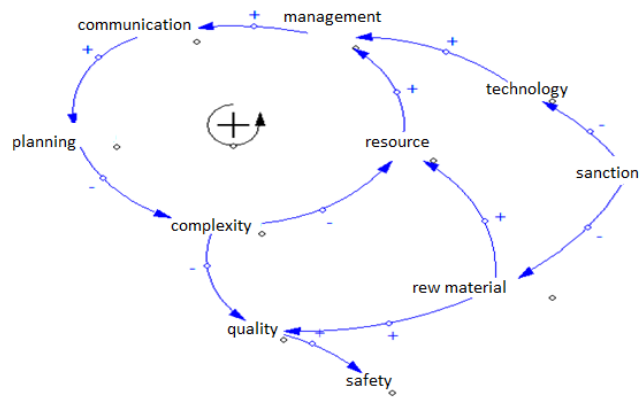


Figure 2. Causal loop -the effect of sanctions on project security

As seen in Figure 3, any action that reduces the risk of the project, reduces the complexity of the project and thus increases the quality and security. The variables that reduce project risk include supervision and cooperation. By improving the level of cooperation

among the project elements, the time and cost spent on paying salaries and possible costs of the project are reduced, which will reduce the final amount of total costs.

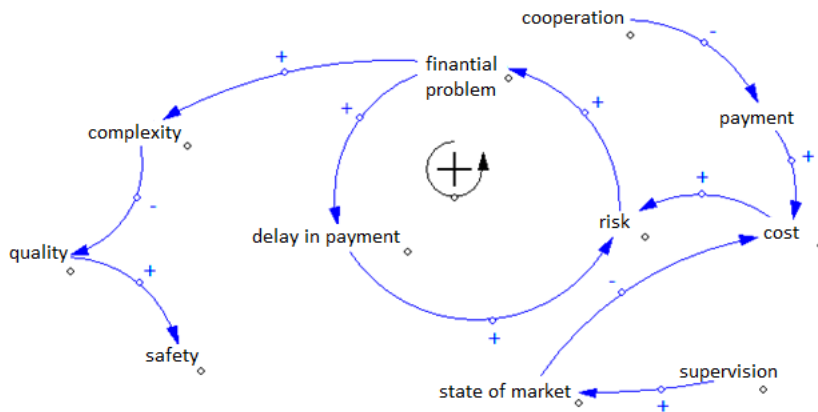


Figure 3. Causal diagram -the effect of supervision, cooperation and risk on the model

With the increase in the level of supervision, more stable market will be created for consumers, which will improve the market situation. With the improvement of the market situation, the cost of providing the necessary materials and tools will also decrease. So, it can be concluded that by increasing the

level of supervision and cooperation, the amount of total costs and project risk will decrease. As mentioned, by reducing project risk, the quality and security level of projects can be improved.

Stock and Flow diagram

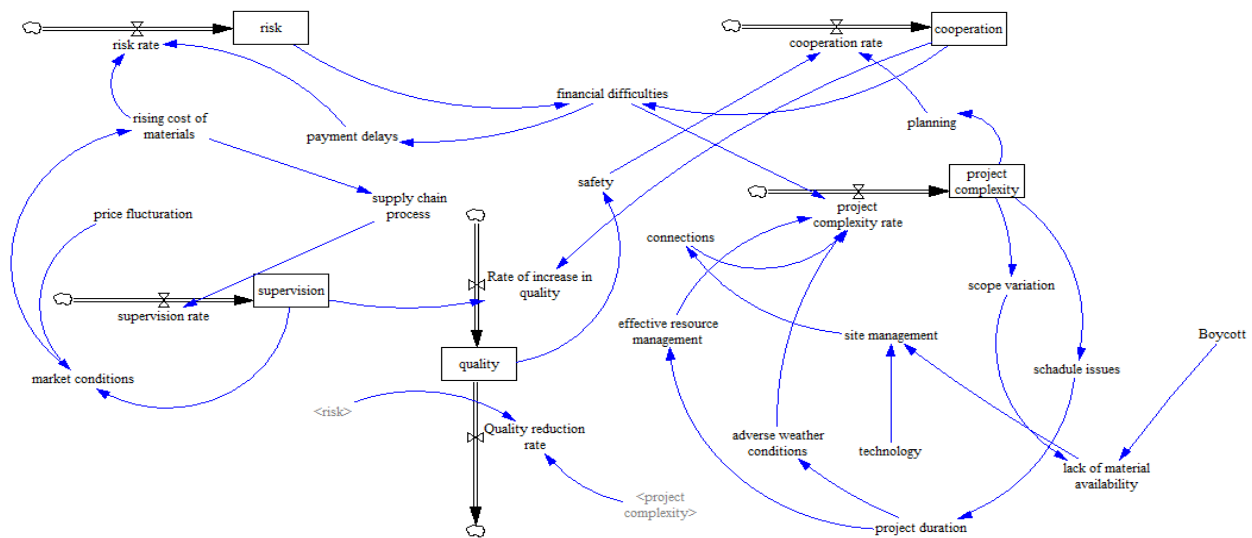


Figure 4. Flow state diagram

Description of stock and flow diagram

Examining the behavior of the system requires the simulation of relationships and variables in Vensim software, which in the simulation, flow diagrams will be equivalent to causal loops. In the flow model, based on an interview with experts, we selected variables that had a greater impact on quality and security, and there was enough information about those variables for writing formulas in the software. First, we defined the desired time period and also the relationship between the variables of the system variables as a hypothesis in the Vensim software. Because there is no precise definition of the relationships between variables, based on the opinion of experts; This

hypothesis and formulas and relations are created and defined based on the logic and data.

Then, based on the input information, the software has simulated a behavior that can be seen in the output of the system. This model has been implemented for a period of 18 months and the behavior of the system is a sign of the validity of these relationships. Therefore, the output behavior of the variables is examined based on the assumption defined below.

After entering the information in the software and running the Vensim simulator, the following outputs are obtained.

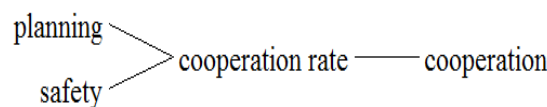
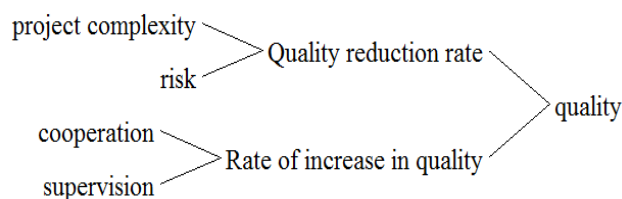


Figure 5. Relationships between variable



Validation of the model

Validation in the approach of system dynamic emphasizes more on the behavior of data over time, which expresses the correctness of the relationship

between the created structure and the behavior. Model testing seeks to trust the model and its results and reach a deeper understanding. In this test, using the values of some variables, it is used to determine

whether the equations and the model behave logically and in accordance with physical laws. In the system dynamics model, specific tests are used to determine the reliability and validity of the designed model, these tests are:

Threshold test: The purpose of performing this test is to answer these questions: Are the important concepts indicative the endogenous problem in the model? Does the behavior of model change significantly when the assumption is changed? Do the scenarios change when the model limits are extended? The tools and methods include: the use of model

diagrams, sub-system diagrams, cause-effect diagram, flow diagram, model equations, as well as the use of interviews, expert opinions, etc.

In the diagram below, you can see the behavior of the system at the lowest and highest quality values, which can be reached by changing the input and output variables.

According to this type of test, it can be concluded that the behavior and relationships between the variables of the model are correct.

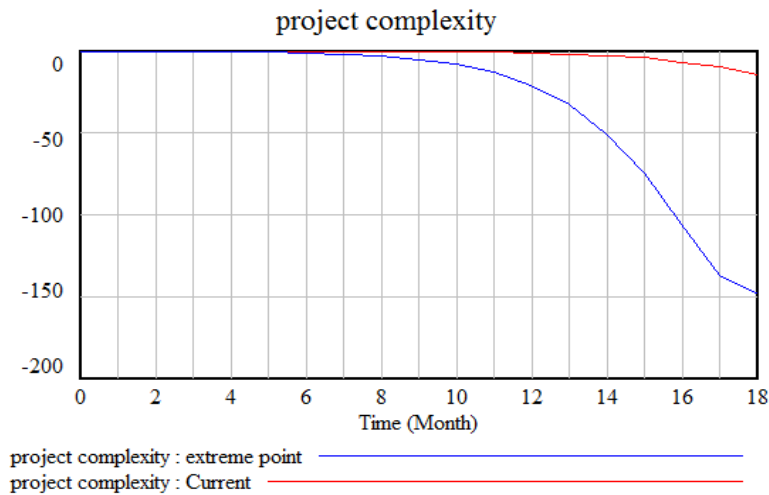


Figure 6. The behavior of the input variable to the quality parameter in extreme point mode

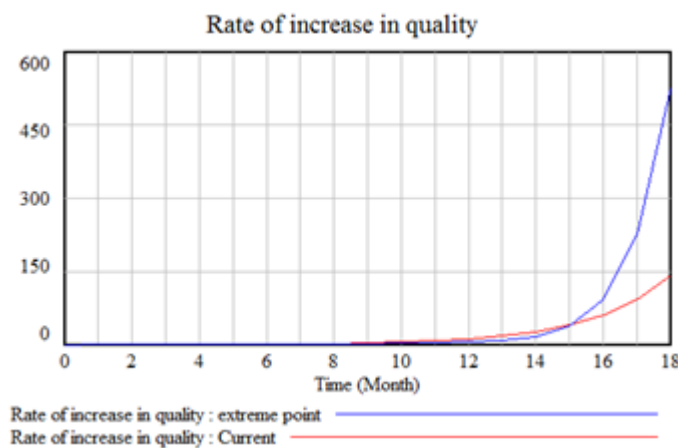


Figure 7. The behavior of the output variable from the quality parameter in extreme point mode

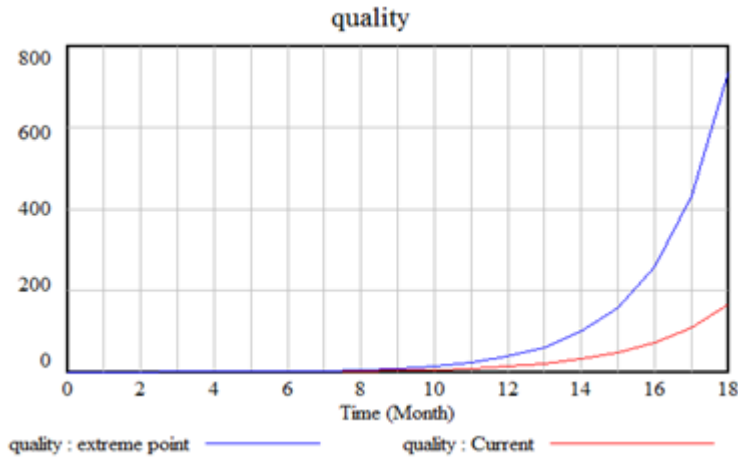
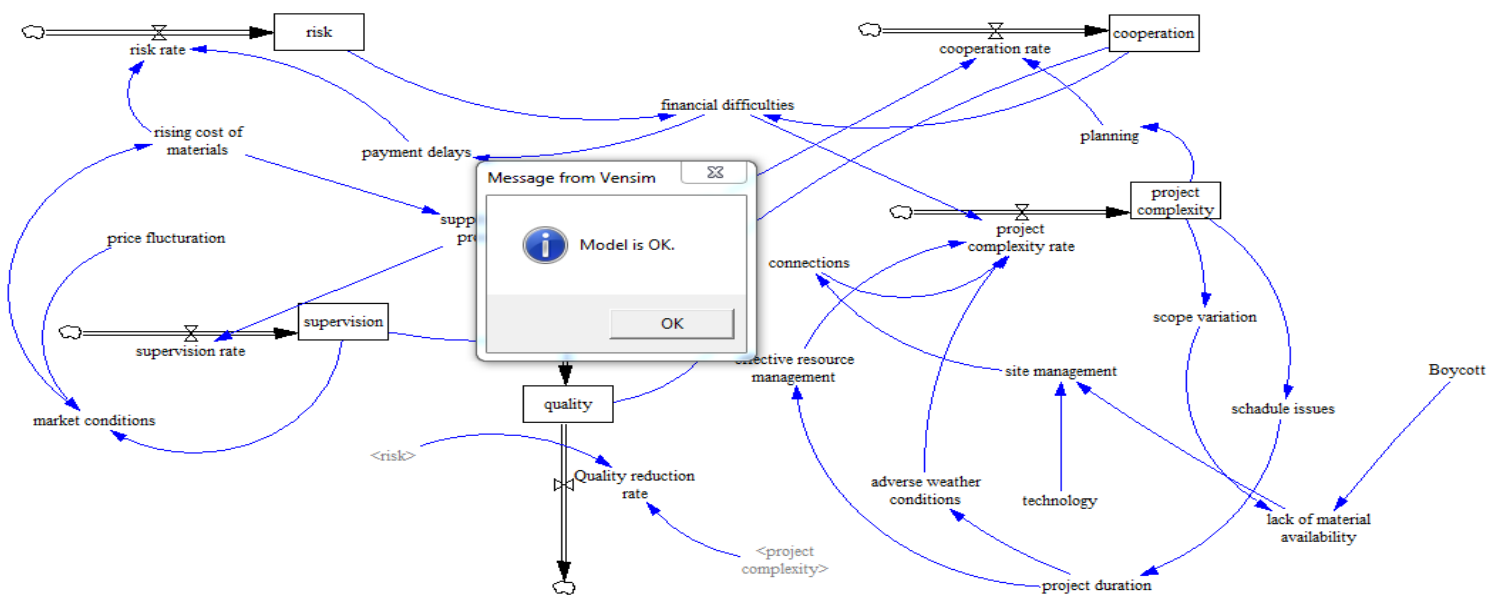


Figure 8. Quality variable in extreme point mode

This type of behavior by comparing the state of the maximum input and the minimum output shows the impact of these variables on the quality change (Figure 8). With the minimization of sanctions, the values of the variables that are affected by this parameter also change as you can see in the two graphs above, the effect of minimizing the sanctions on the quality level. In figure 6 and 7 respectively, the behavior of the input and output variables to the quality parameter is tested "under the influence of minimization of sanctions". In this test, the amount required in each unit is possible in two states, minimum and maximum, so that it can be seen in Figure 8, if the sum of the input is equal to the sum of

the output, the next loop, the minimum quality level, which shows the relationships And healthy behavior is among the variables of the model. In addition to finding the maximum and minimum value of the parameters, this test helps us to check the maximum or minimum effect of the main variables on the model and make appropriate decisions accordingly. For example, with the reduction of sanctions, the level of complexity of the project has decreased, which minimizes the output variable, and the areas for improving supervision and cooperation have been provided, which maximizes the input variable. As a result of this maximization and minimization, the quality level reaches the highest possible level.

Figure 9. model validation in Vensim



Based on the form prepared in Vensim software, the presented model does not have obvious errors and

does not have any defects in the defined variables, and it is further confirmed based on the consistency of the

dimensions of the model, which means that the dimensions of the variables used in the model are consistent with each other. According to the validation section as well as experts' confirmation on the model's function, it can be concluded that the proposed dynamic hypotheses are confirmed.

Scenario planning

In this scenario, we are going to check what will happen to the model in the coming months if the situation continues in this way and without making any changes in the system process.

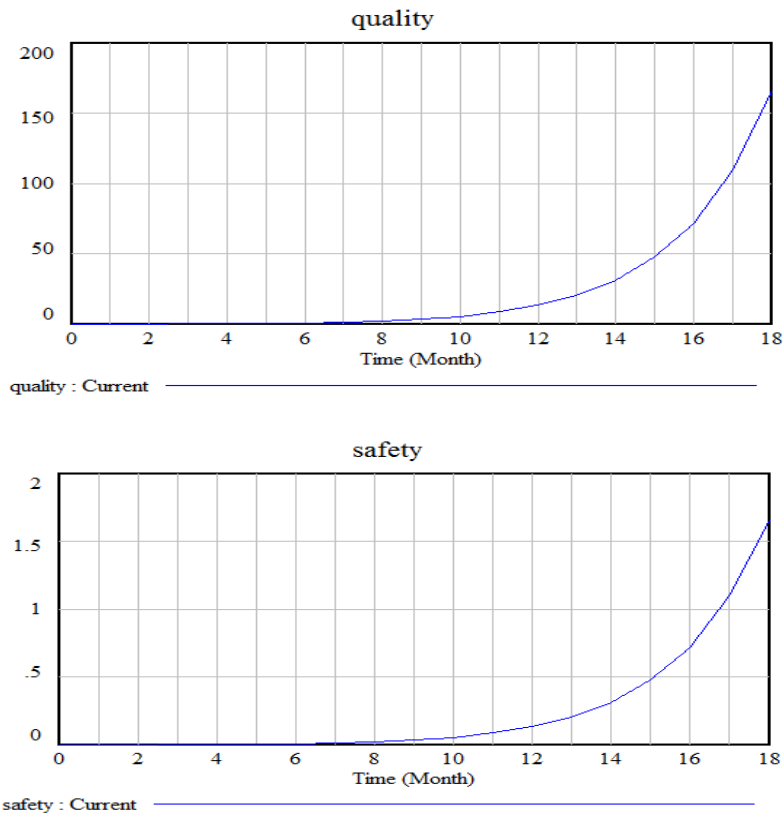


Figure 10. Quality and safety behavior in normal mode

As shown in the figure, with the same conditions after 18 months, the level of quality will increase, compared to the current value of this variable, we will see an increase in this variable.

Following this increase in quality, as can be seen in the graph, the amount of safety also reaches approximately 1.6 times its initial value after 18 months, which is predictable due to the increase in quality.

So, it can be concluded that the processes of the organization are almost approved and if the same

process continues, the quality and security will increase. However, it is clear that by implementing different policies and improving the parameters that have a positive effect on the process of increasing the quality, the level of safety can be increased. And as a result, they have more safety.

Optimistic-pessimistic scenario

In this scenario, by changing the influencing factors on the variables and decreasing or increasing them by 10%, we examine the behavior of the model under the influence of these changes.

Table 3. Optimistic-pessimistic status of influential factors

pessimistic	Optimistic	quality
10% decrease	10% increase	Rate of increase in quality

10% increase	10% decrease	Quality reduction rate
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With the implementation of the optimistic scenario, the quality has taken an upward trend within 18 months, which causes an increase in the level of this

variable, and with the implementation of the pessimistic scenario, the value of this parameter decreases in comparison with the normal state. safety also changes according to the diagram below.

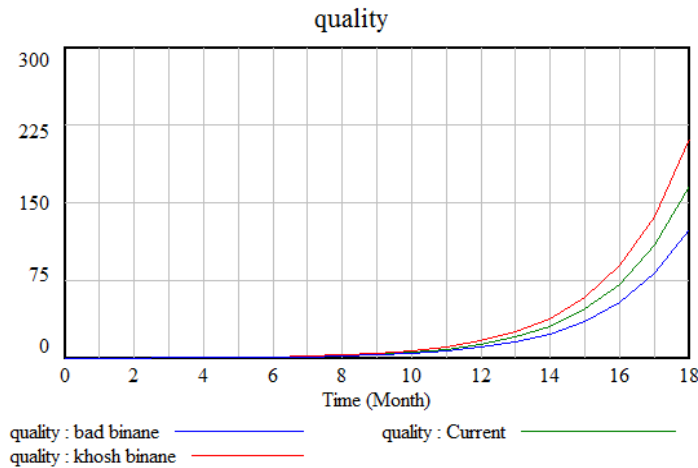


Figure 11. Quality behavior under the influence of the optimistic-pessimistic scenario

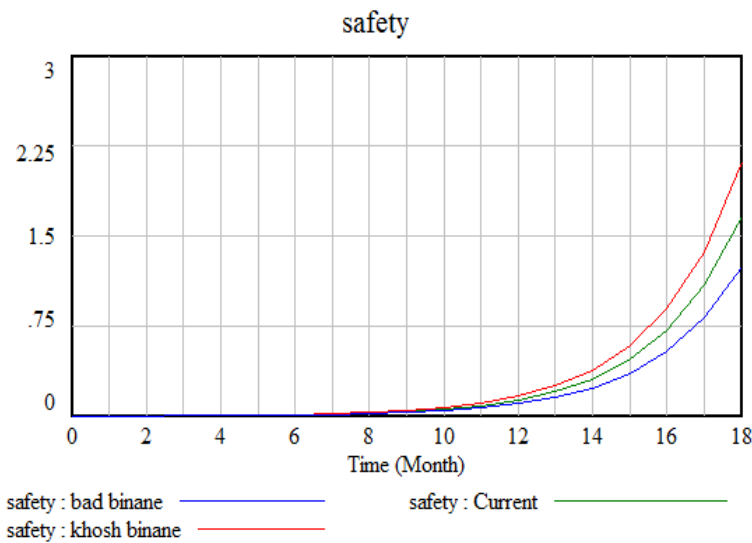


Figure 12. Safety behavior under the influence of the optimistic-pessimistic scenario

As it is shown in the figures, under the influence of the optimistic-pessimistic scenario with the change in quality, the level of safety has also changed, and these changes can be seen in the graph.

According to the table (in an optimistic state) by reducing the factors that have a negative impact on the quality level, it is possible to prevent the reduction of project security. In this parameter, the Quality reduction rate has a negative effect on the quality level, therefore, any policy that causes the increase in quality of the project, increases security. Among the

policies that are used to prevent quality reduction, we can mention monitoring, participation and anything that reduces risk.

In the same way, by increasing the variable that has a positive effect on the quality level, the security of the project can be increased.

Conclusion

The purpose of this research is to use system dynamics in project management, and the proposed model is an example of the implementation of

dynamics in this field, which can be suggested to improve the quality level by considering the optimization and sensitivity testing.

One of the most important achievement in modeling system dynamic is paying attention to all the elements related to the system and examining the feedback of that element on other elements and the whole system. Therefore, by accurately identifying the effective factors in the project and implementing a simulated model of the existing conditions, it is possible to predict the factors that decrease and increase security at the same time through the effect of negative and positive feedbacks that are the result of appropriate planning and policies to the improvement of the system.

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