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Simulation of Delay Factors in Sewage Projects with the Dynamic System Approach

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ABSTRACT

Tehran sewerage company is one of the most important urban management organizations, which project control and delays in its projects is very important. In this regard, the main question of the magnitude and effect of delays, as well as the first step in controlling the delays of each project, is to identify the causes of the time lag of the project. In order to achieve this goal, the information and documentation of sewage networks of Iran - Tehran city (except for projects of main lines of sewage and refineries) has been used during 2011-2017. This study is a descriptive study (case study, survey and library) and the community studied by observers and contractors. For this purpose, all causes of delays in urban projects are identified and classified and the impact of each factor has been determined. Then, the variables have been evaluated using the method of dynamic system and Vensim software in order to influence of factors in the incidence of delays. As a result, the research shows that the total project delays are (respectively, the highest) in the first scenario (baseline) at the end of the 24 months (project completion period) for 140 days, in the fourth scenario for 126 days, in the third scenario for 83 days and in the second scenario for 53 days and the effect of changing the identified factors is examined. In fact, in the first scenario of the full duration work (24 months), a period of 4.7 months is project delays.

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1. Introduction

Delays are one of the most important issues in increasing the duration and cost of civil projects that occur in most construction projects around the world, which can cause damage to contractors and employers in projects. Given that the employer with this update can have a good view of the future time of the project and, if necessary, can warn the contractors, including the termination of the contract, as well as take precautionary measures before the erosion and collapse of the project. There are several studies that have investigated in different construction disciplines specially in bridge industry that is directly depends on the traffic closure time and traffic delays. Many of the previous studies previously pointed on risk assessment and risk evaluation in bridge construction projects [1,2]. Besides, there has been a lot of efforts to minimize the delay on construction projects. Accelerated Bridge Construction (ABC) methods are one of the most innovative techniques to minimizer the construction time and delay on projects. ABC is a paradigm shift in the project planning and procurement approach where the need to minimize mobility impacts which occur due to onsite construction activities are elevated to a higher priority. There are several studies that focused on developing precast members to used them in construction instead of using cast in place time which usually put delay on project timeline. Graber and Shahrokhinasab, recently studied the performance of Full-depth Precast Concrete (FDPC) deck panels to use instead of cast in place concrete decks in bridge construction to speed up the whole construction process while giving better long-term performance [3,4]. Most of these techniques have improved the construction process and decreased delay on projects, but there are still other disciplines that could not benefit from these methods yet including sewage projects. Sewage projects are crucial in today civil life and still struggling with delay issues.

In this study specifically, the issue of delays and their effects on each other from two points of view of system dynamics and delays are studied and to complete the discussion, the following resources are studied:

Wang examines the risk management based on the dynamic system model through a questionnaire and the relationship between variables by studying in two axes of delays in performing tasks and rebuilding the project. thus focusing on the necessity of paying attention to six policies [5]: (1) requests of employer for engineering change, (2) delays in project financing, (3) pressures from compact scheduling, (4) site incorrect information, (5) lack of skilled labor, and (6) poor management of contractor [5] with a sample survey and questionnaire from 86 contractors and consultants, Kharashi studied the delay factors in Saudi construction projects with all relevant variables. As a result, 76 % of average contractors showed a deviation from the time schedule between 10 % and 30 % and 25 % of its advisers between 30 and 50 %. The study also revealed that the minimum cost of the project with the lowest price is the most delay [6]. Al-Momani examines the causes of the delay of 130 general projects in Jordan and assists building managers by making adequate assessments before the contract using quantitative and qualitative data. the results of this research showed that the main reason of delay in construction of public projects related to designers, climate change , site conditions ,deliver late, economic conditions and rising amounts [7]. Frimpong has been investigated by a questionnaire survey on the causes of delays and overflow of construction costs in Ghana's projects. The results of this research showed that poor management, bad weather and inefficient manpower are major problems in the occurrence time delay [8]. Flyvbjerg, by statistical methods, has investigated reasons for increasing completion time of power plants in India. The purpose of this study is to explore whether the cost of transport infrastructure projects, including systematic and reliable information in large-scale projects in India, has been considered. The survey showed that the average increase in rail transportation costs were 45%, in tunnels and bridges 34%,in road projects 20%, and in medium projects 28% [9]. Kotir has studied a simulation model in agricultural production in West Africa by a system dynamics modeling approach. The purpose of this model is to provide a learning tool for policy makers to improve their understanding of the long-term dynamic behavior of the river basin. The objectives of this study were to use this model as an educational tool to improve our understanding of the long-term dynamics of the Ghana VRB as a basis for exploring alternatives policy scenarios for managing sustainable resource of water resources and agricultural development [10], quantification of delay and claim factors in projects with the system dynamics method was proposed by Howick. as a result, in this paper, it is stated that, if a model tried to use a model in a system, it should consider elements such as preparing and precise communication with audiences, complete transparency, size and complexity of the model [11]. Yang has done research on the city traffic phenomenon with the dynamic system model in Beijing. The modeling goal in this paper was to analyze the internal structure of urban traffic from the perspective of urban travelers and urban procurement, which has been analyzed [12]. Othuman has investigated the statistical analysis methods to identify the causes and consequences of delays in private housing development projects in Malaysia. He has suggested solutions to minimize these delays. So, the causes of delays are classified: The weather conditions, poor site conditions, poor management, incomplete documentation of the consultant, inadequate experience and financial difficulties [13]. Aswathi using The Monte-Carlo simulation and the field study introduce delay analysis system in Indian construction projects. In this study has been determined that the contractor has the highest weight in the causes of project delays [14]. Stumpf have studied the construction industry in Malaysia by questionnaire survey. The main objective of this study is to identify factors of delays and their effects on the completion of the project. Also this study has created an empirical relationship between 28 causes and 8 disabilities [15]. Aziz has used brainstorming method to identify delays in construction projects in Egypt. Data were analyzed by using the RII method and delays were prioritized. The purpose of this study is identification of lag factors and its class [16]. In his article, Hasseb has mentioned the main problems of construction and delays in the large building projects in Pakistan. This paper was conducted by field study on the project and using random sampling method, designing a questionnaire and a survey from three sides of contracts. As a result, the most important factors of delay have were expressed in terms of weak contract and unpredictable circumstances, delays in payments to the contractor, completion time of the project and timely delivery respectively [17]. Majid carried out research on delays in construction projects by Ishikawa's charts. His purpose was to investigate the delay factors, such as material items, labor, equipment, financial and so on. It was found that among the factors delay, the main factor is poor performance of contractors [18]. Love, in an article by a systematic dynamic model, presented a model for reducing construction delays caused by overtime. In fact, the effect of overtime on the project cost has been investigated. Also he has mentioned Long-term overtime can cause quality problems, such as rework and additional resources [19,20].

In this paper, the aim is to investigate the delays in network projects and branches of Tehran sewerage company and their effects on each other by using the system dynamics model.

2. Research method

In this study, first, the delay factors were identified and then by creating the dynamic hypothesis (descriptive model) using the system dynamics method, Causal Loop Diagrams (CLDs) and its flow were drawn by using the VENSIM software. So with diagrams and analysis, its effects as well as the interaction were investigated.

The steps and procedures are as follows: recognition and definition of the problem, the drawing of reference diagram, definition of the major variables in the problem, the definition of the relationship between variables, the drawing of the cause and effect diagram between the variables, the definition of the boundaries of the model, the construction of flow diagram for the model, model implementation and model validity. The steps of this research are as follows:

2.1. Determination of model variables

Three delay factors in first step and three delay factors in the second step were considered as accumulation or flow variables in this paper. Their effects on each other, total delays of project, as well as the cost of delays, have been investigated by the method of system dynamics and VENSIM software. To reach this goal, for these six accumulation variables, their proportional variables (such as input and output, etc.) were considered and their data were collected according to the daily reports of the existing contractors (22 out of 52 contractors).

2.2. Modeling

Causal Loop Diagrams (CLDs) was constructed based on the above variables and associated circles with regard to the previous findings and the existing cycle. Then, using the system dynamics, the six above factors were used as the accumulation variables and also the factors of step 4 ,as auxiliary variable was obtained by inserting information from the first and second series tables, as well as the contractor questionnaire table.

2.3. System dynamics definition

System dynamics is a method for modeling and analyzing policy based on feedback systems theory. In the late 1960 s, Jay, one of the pioneer engineering and computer design invented this concept. Since then, system dynamics have been developed as separate areas of such as research in operations and management sciences. The computer simulates these models easily because of their numerical nature. The concept of system dynamics was first introduced by Forester and has grown rapidly over the last 50 years. This science is an approach for discovering dynamic behavior and studying effects of structures and system parameters on behavior patterns of the system. The output of simulation of systems is governed by system dynamics approach, resulting in the structure of each system, which influences its dynamic behavior. In other words, this conceptual approach builds on feedback and existing delays so that dynamic behaviors of complex physical, biological and social systems can be better understood. The system's dynamical approach is one of the most effective tools in dynamic and real conditions. Therefore, the mathematical rules between variables are not explicitly documented in the system dynamics approach and usually refer to the focal point of reference, that is, the type of relationship between the variables and the weight of each factors influencing over other factors is determined by experts. Their model developed by this methodology at this stage has its components, most notably:

- **Causal loop diagrams (CLDs):** These diagrams are a tool for illustrating causal relationship between a set of variables (or factors) involved inside a system. The relationships between variables represent the causal correlation between the two variables. This relationship can be positive or negative. Positive, it is for the situation that the change in effect is the same as the cause, i.e. the increasing (decreasing) in one causes the increasing (decreasing) in another. The negative also indicates that the relationship is inverse.
- **Causal loop (CLDs):** The presence of feedback in cause and effect relationships causes the creationcausal loops. Causal loops have different behavioral patterns that are divided into complementary and equilibrium loops in general division. The reinforcement loops, equivalent to positive feedback and equilibrium loops, are equivalent to negative feedback.

3. Modeling

3.1. Designing the questionnaire

In this study, first the study of relevant resources and the subjects was investigated. Of these, 20 causes of delay were extracted (construct validity benchmark), Out of 22 counselors, they were asked to complete a questionnaire and assign a number among 1 to 10 (10 most works) according to the effect of each of these factors on the contractor's project delay. Then, by SPSS software the reliability or reliability of control (0.788 in the acceptable range) and the Friedman method were done according to table (3 - 1) of the importance questionnaire of the contractors, prioritized that the first three items (manpower, number of machines and rework) were selected with more weight.

3.2. Modeling

All delay criteria stated by contractors have been extracted from 52 delay bill in Tehran's sewage company projects from 2011 to 2017, delays are categorized into three groups. Also, contractual information such as (initial period of contract and initial price of contract) is obtained from the contractor's agreement. In order to determine the delays and related costs, in the cases related to the implementation of network and sewage concluded with Tehran's sewage company, the five main factors of manpower and machinery and Drilling permit delay and financial delay and Others (other than, Traffic permit delay and the absence of a polyethylene tube in Tehran's sewage company) have been used. These relationships are obtained from specific ratios between variables and previous studies, as well as from the database of contractors and supervisors. The following are important variables of the flow intensity model, as follows:

- **Number of manpower and machinery**

In this factor, the manpower with human units and machinery with the unit of machinery and the flow of employment and exit manpower with unit per month and the flow of the use and exit machinery with the machine unit in month is considered. Also, using the contractors' inquiries and sources of information, for the manpower section, the exit rate of 5 people per 100 people in 12 months and The employment rate is based on the amount of manpower shortage in 12 months with an initial manpower of 55 and for the machinery sector, the exit rate of machinery is 5 machine per 1,000 cars in 12 months, and the rate of use machinery based on the amount of machine shortage For 12 months, the machine has an initial value of 6 units.

- **Lack of manpower and machinery**

These variables directly affect the delays of the project with the effect of the ratio of delayed days for each person's shortage, and the employment of manpower and use of machinery on the other hand.

- **Exit and arrival of manpower and machinery:**

According to the questionnaires for projects, the manpower per 100 people, 5 people, and machines for each 1000 devices of 5 devices during 12 months of the project being removed from the project.

- **Delay project flow**

This variable flow is due to three accumulated delays, including Drilling permit delay and financial delay, and others (unit of all three is day), and delays due to shortages of manpower and machinery, and are calculated in the time unit (month), and Delays are produced.

- **Number of project delays**

The variable total number of project delays, accumulation due to project delays (the flow of project delays due to three major delays of Drilling permit delay and financial delay, etc.) per day, the total project delays are considered and the three major factors of delays and Deviation from manpower's aim and machinery, as well as the duration of the whole project are affected.

- **Total of time project**

According to the contractor's information, the average of Initial time project is 151 days and total of time project is derived from the sum of Initial time project and the duration of the project's delay with the unit of the day.

- **Cost of delay**

This section has been calculated using the amount of total project delays (per day) and the ratio of excusable delay to non-excusable delay (without unit) and the cost of each delayed day in a month, the variable of flow and accumulation of delays. The source of this ratio and the cost of each delayed day are obtained from the contractor information.

In the following figure (Fig. 1), the total accumulative costs of delays on project is illustrated:

Fig. 1. Accumulation variable of cost of total project delays.

The above chart is related to the "accumulation variable of cost of total project delays" and is caused by delay factors on the time. This chart has a value of zero or close to zero in the first few months and then grows exponentially. And due to the addition of the "unauthorized delays fine", in the 24th month, it reaches 22 million money. Therefore, by reducing the initial amount of delays due to non-issuance of municipal licenses, the cost of delays is reduced to 5 million and by reducing the combined amount of the initial amount of delays due to financial and other, to 17 million.

In the following figure (Fig. 2), the dynamics model of the system of delay effects of Tehran sewage company projects can be seen:

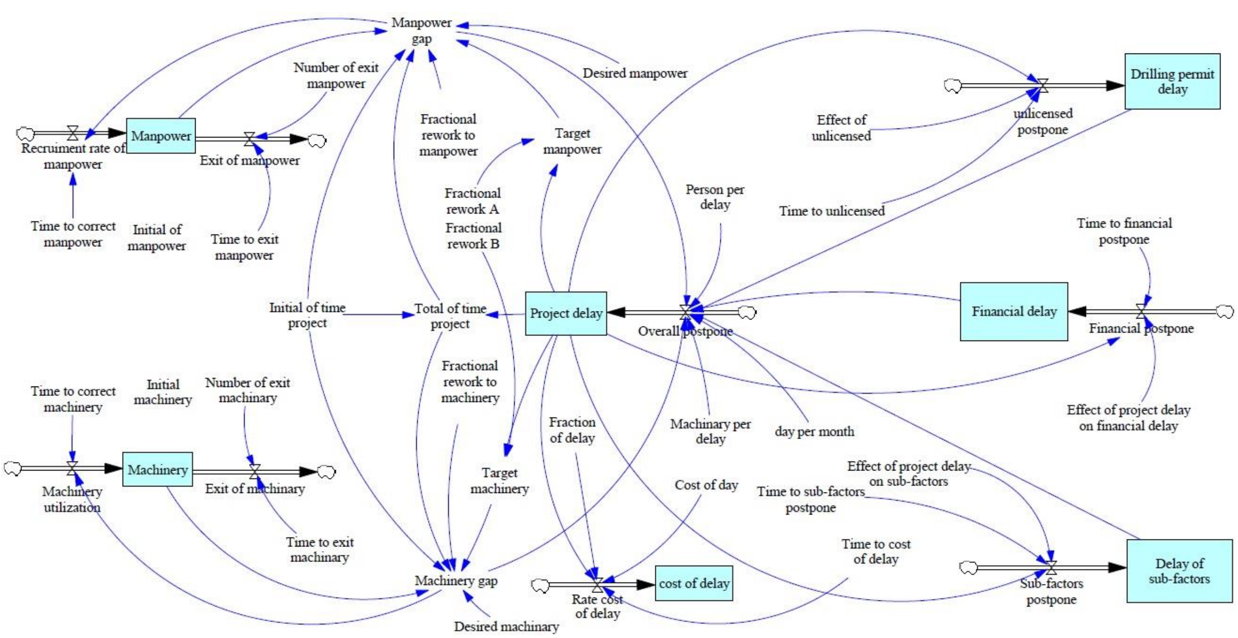

Fig. 2. Delay flow diagram in Tehran sewerage projects.

3.3. Validation and testing of the model and results

After making the flow model, its validation is done. Sterman and Sushil have presented different methods of model validation. In this research, using the dimensional compatibility tests, boundary conditions and structural behavior tests have been investigated model validation.

The result is that in the dimensional compatibility test with respect to the evaluation of equations and using the conventional analysis of system dynamics software to ensure compatibility of model variables with equations, the model is tested by Unit Chick option (in VENSIM software), which after modification of several variables, the model was checked. Also, the stability of the system behavior is verified by using the Check model in the model structure and in the limit state test, by determining the initial values of the variables in the limit states.

3.3.1. Description of the behavior of important variables in causal loop diagrams (CLDs)

- **Section of manpower and machinery variables**

In this section, by reducing the initial number of manpower and machine variables, to zero, the variables of the manpower employment rate and using machinery directly, and the variables of manpower shortage (deficiencies) and machinery, and The total delay of the whole project and also the cost of it indirectly are increased and the total number of variables of manpower and machinery (accumulation variables) is reduced. In fact, the lack of initial manpower resources at beginning of the project will increase the speed of the employment to compensate for the depletion and will affect the overall project delay. According to the initial inquired values, this part is 86, 4 and 18 days, respectively, and also the percentage of its values in relation to the delayed period is 0.8, 0.03 and 0.17%, respectively, and occurs in a period of 17 months, which It has a direct relationship with project latency values and other parts of the model. With zero delay values of the three main factors, the overall project delays also tend to zero

- **Rework and lack of manpower**

In the rework section, according to the contractor's information, the delay of project in this paper, 5% due to rework. (apply more than 5% in the model), to compensate The shortage of manpower resources in the rework sector will lead to an increasing in the shortage of machinery, And vice versa. In fact, in the project, with increasing of error and mistake in the work will result in more rework and the need to employ more people and machine. In this case (5 per cent and other basic values) in the model at the end of the 24th month, 11 of manpower shortages will be due to reworking and someone should be employed in the project every 2 month.

- **Total time and initial time of project and delays**

In this section, the "average initial time of project" from the contractor’s employment file has been extracted by calculating the average of the initial time of 52 contractors reviewed. Also, in most projects, due to the accumulation of project activities in the middle of time project, activities will be increased, as a result, the lack of manpower and machinery variables are significantly increased (compared to the end of project). For this purpose the "initial time of project" is particular important. The total of time project is the total initial time of project and project delays.

- **Delay costs section**

In this section, according to the "contractor's information file", the excusable delay to non-excusable delay in projects is 10 percent. (in fact, of each The amount of delays in projects is 10% for non-excusable delay and the remaining percentage is excusable), and the daily delay (non-excusable delay) for a project is one hundred and fifty thousand dollars, which is calculated based on the number of days of the total delay.

4. Analysis of results

In this section, to design the scenarios, first, the leverage points of the problem are identified and the behavior of its important variables is investigated. In this regard, according to the studies conducted in the articles as well as available variables in the causal-effect model, the leverage points are as follows: 1) Drilling permit Municipality; 2) The initial number of manpower.

4.1. Scenarios

Based on the leverage points, the following scenarios can be proposed for the delay system:

- First scenario (base): This is the same behavior of the model (base state) with the initial assumptions.

- Second scenario (increase in manpower): An increase in manpower, which will reduce the total project delay with the effect of compensating for the shortage of manpower due to rework and accelerating the operation on excusable days. In this scenario, manpower resources increase by as much as 50% as a result of which the project, at the beginning will be started with 83 people instead of 55 people. This will reduce the total delay by 62% and reduce the cost of delay by about 77%.

- Third Scenario (Reducing Municipality Permit Delay): Reducing the number of days without a municipal permit that can be done by initial planning and coordination with the relevant municipal and municipal authorities. In this scenario, the number of municipality-free days decreases by half (up to 43 days and 0.4% growth), which has a direct impact on total delays and indirect effects on recyclers, to 41% Reduce total project delays and reduce costs by 40%.

- The fourth scenario (reduction of financial and other delays): Days of delay due to the lack of financial resource and other items can be reduced by quick and timely preparation of the statement of financial and coordination with the relevant authorities. In this scenario, the delay days and the percentage of both factors are reduced by half (the initial value from 4 to 2 days and the percentage from 0.03 to 0.015 and financial from 18 to 9 and others from 0.17 to 0.085), which leads to 11% Reduce total project delays and reduce costs by 14%.

4.2. Analysis of the behavior variables

This diagram shows the number of manpower (unit units) of the project per unit time (month unit), which starts with an initial number of 55 people and begins with a mild slope and then became steep. Due to the increase in project activities and the activation of all the workfront, we will have a maximum manpower increase in the project.

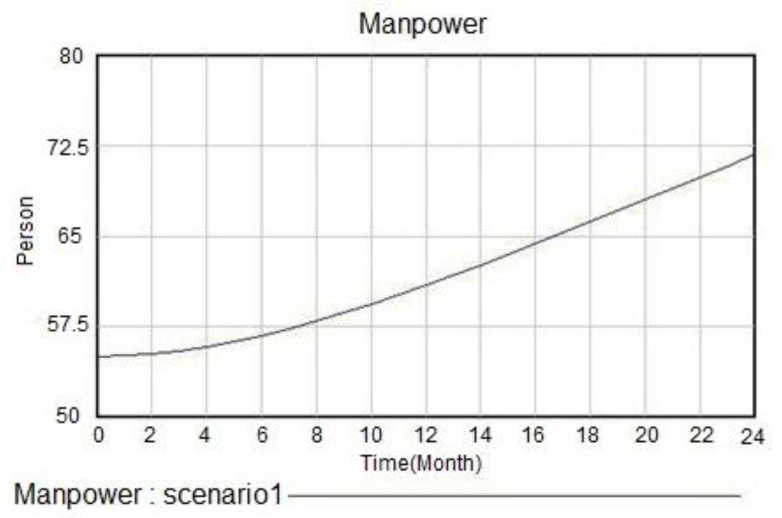

Fig. 3. Number of manpower (base).

In this section, with the reduction of initial manpower resources, the employment rate, shortage of manpower and the total delay and cost be increased and the total number of manpower has been reduced, this case due to an increase in the initial manpower resources relative to their optimal situation with surplus Primary manpower are in employment and in exit of manpower. If the number of employees is zeroed due to the employment and exit of manpower process, 5 months will add to total delay.

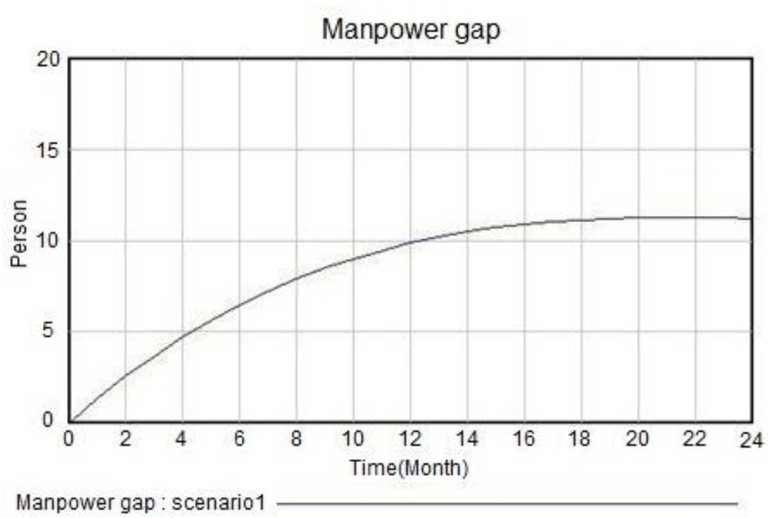

Fig. 4. Shortage of manpower (Basic).

The graph above shows the employment rate of manpower (one person) in a time unit (month) as a target. At the beginning of the project, with the provision of initial manpower, the shortage of manpower is zero, and then the project activities will peak at 12th month. Also, the maximum shortage of manpower occurs this month, and then, with the onset of the downturn, remains almost constant and ultimately leads to zero. The shortage of manpower is affected by the duration of the project, but given the fact that during this period the executive activities were reduced and the contractor's official activities (including following the statement and delays, etc.). It stays in almost the same period in the last months of the project.

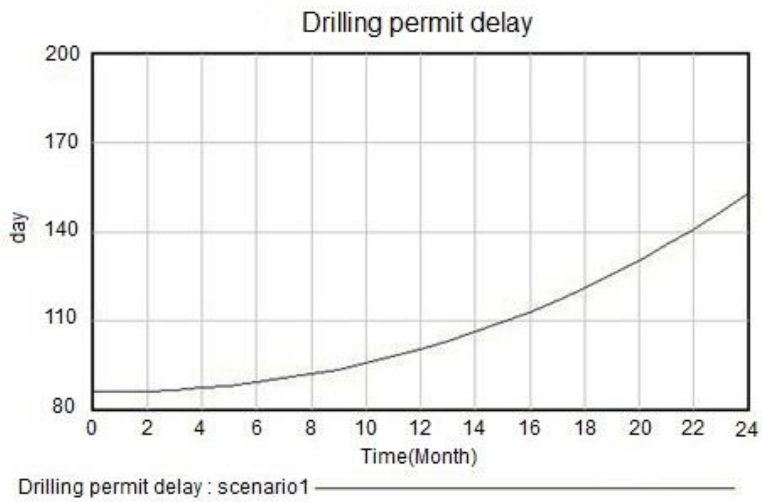

Fig. 5. The number of delays caused by the failure to issue a municipal permit (Basic).

The above graph shows the variable accumulation of delays caused by Drilling permit delay (unit of day) to time (unit of the month) in grows exponentially. As time passes the project, according to its cumulative nature, the slope of its delay is added. Also, increasing in time when the contractor is unable to work due to delay, its magnitude increases exponentially. This function began with an initial value of 86 days, which is related to the amount of delays incurred during the initial time of the project, and then at a growth rate of 0.8 per month, due to the delays in rework and the shortage of manpower and machinery, as well as the rate of Drilling permit delay increases and reaches 150 days in the 24th month. That is, in the total period of 24 months, there is a delay of 5 months. Given that the values of this diagram directly depend on the decisions of the municipality organ, and the municipality organ is also a Public-private organization (independent). It is merely subject to the decisions of its upstream or downstream organizations, so, it is impossible to reduce the delays caused by this case and reduce the slope of this diagram.

Also, the speed of work of the contractors is directly related to the lack of Drilling permit. Because by increasing the speed of the work (due to the lack of modern technology use), citizen complaints also increase, which will result in reduced Drilling permit or slower issuance of them.

The diagram of project delays shows total delays (per day) during the period of work in the time unit (month), which is due to direct delays caused by drilling permit of municipal and financial and other, and indirect delays caused by manpower and Machines and reworking grows exponentially.

The initial delay of this variable is zero and its initial value is indirectly obtained from other variables. Based on the Fig. 5, in the 24th month, the total project delays will reach 141 days. Of course, when the project is prolonged, fatigue of employee should be taken into account, which is neglected in this model.

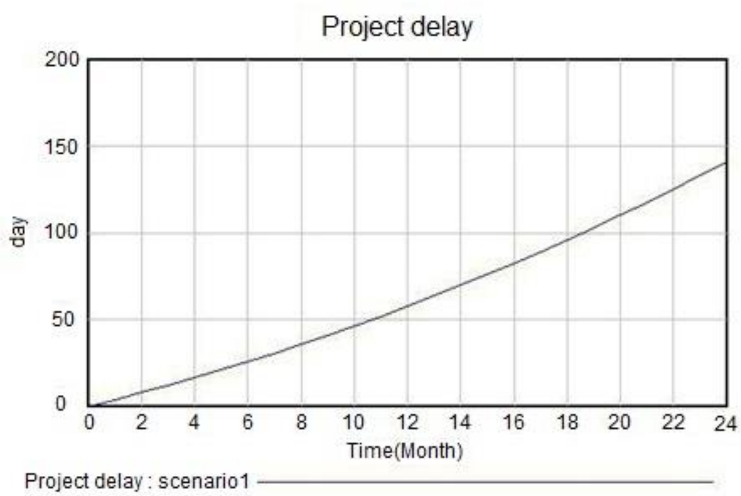

Fig. 6. Total project delay (base).

In order to reduce the slope of this diagram, due to the six factors affect the model, the first factor (drilling permit delay) should be considered. If this factor is zero, the total delay of the project is decreased to 28 days. But by reducing to zero, the combined delay of two direct financial and other factors, can reduce overall delays to 111 days; in this regard, the first factor excel to the second and third factors (combined reduction).

4.3. Model simulation

In the following diagram, the behavior of the delay variable is depicted in various scenarios. In the Fig. 7, scenario numbers are shown. This chart is based on the comparison of the number of delayed days (unit of day) per unit time (month) as follows:

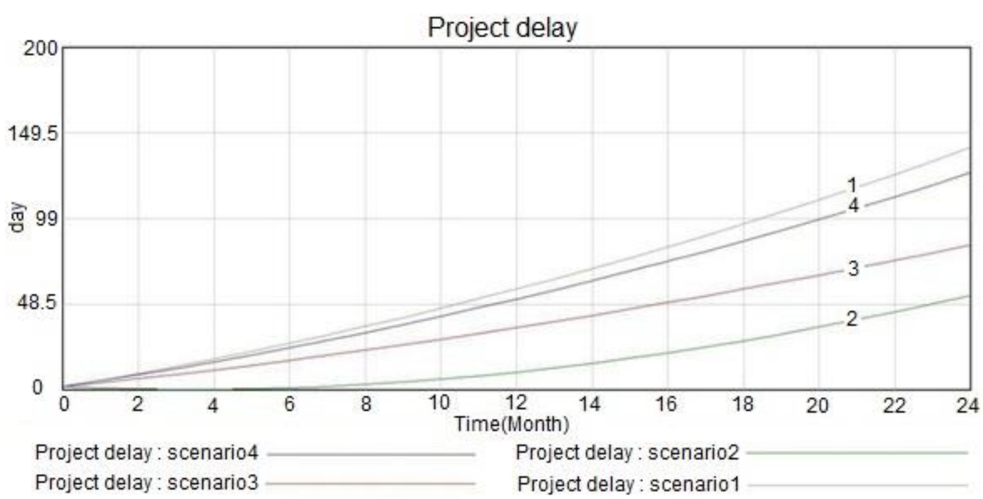

Fig. 7. Four scenarios for total project delays.

As shown in the Fig. 7, all scenarios have exponential growth with varying slopes, and the greatest delay is in the first scenario (base). The third and the second scenarios, respectively, include the reduction of days without a drilling permit 50% compared to the base, and the increase in labor force 50% compared to the base and the fourth scenario (combination of financial and other delays), the least delay will follow.

In the first scenario, according to the project's operation, the maximum total delay of the project is 140 days, and in the second scenario, due to an increase in the number of personnel is 53 days, and in the third scenario, due to the decrease in the drilling permit Will be to 83 days and in the fourth scenario (combination of financial and other delays) will lead to 126 days in the 24th month.

Among the above scenarios, the strongest factor (non-combination) is the avoidance of accumulation of project delays, increasing the number of manpower. Because the contractor, with the coordination and absorption of more forces (especially from the midpoint of the project, when the activities reach their peak), can carry out activities in a timely manner, and if possible, in parallel programs. This research shows that the matters relating to contractor's employees, including motivation, proportional salary, the prevention of the loss of energy of personnel, the employment of qualified technical and moral persons, and etc. are factors should be considered in Project.

The next factor, days without drilling permit, is a variable that has a high percentage (based on contractor's information) of delays because of it has direct effect on the erosion of the whole project, in terms of the burden of additional costs, employee's motivation, change in working season (putting the operation in the second half of the year rather than the first half) and etc. According to the diagram, this factor has an almost constant value and it affects the manpower resource factor throughout the whole project.

The fourth factor, which is considered financially and others, has the least effect on the project due to defect circulars in the country and the dispersion of "other delays". This is because contractors put their maximum energy to claim about drilling permit delay. These two factors can be reduced by timely payment by the employer and coordination with the relevant municipal authorities.

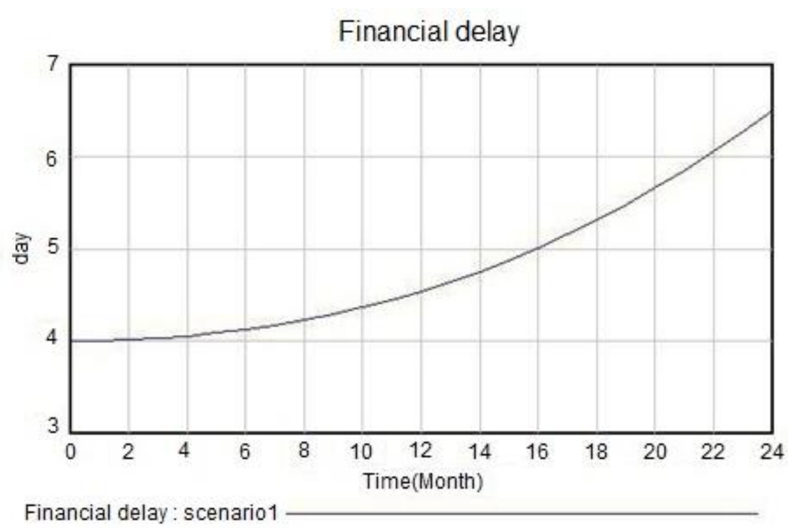

Fig. 8. Financial delay.

The variable of accumulation of delays due to non-timely payment of financial statements. This function starts with the initial value of 4 days, which is related to the amount of delays in the initial period of the project, and then increases with a growth rate of 4% per month due to delays in rework and shortage of manpower and machinery.

5. Conclusion

In all projects, contractors tend to maximize profits and employers tend to reduce project costs. In order to achieve this, it is very important to identify the factors affecting the success of the project and estimate their effects before tender offer for contractors and employers. Delay in projects is one of the things that leads to more resources, reduced profits, or waste of opportunity. Therefore, the purpose of this research is to identify the causes and delays of sewage company projects by analyzing the structure governing the delays in its projects and assessing the effects of different policies and ultimately profitability.

Four general policies in this paper have been reviewed. The abstract of the behavior of variables is shown in the table below. Comparison of these scenarios shows that if at first the appropriate planning and coordination with the relevant organizations (municipal and Department of Traffic) is carried out and also the contractor is selected carefully and the contractor was selected with the ability to increase the power and equipment, the delays will be much lower.

Table 1
A comparison table of four scenarios for total project delays.

Total delays of project(month)	Scenario
4.7	1- Scenario is the base mode
4.2	2- Increase in manpower
2.8	3- Reducing Municipality Permit Delay
1.8	4- Reduction of financial and other delays

Finally, six conclusions are understood of this paper:

1- The weakness of the management and Financing of contractor department at the beginning and in the operational part of the work and the use of unskilled manpower, which leads to a lack of absorption of appropriate force and reworking, and finally major delays in the project.

2- The model is further dependent on the reduction of the number of days without drilling permit, although this scenario is slightly ahead of the increase in manpower.

3- Given the 60-70% predictability of days without drilling permit, they can be included in the contract text, and the contractors can also, plan for this in this regard and costs of this section can be eliminated.

4- Considering that the major activities in sewage company projects are carried out by the manpower (80% of manpower and 20% of machinery), but Additionally, using appropriate equipment and machinery and the choice of contractors, who have ample financial capacity, the duration of activities can be increased and the delay is reduced.

5- The best combination policy is when it comes to reducing the number of days without drilling permit and the employment of appropriate forces.

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