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Research Article

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Comparison of the Critical Path Method and Critical Chain Project Management Effectiveness using Inferential Statistics in Dam Construction Projects

Behnaz Davalu[1], Mohammad Javad Khosravi[2], Mohammad Saeid Sheikhi[3], Hamidreza Sheikhi[4]

[1]Master of Civil Engineering, Islamic Azad University, Science and Research Branch (Tehran), behnazda3@yahoo.com
[2]Ph.D. Student of Urban Planning, Islamic Azad University, Tehran North Branch, khosravicbr@gmail.com
[3]Master of Civil Engineering, University of Lamie Gorgani, sheikhi.saeid67@gmail.com
[4]Bachelor of Architecture, Golestan University, hamid_sh21@yahoo.com

Abstract In the late century, regarding the increasing speed of technology, the use of statistical techniques has attracted the attention of researchers of various branches of science. In the inferential statistics, the researcher calculates the sample values of the statistics and then, by means of estimating or testing the statistical hypothesis, generalizes the statistics to the parameters of the society. In order to analyze the data and to test research hypothesis, the research methods inferential statistics are used. In this research, after choosing the statistical population, the Questionnaire with four hypotheses in the form of eighteen questions was provided and distributed. Required data to perform statistical operations prepared and then using the software SPSS take action statistical Activities were made on the results of questionnaire. The results indicate the recommendation of expert participants to use the CCPM approach alongside the CPM method in large projects, especially in the construction of dams.

Keywords T test, F test, Kahir Reservoir Dam, Cronbach Alpha, Critical Chain Project Management

Introduction

Processing data and converting it to the information required results making in suitable decisions. The art of managers and experts manifests itself in how to use statistical methods and the analysis of information obtained. Nowadays, it is rarely possible to interpret, explain and analyze the results obtained from scientific research without using statistical methods. Statistics are discussed in two branches of descriptive statistics and probabilistic and inferential statistics. In this research, by emphasis on inferential statistical techniques and methods, the intention is to take action to investigate the efficiency of the methods Project Control Critical Path and the critical chain.

Critical Chain Method: The idea of a critical chain was introduced by Eliyahu Goldratt. The Critical Chain Project Management or (CCPM) is a method for project planning and management that focuses on the regarded resources (Persons, equipment, and physical space) which emphasize to carry out tasks. This technique by considering some human errors and other factors tries to waste safety time, a new way to control the optimal time of projects is introduced. Human errors include the Parkinson Law, Student Syndrome, and Murphy Law, and factors that waste the time spent on the activity intended to be active, including the multiplicity of resources and dependencies between different stages of work. In the critical chaining method, due to activities in the shortest possible time The concept of flotation disappears but in this research, due to the focus on flotation as a

supplement for the nutrient buffer, activities are planned as soon as possible and then the project buffer and nutrient buffer are added to increase safety from uncertainties at the end of the project.

In the many studies of the critical chain of project management, (CCPM), that is a method for project planning and management, with emphasis on resources required for project implementation, has been used to prevent project delays. Wenyan Song et all in 2016 stated in an article that SSCM's sustainable supply chain management has gradually become a strategic necessity [1]. Due to its complex nature different sources of risk factors may appear on the SSCM. Many fewer previous studies dealt with about the effect the power of each of the risk factors in interdependencies. To solve this problem, the model of Laboratory decision making and evaluation is presented. Internal resistance and external influence are considered as risk factors. The results show that the lack of choosing suppliers is a major risk factor for SSCM, since the supplier's choice plays an important role in achieving social, environmental, economic, and SSCM benefits. The proposed method can be used as an effective tool in identifying critical SCCM risk and interrelationships between different risk factors. Azar Izmailov et al., in 2016, stated in an article that the CCPM's critical project management chain is a tool used for project planning and management. It can be used in a project and multi-project structures that share resources [2]. In recent years, many studies have been carried out on the construction of dams, their optimal operation [3-14], flood control [15-19], hydrological and hydrological factors in reservoirs and rivers [20-32] and rivers such as water quality [33, 34], sedimentation [35, 36], hydroelectric power generation [37], climate change [38-43], and environmental factors [44] and so on. By applying project control methods, actions can be taken in order to plan more accurate execution time, utilization and maintenance of the dams.

Materials and Methods

Reservoir dams, which are one of the achievements of water management in order to control resources, have a lot of functions and in addition to storing and preventing waste of water and supplying water to various agricultural and drinking areas, as well as controlling floods and its devastating damage to farms and facilities are used. One of the most important outcomes of the construction of reservoir dams is the use of capacity of reservoir water and the lake behind the dam for the construction of watery power station. The construction of dams will minimize human and financial losses due to flood events.

Case study

Kahir Concrete dam is located in the province of Sistan and Balouchestan in the south-east of Iran and in the north of the Oman Sea and includes the Kahir basin and the Down plain of it. The geographical coordinates of the dam are 25 degrees and 38 minutes north latitude and 60 degrees and 09 degrees east longitude. The basin of the Khair River is about 4596 km^2 aeria, its highest point of which is about 2110 m above sea level. The purpose of the construction of Kahir in addition to being a reservoir but also supplies drinking water for cities of Konarak and Chabahar, and also to supply the required agricultural water for the lands of the Kahir plain at the down of the dam's position and to provide water for the preservation of the Kahir aquifer. In this regard, the following specific data can be cited:

- Drinking water supply: 20 million cubic meters per year
- Irrigation water supply: 53 million cubic meters per year in the first 25 years and 30 million cubic meters per year in the second 25 years
- Water supply to maintain aquifer: 5 million cubic meters per year

Methodology

Distributed questionnaire details:

After distributing the questionnaire, the results of the questionnaire were extracted and analyzed between the managers and experts involved in the dam construction projects. The questionnaire was distributed among 45 project control experts.

Figure 1: Locating the Kahir Reservoir Dam

Table 1: Distribution tables for questionnaires

Frequency distribution of working experience

Percentage	working experience
% 6.67	Less than 5 years
%26.67	Between 5 and 10 years
%35.55	10 to 15 years
%31.11	above 15 years old

Frequency distribution of "position" samples

Percentage	position
%17.78	Employer
%17.78	Consultant
%64.44	Contractor

Marital status of the samples

Percentage	Options
%51.11	single
%48.89	married

Sex of samples

The cumulative percentage	Options
%15.55	woman
%84.45	man

Frequency distribution of educational level of samples

Percentage	Level of education
%13.33	Less than bachelor
%33.33	bachelor
%42.22	master
%11.12	PhD

Hypotheses

Assumption 1: Using the CCPM method improves dam project management.

1. The results from of data collection and analysis of data from the implementation of dam construction projects are effective in decision making of managers.
2. The consulting company in taking Quick corrective measures Dam construction projects have been successful.
3. The contractor company in taking actions Quick Correctional Dam construction projects have been successful.
4. Paying attention to the time schedule is important for the consulting company in finishing the dam project.
5. Paying attention to the time schedule is important for the Contractor company when finishing the dam project.
6. The use of modern management methods and new tools the managing dam construction projects is very important.

Assumption 2: Using the CCPM method is in the direction of the management of sustainable development of the dam construction project.

7. The rate of success of the completion of projects is evaluated according to the timetable specified objectives.
8. In the implementation of dam construction projects, the time schedule is more important than the costs.
9. Time objectives are more important than the quality objectives at the completion of dam construction projects.
10. The managers' view of dam construction projects is in line with sustainable development.

Assumption 3: The use of CCPM method in the dam construction project has economic advantages.

11. in dam construction projects, the usual scientific methods and techniques are used in budgeting.
12. Considering the limited resources and numerous projects the employers have been successful in allocating budget for different dam construction projects.
13. Considering the limited resources and numerous projects the contractors have been successful in allocating budget for different dam construction projects.
14. The employer company (local water and sewage and water) in allocating budget for each of dam construction project activities must follow the timetable.
15. Making money from dam construction project is the main goal of the implementation of such projects

Assumption 4: The disadvantages of using CCPM method in dam construction method are greater than its disadvantages.

16. Dam construction projects have been successful in early design of projects and also in following technical standards.
17. The completion time of dam construction projects is more important than its completion cost.
18. The contractor and the main employer are rigid in selecting sub-contractor in connection with timetable.

Sociological inferential analysis of samples

SPSS software: One of the most famous software for researching in the fields of engineering is SPSS. SPSS is a statistical software which enable its users to analyze the required data accurately in a short time. The SPSS software is one of the most widely used practical program in the field of analyzing statistical data. It is also a complete and flexible statistical analyzer and is a data management system which is capable to get data from nearly all kinds of files in preparing practical reports and complex analyzing from combined processing of data.

F test: The first statistical test for general inferencing of a considered model is F test. In this test, the efficiency and effectiveness of the concurrent model variable are taken into account. The basis of this method is the zero hypothesis model. In this hypothesis the influence of all anticipated variables are denied. In this test, the probability of the confirmation and rejection of this hypothesis are considered.

H_0: None of the anticipated variables can influence on independent variables, in other words, all of the model coefficients don't have a meaningful difference with zero.

H_1: at least one anticipated variable influences on independent variable or in other words, at least coefficient of a variable has a meaningful difference with zero.

In this test, the value of F is compared with obtained F from the distribution table on the basis of the number of observation and the number of coefficient and also a specified meaningful level and if the calculated value of F will be greater than the value of F in the table in a specified meaningful level (a), the hypothesis of non-existent linear relation between dependant variable and independent variables (hypothesis H 0) or probability of (1-a) will be rejected.

T test: After the confirmation of desirability and efficiency of the concurrent variables by means of F test, in the next level, it comes to measuring the validity of each of model's coefficient separately. This point specially in relation to the model's coefficient with smaller amount of coefficients with smaller amount has attracted more attention, as the small amount of coefficients make doubt in the significance of that variables. The use of T test is presented which is presented which is the basis of the confirmation or rejection of the hypothesis will be zero. So in this hypothesis the influence of a specified anticipated one variable will be rejected.
H_0: The specified anticipated variable doesn't have any influence on dependant variable, in other words the coefficient of that variable doesn't have a meaningful difference with zero.

H_1: The specified anticipated variable has influence on dependent variable, in other words the coefficient of that variable has a meaningful difference with zero.

In order to do this test, the T model statistics and T statistics obtained from the distribution table were compared together. In situations where the obtained absolute value of T model is greater than the value of tc obtained from the distribution table, hence the hypothesis of non-influence of specified variable on dependant variable or the non-existence of meaningful difference of coefficient with zero will be rejected.

The statistical population

The statistical population of this research includes managers, experts and engineers involving in dam construction projects, who are directly or indirectly are in contact with the projects of this section and have appropriate information about project planning methods. For this purpose, a questionnaire was arranged and then distributed among the statistical society. Various methods are used to determine the sample size in the researchs. Cochran formula is one of the most widely used methods for calculating the sample size.

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N}\left(\frac{z^2 pq}{d^2} - 1\right)} \quad \text{Eq (1)}$$

In the above formula: n: sample Volume, N: Statistical population Volume , Z: the value of the normal variable of the standard unit, p: the proportion of the population with a certain characteristics , $q = (1-p)$: The proportion of the population without a specific characteristics, d: the allowed value of the error or error rate, Z: is the variable value of the normal unit of the standard unit with a 95% confidence level Equals 1.96, d: Allowed error value is usually equals 0/01 or 0/05, P: The values of p and q, which, if not available, can be considered as 0.5, and In this case, the variance reaches its maximum value.

According to the above formula, if we are asked to have which sample size with a population gap of 0.5, that means half of the population has a specific characteristic. In this regard, according to the complete statistical population of the research, about 50 research subjects, the sample size is equals 44.3438914027, which is calculated with a 5% error rate of 45 people selected in accordance with the Morgan table.

Survey of the validity of the information gathering tool

In general, the purpose of the validity is that the measurement device can actually measure the desired attribute, not the other variable. If the measurement tool is inadequate in terms of the feature, the research results will be worthless. The most famous validity Coefficient is through Cronbach's one-time execution of the provided, which is known as the Cronbach Alpha coefficient. This method is used to calculate the internal coordination of the measurement tool, such as the questionnaire. This questionnaire consists of questions and is answered based on the five-scale Likert spectrum will be answered. In this questionnaire, in this questionnaire, responses to the five-choice Likert scale have been used: (I totally agree, agree, not agree, not oppose, disagree, totally disagree)

Reliability

Reliability deals with this issue that if the measuring tool is administered on short certain intervals on a single group several times, the obtained results should be nearly the same as others. In order to measure reliability, we use a so-called reliability coefficient index. The range of reliability coefficient is from zero to 1. The reliability of zero means there is no reliability and the reliability of one equals to complete reliability. There is rarely no complete reliability, and if there is complete reliability, we can doubt about the results. In order to calculate the reliability coefficient of measuring device, various methods are used. The SPSS software is one of the widely used software which is used to determine the reliability.

Results and Discussion

In this research, using statistical population selection and then preparing and distributing the questionnaire, we have prepared necessary data for performing statistical operations. After that, SPSS statistical software was used to analyze the results of the questionnaire.

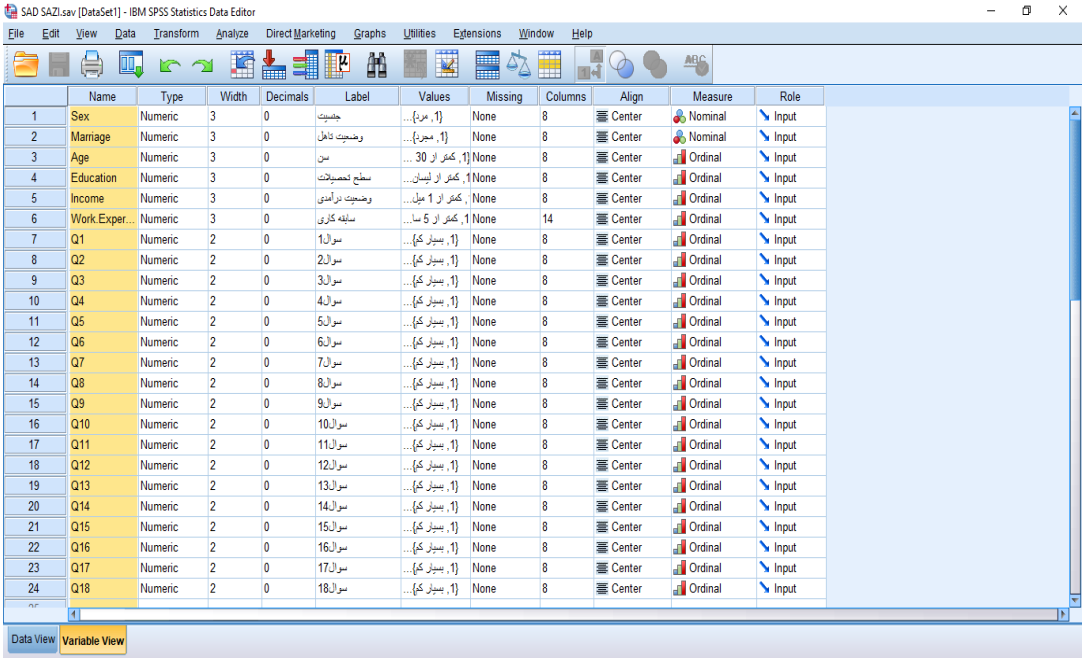

Figure 2: Modeling of the project in SPSS software environment

Kolmogorov-Smironov Test: In order to see if the views are well-suited to the normal level, and what kind of rules and a parametric or nonparametric test are used to analyze the data, the normal test was performed based on the Kolmogorov-Smirnov test.

Table 2: Kolmogorov-Smirnov test

Coping Style Scales	p-value	result
Improvement of dam construction project management	0/66	Normal
Sustainable Development Management Project	0/49	Normal
Economic advantages of dam construction project	0/51	Normal
Advantages and disadvantages of dam construction project	0/64	Normal

In all of the variables of the research, the value of p-value than Significant level is more 0.05. Therefore, it is concluded that the distribution of the statistical population of the research variables was normal. Therefore, nonparametric tests have been used to investigate the normal results of research hypotheses.

Descriptive and inferential statistics of research hypotheses:

Hypothesis 1: The use of the CCPM method improves the management of the dam construction project. (H0) The use of the CCPM method does not improve the management of the dam construction project. H1 The use of the CCPM method improves dam construction project management.)

Table 3: Variable t-test statistics

meaningful level	Degree of freedom df	Number of N	Critical value t	t m	Variables
Dam construction project management	9.858	1.96	45	44	0.05

Since t is calculated (t = 9.858), the confidence level is 95% (α = 0.05) and the degree of freedom is 44 more than from t the critical table (1.96 = t).Therefore, with 95% confidence, the conclusion is that the H0 hypothesis, that is, the use of the CCPM method, improves the management of the dam construction project, is rejected, and the assumption of the H1 study, that is, the use of the CCPM method, improves the management of the dam construction project, is confirmed.

Second hypothesis: Using the CPM in the direction of approach to manage the sustainable development of the dam construction project.

Table 4: Univariate t test statistics

Variables	t_m	Critical value t	Number of N	Degree of freedom df	meaningful level α
Sustainable Development Management	9/107	1.94	45	44	0/05

Because t calculated (t = 9.107) at 95% confidence level (α = 0.05) and the degree of freedom is 44 more than from the critical table t (1.94 = t), therefore, the H0 hypothesis uses the CCPM approach does not for manage the sustainable development of the dam construction project, reject and the H1 hypothesis, that is, the use of the CCPM approach to manage the sustainable development of the dam construction project, is confirmed.

Hypothesis 3: The use of the CCPM method in a dam construction project has economic advantages. (H0) The use of the CCPM method in the dam construction project does not have economic advantages. H1 the use of the CCPM method in the dam construction project has economic advantages.)

Table 5: Univariate t test statistics

Variables	t_m	Critical value t	Number of N	Degree of freedom df	meaningful level α
Economic Advantages	9.638	1.91	45	44	0/05

Since t is calculated (t = 9.938), the confidence level is 95% (α = 0.05) and the degree of freedom is 44 from the critical table more than t (1.91 = t), and the H1 hypothesis, the use of the CCPM method in the dam construction project, has economic advantages is confirmed.

Hypothesis 4: Advantages of using the CCPM method in dam construction project are more than its disadvantages. (H0) The advantages of using the CCPM method in the dam construction project are no more than its disadvantages. H1 the advantages of using the CCPM approach in the dam construction project are more than its disadvantages.

Table 6: Two-variable t-test statistics

Variables	t_m	Critical value t	Number of N	Degree of freedom df	meaningful level α
Advantages and disadvantages of dam construction project	9.075	1.95	45	44	0/05

Since t is calculated (t = 0.975), the confidence level is 95% (α = 0.05) and the degree of freedom is 79 from the critical table more than t (1.95 = t). H0 hypothesis. The advantages of using the CCPM method in the dam construction project, more than its disadvantages, are rejected,and the H1 hypothesis supports the advantages of using the CCPM method in the dam construction project, more than its disadvantages, Confirmed.

Conclusion

The optimal and sustainable use of water resources in the development and development programs of a country is of particular importance. The Build and operation of any construction project, such as reservoir dams, with undeniable positive effects, usually results in unwanted and inevitable effects on the environment and the economic and social characteristics of a region. But what should not be forgotten is that at present, the best way to supply drinkable water to dry and semi-arid countries like Iran is damming. In this research, inferential analyzes of the society were presented with examples and hypotheses. The results show the benefits of using the CCPM approach to control construction projects, especially in dam construction projects. Considering the issues studied in this study, it is recommended to study the impact of the CCMP method on damming project management in other dams and other infrastructure projects.

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