INVESTIGATING THE IMPACT OF THE CORONAVIRUS CRISIS ON THE COST MANAGEMENT OF CONSTRUCTION PROJECTS

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Abstract

The present study investigates the impact of the Coronavirus crisis on the cost management of construction projects. The present study is applied in terms of aim, descriptive and survey in terms of method, and cross-sectional in terms of time. The statistical population of this study included companies that have a portfolio of construction projects with a budget of over 2000 billion Rials. Based on the number of construction projects in the province, and based on the stratified sampling type, 30 projects were selected from interurban, center, and suburban of Isfahan province. A questionnaire was used as a data collection tool in this study. Calculations and analysis were done in Spss Software, and the level of significance for all tests was considered at $p > 0.95$. To identify the causes of the damages caused by the outbreak of the disease to control this crisis, to determine the damages and prevent the increase of costs, prioritizing the damages and classifying the problems were studied. The results related to the cost indicated that in terms of importance, a delay in payments was ranked first; an increase in the price of raw materials was ranked second, and the personnel commuting cost was ranked third. Since the level of significance in the variables of delay in payments (with a correlation coefficient of 0.551), bank formalities and closures (with a correlation coefficient of 0.506), public holidays with a correlation coefficient of (0.446), and observing the protocols (with a correlation coefficient of 0.484) is less than 0.05, these variables increase the cost of projects.

Keywords: Cost management, Construction projects, Delay in payments, an increase in material price

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Introduction

The Covid-19 crisis has been considered a global pandemic by the World Health Organization (WHO). This crisis in different countries and regions is considered a great threat to the health of people's lives. This crisis has put unprecedented pressure on the health and treatment systems and the work system of countries and people [1]. The outbreak of the Covid-19 virus in the world has caused various impacts on one of the most significant economic systems in the world, namely the construction industry and construction projects [2]. Given the unknown characteristics of the virus and the conditions of great uncertainty, it is not possible to consider an exact time for the end of this crisis. Hence, it is very valuable to examine the impact of this crisis management [3].

In an article entitled "The role of engineers of engineering system organizations in the management of natural disasters", Asghari et al. examined crisis management during natural disasters. The mentioned study aimed at enhancing public knowledge and awareness to gain a correct understanding of natural events to predict, prevent, and cope with them rationally and rightly [4]. In their article entitled "The role of crisis management to prevent crisis in management during an earthquake", Rezvani et al. investigated how to act during an incident such as an earthquake. The study aimed at determining the exact planning path for specific organizational preparation during the occurrence of natural events (especially earthquakes) to guarantee and stabilize society using strategic management to minimize human and financial losses caused by earthquakes [5]. Ashtiani et al. investigated crisis

management based on the creation of a safe space in buildings with a passive defense approach to manage the crisis caused by the enemy [6].

Zhou et al. conducted a study on the construction time, cost, and test data of a prefabricated isolated medical unit for COVID-19. Considering construction during the blockade in Shenzhen (and in China), the cost and time of construction can provide valuable information and guidance for the construction or development of appropriate medical facilities for COVID-19 patients [6]. In a study entitled "Crisis management, an opportunity to reduce damages and costs caused by earthquakes", Mirkalaei et al. emphasized that crisis management requires prevention, planning, testing, evaluation, and maintenance to reduce and minimize its consequences [7]. Considering his practical observations, Hallgren et al acknowledged that the uniqueness of the project depends on the proper management of all the problems that delay the progress of the project and disturb its order. The mentioned article aimed at investigating the nature of the crisis and the methods that have disrupted the progress of the project of an international construction company [8]. Sahim et al. investigated the approaches and process of identifying crisis signals and factors that help companies to control the crisis and continue their life without huge financial losses [9]. It is less likely when effective communication is significant, when mutual sensitivity among project members is significant, and when collective responsibility and teamwork are significant. This article presented practical recommendations for project managers working in hostile environments or crisis-prone organizations [10].

Tang et al. explained an agreed price and stated that the existence of an agreed price reduces the conflicts and differences between the involved parties. However, reducing the costs of the project has remained an unsolved problem [11]. In a study entitled "The financial crisis management solutions in controlling the cost of construction projects" Haghighi et al. examined the weakness of cost control planning and budgeting of activities. Their study aimed at investigating the efficient use of budget and cost reduction in construction projects to make realistic predictions about the allocated budget. Construction projects are very significant in the economic system and budgeting of the country [12]. A major part of the country's national income is spent annually on investing in construction projects and infrastructure. However, owing to several problems, sometimes we should manage the financial crisis, and these projects are mostly completed by spending more than the approved budget.

Some of the causes resulting in spending more than the approved budget are wrong estimates of the resources and cost needed to do the work, weakness in planning cost control and budgeting of project activities, weakness in controlling the cost performance of the project, and in general weakness in managing and controlling the project cost [13]. Mirzaei et al. considered an aspect of crisis management that highlights the dependencies and the need to take them seriously, considering the structural effort of the earth and the scientific growth of the world in using the adaptation of dreams to establish their vision by structural or construction engineering [14]. Large sums of money are spent on projects in Iran annually. However, owing to the problems, these projects are completed by spending more time and money than their approved time and money. A better view of the control of project costs can be obtained by identifying and accurately evaluating the factors that affect the cost in each of the work areas of the project. It is possible to prevent the cost increase in the projects, the deficit in the project budget, the possible stoppage of the project, and the failure of the project goals by prioritizing the factors affecting the cost and considering the corrective solutions timely. Prioritizing factors will facilitate the speed of reaction to possible risks and the management of appropriate changes. Based on the stakeholders, the project follows three significant goals, called triple goals [4]. Accordingly, the present study aims at investigating the impact of the Coronavirus crisis on the cost management of construction projects.

Methods

The present study is applied in terms of aim, descriptive and survey in terms of method, and cross-sectional in terms of time. The statistical population of this study included the companies that have a portfolio of construction projects with a budget of over 2000 billion Rials. Based on the number of construction projects in the province, and based on the stratified sampling type, 30 projects were selected from interurban, center, and suburban of Isfahan province. To confirm the face and content validities, an interview was conducted with 6 experts and professors of the construction project management group to get their expert opinions on how to write the

questions, the number of questions, the content of the questionnaire, the relationship between the questions and the options, and the coordinate the questions with research objectives.

After reviewing and considering the opinions and suggestions, the final questionnaire was developed and submitted to the statistical sample of the study. To determine the reliability (internal consistency) of the questionnaire, the reliability of the questionnaire was calculated at 0.745 using Cronbach's alpha formula. In this study, two library and field methods were used to collect data. The library method was used to write the literature and theoretical sections of the thesis. In the field method, 30 construction projects in Isfahan province were used to collect the required data from the statistical population. Based on the statistical population, 30 questionnaires were collected for analysis to collect the data needed to analyze the research hypotheses. Calculations and analysis were done using Spss Software and the level of significance for all tests was considered at the $p > 0.95$.

Results

The results revealed that the frequency of the subjects aged 25 and 30, 30 and 40, between 40 and 50, and above 50 years is 7, 11, 6, and 6, respectively. The frequency of subjects with bachelor's, master's, and Ph.D. degrees is 17, 10, and 3, respectively. The frequency of the subjects with an employment history of below 5, between 5 and 10, between 10 and 20, between 20 and 30, and between 30 and 40, is 1, 9, 10, 7, and 3, respectively. The frequency of subjects with project manager, workshop manager, CEO, contractor, technical expert, supervisor, and employer is 5, 4, 4, 1, 6, 2, and 8, respectively. The frequency of subjects with direct construction and indirect construction activities is 28 and 2, respectively. The frequency of subjects with government, semi-government, and private projects is 8, 8, and 14, respectively. Regarding the project site, 15, 3, and 12 subjects, respectively, were working in interurban, center, and suburban areas. The frequency of subjects who are responsible for project management is 20 with a percentage of 66.7 and the frequency of people who are not responsible for project management is 10 with a percentage of 33.3. The frequency of subjects who have low, moderate, high, and very high knowledge of project scheduling is 1, 7, 11, and 11, respectively.

Table 1: Descriptive statistics and ranking of the impact of the coronavirus on increasing the cost of construction projects

	Sample size	Mean	SD	Min	Max	Rank
Delay in payments	30	3.87	1.07	1	5	4.92
Percentage of increase in the price of raw materials	30	3.56	1.25	1	5	4.55
Personnel transportation costs	30	3.5	1.11	1	5	4.5
Observing the protocols	30	3.5	1.01	1	5	4.42
Banking and administrative formalities and closures	30	3.63	0.99	2	5	4.32
Coronavirus public holidays	30	3.27	0.94	1	5	3.87
Prohibition of intercity traffic	30	3.03	1.09	1	5	3.55
Implementation of night projects	30	2.23	1.25	1	5	2.43
Approximate percentage of increase in project cost	30	3.23				

Based on Table 1, the delay in payments with a mean rank of 4.92 was ranked first, the increase in the price of raw materials with a mean rank of 4.55 was ranked second, the cost of personnel commuting with a mean rank of 4.5 was ranked third, observing protocols with a mean rank of 4.42 was ranked fourth, banking and administrative formalities and closures with a mean rank of 4.32 was ranked fifth, coronavirus

public holidays with a mean rank of 3.87 was ranked sixth, prohibition of intercity traffic with a mean rank of 3.55 was ranked seventh, and the implementation of night projects with a mean rank of 2.43 was ranked eighth in terms of importance. Given a mean of 23.3 for the approximate percentage of the increase in the cost of projects, an increase of 40-80% in the cost of the project was estimated.

Table 2: Summary of the results of the non-parametric test of the coronavirus on the increase in the cost of construction projects

N	30
Chi-square	23.461
Degree of freedom	3
Sig	0.001

Table 2 shows that the significance level of 0.001 and is less than 0.05. Thus, the order of importance for the components has a significant difference.

Table 3: Descriptive statistics of the impact of the coronavirus on increasing the cost of construction projects in the interurban and center of the city

	Sample size	mean	Median	SD	Min	Max	Rank
Delay in payments	18	3.89	4	0.76	3	5	4.67
Observing the protocols	18	3.77	4	1.01	2	5	4.61
Personnel commuting costs	18	3.67	4	1.08	2	5	4.47
Percentage increase in the price of materials	18	3.14	4	0.47	3	5	4.45
Prohibition of intercity traffic	18	3.28	4	1.04	1	5	3.97
Banking and administrative formalities and closures	18	3.56	3.5	0.89	2	5	3.92
Coronavirus public holidays	18	3.22	3.5	0.98	1	5	3.58
Implementation of night projects	18	2.56	2	1.42	1	5	2.78
Approximate percentage of increase in project cost	18	3.12					

Table 3 shows that delay in payments with a mean rank of 4.67 was ranked first, observing the protocols with a mean rank of 4.61 was ranked second, the personnel commuting cost with a mean rank of 4.47 was ranked third, an increase in the price of raw materials with a mean rank of 4.45 was ranked fourth, prohibition of intercity traffic a mean rank of 3.97 was ranked fifth, banking and administrative formalities and closures with a mean rank of 3.92 was ranked sixth, coronavirus public holidays with a mean rank of 3.58 was ranked seventh, and the implementation of night projects with a mean rank of 2.87 was ranked eighth in terms of importance. Given the mean of 3.12 for the approximate percentage of increase in project cost, an increase of 40-80% in the cost of the project was estimated.

Table 4: Summary of Friedman's non-parametric test results related to the cost of intercity projects

N	18
Chi-square	15.086
Degree of freedom	6
Sig	0.02

Table (4) shows that the significance level is 0.001 and is less than 0.05. Thus, the order of importance for the components has a significant difference.

Table 5: Descriptive statistics of the effect of the coronavirus on the increase in the cost of construction projects in suburban areas

	Sample size	mean	Median	SD	Min	Max	Rank
Delay in payments	12	3.83	4	0.99	2	5	6.92
Banking and administrative formalities and closures	12	3.75	4	0.96	2	5	6.67
Personnel commuting costs	12	3.25	3.5	1.13	1	5	5.96
Coronavirus public holidays	12	3.33	3	0.90	2	5	5.88
Observing the protocols	12	3.08	3	0.91	1	4	5.58
Prohibition of intercity traffic	12	2.66	3	1.03	1	5	4.21
Implementation of night projects	12	1.75	2	0.83	1	5	2.71
Percentage of increase in the price of materials	12	1.75	2.5	1.48	1	5	2.66
Approximate percentage of increase in project cost	12	1.92					

Based on Table 5, delay in payments with a mean rank of 6.92 was ranked first, banking and administrative formalities and closures with a mean rank of 6.67 was ranked second, personnel commuting costs with a mean rank of 5.96 was ranked third, coronavirus public holidays with a mean rank of 5.88 was ranked fourth, observing the protocols with a mean rank of 5.58 was ranked fifth, prohibition of intercity traffic with a mean rank of 4.21 was ranked sixth, the implementation of night projects with a mean rank of 2.71 was ranked seventh, and the increase in the price of raw materials with a mean rank of 2.66 was ranked eighth in terms of importance. Given the mean of 1.92 for the approximate percentage of the increase in the cost of projects, an increase of 0-40% in the cost of the project is estimated.

Table 6: Summary of Friedman's non-parametric test results related to the cost of projects in suburban areas

N	12
Chi-square	38.02
Degree of freedom	8
Sig	0.001

Table 6 shows that the significance level is 0.001 and is less than 0.05. Thus, the order of importance for the components has a significant difference.

Table 7: Descriptive statistics of the impact of the coronavirus on increasing the cost of government construction projects

	Sample	mean	Median	SD	Min	Max	Rank

	size						
Personnel commuting costs	8	3.88	3.5	1.13	1	5	6.94
Delay in payments	8	3.88	4	0.99	2	5	6.63
Observing the protocols	8	3.75	3	0.91	1	4	6.56
Banking and administrative formalities and closures	8	3.75	4	0.96	2	5	5.81
Coronavirus public holidays	8	3.5	3	0.90	2	5	5.75
Prohibition of intercity traffic	8	2.87	3	1.03	1	5	4.56
Percentage of increase in the price of raw materials	8	2.88	2.5	1.48	1	5	3.88
Implementation of night projects	8	1.75	2	0.83	1	5	2.25
Approximate percentage of increase in project cost	8	1.75					

Based on Table 7, the personnel commuting cost with a mean rank of 6.94 was ranked first, delay in payments with a mean rank of 6.63 was ranked second, observing the protocols with a mean rank of 6.56 was ranked third, banking and administrative formalities and closures with a mean rank of 5.81 was ranked fourth, coronavirus public holidays with a mean rank of 5.75 was ranked fifth, prohibition of intercity traffic with a mean rank of 4.56 was ranked sixth, an increase in the price of raw with a mean rank of 3.88 was ranked seventh, and the implementation of night projects with a mean rank of 2.25 was ranked eighth in terms of importance. Given the mean of 1.75 for the approximate percentage of increase in the cost of projects, an increase of 0-40% in the cost of the project is estimated.

Table 8: Summary of Friedman's non-parametric test results related to the cost of government projects

N	8
Chi-square	32.770
Degree of freedom	8
Sig	0.001

Table 8 shows that the significance level is 0.001 and is less than 0.05. Thus, the order of importance for the components has a significant difference.

Table 9: Descriptive statistics of the effect of the coronavirus on the increase in the cost of semi-governmental construction projects

	Sample size	mean	Median	SD	Min	Max
Delay in payments	8	3.75	0.99	2	5	6.56
Banking and administrative formalities and closures	8	3.62	0.96	2	5	6.25
Observing the protocols	8	3.5	0.91	1	4	5.75
Prohibition of intercity traffic	8	3.25	1.03	1	5	5.65
Personnel commuting costs	8	3.38	1.13	1	5	5.69
Implementation of night projects	8	3.13	0.83	1	5	5.31

Coronavirus public holidays	8	3.13	0.90	2	5	5.13
Percentage of increase in the price of raw materials	8	1.63	1.48	1	5	1.63
Approximate percentage of increase in project cost	8	2				

Based on Table 9, delay in payments with a mean rank of 6.56 was ranked first, banking and administrative formalities and closures with a mean rank of 6.25 were ranked second, observing the protocols with a mean rank of 5.75 was ranked third, prohibition of intercity traffic with a mean rank of 5.69 was ranked fourth, the cost of personnel commuting with a mean rank of 5.69 was ranked fifth, the implementation of night projects with a mean rank of 5.31 was ranked sixth, coronavirus public holidays with a mean rank of 5.13 was ranked seventh, and an increase in the price of primary raw materials with a mean rank of 1.63 was ranked eighth in terms of importance. Given the mean of 2 for the approximate percentage of the increase in the cost of projects, an increase of 20-40% increase in the cost of the project is estimated.

Table 10: Summary of Friedman's non-parametric test results related to the cost of semi-government projects

N	8
Chi-square	24.679
Degree of freedom	8
Sig	0.001

Table 10 shows that the significance level is 0.001 and is less than 0.05. Thus, the order of importance for the components has a significant difference.

Table 11: Descriptive statistics of the effect of the coronavirus on the increase in the cost of private construction projects

	Sample size	Mean	SD	Min	Max	Rank
Delay in payments	14	3.93	0.99	2	5	6.86
Banking and administrative formalities and closures	14	3.64	1.08	2	5	6.39
Coronavirus public holidays	14	3.57	0.93	2	5	6.11
Personnel commuting costs	14	3.43	1.02	1	5	5.89
Observing the protocols	14	3.36	1.01	1	4	5.39
Prohibition of intercity traffic	14	3	0.78	1	5	4.68
Percentage of increase in the price of raw materials	14	2.71	1.44	1	5	4
Implementation of night projects	14	2.36	1.22	1	5	3.46
Approximate percentage of increase in project cost	14	2				

Based on Table 11, delay in payments with a mean rank of 6.86 was ranked first, bank and administrative formalities and closures with a mean rank of 6.39 was ranked second, coronavirus public holidays with a mean rank of 6.11 was ranked third, personnel commuting cost with a mean rank of 5.89 was ranked fourth, observing the protocols with a mean rank of 5.39 was ranked fifth, prohibition of intercity traffic with a mean rank of 4.68 was ranked sixth, an increase in the price of raw materials with a mean

rank of 4 was ranked seventh, and the implementation of night projects with a mean rank of 3.46 was ranked eighth in terms of importance. Given the mean of 2 for the approximate percentage of the increase in the cost of projects, an increase of 0-40% in the cost of the project is estimated.

Table 12: Summary of non-parametric test results of the increase in the cost of private construction projects

N	14
Chi-square	41.145
Degree of freedom	8
Sig	0.001

Table 12 shows that the significance level is 0.001 and is less than 0.05. Thus, the order of importance for the components has a significant difference.

The impact of different factors on the cost

According to the answers of experienced managers, some participants' answers to the impact of different factors on the cost are mentioned as follows:

1-An increase in the price of materials (inflation and lack of timely financing cause an increase in cost) 2-The cost of observing the protocols 3-Overtime of personnel 4-Employing new forces 5-Overhead costs increased as the duration of the work increased.

2-It causes a delay in the project and consequently, it causes overhead costs, staff salaries, etc.

3-Health costs, such as the purchase of pandemic diagnosis equipment such as pulse oximeter, thermometer, oxygen generator, etc. Purchasing consumables such as masks, disinfectant solutions for surfaces and hands, purchasing high-quality and healthy food, the cost of performing tests for employees daily, and monthly sick leave of staff

4. Given the existing restrictions on transportation, procurement of materials, and barriers to the simultaneous use of labor force, due to the need to observe social distancing.

5- Increase in the price of raw materials and wages

6-The closure of factories and the lack of supply of materials and the high cost of materials increase the cost of the project

7-Closures of businesses and the peak of the disease and the involvement of the forces with Coronavirus

8-1-An excessive increase in the cost of materials 2- Lack of experienced labor force 3- Holidays during quarantine 4- Intercity traffic restrictions 5- Preparation of masks and disinfectants

9. Given the economic issues and the increase in the price of required materials, the wages of executive and specialized agents, the lack of timely provision of money and credits by employers, and the lack of required labor force in some suburban areas.

10- 1-Penalties for the delay in delivery time 2-Increase in cost due to payment of salaries and non-delivery of work from the labor force (costs remained constant or increased but production was greatly reduced) 3-Cost of observing the protocols and services and...

11- 1-Frequent closures and holidays 2-Severe inflation increase due to coronavirus disease 3-Limited contractors 4-Lack of timely vaccination.

12- The closure of shopping centers, increasing the commuting cost, reducing the financial strength of the employer

13. The lengthening of the project time has led to a delay in the delivery of the project, resulting in an increase in project costs due to the existing inflation.

14. The increase in project time will increase the cost of personnel, but the contract amount will remain the same.

Conclusion

The results related to the causes of the increase in the cost of construction projects revealed that a delay in payments, an increase in the price of raw materials, the cost of personnel commuting, observing the protocols, banking and administrative formalities and closures, coronavirus public holidays, prohibition of intercity traffic, and implementation of night projects were ranked first to eighth, respectively, in terms of importance. The cost of these projects has increased by approximately 40-80%.

The results related to the causes of the increase in the cost of construction projects inside and in the center of the city showed that delays in payments, observing the protocols, the cost of personnel commuting, the increase in the price of raw materials, prohibition of intercity traffic, bank and administrative formalities closures, coronavirus public holidays, and implementation of night projects were ranked first to eighth, respectively, in terms of importance. The cost of these projects

has increased by approximately 40-80%.

The results related to the causes of the increase in the cost of construction projects in suburban areas revealed that delays in payments, bank, and administrative formalities and closures, personnel commuting costs, coronavirus public holidays, observing the protocols, prohibition of intercity traffic, implementation of night projects, and the increase in the price of primary materials were ranked first to eighth, in terms of importance. The time of these projects has increased by approximately 0-40%. The cost of these projects has increased by approximately 0-40%.

The results related to the causes of the increase in the cost of semi-government construction projects revealed that delays in payments, bank, and administrative formalities and closures, observing the protocols, prohibition of intercity traffic, personnel commuting costs, implementation of night projects, coronavirus public holidays, and the increase in the price of raw materials were ranked first to eighth, respectively, in terms of importance. The cost of these projects has increased by approximately 20-40%.

The results related to the causes of the increase in the cost of private construction projects revealed that delays in payments, banking and administrative formalities and closures, coronavirus public holidays, personnel commuting costs, observing the protocols, prohibition of intercity traffic, an increase in the price of raw materials, and implementation of night projects were ranked first to eighth, respectively, in terms of importance. The cost of these projects has increased by approximately 0-40%.

Since the level of significance in the variables of delay in payments, bank formalities and closures, public holidays, and observing the protocols is less than 0.05, these variables increase the cost of projects. However, the variables of implementation of night projects and prohibition of intercity traffic and personnel commuting costs do not increase the cost of projects.

Regarding the impact of factors in increasing the cost of the projects, based on the answers of the managers, these factors can be mentioned: 1-An increase in the price of raw materials 2-Increasing the duration of the project causes an increase in the overhead cost 3-Observing the protocols 4-Penalty for project delays 5-Cost of contractors and new forces

According to the answers of the managers, the following solutions can prevent the increase in the cost of the projects: 1- Observing the protocols 2-Personnel training 3- Vaccination 4- Increasing contractors 5- Providing surplus liquidity 6-Having alternative forces

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