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Assessment of the Cost and Time Impact of Variation Orders on Construction Projects in Sulaimani Governorate

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ABSTRACT

Variation orders are an on-going phenomenon in construction and industry projects worldwide, particularly in the province of Sulaimani, where the project's damage from cost and schedule overrun because of variation orders. However, the effect on project costs and time overrun of variation order has yet to be identified. This study evaluates the impact of variation orders on the cost and time off in the Sulaimani governorate. Two hundred twenty-eight projects from various construction sectors built between 2007-2012 were adopted to calculate the contract cost and schedule overruns due to variation orders. Data analysis was applied in the study were descriptive statistics. One-way ANOVA was also applied to determine whether the overrun of project cost and schedule significantly varied depending on project type, size, duration, location, and awarded years. The findings indicated that cost overruns are very common due to variation orders. 95.6% of the projects were studied being impacted, and overrun in project cost are also huge, with 16%. Time also overruns more common than cost overruns due to the variation orders. 98.7% of the projects were studied in Sulaimani were affected by time overrun with an average of 46.3% of initial duration observed. Findings also indicated that two out of five parameters measured in the analysis had a significant correlation with project cost overruns. Three out of five considered variables correlated with construction time overruns.

Keywords: Construction projects, Cost overrun, Time overrun, Variation orders

تقييم الآثار التكلفة والزمنية اوامر التغيير على مشاريع البناء في محافظة السليمانية

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الخلاصة

تعتبر اوامر التغيير ظاهرة دائمة في مشاريع وصناعات البناء في جميع أنحاء العالم وخاصة في محافظة السليمانية حيث تلحق مشاريع البناء والصناعات الضرر من التكلفة وتجاوز الجدول الزمني بسبب اوامر التغيير. بيد أن تأثير التغيرات في

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المشاريع على تكاليف المشروع وتجاوز الوقت لم يتحدد بعد. هذه الدراسة تقيم تأثير أوامر التغيير على تكلفة المشاريع والوقت في محافظة السليمانية. واعتمد 228 مشروعاً من مختلف قطاعات البناء التي شيدت خلال الفترة 2007-2012 لحساب تكلفة العقد والتجاوزات في الجدول الزمني بسبب أوامر التغيير. وأشارت النتائج إلى أن تجاوزات التكاليف شائعة للغاية بسبب أوامر التغيير، حيث تم دراسة 95.6% من المشاريع التي تم دراستها، كما أن تجاوز تكلفة المشروع ضخماً مع متوسط 16% تم تجربته. كما أن تجاوز الوقت أكثر شيوعاً من تجاوزات التكاليف بسبب أوامر التغيير، فقد تم دراسة 98.7% من المشاريع في السليمانية، حيث تأثرت التجاوز الزمني بمتوسط 46.3% من المدة الأولية التي تمت ملاحظتها.

الكلمات الرئيسية: مشاريع البناء، تجاوز التكلفة، تجاوز الوقت، أوامر التغيير

1. INTRODUCTION

By its nature, the construction project is a very complicated activity and requires specialized skills and achieve success (Aljanabei, D.M. and Erzaij, K.R., 2016). The complexity in building activities demonstrates that a whole project is rarely carried out without any design or building process variation. (Charoenngam, C. et al., 2003) defined variation orders or change orders as complex information that have to be managed wisely, if not disputes and claims between contractor and owner related to contract cost and schedule overrun. (Chan and Yeong, 1995) It asserted that variation orders frequently contributed to additional cost and interruption to previously underway works, leading to an overrun of cost and time. (Arian and Pheng, 2005a) indicated that the most occurrence effect of variations in projects is cost and schedule overrun because of additional work or change in design which is not incorporated before contract award. (Koushki et al., 2005) stated that the projects that suffered variation orders experienced more than 58% schedule delay and cost overrun compared to those projects not affected by variation orders. These cost and time overrun can occur for many various causes. Many of these causes can attribute to variation orders or scope changes (Serag, et al., 2010). In the Sulaimani government, where new infrastructure and buildings are constructed, the construction projects' occurrence of variation orders appears usual. Almost all of the projects in the Sulaimani government were delayed with a certain amount of the variation orders and increasing from the initial value of the contract amount due to frequent issued of variation orders. Due to the general background of the construction project's problem, there is a reason for a study to be made on the assessment of the cost and schedule effect of variation orders on construction projects in the Sulaimani government. The research quantitatively measures the proportion of overall project budget and duration overruns directly due to variation orders.

2. PREVIOUS STUDY

To better understand the research goal, a comprehensive review was carried out to identify the importance of variation orders as the most effective reasons for the cost and time overrun in construction projects and quantitative assessment of project cost and time overrun.

2.1 The Causes of Cost and Schedule Overrun

Various studies have listed variation orders among the reasons for construction project cost, and schedule overruns (Sterman, 1992) are prevalent in international construction. A major cause of a successful project is the completion of its contract amount and schedule. Cost overrun is a common international issue, but it is an important challenge in developing countries. Cost overrun is calculated as the deviation between the tender amount and the actual amount on completion. Several researchers identified the main reasons for project cost overruns in different countries. (Arditi, et al., 1985) conducted a study in Turkey construction projects to identify the main causes of cost overrun in construction projects. The findings indicated that the main reasons that contributed to cost overrun were increased material price, the fast growth of inflation, and change in design and specification. (Olawale YA and Sun M, 2010) performed research in the UK's



projects to uncover the most occurrence causes of cost overrun. Results showed that variation orders were the most important cause of cost overrun. In Israel, (Rosenfeld, Y. 2014) conducted a study and revealed that premature tender documents and too many variation orders by owner are the most effective causes of cost overrun. In terms of time overruns (Assaf, et al., 2006), schedule overrun or delay occurs in most construction projects, simple or complex projects.

Time overrun could be defined as the overrun beyond the initial contract completion date. (Amer, 1994) investigated schedule overrun problem in Egypt by analyzing the causes that initiate time overrun. This research indicated that the most influencing reasons for time overrun in Egypt projects were poor contract management, unrealistic scheduling, and variation orders during construction. (Chan and Kumaraswamy, 1997) assessed the importance of 83 causes of schedule overrun in Hong Kong, findings indicated that variation orders ranked in 4th position as the most influencing causes of time overrun. Depending on reviewed studies, it is clear that the most influential causes of cost and time overrun differ from country to country.

In contrast, some authors identified variation orders as the most influencing factor. Any other factors, such as unexpected conditions or existing facilities, might also require additional work that was not originally part of the project scope. And many other reasons that identified as the major causes of cost and schedule overrun may also lead to needing variation orders. So, it is essential to examine the effect of variation orders on the cost and schedule overrun. **Table 1.** presented the importance of variation order as the most influential reason for cost and schedule overrun in a different country.

Table 1. Variation orders ranking as the most important cause of time and cost overrun.

The rank of variation orders as the important cause of time overrun		
Author (Year)	Country	The rank of variation orders as the important cause of time overrun
(Assaf et al., 1995)	Saudi Arabia	3
(Chan and Kumaraswamy; 1997)	Hong Kong	4
(Kaming et al., 1997)	Indonesia	1
(Al-Moumani, 2000)	Jordan	2
(Koushki et al., 2005)	Kuwait	1
(El-Razak et al., 2008)	Egypt	3
(Kazaz et al., 2012)	Turkey	1
The rank of variation orders as the important cause of cost overrun		
Author (Year)	Country	The rank of variation orders as the important cause of cost overrun
(Arditi et al., 1985)	Turkey	3



(Omoregie A, 2006)	Nigeria	3
(Azhae et al., 2008)	Pakistan	4
(Olawale YA and Sun M, 2010)	UK	1
(Rosenfeld, Y, 2014)	Israel	2
(Bekr, G, A, 2016)	Jordan	2
(Abusafiya H.A., & Suliman, S. M, 2017)	Bahrain	1
(Jergeas GF and Ruwanpura J, 2010)	Canada	2

2.2 Quantitative Assessment of Project Cost and Time Overrun

Bad cost performance in construction was a very common problem worldwide and contributed to sustainable cost overruns (Al-Ageeli, H.K. and Alzobae, ASJA, 2016). Cost overrun due to variation orders are common and worldwide. Projects overrun their cost due to variation orders that may vary from country to country. (Flybjerg, et al., 2003) stated that nine projects out of ten mega infrastructure projects suffered cost overruns. Their findings indicated that all projects which were studied overrun their costs with an average of 28%. (Flybjerg, et al., 2004) also conducted another study on bridge and tunnel projects, results indicated that larger project size suffered a cost overrun by a larger amount. They also stated that projects with longer duration overrun their costs with a greater percentage. The study also indicated that public projects are more impacted by cost overrun than private projects. (Odeck, 2004) conducted a study on 620 projects implemented by Norwegian public road administration, findings showed that 52.5 percent of projects had overrun cost with an average of 7.88 percent. (Oladapo, 2007) reported that variations had a wonderful impact on both project cost and time overrun, accounting for around 79% and 68% of overrun costs and time, respectively. (Cantarelli, et al., 2012) conducted research with Netherland's projects, findings revealed that 38% of the projects overrun their initial contract amount with an average of -4.5%, it indicated that in Netherland projects tend to underrun their contract amount. (Shresta, et al., 2013) conducted a research on 236 transportation projects in the USA, results revealed that studied projects overrun their costs with an average of 3.23%. (Shehu, et al., 2014) investigated 359 projects in Malaysia and revealed that 55 percent of the projects is affected by cost overrun with an average of 2.08%, and 22.8% of the projects overrun their costs with an average of more than 10%. (Love, et al., 2014) conducted a study in Australia on 58 projects, the study revealed that the average of the project cost overrun was found to be 13.28%. In terms of time overruns (Ahsan and Gunawan, 2010) investigated 100 infrastructure projects in four Asian countries: India 20 projects, China 30 projects, Bangladesh 31 projects, and Thailand 10 projects. Results indicated that 86 percent of all projects were impacted by time overrun, and the average time overrun for studied countries 13.6%, 55.7%, 34.4%, and 32.7%, respectively. (Love, et al., 2014) investigated 58 transportation projects in Australia, indicating that the average time overrun was 8.91% of studied projects. (Shresta, et al., 2013) conducted a study on 236 projects in Nevada, USA, they found that the average construction time overrun to be 1.1% of contract duration. (Wali, K.I. and Saber, N.I., 2019) carried out the analysis for 12 project documents from recently completed public projects comprised of the highway and building projects in Kirkuk Governorate



in Iraq. The study revealed that the change orders in the projects' cost ranged from 0.03% to 28.8% due to various causes of a variation order. Reviewed studies indicated that cost and time overrun is a very common cooccurrence and widespread. In this study, the correlation between the cost and time overrun due to variation orders with the project type, size, duration, location on cost, and time overrun has been investigated. **Table 2.** presented the percent of cost and time overrun from reviewed studies.

Table 2. Percent of cost and time overrun.

Cost overrun				
Country	Author (year)	No. of projects	% with cost overrun	Average cost overrun
Australia	(Love, et al., 2014)	58	unknown	13.28
Malaysia	(Shehu, et al., 2014)	359	55	2.1
USA	(Shresta, et al., 2013)	236	unknown	3.2
South Korea	(Lee, 2008)	161	95	50
Norway	(Odeck, 2004)	620	52	7.9
Time overrun				
Country	Author (year)	No. of projects	% with time overrun	Average time overrun
Chine	(Ahsan and Gunawan, 2010)	30	86	13.6
India		20		55.7
Bangladesh		31		34.4
Thailand		19		32.7
USA	(Shresta, et al., 2013)	236	unknown	1.1
Australia	(Love, et al., 2014)	58	unknown	8.9

3. METHODOLOGY

3.1 Data Collection

The following information has been collected from the provinces of Sulaymaniyah, directorate of rehabilitation, roads, and municipalities about each of 228 projects so as to examine the case study research objectives were: name of the project, project location, initial contract amount, actual project cost, the start date of the project, contract completion date, actual completion date, contract duration, and actual duration.



3.2 Data Analysis

The performance system of measurement was analyzed for this case study, it was project cost and schedule overrun. For estimating project cost and time overruns, the following formula was used (Shrestha, P. P., 2013).

$$\text{Cost Overrun} = \left(\frac{\text{Actual Construction Cost} - \text{Contract Awarded Cost}}{\text{Contract Awarded Cost}} \right) \times 100 \tag{1}$$

$$\text{Time Overrun} = \left(\frac{\text{Actual Construction Duration} - \text{Contract Awarded Duration}}{\text{Contract Awarded Duration}} \right) \times 100 \tag{2}$$

After analysis of the cost and time overrun by percentage, there were entered into Minitab software along with variables for processing. One-way ANOVA single factor was adopted to compare the mean of the samples and identify the most influential factors on project cost and time overruns. The factors or variables considered in this study were: type of project, size of the project, duration of the project, year of the awarded contract, and location of the project. The confidence interval for this study was set at 95 percent because the statistical analysis should be conducted in this range, which considered to be acceptable in construction projects. One-way ANOVA assumed a null hypothesis that the ample means of different groups were equal. For a null hypothesis to be incorrect, the P-value should be less than or equal to 0.05. P-value represented the probability of observing a random sample at least as large as an observed sample. If P-value is below 0.05, it means that statistically, there is a significant difference in the means of samples (Shrestha, P. P., 2013).

4. RESULT AND DISCUSSION

4.1 Project Characteristics

Table 3. summarizes the main characteristics of the projects

Table 3. Project Characteristic.

Details		Frequency	Percent	Cumulative percent
Type of projects				
Stadium and community sports		33	14%	14%
Schools and preschool		45	20%	34%
Road and pavement		30	13%	47%
Sewer and sewerage		35	15%	63%
Different functions building		38	17%	79%
Park and garden		12	5%	85%
Celebrating hall		15	7%	91%
Residential building		20	9%	100%
Location of the projects				
Sulaimani city	Sulaimani Province	82	36%	36%



Darbandikhan		5	2%	38%
dukan		15	7%	45%
Penjwen		6	3%	48%
Qaradagh		2	1%	49%
Saidsadq		10	4%	53%
Sharazwr		11	5%	58%
Sharbazher		9	4%	62%
Chamchamal	Garmian administration	15	7%	69%
Kalar		26	11%	80%
Pshdar	Raparin Administration	10	4%	84%
Ranya		26	11%	95%
Halabjay shahid	Halabja Administration	11	5%	100%
Project size in million IQD				
50-1,000		139	61%	61%
1000 to 5000		78	34%	95%
Over 5000		11	5%	100%
Project duration in days				
45 to 150		103	45%	45%
151 to 300		92	40%	85%
Over 300		33	15%	100%
Project awarded years				
2007		16	7%	7%
2008		80	35%	42%
2009		86	38%	80%
2010		26	11%	91%
2011/2012		20	9%	100%

4.2 Projects Cost Overruns

The total cost of the 228 projects was 364,964,790,800 IQD. All the costs were initial tender amounts. The size of the projects started from 71,530,000 IQD to 28,697,348,800 IQD. The project's actual cost was also taken, and these values ranged from 82,156,207 IQD to 30,431,679,844 IQD. The combined actual cost of the 228 projects was 414,361,310,904 IQD.



Fig.1. shows the distribution of contract amount and actual cost. The way preferred to show distributions in this study is a box and whisker. It involves a box that extended from the bottom of the box means 25% of all values, to the top of the box means 75 percent of all values. The box median is representing as a line with the box: the minimum and the maximum value represented as the whiskers. As shown in **Fig.2**, most project values were distributed down the cost scale. **Fig. 2.** shows the percentage of cost overrun. Positive values represent a project impacted by cost overrun, and negative values show a project that costs less than their initial contract amount.

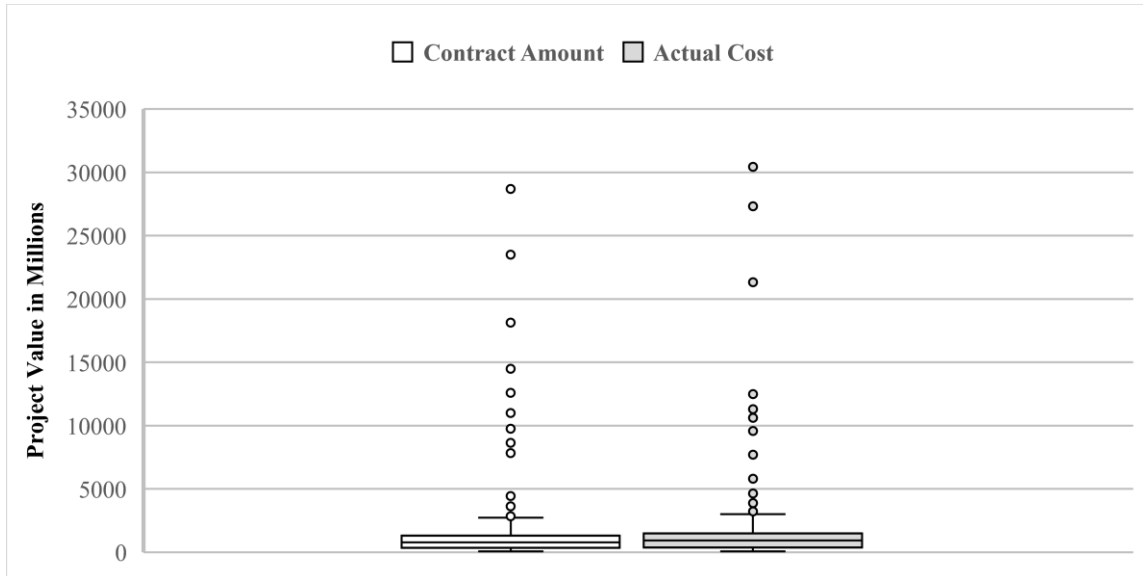


Figure 1. Distribution of project values.

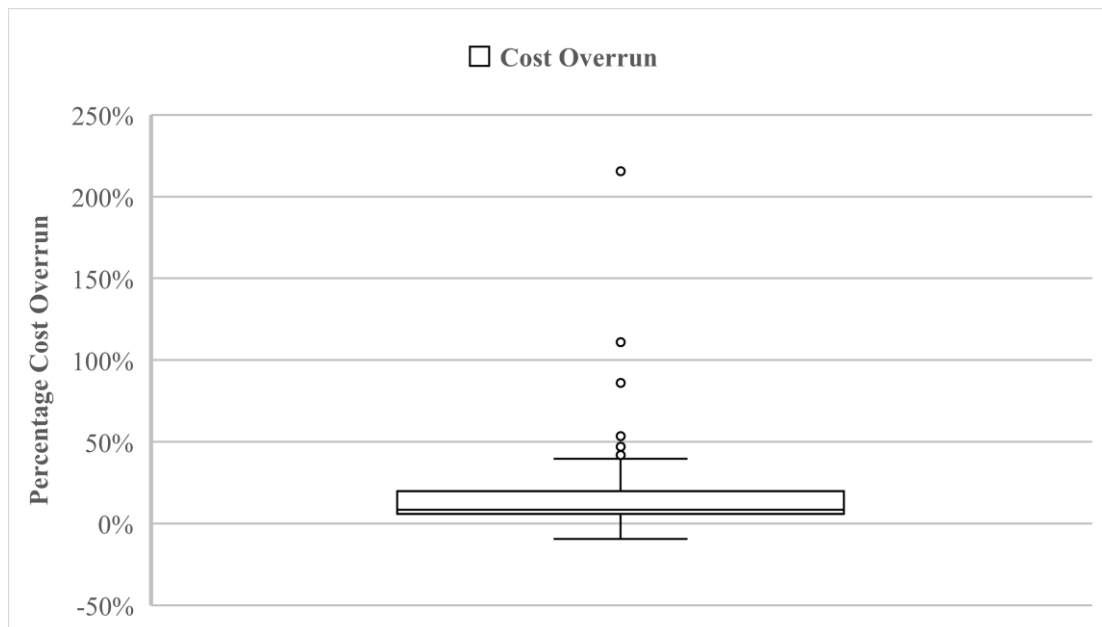


Figure 2. Distribution of project cost overrun in percentage.



4.2.1 Cost Overrun by Type of Projects

Table 4. shows the cost overrun mean values of projects due to variation orders for various types of projects with their P-value, F value, and F critical value. The mean of cost overruns of stadium and community sports, schools and preschool, road and pavement, sewer and sewerage, different functions building, park, garden, celebrating hall and residential building projects were statistically different. The significant test was conducted in project cost overruns; it indicates that P-value is a lesser amount of 0.05. So, with statistical certainty, the null hypothesis could be rejected. It means sample means were difference. Depending on ANOVA results it could be asserted that, in this sample, the project cost overrun for one of these types of the project were different from other types. **Table 5.** presented the ratio of projects in each type that overrun their contract amount. It also indicated the cost overrun (CO) mean, median, and standard deviation. Findings indicated that cost overruns impact nearly more than 95% of all projects with an average of 16 percent, median 9.8% and standard deviation is too high; it shows a great difference between cost overruns of various projects. The collected data could be concluded that cost overruns due to variation orders are very common. It is clear that the sewer and sewerage types of projects have a lower percentage of projects affected by cost overrun due to the variation orders with lower mean overrun. In contrast almost, all types of building projects such as a stadium and community sports, schools and preschool, residential building, and different functions building affected by cost overruns with larger mean overrun.

Table 4. Cost overrun ANOVA findings by project types.

Type of projects	Unite	Mean	F value	P-value	F-critical
Stadium and community sports	%	19.2	3.74	0.00075	2.05
Schools and preschool	%	19.0			
Road and pavement	%	7.9			
Sewer and sewerage	%	8.2			
Different functions building	%	13			
Park and garden	%	5.3			
Celebrating Hall	%	25.1			
Residential building	%	25.3			



Table 5. The percent of cost deviation with project types.

Type of projects	Cost overrun percent					
	Number of projects	Number of projects with CO>0	Percent of projects with CO>0	Mean CO	Standard deviation	Median CO
Stadium and community sports	33	32	97.0%	19.2%	21.4%	12.1%
Schools and preschool	45	44	97.8%	19.0%	32.2%	9.6%
Road and pavement	30	27	90.0%	7.9%	7.1%	6.6%
Sewer and sewerage	35	31	88.6%	8.2%	10.1%	6.8%
Different functions building	38	37	97.4%	13.0%	12.9%	7.0%
Park and garden	12	11	91.7%	5.3%	3.8%	6.4%
Celebrating Hall	15	15	100.0%	25.1%	19.4%	22.3%
Residential building	20	20	100.0%	25.3%	10.7%	26.4%
All	228	217	95.6%	16%	19.8%	9.8%

4.2.2 Cost Overrun With Size of Projects

Table 6. illustrations the project cost and time overruns mean values for various types of projects with their P value, F value and F critical value. Statistically, cost overruns for all project sizes were not different. P value exceeded 0.05, it could not be statistically assumed that the sample mean was different. But actually, for this study, evidence appeared that project cost overrun for 50-1,000 Million IQD projects was higher than for projects over 5000 Million IQD size and projects over 5000 Million IQD size.

Table 6. Cost overrun ANOVA results by project size.

Project size in a million IQD	Unite	Mean	F Value	P Value	F- Critical
50-1,000	%	17.5	2.69	0.07	3.036
1000 to 5000	%	10.7			
over 5000	%	15.6			



4.3 Project Time Overrun

The project's shortest duration by initial duration 45 working days long, and the longest project was 750 working days. The shortest project was 67 days by the final duration, and the longest was 2014 working days. **Fig.3.** shows the distribution of the initial and final duration of all 228 projects. It indicates that all projects tend to overrun their initial contract duration by a significant margin. The major difference between the two boxes can be seen. **Fig.4.** presents the time overrun percentage, a positive value for time overrun (TO) indicates a project impacted by time overrun and negative values show a completed project at an early stage.

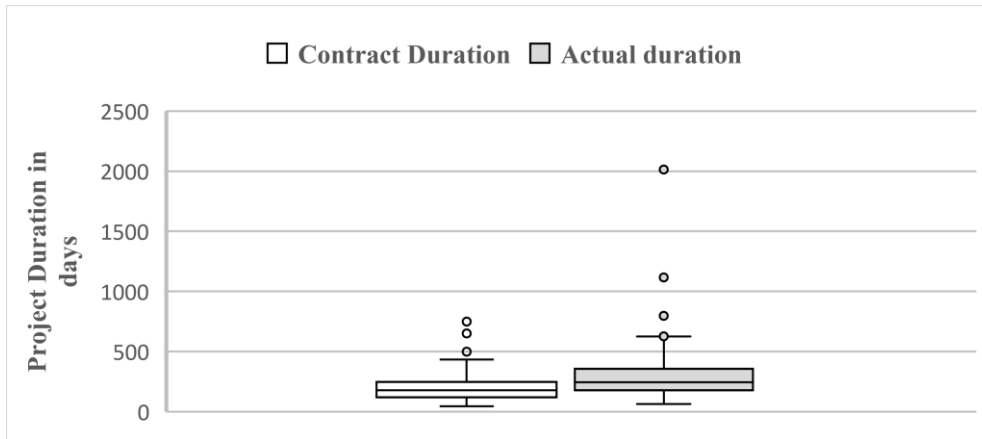


Figure 3. Distributions of Project Duration.

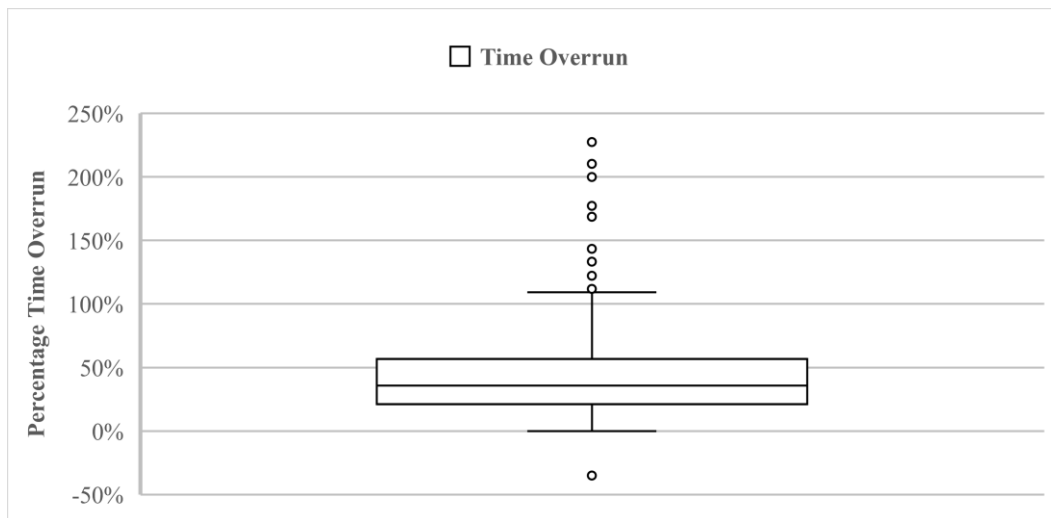


Figure 4. Distribution of project time overrun in percentage.

4.3.1 Time Overrun by Type of Projects

Table 7. shows the mean time overrun project values for various types of projects with the P-value, F Value, and F critical. Findings showed that P-value was below 0.05. The null hypothesis could be rejected with statistical evidence; accepting the sample means difference. Based on the findings of ANOVA, it could be decided that in this study, the time overrun of projects for one of these project types varied from other project types. **Table 8.** shows the percentage of projects of different types that overrun their contract duration. The finding indicates that nearly all types of



projects are affected by time overrun, with a mean time overrun of 46.6% and a median of 35.6%. Often too high the standard deviation, meaning there is a major gap between the various project types' time overrun. From data collected, it can be inferred that time overrun are very normal due to variation orders. It is obvious that all types of the project had a high percentage (100%) of projects effected by time overrun due to the variation orders with large mean time overrun. Schools and preschool type of project has a lower mean time overrun with 33.1%. In contrast, road and pavement had the largest meantime overrun with 63 percent.

Table 7. Project time overrun ANOVA results by type of project.

Type of projects	Unit	Mean	F value	P-value	F- critical
Stadium and community sports	%	45.6	2.72	0.010	2.052
Schools and preschool	%	33.1			
Road and pavement	%	63.0			
Sewer and sewerage	%	54.0			
Different functions building	%	33.5			
Park and garden	%	39.4			
Celebrating hall	%	62.0			
Residential building	%	54.0			

Table 8. The percent of cost deviation with project types.

Type of projects	Time overrun percent					
	Number of projects	Number of projects with TO>0	Percent of projects with TO>0	Mean	Standard deviation	Median
Stadium and community sports	33	33	100%	45.6%	32.0%	37.8%
Schools and preschool	45	43	96%	33.1%	32.0%	27.4%
Road and pavement	30	30	100%	63.0%	54.6%	49.4%
Sewer and sewerage	35	35	100%	54.0%	41.9%	41.6%
Different functions building	38	38	100%	33.5%	29.1%	27.0%
park and garden	12	12	100%	39.4%	20.1%	40.0%
Celebrating Hall	15	15	100%	62.0%	52.6%	47.3%



Residential Building	20	19	95%	54.0%	45.6%	35.8%
All	228	225	98.7%	46.3%	46.3%	35.6%

4.3.2 Time Overrun With Size of Projects

Table 9. displays the mean value of the project schedule overrun for various project sizes with P, F, and F critical values. Results indicate that the P-value was below 0.05, which indicates that the null hypothesis could be denied with statistical certainty. It could be concluded the project time overrun for one of these projects with different size were different from other sizes of project. Results showed that project contract duration overrun was significantly higher for longer project duration than for smaller project duration. As stated in the previous subsection, nearly 98.7% of all the projects were affected by time overruns due to variation orders. In terms of the size of the project from **Table 10.** From the smallest size to the largest size of the project, it can be concluded that the largest percentage of projects that are affected by schedule overrun with 99% and 100%, respectively. Depending on results, the largest size of projects had the largest mean of time overrun with 83.9%, demonstrating they overran their contract duration the greatest and by the greatest amount. In contrast, the smaller projects had the least percent of the project that overran their initial tender duration with 99% and with the middle value of mean schedule overrun 45.4%. Therefore, greater projects than smaller projects overrun their initial duration and overrun their contract duration by a higher percentage than smaller projects.

Table 9. Project time overrun ANOVA results by project size.

Project size in a million IQD	Unit	Mean	F Value	P-Value	F-critical
50-1,000	%	45.4	5.57	0.0044	3.036
1000 to 5000	%	42.3			
over 5000	%	83.9			

Table 10. The percent of time deviation with project size.

Project size in a million IQD	Time overrun percent					
	Number of projects	Number of projects with TO>0	Percent of projects with TO>0	Mean	Standard deviation	Median
50-1,000	139	138	99%	45.4%	41.0%	33.7%
1000 to 5000	78	77	99%	42.3%	32.9%	35.4%
over 5000	11	11	100%	83.9%	59.6%	52.3%



4.4 Project Cost and Time Overrun by Location

The research revealed no correlation between project location with a cost overrun and project location with overrun time. **Table 11.** shows project cost and time overruns for projects in Raparin administration, Garmian administration, Sulaimani province, and Halabja administration with P, F, and F critical values. Findings indicated that the value of P was higher than 0.05. Statistical proof could not reject the null hypothesis. This result is confirming that the project cost and time overrun for projects in four different administrations over the Sulaimani governorate were statistically equal. It means cost and schedule overrun statistically equal in the projects located in the mountainous area and projects located in the plains.

Table 11. Project cost and time overrun ANOVA results by project location.

Project Location	Unit	Mean	F value	P-value	F-critical
Project Cost Overrun					
Raparin Administration	%	15.0	0.816	0.486	2.647
Garmian Administration	%	11.8			
Sulaimani City	%	17.1			
Halabja Administration	%	18.1			
Project Time Overrun					
Raparin Administration	%	37.2	2.408	0.068	2.647
Garmian Administration	%	36.4			
Sulaimani City	%	52.0			
Halabja Administration	%	53.0			

4.5 Construction Cost and Time Overruns by Construction Duration

Table 12. shows mean of project budget and schedule overrun for projects less than 150 working days, 151-300 working days, and over 300 working days with P, F, and F values. Findings indicated that P-value for project cost overrun was greater than 0.05. So, it couldn't be assumed the sample means were different statistically. In terms of time, the overrun P-value was below 0.05, which means that statistically, the null hypothesis could be rejected, approval of differences in sample means. It indicated that time overrun for projects with contract duration less than 150 working days were higher than those for projects with contract duration between 151-300 working days and projects with contract duration more than 300 working days.



Table 12. Project cost and time overrun ANOVA results by project duration.

Project Duration	Unit	Mean	F value	P-value	F-critical
Project Cost Overrun					
45-150 days	%	15.6	0.281	0.755	3.036
151-300 days	%	15.3			
Over 300 days	%	12.7			
Project Time Overrun					
45-150 days	%	54.1	4.351	0.014	3.036
151-300 days	%	37.3			
Over 300 days	%	46.3			

4.6 Construction Cost and Time Overrun by Awarded Year.

Table 13. presents the mean values of project cost and schedule overrun depending on their awarded contract years with their P-value, F value, and F critical value. From the results, P-value for time overrun was equal to 0.106, which was larger than 0.05. So, it could not be decided that statistically, the sample means of cost overrun were different. In terms of cost overrun P value was equal to 0.036, which was less than 0.05. So, with statistical evidence, the null hypothesis could be rejected. It was concluded that the cost overrun of projects were awarded in 2007 was higher than the cost overrun of projects awarded in the following years, with a cost overrun amount of 22.9% of the contract amount. In contrast, projects were awarded in 2011 and 2012 had a lower cost overrun, with 8.8% of the initial contract amount.

Table 13. Project cost and time overrun ANOVA results by awarded years.

Project Awarded Year	Unit	Mean	F value	P-value	F-critical
Project Cost Overrun					
2007	%	22.9	2.611	0.036	2.412
2008	%	12.5			
2009	%	18.8			
2010	%	11.0			
2011/2012	%	8.8			
Project Time Overrun					
2007	%	38.3	1.931	0.106	2.412



2008	%	38.3			
2009	%	53.3			
2010	%	44.2			
2011/2012	%	56.1			

5. CONCLUSIONS

This study collected data and analyzed 228 projects in the Sulaimani governorate that suffered cost and time overrun due to issued variation orders. All of the projects were administrated by the public sector. The projects were different in terms of type, size, contract duration, awarded year, and location. Findings showed that two out of five variables considered had a great relationship with the overrun of project costs. Three out of five considered variables had a strong relationship with the overrun of project duration. The following findings were outlined on the basis of the results of the study.

- Findings from the collected data indicated that cost overruns were very common due to variation orders, 95.6% of the studied projects being affected by cost overrun with an average cost overrun of 16% was observed. Time overruns were also more common than cost overruns due to the variation orders; 98.7% of the projects were influenced by time overrun, with an average time overrun of 46.3% observed.
- The result showed that cost and schedule overrun had a significant correlation with the type of projects. The results indicated that sewer and sewerage types of projects have a lower percentage of projects affected by cost overrun due to the variation orders with lower mean overrun. In contrast almost, all types of building projects effected by cost overruns with larger mean overrun. Regarding time overrun Schools and preschool type of project has a lower mean time overrun with 33.1%. In contrast, road and pavement had the largest meantime overrun with 63 percent.
- Findings showed that the time overrun of the larger size of projects statistically higher than the time overrun for smaller projects. The study did not find the relationship between project cost overrun with project size.
- 4. The study confirmed that the cost and duration overruns for projects located in four different administrations over the Sulaimani governorate were statistically equal and also did not find a relationship between the location of projects and these overruns.
- 5. Regarding project duration, the study did not find a relationship between project cost overrun and project duration. But contract time overrun had a significant relationship with project duration. When the contract duration increased, the mean of project time overrun decrease it was indicated that time overrun of projects with construction duration less than 150 working days were higher than time overrun for projects with construction duration between 151-300 working days and projects with more than 300 working days.
- 6. In terms of the awarded year, it was concluded that cost overrun for projects their tender were awarded in 2007 were higher than those for projects were awarded in the following years. But the study could not find any correlation between time overrun with project awarded years.



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Appendix A: Information about the project's Cost and Time Overrun Due to Variation Orders

Name of the project:
Location / Place:
No. of Project:
Cost of the project (as per awarded contract) (Tender amount) (ID and/ or \$):
Actual cost (as per final measurement) (Final cost) (ID and/ or \$):
Time (Initial duration) (as per awarded contract)(Day):
Commencement date (Start date):
Initial Completion Date:
Actual Completion Date:
Final Duration:
Acceptance date of project:
Variation order Number:



Variation orders date Date:
Variation order Time:
Variation order Cost: