Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 164 (2016) 368 – 375

Procedia Engineering

www.elsevier.com/locate/procedia

Creative Construction Conference 2016, CCC 2016, 25-28 June 2016

Time Delay and Cost Overrun in Qatari Public Construction Projects

Ahmed Senouci[a]*, Alaa Ismail[b], Neil Eldin[a],

[a]*University of Houston, Department of Construction Management, Houston, TX 77204, USA*
[b]*Qatar University, Department of Civil and Architectural Engineering, Doha, Qatar*

Abstract

This paper investigated cost overruns and delays in Qatari public construction projects. An extensive review of regional and international publications was conducted to get a better understanding of the problem and the various methodologies that were used to analyze it. The data that was collected from Qatar public work authority ASHGHAL included 122 public road, building, and drainage projects. ANOVA method was used for data analysis and inference. A regression analysis was also conducted to establish the relationships between project contract prices and cost overruns and to develop prediction models for estimating cost overruns. Two linear regression models were developed for predicting cost overruns for building and drainage public projects, respectively. Cost overruns for building projects increased with contract prices. On the other hand, cost overruns for drainage projects decreased with increasing contract prices. A significant effort was spent in collecting data on cost overruns and delays in public construction projects. However, data confidentiality did allow the collection of enough data to ensure the robustness of the developed regression prediction models.

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2016

Keywords: Cost Overrun, Construction Delays, Qatar Public Projects, Statistical Analysis, Regression Analysis, Analysis Of Variance

1. Introduction

Changes are facts of the construction process. They are issued to respond to newly developed circumstances. Extensive and poorly managed changes may have significant negative impacts on project time and cost performances. Two major problems facing the construction industry are project delays and cost overruns. In today's highly competitive economic environment, the need for completing construction projects within the stipulated cost, time frame, and expected performance expectations is becoming increasingly important.

* Corresponding author. Tel.: +1-713-743-6131; fax: +1-713-743-0602.
E-mail address:asenouci@uh.edu

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2016
doi:10.1016/j.proeng.2016.11.632

In the state of Qatar, the public projects that were performed between the years of 2000 and 2013, had a 54% cost overrun and a 72% time delay. On the other hand, the maintenance projects during the same period had both 50% cost overrun and time delay. Thus, there is a real need to investigate time delays and cost overruns in Qatar public construction projects because of their criticality and the limited number of published studies that addressed these issues.

2. Objectives and Methodology

2.1. Objectives

The main objectives of the study are to:

- Analyze statistically time delays and cost overruns commonly found in Qatari public projects.
- Develop prediction models for predicting project cost overruns based on the contract price value.

The scope of the study is limited to public construction projects whose data were obtained from public work authority (ASHGHAL).

2.2. Methodology

The methodology included six phases, namely, data collection, data mining, statistical data analysis, and building conclusions based on statistical findings. A total of 122 construction projects were studied with a focus on construction phase only. All construction projects were completed between the years of 2000 and 2013 and all claims were settled by 2013. All construction projects were lump sum contracts and had the traditional delivery method of design-bid-build. The collected data included project category, project type, contract cost, contract duration, duration and cost at completion at completion. Time and cost overrun percentages had been calculated, using this data. The data was studied using the analysis of variance (ANOVA) and regression analysis. MS Excel 2007 software was used for both analyses.

3. Literature Review

Time delays and cost overruns usually lead to adverse effects on the growth of national economies, contribute to major financial losses, and hold back the development of the construction industry. A long-term study of a number of public works projects, which was conducted in the state of Nevada in the United States, showed the negative and costly impacts of time delays. The study investigated several design-bid-build state construction projects between the years of 1991 to 2008 and concluded that large size and long-duration projects had significantly higher cost and schedule overruns than smaller size and short-duration ones [1]. The main factors for time delays and cost overruns are: 1) scope definition, 2) coordination of roles and responsibilities among involved parties, 3) initial estimation and contingency planning, and 4) monitoring and control systems [2]. Most construction projects in developing countries are characterized by time delays [3]. The projects with extensive delays may end up losing their economic justification, which in turn may result in the termination of the project [4]. The following complications due to delay increase in governmental projects were identified: 1) confusion regarding public development plans, 2) disturbance of the budget execution plan, and 3) public inconvenience resulting from project delays [5].

The following major causes of construction/delivery delays were reported: 1) insufficient data collection and survey before design, 2) higher than expected increase in costs due to inflation, and 3) repair/reconstruction work due to errors during construction [4]. The three most important causes for construction delay were improper planning, poor site management, and inadequate and/or limited experience [6].

The majority of cost overruns are encountered in lump sum contracts, fewer occur in unit-price contracts and even less in reimbursement contracts [7]. They reported the following causes of cost overruns: 1) awarding contracts to the lowest bidder; 2) site conditions; 3) incompetent subcontractors and poor site management; and 4) inaccurate estimates and client-led change orders. The following major cause of cost overruns were identified: 1) market conditions, 2) personal experience in the contract work, 3) insufficient estimated time for construction items, 4) material fluctuation, and 4) political situations [8].

Qatar is one of the fastest growing GDP in the world. Moreover, Qatar has the highest saving rate in the world, with a saving percentage of 60.8% of GDP. The construction industry showed the second largest growth in 2013 by contributing 2.7% to the non-hydrocarbon GDP growth. The construction activities have been expanding rapidly to be completed ahead of the FIFA World Cup in 2022. Qatar is currently constructing major infrastructure projects such as Doha metro, a network of expressways, Sharq crossing Doha bay, and several tunnels and bridges. Moreover, several real estate projects are underway in Lusail city, to the north of Doha. The Qatari construction sector currently suffers delays and cost overruns. New projects are currently experiencing 54% cost overrun and 72% delay. On the other hand, the maintenance projects are experiencing 50% for both cost overrun and delay. The $1.7 billion project, which aimed to convert a jammed traffic road into a new layout of junctions, underpasses and bridges was a nightmare for vehicle movement and shops running along since construction began in 2010. The initial target was due to the end of 2012. However, the date was pushed to the third quarter of 2013. The long-awaited Hamad International airport, a $15.5 billion planned investment, was delayed four years. It was partially opened in April 2014, with a later phase expected to finish by year 2017-2018. Possible justifications to project delays were reported as poor management and control systems, manpower low quality, construction material and equipment shortage, inappropriate estimation of massive scale of projects, harsh summers, and funding constraints of private projects. Public projects are also suffering from imposed changes and unclear work scope and objectives.

4. Data Collection and Analysis Methods

4.1. Data Collection

Several meetings were conducted with department heads, project managers, and planning engineers at ASHGHAL to discuss data collection and getting needed approvals.

Qatari public projects are classified either roads, buildings, or drainage. They are also categorized as new construction or maintenance projects. Road projects include all expressways, major, and minor roads in the country. The building projects consists of public buildings, schools, hospitals, parks, and cultural centers. Drainage projects include storm and rain water, waste water, and sewerage.

The data for 122 projects was provided by ASHGHAL. The collected projects started in or after year 2000 and were completed before or on year 2013. Their contracts and delivery methods were lump sum and design-bid-build, respectively.

The collected data included the project category, project type, contract cost, contract duration as well as the duration and cost at completion. The durations were measured in calendar days and costs in Qatari Riyals. 67% of the received data was from roads, 21% from buildings, and 12% from drainage. On the other hand, all drainage projects were new construction.

4.2. Analysis Methods

ANOVA was used to compare samples and to determine if their differences were statistically significant. The confidence level selected for the analysis was set to 95%. ANOVA assumed a null hypothesis, assuming that the means of compared samples were to be statistically equal. For the null hypothesis to be false, the p-value must be less than or equal to 0.05. If the p-value is less than 0.05, the difference between means is considered to be statistically significant (Weinstein, 2007).

This study covered three projects types, namely, road, building and drainage construction projects. The cost overruns and time delays were compared based on the following five categories:

- Project Type: road, building, drainage
- Project Category: new construction, maintenance construction
- Project Size: final cost less than or equal QR10 million; final cost between QR10–QR100 million; final cost between QR100–QR1000 million, final cost greater than QR1 billion.

- Project Duration: duration less than or equal 1 year; duration between 1 and 2 years; duration between 2 and 3 years; duration between 3 and 4 years; duration greater than 4 years)
- Project Year of Completion: completed between 2000 and 2006; completed between 2007 and 2013.

When multiple groups were identified, a single factor ANOVA test was carried between the groups of highest and lowest means.

Linear regression analysis was used to identify possible relationships between the project contract price and cost overruns. The coefficient of determination R^2 was used to measure the strength of these relationships. The closer the values of R^2 are to 1, the stronger are the correlations between the variables. The cost overrun and contract price were set as the dependent and independent variables, respectively.

The regression analysis was conducted using the following steps:

1. Plot the data in one chart only.
2. Plot the data in several charts using several contract cost / contract duration intervals.
3. Analyze the charts with outliers.
4. Analyze the enhanced charts after removing the outliers.

5. Result Analysis

5.1 ANOVA

Statistical tests were used to determine the descriptive statistics of the dependent variables. The first test was to investigate whether the sample means of various groups were statistically different or of equal variances. For this goal, MS-Excel 2007 ANOVA tool was used.

5.1.1 Project Type.

Table 1 shows the ANOVA analysis of cost overruns and delays for the three project types. The cost overruns and delays for the three project types were not statistically significant at a significance level of 0.05.

Table 1. ANOVA project type

Metrics	Building	Road	Drainage	F Value	P Value	F Critical
Cost Overrun (%)	0.703	0.182	0.108	0.596	0.449	4.351
Number of Projects	14	40	8			
Delays (%)	2.616	0.815	0.782	0.322	0.576	4.260
Number of Projects	18	51	8			

5.1.2 Project Category

Table 2 shows the ANOVA analysis of the cost and time overruns for the two building project categories. The cost and time overruns for the two building project categories were not statistically significant at a significance level of 0.05.

Table 2. ANOVA project category

Metrics	New	Maintenance	F Value	P Value	F Critical
Cost Overrun (%)	0.965	0.078	0.451	0.515	4.747
Number of Projects	10	4			
Delay (%)	3.057	0.412	0.204	0.658	4.494
Number of Projects	15	3			

5.1.3 Project Size Category

Table 3 shows the ANOVA analysis of the cost overruns and delays for the four project size categories. The cost overruns and delays for the four project size categories were not statistically significant at a significance level of 0.05.

Table 3. ANOVA project size

Metrics	Less than 1 million QRs	10 to 100 Million QRs	100 to 1000 Million QRs	Larger than 1 billion QRs	F Value	P Value	F Critical
Cost Overrun (%)	0.148	0.387	0.193	0.120	0.072	0.790	4.130
Number of Projects	10	34	16	2			
Delay (%)	0.778	1.591	0.845	0.659	0.073	0.789	4.067
Number of Projects	14	42	18	3			

5.1.4 Project Duration Category

Table 4 shows the ANOVA analysis of the cost overruns and delays for the five project duration categories. The cost overruns for the five project categories were not statistically significant at a significance level of 0.05. On the other hand, the delays for the five project categories were statistically significant at a significance level of 0.05.

Table 4. ANOVA project duration

Metrics	Less than 1 year	1 to 2 years	2 to 3 years	3 to 4 years	Larger than 4 years	F Value	P Value	F Critical
Cost Overrun (%)	0.140	0.518	0.143	0.238	0.150	0.569	0.456	4.149
Number of Projects	12	22	13	9	6			
Delay (%)	0.554	1.648	0.907	0.902	1.662	11.652	0.004	4.494
Number of Projects	11	32	17	10	7			

5.1.5 Project Year of Completion Category

Table 5 shows the ANOVA analysis of the cost overruns and delays for the two project completion year categories. The analysis results show that the cost overruns for the two project completion year categories were statically different at a significance level of 0.05. On the other hand, the delays were not statistically different at a significance level of 0.05.

Table 5. ANOVA project year of completion category

Metrics	2000 to 2006	2007 to 2013	F Value	P Value	F Critical
Cost Overrun (%)	0.900	0.143	5.606	0.021	4.001
Number of Projects	12	50			
Delay (%)	2.677	0.759	2.792	0.099	3.968
Number of Projects	19	58			

5.2 Linear Regression

The regression analysis was used to develop cost overrun prediction models for each project type.

5.2.1 Building Projects

The analyzed sample included 15 projects with contract prices ranging from QR 2 million (1 US$=3.65 QR) to QR190 million. Figure 1 shows a relatively strong positive correlation between cost overruns and contract prices for building projects. This can be explained by the fact that the higher contract prices are, the higher are the risks associated with the project due to its increased size and/or complexity.

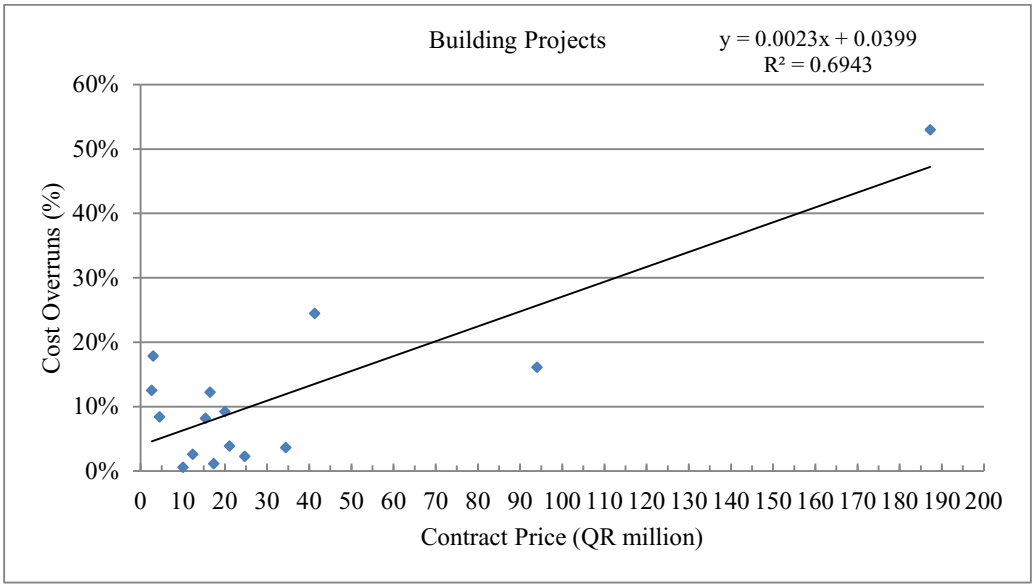

Fig. 1. Project Cost Overrun versus Contract Price - Building Projects

5.2.2 Drainage Projects

The analyzed sample included 8 drainage projects with contract prices ranging between QR 40 million and QR 210 million. Fig. 2 shows that the cost overruns for drainage projects decreased with increasing contract prices. It also shows a relatively strong negative correlation between cost overruns and contract prices with a coefficient of determination R^2 of 66.7%. This finding can be explained as follows. The drainage projects in Qatar were handled by qualified designers and contractors, which limited poor quality work and reduced design changes. Moreover, most drainage projects were new constructions that were conducted on clear sites with no surrounding restrictions. This helped to reduce frequent interruptions or delays due to existing site conditions. This also helped in expediting governmental approvals during the construction phase. Moreover, drainage projects depended mostly on locally available material and equipment, which reduced the risks associated with procurement delays. Finally, the

discussions conducted with projects managers and engineers from drainage contracting companies confirmed that the drainage affairs department at the Qatari public work authority ASHGHAL is more accurate in evaluating bidding proposals and in giving and directing site instructions when needed. This helped to clearly define needed changes and to quickly respond to them with minimum alterations to the project schedule.

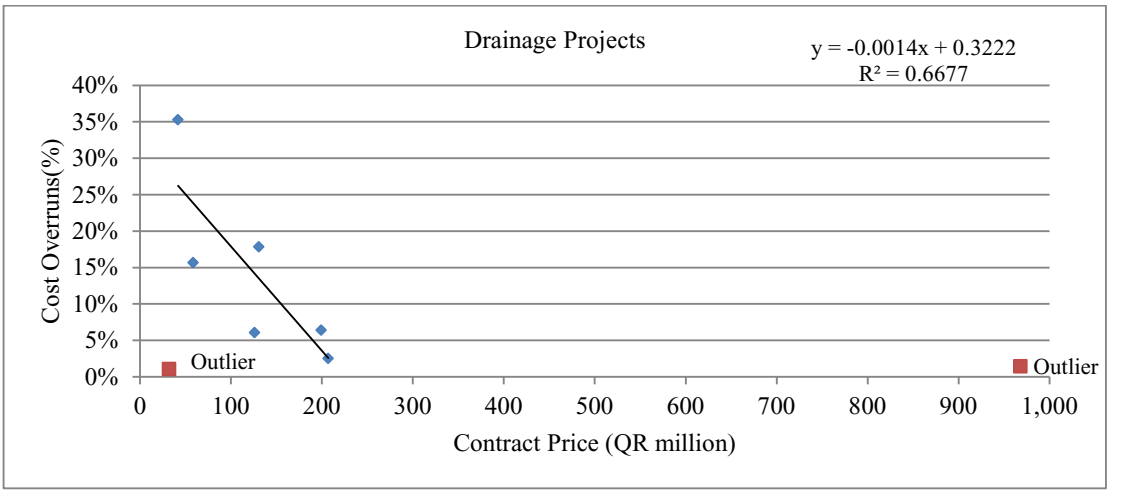

Figure 2. Project Cost Overrun versus Contract Price – Drainage Projects

6. Conclusions

This present study investigated cost overruns and delays in Qatari public construction projects. A set of data from 122 Qatari public construction projects was provided by ASHGHAL. ANOVA method was used for data analysis and inference. The analysis results showed that the cost overruns and delays were not significant at a significance level of 0.05 with respect to project type (i.e., building, road, or drainage), category (i.e., new or maintenance), and size. They also showed that the cost overruns were not significant at a significance level of 0.05 with respect to the project duration. However, the delays were statistically significant at a significance level of 0.05 with respect to the project duration. Finally, the analysis results showed that the construction project cost overruns were statistically significant at a significance level of 0.05 with respect to their year of completion. In other words, the construction project cost overruns for the project completed between 2007 and 2013 are lower than those completed between 2000 and 2007.

A regression analysis was conducted to establish the relationships between project contract prices and cost overruns and to develop prediction models for estimating cost overruns. Two linear regression models were developed for predicting cost overruns for building and drainage public projects, respectively. Cost overruns for building projects increased with contract prices. On the other hand, cost overruns for drainage projects decreased with increasing contract prices.

A significant effort was spent in collecting data on cost overruns and delays in public construction projects. However, data confidentiality did allow the collection of enough data to ensure the robustness of the developed regression prediction models.

7. References

[1] Shrestha, P. P., Burns, L. A., & Shields, D. R. Magnitude of construction cost and schedule Overruns in Public Work Projects. *Journal of Construction Engineering*, (*2013)*, 1-9. doi:10.1155/935978

[2] Halloum, M. A., & Bajracharya, A. A., Cost and time overrun revisited: A study on the infrastructure construction projects in Abu Dhabi, UAE, *The Third Conference on Construction in Developing Countries,* Bangkok, Thailand (2012)..

[3] Sweis, G. J., Factors affecting time overruns in public construction projects: the case of Jordan, *International Journal of Business and Management*, (2013), *8*., doi:10.5539/ijbm.v8n23p120

[4] Alavifar, A. H., & Motamedi, S., Identification, evaluation and classification of time delay risks of construction project in Iran, *The 2014 International Conference on Industrial and Operations Management,* Bali, Indonesia (2014).

[5] Mahamid, I., Risk matrix for factors affecting time delay in road construction projects: Owners' prespective, *Engineering Construction and Architectural Management,* (2011), 18, 609-617. doi:10.1108/09699981111180917

[6] Sambasivan, M., & Soon, Y. W., Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management*, (2006), *25*, 517-526. doi:10.1016/j.ijproman.2006.11.007

[7] Papadopoulou, T. C., & Park, Y. I., Causes of cost overruns in transport infrastructure projects in Asia: Their significance and relationship with project size, *Built Environment Project and Asset Management*, (2012), *2*, 195-216, doi:10.1108/20441241211280873

[8] Kasimu, M. A, Significant factors that causes cost overruns in building construction projects in Nigeria, *Interdisciplinary Journal of Contemporary Research in Business*, (2012), *3*, 775-779