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Empirical Evaluation of Performance of Construction Management At-Risk (CM at -Risk) Project Delivery System with and Without Agency-CM

Shaik Abdul Khader Jeelani, Adel S. Al-Dosary, J.Karthikeyan

***Abstract*— A project delivery system is a comprehensive process of assigning the contractual responsibilities for designing and constructing a project. Design-Bid-Build (D-B-B), Design-Build (D-B), and Construction Management at risk (CM- at - Risk) are the three principal project delivery systems. Agency CM is as a construction management system, and is a way to manage the process of construction.**

Agency-CM doesn't take any performance risk in guaranteeing project cost, project schedule and project quality. Generally Agency CM is remunerated on monthly fee/ lump sum fee or by the percentage of the project cost that has conflict of interest with the final project schedule and final project cost. Considerable amount of fee is paid to the Agency CM in order to improve the efficiency of the project. This necessitates a comprehensive investigation in to the performance of projects delivered with Agency CM and projects delivered without Agency CM.

Agency-CM can be used with any type of Project Delivery system. This paper presents the evaluation of the project performance metrics such as Project Cost, Project Schedule and Project quality where CM –at - Risk Project Delivery System was used with Agency CM and without Agency CM. It compared the Cost Growth, Time Growth, and quality performance of 200 CM-at-Risk projects of which 100 projects where Agency CM was used and 100 projects where Agency CM was not used. Analysis of data pertaining to project performance metrics was done by using SPSS statistical software.

An understanding of this study may help an owner/client better select the suitable CM-at-Risk Project Delivery System either with or without Agency Construction Management.

***Index Terms*— Agency Construction Management, Project Delivery Systems, CM-at-Risk with Agency CM, Project performance metrics, CM-at-Risk without Agency CM, Construction Projects, Design-Build, Design-Bid-Build**

I. INTRODUCTION

The efficient delivery of construction projects is foundation to the success of the construction industry. To increase the probability of success, owners must choose the appropriate project delivery systems to match their project needs. Most groups agree that there is no perfect project delivery system. Every project is unique and has its own unique set of challenges. Therefore, industry consensus is that every project should be considered on a case-by-case basis to determine the most appropriate project delivery system. A project delivery system is the comprehensive process of assigning the contractual responsibilities for designing and constructing a project. A delivery system identifies the primary parties taking contractual responsibility for the performance of the work. The essential elements of any project delivery system are cost, time, quality and safety.

Agency CM firms are the agents of the owners to give pre-construction advice on scheduling, budgeting, value analysis and bidding and continue to assist the owners in construction phase, but doesn't take any performance risk in guaranteeing the Project cost, Project schedule or Project quality. These risks remain for someone else to take.

A common misconception is that Agency CM is a project delivery system. An Agency CM is not contractually responsible for delivering the bricks and sticks in construction. Rather responsible for management services necessary to deliver construction. Agency Construction Management is a management system based on an owner's agreement with a qualified construction management firm to provide coordination, administration and management within a defined scope of services. While Agency CM is not limited to a certain sized project, it is frequently used on large, complex projects where the owner desires to supplement its in-house staff and expertise.

Design-Bid-Build (D-B-B), Design-Build (D-B), and Construction Management at risk (CM at - Risk) are the three principal project delivery systems. Agency CM can be used with any type of project delivery system. [1]

Construction industry has been using D-B-B, D-B and CM-at-Risk project delivery systems. The most recent period has seen an increase in the use of Agency CM along with these three project delivery systems. Considerable amount of fee is paid to the Agency CM in order to improve the efficiency of the project. Is the use of Agency CM improving the quality of the project? Is the amount of fee paid to the Agency CM increasing the Project cost or decreasing the project cost?

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***** Correspondence Author (s)
Shaik Abdul Khader Jeelani*, Ph.D Scholar , Department of Civil Engineering, SV University College of Engineering, India.
Dr. Adel S. Al-Dosary, Professor, King Fahd University of Petroleum & Minerals,Dhahran, Saudi Arabia.
Dr. J.Karthikeyan, Professor, Department of Civil Engineering, SV University College of Engineering, India.

When Agency CM is used, is there any improvement in the Project time Schedule? To answer these questions, it necessitates a comprehensive investigation in to the performance of projects delivered with Agency CM and Projects delivered without Agency CM.

This study may help an owner/ Client better select a project delivery system that is suitable between the CM-at-Risk Project Delivery System with Agency CM and the CM-at-Risk Project Delivery System without Agency CM.

This paper covers the Literature Review in brief, Research Methodology, Data analysis, Results, Testing of Hypotheses and Conclusions.

II. OBJECTIVES OF RESEARCH

1. To compare the Cost Growth between CM-at-Risk Projects with Agency CM and CM-at-Risk Projects without Agency CM
2. To compare the Time Growth between CM-at-Risk Projects with Agency CM and CM-at-Risk Projects without Agency CM
3. To compare the Quality Performance between CM-at-Risk Projects with Agency CM and CM-at-Risk Projects without Agency CM
4. To distinguish the project performance between CM-at-Risk Projects With and Without Agency CM

III. LITERATURE REVIEW

A way to understand the distinction between Agency CM and the project delivery system is to think about which project delivery system can be used with Agency CM. The answer is: all of them.

For example, an owner may hire an Agency -Construction manager as its agent to represent it throughout the process under a Design- Bid-Build (D-B-B) system. In this example Agency- Construction Manager may interview and select the designer, prepare the bid packages based on the completed design; and bid the project to a General contractor that actually constructs the project.

A second example is that an owner may hire an Agency-Construction manager as its agent to represent it throughout the process under Design-Build (D-B) system. In this example Agency Construction Manager may interview and select the Design-Builder, review certain trade bid packages and otherwise serve to monitor the owner's interests, because the traditional checks and balances between design and construction do not exist when design and construction are integrated into one contract.

A final example is that an owner may hire an Agency construction manager as its agency to represent it throughout the process under a Construction Management at-Risk system. In this example, the Agency Construction Manager may interview and select a designer, interview and select the construction manager at risk, coordinate activities among the parties and otherwise serve to protect the owner's interests based on the scope of services in the agreement. [2]

The CM- at- Risk hold trade contracts and is at Risk for the performance of the work and Agency CM do not hold the trade contracts and is not responsible for the performance risk. [3]

Any Agency CM is usually paid on hourly basis/lump sum fee/percentage of project cost. In each of these cases, the owner has certain disadvantages.

The disadvantages of Owner contracting with Agency CM on hourly CM-Fee are that the Agency CM is tempted to work hours that are not needed to maximize the fee. The Agency CM and the Owner need to carefully monitor Agency CM'S efforts Vs Results. When the Agency CM is contracted on Lump sum Fee/percentage of project cost, Agency CM is committed to provide defined services and results. It requires a thorough definition of results expected from Agency CM'S efforts and services required to attain such results prior to signing Agency CM contract. The disadvantage in this case is that the Agency CM may maximize profits by cutting corners on services at risk of not obtaining expected results. [4]

Many researchers put their efforts to evaluate the project delivery systems in the past.

- Fouad Mansoor Al Sinan (1986)evaluated the construction management Contracts in developing Countries.[5]
- Kyungsoon Chang (2004) suggested a proper model for best value selection in public sector Design Build projects. [6]
- Joseph A. Mannarino (2001) evaluated the Construction management delivery system. [7]
- Edmond W.M.Lam (2004) bench marked the Design-Build procurement systems in Construction. [8]
- AdetokunboA.Oyetunji and Stuart D. Anderson (2001) studied the relative effectiveness of Project Delivery and Contract Strategies. [9]
- The university of Reading Design and Build Forum using multivariate analysis techniques compared the cost, schedule and quality performance of 332 Design Build and Design Bid Build projects built in UK. [10]
- Mark D Konchar (1998) empirically compared the cost, schedule and quality performance of Construction Management at Risk, Design-Build and Design – Bid – Build delivery systems for US building projects. [11]
- Sami W. Fahmi (2005) compared the owner expectations and actual performance of the Design-Build projects. [12]
- Chuck Kluenker (2001) studied the Risk Vs Conflict of Interest – What Every Owner Should Consider When Using Construction Management and stated that the disadvantages in hiring an Agency CM on hourly fee and lump sum fee were that the Agency CM might be tempted to work hours that were not needed to maximize fee and Agency CM might maximize profits by cutting corners on services at risk of not obtaining expected results. [13]
- Some research (AIA 2007, Ballard and Morris2010) consisted of opinion surveys to investigate attitudes toward specific project delivery methods by owners who frequently procured design and construction services. [14]

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- Several case studies of industry builders and clients, (Bruns, 1997) such as the US Postal service, explained variations in the way project delivery systems were administered both privately and in the public sector. [15]
- Konchar and Sanvido (1998) found that DBB projects generally faced 5.2% more change orders than DB projects. [16]
- Rojas and Kell (2008) studied completed construction projects and established that the degree of collaboration/Integration had a significant relationship with the team practices imposed by the project procurement approach. The research was completely survey based and made no comparison to the cost benefits achieved on projects based on level of integration and type of delivery system. [17]
- Aditi Kulkarni, Zofia K.Rybhowski, and James Smith (2012) through cost comparison of collaborative and IPD-like project delivery methods versus competitive Non-Collaborative Project delivery methods concluded that collaborative project delivery systems produced a more reliable cost outcome for public owners. [18]

Despite substantial efforts in the past to evaluate the project delivery systems, there is no study that was conducted to compare the quantifiable cost, schedule and quality performance of Design-Build and Design- Bid-Build and CM-at-Risk project delivery systems with Agency CM and Without Agency CM.

However the scope of this paper is only limited to present a comparison of cost, schedule and quality attributes between the CM-at-Risk projects where Agency CM was used and the CM-at-Risk projects where Agency CM was not used.

IV. RESEARCH METHODOLOGY

This study developed and utilized a data collection instrument (Questionnaire) to obtain project specific data, which was used to measure the Project Cost Growth, Project Time Growth and Project Quality scores. The data was collected from various contractors, Agency CMs, representatives of Owners. The results were used to compare the Cost Growth, Time Growth and Quality Scores and to test several hypotheses to compare the Performance of CM-at-Risk projects With Agency CM and CM-at-Risk Projects without Agency CM.

A. Performance metrics:

Though various performance metrics were used by previous researchers to describe the performance of the project delivery process, this study considered only three most important metrics namely, Cost, Time, and Quality.

1) Cost Growth

This metric provides an indication of the growth of the project cost over the initial award cost of Project.

Cost growth = (Final Project Cost – Award Cost)/Award Cost *100

Where Award Cost is the Construction Contract Cost including the Agency CM‘s fee

Final project cost is the final cost of construction including Agency CM’s fee.

2) Time Growth

This performance metric provides an indication of the growth of schedule (Project Time Duration) over the Initial Planned Duration of the Project.

Time growth = (Actual Duration-Planned duration)/Actual duration*100

3) Quality Measure

Quality was defined as the degree to which the facility met the expected facility requirements. Quality was measured in six areas. Each was a measure of the actual performance versus the facility user’s or owner’s expectations of the referenced building. The maximum scores against which the quality scores measured were based on the importance of the criteria.

To distinguish the Project performance between the CM-at-Risk Projects with Agency CM and the CM-at-Risk Projects without Agency CM, the two independent populations’ means were compared to test the hypothesis.

B. Testing Of Hypotheses

Comparing Two Independent Populations’ Means of CM-at-Risk Projects with Agency CM and CM-at-Risk Projects without Agency CM:

Assumptions:

1. The observations in CM-at-Risk project delivery method without Agency CM are independent of the observations in CM-at-Risk project delivery method with Agency CM.
2. The two sampled populations are normally/approximately normally distributed.
3. The standard deviations of the two populations are nearly equal.

1) Cost Growth-Hypotheses

Null Hypothesis:

The mean Cost growth of CM-at-Risk projects with Agency CM is at least equal to the mean Cost growth of CM-at-Risk projects without Agency CM.

$\mu 1 \geq \mu 2$ where $\mu 1$ = mean Cost growth of CM-at-Risk projects with Agency CM.

$\mu 2$ = mean Cost growth of CM-at-Risk projects without Agency CM

Alternate Hypothesis:

The mean Cost growth of CM-at-Risk projects with Agency CM is less than the mean Cost growth of CM-at-Risk projects without Agency CM.

$\mu 1 < \mu 2$

2) Time Growth/Schedule Growth-Hypotheses:

Null Hypothesis:

The mean Time growth of CM-at-Risk projects with agency CM is at least equal to the mean Time growth of CM-at-Risk projects without Agency CM.

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μ 1 ≥ μ 2 where μ 1 = mean Time growth of CM-at-Risk projects with Agency CM.

μ 2 = mean Time growth of CM-at-Risk projects without Agency CM

Alternate Hypothesis:

The mean Time growth of CM-at-Risk projects with agency CM is less than the mean Time growth of CM-at-Risk projects without Agency CM.

μ 1 < μ2

3) Quality Performance-Hypotheses:

Null Hypothesis:

The mean quality score of CM-at-Risk projects with agency CM is at most equal to the mean quality score of CM-at-Risk projects without Agency CM.

μ 1≤ μ 2 where μ 1 = mean Quality Score of CM-at-Risk projects with Agency CM.

μ 2 = mean Quality Score of CM-at-Risk projects without Agency CM

Alternative Hypothesis:

The mean quality score of CM-at-Risk projects with agency CM is greater than the mean quality score of CM-at-Risk projects without Agency CM.

μ 1>μ 2

Using SPSS comparing means, t-test was conducted at 0.05 significance level to test the above hypotheses.

V. ANALYSIS AND RESULTS

Data related to Cost, Schedule and Quality from 200 projects of which 100 CM-at-Risk projects with Agency CM, and 100 CM-at-Risk projects without Agency CM were collected. Using the formulae the Cost Growth, Time Growth of projects were calculated and tabulated against each project. For measuring the Quality, the subjective evaluation of quality performance for difficulty in project start up was transformed to the scale of 10, 5 and 1 respectively for low, Medium and High. For number and magnitude of callbacks the scale was 10, 5, 1 for none, a few, many respectively. For operating/maintenance cost of the building was 10, 5, 1 for none, a few, many respectively. Similarly the quality performance related to quality of envelop/roof/structure/foundation, quality of interior space/layout and quality of environmental system to meet the expectations was transformed to the scale of 5,8,10 respectively for the lowest, average and the highest. The quality scores were tabulated against each project. SPSS software was used for data analysis and the results are as following.

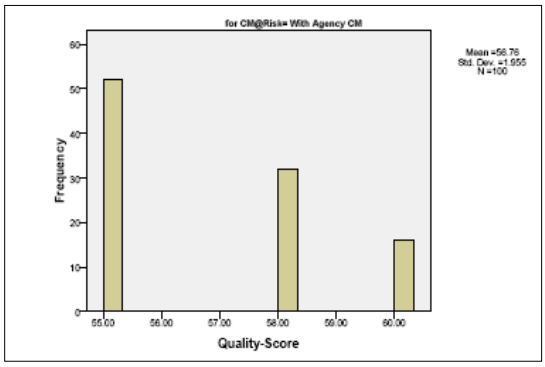

Figure 1: Quality Scores Histogram for CM-at-Risk Projects with Agency CM

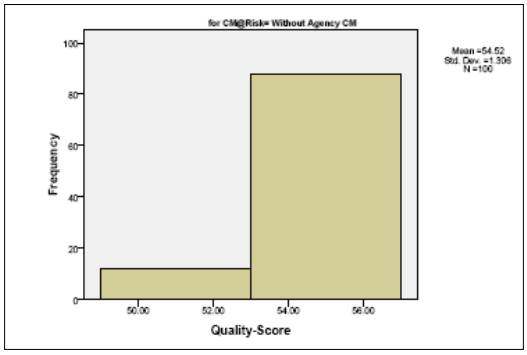

Figure 2: Quality Scores for CM-at-Risk Projects without Agency CM

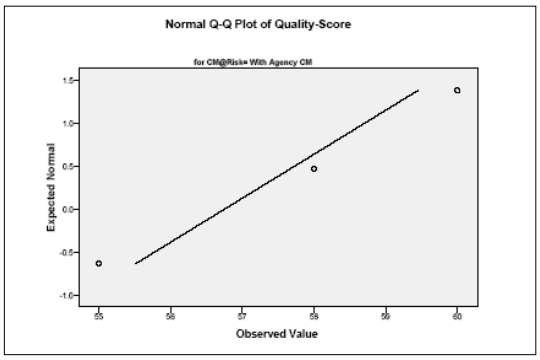

Figure 3: Normal Q-Q Plot of Quality Score for CM-at-Risk Projects with Agency CM

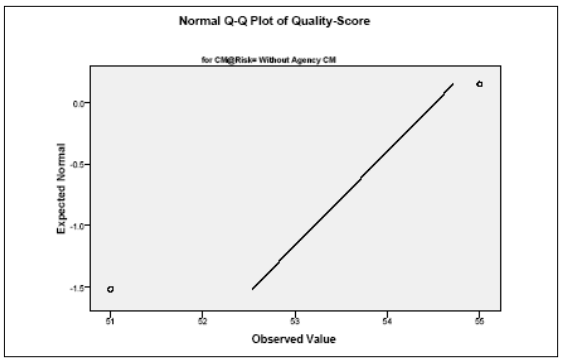

Figure-4 Normal Q-Q Plot of Quality Scores for CM-at-Risk Projects without Agency CM

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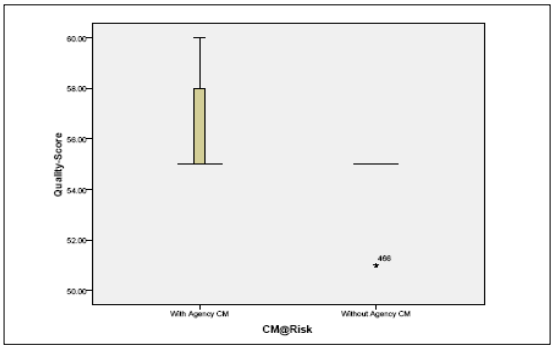

Figure 5: Quality Score for CM-at-Risk Projects with and without Agency CM

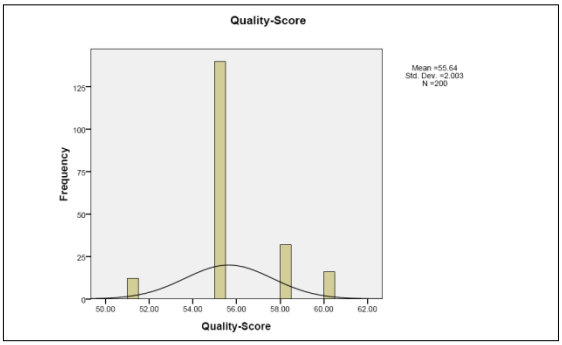

Figure 6: Frequency Distribution of Quality Scores in CM-at-Risk Projects

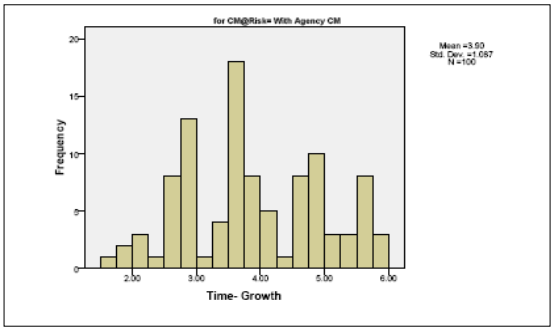

Figure 7: Time Growth Histogram for CM-at-Risk Projects with Agency CM

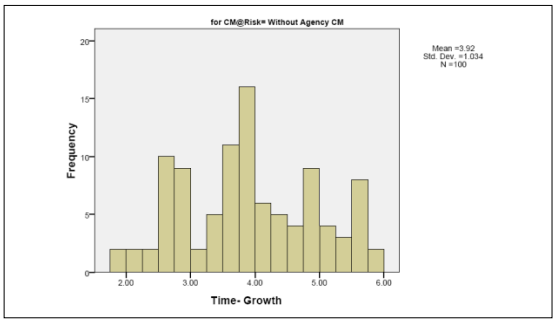

Figure 8: Time Growth Histogram for CM-at-Risk Projects without Agency CM

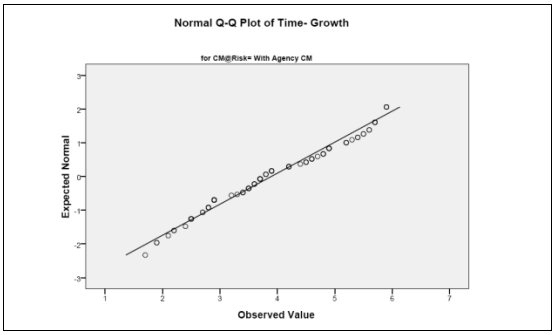

Figure 9: Normal Q-Q Plot of Time Growth for CM-at-Risk Projects with Agency CM

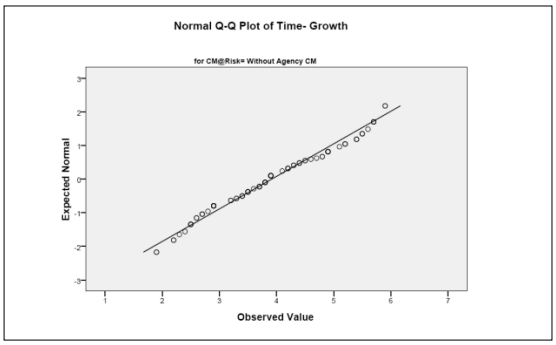

Figure 10: Normal Q-Q Plot of Time-Growth CM-at-Risk Projects without Agency CM

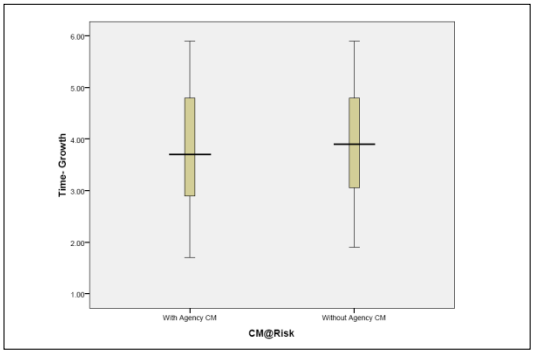

Figure 11:Time Growth for CM-at-Risk Projects with and without Agency CM

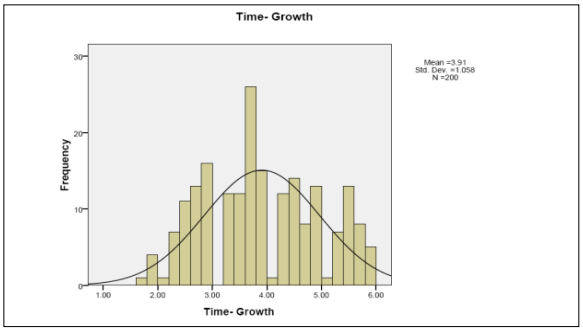

Figure 12: Frequency Distribution of Time Growth in CM-at-Risk Projects

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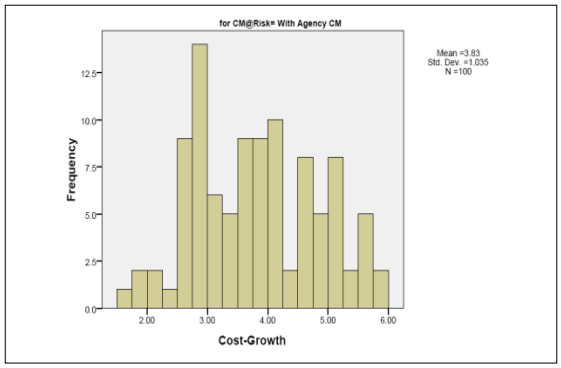

Figure 13: Cost Growth for CM-at-Risk Projects with Agency CM

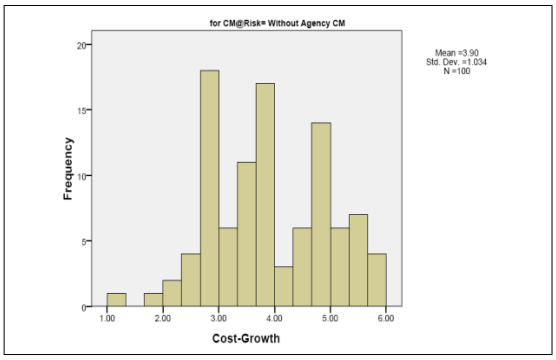

Figure 14: Cost Growth Histogram for CM-at-Risk Projects without Agency CM

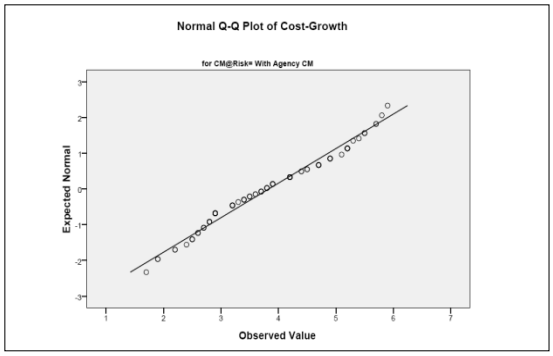

Figure 15: Normal Q-Q Plot of Cost Growth for CM-at-Risk Projects with Agency CM

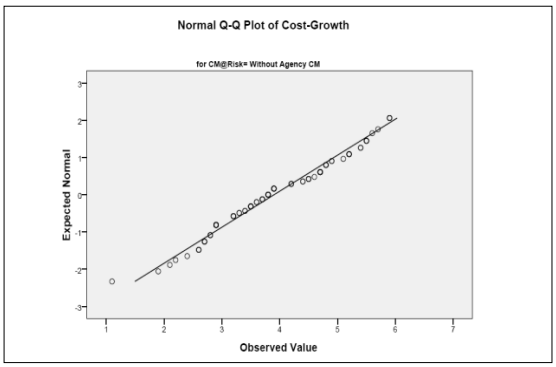

Figure 16: Normal Q-Q Plot of Cost Growth for CM-at-Risk Projects without Agency CM

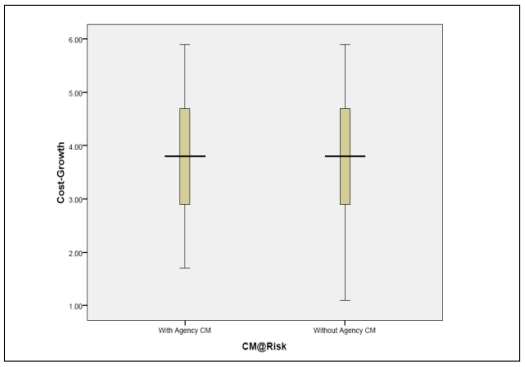

Figure 17: Cost Growth for CM-at-Risk Projects with and without Agency CM

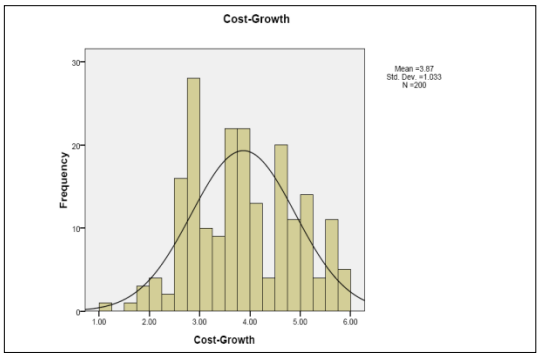

Figure 18: Frequency Distribution of Cost Growth in CM-at-Risk Project

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CM-at-Risk- Quality Score

Table-1: Quality Scores- Case Processing Summary and Descriptive Statistics of CM-at-Risk Projects with and Without Agency CM

CM@Risk

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	CM@Risk	N	Percent	N	Percent	N	Percent
Quality-Score	With Agency CM	100	100.0%	0	.0%	100	100.0%
	Without Agency CM	100	100.0%	0	.0%	100	100.0%

Descriptives

	CM@Risk			Statistic	Std. Error
Quality-Score	With Agency CM	Mean		56.7600	.19546
		95% Confidence Interval for Mean	Lower Bound	56.3722	
			Upper Bound	57.1478	
		5% Trimmed Mean		56.6778	
		Median		55.0000	
		Variance		3.821	
		Std. Deviation		1.95464	
		Minimum		55.00	
		Maximum		60.00	
		Range		5.00	
		Interquartile Range		3.00	
		Skewness		.444	.241

Descriptives

	CM@Risk			Statistic	Std. Error
Quality-Score	With Agency CM	Kurtosis		-1.374	.478
	Without Agency CM	Mean		54.5200	.13064
		95% Confidence Interval for Mean	Lower Bound	54.2608	
			Upper Bound	54.7792	
		5% Trimmed Mean		54.6889	
		Median		55.0000	
		Variance		1.707	
		Std. Deviation		1.30639	
		Minimum		51.00	
		Maximum		55.00	
		Range		4.00	
		Interquartile Range		.00	
		Skewness		-2.375	.241
		Kurtosis		3.712	.478

Table 2: Test of Normality of Performance Metrics of CM-at-Risk Projects' Quality Score with and without Agency CM

Tests of Normality

		Kolmogorov-Smirnov [a]			Shapiro-Wilk		
	CM@Risk	Statistic	df	Sig.	Statistic	df	Sig.
Quality-Score	With Agency CM	.336	100	.000	.748	100	.000
	Without Agency CM	.523	100	.000	.379	100	.000

a. Lilliefors Significance Correction

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CM-at-Risk Time Growth:

Table-3: Time Growth – Case Processing Summary and Descriptive Statistics of CM-at-Risk Projects with and Without Agency CM.

CM@Risk

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	CM@Risk	N	Percent	N	Percent	N	Percent
Time- Growth	With Agency CM	100	100.0%	0	.0%	100	100.0%
	Without Agency CM	100	100.0%	0	.0%	100	100.0%

Descriptives

	CM@Risk			Statistic	Std. Error
Time- Growth	With Agency CM	Mean		3.8960	.10875
		95% Confidence Interval for Mean	Lower Bound	3.6802	
			Upper Bound	4.1118	
		5% Trimmed Mean		3.8967	
		Median		3.7000	
		Variance		1.183	
		Std. Deviation		1.08748	
		Minimum		1.70	
		Maximum		5.90	
		Range		4.20	
		Interquartile Range		1.90	
		Skewness		.103	.241

Descriptives

	CM@Risk			Statistic	Std. Error
Time- Growth	With Agency CM	Kurtosis		-.914	.478
	Without Agency CM	Mean		3.9180	.10338
		95% Confidence Interval for Mean	Lower Bound	3.7129	
			Upper Bound	4.1231	
		5% Trimmed Mean		3.9156	
		Median		3.9000	
		Variance		1.069	
		Std. Deviation		1.03381	
		Minimum		1.90	
		Maximum		5.90	
		Range		4.00	
		Interquartile Range		1.82	
		Skewness		.110	.241
		Kurtosis		-.854	.478

Table 4: Test of Normality of Performance Metrics of CM-at-Risk Projects' Time Growth with and without Agency CM

Tests of Normality

		Kolmogorov-Smirnov [a]			Shapiro-Wilk		
	CM@Risk	Statistic	df	Sig.	Statistic	df	Sig.
Time- Growth	With Agency CM	.100	100	.015	.968	100	.017
	Without Agency CM	.097	100	.022	.971	100	.027

a. Lilliefors Significance Correction

CM-at-Risk Cost Growth

Table-5: Cost Growth – Case Processing Summary and Descriptive Statistics of CM-at-Risk Projects with and Without Agency CM.

CM@Risk

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	CM@Risk	N	Percent	N	Percent	N	Percent
Cost-Growth	With Agency CM	100	100.0%	0	.0%	100	100.0%
	Without Agency CM	100	100.0%	0	.0%	100	100.0%

Descriptives

	CM@Risk			Statistic	Std. Error
Cost-Growth	With Agency CM	Mean		3.8340	.10354
		95% Confidence Interval for Mean	Lower Bound	3.6286	
			Upper Bound	4.0394	
		5% Trimmed Mean		3.8322	
		Median		3.8000	
		Variance		1.072	
		Std. Deviation		1.03536	
		Minimum		1.70	
		Maximum		5.90	
		Range		4.20	
		Interquartile Range		1.80	
		Skewness		.126	.241

Descriptives

	CM@Risk			Statistic	Std. Error
Cost-Growth	With Agency CM	Kurtosis		-.934	.478
	Without Agency CM	Mean		3.9040	.10340
		95% Confidence Interval for Mean	Lower Bound	3.6988	
			Upper Bound	4.1092	
		5% Trimmed Mean		3.9078	
		Median		3.8000	
		Variance		1.069	
		Std. Deviation		1.03396	
		Minimum		1.10	
		Maximum		5.90	
		Range		4.80	
		Interquartile Range		1.80	
		Skewness		.042	.241
		Kurtosis		-.620	.478

Table 6: Test of Normality of Performance Metrics of CM-at-Risk Projects' Cost Growth with and without Agency CM

Tests of Normality

		Kolmogorov-Smirnov [a]			Shapiro-Wilk		
	CM@Risk	Statistic	df	Sig.	Statistic	df	Sig.
Cost-Growth	With Agency CM	.106	100	.007	.970	100	.024
	Without Agency CM	.102	100	.013	.974	100	.043

a. Lilliefors Significance Correction

CM-at-Risk Projects – T- Test

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Table7: Group Statistics of Cost Growth, Time Growth and Quality Score In CM-at-Risk Projects with and without Agency CM

Group Statistics

	CM@Risk	N	Mean	Std. Deviation	Std. Error Mean
Time- Growth	With Agency CM	100	3.8960	1.08748	.10875
	Without Agency CM	100	3.9180	1.03381	.10338
Cost-Growth	With Agency CM	100	3.8340	1.03536	.10354
	Without Agency CM	100	3.9040	1.03396	.10340
Quality-Score	With Agency CM	100	56.7600	1.95464	.19546
	Without Agency CM	100	54.5200	1.30639	.13064

Table 8: T-Test Independent Sample Test for Cost Growth, Time Growth and Quality Score in CM-at-Risk Projects with and Without Agency CM.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Time- Growth	Equal variances assumed	.587	.445	-.147	198	.884
	Equal variances not assumed			-.147	197.495	.884
Cost-Growth	Equal variances assumed	.037	.848	-.478	198	.633
	Equal variances not assumed			-.478	198.000	.633
Quality-Score	Equal variances assumed	68.305	.000	9.528	198	.000
	Equal variances not assumed			9.528	172.734	.000

Independent Samples Test

		t-test for Equality of Means			
		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
				Lower	Upper
Time- Growth	Equal variances assumed	-.02200	.15005	-.31789	.27389
	Equal variances not assumed	-.02200	.15005	-.31790	.27390
Cost-Growth	Equal variances assumed	-.07000	.14632	-.35855	.21855
	Equal variances not assumed	-.07000	.14632	-.35855	.21855
Quality-Score	Equal variances assumed	2.24000	.23510	1.77638	2.70362
	Equal variances not assumed	2.24000	.23510	1.77596	2.70404

1) Cost Growth

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The mean Cost growth in CM-at-Risk projects without Agency CM =3.904
The mean Cost growth in CM-at-Risk projects with Agency CM = 3.834
T-test for Equality of means (Table-8) illustrates that at 95% confidence interval of the difference, there is no significant difference in means of Cost growth of CM-at-Risk projects with Agency CM and Cost growth of CM-at-Risk projects without agency CM. Hence the null hypothesis, "the mean Cost growth of CM at Risk projects with Agency CM is at least equal to the mean Cost growth of CM-at-Risk projects without agency CM" cannot be rejected statistically. The alternate hypothesis, "the mean Cost growth of CM-at-Risk projects with Agency CM is less than the mean Cost growth of CM-at-Risk projects without Agency CM" is statistically rejected. Cost growth in both the cases is nearly equal.

2) Time Growth

The mean Time growth in CM-at-Risk projects without agency CM=3.918
The mean Time growth in CM-at-Risk projects with agency CM=3.896
T-test for Equality of means (Table-8) illustrates that at 95% confidence interval of the difference, there is no significant difference in means of Time growth of CM-at-Risk projects with Agency CM and Time growth of CM-at-Risk projects without agency CM. Hence the null hypothesis, "the mean Time growth of CM-at-Risk projects with Agency CM is at least equal to the mean Time growth of CM-at-Risk projects with Agency CM" cannot be statistically rejected and the alternate hypothesis "the mean Time growth of CM-at-Risk projects with Agency CM is less than the mean Time growth of CM-at-Risk projects without Agency CM is statistically rejected. Time growth in both the cases is nearly equal.

3) Quality Performance

The mean Quality Score in CM-at-Risk projects with Agency CM=56.76
The mean Quality Score in CM-at-Risk projects without Agency CM=54.52
T-test for Equality of means (Table-8) illustrates that at 95%Confidence Interval of the difference, there is significant difference in means of Quality Score of CM-at-Risk projects with Agency CM and Quality Scores of CM-at-Risk projects without Agency CM. Hence the null hypothesis, "the mean quality score of CM-at-Risk projects with Agency CM is at most equal to the mean quality score of CM-at-Risk projects without Agency CM" is statistically rejected. The alternate hypothesis, "the mean quality score of CM-at-Risk projects with Agency CM is greater than the mean quality score of CM-at-Risk project without Agency CM", cannot be statistically rejected.

VI. CONCLUSION

The study of empirical evaluation of performance of CM-at-Risk Projects with and Without Agency CM shows that the Cost Growth and Time Growth of CM-at-Risk projects with Agency CM are nearly equal to CM-at-Risk Projects where Agency CMs are not used. The quality performance of the CM-at-Risk Projects with Agency CM is found to be better than the CM-at-Risk projects without Agency CM. Though the remuneration payable to the Agency CM as a monthly fee or as a percentage of the project has a conflict of interest with the final duration and final cost of the project, this study suggests that the Owners/Clients may select the CM-at-Risk project Delivery System with Agency CM compared to CM-at-Risk Project Delivery system without Agency CM, despite the considerable amount of fee required to be paid to Agency CM firms. It is because the results of the study indicated 1) the quality performance of projects had improved when CM-at-Risk Project delivery system was used with Agency CM , 2) there was no increase in time growth and cost growth in projects though there was a possible conflict of interest between the time based remuneration of Agency and the project's final duration and final cost.3) An Agency CM- may also provide services such as interviewing and selecting the designer and the CM at Risk, coordinate activities among parties and otherwise serve to protect the owner's interests based on the scope of services in agreement.

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