

Quantifying the Impact of Incentives on Cost and Schedule  
Performance of Construction Projects in United States

by

Bala Sai Krishna Paladugu

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Graduate Supervisory Committee:

Mounir El Asmar, Chair  
James Ernzen  
Kenneth Sullivan

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## ABSTRACT

In today's era a lot of the construction projects suffer from time delay, cost overrun and quality defect. Incentive provisions are found to be a contracting strategy to address this potential problem. During last decade incentive mechanisms have gained importance, and they are starting to become adopted in the construction projects. Most of the previous research done in this area was purely qualitative, with a few quantitative studies. This study aims to quantify the performance of incentives in construction by collecting the data from more than 30 projects in United States through a questionnaire survey. First, literature review addresses the previous research work related to incentive types, incentives in construction industry, incentives in other industry and benefits of incentives. Second, the collected data is analyzed with statistical methods to test the significance of observed changes between two data sets i.e. incentive projects and non-incentive projects. Finally, the analysis results provide evidence for the significant impact of having incentives; reduced the cost and schedule growth in construction projects in United States.

## DEDICATION

I dedicate this work to my parents – Prasad and Jayalalithaa, my brother- Manoj Kumar, my professor - Mounir El Asmar, and my friend - Richard Standage, for their love, support and encouragement for giving me a chance to prove and improve my-self .

## ACKNOWLEDGMENTS

Firstly, I would like to express my sincere gratitude to my advisor Dr. Mounir El Asmar for the continuous support of my research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor. My graduate year and this research work would have not been successful if not for his continuous dedication to help encourage and support.

I would also like to thank Dr. James Ernzen and Dr. Kenneth Sullivan, Committee members, who have always guided me through graduate studies. I am heartily thankful to Richard Standage, Abbas Chokar, Jera Sullivan, Tober Francom, David Ramsey, my parents, my brother, friends and all those who supported me through this research.

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# CHAPTER 1

## INTRODUCTION

Construction is a major industry throughout the world accounting for a sizeable portion of most countries Gross Domestic Product (GDP) (David Crosthwaite, 1999). According to a recent report published in 2014 by the Bureau of Economic Analysis, the construction industry accounts for about 3.7 percent of the United States Nation's GDP, with 6.38 million workers working in this industry by the end of August, 2015 (BLS, 2015).

Many construction projects suffer performance problems due to time delay, cost overrun and quality defect (Sun and Meng, 2009). A large number of research efforts have been made to identify various possible solutions to address these types of performance problems. Jaafari (1996) states that incentive provisions can be used as a contractual strategy; which has a significant potential to address performance problems in construction projects.

The correct use of incentives can motivate substantial change in the industry. For example: In energy industry; tax incentives are drivers for usage of renewable energy growth in the United States. In industries motivating employees is always one of the management's biggest concerns. Most of them use rewards and recognition programs to help them achieve their goals and objectives (Severt and Breiter, 2010). Organizations that develop cultures based on employee recognition and rewards programs will be better positioned to survive and even thrive, because their employees remain motivated and engaged (Severt and Breiter, 2010). Rose and Manley (2011) saw the use of incentives as



a key means of improving performance by simulating the motivation to work harder and smarter in pursuit of high-order performance objectives.

The basic principle of incentive in construction contracting is to take advantage of a contractor's general objective to maximize his profits by giving him the opportunity to make more profits if he performs the contract efficiently (Bower et al., 2002). According to Bubshait (2003), clients can provide time incentives for early completion, cost incentive for cost saving, quality incentives for zero or minor defects, and sometimes safety incentives for complying with safety rules and standards. This research analyzes the impact of incentives currently being used in construction, specifically on how they impact cost and schedule performance in construction projects in United States.

## CHAPTER 2

### LITERATURE REVIEW

Many studies have been carried out in different parts of the world to understand the various aspects of incentives; these are discussed in the following paragraphs.

#### **Incentives:**

The literal definition of incentive states that incentive is “a payment or concession to stimulate greater output or investment” (Oxford Dictionary, n.d). Stukhart (1984) says that incentives are used in construction contracting to reduce overall contract cost, to control time and to increase support of specific performance goals such as productivity, quality, safety, technological process, innovation and management. Similarly, in terms of the construction industry this definition is translated into, attempts to increase production or performance in return for increased psychological or material rewards (Liska and Snell, 1992). From a client perspective, it is ideal that a project is completed in the minimum time, at the minimum cost, and with the best quality (Arditi et al. 1997).

In addition to incentives, disincentives are often seen in practice, for example: time disincentive for late completion of project (Shr and Chen, 2004), cost disincentive for cost overrun and quality disincentive can be set for major defects (Meng and Gallagher, 2011). Therefore, an incentive refers to a reward and a disincentive refers to penalty (Bubshait, 2003). The purpose of an incentive/disincentive scheme is to motivate the contractor for excellent performance or demotivate the contractor for poor performance (Meng and Gallagher, 2011). However, this study focuses on incentives performance only.

### **Incentives in Construction:**

As stated earlier, there are generally four types of incentives in construction projects, e.g. time, cost, quality, (Stukhart, 1984) and safety incentives (Ibbs and Ashley, 1987). In recent years, an incentive mechanism in construction industry has gained an important attention from researchers and practitioners. For example,

- Jaraiedi et al. (1995) developed a set of guidelines for the use of incentives in highway construction contracts.
- Bubshait (2003) compared the perceptions of clients and contractors regarding the use of incentives.
- Rose and Manley (2010) provided practical recommendations for clients who design and implement financial incentives in their projects.
- Meng and Gallagher (2011) analyzed the relationship between use of incentives and performance of projects in UK and ROI.
- Hasan and Jha (2015) listed out various attributes affecting the successful use of incentive / disincentive clauses in reaching the performance goals.

#### *Cost and Time Incentives:*

Cost incentive is provided for the construction project; if the owner has cost saving in the project. Cost saving is often split between the client and the contractor in terms of a sharing ratio (Al-Harbi, 1998; Broome and Perry, 2002). Similarly, time incentive is

provided for the construction project; if the project is completed within estimated schedule. Time incentive is generally paid to the contractor in the form of a bonus, e.g. a certain amount for each day of early completion (Arditi et al., 1997).

By comparison, cost and time incentives have received much more research attention than other incentives such as quality and safety incentive. For example, Ibbs and Ashley (1987) emphasized that schedule in a construction project is definitely improved by the inclusion of positive incentive provisions. Hijleh and Ibbs (1989) studied the different types of schedule incentives in construction projects. Jariedi et al. (1995) concluded that incentive/disincentive provisions enable project completion time to be reduced by up to 50%. Jaafari (1996) analyzed time and cost incentives in marine construction projects. On the other hand, Shr and Chen (2004) analyzed how to set maximum time incentives for highway construction projects, whilst Chan et al. (2010) evaluated how to achieve better performance through target cost contract in an underground railway station modification project.

*Other Incentives: (Quality and Safety)*

Quality incentives are provided if contractor performs the job without any defects. Similarly, safety incentives are provided in the construction projects for complying with safety rules and standards. Both safety and quality incentives are paid as a bonus in construction projects.

As mentioned earlier, research efforts for safety and quality incentives are quite limited. Ibbs and Ashley (1987) emphasized safety is definitely improved by the inclusion of positive incentive provisions in construction projects. Construction Industry

Institute (CII) (1993) identified “written safety incentive program” as one among the five high-impact safety techniques for construction, which are known as zero-injury techniques. Similarly, Gellar (1999) emphasized that having incentive schemes reduced the accidents and injuries in the construction site. According to Teo et al. (2005) site safety is affected by four main factors: company safety policy, construction process, personnel management with regard to safety, and incentives. Molenaar et al. (2009) states that safety incentives increase the safety performance in construction project and have a greater effect on safety motivation than do disincentives. Similarly, with respect to quality incentives, Meng and Gallagher (2011) provided an empirical evidence for how quality incentives have improved projects’ performance in construction projects in UK and ROI.

To ensure the success of incentive mechanisms the contractor needs to make an extra effort for the enhancement of project management processes, the creation of collaborative working environments, and the motivation of his staff and workforce (Meng and Gallagher, 2011). Similar to the construction industry, incentives are also adopted and they have been successful in other industry to achieve better performance; this is explained in following paragraphs.

### **Incentives in Other Industries:**

Compared to the construction industry, very limited amount of research is available in other industry which is more a type of qualitative study. For example, Besley and Ghatak (2003) studied the incentives in public bureaucracies and private non-profits emphasizing the role of matching principals’ and motivational agents’ mission preferences in

increasing organizational efficiency, Jeffrey (2003) emphasized a strong causal relationship between managerial compensation and investment policy, debt policy, and firm risk. Similarly, Belghitar and Clark (2014) assessed the impact of compensation based incentives, together with monitoring mechanisms on investment related agency costs.

In recent times, incentives were more successful in energy industry and gained more attention from public and private industry. Ozcan (2014) says countries apply different incentive systems in order to encourage the use of renewable energy source for electricity. Similarly, Black et.al (2014) stated that many states in United States have implemented legislation in the form of financial incentives and renewable portfolio standards to support wind development. It is shown that state tax incentives and physical drivers have a significant positive impact on wind energy growth. One of the supportive tax credit incentive schemes applicable for renewable energy generations adopted in United States is Production Tax Credit (PTC), which provides a tax credit for the production of electricity from renewable sources and the sale of that electricity to an unrelated party (KPMG, 2013). Furthermore, benefits of having incentives are discussed in the following paragraphs.

### **Benefits of Incentives:**

“Incentivization is “a process by which a provider is motivated to achieve extra ‘value-added’ services over those specified originally and which are of material benefit to the user. These should be assessable against predefined criteria. The process should benefit both parties. It creates a more proactive cooperative relationship between the

contracting parties and reinforces the cultural shift away from the traditional, adversarial approach to contracting.” (HM, 1991) (Bower et al., 2002) Some benefits that can be delivered by Incentivization in addition to those inherent in the base contract include (HM, 1991; Bower et al, 2002):

- Lower cost
- Faster or more timely delivery of service with no compromise of quality
- Full understanding of the relationship cost, the quality of the service delivery, and the ability to deal more effectively with changes during the contract
- Increased service level
- Greater price stability
- Enhanced achievement of the desired outcome
- Improved management of information
- Improved management, control, and monitoring of contract.

Furthermore, the construction industry Institute (CII) reported similar benefits, which include the following (CII 1995; Bower et al., 2002):

- Lower cost facilities
- Improved schedule performance
- Improved customer satisfaction

- Improved alignment and focus on client's objective, and
- Pay for performance

Stukhart (1984) concluded that owners must emphasize negotiation of the most reliable targets rather than elaborate sharing schemes and complex incentives, and it is essential that targets must be realistic estimates of actual costs, labor hours or schedules. If contractor wants to successfully obtain the incentive offered, they need to anticipate problem areas and fix them before occurrence, and incentives should be made measurable and objective using relevant benchmarks (Bower et al., 2002). Contractors should ensure that the level of quality and safety are not affected due to the fast tracking of a project with every effort to maintain standards (Bubshait, 2003).

Although previous studies present the good understanding of incentive mechanisms to a project's success, most of these studies have not provided any empirical data for the performance outcomes of incentives project. Therefore, there exists a gap in knowledge to evaluate the actual impact of incentives on project performance parameters. This research objective makes an attempt to quantify the impact of incentives on cost and schedule growth performance in the construction projects. This objective is achieved by analyzing the real data collected from more than 30 construction projects in United States through a questionnaire survey.

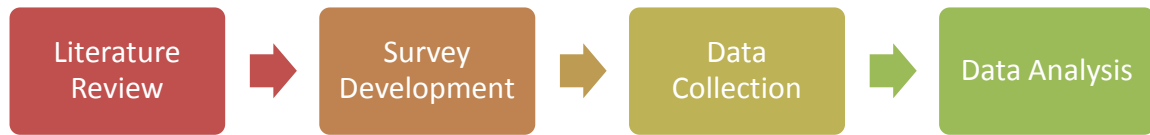


## **CHAPTER 3**

### **OBJECTIVE AND METHODOLOGY**

The present study was carried out to quantify the performance of incentive based construction projects by comparing with the non- incentive construction projects in United States. The main objectives of this research study are: 1) Quantifying the impact of incentives on cost growth and 2) Quantifying the impact of incentives on schedule growth.

This study requires quantitative methodology to evaluate the changes observed between incentive and non-incentive projects. The research method begins with a summary of literature review on incentives study that was reviewed in context for both the construction industry and other industries. Based on the identification of strengths and weaknesses within previous studies, the review helped identify a gap for this research. After completing the literature review, a survey questionnaire was developed. After the iterative revision from the industry experts, the questionnaire was advertised nationally. The survey was sent to the construction firms that have incentives in their projects and also to the firms that did not provide incentives to set a baseline for comparison. Finally, a quantitative analysis was done on the collected data to investigate the impacts of incentives on cost and schedule performance. Figure 1 show the research methodology used in this study.



**Figure 1: Flow Chat of Research Methodology**

**Literature Review:**

The literature review shows the qualitative responses among researchers and practitioners regarding the importance of incentives construction projects and other industry. Although, most of the earlier research contributes a good understanding of impact of incentive mechanism, there are obvious limitations with in these studies. For example, most of the previous studies, such as Bower et al. (2002), Bubshait (2003), Rose and Manley (2011), and Black et al.(2014) have performed only a qualitative analysis and not a quantitative study of performance. Therefore, it is hard to quantify the real effect of incentives on project performance. Although, Meng and Gallagher (2011) provided some empirical results on incentives, concluding construction projects with incentives have better performance in UK and ROI. There exists a research gap to evaluate the impact of incentives on construction project performance parameters in United States. The following paragraphs explain the survey development and data collection process adopted in this study.

### **Survey Development:**

Identifying the key incentive variables and performance metrics provides guidance about the type of data that needs to be collected. Therefore, the completion of the literature review serves as a foundation for the survey development. The survey was developed based on the identified incentive variables and purposely designed to gather incentive input data and quantitative project performance metrics. Before the survey was administered, it was reviewed by industry and academic experts as well as survey experts and was pilot tested on a limited number of projects to maximize its effectiveness. The survey included a question that categorizes projects into incentive and non-incentive based projects; a question that identifies the performance metrics on which incentives are based (e.g., cost, schedule); a question to gauge the value of the incentives and their distribution among project stakeholders and questions to assess the cost performance (e.g., initial cost versus final costs) and schedule performance (estimated date versus final date) of the project.

### **Data Collection:**

The resulting survey allowed for a data collection effort targeting incentives characteristics and performance metrics for individual construction projects. The data collection was aimed at institutional projects completed in the last decade, and representing all major project delivery systems. The survey targeted projects that have incentives, as well as projects that do not. The data of non-incentive projects acts as a baseline for this study. This data collection effort resulted in more than 30 construction projects, of which two-thirds are non-incentive based, and one third are incentive based.

### **Data Analysis:**

For the purpose of analysis of the data collected from the questionnaire survey three statistical methods have been chosen in these research studies which are discussed in the following paragraphs.

#### ***Box –and -Whisker Plots:***

The box plot is an exploratory graphic, created by John W. Tukey, used to show the distribution of a data set. It is a nonparametric graphical summary of data, displaying the sample minimum, lower quartile, median, upper quartile, and maximum. A thick black line, dividing the dataset in half, represents the median value. The rectangle represents the 50% of the data around the median, whereas the remaining 50% of the data are divided equally above and below the rectangle (El Asmar et al., 2013). If the data set includes one or more outliers, they are plotted separately as points on the chart. Box plots provide a useful way to visualize the range and other characteristics of responses for a large group. In this research study box plots are used to analyze the distribution of data, and to identify outliers. The outliers are the data points which are above or below 1.5times the inter-quartile range values in box-plot (Lehmann and Romano, 2005).

#### ***Quantile –Quantile (Q-Q) Plots:***

The quantile –quantile (q-q) plots are the probability plot, which is graphical method for comparing two probability distributions by plotting their quintiles against each other (Wilk, 1968). In general, the basic idea is to compute the theoretically expected value for each data point based on the distribution in question. If the data indeed follow the

assumed distribution, then the points on the q-q plot will fall approximately on a straight line (David, n.d)

A q-q plot is a plot of the quantiles of the first data set against the quantiles of the second data set. By a quantile, it means the fraction (or percent) of points below the given value. That is, the 0.3 (or 30%) quantile is the point at which 30% percent of the data fall below and 70% fall above that value. A 45-degree reference line is also plotted. If the two sets come from a population with the same distribution, the points should fall approximately along this reference line. The greater the departure from this reference line, the greater the evidence for the conclusion that the two data sets have come from populations with different distributions (Lehmann and Romano, 2005). In this study Q-Q plots are used to test the normality of the two data sets i.e. incentives projects and non-incentives projects.

***Mann –Whitney -Wilcoxon Test:***

The Mann-Whitney-Wilcoxon (MWW) test is the alternative test to the independent sample t-test. It is a non- parametric test that is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. It is also used to test whether two population means are equal or not. MWW test assumes the sample drawn from the population is random. The specific formula given below is used to calculate U-value in MWW test (Lehmann and Romano, 2005).

$$U = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - \sum_{i=n_1+1}^{n_2} R_i$$

Similar to parametric tests, alpha value of 0.05 is used to test the significance. A p-value smaller than 0.05 indicates the differences observed between the two samples are significant. In this study, MWW test is used to test the significance of changes observed, for the assumed observations for non-linear distribution data which is concluded from q-q plots. The following section presents and discusses the results of the analysis, starting with the characteristics of the construction projects studied for this paper.

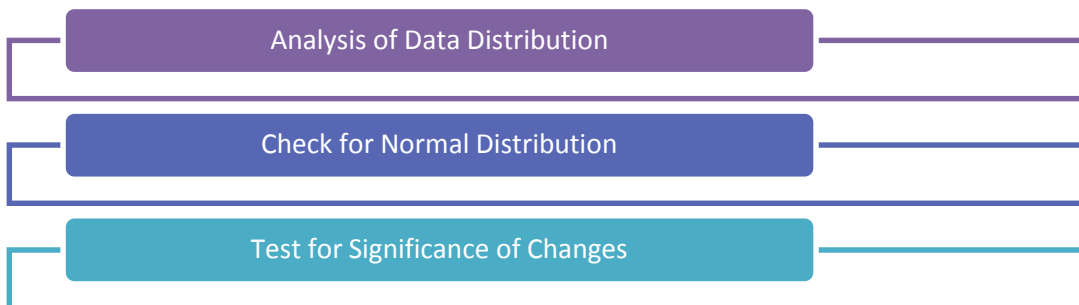
## CHAPTER 4

### RESULTS

#### Data Characteristics:

Through the collaboration with contractors, cost and schedule data was collected from the 35 construction projects, which are all predominantly located in the U.S. Midwest and Pacific Southwest regions. Of these 35 data sets, 24 data sets are from non –incentive projects which are used as a baseline for comparison with 11 incentive based projects to identify the impact of incentive on project performance in terms of cost and schedule.

On the collected data sets, the quantitative analysis is performed between incentives and non-incentives projects in a comparative way, from which it is clear to see the influence of having incentives had improved the cost and schedule performance in construction projects in United States. The statistical analysis provides a quantitative evidence for the significance of changes observed in cost and schedule growth data between incentive and non-incentive projects. The overall data analysis is done in the following three steps; as shown in Figure 2. The analysis of difference between incentive and non-incentive projects in terms of cost and schedule performance is addressed in the following sections.



**Figure 2: Steps of Data Analysis**

**A) Impact of incentives on cost growth:**

In the survey questionnaire, the respondents are asked to provide the information about initial cost and final cost of the project from which the cost growth percentage is calculated for the corresponding project. The mathematical formula used to calculate the cost percentage is shown below:

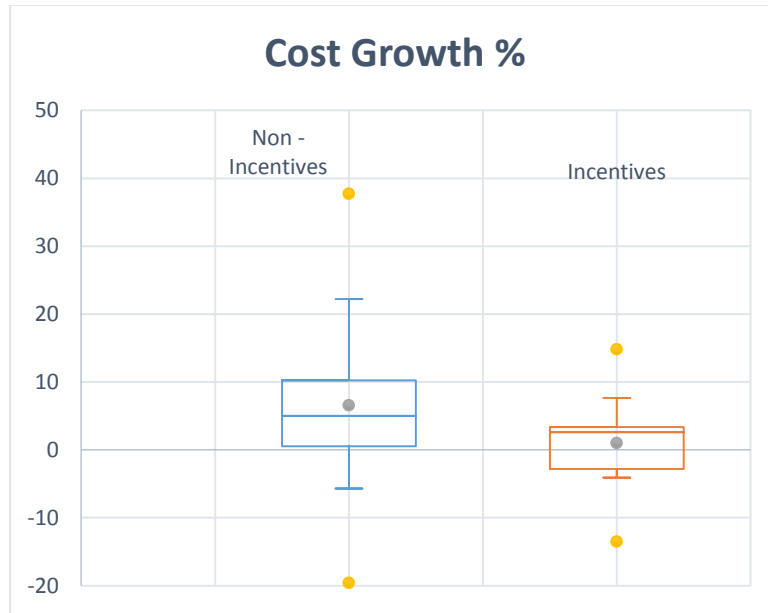
$$\text{Cost Growth \%} = \frac{\text{Final cost} - \text{Initial cost}}{\text{Initial cost}} \times 100$$

The calculated values from the collected data are used in this study for performing analysis with statistical methods.

**Analysis of Data Distribution:**

First, in this study box plot is used to analyze the data distribution and identify the outliers in the data. A boxplot can give information regarding variability, mean and median of statistical data set.





**Figure 3: Data Distribution of Cost Growth%**

Figure 3 shows the boxplot of incentive and non- incentive projects over cost growth percentage data. From the box plot it is observed that non-incentive projects have higher distribution than incentive projects, the median value is found to be near to each other. Similarly, the mean value of non-incentives projects is greater than the incentives projects. And also substantially more variance is observed in non –incentive projects’ which ranges from -6% to 22% whereas incentives projects’ ranges from -4% to 8%. Table 1 shows the descriptive statistics between incentive and non- incentive projects with respect to cost growth data.

**Table 1: Descriptive Statistics of Cost Growth %**

<b>Statistic</b>	<b>Non - incentive</b>	<b>Incentive</b>
<b>Number of observations</b>	24	11
<b>Minimum</b>	-19.573	-13.538
<b>Maximum</b>	37.719	14.802
<b>Range</b>	57.292	28.340
<b>1st Quartile</b>	0.526	-2.795
<b>Median</b>	5.024	2.609
<b>3rd Quartile</b>	10.217	3.355
<b>Mean</b>	6.571	0.977
<b>Variance (n)</b>	125.467	47.469
<b>Variance (n-1)</b>	130.922	52.216
<b>Standard deviation (n)</b>	11.201	6.890
<b>Standard deviation (n-1)</b>	11.442	7.226

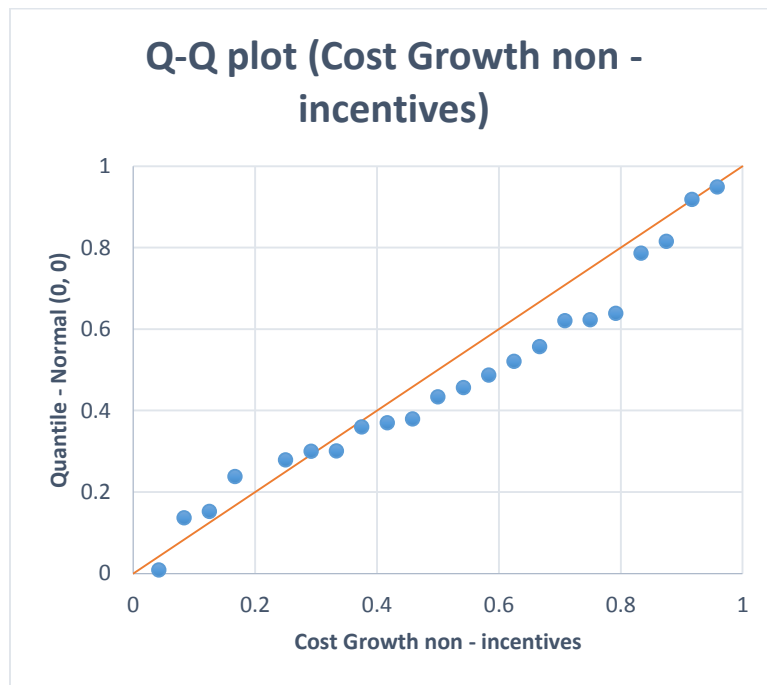
Continuing, the variance in non-incentive projects is more than double the value of incentive projects. From all these observations it is clearly seen that the data set of incentive projects and non –incentive projects are independent to each other, difference between means is relevant and incentive projects have less cost growth compared to that of non- incentives projects. From the analysis it is also observed that most of the projects with incentives have completed within the estimated cost. Though there are some projects that exceeded budget, but this value is comparatively less when compared to that of non-incentive projects.

Overall, two outliers are observed in each of incentive and non-incentive projects data set. These outlier values are greater than 1.5 times the inter-quartile range. For better accuracy of results, these outliers are removed in further study during the test for

significance of changes, because an outlier may indicate an experimental error; which may commonly affect the results and assumptions (Grubbs, 1969).

Check for Normal Distribution:

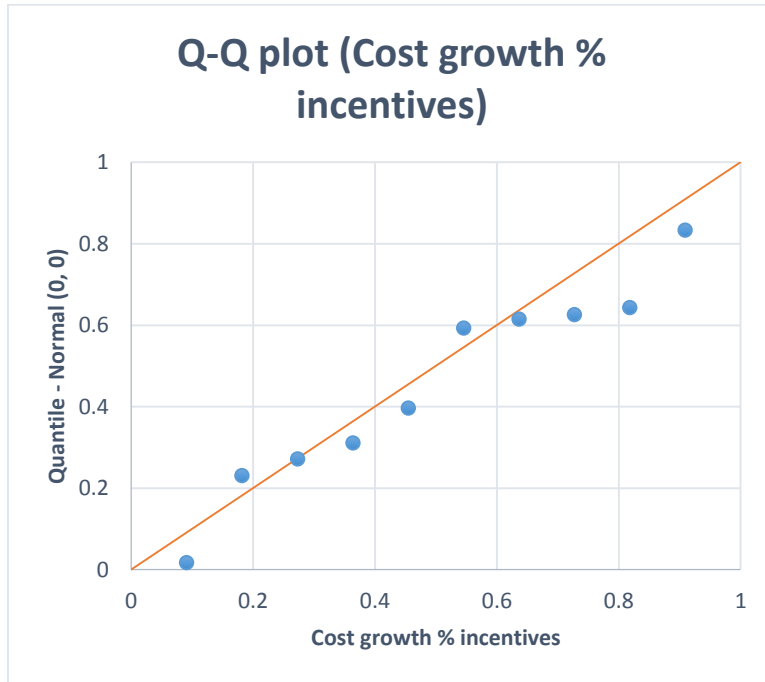
From the above distribution analysis, clear changes are observed between the data sets due to the presence of incentives. Now, it is important in this study to understand whether the data is normally distributed or non –normally distributed, because most of statistical tests rest up on the assumption of normality which have a tendency to change final results. For this purpose q-q plots are used in this research work to study the visual distribution of the data sets, which are presented in Figure 4 & 5.



**Figure 4: Q-Q Plot / Cost Growth % of Non –Incentive projects**

Figure 4 shown above present the q-q plot of non- incentive projects with cost growth percentage data values. From this figure, it is clearly observed that most of the data set

values don't fall near to the 45<sup>th</sup> quartile line; which means the cost growth data of non - incentive projects are non-normally distributed.



**Figure 5: Q-Q plot/ Cost Growth% of Incentive projects**

Similar to the observations made in Figure 4, in Figure 5 the Q-Q plot presents the cost growth percentage values of incentive projects. From this figure, it is observed that most of the data set values don't fall near to the 45<sup>th</sup> quartile line; which means the cost growth data of incentive projects are non- normally distributed.

#### Test for Significance of Observed Changes:

As the two dataset values are non-normally distributed, in this study non-parametric test i.e. Mann- Whitney Wilcoxon (MWW) test is used to test for the significance of

changes observed in Figure 3. The MWW-test is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous but not normally distributed. Usually, the test is conducted at a confidence level ( $\alpha$ ) value of 5% (Zar, 1984). Initially the test is conducted without removing the outliers from the data set.

From MWW-test, it is observed that “p” value i.e. 0.065 (6.5%) is greater than the “ $\alpha$ ” value i.e. 0.05 (5%) which means that probability of null- hypothesis to be true is only 6.5%. This means that changes observed between median values of incentive and non –incentive projects in Figure 3 are not significant.

Similarly, as mentioned earlier in order to observe the accurate results, two extreme outliers are removed from the two data sets of incentives and non- incentives projects, and MWW-test is conducted again on the data set; assuming that outliers have an impact on the above results. After retesting, it is observed that “p” value i.e. 0.047 (4.7%) is less than the  $\alpha$ -value i.e. 0.05 (5%) which mean that probability of null- hypothesis to be true is only 4.7%. In other words the probability of disproving the null –hypothesis is 95.3%, which means the observed changes in Figure 3 between the median values of incentives and non- incentives project are significant. Therefore, based on the collected sample data the author can’t reject the hypothesis i.e. having incentives in the project had decreased the construction cost growth in United States.

## **B) Impact of Incentives on Schedule growth:**

In the survey questionnaire, the respondents are asked to provide the information about estimated final date and actual final date of the project schedule; from which the number of work days for the project is determined, and schedule growth percentage is calculated. The mathematical formula used to calculate the cost percentage is shown below:

$$\text{Schedule Growth \%} = \frac{\text{Actual work days} - \text{Initial contract days}}{\text{Initial contract days}} \times 100$$

The calculated values from the collected data are used in this study for performing analysis with statistical methods to identify the performance of incentives on schedule growth of the construction project.

### Analysis of Data Distribution:

Similar to the cost growth data, box plots are used to analyze the data distribution and to identify the outliers in the data. Initially, all 35 projects are used for the distribution analysis. Figure 6 shows the data distribution of incentive and non-incentive projects over schedule growth percentage. From Figure 6, on incentives distributions it is clearly observed that the mean value is out of inter quartile range or box plot. This is because one of the incentive based project is having a schedule growth of 329.3%. From enquiry, it is known that the project is halted for several months in order to get permissions from the

local government agencies which resulted in high percentage of schedule growth. For the feasibility of analysis, this project is excluded from incentive project data set.

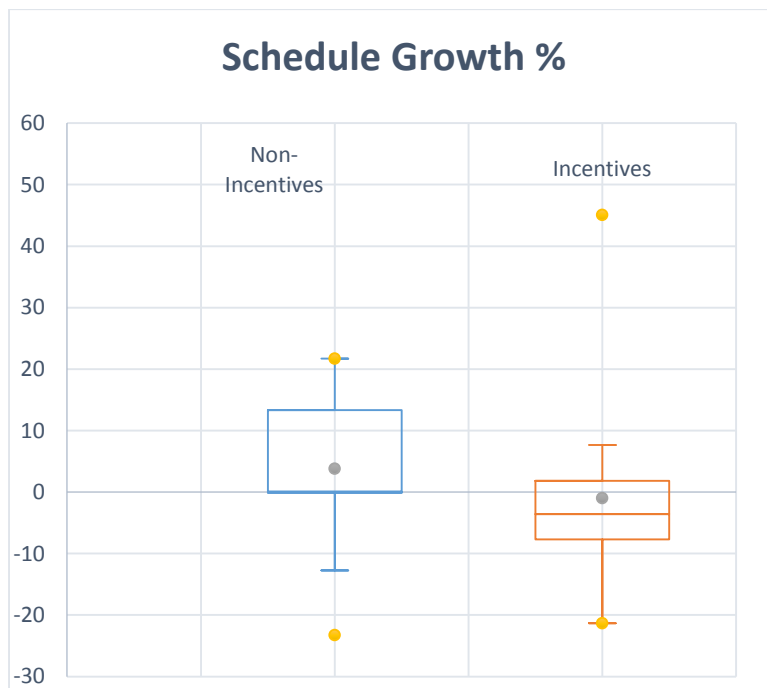


**Figure 6: Data Distribution of Schedule Growth% with Extreme Outlier**

Figure 7 shows the box plot of incentive and non- incentive projects over schedule growth percentage data. A Total of 34 projects are used for this analysis; of which 24 are non –incentive based and 10 projects are incentive based.

The mean values of incentives and non-incentives data set are different from each other i.e. the mean value of incentive projects is close to zero whereas the mean value of non-incentive projects is found to be at 3.7%. The median value of schedule growth in non- incentive projects is found to be approximately lying on the first quartile value that is very close to zero which means that 50 % of the construction projects in this data set

are facing schedule growth problem; where as in case of incentives the median value is negative and it is observed to have 70% of construction projects are completed on time or prior to the schedule. And also substantially more variance is observed in non –incentive projects’ which ranges from -11% to 21% whereas incentives projects’ ranges from -21% to 9%. Table 2 shows the descriptive statistics between incentives and non- incentives projects with respect to schedule growth data.



**Figure 7: Data Distribution of Schedule Growth %**



**Table 2: Descriptive Statistics of Schedule Growth %**

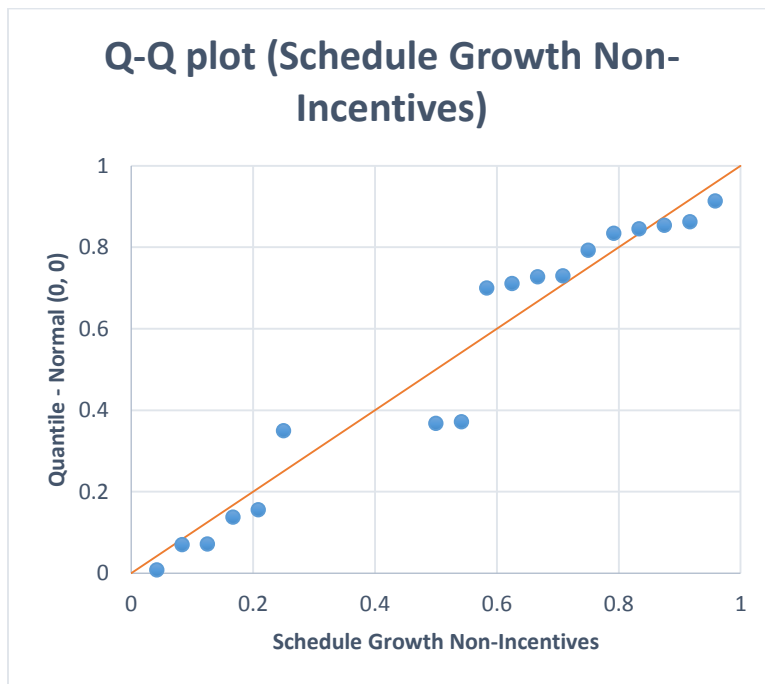
<b>Statistic</b>	<b>Non-Incentives</b>	<b>Incentives</b>
<b>Number of observations</b>	24	10
<b>Minimum</b>	-23.232	-21.317
<b>Maximum</b>	21.725	45.055
<b>Range</b>	44.957	66.372
<b>1st Quartile</b>	-0.139	-7.712
<b>Median</b>	0.055	-3.594
<b>3rd Quartile</b>	13.344	1.838
<b>Mean</b>	3.788	-0.988
<b>Variance (n)</b>	125.456	315.527
<b>Variance (n-1)</b>	130.911	350.585
<b>Standard deviation (n)</b>	11.201	17.763
<b>Standard deviation (n-1)</b>	11.442	18.724

From all these observations it is clearly seen that the data set of incentive projects and non –incentive projects are independent to each other. Difference between the mean values shows that incentive projects have less schedule growth compared to that of non-incentives projects. From the analysis it is also observed that most of the projects with incentives have completed within the estimated schedule. Though there are some projects that exceeded schedule, but this value is comparatively less when compared to that of non-incentive projects.

Overall, two outliers are observed in each of incentive and non-incentive projects data set. For better accuracy of results, these outliers are removed in further study during the test for significance of changes observed in figure 7.

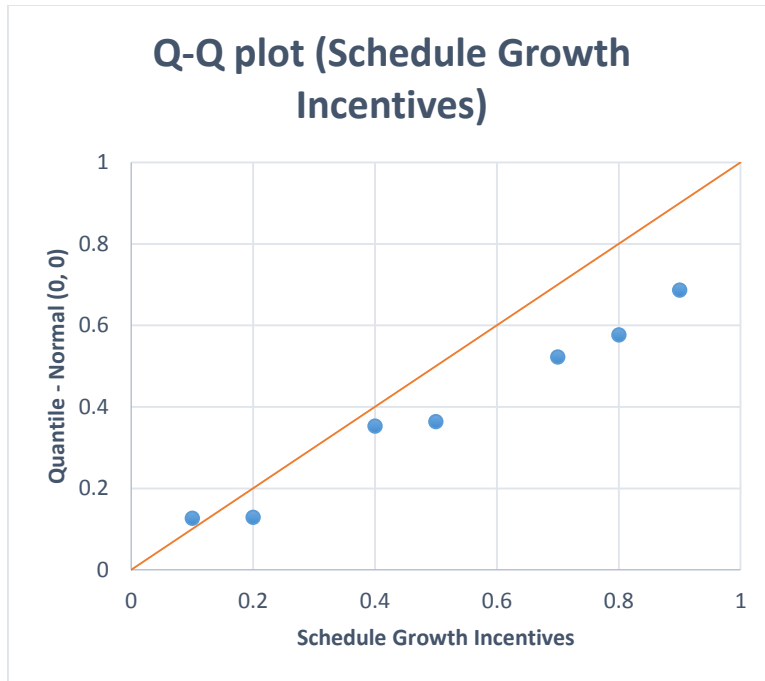
Check for Normal Distribution:

From the above distribution analysis, clear changes are observed between the data sets due to the presence of incentives. In this study, q-q plots are plotted for both incentives and non-incentive projects data sets to observe the normality in distribution, which are presented in Figure 8 & 9.



**Figure 8: Q-Q Plot/ Schedule Growth % of Non-Incentive Project**

Figure 8 shows the Q-Q plot of non- incentive projects with schedule growth percentage values. From this figure, it is clearly observed most of the data set values are not lying on the 45<sup>th</sup> quartile line; which means the schedule growth data of non - incentive projects are non-normally distributed.



**Figure 9: Q-Q Plot / Schedule Growth% of Incentive Projects**

Similarly, Figure 9 shows the q-q plot of incentive projects with schedule growth percentage values. From this figure, it is observed that, all the data set values don't fall on the 45<sup>th</sup> quartile line; which means the schedule growth data of incentive projects are non - normally distributed.

Test for Significance of Observed Changes:

As both the data set are non-normally distributed, in this study Mann- Whitney Wilcoxon (MWW) test is used to test the significance of changes observed between the mean values in Figure 7. Usually, the test is conducted at a confidence level ( $\alpha$ ) value of 5% (Zar, 1984). Initially the test is conducted without removing the outliers from the data set.

From MWW-test, it is observed that “p” value i.e. 0.082 (8.2%) is greater than the “ $\alpha$ ”value i.e. 0.05 (5%) which means that probability of null- hypothesis to be true is 8.2% which means the changes observed between the data sets are not significant.

Similarly, as stated earlier in order to observe the accurate results, two extreme outliers are removed from the two data sets i.e. one each from incentives and non-incentives projects, and MWW test is conducted again on the data set, assuming that outliers have affected the above results.

From retesting, it is observed that p-value i.e. 0.013 (1.3%) is less than  $\alpha$ - value i.e. 0.05 (5%) which means that probability of accepting null- hypothesis is only 1.3%. In other words the probability of disproving the null –hypothesis is 98.7%, which means the observed changes in Figure 7; between the median values of incentive and non- incentive projects are significant. Therefore, based on the collected sample data the author can't reject the hypothesis i.e. having incentives in the project had decreased the construction schedule growth in United States.

## CHAPTER 5

### CONCLUSION

This study analyzes the cost and schedule performance of construction projects in presence of incentives. Based on the quantitative data obtained from a questionnaire survey, the author can't disprove the hypothesis i.e. having an incentive improves the cost and schedule performance of construction projects in United States. On the whole, this paper shows that incentives play role in completing the project on time and within the planned budget. The main finding of this paper include 1) having incentives decreased the cost growth in construction projects in United States, 2) having incentives decreased the schedule growth in construction projects in United States. From the analysis it is observed that most of the projects with incentives have completed within the estimated schedule and cost. Though there are some projects that exceeded budget and schedule, but this value is comparatively less when compared to that of non-incentive projects. These findings are similar to Meng and Gallahar (2011) work in UK and ROI, in which they provided empirical evidence that shows having quality and time incentives improved the performance in construction projects.

One limitation of this study is the size of the dataset. Further research in this area can be conducted by collecting the more quantitative data on incentives projects, and categorizing the projects in to specific type of incentives. Based on the type of incentives; performance metrics of project is evaluated, and also, developing a probabilistic model that determines the performance metrics based on the incentive value will reduce the decision making time in construction projects. Similarly, quantifying the performance of disincentives and qualitative study of its impact on business relationships in construction

projects will be one of the interesting topics to work on. In addition, further investigation is recommended in this area for deeper understanding of incentives on project performance objectives.

## REFERENCES

- Abid Hasan and Kumar Neeraj Jha “Acceptance of the Incentive/Disincentive Contracting Strategy in developing construction markets: Empirical study from India. DOI: 10.1061/(ASCE)CO.1943-7862.0001048.© 2015 American Society of Civil Engineers.
- Al-Harbi, K.M.A., 1998. Sharing fractions in cost-plus –incentive –fee contracts. *International Journal of Project Management* 16 (2), pg. 72-81.
- Arditi, D., Khisty, J., Yasamis, F., 1997. Incentive/disincentive provisions in highway contracts. *Journal of Construction Engineering and Management* 123 (3), 302–307.
- Ashley, D. B., and Workman, B. W. ~1986!. “Incentives in construction contracts.” A Report to the Construction Industry Institute (CII), Source Document 8, The Univ. of Texas at Austin, Austin, Texas.
- Berends, T.C., 2000. Cost plus incentive fee contracting: experiences and structuring. *International Journal of Project Management* 18 (3), 165–171.
- Bower, D., Ashby, G., Gerald, K., Smyk, W., 2002. Incentive mechanisms for project success. *Journal of Management in Engineering* 18 (1), 37–43.
- Broome, J., Perry, J., 2002. How practitioners set share fractions in target cost contracts. *International Journal of Project Management* 20 (1), 59–66.
- Bubshait, A.A., 2003. Incentive/ Disincentive contracts contracts and its effects on industrial projects. *International Journal of Project Management* 21(1), 63-70.
- Bureau of Economic Analysis (2014). “Estimated compensation and construction GDP” <[http://www.bea.gov/industry/gdpbyind\\_data.htm](http://www.bea.gov/industry/gdpbyind_data.htm)>
- Bureau of Labor Statistics (2015). “Estimation of current labor force in construction industry”. < [http://data.bls.gov/timeseries/CES2000000001?data\\_tool=XGtable](http://data.bls.gov/timeseries/CES2000000001?data_tool=XGtable) >
- Chan, D.W.M., Lam, P.T.I., Chan, A.P.C., 2010. Achieving better performance through target cost contracts: the tale of an underground railway station modification project. *Facilities* 28 (5/6), 261–277.
- Chappell, D., Marshall, D., Powell-Smith, V., Cavender, S., 2001. *Building Contract Dictionary*. Blackwell, Oxford.
- Construction Industry Institute ~CII~1995. “Use of incentives.” Implementation Status Report, 1995 CII Con., Austin, Texas.

- Crosthwaite, D. (2000). "The global construction market: a cross-sectional analysis." *Construction Management and Economics*, 18(5), 619-627.
- David Scott "Quantile-Quantile (Q-Q) plots". <http://onlinestatbook.com/2.html>
- DeCenzo, D, and Holoviak, S. (1990). *Employee Benefits*. Prentice Hall, City, New Jersey, 55-56.
- El Asmar, M., and Hanna, A. S., (2013) "Quantifying Performance for the Integrated Project Delivery (IPD) System as Compared to Established Delivery Systems," *Journal of Construction Engineering and Management*, ASCE. Vol. 139, No. 11, 04013012.
- Eric L.Lehmann, Joseph P.Romano.,(2005) " Testing Statistical Hypothesis (Springer text in statistics).
- Geller, E. S. (1999). "Behavior-based safety: Confusion, controversy and clarification." *Occup. Health Saf.*, 68(1), 40–49.
- Geoffrey Black , Donald Holley , David Solan , Michael Bergloff. "Fiscal and economic impacts of state incentives for wind energy development in the Western United States". *Renewable and Sustainable Energy Reviews* 34 (2014), 136–144.
- George Stukhart (1984), M. ASCE. "Contractual Incentives." *Journal of Construction Engineering and Management*, Vol. 110, No. 1, March, 1984
- Grubbs, F. E. (February 1969). "Procedures for detecting outlying observations in samples". *Technometrics* **11** (1): 1–21.
- Her Majesty's ~HM! Treasury, Central Unit on Procurement. (1991). *Guidance No. 58: Incentivisation*, Her Majesty's Stationary Office, London.
- Ibbs, C.W., and Ashley, D. B. (1987). "Impact of various construction contract clauses." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364 (1987)113:3(501), 501–521.
- Jaafari, A., 1996. Twinning time and cost in incentive-based contracts. *Journal of Management in Engineering* 12 (4), 62–72.
- Jaraiedi, M., Plummer, R.W., Aber, M.S., 1995. Incentives/disincentives guidelines for highway construction contracts. *Journal of Construction Engineering and Management* 121 (1), 112–120.
- Jeffrey, S. (2003). *The benefits of tangible, non-monetary incentives*. The SITE Foundation.
- KPMG international (2013), *Taxes and incentives for renewable energy*.
- Meng, X., and Gallagher, B. (2011). "The impact of incentive mechanisms on project performance." *Int. J. Proj. Manage.*, 30(3), 352–362.



- Molenaar, K. R., Jeong-II, P., and Washington, S. (2009). "Framework for measuring corporate safety culture and its impact on construction safety performance." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364 (2009)135:6(488), 488–496.
- Mustafa Ozcan , "Assessment of renewable energy incentive system from investors' perspective" *Renewable Energy* 71 (2014), 425-432
- Perry, J.G., Barnes, M., 2000. Target cost contracts: an analysis of the interplay between fee, target, share and price. *Engineering Construction and Architectural Management* 7 (2), 202–208.
- Prichard, R. (200 1). Safety incentive programs: A critical assessment. Retrieved November 30, 2004. < <http://www.irmi.com/articles/expert-commentary/safety-incentive-programs-a-critical-assessment>.>
- Roger W. Liska and Bill Snell "Financial Incentive Programs For Average Size Construction Firm". *Journal of Construction Engineering and Management*, Vol. 118, No. 4, December, 1992.
- Rose, T., Manley, K., 2010. Client recommendations for financial incentives on construction projects. *Engineering Construction and Architectural Management* 17 (3), 252–267.
- Rose, T., Manley, K., 2011. Motivation toward financial incentive goals on construction projects. *Journal of Business Research* 64 (7), 765–773.
- Rowlinson, M., and Proctor, S. (1999). 'Organizational Culture and Business History' *Organization Studies* 20(3) pp.369-96.
- Sanders, S. R. and Thomas, H. R. (1991). "Factors affecting masonry productivity." *Journal of Construction Engineering Management*, 117(4), 626-644.
- Samer F. Abu-Hijleh<sup>1</sup> and C. William Ibbs,(1989), "Schedule based construction incentives" *Journal of Construction Engineering and Management* 115:430-443.
- Schexnayder, C., and Anderson, S. (2010). "Emergency accelerated construction." *Proc., Construction Research Congress*, J. Ruwanpura, Y. Mohamed, and S. Lee, eds., ASCE, Reston, VA, 837–848.
- Shr, J.F., Chen, W.T., 2004. Setting maximum incentive for incentive/disincentive contracts for highway projects. *Journal of Construction Engineering and Management* 130 (1), 84–93.
- Smith, S. (2002). Safety incentives: It's not just a breakfast anymore. *Occupational Hazards*. November 30,2004.
- Sun, M., Meng, X., 2009. Taxonomy for change causes and effects in construction projects. *International Journal of Project Management* 27 (6), 560–572.

- Teo, E. A. L., Ling, F. Y. Y., and Chong, A. F. W. (2005). "Framework for project managers to manage construction safety." *International Journal of Project Management*, 23(4), 329–341.
- Timothy Besley and Maitreesh Ghatak (2003) "Competition and Incentives with Motivated Agents" Research Paper No. TE/2003/465.
- Walker, D.H.T., Hampson, K., Peters, R., 2002. Project alliancing vs project partnering: a case study of the Australian National Museum Project. *Supply Chain Management: An International Journal* 7 (2), 83–91.
- Wilcox, S., Stringfellow, B., Harris, R., and Martin, B. (2000). *Management and Productivity*. Transportation Research Board, Committee on Management and Productivity, Washington, DC.
- Yacine Belghitar, Ephraim Clark, "Managerial Risk Incentives and Investment Related Agency Costs". *International Review of Financial Analysis* (2014), doi:10.1016/j.irfa.2014.11.012
- Zar, J.H. (1984) *Biostatistical Analysis*. Prentice Hall International, New Jersey. pp 43–45