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A COMPARATIVE ANALYSIS OF THE PERFORMANCE OF CONSTRUCTION DELIVERY SYSTEMS WITHIN THE SCHOOLS IN KISUMU COUNTY

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Abstract: The delivery of a construction project is characterized by the participation of several individuals. Owner, architect, engineer, and contractor are the most important players of this process. Multiple prime is one type of delivery system that is the subject of many discussions in the industry. General contractors, architects and owners believe that this system inherently has coordination problems. On the other side, specialty contractors believe that this system has several advantages because of the exclusion of the middleman and the direct relationship of these contractors to the owner. The goal of this study is to objectively analyze the performance of construction delivery systems within the County of Kisumu in Nyanza province. The schools in the districts of Nyando, Nyakach, Kisumu East, Kisumu West, and Kisumu North form the population of this study. Quantitative and qualitative measurements are used as the variables for comparison. ANOVA and two-sample t- tests are used as statistical tools for the quantitative and, the Chi-Square test is used for the qualitative analysis. The data collected is divided into two different sets. The first set includes all the valid responses. The second set is limited to the analysis of projects greater than Ksh. 5,000,000 and the data obtained is not significant to this study. A section with the descriptive statistics of litigation cases is also included in this study.

Keywords: Construction Projects, Delivery Systems, ANOVA, Two- Sample t-test, Chi-Square Test and County Population.

INTRODUCTION

Humans use engineering principles to develop and change the environment. As our behavior and intelligence develops; Civil Engineering and construction Engineering and Management changes and evolves. New materials, processes and procedures arise, and construction has become more complex. As a result, the art of building today requires skilled and specialized individuals. Because of the complexities involved in this process, several norms, statutes, codes, and regulations have been created that dictate the way that buildings are built. Legislation has also influenced the relationship among players that are involved in the construction process. Because of such complexity, standardized techniques guide the delivery of construction projects. These techniques and processes are the basis of what is known as Project Delivery Systems. Dorsey (1997) states that "… project delivery system is a general term describing the comprehensive design / construction process, including all the procedures, actions, sequences of events, contractual relations, obligations, interrelations, and various forms of agreement – all aimed at successful completion of the design and construction of buildings and other structures."

The intention of this study is to objectively analyze the performance of different delivery systems used in construction by schools in all the districts. Cost, schedule and quality measurements are the basis of the analysis.

OVERVIEW OF THE CONSTRUCTION PROCESS AND BACKGROUND

Cleland and Ireland (2002) define a project as "… a combination of organizational resources pulled together to create something that did not previously exist and that will provide a performance capability in the design and execution of organizational strategies. Projects have a distinct life cycle, starting with an idea and progressing through design, engineering, and manufacturing or construction, through use by a project owner."

The construction industry is based on the execution of projects. In contrast to manufacturing products, the deliverables of these projects are, with very few exceptions, very unique. However, common questions are always involved in every type of project (Cleland and Ireland, 2002):

- What will it cost?
- What time is required?
- What technical performance capability will it provide?
- How will the project results fit (long and short term) into the design and execution of organizational strategies?

The project has to fit into the strategic and operational strategies of both parties. A successful project is characterized when owner and contractor, at the end of the project, are in a win-win situation, i.e., situations where the contractor is able to successfully develop the project within cost and time objectives while realizing a good profit margin, and when the owner is completely satisfied with the quality, and is able to profit from the deliverable.

CONSTRUCTION CLASSIFICATION

Correlation of strategic and operational strategies between parties in a construction project is directly related to the type of construction involved in the project. Some organizations have specialized according to construction classifications, which in some cases define their area of expertise. There are different ways to classify the construction industry. According to Halpin & Woodhead (1998), there are three major construction categories:

a. **Heavy and Highway**: Construction of highways, bridges, airports, pipelines, dams, tunnels, etc.

b. **Nonresidential Building**:

   i. **Building (Institutional and Commercial)**: Construction of schools, universities, hospitals, warehouses, theaters, government buildings, recreation centers, commercial office centers, etc.

   ii. **Industrial (light and heavy)**: Construction of petroleum refineries, petrochemical plants, nuclear power plants, steel mills, etc.

c. **Residential Construction***:* Construction of single-family homes, multi-unit townhouses, high-rise apartments and condominiums.

OWNERS CLASSIFICATION

Owners play the most important role within the construction process. Typically, there would not be a construction project without their need and without the financial resources that they provide to complete the project. They can be classified as public and private owners. Public owners correspond to entities that make use of public funds to provide constructed facilities for public use. Private owners are individuals or institutions that make use of private money to construct facilities that are solely for the benefit of the owner.

CONTRACTORS CLASSIFICATION

Agreements in the construction industry are usually established in contracts between the parties. Companies and individuals involved in this type of business are referred to as contractors. Based on the type of work, contractors can be classified as *general* and *specialty contractors*. General contractors execute most major construction projects and are able to perform a wide variety of activities. Specialty contractors execute specific activities in a project, such as electrical, mechanical, or plumbing work. The specialty contractors focus their work in just one activity because such activity requires a specialized and skilled labor force.

THE CONSTRUCTION PROCESS AND ITS LIFE CYCLE

The construction project starts with the identification of the need to build a facility, followed by the planning and design phases, where the facility is conceptualized and parameters for monitoring and controlling the project are generated. The construction project starts with the identification of the need to build a facility, followed by the planning and design phases, where the facility is conceptualized and parameters for monitoring and controlling the project are generated. The construction phase represents the time where the facility is built. Operation and maintenance is the utilization of the facility until its retirement that represents the end of the project's life cycle.

CONSTRUCTION PROJECT STAKEHOLDERS

Stakeholders are individuals, groups, organizations, institutions and other claimants who have or claim ownership, rights, or interests in a project and its activities. Based on this, every project is influenced and must be managed from a perspective that goes beyond the basic relationship between customers and the company that is performing the project. Because stakeholders may influence the development of the project, it is extremely important to identify, manage and predict their behavior. Cleland and Ireland (2002) presents the following steps for managing stakeholders:

a. Identify appropriate stakeholders.
b. Specify the nature of the stakeholders' interest.
c. Measure the stakeholders' interest.
d. Predict what each stakeholder's future behavior will be to satisfy his or her stake.
e. Evaluate the impact of the stakeholders' behavior on the project team's latitude in managing the project.

Companies that can clearly identify stakeholders that are directly and indirectly involved with respective interests and how they can influence the final results of the project have a great advantage compared to the competition. During the identification process, companies can classify stakeholders in two major groups: *primary* and *secondary*.

"Primary stakeholders are those persons or groups on the project team who have a contractual or legal obligation to the project team and have the responsibility and authority to manage and commit resources according to schedule, cost, and technical performance objectives." (Cleland and Ireland, 2002) Because primary stakeholders are directly involved on the project and are, in most cases, committed to the successful accomplishment of it, they are usually easy to manage and direct.

"Secondary stakeholders are those who have no formal contractual relationship to the project but can have a strong interest in what is going on regarding the project." (Cleland and Ireland, 2002) They represent the group that will not necessarily benefit from the project. As a result, project success may rely on the management of this group that, in some cases, may stop or delay the completion of the project.

METHODOLOGY

The target population consists of schools located in the five different districts in the County of Kisumu: Nyando, Kisumu East, Kisumu West, Kisumu North, Kisumu East, and Nyakach. All schools districts headquarters in each district were sent survey questionnaires for a total of 704 schools. The questionnaires were sent to the Works Superintendents who, in some cases, forwarded it to staff and/or schools Head teachers. The list of addresses was downloaded from each District's Departmental web site. The strategy for the mailing process was based on Salant and Dillman's recommendations (1994). At least four mailings were sent.

a. **First:** Advance-notice letter. The purpose of this letter is to let the sampling population know that they will be receiving a survey in the near future.

b. **Second:** Package with cover letter, questionnaire and a prepaid return envelope.

c. **Third:** A reminder letter about the survey and the importance of their participation in the study. It was sent to every district that had not answered the survey at that time.

d. **Fourth:** Final mailing with cover letter, questionnaire and prepaid return envelope to all non-respondent districts. This letter would stipulate a deadline for the study.

This strategy was extremely effective in reaching the response rate that was achieved.

DATA COLLECTION INSTRUMENT

The instrument used in this study was a seven sections questionnaire. The first section is general information about the respondent, in case it is necessary to contact them for clarification. The second section relates to general information about the project. The third section was used to indicate the type of delivery system used. It was decided to include single prime, multiple prime, single prime with an agent, and multiple prime with an agent, design-build, and CM @ Risk. Section IV collects the cost of the project. Section V collects information about the project's schedule. The next section asks for the number and shilling amount of litigation cases involved in the project. Section VII is related to the quality parameters of the project. Even though there were three other building system quality questions, the punch list, difficulty of startup, number of call backs, overall expectations and level of administrative burden were the only information used in this study. Finally, the last section evaluates some team characteristics. This section was essential to have an idea of the members' experience and levels of communication, chemistry and complexity involved in the project. A glossary of terms was also included at the end of the questionnaire in order to give the respondents definitions of the terms used.

DEFINITION OF VARIABLES

There are quantitative and qualitative types of variables used to compare the performance of the delivery systems in this study. Although, quantitative (or continuous) measurements are extremely important to the analysis because of their objectivity, qualitative (or categorical) measures indicate the perception of the owner about the construction project and the delivery system. The following tables present the types of variables that are used in this study.

Table 3.0: Types of Quantitative Variables Used in the Study

Quantitative Variables
a. Construction Speed (m^2/day) = $\frac{Area}{Total\ as\ Built\ Const.\ Time}$
b. Unit Cost (Kshs./m^2) = $\frac{Area\ Total\ Cost}{Area}$
c. Cost Growth (%) = $\frac{Actual\ Total\ Cost\ - Contract\ Award\ Total\ Cost\ \times 100}{Contract\ Award\ Total\ Cost}$
d. Cost Schedule Growth (%) = $\frac{Total\ as\ Built\ Const.\ Time - Total\ as\ Planned\ Const.\ Time\ \times 100}{Total\ as\ Planned\ Const.\ Time}$
e. Change Order (%) = $\frac{Total\ Change\ Order\ \times 100}{Actual\ Total\ Cost}$
f. Number of Litigation Cases

Table 3.1: Qualitative Variables Used in the Study

Qualitative Variables
a. Length of Punch List
b. Difficulty of Facility Startup
c. Level of Call Backs after Owner Occupancy
d. Level of Administrative Burden
e. Project Team Communication
f. Project Team Chemistry
g. Litigation

STATISTICAL TOOLS

Different types of statistical tools are used in this study in order to compare the performance of the three delivery systems. One-way ANOVA and two-sample t – tests are used to analyze continuous variables, while the Chi-Square test is used for categorical analyses.

CALCULATION METHODOLOGY

The use of the statistical tools follows a calculation methodology. Figure 3.2 presents a general example of the flow chart that is presented in every quantitative analysis. The flow indicates the tests performed, their sequence, and if any significance was found during the test. Solid lines represent analysis performed, while dotted lines indicate that the analysis was not performed based on the necessities and consequences of the results previously obtained. This chart was slightly modified and adopted for different analyses.

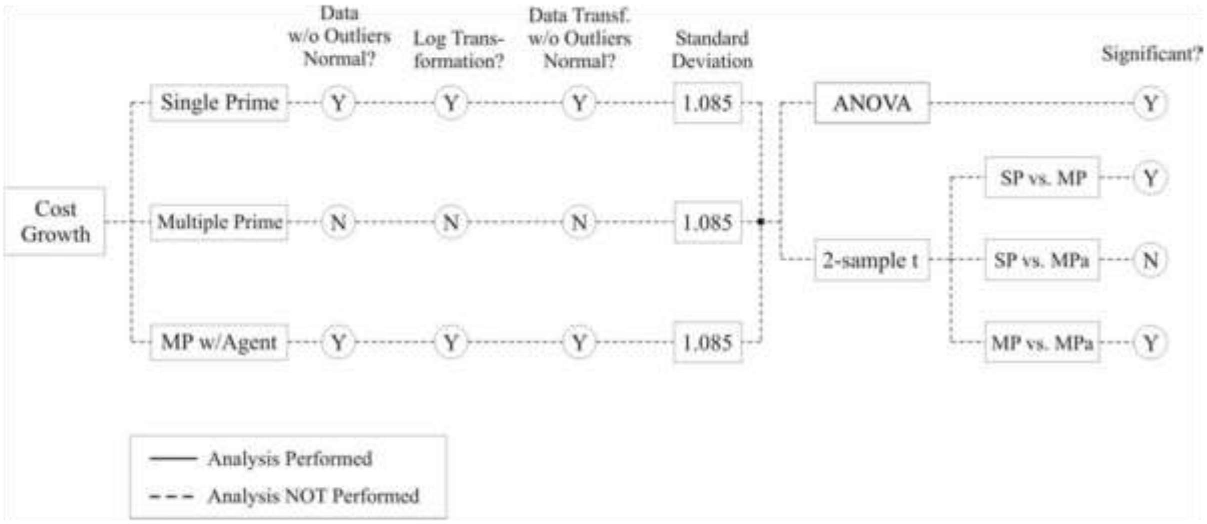


Figure 3.2: General Example of the Calculation Process Flow Chart (Coldebella D-2004)

CODIFICATION

This section shows the codification of categorical variables. Below is a sequence of tables with the categorical codes used during data analysis.

Table 3.2: Delivery System Codes

Code	Type of Delivery System
1	Single Prime
2	Multiple Prime
3	Agent CM w/ Single Prime
4	Agent CM w/ Multiple Prime
5	CM @ Risk
6	Design-Build

Table 3.3: Team Chemistry Codes

Code	Description
1	Excellent
2	Adequate
3	Poor

Table 3.4: Tea Communication Codes

Code	Description
1	High
2	Medium
3	Low

Table 3.5: Complexity Codes

Code	Description
1	Less than a week
2	More than a week but less than 2 weeks
3	More than 2 weeks but less than 4 weeks
4	More than 4 weeks but less than 8 weeks
5	More than 8 weeks

Table 3.6: Punch List Length Codes

Code	Description
1	High
2	Average
3	Low

Table 3.7: Difficulty to Startup Codes

Code	Description
1	High
2	Medium
3	Low

RESULT ANALYSIS AND DISCUSSION

A total of 704 schools were contacted during this study. From the 126 (17.9%) schools that responded, 73 (10.4%) said that they would not participate. 39 cases of the 73 did not have a recent construction project. The remaining cases gave reasons that vary from no financial capability to no building ownership. From the 53 (7.5%) schools that returned the survey, 13 cases did not have enough data to be considered in the study and 40 (5.64%) presented good quality data. Considering just the 40 cases of good quality data and a population of 704 schools in the five districts, the response rate of this study is 5.68%. This rate can be considered as the gross rate of the study because the real target population would be equivalent to the number of schools that have had a construction project completed in less than 10 years. This number is impossible determine from the data collected. As a result, this study considers the nominal response rate of 5.68% based on the total number of schools contacted as the effective survey response. The strategy of contacting the districts and schools through the use of four sequential mailings was effective in raising the response rate of the study. Figure 4.1 indicates the number of schools that made contact after each mailing.

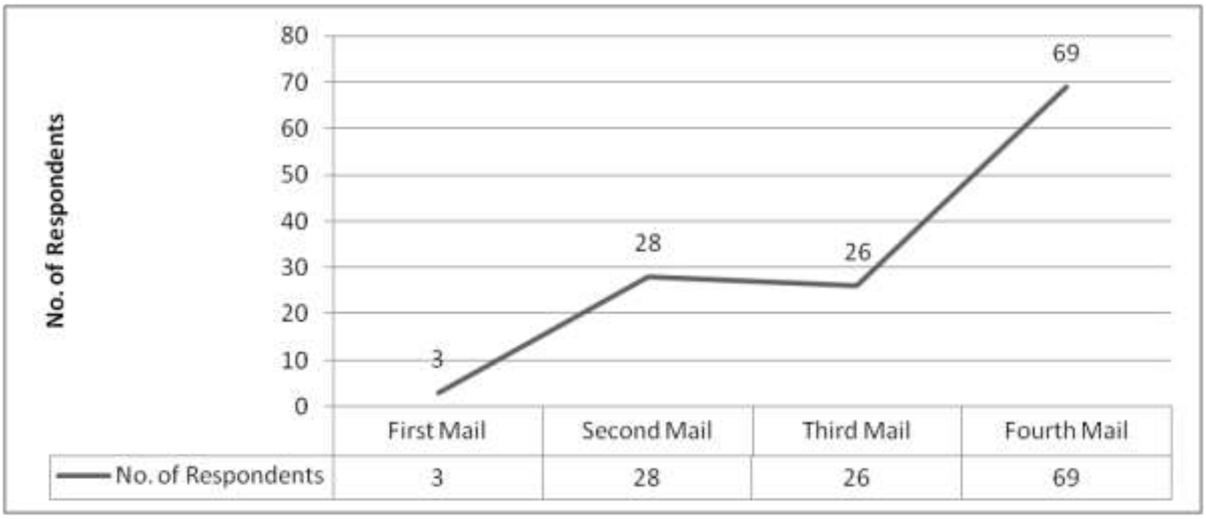


Figure 4.1: Number of Respondents per Mailing

The 34 responses after the first mailing said that they did not have valid cases for the study and therefore would not be able to participate. Four cases from the 40 valid ones were excluded; they represented the three delivery systems that contained samples too small to be considered in the study: one case of CM @ Risk, one design-build and two single prime with agent CM. Consequently, the remaining 36 are the cases used in the analysis. They represent single prime, multiple prime, and multiple prime with an agent CM system. The following four figures (4.2 - 4.5) indicate the response classified by type of delivery system, district and district percentage.

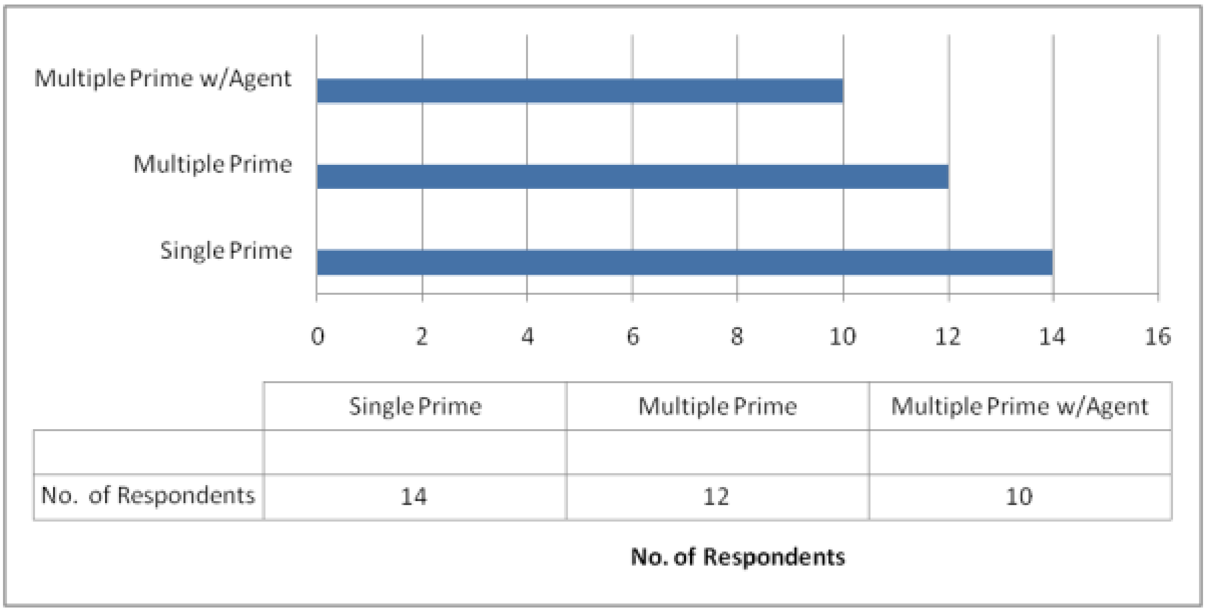


Figure 4.2: Response by Delivery System

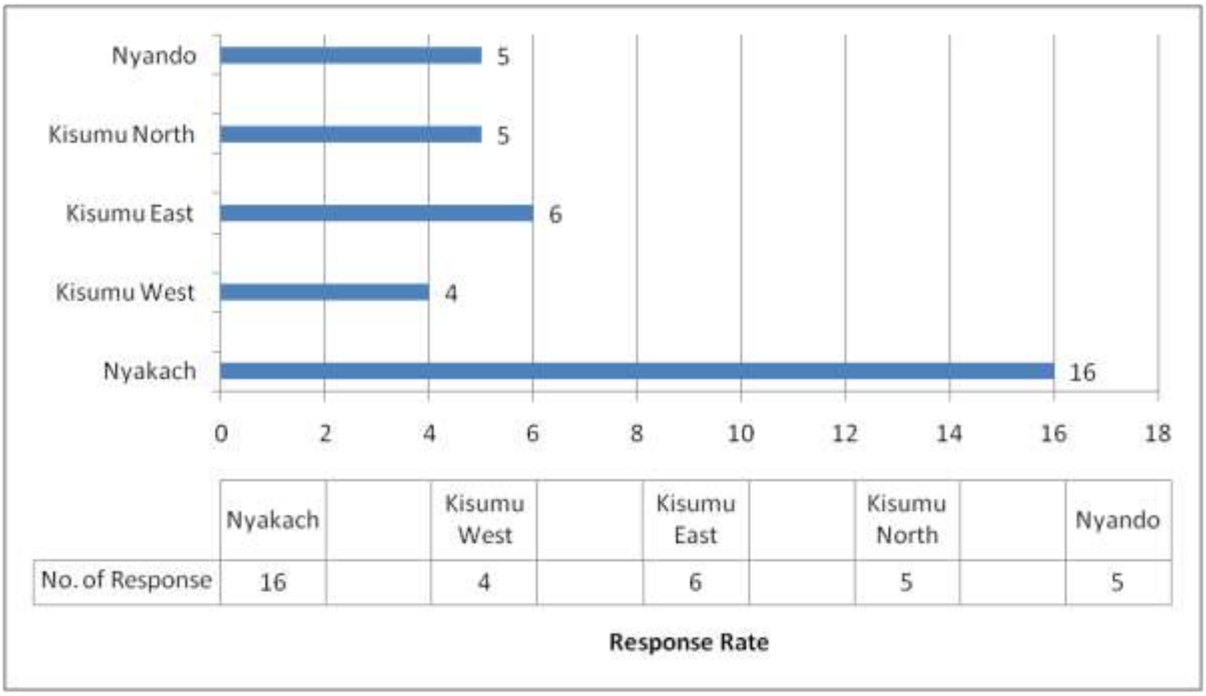


Figure 4.3: Response by District

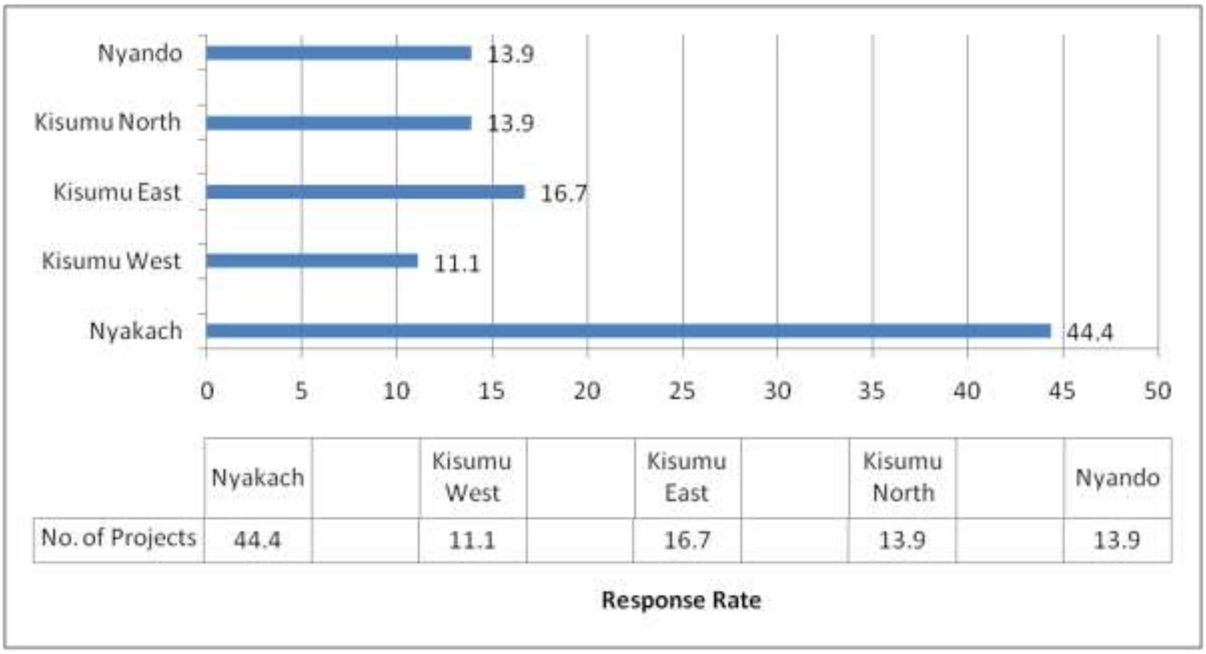
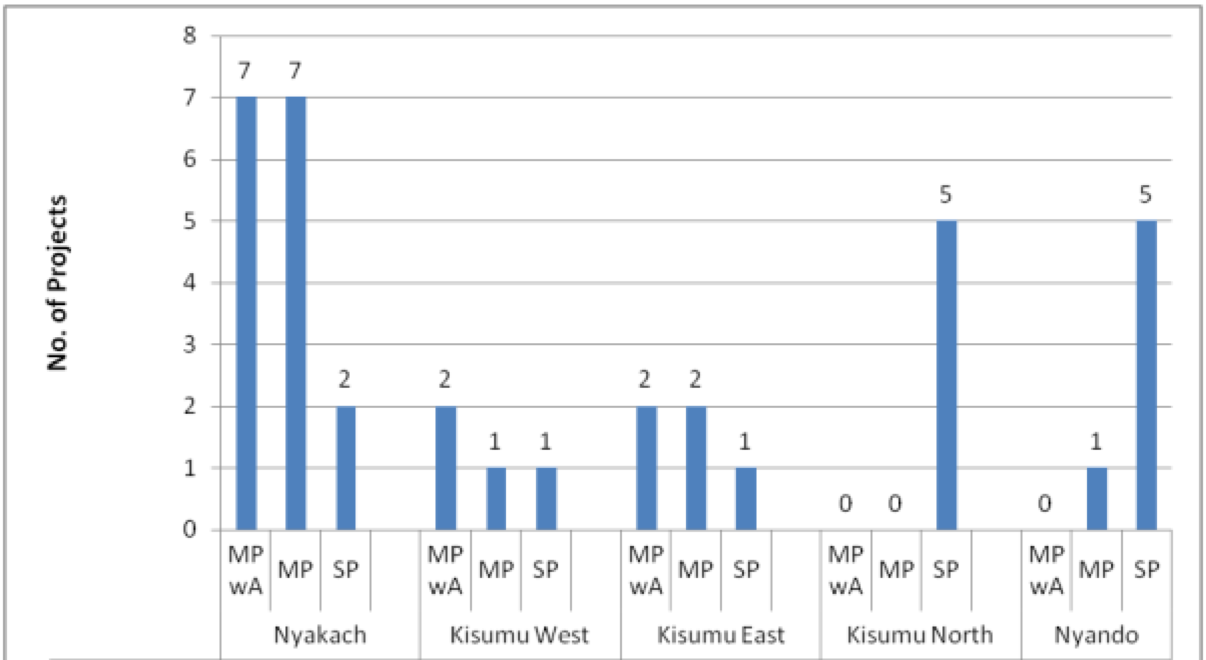


Figure 4.4: Percentage Response of Schools per District



No. of Projects	7	7	2	2	1	1	2	2	1	0	0	5	0	1	5

Figure 4.5: Cases by District and Delivery System

ANALYSIS PROCEDURES USED

Cost Correction for Time and Location

The total cost includes the design, construction, and coordination costs with the change orders and litigation costs of the project. All cases where the districts/schools specified the shilling amount of litigation and the disputes that were settled, the amount was added to the total actual cost. Every analysis involving cost was corrected to time and location according to construction indexes. Following is a brief description of the corrections performed in this study.

Analyses Based on the Size of the Project

Two sets of data analyses are performed in this study. The first set presents the analysis of all projects and the second one of projects with total cost greater than Kshs. 5,000,000. The intention is to compare and verify if there is any performance difference between the two groups and to check if there is a possibility that smaller renovation and systems replacement projects would skew the results. For now on, the two data sets would have the following codification:

DATA SET 1 –Includes ALL data collected;

DATA SET 2 –Includes data of projects with total cost greater than Kshs. 5,000,000.

The next section presents a summary table of descriptive statistics of continuous variables from the two data sets described above. There are two sets of table (table 4.3 - 4.4) for data set 1. The first table is related to all data including outliers. The second table does not include data outliers. Outliers are points below the lower limit and above the upper limit.

Lower Limit: Q1 - 1.5 (Q3 - Q1)

Upper Limit: Q3 + 1.5 (Q3 - Q1)

Where, Q1 represents the first quartile and Q3 the third quartile.

DATA SET 1: SUMMARY TABLES OF DESCRIPTIVE STATISTICS

Variable	Dlv Sys	N	Mean	Median	St. Dev.	Q1	Q3
Construction	MPwA	10	311.5	251.4	193.3	187.0	384.9
Speed	MP	10	187.2	152.8	135.1	61.60	271.1
(M^2/day)	SP	12	284.0	164.0	588.0	76.0	210.0
Unit cost	MPwA	10	119.7	126.7	53.5	83.0	161.3
(\$/M^2)	MP	10	120.2	112.3	58.7	78.7	166.3
	SP	12	126.6	139.6	68.1	78.3	160.9
Cost	MPwA	10	5.66	3.59	5.63	1.46	8.41
Growth	MP	12	5.24	3.07	8.00	0.87	6.70
(%)	SP	14	5.94	3.96	10.03	1.01	5.85
Schedule	MPwA	10	4.86	0.00	21.17	0.00	5.84
Growth	MP	12	6.77	2.05	14.4	0.00	12.93
(%)	SP	14	12.27	0.28	29.33	0.00	18.01
% Change	MPwA	10	4.31	3.345	3.750	1.215	6.108
Order	MP	12	3.45	2.66	3.838	0.580	4.22
(%)	SP	14	4.70	3.44	6.260	1.220	5.53

Table 4.3: Data Set 1- Summary Table of Descriptive Statistics with Outliers

Table 4.4: Data Set 1 - Summary Table of Descriptive Statistics without Outliers

Variable	Dlv Sys	N	Mean	Median	St. Dev.	Q1	Q3
Construction	MPwA	10	265.1	250.6	107.2	186.1	358.6
Speed	MP	10	174.6	151.5	121.2	58.1	256.7
(M^2/day)	SP	10	153.3	146.0	105.8	69.8	198.8
Unit cost	MPwA	10	127.94	141.61	46.44	92.87	163.59
(\$/M^2)	MP	10	124.90	118.00	54.80	82.40	167.40
	SP	10	140.77	141.82	39.05	121.95	164.54
Cost	MPwA	10	4.471	3.315	3.652	1.360	6.985
Growth	MP	10	3.293	2.900	2.989	0.595	4.888
(%)	SP	13	4.021	3.410	3.725	0.780	5.585
Schedule	MPwA	8	1.321	0.00	2.312	0.00	3.345
Growth	MP	10	4.730	0.00	9.220	0.00	10.860
(%)	SP	10	3.130	0.00	6.990	0.00	8.100
% Change	MPwA	10	3.797	3.300	2.626	1.160	5.680
Order	MP	10	2.409	2.530	2.117	0.460	3.470
(%)	SP	13	3.264	2.210	2.815	1.060	5.070

QUANTITATIVE ANALYSIS – DATA SET 1

This section presents the quantitative analyses of data set 1, which includes all projects surveyed. Construction speed, unit cost (cost/sm), cost growth, schedule growth, percentage of change order cost, and number of litigation cases are tested against the types of delivery systems.

Construction Speed

Data for all three delivery systems passed the Anderson-Darling normality test. The P-values for this test were 0.576, 0.107 and 0.242 for multiple prime with an agent (MPwA), multiple prime (MP) and single prime (SP) respectively. The second step is to verify the relationship between the largest and smallest standard deviations in order to validate the ANOVA test:

Largest S / Smallest S < 2.0 = 121.1/105.8 = 1.15 < 2.0 (OK)

The ANOVA test was performed and Figure 4.6 presents the output obtained from the test:

ANOVA: Two-Factor: CS versus DSys 1 -2
ANOVA

Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit.**
Levels	1757.165	2	878.5825			
Dsys	77289.077	3	25763.026	28.4137	0.0006065	4.7570627
Error	5440.2683	6	906.71139			
Total	84486.51	11				

Pooled St. Dev = 111.4

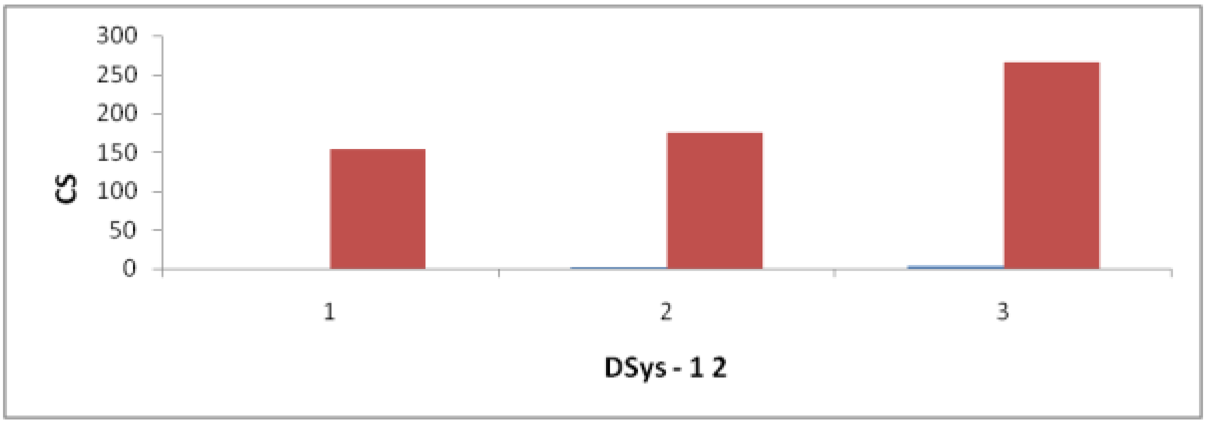


Figure 4.6: Construction Speed Results

The P - value of 0.000605 is significant and the null hypothesis can be rejected. Therefore, it is possible to conclude that there is a relationship between construction speed and delivery systems. From the side-by-side column chart above, it is possible to see that the MPwA is responsible for bringing the P-value down. The difference between the MP and SP means is not statistically significant.

Unit Cost

The unit cost is the total cost of the project divided by its area. All three delivery systems presented acceptable P-values for the Anderson-Darling normality test: 0.642, 0.254, and 0.565 (MPwA, MP, and SP respectively). The values of the standard deviations are close to each other, and the assumption of equal standard deviations can be used. Therefore, the ANOVA test can be used for analysis.

Largest S / Smallest S < 2.0 = 54.8/39.05 = 1.40 < 2.0 (OK)

The result of the test indicated a P-value of 0.454. There is not enough evidence to conclude that there is any difference among the delivery systems regarding unit cost. Figure 4.8 indicates the tests performed and details of the results can be found in Appendix C.

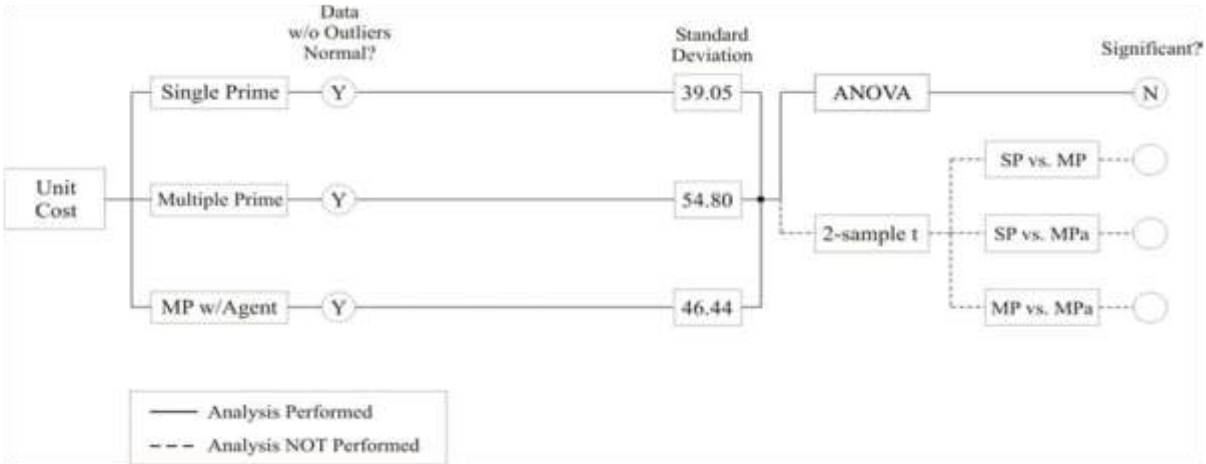


Figure 4.8: Unit Cost Flow Chart

Cost Growth
The P-values for the normality test are 0.008, 0.211, and 0.017 for SP, MP, and MPwA respectively. Just the multiple prime delivery system passed the test. After data transformation, the P-values were 0.261, 0.127, and 0.275 (SP, MP, and MPwA). One of the problems with data transformation is related to the interpretation of the results obtained. However, this procedure is commonly used in statistics. The standard deviations of the systems after the mathematical modification are 0.5799, 0.716, and 0.578 (SP, MP, and MPwA). The relationship between the largest and smallest standard deviations is:

Largest S / Smallest S < 2.0 = 0.716/0.578 = 1.24 < 2.0 (OK)

Consequently, the ANOVA test was used. The results obtained were not statistically significant (P-value = 0.557). There is not enough evidence to conclude the existence of a relationship between cost growth and delivery systems. Basically, all systems present similar cost growth means and the differences among them may result from sampling variation. Figure 4.9 indicates the tests performed and the results obtained.

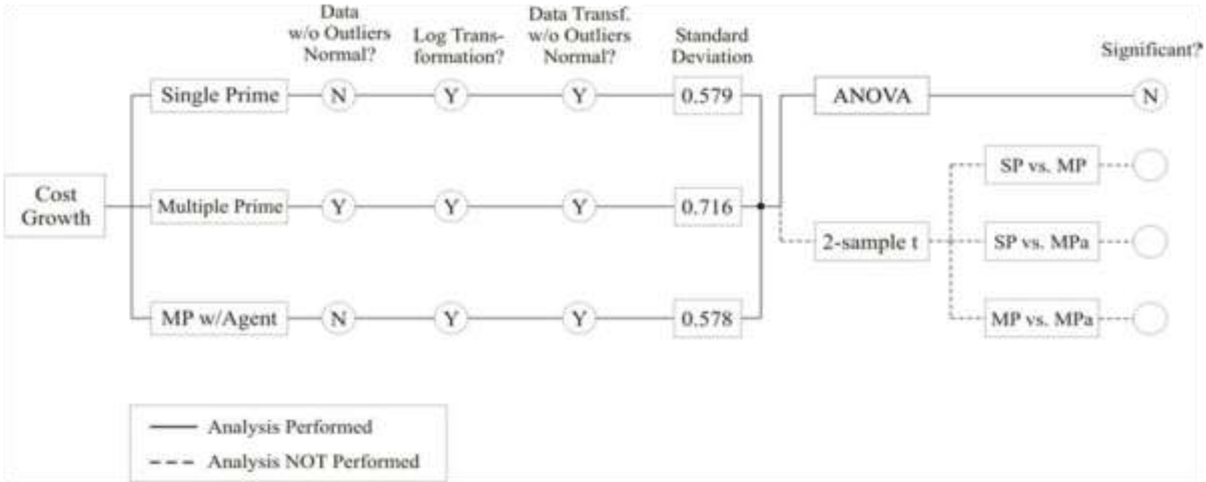


Figure 4.9: Cost Growth Flow Chart

Schedule Growth

The normality test for data set 1 schedule growth fails in all three delivery systems. The P-values of the Anderson-Darling test are 0.000, 0,010, and 0.000 for SP, MP, and MPwA respectively. The data was transformed with natural log. The normality test results obtained after the transformation were not satisfactory to perform the statistical tests used in this study (0.000, 0.006, and 0.000). Therefore, there are no conclusions for data set 1 related to this variable.

The situation described above could be perceived from the data set collected. From the 36 cases, there were 7 outliers excluded from the original data. Also, after transformation, the number of cases was decreased to 28 cases (8 outliers removed). Figure 4.10 summarizes the tests performed in this section, which were limited to the normality tests of the data.

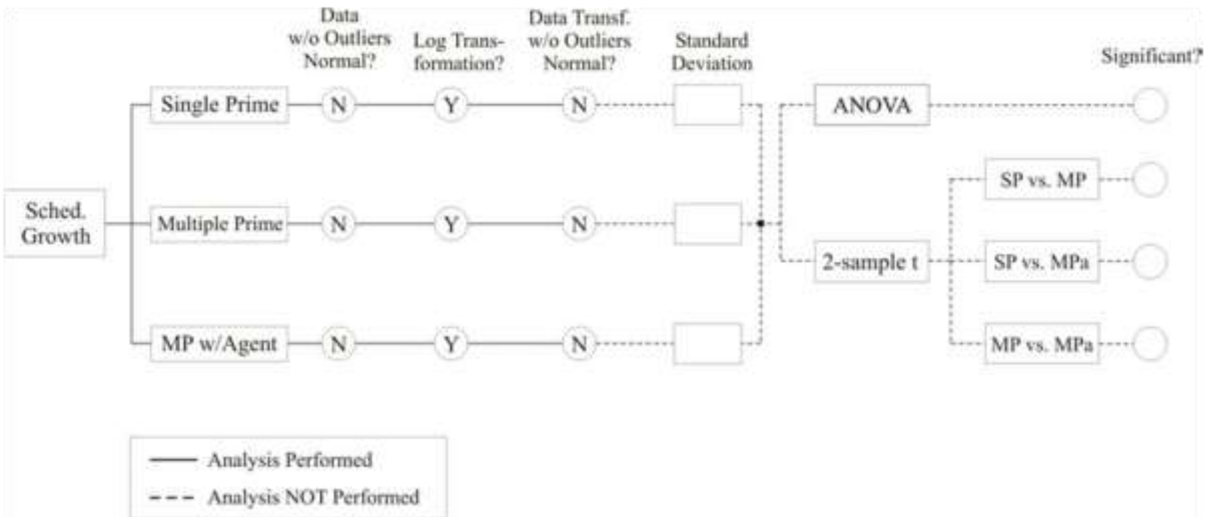


Figure 4.10: Schedule Growth Flow Chart

% Change Order

The P-values obtained for the normality tests are 0.063, 0.452, and 0.151 (SP, MP, and MPwA respectively). SP fails the test and needs to be transformed. Two-sample t test can be performed to analyze MP and MPwA systems. The standard deviations of the last two systems are close to each other and a "pooled" analysis can be performed. Figure 4.11 summarizes the findings obtained before data transformation.

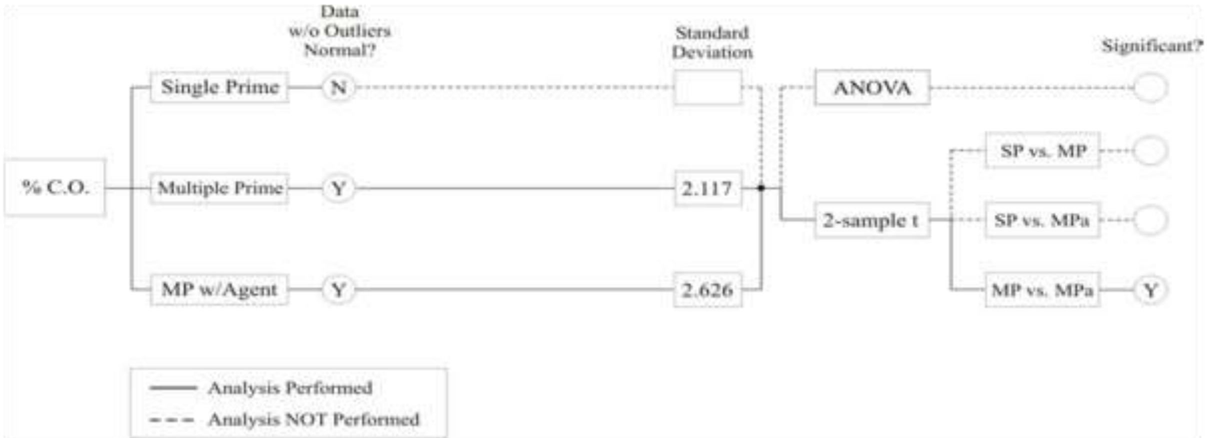


Figure 4.11: % CO Flow Chart (MPwA vs. MP)

A P-value of 0.037 indicated statistical significance on the results at the 5% level (α = 0.05). The hypotheses were created to verify if there are differences on the population means (Ha: $\mu_{MP} = \mu_{MPwA}$ and Ho: $\mu_{MP} \neq \mu_{MPwA}$). Figure 8.7 presents the results.

t-Test: Two-Sample T - Test and CI: %CO4, %CO2

	N	Mean	St. Dev
%CO4	10	3.80	2.63
%CO2	10	2.41	2.41
Difference = mu %CO4 - mu %CO2			
Pooled StDev		2.390	
Hypothesized Mean Difference		1.387	
df		52	
P- Value		0.037011085	
t Critical two-tail		2.142445105	
95% CI for difference		(0.084 2.690)	

Figure 4.12 - Two -Sample t Results for %CO (MPwA vs. MP)

From the data analysis, it is found that MPwA has a higher %C.O. mean when compared to the MP system. In the sample, MPwA is approximately 58% higher than MP.

The transformation of the data set with natural log normalized the SP system. The P-values are 0.411, 0.523, and 0.344 (SP, MP, and MPwA respectively). Two tests are performed after transformation. One tests SP vs. MP and the other SP vs. MPwA. The hypotheses are:

Test 1 $\longrightarrow$ Ho: $\mu_{SP} = \mu_{MP}$ and Ha: $\mu_{SP} \neq \mu_{MP}$

Test 2 $\longrightarrow$ Ho: $\mu_{SP} = \mu_{MPwA}$ and Ha: $\mu_{SP} \neq \mu_{MPwA}$

No significance could be found in either test. A P-value of 0.552 was found in the first test and a P-value of 0.448 was found in the second test. For additional details, see Appendix C. Figure 4.13 indicates the tests performed.

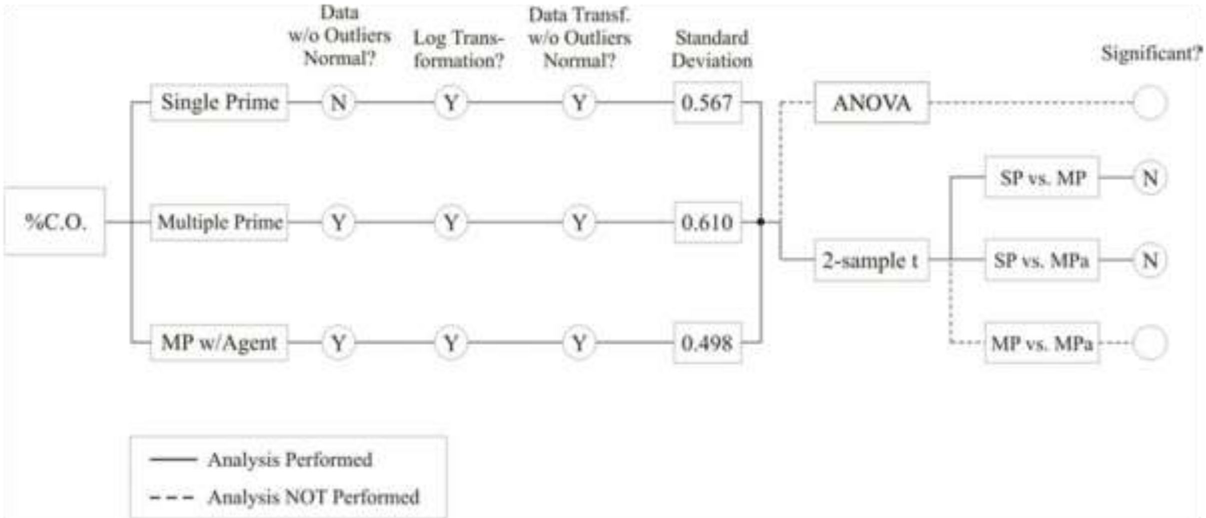


Figure 4.13: %CO - Transformed Flow Chart

There is a consideration in this test that should be mentioned. The survey asked for the reasons for the change orders granted in the project. The list of responses included the following items (see Appendix B for a copy of the questionnaire):

i. Lack of detail during the design phase
ii. Owner has changed the scope of work
iii. Conditions unforeseen when the contract was agreed
iv. Avoid litigation and settle disputes
v. Other reason to be indicated by the respondent

The only significant test in this section indicates that MPwA has higher %CO. than MP including the cases where the owner has changed the scope of the project. This conclusion may not be significant because a change order not controlled by the contractor may not represent a valid measurement of performance.

Litigation

The intention of both owner and contractor is to conclude the project without any type of disputes. However, litigation cases may result from construction contracts. For this sample, 9.57% (approximately 4 schools) of the projects had litigation cases. The majority of the sample did not have litigation, so the distribution of cases was not normal and it was impossible to perform quantitative analysis. Therefore, this section is limited to the descriptive statistics. Furthermore, litigation cases will be considered as a binary variable and analyzed with the Chi-Square test (see Sections 4.5.2). There were 9 litigation cases in 4 different projects. Figure 4.14 indicates the number of cases with their respective delivery systems.

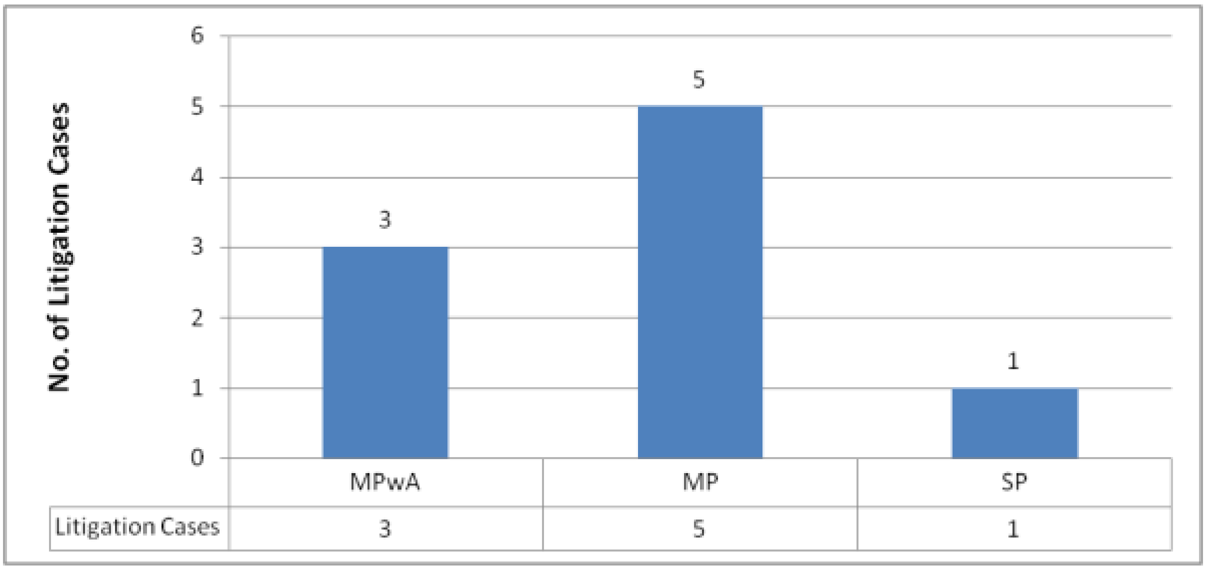


Figure 4.14: Number of Litigation Cases per Delivery System

There were 5 cases related to multiple prime, 3 to multiple prime with an agent and one case to the single prime delivery system. Even though it is not possible to make any inference about the population, the small sample collected indicates that single prime presents considerably fewer numbers of litigation cases when compared to the other two types of delivery systems. This can be explained by the direct and simple relationship that just one entity has with the owner. In the other two cases the owner has to deal with several prime contractors and the possibility of litigation is greater. Figure 4.15 indicates the litigation cases expressed as a percentage of projects per delivery system.

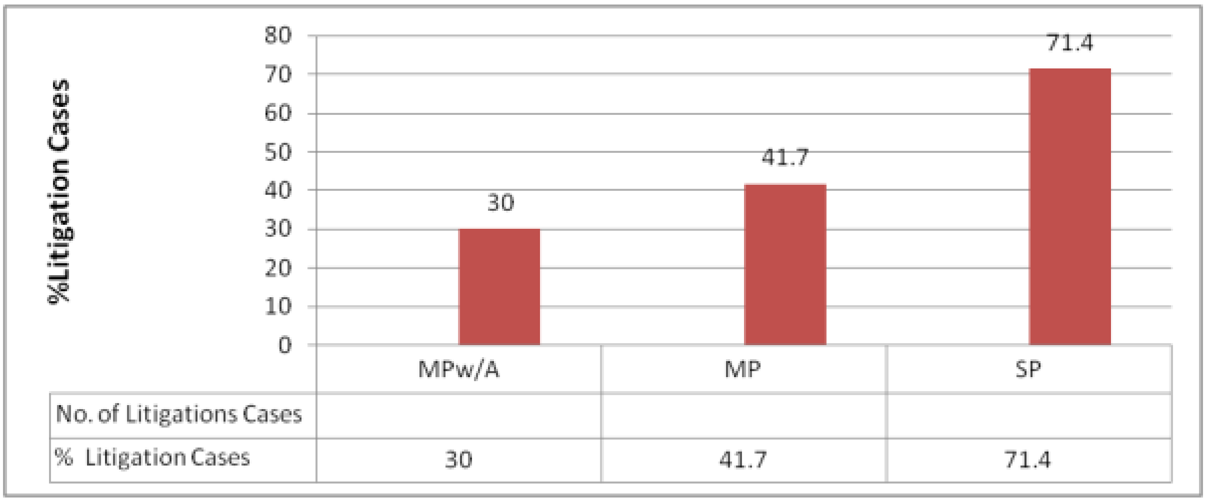


Figure 4.15: Litigation Cases Expressed as a % of Projects Delivery System

QUALITATIVE ANALYSIS

Seven variables are analyzed in this section against the three delivery systems: length of punch list, difficulty of facility startup, level of call backs after owner occupancy, level of administrative burden, project team communication, project team chemistry, and litigation cases.

The length of the punch list was divided into 5 levels (for more detail, see Section 3.6). The result including all 5 levels indicated 11 cells with expected counts less than 5.0. Because of the condition previously explained, levels 1 and 2 were combined with level 3. As a result, level 3 corresponds to the cases where the punch list length is more than one day and less than four weeks. This combination resulted into 3 levels of punch list length with 2 cells with expected count less than 5.0. These 2 cells represent 22.22% of the total, being close to the requirement of the test. The P-value is 0.294 and it is conclusive that the variables are independent.

The difficulty of facility startup was classified in high, medium, and low (levels 1, 2, and 3 respectively). Three cells with expected counts less than 5.0 resulted from the first test. This represents 33.33% of the cells and fails the test. Therefore, level 1 (high) was deleted from the analysis because of the small number of cases. The P-value of 0.627 indicates that there is no relationship between the delivery systems and the difficulty of facility to startup.

The number of call backs after owner occupancy was also classified in three levels: high, medium, and low (levels 1, 2, and 3 respectively). The high level of call backs had the least occurrence among all delivery systems. They represented the cells with expected counts less than 5.0 (3 cells out of 9 = 33.33%). Therefore, the cases with high level of call backs were excluded from the analysis. The P-value of 0.694 indicated that there is not enough evidence to reject Ho. No relationship exists between delivery systems and level of call backs.

The level of administrative burden is classified in a five level scale where 1 represents the highest level and 5 the lowest level. Because of the small number of cases with levels 4 and 5, the results of this test indicated the presence of 3 cells with expected counts with less than 1.0 and 6 cells with less than 5.0. The test is invalid. The exclusion or combination of the cells in this test is not convenient because the scale would be reduced to 3 levels and the low levels would not have representation. Therefore, no conclusions can be drawn about the level of administrative burden.

CONCLUSION

Projects are building blocks that help organizations achieve objectives and goals that support their mission and vision. Three key criteria are always involved in a project: schedule, cost and technical performance. The choice of the project delivery system has a significant impact on the three criteria of schedule, cost and technical performance.

Because of legal requirements, public entities do not have the same flexibility as private entities in choosing the type of delivery system in a construction project. There are five Kisumu County Districts/Sub Counties that require the use of the multiple prime contracting system on public projects. This study objectively analyzed the performance of this system in comparison to single prime and multiple prime with a CM agent. The motivation was based on the controversies that multiple prime have raised in the construction industry.

Two sets of data were created in the study. This first set of data included all the valid sample cases collected from school districts. The three delivery systems (SP, MP, and MPwA) did not present significant differences on several statistical analyses. However, significance was found in some tests.

Considering the full data set, projects using multiple prime with a CM agent constructed more square feet per day than multiple prime and single prime. No significance was found between the construction speed of multiple prime and single prime. A two-sample t test indicated that MPwA has a higher percentage of change orders than MP.

Unit Cost

No difference in unit cost could be found between multiple prime and single prime. Therefore, the argument by specialty contractors that the use of the multiple prime system results in lower construction cost than single prime is not supported.

Cost Growth and % Change Orders

No differences in cost growth or % change orders could be found between multiple prime and single prime, both when owner changes of scope were considered and when they were not. Therefore, the position that single prime systems have less cost growth and fewer change orders is not supported.

Schedule Growth and Coordination

The non-normality of the sample distributions did not allow for the comparison of delivery systems based on schedule growth. Therefore, the position that multiple prime systems incur project delays could not be tested. In addition, no relationship was found between several qualitative variables relating to coordination and delivery systems.

Litigation

Finally, based on the statistics related to litigation cases; single prime presented a considerably smaller number of cases when compared to multiple prime and multiple prime with an agent systems. As discussed previously, this conclusion cannot be inferred to the population, but gives a good idea regarding the volume of litigation involved in the different types of delivery systems.

There is no perfect system. There are advantages and disadvantages to every system. However, there is a better choice depending upon the circumstances of the project and on the benefits that the primary stakeholders may realize from specific project delivery systems. In every project, but especially in the construction industry, uniqueness is a basic characteristic. The owner, consequently, has to analyze the peculiarities of every project, making the choice where the advantages overcome the disadvantages. The ideal situation would be if public owners had the same flexibility as private owners in choosing the delivery system that best fits their situation. However, a case of the Minnesota alternative is an example on how to make use of the good aspects of both the single and multiple prime systems.

This study found fewer significant differences than similarities when comparing the delivery systems. However, the sample size limited the analysis and should be taken into consideration. The conclusive differences found in this study indicate that multiple prime systems with the addition of a construction manager have faster construction speed. It has been perceived that specific groups tend to prefer specific systems based on their individual interests. The choice of the most appropriate delivery system for the project must be based on the needs of the owner and, for public projects, the protection of the public interest. The development of alternatives that would satisfy every stakeholder involved in the construction process will not progress without continuous analyses and debate of the topic. Hopefully this study contributes to this debate, and stimulates additional studies and discussions of the subject.

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