Use of Team Building on Construction Projects to Reduce Cost Growth and Schedule Growth

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(ABSTRACT)

The benefits of the team building process have been examined for many years by several organizations. The Army Corp of Engineers, Project Management Institute, and Construction Industry Institute studies provided the foundation for this research. Cost growth and schedule growth are two areas that were suspected to be improved by the use of team building. A thorough statistical and graphical analysis was conducted to evaluate the effects of the team building process on cost growth and schedule growth. The project phases and demographic slices were examined for both the contractors and owners.

The analysis of the relationship between the team building process and reduction of cost growth and schedule growth provides overwhelming support for implementing the process on construction projects. Although results of particular projects are not always supportive, the overall trends indicate that both budget overruns and schedule extensions can be reduced by the use of a team building process. Particular project categories have been identified as very susceptible to the positive influences of the team building process. Early implementation appears to be crucial in maximizing the benefits of the team building process.

Acknowledgements

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Table of Contents

List of Figures

List of Tables

Chapter 1 - Introduction

1.1 Overview

Owners, designers, and contractors have successfully utilized project teams on construction projects for many years. Management of projects with a project team should yield a higher success rate than traditional styles. The process of creating and maintaining this interorganizational team is referred to as team building. Members of the team typically include representatives from key participants of the project. As new participants, such as subcontractors or suppliers, begin working on the project, they too are added to the project team. The dynamic project team works together with a common mission of project success. Trust, communication, and shared problem solving skills are crucial elements in the team building process. The Construction Industry Institute (CII) Project Team Building Task Force has defined the process as follows:

> "It is a process that brings together a diverse group of individuals and seeks to resolve differences, remove roadblocks and proactively build and develop the group into an aligned, focused and motivated work team that strives for a common mission and for shared goals, objectives and priorities." (Albanese 1993b, pg. V)

The Project Team Building Task Force, established in 1990, has carried out extensive research in this area. It is important to note that the task force has previously made a distinction between team building and partnering. The most notable difference is that partnering encompasses long-term commitments to attain business objectives while team building is project specific (Albanese 1993a). Team building ceases to exist at the completion of a project but may be an integral component of a partnering process. It is not uncommon for the terms to be used interchangeably in practice. The Army Corps of Engineers commonly refers to project team building as partnering.

A critical aspect of both team building and partnering as management strategies is the reduction of adversarial relationships among project participants. On construction projects it is common practice to accuse, dispute, and litigate rather than to solve issues. The existence of these relationships is widespread and usually has an adverse impact on project results. Transforming these negative attitudes into positive commitments can be beneficial to all parties involved.

Budget overruns and schedule extensions are two common problems on construction projects that could be greatly influenced by team building. CII's task force has revealed an overall positive qualitative effect between use of team building and these two issues (Albanese 1993b). In addition, the CII Benchmarking and Metrics Committee has revealed a positive trend between the team building process and reduction in total cost growth.

1.2 Research Focus

The focus of this research is the relationship between the team building process and cost growth and schedule growth by project phases and by demographic slices. The Benchmarking and Metrics Committee has defined six phases of a construction project for the Completed Project Questionnaire (Version 2.0) that will be adopted for the study, see Appendix A for a description of the phases. This research compares the extent of use of the team building process with cost growth percentage and schedule growth percentage. Cost growth will be defined as the difference between the allocated budget and the actual cost. Likewise, schedule growth will be the difference between the expected and actual time for completion.

The research builds on existing studies by isolating the cost and schedule growth into project phases and demographic slices. Focussing on the individual phases will provide a means for determining which phases are most influenced by the team building process. The data is also sliced by several project characteristics such as industry group and project nature. A thorough statistical analysis of the relationship between the team building process and the growth variables also differentiates this study from previous work. Evaluation of the relationship between team

building and schedule growth has been omitted in past research. This research benefits the entire construction industry including owners, designers, and contractors by examining the team building influence across the many phases and slices on both cost growth and schedule growth.

1.3 Purpose, Scope, and Objectives

The purpose of this research is to quantify the importance of the team building process in terms of cost growth and schedule growth. The detailed study builds on existing research by examining the relationship for each of the project phases and demographic slices.

The scope of this research will be limited to the evaluation of the team building process as related to the cost growth and schedule growth variables. Similar to previous CII studies, the emphasis will be on evaluating cost growth and schedule growth improvements related to the extent of use of the team building process.

Objectives to be met by this research are as follows:

1) Evaluate the relationship between the team building process with cost growth and schedule growth for the phases and demographic slices.
2) Identify project phases or demographic slices that are noticeably improved by the team building process.
3) Investigate the effect of early implementation of the team building process.

1.4 Document Format

This document is structured to present the development of the research and data analysis along with the presentation of results, key findings, and conclusions.

Chapter 2: Literature Review of the existing research including studies by the Army Corps of Engineers, Project Management Institute (PMI), and Construction Industry Institute (CII), all of which have investigated the use of team building.

Chapter 3: CII's Unfunded Research Program is explained as well as the process of obtaining access to the their database.

Chapter 4: The Database used for the analysis is defined. The Benchmarking and Metrics Questionnaire is discussed along with the size and demographics of the database.

Chapter 5: Variable Definitions used in the analysis are introduced. The team building index, cost growth, and schedule growth variables are all clearly defined.

Chapter 6: Scope of Analysis presents the replication process and adjustments made along with an explanation of the splitting of data into classes, phases, and slices.

Chapter 7: Methodology of Data Analysis introduces the graphical and statistical methods used in the analysis. The production of charts, plots, and statistical tests is explained as well as the meaning of results.

Chapter 8: Results of Cost Growth Analysis are illustrated using three-dimensional bar charts, statistical tables, scatter plots, and whisker box-plots.

Chapter 9: Results of Schedule Growth Analysis are presented with a much briefer commentary because the results are illustrated similar to the cost growth analysis results.

Chapter 10: Summary of Cost Growth Analysis is included to review the cost growth results.

Chapter 11: Summary of Schedule Growth Analysis is included to review schedule growth results.

Chapter 12: Early Implementation Analysis documents an additional investigation based upon the findings of the primary data analyses.

Chapter 13: Key Findings and Conclusions are stated about the entire research analysis.

Chapter 2 - Literature Review

2.1 Overview

Several studies have been conducted by different organizations to evaluate the effectiveness of team building as a viable project management strategy. The U.S. Army Corp of Engineers has compared the performance of partnered projects to non-partnered projects. A Study by the Project Management Institute (PMI) examined the effects of partnering on 280 construction projects. The Construction Industry Institute (CII) established a task force to evaluate team building as means for reducing adversarial relationships. CII's Benchmarking and Metrics Committee has begun to quantify the impacts of the team building process on cost growth.

2.2 Army Corps of Engineers Study

"Partnering - Project performance in U.S. Army Corp of Engineers" (Westen and Gibson 1993), discusses a study of the Corp's projects used to evaluate the use and benefits of partnering. The Corp is unable to undertake long term commitments with organizations and therefore their project specific partnering could be referred to as team building. Partnering on Corp projects is voluntary and the costs are shared among the project participants. The study included 16 partnered projects and 28 non-partnered projects, which were selected because of similarities with the partnered projects.

Results of the study indicate a strong relationship between partnering and cost growth and schedule growth reduction for the sample projects. The average cost growth for the partnered projects was about 6% less than the cost growth for the non-partnered projects. It was felt that this was a direct result of reduction in change order costs, fewer claims, and more value engineering. Likewise, the average schedule growth for the partnered projects was about 6.5% less than the schedule growth for the non-partnered projects. Costs for implementing the partnering process were estimated to be less than 1% of the project cost.

The study was limited to the Corp's projects and the small sample size may not represent the population as a whole. Projects were classified as either partnered or non-partnered with disregard to the extent of use of the partnering process. Although the results of the study reveal tremendous benefits from implementing a partnering process, effects of partnering on Corp's projects should be re-examined now that many more projects have been completed.

2.3 Project Management Institute Study

Erik Larson has published two journal articles discussing a Project Management Institute (PMI) study of partnering. The articles are entitled "Project Partnering: Results of study of 280 construction projects" (Larson 1995) and "Partnering on Construction Projects: A study of the relationship between partnering activities and project success" (Larson 1997). The term partnering is defined in the study to be synonymous with team building. A questionnaire, which inquired about the partnering process and resulting effects on completed projects, was mailed to randomly selected PMI members. A 32% response rate yielded 280 projects for the study. The size of the firms and projects varied for the respondents. Responses were based upon perceptions of project engineers, project managers, or other management staff.

The first article dealt with the examination of project management types and related success factors. Respondents were asked to classify the project as one of the following project management types defined in the study:

Adversarial	Parties pursued their own concerns with disregard of the other party and problems were deferred to upper management.
Guarded Adversarial	Parties cooperated within the limits of the contract and problems were solved by superiors according to the contract.
Informal Partners	Parties attempted to cooperate beyond contractual obligations and problems were solved with concern for all parties involved.
Partners	Parties considered themselves part of the same team and worked together for project success.

The respondents were distributed fairly evenly distributed among the four project management types. Project success characteristics were measured and grouped according to management type. Results of the study were described to be exploratory because the responses were based solely on perceptions. It was found that the success rate increased for meeting schedule and controlling cost with the reduction of adversarial relationships and increased partnering. The article also suggested that the partnering process equally effected the low-bid and non-low-bid contract types.

The second article discussed the effects of specific partnering elements. It was suggested that establishment of a problem solving strategy was essential for improved schedule and cost performance. The article also stressed that it is best to implement all aspects of a partnering process to ensure the maximum effect.

2.4 CII's Project Team Building Task Force

The Project Team Building Task Force was established by CII in 1990 to examine the possibility of reducing adversarial relationships among construction project participants. The task force used meetings, literature reviews, mail surveys, and interviews to define the focus and perform the research. The first phase of the task force research was to evaluate the existence of adversarial relationships and define the terms and scheme for the research. Phase two consisted of the development of interview questions and a written questionnaire which were used to evaluate the effectiveness of the team building process in reducing adversarial relationships. The results of the Project Team Building Task Force research are documented in CII Source Document 87 and Publication 37-1 (Albanese 1993a, 1993b).

Phase one of the task force's research was made up of three studies each building on knowledge acquired by the previous. Study A consisted of a preliminary survey sent to 60 contractors selected from ENR's 1989 "Top 400 Contractors." Study B included the refinement of the preliminary survey and it was sent to CII member firms. Study C queried the Construction Personnel Executives Group (CPEG) to obtain the perspective of human resource personnel.

The results of the three studies formed the basis of the task force research. Phase two contained the heart of the task force's research, an examination of the relationship between the team building process and costs and schedules.

Top management personnel of construction contractors were the subjects for Study A. The limited focus of the preliminary survey was used to obtain a feeling as to the magnitude of existing adversarial relationships. Multiple types of questionnaires were used to determine the most effective style for later surveys. The results of the preliminary survey confirmed common beliefs that parties must work together to achieve cost effectiveness and that adversarial relationships frequently exist. Causes for the adversarial relationships were suspected to be tied to poor definition and dynamic scope, poor communication, and differences in priorities. The findings led to the development of Study B.

The purpose of Study B was to examine the relationship between the existing adversarial relationships and costs and schedules of construction projects. There were 143 CII member respondents, comprised of 75 owners, 24 designers, and 44 contractors. The results confirmed the findings of Study A in that scope definition and change orders were the most influential elements in cost growth. About 80% of the respondents replied that if adversarial relationships could be removed from the project then a reduction of cost between 10% and 30% is possible. Although the respondents believed that the type of contract slightly influenced the cost growth of a project, they did not feel that it effected the influences of the team building process on cost growth. The majority of the respondents believed that the team building process was a positive influence on cost and that it reduced adversarial relationships.

Study C was conducted to confirm the findings of Study B with the Construction Personnel Executives Group (CPEG) and to explore the possibility of an untapped resource. CPEG is a group of human resource executives whose purpose is to better their practices within the construction industry. These human resource personnel are sometimes skilled in team building within an organization and could be utilized in the development of inter-organizational

project teams. The results of Study C did not indicate any new findings, but did reveal that the human resource personnel are rarely utilized even though they are interested in participating.

The Project Team Building Task Force preliminary research reinforced common suspicions about the team building process and its effect on adversarial relationships. The specific conclusions for phase one are detailed in CII Source Document 87. The three studies provided a basis for the development of the major research objectives of the task force.

Phase two contained the task force's major research process, which was the evaluation of the team building process as a way to improve the management of the relationship between the owner, designer, and contractor. Their research questions were aimed at reduction of adversarial relationships, costs, schedules, and identification of implementation obstacles as well as key characteristics for success.

The task force mailed questionnaires to CII members, which queried the respondent as to the extent of use of the team building process. Completed questionnaires were used to select the projects that would be studied for the research and then interviews were conducted with participants of the 41 chosen projects. The focus of the interviews was on the decision to implement the process, implementation obstacles, key steps of the process, success characteristics, and the cost and benefits.

The decision to implement a team building process was typically based on one of two factors. Either the organization had previous experience with the process or a champion was present. A champion is someone who takes it upon him or herself to whole-heartedly support a new concept or idea. Interviewees felt that the team building process was most effective when implemented as a pro-active approach to preventing problems rather than a cure for existing problems.

Contrary to the suspicions of the Task Force, no common obstacles to implementing the team building process were found. Lack of top-management support was expected, but the respondents did not indicate that such a problem was common. It was noted that the sample was made up of many organizations that had previous experience with the process.

The Task Force did not research "how to" best use the team building process, but they did investigate common features used by the respondents and its results. They found that 100% of the respondents said that they would use team building again. Expectations were met for two-thirds of the respondents. Both internal and external consultants were used to facilitate the team building sessions. A common concern in using internal facilitators was the ability to maintain objectiveness. Of the projects, which did use an internal facilitator, there were no differences found in the effects of the process. Suggested changes to be made to the process included starting the process earlier, involving more people, and more training.

Success characteristics included both intrinsic and extrinsic rewards. Working relations were much more productive and enjoyable as a result of team building. Weekend retreats, hats, coffee mugs and the like were extrinsic rewards used to promote the process. The respondents commonly implied that team building was not a miracle management strategy, rather it created an environment for identifying and discussing problems. The problems were not always solved.

Actual accounting costs and benefits were not recorded because it was felt the benefits of team building overshadowed any costs of the process. Hard costs associated with the team building process are virtually negligible. Soft costs or opportunity costs of personal having to take time away from other responsibilities were reported as the most significant cost. Benefits of the team building process were widespread throughout the projects. Project costs and schedules were two areas of particular interest that were believed to be positively effected.

2.5 CII's Benchmarking and Metrics Committee

Established by CII in 1993, the Benchmarking and Metrics Committee was formed to develop benchmarking practices and to distribute analysis results to members. The committee is made up of member contractors and owners as well as CII staff and graduate students. Their work is documented in the Benchmarking and Metrics Report for 1996 and the Benchmarking and Metrics Data Report for 1997. This work represents CII's first quantitative evaluation of the team building process. To clarify their purpose, the committee defined the following terms:

Metric	A quantifiable, simple, and understandable measure which can be used to compare and improve performance.
Benchmarking	A systematic process of measuring one's performance against results from recognized leaders for the purpose of determining best practices that lead to superior performance when adopted and utilized.
Best Practice Use	A measure of extent of use of a recommended concept or process.
Value	A measure of improvement associated with the use of a best practice.

The committee developed a questionnaire for compiling information about project performance characteristics and the extent of use of CII's recommended best practices. Analysis results of Version 1.0 are detailed in the Benchmarking and Metrics Report for 1996. The questionnaire was modified to include more detail concerning practice use and redistributed in 1997. Version 2.0 analysis results are included in the Benchmarking and Metrics Committee Data Report for 1997. The database is cumulative and will continue to grow from year to year. Major findings of the committee's research dealing with the team building process are included in the 1997 report. The questions of the Benchmarking and Metrics Questionnaire used in this research are included in Appendix B.

A team building index was developed to evaluate the extent of use of the team building practice based on the responses from the questionnaire. The questions were weighted equally and scaled to ten. A table defining the calculation of the committee's team building index is

included in Appendix C. The findings documented in the 1997 Report indicated that owners use team building slightly more than contractors and both use more team building with larger projects.

The relationship between team building and cost growth was investigated for heavy industrial projects. Cost growth, as defined by the committee, was the difference between actual cost and budgeted cost divided by the budgeted cost. A scatter plot and best-fit line was used to illustrate the positive relationship between increased team building and decreased cost. The variability in cost growth was also shown to decrease with increased team building. Whisker box plots were used to illustrate the reduction of cost growth means and medians for each of the quartiles. Replication of these analyses will be discussed in Chapter 6 - Scope of Data Analysis.

The result from the Benchmarking and Metrics 1996 analysis is best summarized in Figure 2.5-(1). A scatter plot and best-fit line were produced to illustrate the relationship between team building and cost growth for owner and contractor heavy industrial projects. It appeared obvious that team building had a substantial impact on cost growth.

Modifications to the 1997 analysis included the separation of the data into owner and contractor classes as well as the addition of whisker box-plots to illustrate quartile distributions. The scatter plot of Figure 2.5-(2) and whisker box-plots of Figure 2.5-(3) represent the combined analysis on Version 1.0 and 2.0. Explanation of these illustration tools is included in the Chapter 7 - Methodology of Data Analysis.

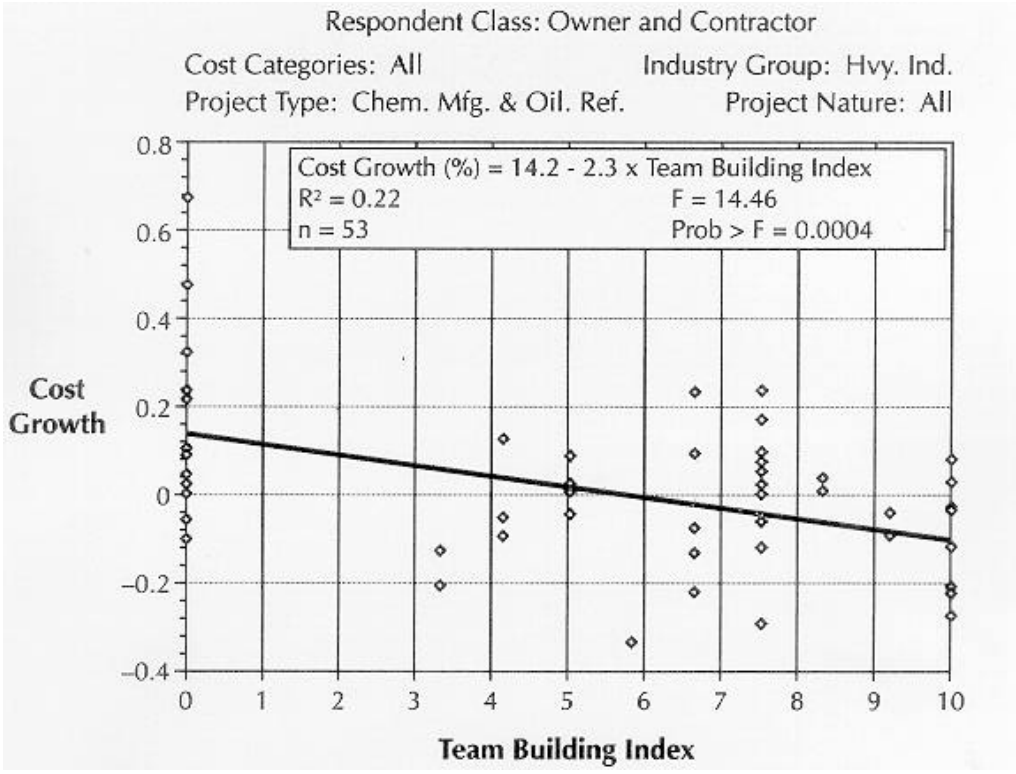

Figure 2.5-(1): CII's Figure 22 of the 1996 Analysis (Benchmarking 1996, pg. 29).

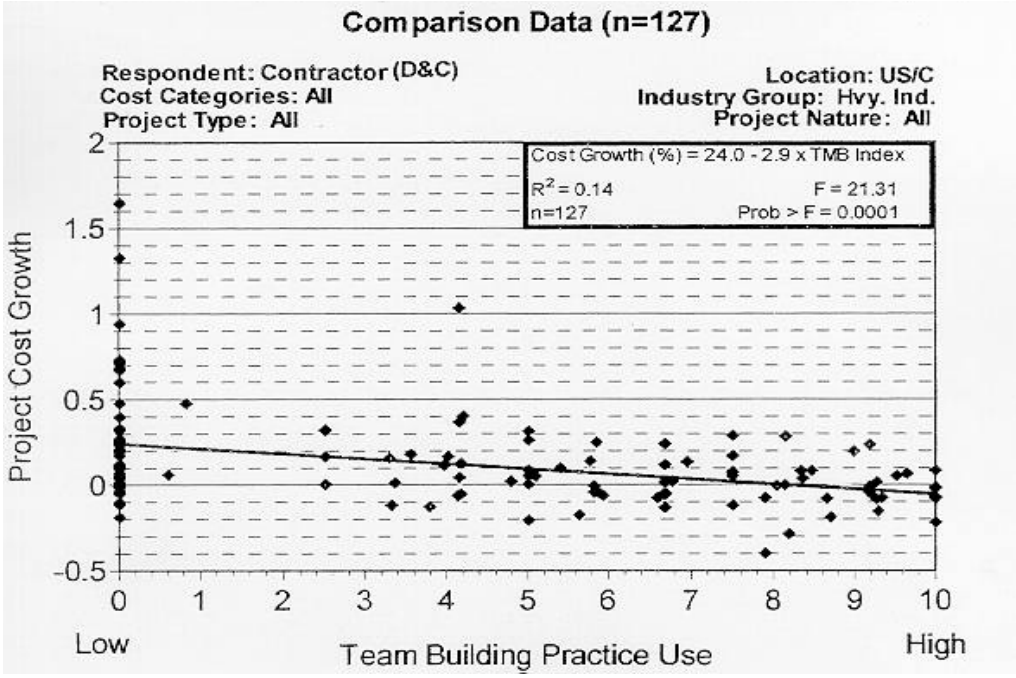

Figure 2.5-(2): CII's Figure 4-5 of the 1997 Analysis (Benchmarking 1997, pg. 4-7).

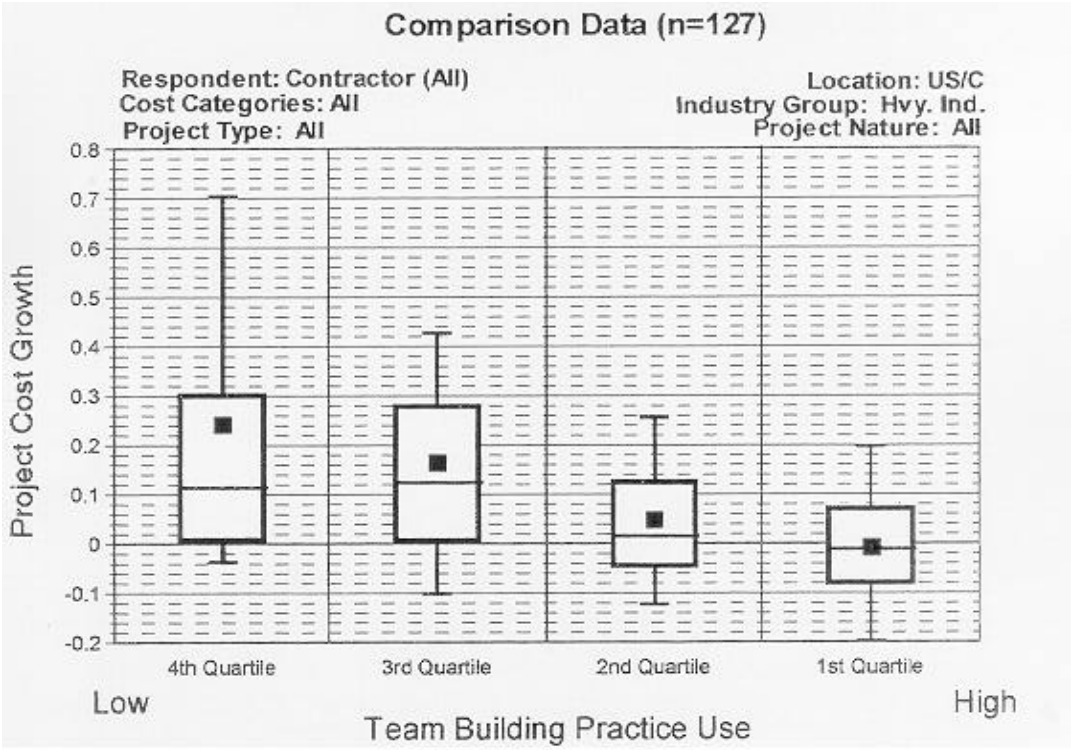

Figure 2.5-(3): CII's Figure 4-6 of the 1997 Analysis (Benchmarking 1997, pg. 4-8).

Chapter 3 - CII's Unfunded Research Program

3.1 Background

The Construction Industry Institute (CII) and National Science Foundation (NSF) sponsored a workshop in May of 1997 to discuss opportunities for improving construction-related research. Participants in the workshop included individuals from academia, the construction industry, and engineering. Proceedings of the meetings are documented in a NSF Publication (NSF 1997).

The group estimated that about one-half of construction related research conducted by graduate students is unfunded. They identified this as a possible opportunity for improvement. Those that fund research such as CII, NSF, and industry can only sponsor a fraction of research projects because of limited funds. Many viable research projects are not approved for funding and often disappear. One recommendation of the workshop was to recirculate these topics to graduate students looking for research topics that are of value to the construction industry. The group produced Figure 3.1-(1) to illustrate the possible improvement to the research cycle.

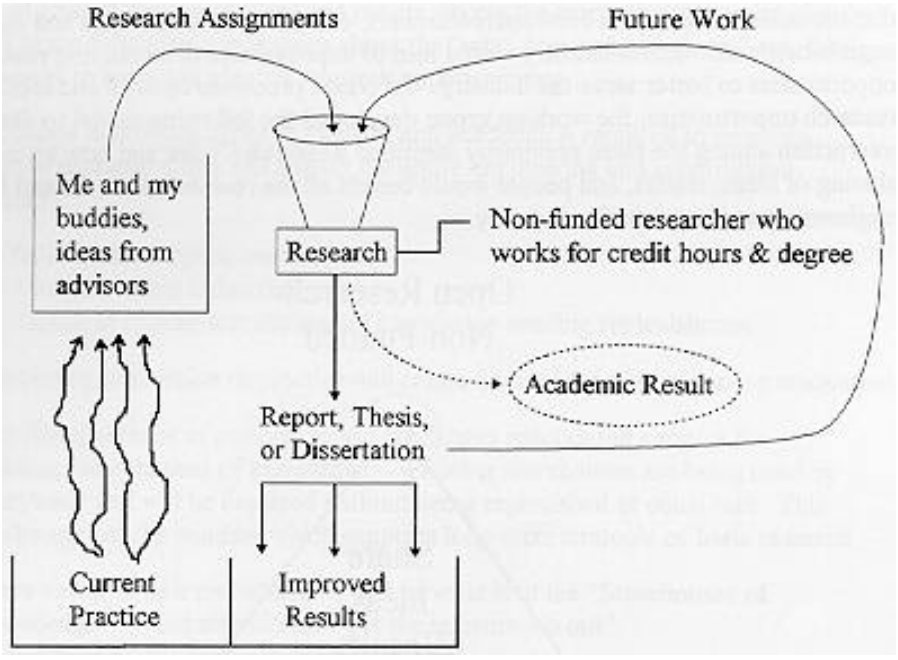

Figure 3.1-(1): Addition of Unfunded Research to the Cycle (NSF 1997, pg. 17).

As shown in the figure, ideas from current practice filter to the academic community. The student's advisor and peers may contribute to the selection of a topic. If a topic is not chosen or the student wishes to search for a topic that is of keen interest to the industry, the unfunded hopper would serve as an excellent resource. The graduate students could scour projects left in the unfunded "hopper" for topics of interest to them and the industry. Students could then further develop these research topics into a report, thesis, or dissertation and accomplish their research requirements. The product of the cycle would represent the student's contribution to industry research. If the contribution represented a finished product, the cycle would be complete, otherwise the topic could be thrown back into the hopper. Recycling the topics that would normally be discarded improves the efficiency of the research cycle.

3.2 CII's Program

CII is developing a program to implement the recommendation of recirculating the unfunded research projects to graduate students. After CII chooses the projects they will fund each year, unfunded topics are thrown into the CII "hopper". Typically these topics remain in the hopper unless the proposal is revised or funding is acquired through other sources.

Through CII's Unfunded Research Program, these topics are distributed to the universities via a point of contact. Graduate students can examine the list to see if any of the topics valued by the industry are appropriate for their research. After a topic has been chosen, a research proposal must be drafted and approved by the student's committee and the university's point of contact. Upon approval, the point of contact sends the proposal to CII for review. If the proposal is approved, the research is then classified as CII Unfunded Research and the graduate student may be granted limited access to CII information. Upon completion of the research, the graduate student must submit the project, thesis, or dissertation to CII for final approval. Awards and prizes may be distributed to the researchers in recognition of their contribution to industry research. The costs associated with the Program would be minimal as compared to the benefits of the research produced without funding.

Confidentiality of CII members' information must be considered a top priority in this process. This "win-win" situation can benefit the graduate students, CII, and its members. The data analysis of this thesis was performed on data obtained through the CII Unfunded Research Program. This pilot project provided an excellent opportunity to further investigate the team building process.

Chapter 4 - The Database

4.1 Overview

Access to the Benchmarking and Metrics database was permitted via the CII Unfunded Research Program. The database represents the information obtained by the annual questionnaire distributed by the committee. The Benchmarking and Metrics Completed Project Questionnaire was distributed to CII members in 1996 and 1997. Modifications are made to the questionnaire each year and the database is cumulative from year to year. The database contains information about project characteristics and performance as well as details concerning the extent of use of CII's recommended best practices. The set of questions representing the information used in this research is included in Appendix B.

The database is structured to allow extrapolation of pertinent project information. The team building index was calculated using the answers to the questions about the team building process. Cost and schedule growths were calculated from the project performance information. The data was easily split according to project phases because information was available for each of the phases. A description of project phases is included in Appendix A. Project characteristics were then used to slice the data by respondent type, industry group, cost category, project nature, contractor function, and contractor remuneration. The demographics used to slice the data are illustrated in the following sections.

4.2 Respondent Type

As illustrated in Figure 4.2-(1), the proportion of contractors and owners is fairly even. Of the 392 projects, there were 187 (48%) owners and 205 (52%) contractors. The respondents represent about $20 billion in construction projects. The database was split by respondent type because contractor and owner responses were significantly different in many cases.

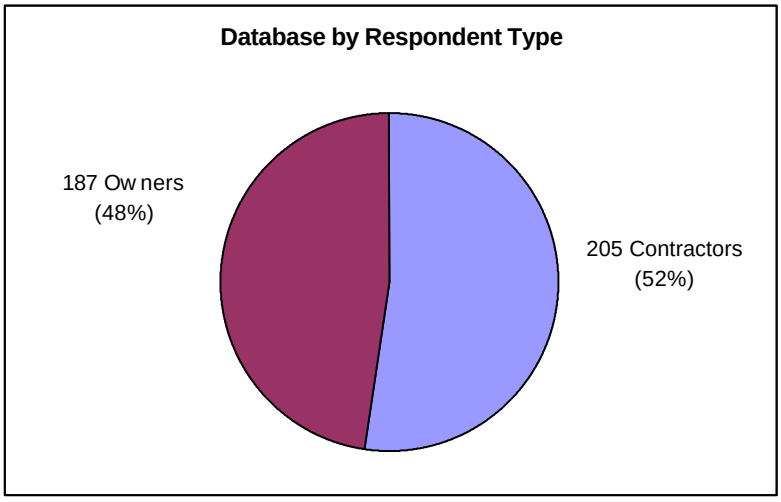

Figure 4.2-(1): Proportions of contractors and owners.

4.3 Industry Group

Responses to the project type question were classified according to the four industry groups defined in Appendix B. The distribution of projects among the groups is shown in Figure 4.3-(1) for both the owners and contractors. It is obvious that the majority of the projects are in the heavy industrial group. Slightly more than 70% of the contractor projects are classified as heavy industrial. The owner distribution is somewhat less skewed with only 55% of the projects in the heavy industrial group.

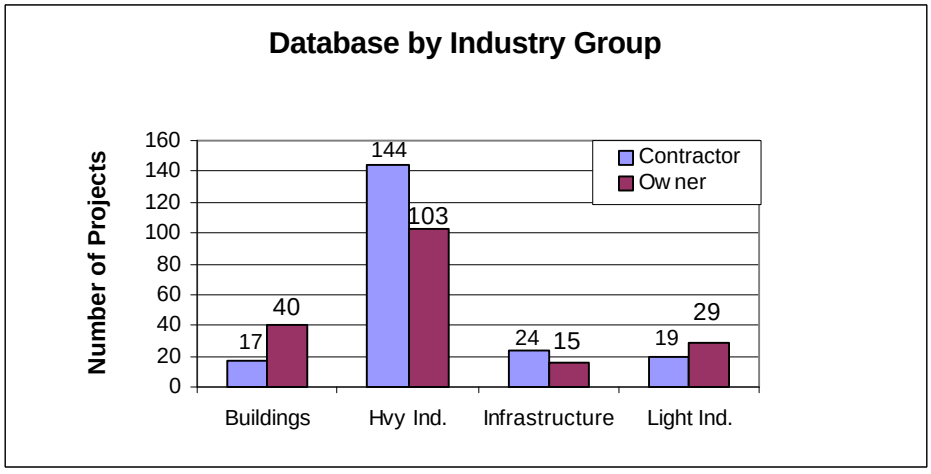

Figure 4.3-(1): Distribution of projects among industry groups.

4.4 Cost Category

Projects of the database were separated into four cost categories. Most of the projects are in one of the two categories below $50 million. As shown in Figure 4.4-(1), the owner to contractor values for each category are well balanced.

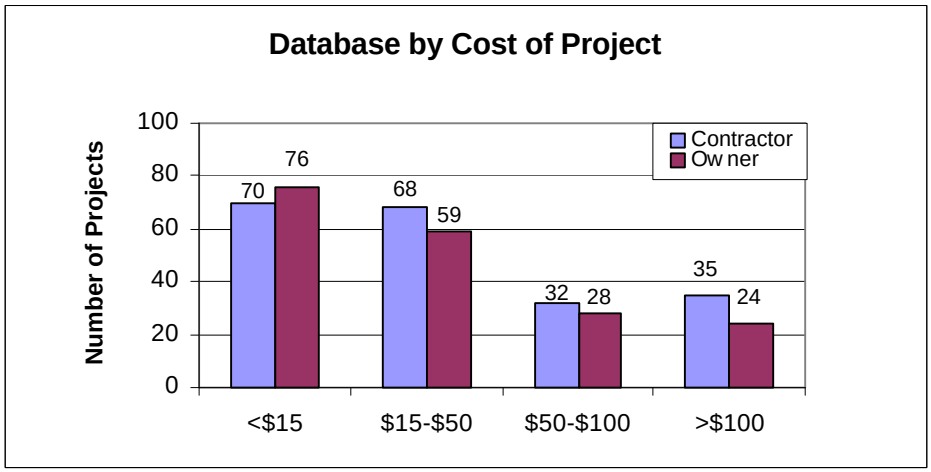

Figure 4.4-(1): Distribution of projects among cost categories.

4.5 Project Nature

Analyzing the database by project nature also produced a relatively even distribution among the groups. It is shown in Figure 4.5-(1) that the number of contractors and owners are relatively equal for addition, grass roots, and modernization projects.

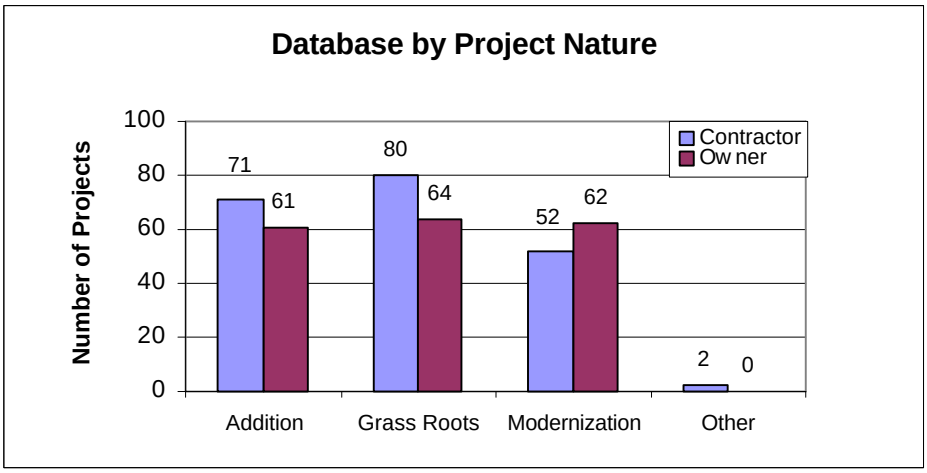

Figure 4.5-(1): Distribution of projects by project nature.

4.6 Contractor Function

The contractors' functions were classified as construct-only, design-only, or design-and-construct based upon costs incurred during the appropriate project phases. As shown in Figure 4.6-(1), about one-half of the projects were design-and-construct with the majority of the others being construct-only. Classification was not feasible for the owner because the owner typically has multiple functions.

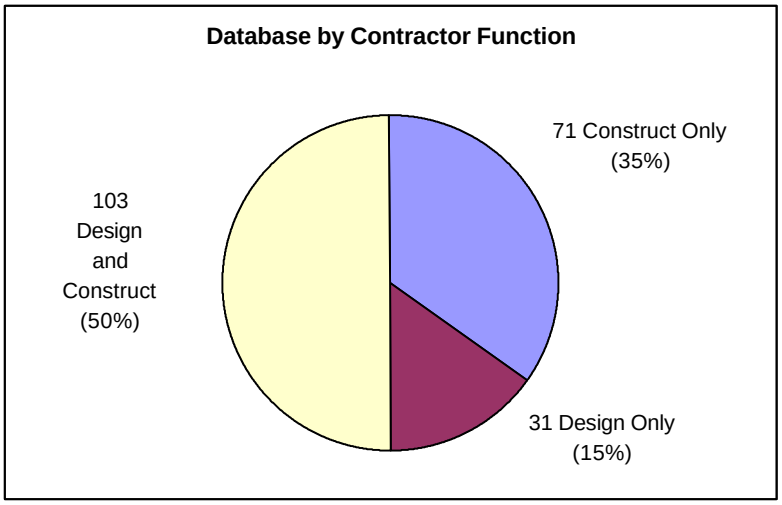

Figure 4.6-(1): Proportions of contractor functions.

4.7 Contractor Remuneration

Likewise, owner remuneration types were not isolated because the owner typically has more than one contract type on a project. Figure 4.7-(1) reveals that the majority of the contractor projects are in the cost reimbursed (CR) and lump sum (LS) groups. The responses were low for guaranteed price (GP) and unit price (UP) contracts.

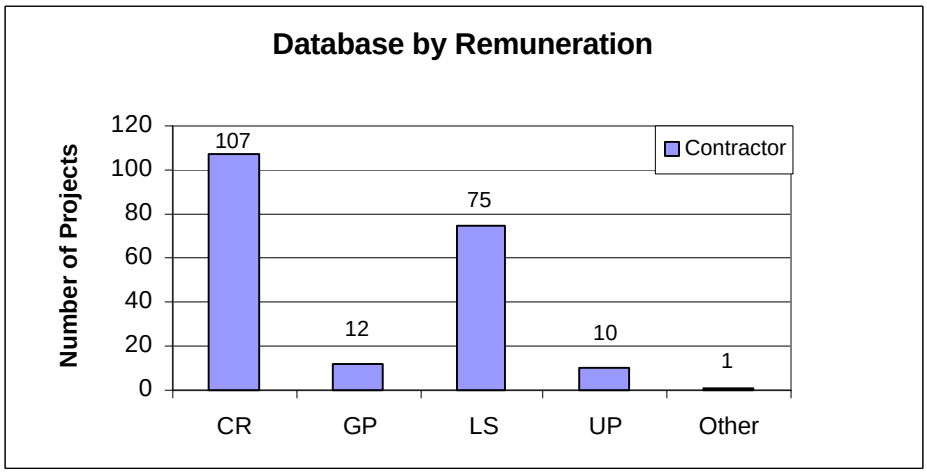

Figure 4.7-(1): Distribution of contractor contract types.

Chapter 5 - Variable Definitions

5.1 Overview

Three variables, developed by CII, are used in the data analysis to gage the influence of the team building process on costs and schedules. A team building index is employed to represent the extent of use of the team building process. Cost and schedule growth percentages are computed from project data to measure performance.

5.2 Team Building Index

CII's questionnaire includes a series of questions about the use of the team building process on the projects. A complete list of questions regarding the team building process, questions 36-36h, is included in Appendix B. The responses to the questions reveal if CII's recommended practice steps were fulfilled. They also reveal which phases and participants implemented the team building process. The team building index represents the extent to which the team building process was implemented.

The team building index was based on a zero to ten index. Each question asked was weighted equally and then scaled to ten. If there would have been ten questions then each question would have been worth one point and that point would be distributed among the possible answers for that question. This team building index will be referred to as TBI 10 to indicate the number of questions used. However, the actual number of questions was not ten. Version 1.0 & 2.0 of the questionnaire only contained five and nine questions respectively. Version 1.0 of the questionnaire did not contain as many questions as Version 2.0 because questions 36c, 36d, 36g, and 36h had not yet been added. If the team building indexes would have been applied to all of the questions they would be denoted as TBI 5 and TBI 9. However, the Benchmarking and Metrics Committee used only four of the five questions for Version 1.0 and did use all nine questions in Version 2.0. This inconsistency will be discussed in more detail later in the Replication of Existing Analysis section of Chapter 6 - Scope of Data Analysis.

A table was included in the Benchmarking and Metrics Data Report for 1997 that clearly defined the distribution of value among the nine questions of Version 2.0. CII's table, shown in Table 5.2-(1) below, shows that each of the questions was weighted equally. Question 36g does have its answers weighted unequally to accentuate the importance of certain phases. Such a table was not included for the Version 1.0 analysis and a trial and error process was conducted to determine how the team building index was calculated in that version. This procedure is also discussed in detail in the Replication section of Chapter 6. The adjustments made to CII's team building index for the current research are documented in the Adjustments and Limits section of Chapter 6.

Table 5.2-(1): CII's table for team building index calculation (Benchmarking 1997, App. C-3).

Team Building Practice Use

Question		Yes / No
36	Was a team building process used for this project?	1.0 / 0.0
36a	Was an independent consultant used to facilitate the team building process?	1.0 / 0.0
36b	Was a team building retreat held early in the life of the project?	1.0 / 0.0
36c	Did this project have a documented team-building implementation plan?	1.0 / 0.0
36d	Were objectives of the team building process documented and clearly defined?	1.0 / 0.0

Question	
36e	Were team building meetings held among team members throughout the project?
	(Regularly=1.0, Sometimes=0.67, Seldom=0.33, Never=0.00)

36f	Were follow-up sessions held to integrate new team members and reinforce concepts?
	(Regularly=1.0, Sometimes=0.67, Seldom=0.33, Never=0.00)

36g	Please indicate the project phases in which team building was used.				
	Pre-Project Planning	Design	Procurement	Construction	Start-up
	0.30	0.30	0.10	0.20	0.10

36h	Please indicate the parties involved in the team building process.
	Owner - Designer - Contractors - Major Suppliers - Subcontractors - Constr. Mngr. - Other
	(each response receives 0.167)

9 Questions, Maximum Score of 9 --> Divide by 0.9 to scale to 1 -10 point range

5.3 Cost and Schedule Growth

The influence of team building on costs and schedules was gagged by percent growth variables. Cost growth is defined as the difference between the actual cost of the project and the budget cost set at authorization. Likewise, schedule growth is defined as the difference between actual duration and the planned duration. Percent growth is simply the growth divided by the budgeted cost or planned duration multiplied by one hundred. It was felt that the percent growth would be a much more effective variable for comparison than actual growth. The equations used to calculate the cost growth percentage and schedule growth percentage are shown below.

$$\text{COST GROWTH \%} = \frac{(\text{Actual Cost} - \text{Budgeted Cost})}{(\text{Budgeted Cost})} * 100$$

$$\text{SCHEDULE GROWTH \%} = \frac{(\text{Actual Duration} - \text{Planned Duration})}{(\text{Planned Duration})} * 100$$

It is important to note that the costs of a project are different for the contractors and owners. The contractors' costs would be expenses associated with subcontractors, suppliers, labor, equipment, and overhead. The owners' cost would be primarily payment to designers, construction managers, and contractors. These differences are of critical importance when analyzing the effects of the team building process on the two groups. For example, in theory a lump sum contract should yield zero cost growth for the owner while the cost growth for the contractor could vary greatly.

Chapter 6 - Scope of Data Analysis

6.1 Overview

The data analysis for this research builds upon and complements the existing research performed by the CII research teams. The Benchmarking and Metrics database provided the basis for replication of the existing analysis and an opportunity to pursue alternative approaches for additional research. Adjustments were made to the methodology and the computation of the team building index as well as the development of a more in depth slicing process. Inclusion of the schedule growth variable also added another dimension to the existing research.

6.2 Replication of Existing Analysis

It was critical to replicate the existing analysis before proceeding with modifications and further expansion. As explained in Chapter 2 - Literature Review, Figure 22 of the Benchmarking and Metrics Summary for 1996 represents CII's analysis for Version 1.0 or 1996 . Likewise, Figure 4-5 of the Benchmarking and Metrics Data Report for 1997 represents their cumulative analysis for Version 1.0 and 2.0 or 1996 and 1997. The figures are scatter plots of the team building index versus the cost growth percentage with a best-fit line used to represent trends in the data.

The first step in replicating Figure 22 was to determine the equation used for the team building index. As previously mentioned in the discussion of the database, there were five questions referring to the extent of use of team building in Version 1.0. It was also mentioned in the Summary for 1996 that each of the questions was generally weighted equally. The original hypothesis, TBI5, assumed that the weighting scheme was equivalent to the scheme used for the same five questions of Version 2.0 and then scaled up to ten. When the scatter plots were compared, the data points were not correctly aligned in the vertical direction. The results indicated that the assumed equation to calculate the team building index, TBI5, was not the same as the actual equation used to calculate the team building index in the Version 1.0 analysis. The next hypothesis, TBI4, excluded the use of question 36 leaving only four questions to be used for

the computation of the team building index. The four questions were weighted according to the table for Version 2.0 and then scaled up to ten. The logic for eliminating this question was that it seemed to be more of an indicator as to whether or not the respondent replied to any of the questions in the section rather than an actual indicator to the extent of use of team building. The exclusion of question 36 and subsequent use of 36a-36d appeared to be the key to vertical alignment of the data indicating that the team building index of the second hypothesis, TBI4, was correct.

The second step in the replication of their Figure 22 was to arrive at a best-fit line similar to the line shown for the Version 1.0 analysis. The first line included all of the data points available from the database and did not match well with the existing line. It was noticed that the current n-value, number of respondents, was much higher than the n-value of the previous study. After an extensive trial and error process, a consistent pattern for eliminating data points could not be determined. However, it was found that when the two extreme data points of 440% and 102.7% were eliminated, the equations for the best-fit line became very similar. The replication analysis and best-fit line for the original research are shown in Figure 6.2-(1). The data points, best-fit line, and equation for the current analysis are shown in black and CII's analysis is represented with a best-fit line and equation shown in red.

Minor differences are most likely associated with the higher n-value for the replication, but the figure indicates that the replication is a good representation of the original analysis. The calculation of the team building index with questions 36a-36d and the elimination of the two extreme data points seem to be the key findings of this replication process.

The replication of Figure 4-5 was made much easier by a table included in the Benchmarking and Metrics Data Report for 1997 which documented the calculation of the team building index, TBI9, for Version 2.0. CII's table is included in Appendix C of this document. All of the nine question, 36-36h, were weighted equally and for the questions with multiple

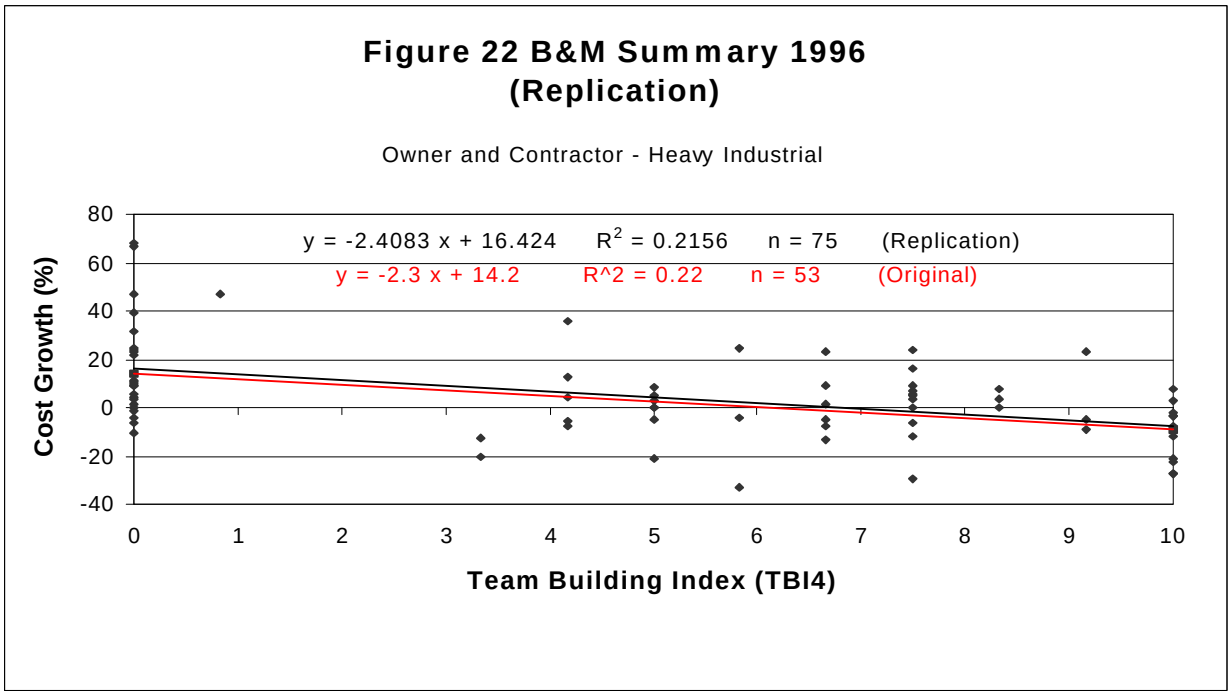

Figure 6.2-(1): Replication of CII's Figure 22 Benchmarking and Metrics Summary 1996.

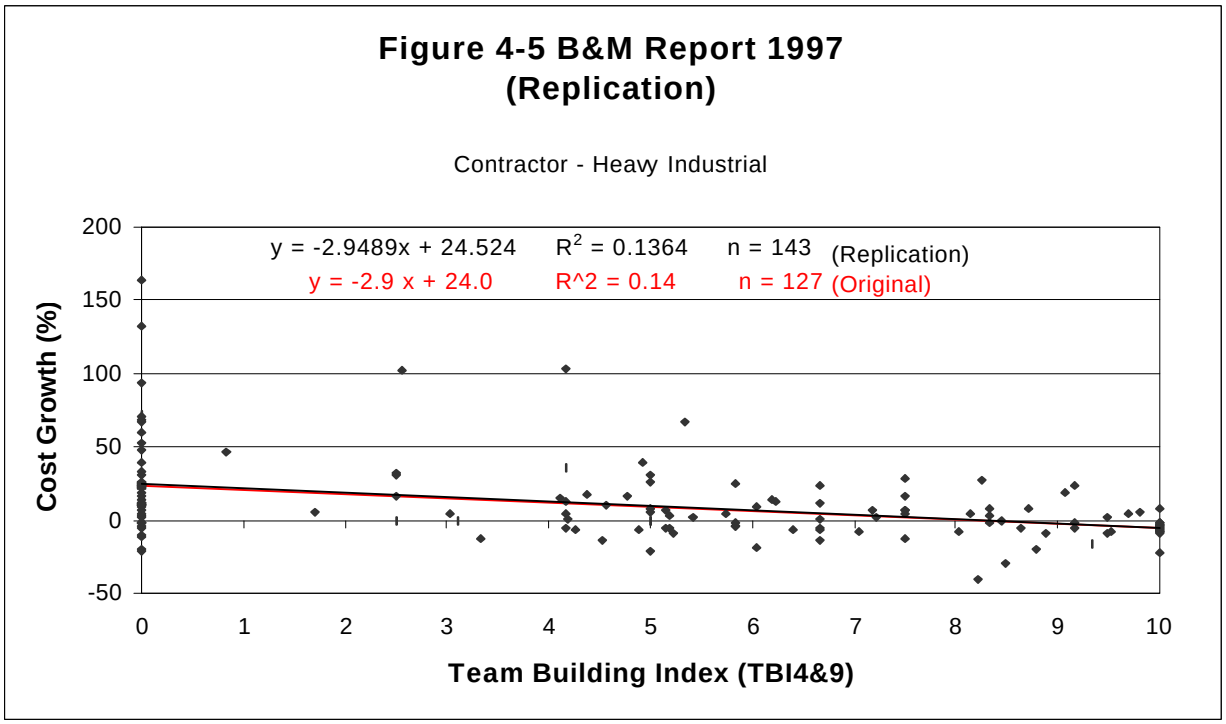

Figure 6.2-(2): Replication of CII's Figure 4-5 Benchmarking and Metrics Data Report 1997.

answers the value of the question was equally divided up among the possible answers. The first hypothesis for this replication assumed that the documented weighting scheme was applied to both Version 1.0 and Version 2.0 and then appropriately scaled to ten. Version 2.0 included question 36 in the calculation of the team building index; therefore, it was suspected that the Version 1.0 team building index, TBI4, would have to be recalculated using all five of the questions. By investigating the vertical alignment of the data this hypothesis was found to be incorrect. Based upon these findings the second hypothesis assumed the use of TBI4 to represent the data from Version 1.0. The vertical alignment of the second hypothesis was correct. The next step was to reproduce the best-fit line representing the data. By eliminating the one major extreme point at 440% and using TBI4&9 an excellent replication resulted. The replication analysis and best-fit line for the original research are shown in Figure 6.2-(2).

6.3 Adjustments and Limits

Upon the successful completion of the replication process it became apparent that a few adjustments should be made. One inconsistency was the use of question 36 in the Version 2.0 analysis and the exclusion of it from the Version 1.0 analysis. Question 36 simply asks the respondent if a team building process was used on the project. It seems that the information obtained by this question simply reveals whether or not the respondent answered positively to any of the questions in the section. When scatter plots of the two index systems are compared, it can be seen that including question 36 simply increases the index for all of the respondents who replied positively to any question. Therefore, it does not seem logical to assign value to this question when evaluating the extent of use of the team building practice. The team building indexes adopted for this research are TBI4&8, which result in practically the same best-fit line as TBI4&9.

Another inconsistency was the manner of treatment of extreme values. A distinguishable pattern was not recognized and there was no documented explanation for elimination of data points. Caution must be taken when eliminating real data points; therefore, limits were established for this research and will be discussed in detail later.

Finally, question 36h has seven answers possible that are weighted as if there are only six answers. The last answer is 'Other' and was probably included for respondents who would not use the given answers to describe their project. The value of this question exceeds the maximum weight assigned to it when all of the seven answers are replied to positively. This only occurs a few times but does give one respondent a score greater than the maximum ten points for the team building index. To adjust for this problem, if in question 36h the respondent answered positively for all seven answers, then the 'Other' points were not added to the weight of the question. This adjustment ensures that all of the questions used for the team building index are equally weighted.

6.4 Splitting and Slicing of the Data

The questionnaire for Version 1.0 and Version 2.0 covered many different aspects of the project that enabled the data to be split and sliced in several valuable ways. The first major distinction, which also required separate questionnaires, was between owners and contractors. It should be easily anticipated that the two parties could have varying views due to their different roles. After splitting the respondents into these two groups, the data can be broken down even further by project phases and demographics.

The extent of use of team building, or team building index, has been previously compared to total cost growth for both the owner and contractor respondent classes. The next step is to compare the team building index with the cost growth for each of the six project phases defined in the questionnaire. These phases, defined in Appendix A, include pre-project planning (PPP), design (DES), procurement (PRO), demolition (DMO), construction (CON), and start-up (STU). There was no existing research found for the analysis of team building and schedule growth. Total schedule growth can not be directly determined for the project from the given data, but the schedule growth for each project phase is readily available.

Slicing of the data by the demographics, previously discussed in Chapter 4 - The Database, allows for a more detailed examination of the relationship between the team building

index and the growth variables. Whereas the total cost growth can be sliced according to the demographics, the lack of total schedule growth information requires a minor adjustment. The demographic slicing for schedule growth was performed on the design, procurement, and construction phases. These phases were chosen because of their consistently high number of respondents.

The database was sliced by the following five divisions:

1) Industry Group - buildings, heavy industrial, infrastructure, and light industrial
2) Project Nature - addition, grass roots, and modernization
3) Cost Category- < $15 mill., $15 to $50 mill., $50 to $100 mill., and > $100 mill.
4) Function* - construct only, design only, and design and construct
5) Remuneration* - cost reimbursed, guaranteed price, lump sum, and unit price

*Notice that Function and Remuneration were only sliced for the contractor because the owner is usually involved in all functions and can have multiple contract types on the same project.

Table 6.4-(1) illustrates the scope of analysis performed for both the contractor and owner classes. The team building index was analyzed in terms of total cost growth, all six phase cost growths, and all six phase schedule growths. The team building index for each of the demographic slices was analyzed in terms of total cost growth and for design, procurement, and construction phase schedule growths. As previously mentioned, the Function and Remuneration slices were not analyzed for the owner class.

Table 6.4-(1): Scope of analysis performed for contractor and owner classes.

		Cost Growth							Schedule Growth						
Demographic Slices		Total	Phase:						Total	Phase:					
			PPP	DES	PRO	DMO	CON	STU		PPP	DES	PRO	DMO	CON	STU
NA	TBI vs -->	C / O	C / O	C / O	C / O	C / O	C / O	C / O	NA	C / O	C / O	C / O	C / O	C / O	C / O
Industry Group	TBI vs -->	C / O	NA	NA	NA	NA	NA	NA	NA	NA	C / O	C / O	NA	C / O	NA
Project Nature	TBI vs -->	C / O	NA	NA	NA	NA	NA	NA	NA	NA	C / O	C / O	NA	C / O	NA
Cost Category	TBI vs -->	C / O	NA	NA	NA	NA	NA	NA	NA	NA	C / O	C / O	NA	C / O	NA
Function	TBI vs -->	C /	NA	NA	NA	NA	NA	NA	NA	NA	C /	C /	NA	C /	NA
Remuneration	TBI vs -->	C /	NA	NA	NA	NA	NA	NA	NA	NA	C /	C /	NA	C /	NA

C - Indicates analysis performed for contractor
O - Indicates analysis performed for owner
NA - Not Adressed

The analysis performed for the total growth, phase growth, and demographic slices is detailed in the following chapter. Several illustrations and statistical tests were used to fully evaluate existing relationships in the data.

Chapter 7 - Methodology of Data Analysis

7.1 Overview

The methodology for analysis can be broken down into two phases. The preliminary analysis consisted of simple bar charts for evaluating the effect of using or not using a team building process on average cost and schedule growths. The illustration of these simple bar charts raised expectations that a positive relationship existed between the use of a team building process and the growth variables. This led to the primary phase of the research, which consisted of a thorough investigation of the extent of use of a team building process as related to cost and schedule growths. The effects were examined across the project phases and demographic slices as explained in the previous chapter.

7.2 Simple Bar Charts

Simple bar charts were used for the preliminary analysis to examine the given data and determine if a positive relationship might exist between the use of a team building process and cost and schedule growths. Question 36 simply asked if a team building process was used on the project. This yes-or-no answer separated the respondents into two groups, those who used a team building process and those who did not. The average total cost growth for the projects was calculated for each of the two groups. The average schedule growths for the phases of design, procurement, and construction were also calculated. These averages were then illustrated with the appropriate yes-or-no label in simple bar charts. The difference between the average growths for the yes-group and no-group could be viewed as the effect of a team building process on the cost and schedule growths. Figure 7.2-(1) shows a sample bar chart of the total cost growth for the contractor and owner class. It can be seen that there are about 5.4% and 2.7% reduction in average cost growth for the contractors and owners respectively who use a team building process. This operation was performed for the project phases and demographic slices and in most cases the positive relationship appeared obvious. However, this visual examination of the data does not have a statistical significance associated with the apparent results.

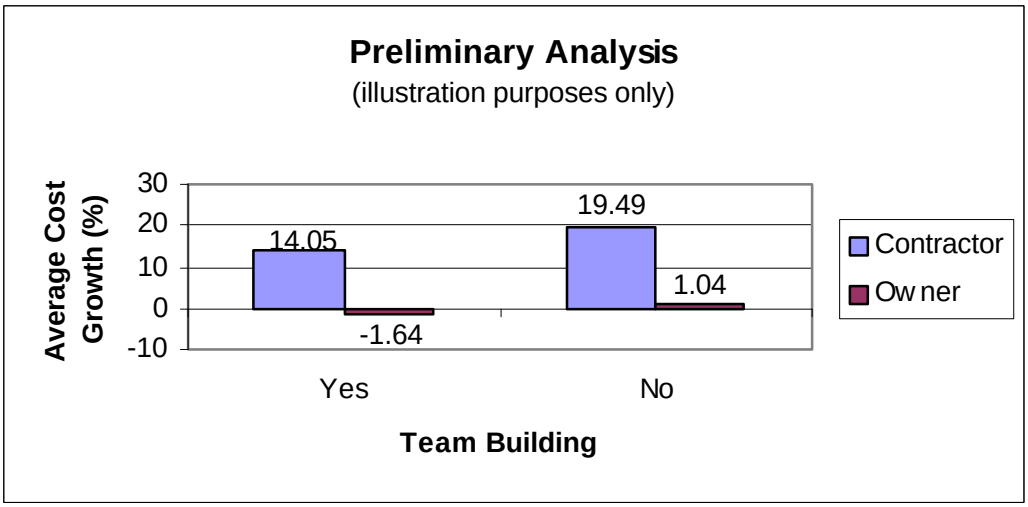

Figure 7.2-(1): Sample bar chart for the preliminary analysis.

7.3 Three-Dimensional Bar Charts

The true meaning of simple bar chart is limited to an indication as to whether or not the positive relationship exists. A three-dimensional bar chart enhances the information of a simple two-dimensional bar chart. The most notable feature is the ability to illustrate the differing effects of a team building process across a third parameter. This provides a visual indication as to whether or not the team building process has more of an effect on any particular phase or slice. If there are no differences in the effect then this would indicate a lack of need for examining the phases or slices individually. Figure 7.3-(1) demonstrates the use of a three-dimensional bar chart as an indicator for further splitting of the data. The effect of the team building process on each group is represented by delta. The figure clearly indicates that there is a positive relationship between the use of a team building process and reduction in the growth variable. This could also be viewed by a simple bar chart, but the third dimension allows for a comparison of the effect between the two groups. There appears to be a stronger effect on group B as compared to group A. It is important to note that the effect is the difference between the average growth value of the yes-and-no responses. The magnitude of the individual average growths are not of concern when evaluating the effect of the team building process. This point is illustrated in another sample three-dimensional bar chart, Figure 7.3-(2). In the figure the magnitudes of the growth variable are different, but the effect of team building is the same in

both cases. A phase or slice containing less than 20 observations will be shown colorless to warn of the situation.

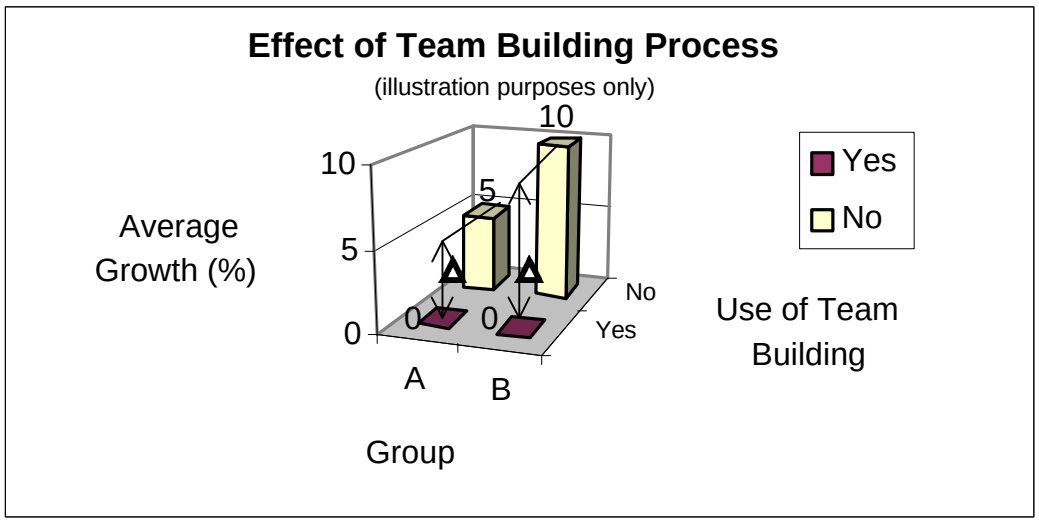

Figure 7.3-(1): Sample three-dimensional bar chart with team building effecting groups differently.

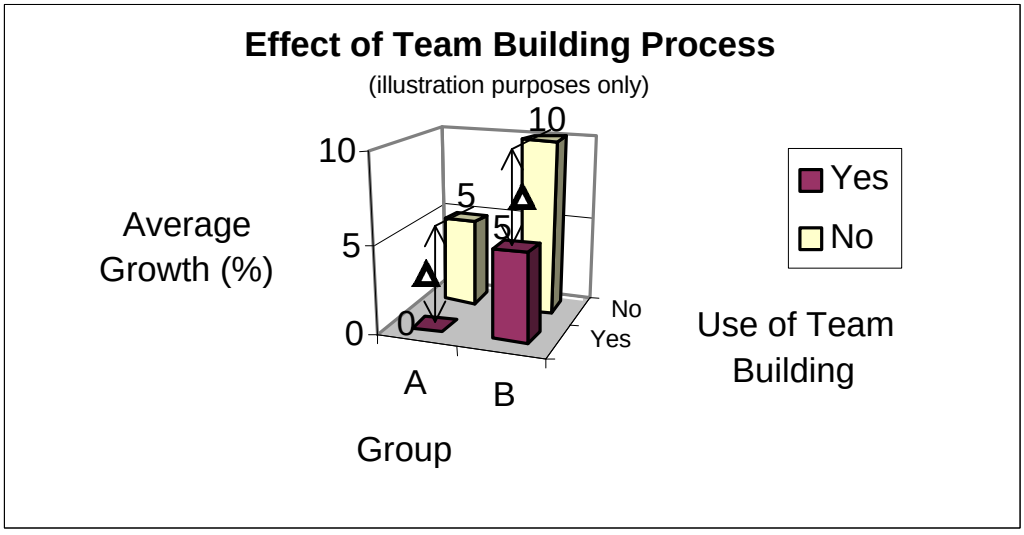

Figure 7.3-(2): Sample three-dimensional bar chart with team building effecting groups similarly.

7.4 Scatter Plots

The extent of use of the team building process and its relationship with cost and schedule growth reduction is best illustrated with scatter plots. As shown earlier in the replication phase, scatter plots can be used to determine possible visual trends in the data. The horizontal axis ranges from 0 to 10 representing the team building index. The vertical axis represents the percent of cost or schedule growth. Each data point is plotted and a best-fit line is drawn using the "least squares" method. The slope of this line is the key indicator as to whether or not a positive relationship exists between increased use of team building and reduction in the growth variables. If the team building index increases from left to right on the x-axis and the growth variables increase in the upward direction on the y-axis, then a negative slope indicates a positive relationship.

All of the data points were used in the production of the scatter plots for the total cost growth. Extreme points such as the cost growth values above 300% were included because there was no obvious justification for eliminating them. Limits were imposed on the cost and schedule growth values for the project phases and slices and some extreme data points were eliminated. The reasoning for this was that some of the extremes seemed to have possible data entry errors. The upper limit was set at 500% because if anything grew by more than six times there must be a factor much more significant than the team building process. Likewise, the lower limit was set at -80% to avoid such extremes.

Applying the limits and using TBI4&8, as previously discussed, the scatter plots were produced for the owners and contractors. The scatter plots for the total cost growth as well as the cost growth and schedule growth for each of the project phase were produced. Next, plots were formed for the slices taken of the total cost growth. It should be noted that the plots were not created for the slicing of the schedule growth because the total schedule growth was unknown and the slices would have had to be performed on individual phases.

It was suspected that a higher team building index would be associated with a lower cost or schedule growth, whereas a lower team building values should be associated with higher cost and schedule growth. Thus, one would expect the best-fit line to have a negative slope. A negative slope provides support to the suspicion of a positive relationship between team building and reduction of cost and schedule growth.

Problems arise when an effort is made to assign statistical significance to the scatter plots. The r-squared value is interpreted as the variance in the y-value that is explained by the variance in the x-value. It is commonly used to measure the degree by which the best-fit line represents the data. For almost all of the plots compiled, the r-squared value indicated that the best-fit line was not a statistically sound representation of the data. R-values were typically below 0.2 on a scale of 0 to 1 with 1 being optimal. The bar charts and scatter plots provided valuable information for further analysis, but it would be difficult to draw conclusions without sound statistical support in the form of hypothesis tests.

7.5 Normality Test

A test for normality was performed on the cost and schedule growth variables for the total project, phases, and slices. The test was conducted to determine whether or not the data set originated from a normal distribution. P-values, resulting from the test, should be greater than 0.2 for the sample to be considered normal. If the data had been normal, a traditional approach could have been used to statistically analyze the data; instead, a non-parametric approach was warranted since the Normality Test failed. The extremes or outliers can have a detrimental effect on the outcome of the hypothesis tests if normality is incorrectly assumed. In contrast to classical tests, non-parametric procedures do not require the assumption of normality. The tests conducted in this analysis use a ranking method and focus on medians instead of means to reduce the effect of outliers.

7.6 Two Sample Wilcoxon Test

In an effort to add statistical significance to the bar charts representing the data with respect to question 36, the Two Sample Wilcoxon Test was performed on the total project, phases, and slices. Rather than comparing the means, which can be easily distorted by outliers, the test focuses primarily on the medians of the yes-and-no groups. The test was used to determine if a statistically significant difference existed between the medians of the two data sets. The null hypothesis for the Wilcoxon Test is that the median for the yes-group is equal to the median for the no-group. The alternative hypothesis is that the median of the yes-group is not equal to the median of the no-group. The test will return a p-value less than 0.05 if the median for either of the groups is significantly lower than the median of the other group. Therefore, manual examination of the medians is necessary to ensure that the median for the yes-group is less than the median for the no-group. Setting the acceptable limit for the p-value equal to 0.05 means that an incorrect conclusion will be reached 5% of the time. An incorrect conclusion refers to the results of the sample not matching the population. The 5% limit is an acceptable and standard risk (Hollander 1973). Even though the bar chart comparison of the mean values was overwhelmingly supportive of a positive relationship, the results from the Two Sample Wilcoxon Test varied.

7.7 Jonckheere-Terpstra Test for Ordered Alternatives

It was thought that if the data could be divided into quartiles then the median for each quartile could be compared to evaluate the relationship of the team building index with the cost and schedule growth variables. The quartiles were established by splitting the team building axis so that an equal number of data points were in each quartile. Quartiles were then shifted to avoid separating data points with the same team building index. Shifting of the quartiles can best be explained using Figure 7.7-(1). It can be seen in the figure that if the given TBI's were to be split evenly, then there would be a zero in the first two quartiles. Because there is no way to distinguish between a zero in the first quartile and a zero in the second quartile, the first quartile is shifted to include all of the zeros. All of the quartiles are established in this manner and are numbered from left to right.

Given TBI's	Even Split	Shifted
00023689	00/02/36/89	000/2/36/89

Figure 7.7-(1): Illustration of quartile separation.

This Jonckheere-Terpstra Test uses a ranking system to approximate a distribution for each of the quartiles. The null hypothesis is that the estimated distributions of the four quartiles span equal growth values. The alternative hypothesis for the test states that the location of the estimated distributions decreases moving from left to right for each quartile. In other words the location on the growth axis of the estimated distribution for the first quartile is higher than the second and so on. The alternative hypothesis was found to be correct if the quartiles were ordered to support a positive relationship between increased use of team building and reduction of the growth variable. Because the test evaluates deviation along with the medians, it is possible for the location of the distributions to be ordered when the medians are not ordered correctly. The result is described by a p-value, values less than 0.05 mean that the quartiles are ordered correctly (Hollander 1973). Quartile systems are most effectively illustrated with whisker box-plots.

7.8 Whisker Box-Plots

The data for each of the quartiles is grouped together and the vertical location of the data can be shown with a whisker box-plots. By quarters, the data of each quartile is again split into four groups, but this time it is according to the vertical axis. Boxes and lines, or whiskers, represent the inner and outer quarters respectively. Asterisks beyond the whiskers symbolize extreme data points as compared to the distribution of other data in the quarter. These features are shown in Figure 7.8-(1). Each line or box represents a quarter of the quartile's data if the splits occur between points with different y-values. Like the separation of the team building quartiles, this does not always occur and sometimes there are more or less data points represented by the quarters. The border between the two inner quarters represents the median for each of the quartiles.

The second quartile is often easily skewed because of adjustments. The first quartile sometimes includes more than 25% of the respondents since many have a team building index score of 0. If respondents are pulled from the second quartile with the adjustments, then the data of the second quartile is easily skewed because of the low number of respondents represented in that quartile. Because the Jonckheere-Terpstra Test analyzes the estimated distributions and the whisker box-plots illustrate the location of quarters within each quartile, the statistical test and graphical illustration may occasionally contradict one another.

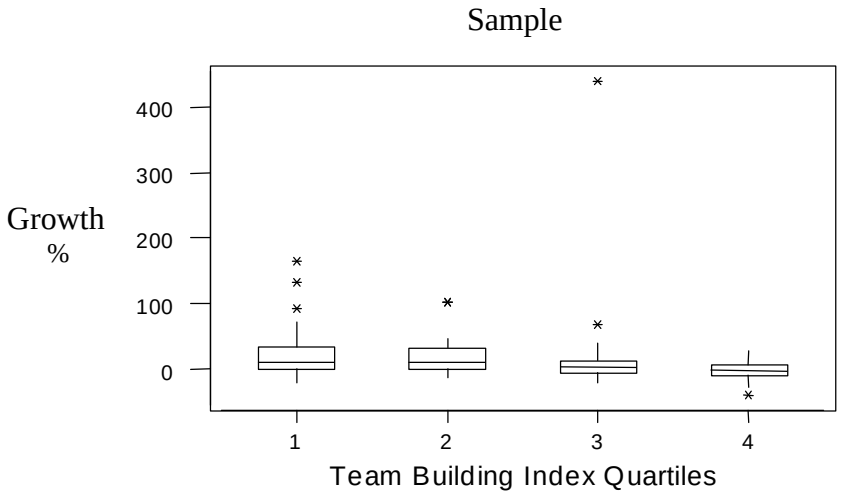

Figure 7.8-(1): Sample Whisker Box-Plots.

The statistic analyses were not performed on subsets with less than 20 respondents because of confidentiality issues and the lack of meaning associated with the low sample size. Likewise, the average cost growths representing sample sizes less than 20 are shown colorless in the three-dimensional bar charts.

Chapter 8 - Results of Cost Growth Analysis

8.1 Overview

Both the graphical and statistical results of the data analysis are presented in this chapter along with comments and explanations. The primary functions of the graphical illustrations are for preliminary exploration and to aid in the visualization process. Typically the graphs or plots have little meaning until they are supported by statistical analysis. Likewise, the statistical analysis has added meaning if the results are graphically obvious. In conjunction with one another, the two approaches are combined to help explain the existing relationships in the data.

Simple bar charts were used in the preliminary analysis to preview the data for possible relationships. These simple bar charts are not shown because the same information appears on the three-dimensional bar charts. They did however lead to further investigation of the relationship between the yes-and-no responses regarding the use of a team building process and the growth variable. The charts overwhelmingly showed that the average cost growth for the respondents who used a team building process was less then those who did not use the process. This concept is further investigated using statistical tests.

The three-dimensional bar charts represent the beginning of an analysis for the data divided into different groups. For example, the first split of the data deals with the contractors and owners and this analysis is preceded by the three-dimensional bar chart showing the effects of the team building process on the two groups. Justification for separating the data by phases and slices is aided by the use of these three-dimensional bar charts. The charts illustrate the effect of the team building process on the growth variable for each subset of the phases or slices.

Following the bar charts are a series of illustrations representing the primary data analysis. Tables of statistical analysis results, scatter plots, and box-plots exist for each subset of every section. The only exception to this format is when the sample size for the subset is extremely small or when confidentiality is an issue.

8.2 Total Cost Growth for Contractors and Owners

The first analysis of the data included bar charts representing the average cost growth of the projects for contractors and owners with respect to their response to question number 36, which simply asked if a team building process was used. Figure 8.2-(1) indicates a positive relationship may exist between the use of a team building process and reduction of average cost growth. When a team building process is used, the average cost growth percentage is reduced by 5.44% and 2.67% for the contractors and owners respectively. The effect of a team building process is more prominent for the contractors, but this is not surprising since there exists more room for improvement. Justification can be made for separation because of the varying effect of the team building process on each group. The figure represents an exploratory analysis and prompts further investigation.

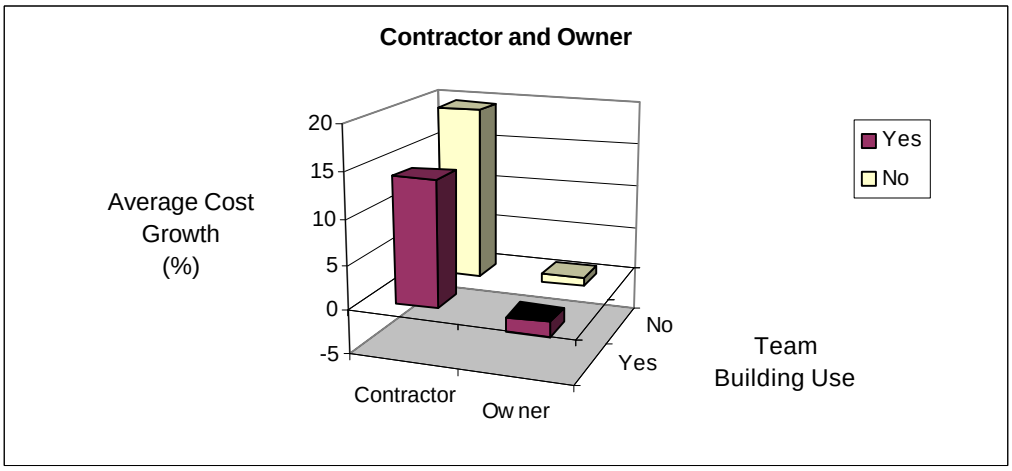

Figure 8.2-(1): Effect of team building on contractor and owner cost growth.

There were 204 out of 205 contractor respondents who reported a total cost growth and the distribution of that data was non-normal as shown by the Normality Test results in Table 8.2-(1). The Wilcoxon Test was performed to determine if a statistical difference existed between the medians of the yes-and-no responses. As previously mentioned this non-parametric test detects differences in the location of the distributions using a ranking system rather then means and standard deviations in a traditional analysis. The resulting p-value for the test is

shown in Table 8.2-(1) along with the n-value (sample size) and median for each group. A p-value of 0.0038, which is less than the required 0.05, represents a statistically significant difference between medians of the yes-and-no cost growths. The results of the Jonckheere-Terpstra Test (JT) will be discussed later with the box-plots.

Table 8.2-(1): Contractor statistics for total cost growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Total Cost Growth	204	0	124	80	4.8555	10.9535	0.0038	0.0006

The cost growth data for the 185 out of 187 owner respondents was also non-normal. The yes-and-no responses to question 36 were averaged and are illustrated in Figure 8.2-(1). The Wilcoxon Test was then performed and the results for the owners were much different than the results for the contractors. A p-value of 0.5306 shown in Table 8.2-(2) indicates there is not a statistically significant difference between the cost growths of the two groups. Even though it is not statistically significant, both the means and the medians, as shown in Figure 8.2-(1) and Table 8.2-(2) respectively, indicate that a positive relationship may exist.

Table 8.2-(2): Owner statistics for total cost growth.

Owner:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Total Cost Growth	185	0.001504	132	53	-0.5861	-0.3597	0.5306	0.2116

The contractors' scatter plot of the entire data set for the team building index versus the total cost growth percentage was produced and is shown in Figure 8.2-(2). The equation of the best-fit line is given along with the r-squared value and the n-value. There were 205 respondents who provided enough information to calculate a team building index and cost growth percentage. The relatively steep negative slope of the line represents a very influential positive relationship between increased team building and reduction of cost growth. According to the best-fit line, a cost growth reduction from 22.9% to 5.9% is possible by increasing the team building index from 0 to 10. Further investigation was warranted because of the low r-squared value, which indicates that the best-fit line is not a good statistical representation of the data set.

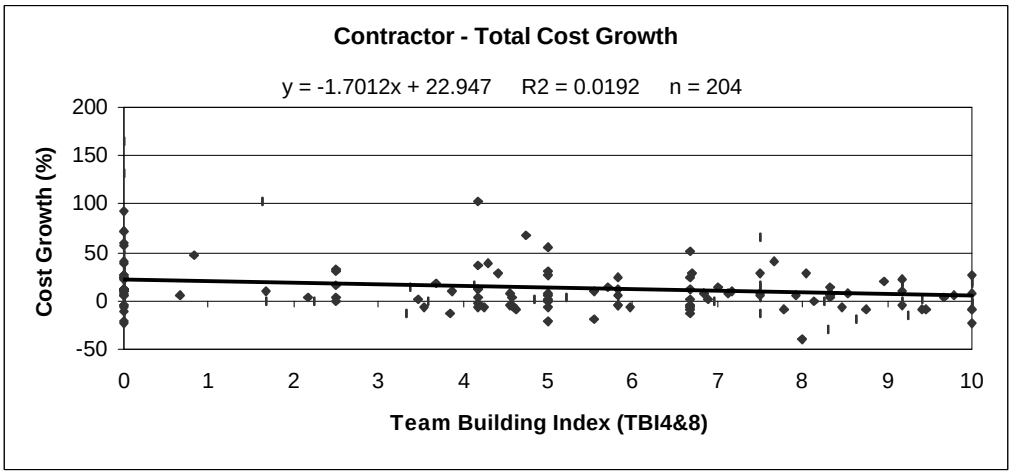

Figure 8.2-(2): Contractors' team building index versus total cost growth.

To further explore the data set, the Jonckheere-Terpstra Test was performed and the resulting p-value is shown in Table 8.2-(1). The value of 0.0006 is much lower than the required 0.05 and this statistical significance is illustrated in the whisker box-plots of Figure 8.2-(3). As indicated by an acceptable p-value, the locations of the distributions for the quartiles decrease with increased use of team building. If the extreme points above 300% cost growth are eliminated for the second and third quartiles, then the variability also decreases with increased use of team building.

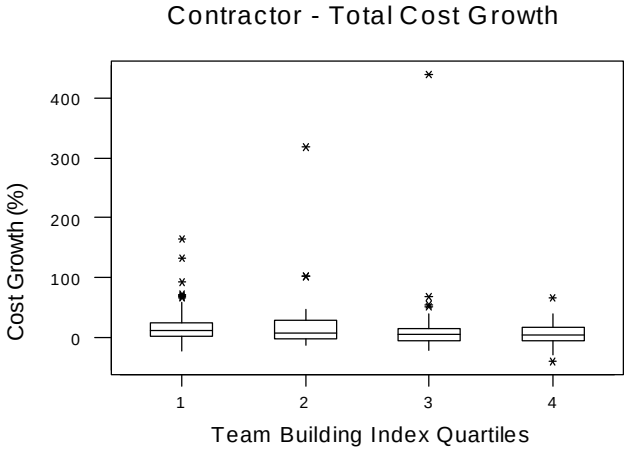

Figure 8.2-(3): Contractors' quartile distribution for total cost growth.

The scatter plot of the team building index versus the total cost growth percentage for 185 owners is shown in Figure 8.2-(4) along with the equation and statistics of the best-fit line. The slope of the line is negative indicating a positive relationship, but it is much less steep than the slope of the line for the contractor data set. This situation was expected upon examination of Figure 8.2-(1), the three dimensional bar chart. The lower y-intercept, or the lower cost growth percentage for respondents without a team building process, provides less opportunity for a team building process to dramatically influence the cost growth. According to the best-fit line, a reduction from 1.2% to -4.3% is possible by increasing the team building index from 0 to 10. Again, the low r-squared value indicates that best-fit line is not a statistically sound representation of the data set.

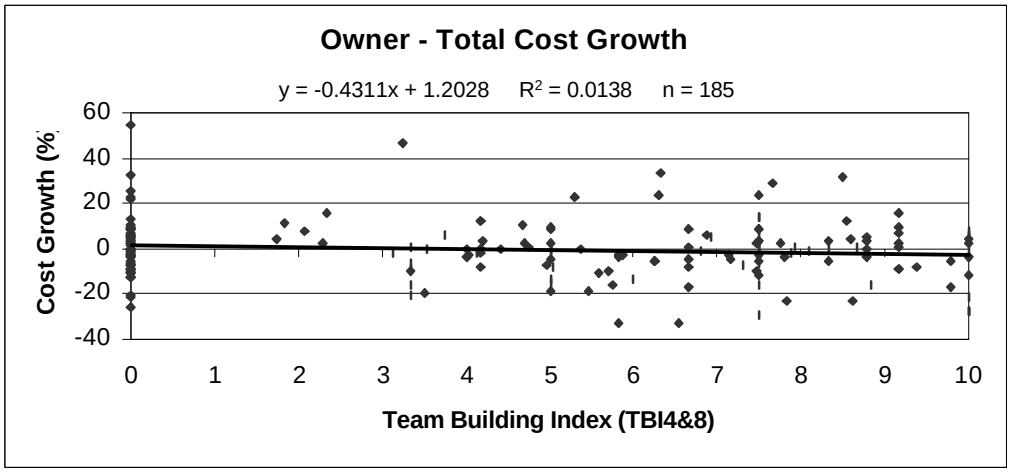

Figure 8.2-(4): Owners' team building index versus total cost growth.

The result of the Jonckheere-Terpstra Test for the owners' total cost growth fails to reject the null hypothesis that the locations of the quartiles are equal (i.e., 0.2110 > 0.05). As illustrated in the whisker box-plots of Figure 8.2-(5), it can be seen that the medians of the first, second, and fourth quartiles are approximately equal with the median of the third quartile lying slightly lower than the other three quartile medians. Although the Jonckheere-Terpstra Test fails, the box-plots do not reveal a negative relationship and the scatter plot and three-dimensional bar chart indicate a slight positive relationship may exist.

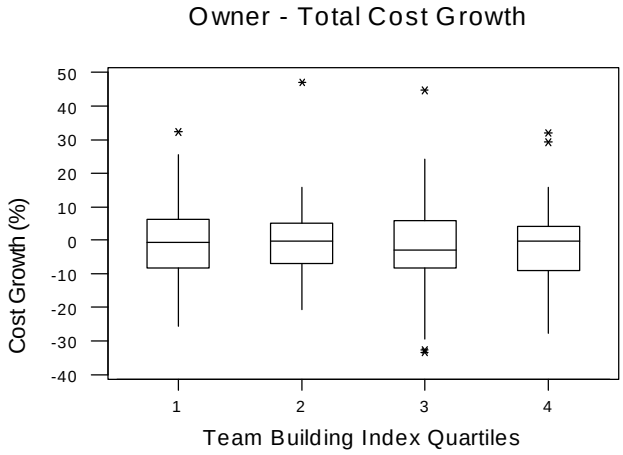

Figure 8.2-(5): Owners' quartile distribution for total cost growth.

8.3 Contractors' Cost Growth by Phases

As shown in Figure 8.3-(1), separation of the contractors' total cost growth into the six phases yielded unexpected results. The average cost growth for the respondents who used a team building process was higher than those who did not in all of the phases except for the design and start-up phases. Average cost growth for the demolition phase is shown colorless because of the low sample size. The result is puzzling but may be explained with further investigation of the medians.

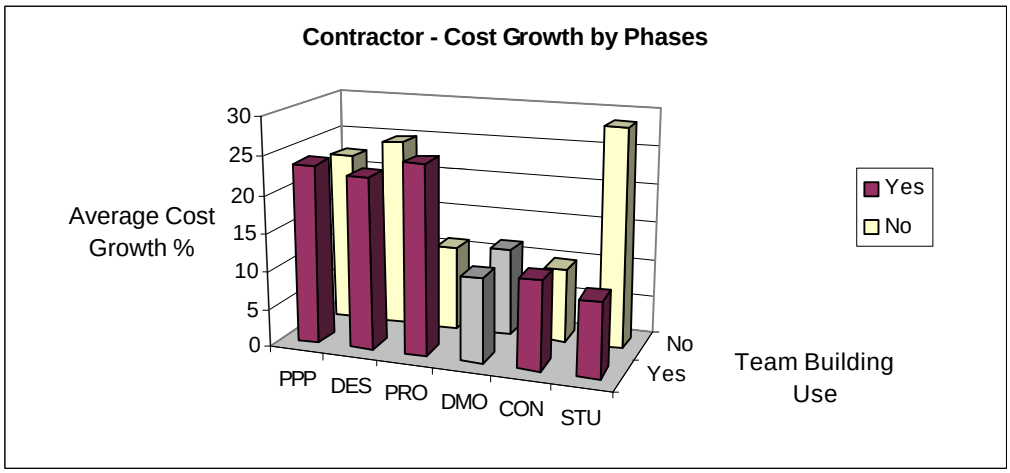

Figure 8.3-(1): Effect of team building on contractors' cost growth by phases.

Medians for the individual phases are shown in Table 8.3-(1) along with the results of the Wilcoxon Test. Upon examination of the medians of the yes-and-no respondents, it can be seen that the medians for those who used a team building process are lower than or equal to those who did not use the process for all of the phases. The extreme data points could explain differing results of the mean and median comparisons. The mean is much more effected by an extreme data point as compared to the median. The values for the Wilcoxon Test do not reveal a statistically significant difference between the medians of the yes-and-no respondents for any of the phases. It should also be noted that the cost growth for the individual phases are non-normal as was the total cost growth.

Table 8.3-(1): Contractor statistics for phase cost growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Pre-Project Planning	66	2.09E-14	41	25	0	0	0.0891	0.0108
Design	131	0	81	50	8.511	12.5085	0.1343	0.0046
Procurement	120	0	78	42	-2.9485	0	0.2027	0.0685
Demolition	18	.	.	.	.	.	.	.
Construction	166	0	97	69	8.112	11.579	0.0869	0.0604
Start-Up	36	5.68E-08	20	16	3.111	27.34	0.2322	0.1794

8.3.1 Contractors' Pre-Project Planning Phase Cost Growth

There were 66 contractors who responded to the pre-project planning phase. The scatter plot of Figure 8.3.1-(1) includes the equation of the best-fit line and the r-squared value. The slope is negative indicating a positive relationship, with a possible reduction from 9.2% to -0.8% when the team building index is increased from 0 to 10. A low r-squared value suggests that the best-fit line is not a good statistical representation of the data set. Because the sample size is small, the points above 50% cost growth could be classified as extreme and may be the cause for the unusual mean comparison in Figure 8.3-(1).

The resulting p-value for the Jonckheere-Terpstra Test shown in Table 8.3-(1) is less than 0.05, which indicates that the quartiles are ordered to support a positive relationship. The quarters of the quartiles for the contractors' pre-project planning phase are illustrated in the whisker box-plots of Figure 8.3.1-(2). Re-examination of the data files used to create the

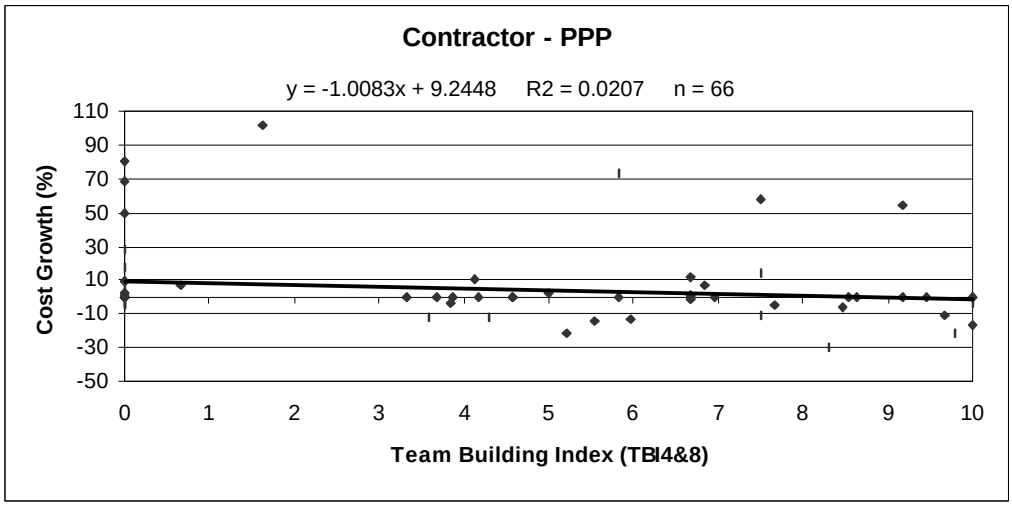

Figure 8.3.1-(1): Contractors' team building index versus pre-project planning cost growth.

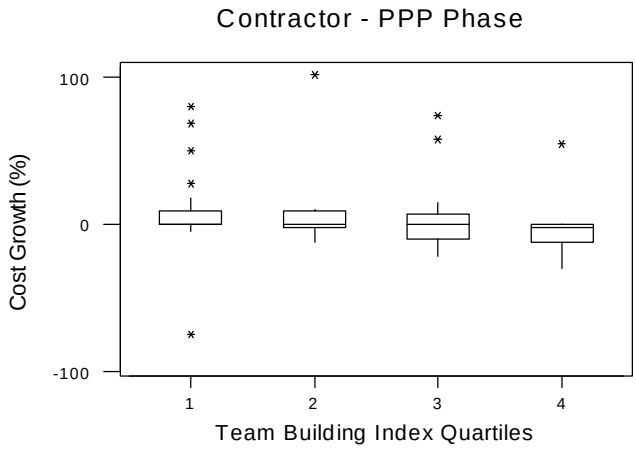

Figure 8.3.1-(2): Contractors' quartile distribution for pre-project planning cost growth.

box-plots was necessary because only three quarters appeared in the first quartile. A similar situation was discovered with the quarter separation as was with the separation of quartiles. Separation of each of the quartiles into four equal quarters was distorted because of similar cost growth values. It was found that the cost growth value of 0% was common and the separation inconsistencies occurred at this value. Distribution divisions were adjusted to avoid separation of identical cost growth values, just like the quartile divisions were adjusted. The medians for

the first three quartiles decrease slightly but appear to be equal and the fourth quartile is obviously lower than the third. Not only are the distributions ordered correctly, but the quarter distributions below the median are also supportive of the positive relationship. Proceeding from left to right, the third and fourth quarters are distributed over a wider range, and hence a lower cost growth range.

8.3.2 Contractors' Design Phase Cost Growth

There were 131 contractors who responded with cost growth information for the design phase. The equation and statistics of the best-fit line are shown in Figure 8.3.2-(1). The slope of the line is notably high and is supported with a substantial number of respondents. A possible reduction from 31.4% to 9.9% is associated with an increase from 0 to 10 for the team building index. Although the best-fit line can only be used as an indicator because of the low r-squared value, it does suggest that the team building process is extremely influential in reducing the design phase cost growth. The red lines were manually drawn on the figure indicate the decrease in variability of the cost growth associated with an increased team building index.

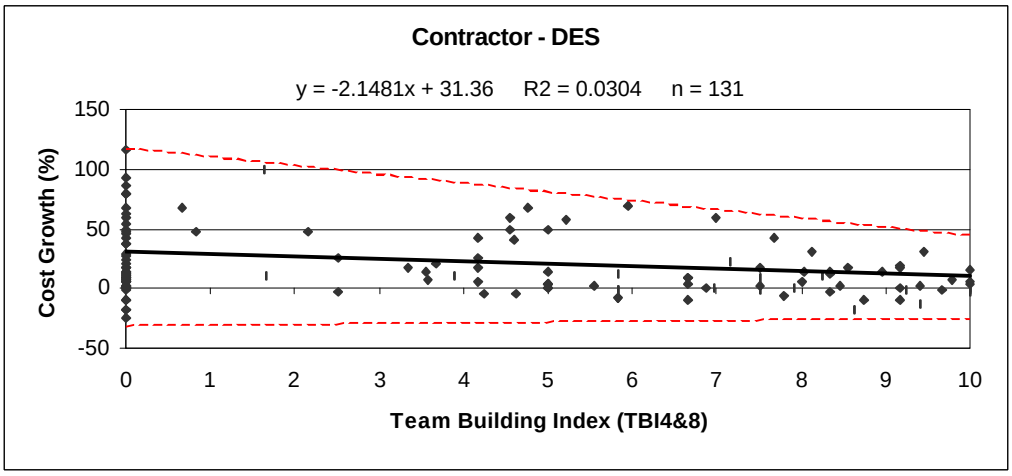

Figure 8.3.2-(1): Contractors' team building index versus design cost growth.

Results of the Jonckheere-Terpstra Test, see Table 8.3-(1), also support the indications of the scatter plot for the contractors' design phase cost growth. According to the whisker box-plots

of Figure 8.3.2-(2), it appears that the quartiles are not ordered, but the Jonckheere-Terpstra Test actually compares the entire quartile distributions approximated from rankings. Another factor in the discrepancy is that the distribution for the second quartile is easily skewed because it represents less data points. The first quartile incorporates the missing points of the second quartile through the adjustments previously discussed. If the asterisks representing extreme values are eliminated for each quartile then the variability of the distributions also decrease moving from the first to the forth quartile. The data for the contractors' design phase cost growth displays a significant positive influence of team building on reducing cost growth.

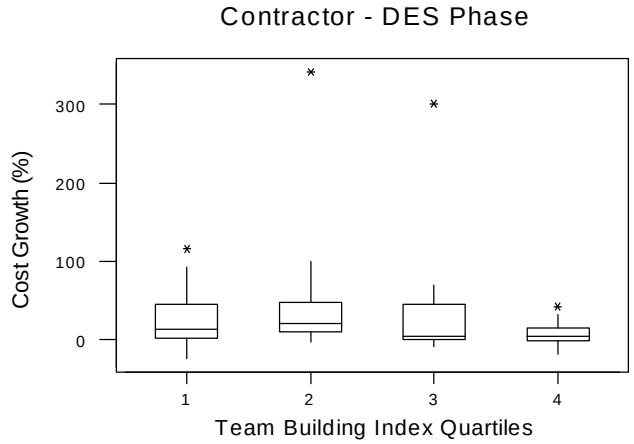

Figure 8.3.2-(2): Contractors' quartile distribution for design cost growth.

8.3.3 Contractors' Procurement Phase Cost Growth

Illustrated in Figure 8.3.3-(1) is the scatter plot of team building index versus procurement phase cost growth for the120 contractors. The best-fit line represents a possible reduction in cost growth from 15.7% to 3.5% by increasing the team building index from 0 to 10. Again the low r-squared value removes the statistical significance from the representation of the data with a best-fit line. As with most of the scatter plots having a significantly high number of respondents, the distribution of points for the 0 index is considerably different then the distribution of points for the 10 index. The values for the 0 index range from -33% to 101% while the range on the 10 index is -22% to 1.38%.

Results of the Jonckheere-Terpstra Test, shown in Table 8.3-(1), reveal that the quartiles are not ordered as suspected. A magnified visual observation of the whisker box-plot in Figure 8.3.3-(2) reveals that the medians of the distributions for the first three quartiles are approximately equal with the fourth being slightly lower. Excluding the extreme values and the skewed distribution of the second quartile, the variability for the quartiles also decreases moving from left to right through the quartiles.

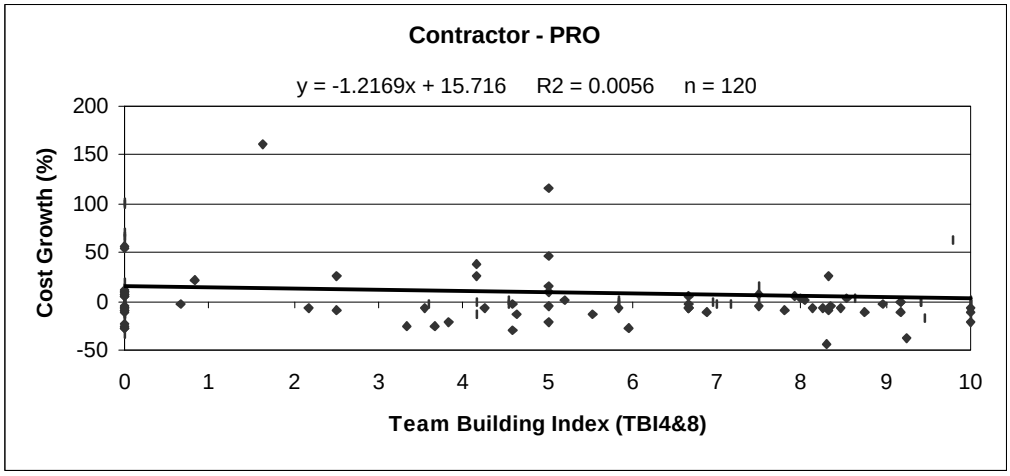

Figure 8.3.3-(1): Contractors' team building index versus procurement cost growth.

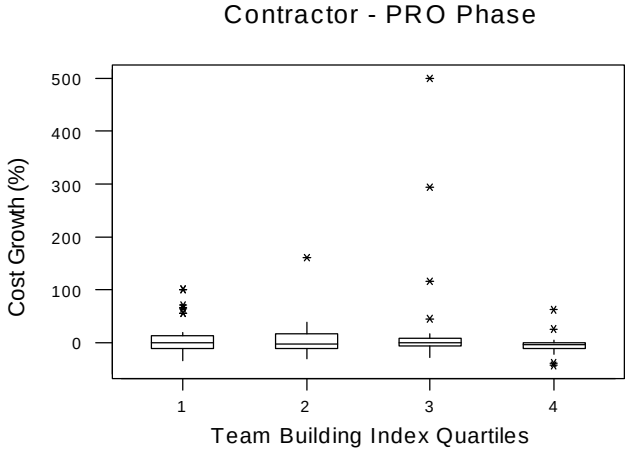

Figure 8.3.3-(2): Contractors' quartile distribution for procurement cost growth.

8.3.4 Contractors' Demolition Phase Cost Growth

Statistical results were not calculated for the demolition phase because of the low number of respondents. The scatter plot for the 18 contractors' who responded is not shown because of confidentiality issues and statistical insignificance. Likewise the whisker box-plots are not shown because their meaning diminishes when there are not enough points represented within each of the quartile quarters. Version 1.0 of the questionnaire did not include questions regarding the costs related to the demolition phase.

8.3.5 Contractors' Construction Phase Cost Growth

Intuition would suggest that the majority of the cost associated with construction projects would be incurred during the construction phase. A quick analysis of the raw data also supports this concept with the average total cost of the projects around $58.9 million and the average cost of the construction phase around $36.3 million. Because of the high cost of this phase, even a small percent improvement would be significant.

There were 166 contractors who reported cost figures for the construction phase. The scatter plot is shown in Figure 8.3.5-(1) along with the equation and statistics of the best-fit line. A somewhat lower slope occurs as compared to the other phases of the project. The best-fit line suggests that by increasing the team building index from 0 to 10 the cost growth reduces from 19.7% to 13.6%. An average construction budget of $33.4 million relates to a possible reduction of $2.0 million. The low r-squared value indicates that the best-fit line is not a statistically sound representation of the data.

The result of the Jonckheere-Terpstra Test shown in Table 8.3-(1) reveals that the quartiles are not ordered to support the positive relationship. Likewise, the whisker box-plots of Figure 8.3.5-(2) do not support the hypothesis of the team building process reducing cost growth.

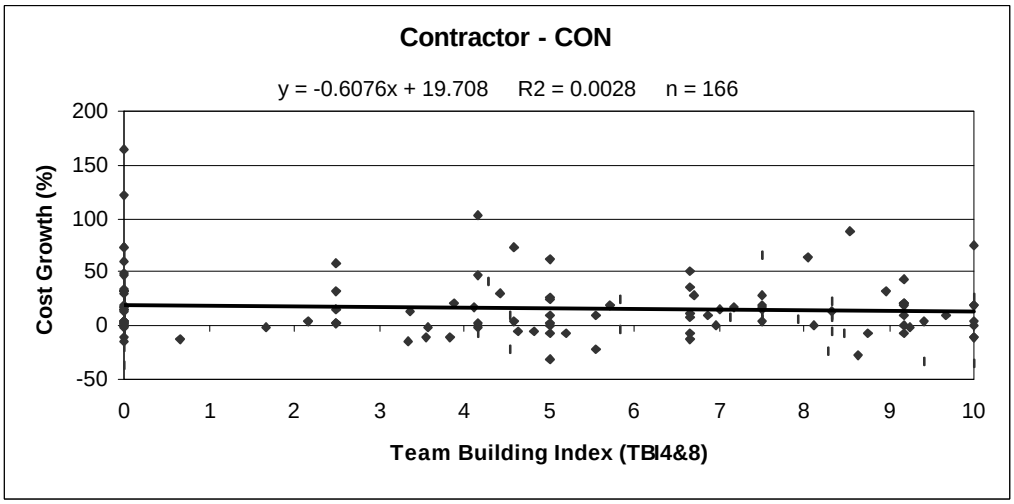

Figure 8.3.5-(1): Contractors' team building index versus construction cost growth.

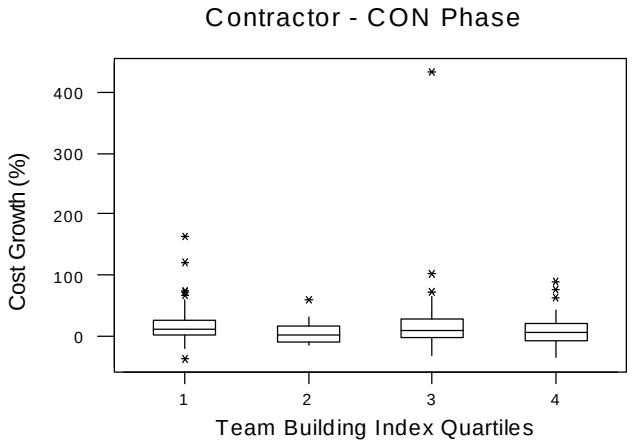

Figure 8.3.5-(2): Contractors' quartile distribution for construction cost growth.

8.3.6 Contractors' Start-Up Phase Cost Growth

Caution must be used when examining the scatter plot of the team building index versus start-up phase cost growth because only 36 contractors are represented. The equation and statistics of the best-fit line are shown in Figure 8.3.6-(1). It is difficult to accept that it would be possible to reduce the cost growth from 64.1% to -7.7% by increasing the team building index from 0 to 10. Figure 8.3-(1) also indicates a strong relationship between using a team building

process and reducing the average cost growth for the phase. These charts can only be used as indicators that team building probably has a very influential effect on the start-up cost growth.

Unsurprisingly the Jonckheere-Terpstra Test reveals that the quartiles are not ordered as suspected. The whisker box-plots of Figure 8.3.6-(2) are virtually meaningless because at best the quartile quarters are only representing two of the 36 points.

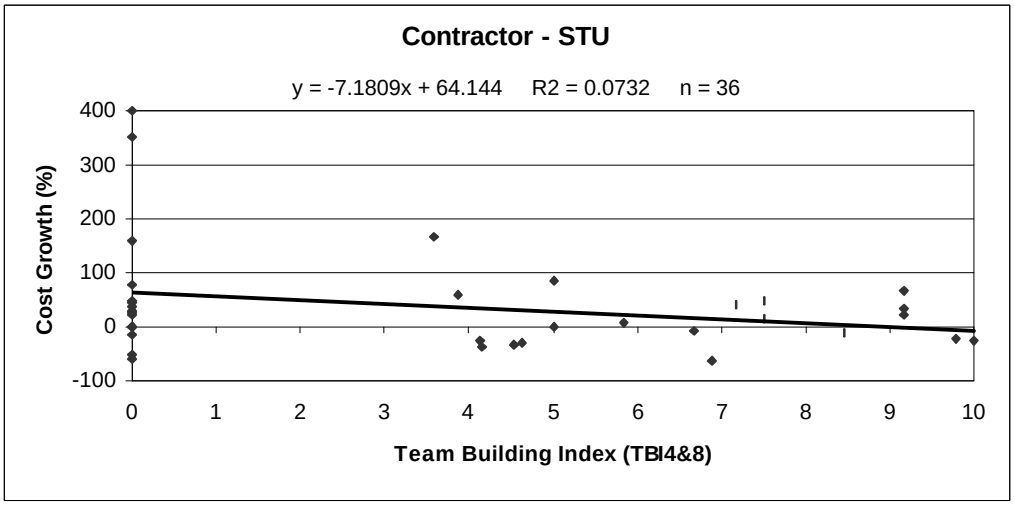

Figure 8.3.6-(1): Contractors' team building index versus start-up cost growth.

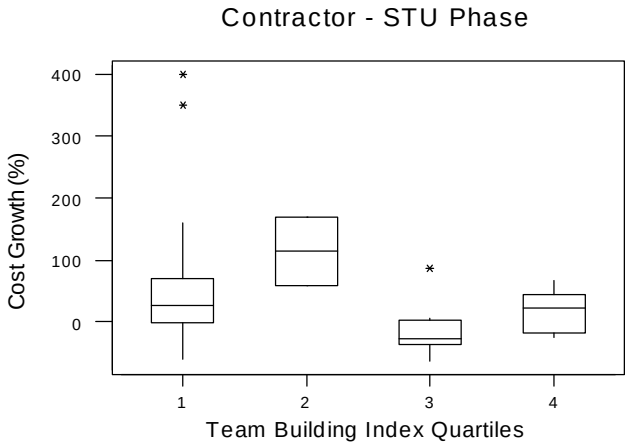

Figure 8.3.6-(2): Contractors' quartile distribution for start-up cost growth.

8.3.7 Check of Contractors' Total Cost Growth

A check was performed to ensure that the sum of the cost growth for each of the phases resembled the total cost growth for the project. Figure 8.3.7-(1) represents the scatter plot of the team building index verses the sum of the cost growth for all of the phases. The plot was compared to Figure 8.2-(2) which represented the total cost growth. Only slight difference occurred and they may be a result of some respondents not completing the phase cost growth information.

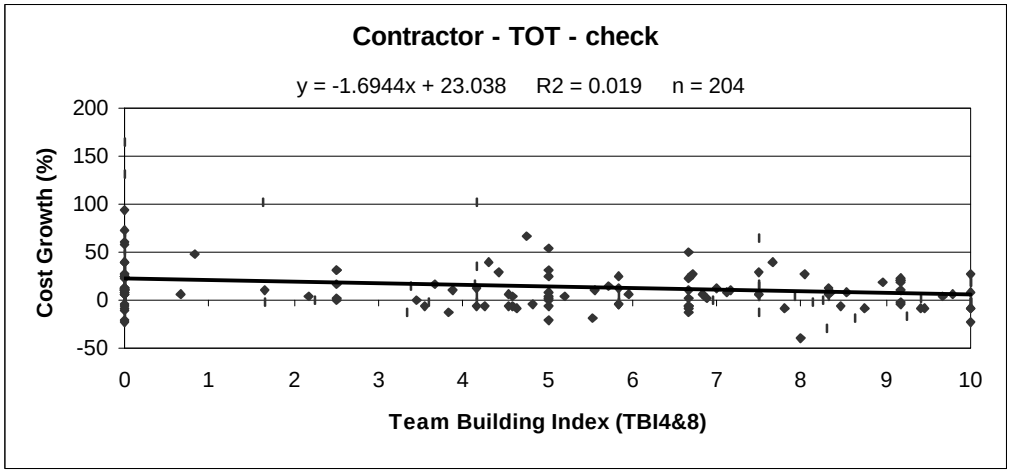

Figure 8.3.7-(1): Contractors' team building index versus total cost growth (check).

8.4 Owners' Cost Growth by Phases

With respect to average cost growth, the separation of the owners' projects into phases produced much better results than the contractors' phase separation. As shown in Figure 8.4-(1), all phases except design, demolition, and start-up had a lower average cost growth for those respondents who used a team building process. Although the averages can only be used as indicators, this suggests that the effect of team building may be very influential on the owners' projects. Further investigation is warranted to confirm or refute the suggestion.

The number of responses for the owners' six phases is higher than the number of contractors' responses because the owner is generally involved in more phases. Comparison of the medians, shown in Table 8.4-(1), reveals less dramatic results from implementing the team

building process. The values for the Wilcoxon Test are above the required p-value of 0.05 and therefore do not add any statistical significance to the differences between medians of the yes-and-no groups.

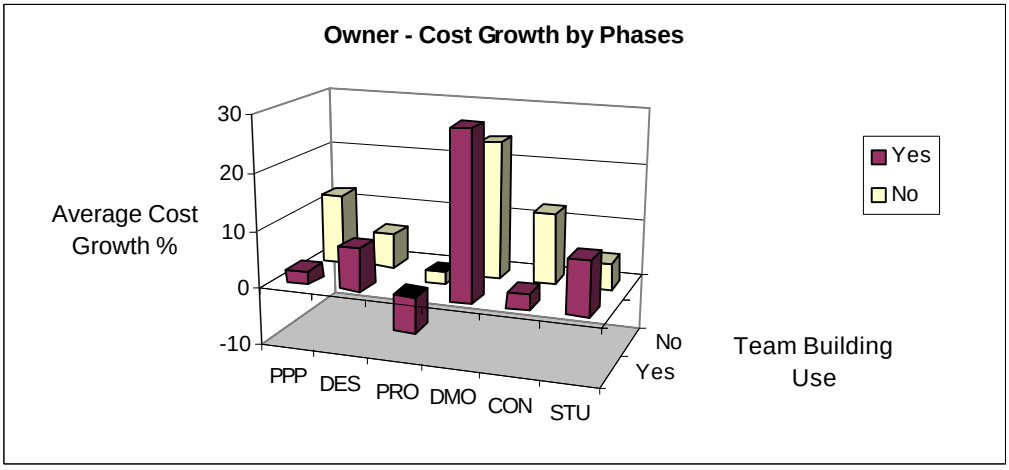

Figure 8.4-(1): Effect of team building on owners' cost growth by phases.

Table 8.4-(1): Owner statistics for phase cost growth.

Owner:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Pre-Project Planning	118	0	87	31	0	0	0.09742	0.0138
Design	163	0	117	46	1.363	-0.4125	0.21263	0.7393
Procurement	138	8.65E-07	100	38	-7.7673	-4.5634	0.22508	0.4402
Demolition	40	4.24E-07	32	8	1.3335	2.837	0.95951	0.3677
Construction	166	0	117	49	1.89	3.111	0.18314	0.1077
Start-Up	82	0	63	19	0	0	0.67081	0.622

8.4.1 Owners' Pre-Project Planning Phase Cost Growth

The influence of a team building process was found to be less dramatic for the owners' total cost growth as compared to the contractors' total cost growth; therefore, it would be expected that the phases would reflect a similar effect. Figure 8.4.1-(1) illustrates the team building index versus the owners' cost growth for the pre-project planning phase. The slope of the best-fit line is somewhat steep as compared to the slope for the owners' total cost growth (i.e., -1.4059 vs. -0.4311).

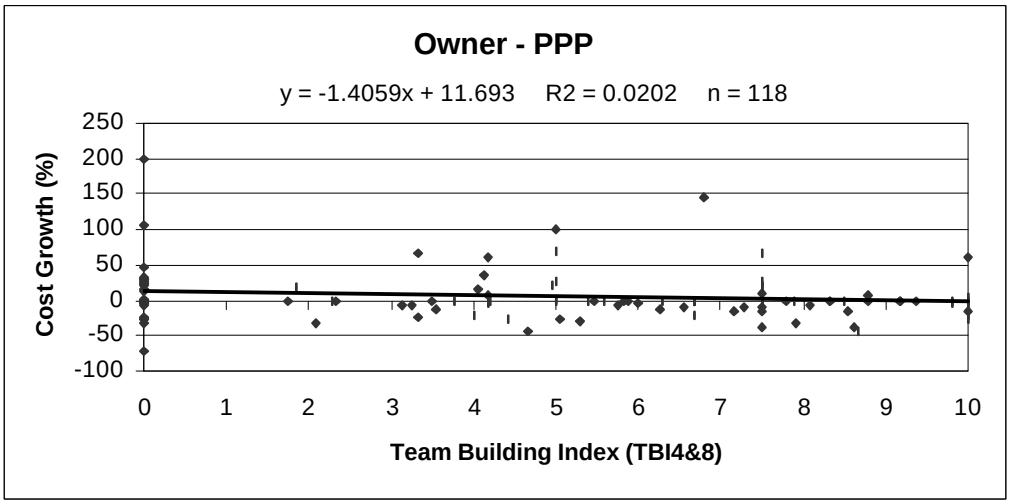

Figure 8.4.1-(1): Owners' team building index versus pre-project planning cost growth.

The pre-project planning phase is the only owners' phase to pass the Jonckheere-Terpstra Test. Medians decrease from left to right; therefore, the quartiles are ordered in a decreasing fashion. Figure 8.4.1-(2) contains the whisker box-plots, which support the result of the Jonckheere-Terpstra Test. It appears that the medians and corresponding distributions are positioned lower for each increasing quartile. Also, the variability has a general shrinking trend across the four quartiles.

Because the pre-project planning phase is the only owners' phase that appears to have ordered quartiles, an investigation was prompted as to whether or not the respondents who used team building in the pre-project planning phase had better performance for the remaining phases than those who did not. The use of team building early in the project may be key to the overall effectiveness of the process.

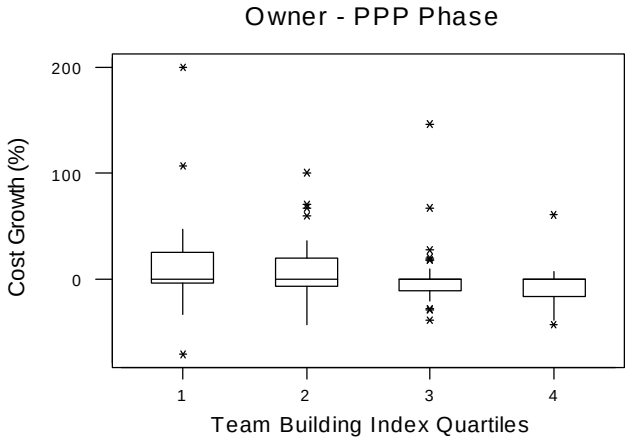

Figure 8.4.1-(2): Owners' quartile distribution for pre-project planning cost growth.

8.4.2 Owners' Design Phase Cost Growth

The scatter plot of the team building index versus the design cost growth for the 163 owners is illustrated in Figure 8.4.2-(1) along with the equation and statistics of the best-fit line. The slope is relatively flat but does yield a slight reduction from 7.5% to 7.1% with an increase from 0 to 10 in the team building index. Again, the r-squared value removes any statistical soundness for the best-fit line's representation of the data. It is worth noting the difference in the distribution of points on the 0 index as compared to the 10 index. The range on the 0 index is from -61.0% to 300.0% with only one point above 100%, while the 10 index only ranges from -27.1% to 60.1%. The distribution of the points is tighter and located lower; indicating that in general the 10 index has less variability and lower cost growth.

The only support that the positive relationship exists in the owners' design phase comes from the comparison of the averages and the scatter plot. Comparison of the medians, statistical tests, and whisker box-plots do not support the hypothesis that increased team building reduces cost growth. Figure 8.4.2-(2) does show that the likeliness of having high extreme data points decreases across the quartiles.

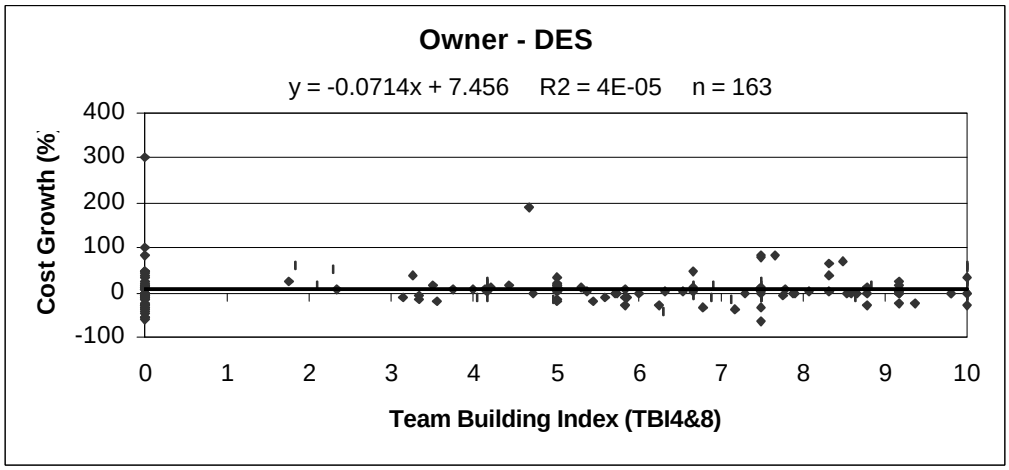

Figure 8.4.2-(1): Owners' team building index versus design cost growth.

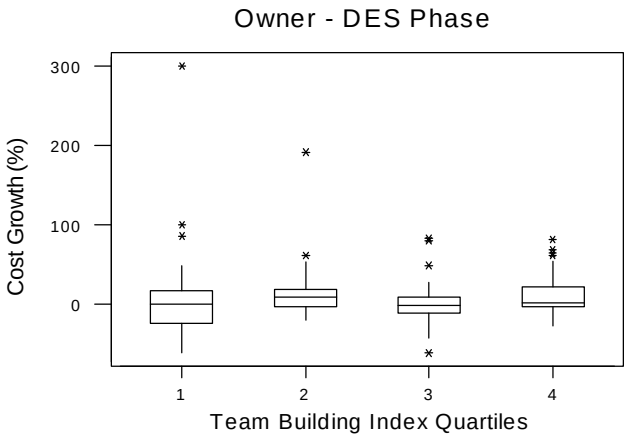

Figure 8.4.2-(2): Owners' quartile distribution for design cost growth.

8.4.3 Owners' Procurement Phase Cost Growth

Examination of Figure 8.4-(1) reveals that average cost growth for the 138 owner projects was substantially low for the procurement phase. As can be seen in Figure 8.4.3-(1), the best-fit line for the scatter plot intersects the y-axis below zero. Little room for improvement exists, but the line represents a reduction from -3.6% to -6.8% with an increase from 0 to 10 in the team building index.

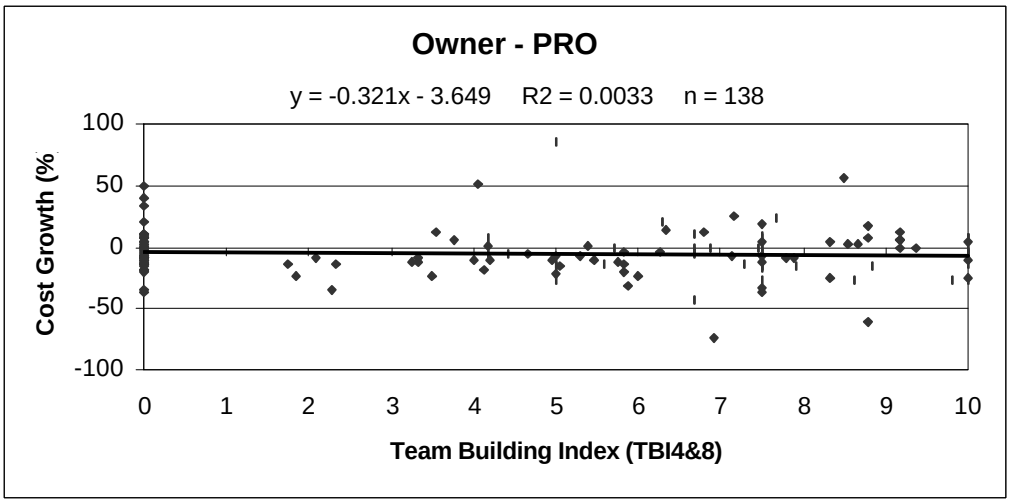

Figure 8.4.3-(1): Owners' team building index versus procurement cost growth.

Results of the Jonckheere-Terpstra Test reveal that the quartiles are not ordered correctly. This is supported by the whisker box-plots of Figure 8.4.3-(2), which also fails to indicate a decrease in variability associated with increased team building.

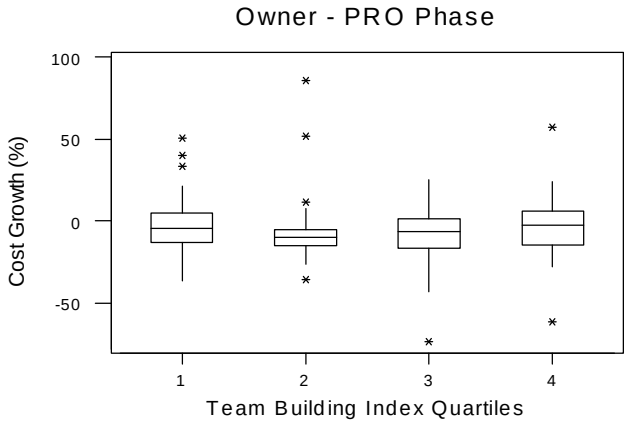

Figure 8.4.3-(2): Owners' quartile distribution for procurement cost growth.

8.4.4 Owners' Demolition Phase Cost Growth

The scatter plot for the owners' demolition phase cost growth is shown in Figure 8.4.4-(1) along with the equation and statistics of the best-fit line. Only 40 responses were obtained

because the demolition phase was not included in the Version 1.0 Questionnaire. The slope for the demolition phase is steep for the owner class but not substantiated with a large sample.

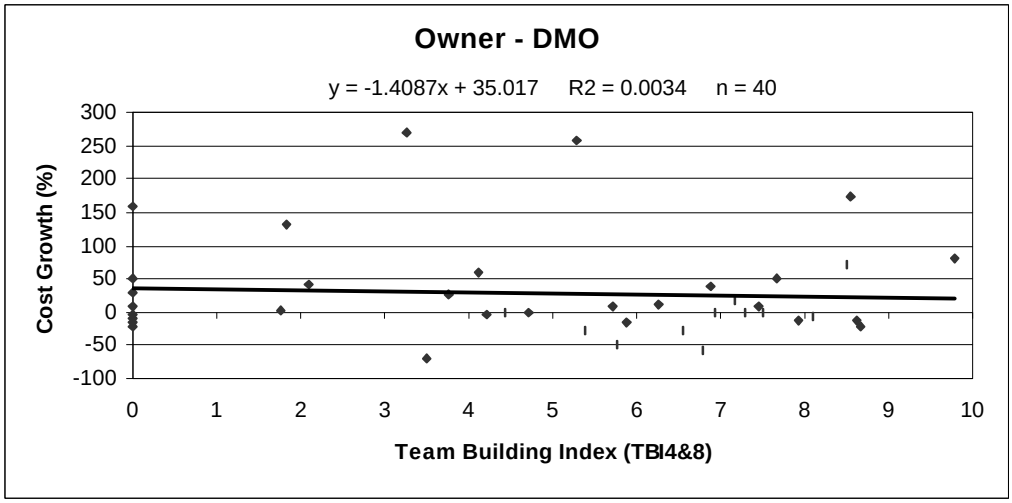

Figure 8.4.4-(1): Owners' team building index versus demolition cost growth.

Neither the Jonckheere-Terpstra Test result in Table 8.4-(1) nor the whisker box-plots of Figure 8.4.4-(2) indicate that a positive relationship exists for the demolition phase.

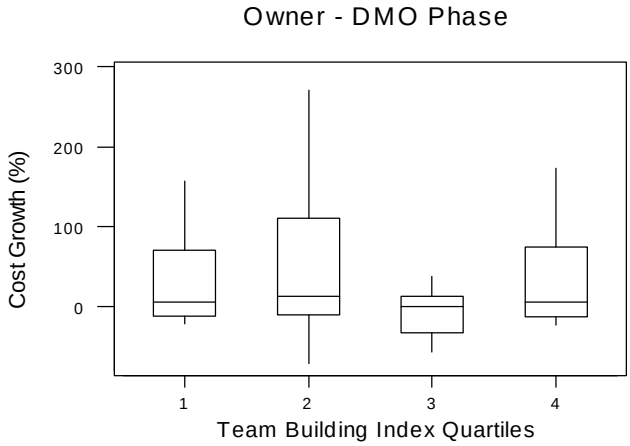

Figure 8.4.4-(2): Owners' quartile distribution for demolition cost growth.

8.4.5 Owners' Construction Phase Cost Growth

The owners' construction phase actual cost averages about 53.1% of the total cost for the project. The scatter plot for the owners' team building index versus cost growth is shown in Figure 8.4.5-(1) along with the equation and statistics for the best-fit line. As compared to the other phases and total cost growth, a steeper slope resulted for the 166 owner respondents. According to the best-fit line, a reduction from 12.1% to -1.7% is possible with an increase from 0 to 10 in the team building index. When applied to the owners' average budgeted cost for construction of $25.4 million, this amounts to a reduction in cost growth of about $3.5 million.

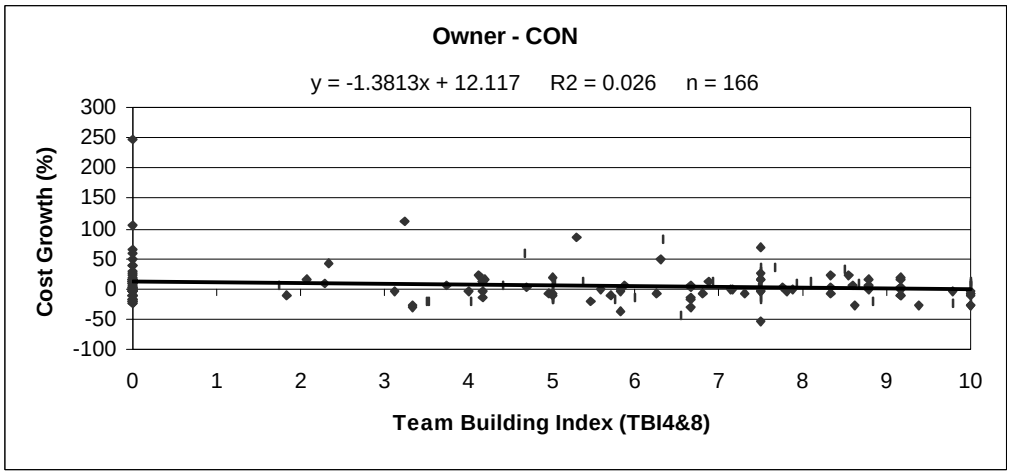

Figure 8.4.5-(1): Owners' team building index versus construction cost growth.

Results of the Jonckheere-Terpstra Test fail to support the hypothesis for the ordered quartiles. The location of the medians and corresponding distributions are not decreasing with increased team building use. The whisker box-plots of Figure 8.4.5-(2) do hint towards a positive relationship. Medians for the first three quartiles are slightly decreasing with increasing use of team building. The median for the fourth quartile is somewhat higher than the third, but compression of the variability offsets this divergence. The presence of the extreme points also decreases with the increased use of the team building process. Although the statistical tests are not supportive, the comparison of the means and medians, scatter plot, and box-plots are all supportive of the existence of a positive relationship between the team building process and reduction of cost growth in the owners' construction phase.

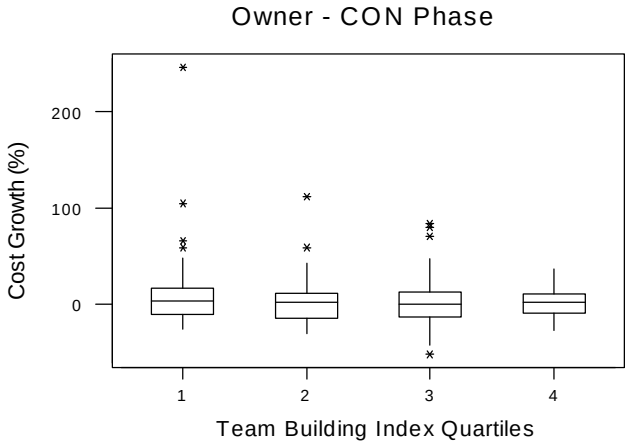

Figure 8.4.5-(2): Owners' quartile distribution for construction cost growth.

8.4.6 Owners' Start-Up Phase Cost Growth

The slope for the scatter plot of the owners' start-up phase, shown in Figure 8.4.6-(1), is less steep than the slope for the contractors' start-up phase (i.e., -0.1565 vs. -7.1809). The moderate slope produces a reduction from 9.2% to 7.6% with and increase from 0 to 10 in the team building index. One noticeable feature of this plot is the excessive number of extreme data points for the upper half of the team building index. As would be suspected with the abundance of outliers, the r-squared value is extremely poor.

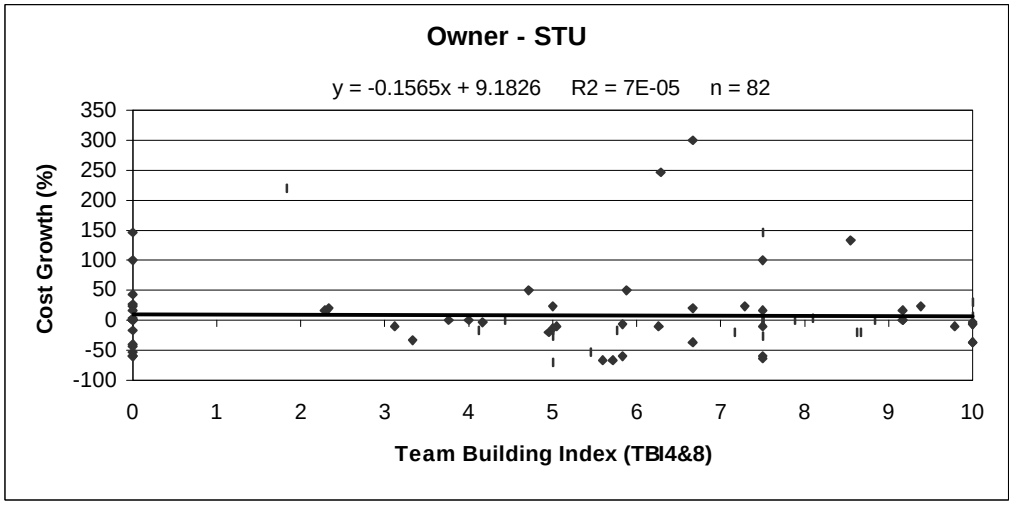

Figure 8.4.6-(1): Owners' team building index versus start-up cost growth.

Statistical support for the positive relationship in the start-up phase is not provided by the Jonckheere-Terpstra Test of Table 8.4-(1) nor the whisker box-plots of Figure 8.4.6-(2). Likewise, comparison of the means and medians do not suggest that there is a positive influence of team building on reducing cost growth for this phase.

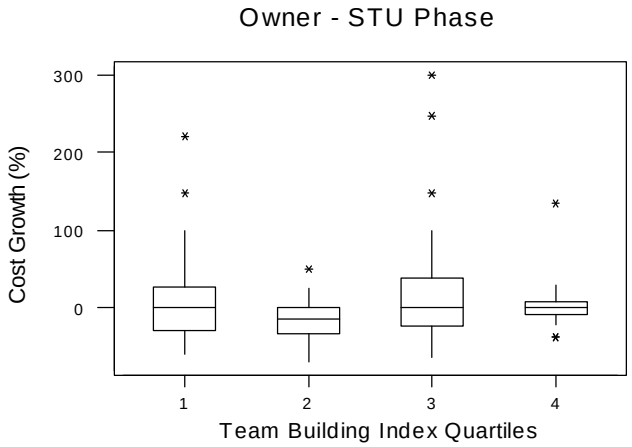

Figure 8.4.6-(2): Owners' quartile distribution for start-up cost growth.

8.5 Contractors' Cost Growth by Industry Group

Upon slicing the contractors by industry group, it was found that the majority of the contractors were classified as heavy industrial. As discussed in the Chapter 4 - The Database, the heavy industrial group makes up about 70% of the contractor class with the other three groups each containing about 10% of the respondents. It was decided to focus on the heavy industrial group and omit a complete analysis for the other three groups. The buildings and light industrial groups are shown colorless in Figure 8.5-(1) to warn of the low number of responses documented in Table 8.5-(1).

As shown in Figure 8.5-(1), the average cost growth for the heavy industrial group respondents who use a team building process is less than half of the average cost growth achieved by the respondents who did not use a team building process. The Wilcoxon Test results in Table 8.5-(1) indicate a statistically significant difference between the medians of the heavy

industrial group. The average cost growth for the infrastructure group is extremely skewed by the outliers.

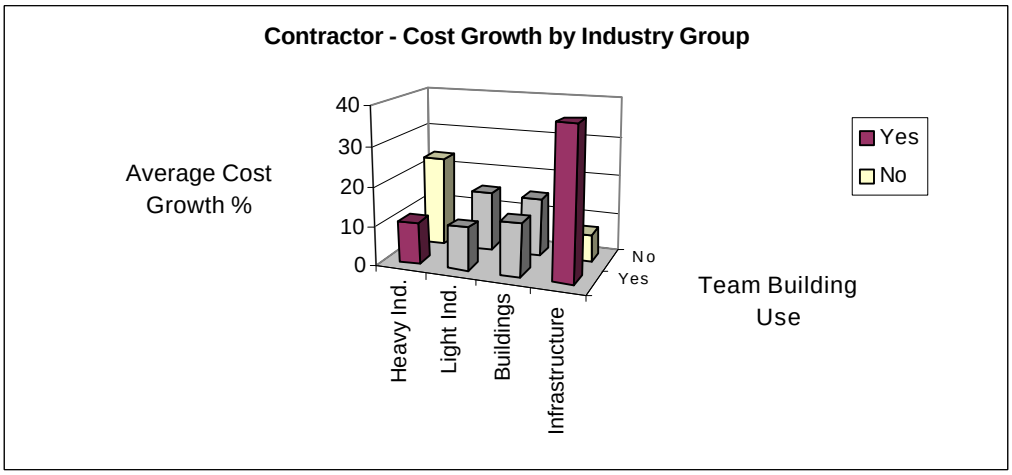

Figure 8.5-(1): Effect of team building on contractors' cost growth by industry group.

Table 8.5-(1): Contractor statistics for industry groups.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	144	0	92	52	3.452	11.579	0.00051	5E-06
Buildings (B)	18	.	.	.	.	.	.	.
Light Industrial (LI)	19	.	.	.	.	.	.	.
Infrastructure (I)	24	2.37E-10	16	8	18.723	6.819	0.04325	0.8778

8.5.1 Contractors' Cost Growth for Heavy Industrial Projects

The scatter plot of the team building index versus heavy industrial cost growth for the 144 contractors is shown in Figure 8.5.1-(1) along with the equation and statistics of the best-fit line. The slope of the line is steep as compared to the total cost growth for the contractor class and it is supported by a large number of data points. According to the best-fit line, a reduction from 26.2% to -1.1% is possible with an increase from 0 to 10 for the team building index. When applied to the contractors' average construction budget of $54.9 million for heavy industrial projects, it relates to a possible reduction in cost growth around $15 million. The low r-squared value indicates that the best-fit line is not a statistically sound representation of the data.

Red lines were manually drawn on the figure to illustrate the convergence of points towards the best-fit line. The trapezoidal shape represents the decreased variability associated with the increased use of team building. It should be noted that deviation above the line is associated with a higher than normal cost growth and is much more detrimental than deviation below the line that represents less than normal cost growth. The majority of the variability for the lower team building indexes is positioned above the line, while the majority of the variability for the higher indexes is below the line. Another important observation can be made about the number of data points for the 0 index as compared to the 10 index. It seems as if it is much more common to not use any team building as compared to using an extensive amount.

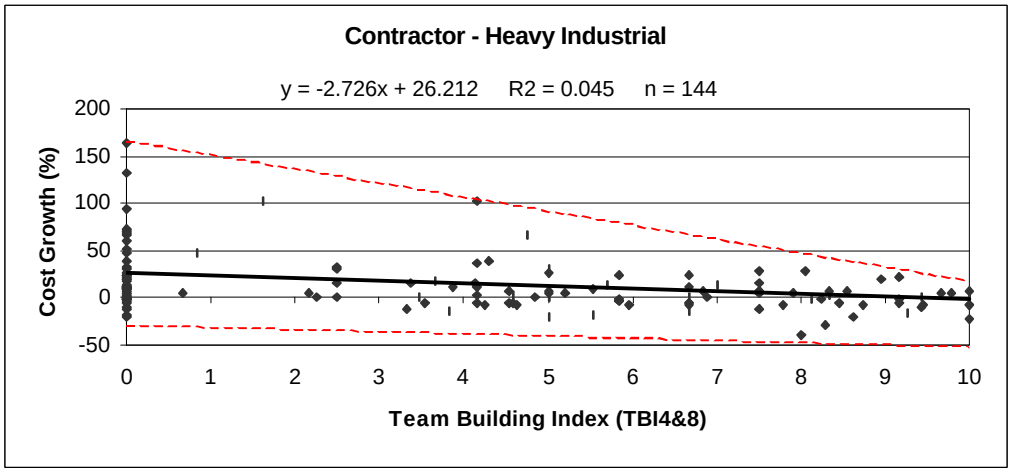

Figure 8.5.1-(1): Contractors' team building index versus cost growth for heavy industrial.

The Jonckheere-Terpstra Test of Table 8.5-(1) overwhelmingly indicates that the quartiles of the heavy industrial group are ordered to support the positive relationship. This statistical result is supported by the illustration of the whisker box-plots in Figure 8.5.1-(2). It can be seen that the distributions are ranked properly and the variability is decreasing with increase use of team building.

All aspects of the data analysis for the contractors' heavy industrial group indicate that increased use of team building has a positive effect on cost growth. The average comparisons

reveal over a 50% reduction in cost growth for those who use the process as compared to those who do not. Wilcoxon Test results support the average comparison through a statistical analysis focused on the medians. The scatter plot reveals a dramatic slope and reduced variability in the data resulting from increased use of team building. Statistical results of the Jonckheere-Terpstra Test show that the quartiles are ordered and the whisker box-plots support the finding.

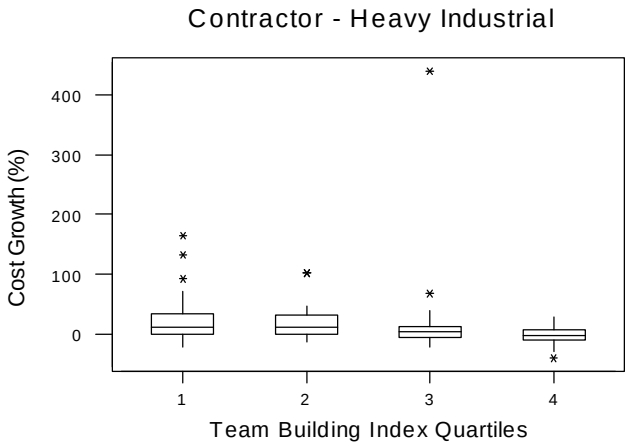

Figure 8.5.1-(2): Contractors' quartile distribution for heavy industrial cost growth.

8.6 Owners' Cost Growth by Industry Group

Slicing of the owner class by industry group resulted in a better distribution of projects among the groups as compared to the contractor class. The only exception was the infrastructure group, shown colorless in Figure 8.6-(1), which only had 10 respondents. It can be seen that the other three groups have decisive differences between the average cost growths of the groups implementing and those not implementing a team building process. Although the Wilcoxon Test results of Table 8.6-(1) do not add statistical significance, examination of the medians does support the existence of the positive relationship for all three groups.

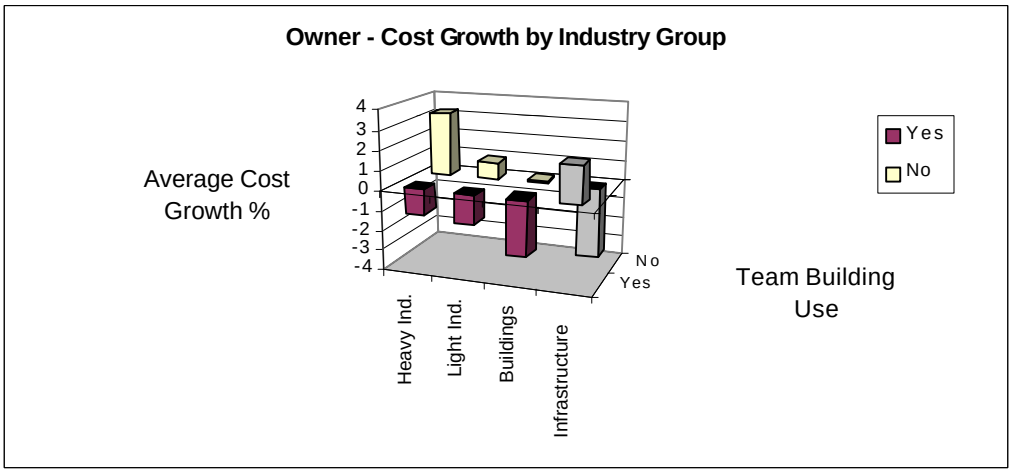

Figure 8.6-(1): Effect of team building on owners' cost growth by industry group.

Table 8.6-(1): Owner statistics for industry groups.

Owner:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	103	0.131944	79	23	-0.0167	3.588	0.13017	0.0574
Buildings (B)	40	0.06542	30	9	-2.713	-0.8646	0.70146	0.9059
Light Industrial (LI)	29	0.00519	18	11	-0.7656	-0.3597	0.75302	0.2647

8.6.1 Owners' Cost Growth for Heavy Industrial Projects

The scatter plot for the heavy industrial group of the owner class is shown in Figure 8.6.1-(1) along with the equation and statistics for the best-fit line representing the 103 respondents. A much flatter line exists for the owners' heavy industrial group than did for the contractors' heavy industrial group (i.e., -0.7502 vs. -2.7260). The best-fit line indicates that it is possible to reduce the cost growth from 3.8% to -3.7% by increasing the team building index from 0 to 10. When applied to the owners' average budget of $46.7 million, a possible reduction in cost growth of $3.5 million results.

The result of the Jonckheere-Terpstra Test shown in Table 8.6-(1) for the owners' heavy industrial group indicates that the quartiles are not ordered correctly. Figure 8.6.1-(2) illustrates the whisker box-plots that support the finding of the statistical test. In this case the variability does not appear to be influenced by the team building process.

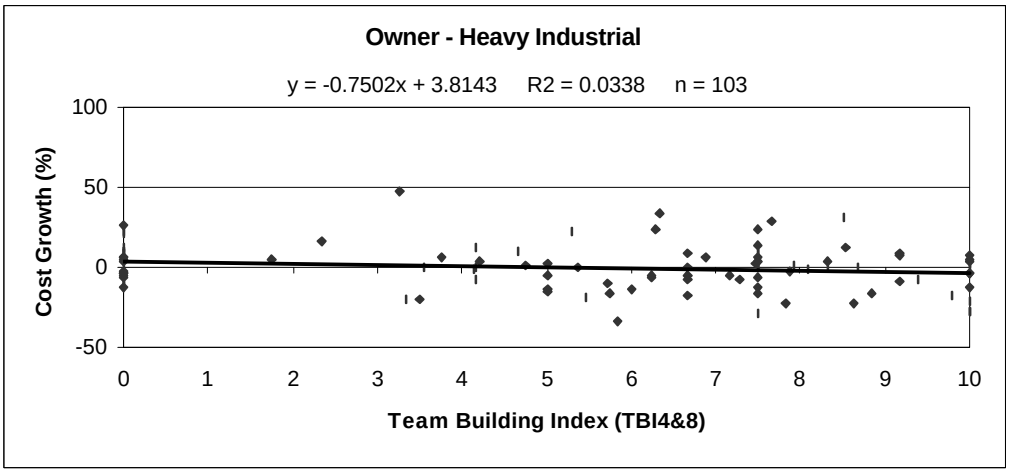

Figure 8.6.1-(1): Owners' team building index versus cost growth for heavy industrial.

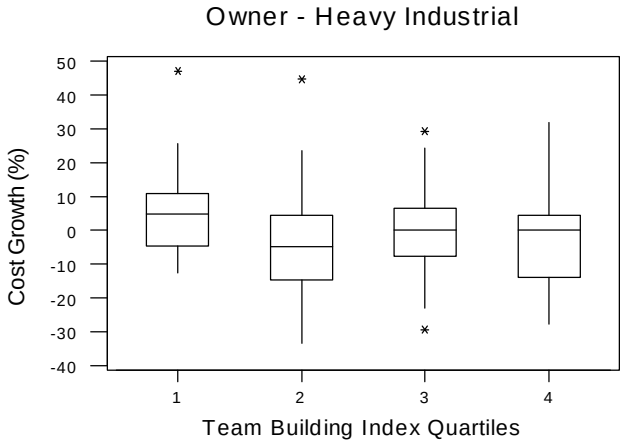

Figure 8.6.1-(2): Owners' quartile distribution for heavy industrial cost growth.

8.6.2 Owners' Cost Growth for Buildings Projects

The scatter plot of the 40 owner respondents for the buildings group is shown in Figure 8.6.2-(1) along with the equation and statistics of the best-fit line. The y-intercept is below 0 and the slope is moderate.

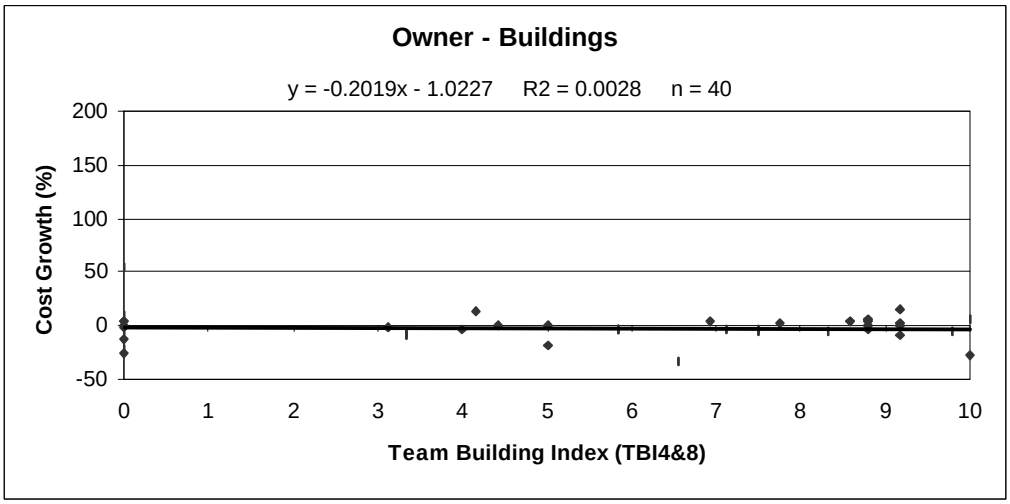

Figure 8.6.2-(1): Owners' team building index versus cost growth for buildings.

The results of the Jonckheere-Terpstra Test and the whisker box-plots, shown in Figure 8.6.2-(2), both concur that the quartiles are not ordered as suspected. The variability does not appear to be decreasing with increased use of team building.

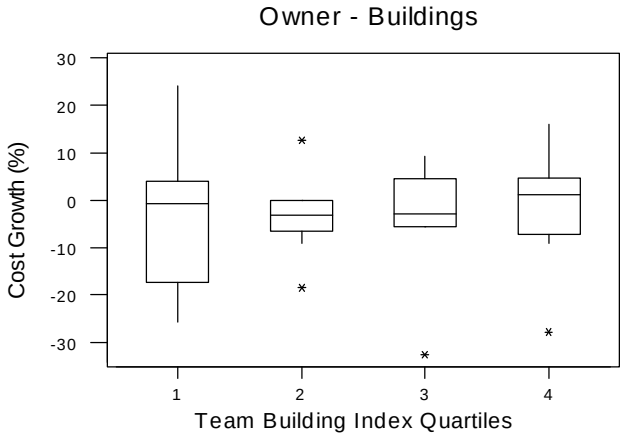

Figure 8.6.2-(2): Owners' quartile distribution for buildings cost growth.

8.6.3 Owners' Cost Growth for Light Industrial Projects

Of the 29 owner respondents in the light industrial group, none of them received a team building index greater than 8. This may indicate that the members of the group are not prone to

extensively use the team building process. Figure 8.6.3-(1) illustrates the scatter plot for the light industrial group along with the equation and statistics for the best-fit line.

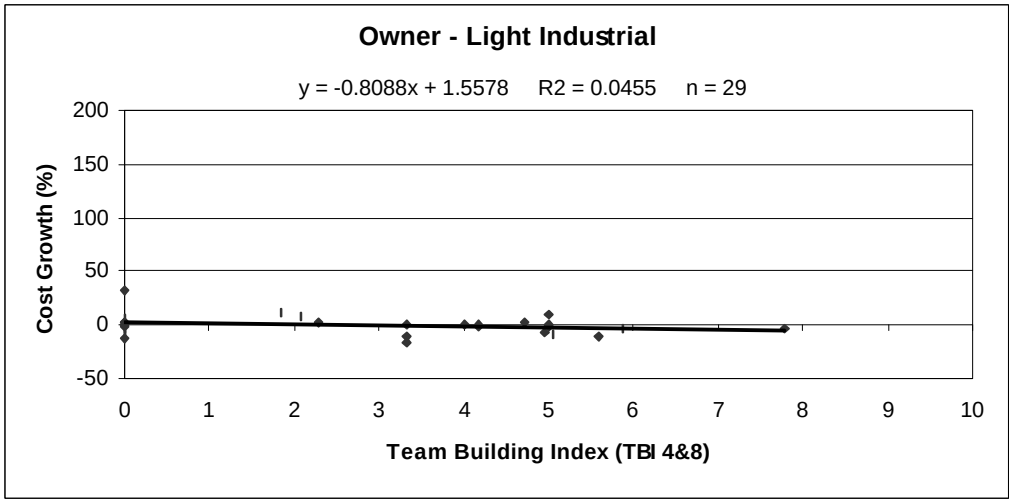

Figure 8.6.3-(1): Owners' team building index versus cost growth for light industrial.

The results of the Jonckheere-Terpstra Test and the whisker box-plots, shown in Figure 8.6.3-(2), both indicate that the quartiles are not ordered to support the positive relationship. The variability appears to be decreasing except for the second quartile, which is skewed because of the adjustments made to the quartile borders.

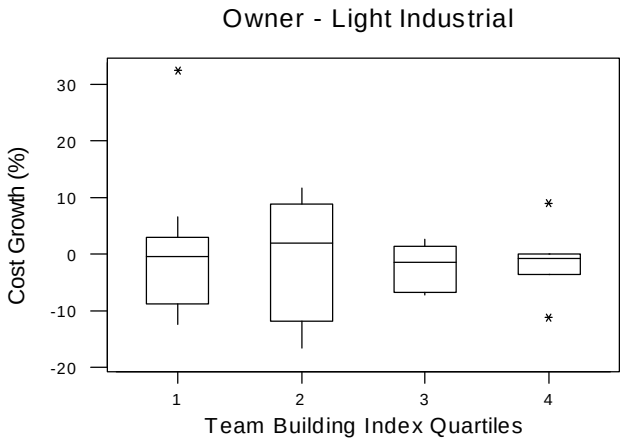

Figure 8.6.3-(2): Owners' quartile distribution for light industrial cost growth.

8.7 Contractor's Cost Growth by Project Nature

Slicing of the contractors' cost growth by project nature resulted in three groups with relatively the same number of respondents. The effects of the team building process on the average cost growth for these groups are shown in Figure 8.7-(1). Average cost growth for the grass roots projects is cut in half for those who used a team building process. A reduction of two thirds occurs for the addition projects implementing the team building process. Modernization projects appear to be influenced negatively by the team building process.

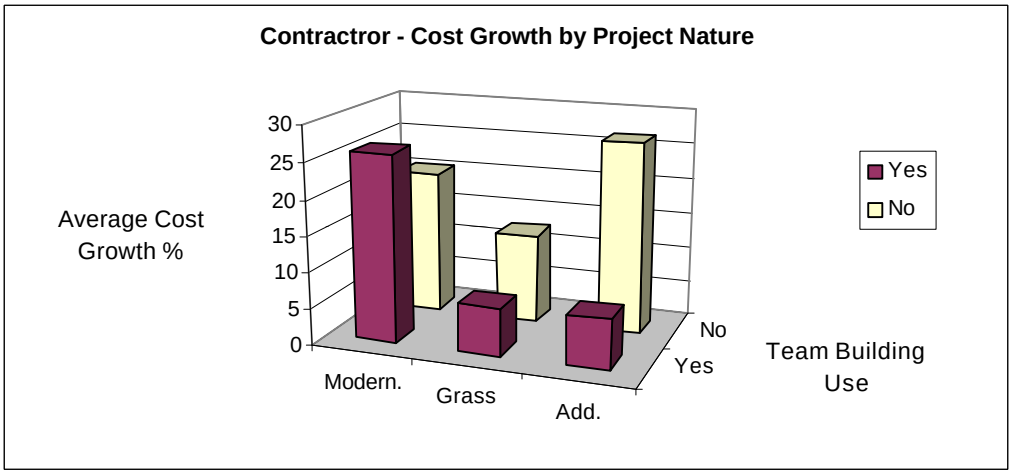

Figure 8.7-(1): Effect of team building on contractors' cost growth by project nature.

Comparison of the medians shown in Table 8.7-(1) indicates that a positive relationship exists between team building and cost growth reduction for all three project types. According to the Wilcoxon Test, a statistically significant difference does not exist for the modernization projects. However, a significant difference does not exist for the addition and grass roots projects. Both the three-dimensional bar chart and the statistical test demonstrate a positive relationship between the use of team building and reduction of cost growth for the grass roots and modernization projects.

Table 8.7-(1): Contractor statistics for project nature cost growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	52	1.67E-16	27	25	7.816	14.544	0.59533	0.2922
Addition (A)	71	8.71E-13	45	26	4.8955	11.0365	0.02913	0.0034
Grass Roots (GR)	82	0	53	29	4.31	10.619	0.04071	0.0030

8.7.1 Contractors' Cost Growth for Modernization Projects

The scatter plot for the 52 modernization projects is shown in Figure 8.7.1-(1) along with the equation and statistics of the best-fit line. The negative slope supports the median comparison on the previous table. A high percentage of the contractors in the modernization group do not use any degree of a team building process.

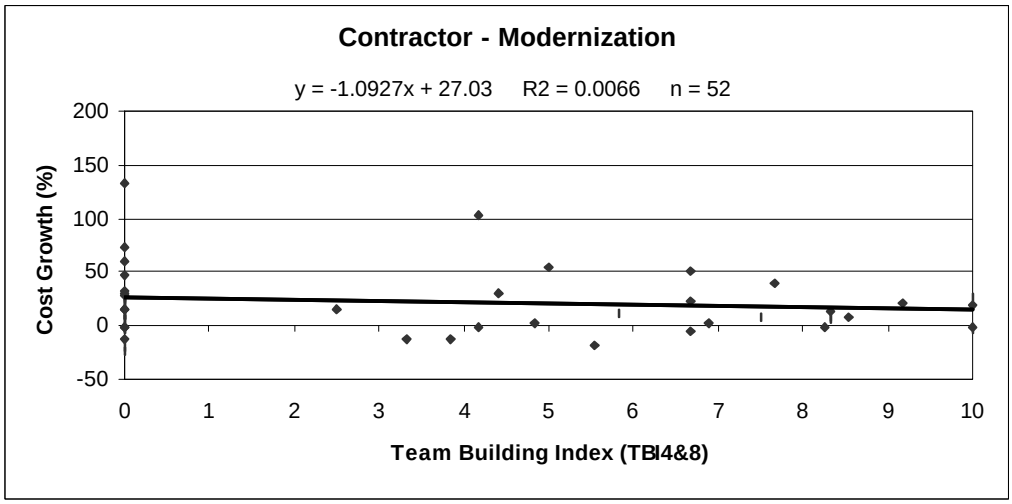

Figure 8.7.1-(1): Contractors' team building index versus cost growth for modernization projects.

Results of the Jonckheere-Terpstra Test reveal that the quartiles are not ordered correctly. The medians and corresponding distributions of the quartiles illustrated in the whisker box-plots of Figure 8.7.1-(2) appear to support the findings of the statistical test. The second quartile is totally consumed by the first quartile in the adjustment because over half of the respondents had a team building index of 0.

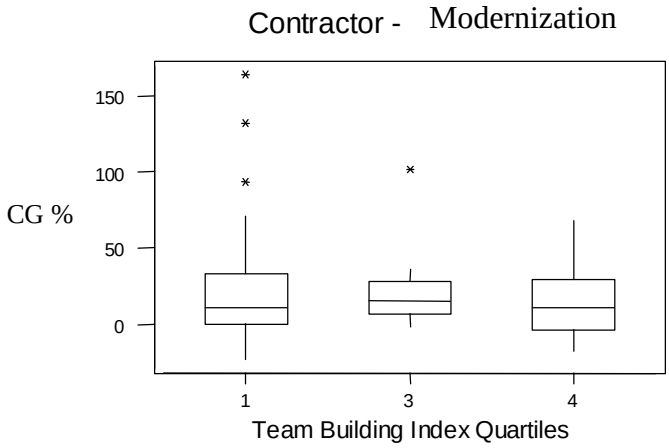

Figure 8.7.1-(2): Contractors' quartile distribution for modernization cost growth.

8.7.2 Contractors' Cost Growth for Grass Roots Projects

The contractors' scatter plot for the grass roots projects is illustrated in Figure 8.7.2-(1) along with the equation and statistics of the best-fit line. The rather steep slope supports the implications from the comparison of the means and medians.

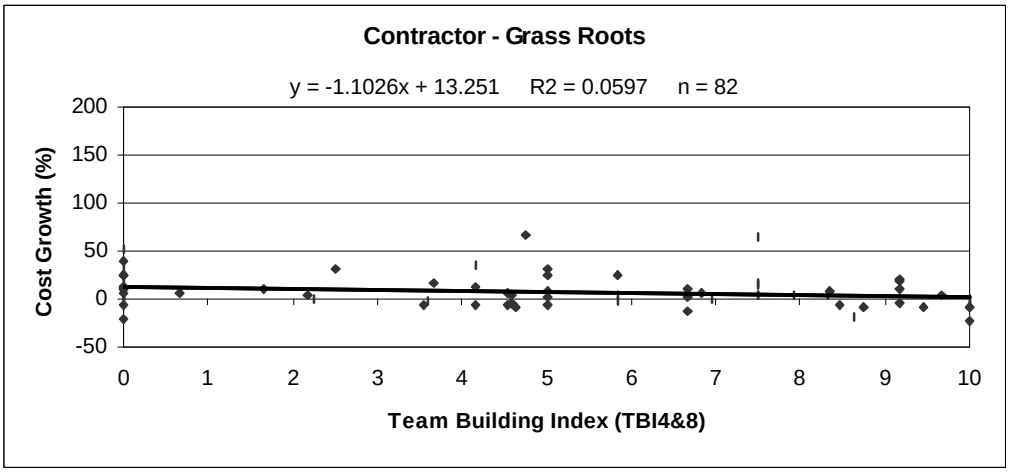

Figure 8.7.2-(1): Contractors' team building index versus cost growth for grass roots projects.

The Jonckheere-Terpstra Test of Table 8.7-(1) reveals that the quartiles are ordered to support a positive trend in the data. Whisker box-plots of Figure 8.7.2-(2) illustrate the positive

relationship between the use of team building and reduction of cost growth for the contractors' grass roots projects.

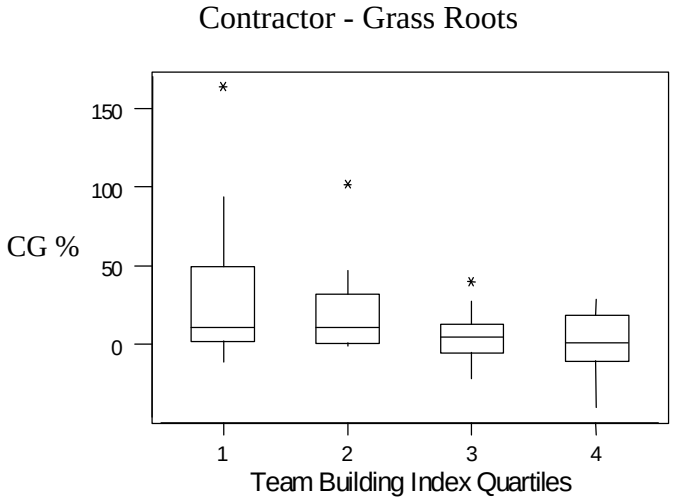

Figure 8.7.2-(2): Contractors' quartile distribution for grass roots cost growth.

8.7.3 Contractors' Cost Growth for Addition Projects

The scatter plot of Figure 8.7.3-(1) provides support to the dramatic findings of the comparison between the means and medians for the contractors' addition group. The best-fit line representing the 71 data points has the steepest slope of any significant scatter plot in the cost growth analysis. Based on the best-fit line, a reduction from 26.9% to -5.2% is possible with an increase in the team building index form 0 to 10. A 32% reduction in the cost growth represents an enormous improvement regardless of the project cost.

The positive results from the comparison of means and medians and the slope of the scatter plot's best-fit line are reinforced with statistical significance by the Jonckheere-Terpstra Test. The whisker box-plots of Figure 8.7.3-(2) represent the medians and corresponding distributions of the quartiles. Although the whisker box-plots do not clearly show all of the quartiles being ordered, comparison of the first and fourth quartiles indicates a definite influence.

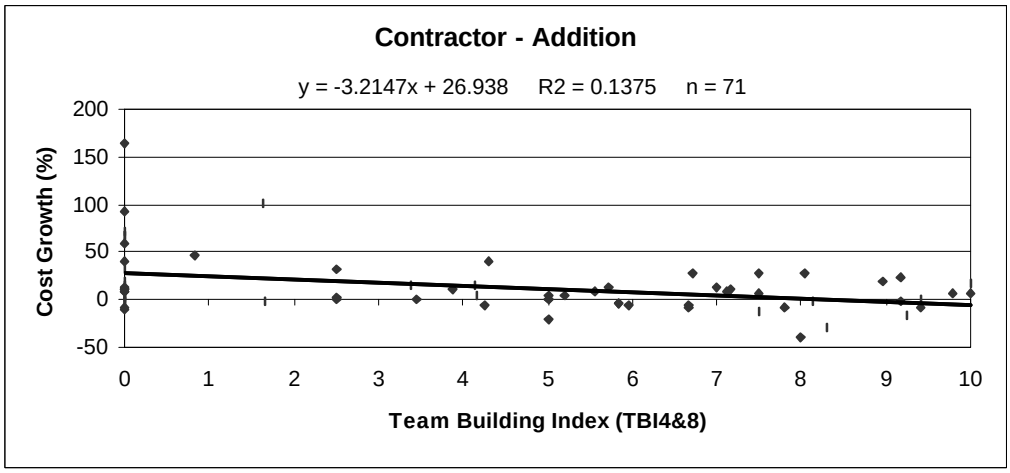

Figure 8.7.3-(1): Contractors' team building index versus cost growth for addition projects.

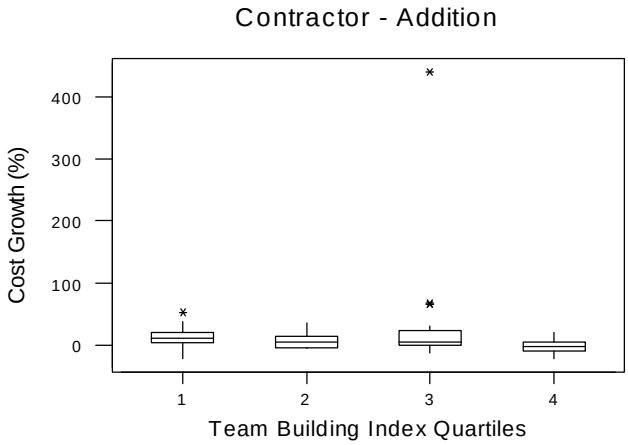

Figure 8.7.3-(2): Contractors' quartile distribution for addition cost growth.

The contractors' addition projects have proven to be a project type that is easily susceptible to the positive influences of a team building process. The slope of the best-fit line for the scatter plot is unchallenged as the steepest in the cost growth analysis of those having a substantial sample size. Both the graphical and statistical analysis indicate the existence of a strong relationship between the use of team building and cost growth reduction among the contractors' addition projects.

8.8 Owners' Cost Growth by Project Nature

Slicing of the owners' cost growth by project type revealed a decrease in average cost growth associated with the team building process for all three project types. It is shown in Table 8.8-(1) that the responses are distributed relatively evenly among the groups. Figure 8.8-(1) illustrates a slight reduction in average cost growth for modernization and addition projects and a major reduction for grass roots projects. The addition projects were the group most influenced by the team building process for the contractors.

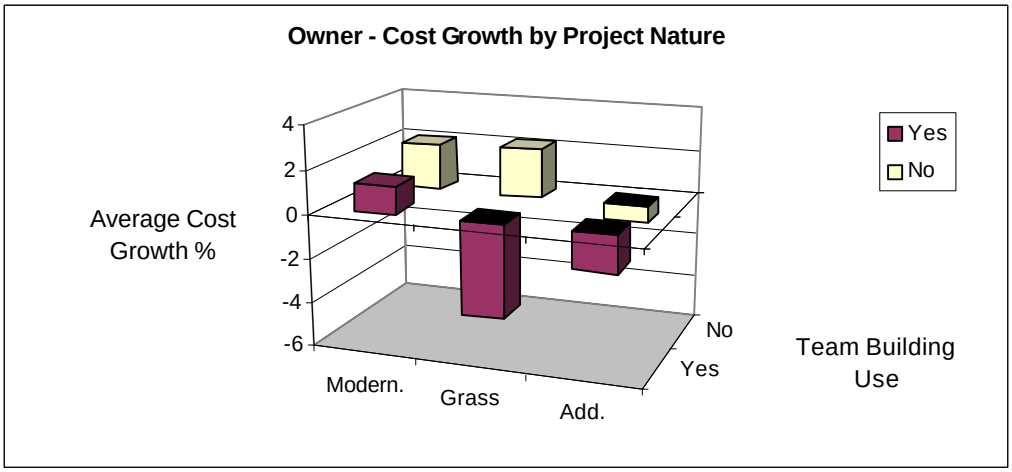

Figure 8.8-(1): Effect of team building on owners' cost growth by project nature.

The Wilcoxon Test of Table 8.8-(1) indicates that there is not a statistically significant difference between the groups who did or did not use team building for any of the project types. Comparison of the medians reinforces the existence of a positive relationship for the grass roots projects. Review of the cost growth analysis suggests that it is much less likely to prove statistical significance when the influences are not dramatic.

Table 8.8-(1): Owner statistics for project nature cost growth.

Owner:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	62	0.125386	47	15	1.029	1.1905	0.83024	0.4201
Addition (A)	61	0.066962	38	23	-1.1686	-2.2147	0.87583	0.425
Grass Roots (GR)	64	0.124594	47	17	-3.125	-0.4368	0.27245	0.2824

8.8.1 Owners' Cost Growth for Modernization Projects

The owners' scatter plot of the team building index versus the cost growth for modernization projects is shown in Figure 8.8.1-(1) along with the equation and statistics of the best-fit line. It can be seen that the slope of the line is very minimal. A decrease of less than a percent occurs between the 0 and 10 team building indexes. The scatter plot for the owners' modernization projects represents the project type most resistant to the influences of the team building process.

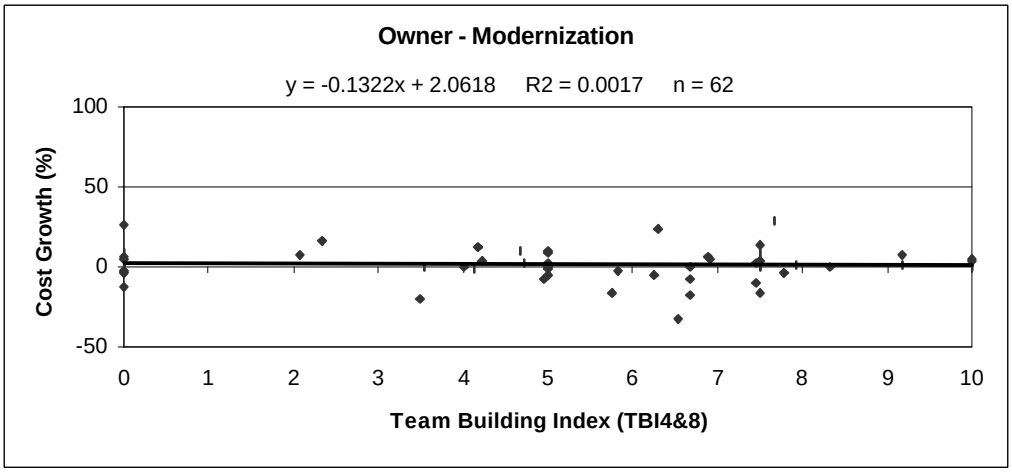

Figure 8.8.1-(1): Owners' team building index versus cost growth for modernization.

The Jonckheere-Terpstra results of Table 8.8-(1) do not reveal any statistical significance for the order of the quartiles. Likewise the whisker box-plots of Figure 8.8.1-(2) conceal any indications to the existence of a positive relationship between team building and cost growth reduction for the owners' modernization projects.

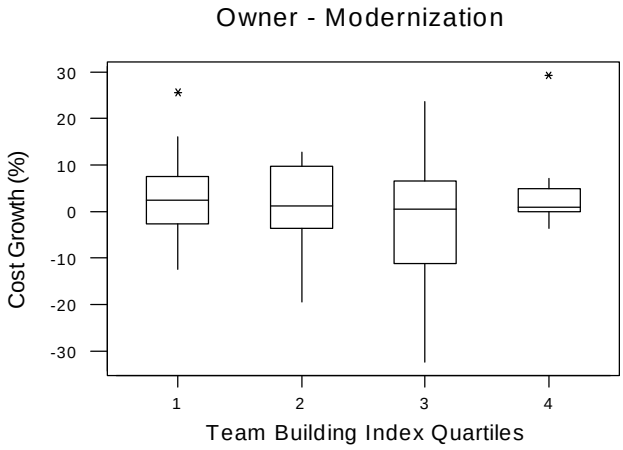

Figure 8.8.1-(2): Owners' quartile distribution for modernization cost growth.

8.8.2 Owners' Cost Growth for Grass Roots Projects

The scatter plot for the owners' grass roots projects is shown in Figure 8.8.2-(1) along with the equation and statistics of the best-fit line. This represents the project type most effected by the team building process for the owner class. As indicated by the slope of the best-fit line, almost a 6% reduction in cost growth is attainable by increasing the index form 0 to 10.

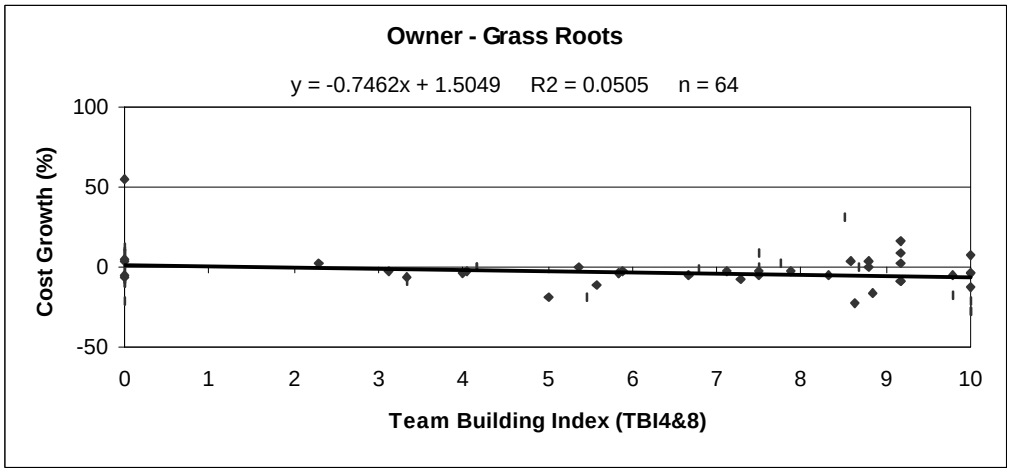

Figure 8.8.2-(1): Owners' team building index versus cost growth for grass roots.

According to the Jonckheere-Terpstra Test results of Table 8.8-(1), the quartiles are not ordered to support a positive relationship between increase team building and cost growth

reduction. The whisker box-plots of Figure 8.8.2-(2) support this result and do not indicate any reduction of the variability associated with increased use of team building.

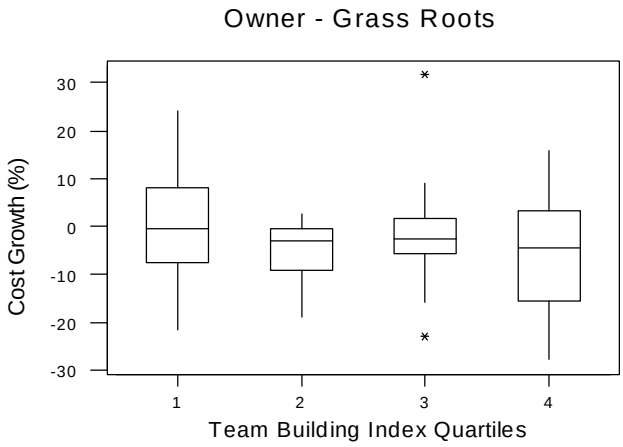

Figure 8.8.2-(2): Owners' quartile distribution for grass roots cost growth.

8.8.3 Owners' Cost Growth for Addition Projects

The results of the scatter plot for the owners' addition projects illustrated in Figure 8.8.3-(1) lies between the other two groups. The slope is moderate for the class with a possible decrease in cost growth of 3.2% associated with an increase from 0 to 10 in the team building index.

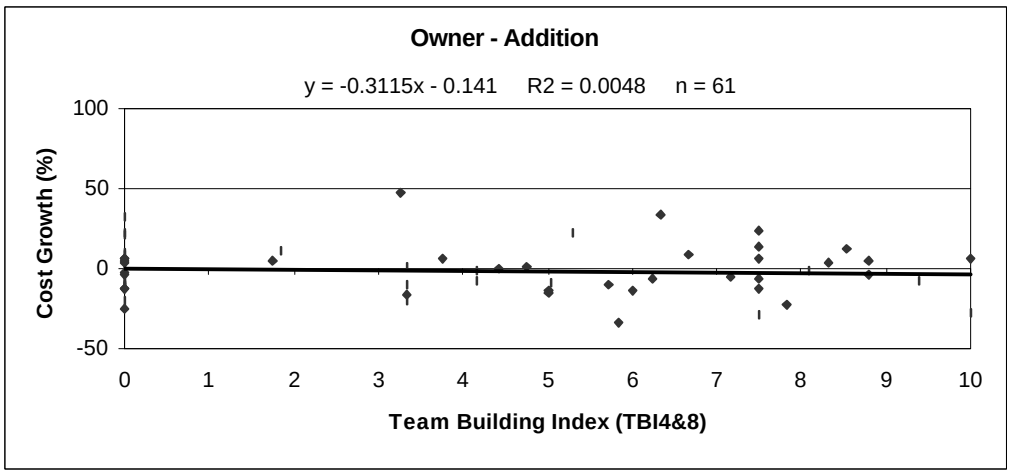

Figure 8.8.3-(1): Owners' team building index versus cost growth for addition.

Like the other two types of projects, the Jonckheere-Terpstra Test reveals that the quartiles are not ordered according correctly. The whisker box-plots of Figure 8.8.3-(2) support this finding and do not suggest any decrease in the variability associated with the increased team building.

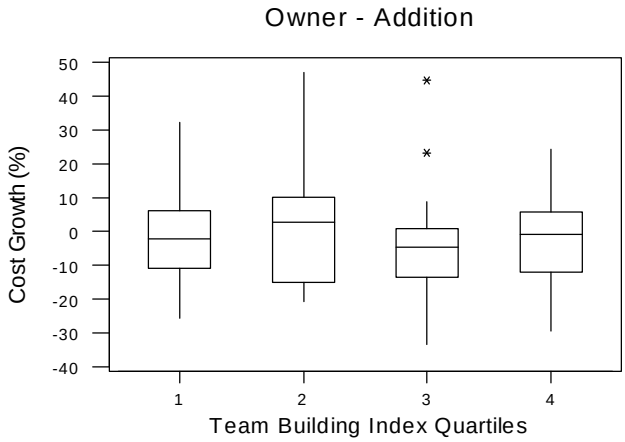

Figure 8.8.3-(2): Owners' quartile distribution for addition cost growth.

8.9 Contractors' Cost Growth by Remuneration

Upon slicing the contractors' projects by contract type, it was found that the cost reimbursed and lump sum contracts were the only types with a sufficient number of responses to justify analysis. Figure 8.9-(1) reveals a much greater team building influence on average cost growth for cost reimbursed contracts than for lump sum contracts. Average cost growth for unit price and guaranteed maximum price contracts are shown colorless to warn of the low sample size. Average cost growth is reduced by 11.2% by implementing a team building process for the cost reimbursed contracts. On the other hand, there is virtually no team building effect on the average cost growth for the lump sum contracts. This is not surprising considering the nature of the two project delivery systems.

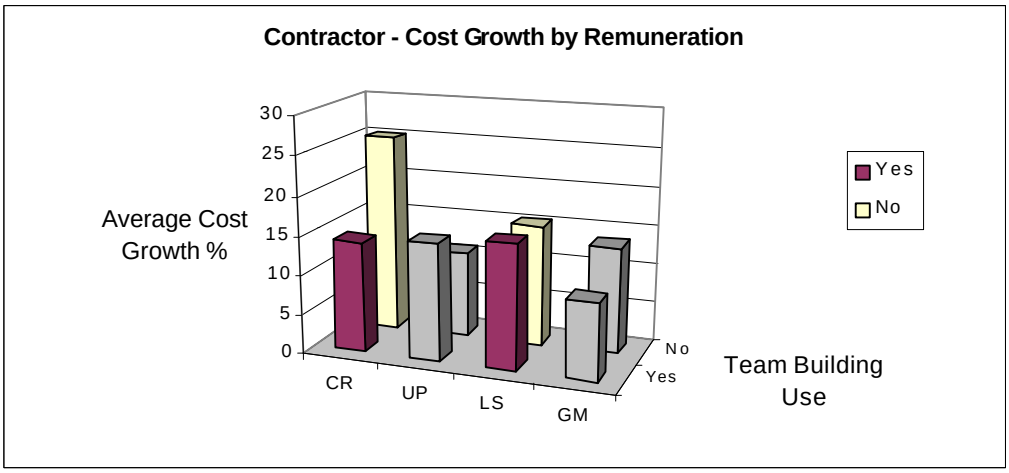

Figure 8.9-(1): Effect of team building on contractors' cost growth by remuneration.

The number of respondents for each contract type is listed in Table 8.9-(1) along with the results of the Wilcoxon Test and Jonckheere-Terpstra Test. As indicated by the Wilcoxon results, a statistically significant difference between the medians only exists for the cost reimbursed contracts.

Table 8.9-(1): Contractor statistics for remuneration cost growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Cost Reimbursed	107	0	73	34	4.659	16.913	0.00811	6E-05
Unit Price (UP)	10	.	.	.	.	.	.	.
Lump Sum (LS)	75	0	39	36	4.682	9.381	0.36176	0.2808
Guaranteed Maximum	12	.	.	.	.	.	.	.

8.9.1 Contractors' Cost Growth for Cost Reimbursed Contracts

The scatter plot for the cost reimbursed contract type is shown in Figure 8.9.1-(1) along with the equation and statistics of the best-fit line. Only the contractors' addition group possessed a steeper slope than the -2.7 slope for this contract type. According to the best-fit line, a reduction from 29.5% to 2.2% is possible with an increase from 0 to 10 in the team building index. Red lines were added to illustrate the convergence of the variability associated with increased team building. The team building influence appears to be strong in the cost reimbursed project delivery system.

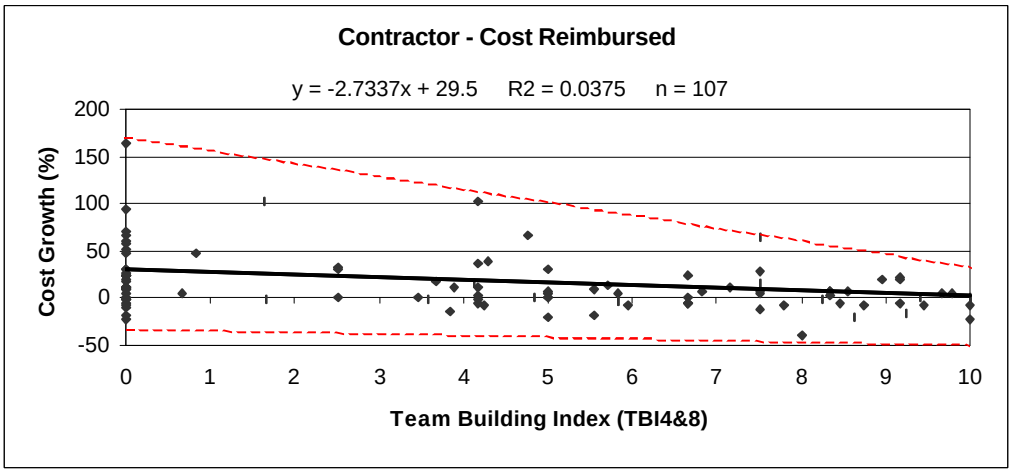

Figure 8.9.1-(1): Contractors' team building index versus cost growth for cost reimbursed.

The result of the Jonckheere-Terpstra Test of Table 8.9-(1) verifies that the quartiles are ordered according to support the positive relationship. The whisker box-plots of Figure 8.9.1-(2) support the statistical prognosis and with the exception of the extreme point in the third quartile, the variability decreases with increased use of team building.

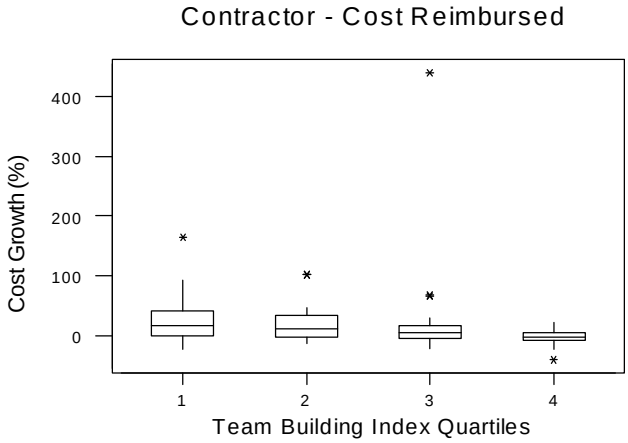

Figure 8.9.1-(2): Contractors' quartile distribution for cost reimbursed cost growth.

8.9.2 Contractors' Cost Growth for Lump Sum Contracts

The scatter plot for the contractors' lump sum type contracts shown in Figure 8.9.2-(1) also indicates that the team building influence is less influential for this type of contract. The

slope does indicate that a positive relationship exists, but it is much less extreme compared to the cost reimbursed contracts.

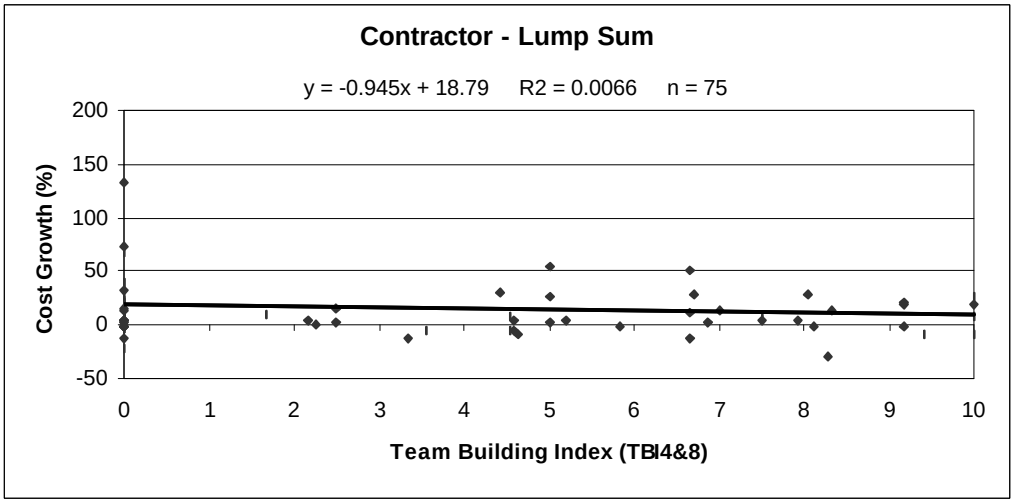

Figure 8.9.2-(1): Contractors' team building index versus cost growth for lump sum.

Results of the Jonckheere-Terpstra Test suggest that the quartiles are not ordered correctly. The whisker box-plots of Figure 8.9.2-(2) confirm the refusal of the ordered quartiles.

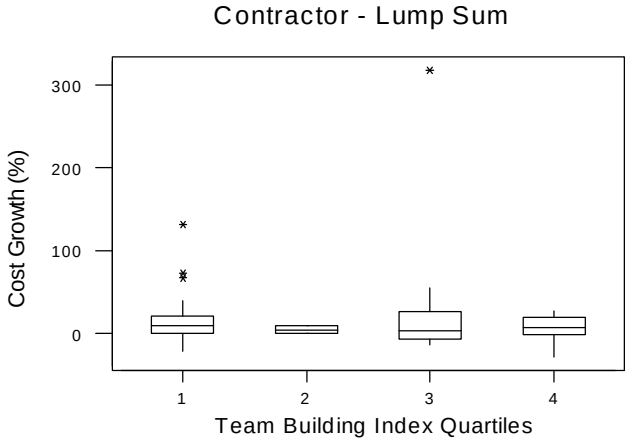

Figure 8.9.2-(2): Contractors' quartile distribution for lump sum cost growth.

8.10 Contractors' Cost Growth by Function

As shown in Figure 8.10-(1), the average cost growth for the designers and contractors is drastically reduced for those who implement the team building process. The design-and-construct group appears to be resistant to the positive effects of the team building process. For those who use team building, the average cost growth is reduced by one-half and two-thirds for the construct-only and design-only groups respectively, and the design-and-construct group's cost growth doubles.

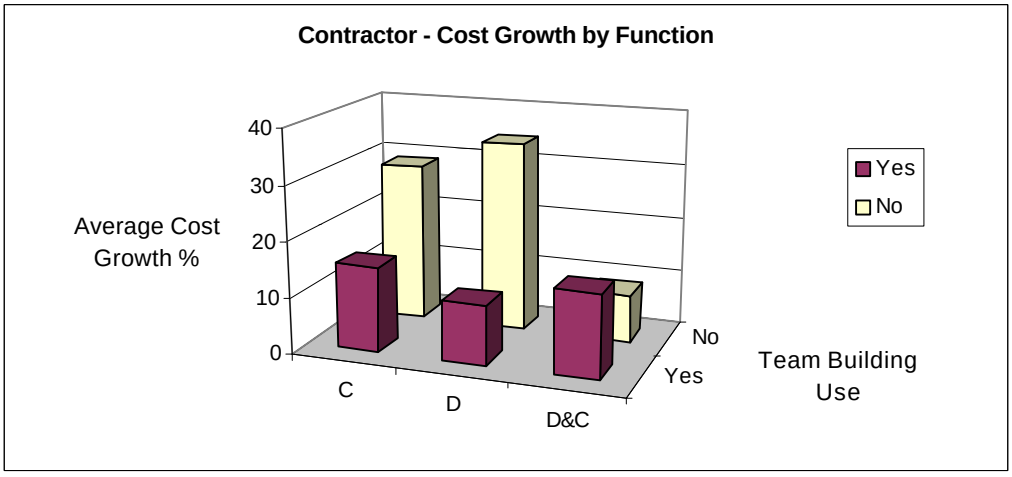

Figure 8.10-(1): Effect of team building on contractors' cost growth by function.

The distribution of the number of respondents among the three functions is shown in Table 8.10-(1) along with the results of the Wilcoxon Test. A comparison of the medians and the Wilcoxon Test results contradict the observations of the means. A statistically significant difference exists for the construct-only and design-and-construct groups. These varying results are probably due to the two extreme values that were above 300% in the design-and-construct group.

Table 8.10-(1): Contractor statistics for function cost growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Builder (C)	71	6.33E-12	41	30	13.57	12.083	0.26239	0.1497
Designer (D)	31	0.001692	21	10	4.935	25.5755	0.02377	0.0003
Both (DC)	103	0	62	41	3.452	9.254	0.04724	0.0156

8.10.1 Contractors' Cost Growth for Construct-Only Function

The contractors' scatter plot for the construct-only group is shown in Figure 8.10.1-(1) along with the equation and statistics for the best-fit line. A moderate slope for the construct-only group is a compromise between the mean and the median results.

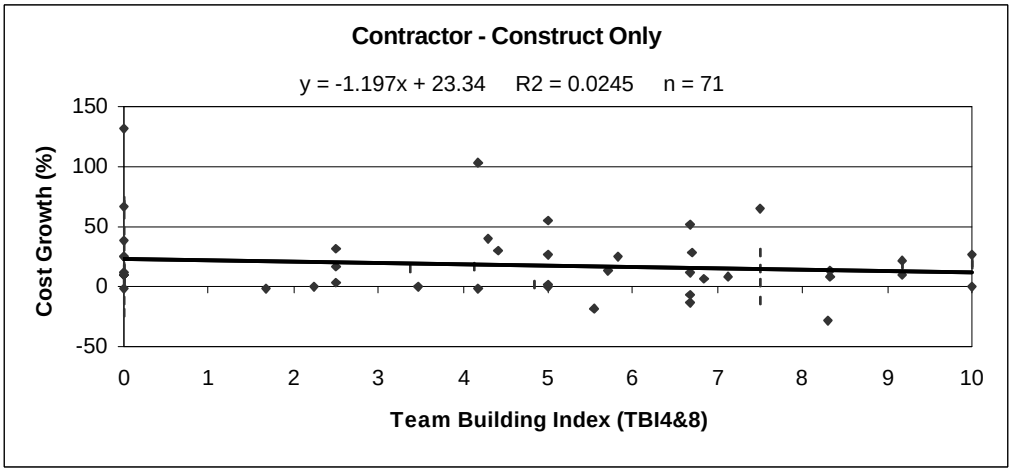

Figure 8.10.1-(1): Contractors' team building index versus cost growth for construct-only.

The Jonckheere-Terpstra Test indicates that the quartiles are not ordered correctly for the construct-only group. Visual observation of the whisker box-plots in Figure 8.10.1-(2) sustains the findings of the statistical test. The variability appears to decrease with increased team building, except for the second quartile that is skewed because of the quartile adjustments.

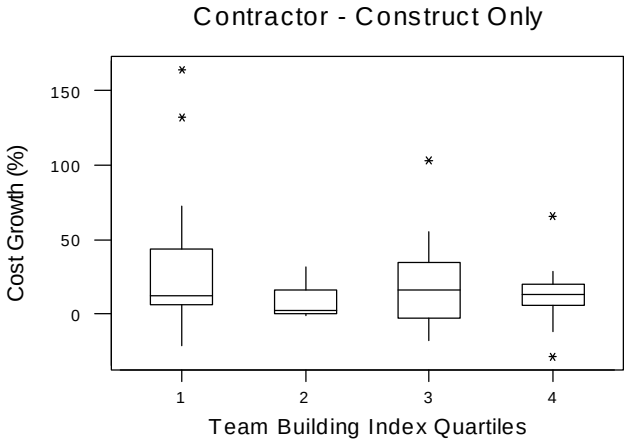

Figure 8.10.1-(2): Contractors' quartile distribution for construct-only cost growth.

8.10.2 Contractors' Cost Growth for Design-Only Function

The scatter plot for the 31 design-only projects shown in Figure 8.10.2-(1) reveals an extremely dramatic slope for the best-fit line. Caution should be used in drawing conclusions because of the somewhat low number of respondents. The best-fit line represents a possible reduction from 38.3% to -9.6% with an increase from 0 to 10 in the team building index. These results are supported to a lesser degree by the comparison of the mean and median. Although, the r-squared value asserts that the line is not a statistically sound representation of the data, it is one of the higher values for the cost growth analysis.

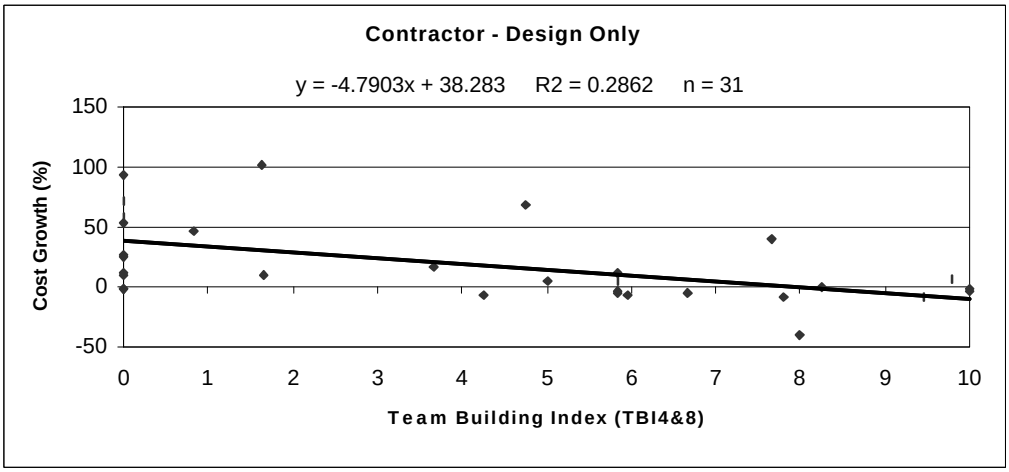

Figure 8.10.2-(1): Contractors' team building index versus cost growth for design-only.

The Jonckheere-Terpstra Test of Table 8.10-(1) indicates that the quartiles are ordered correctly. Figure 8.10.2-(2) illustrates the whisker box-plots that support the test results except for the second quartile that is skewed because of the quartile adjustments.

Even though the number of respondents is not sufficient to justify stern conclusions, the entire analysis supports a strong relationship between a team building process and reduction of cost growth for the design-only function. The comparison of the means and medians, scatter plot, whisker box-plots, and statistical tests all provide evidence to support this notion. An

increased number of respondents would probably result in a less dramatic but positive conclusion.

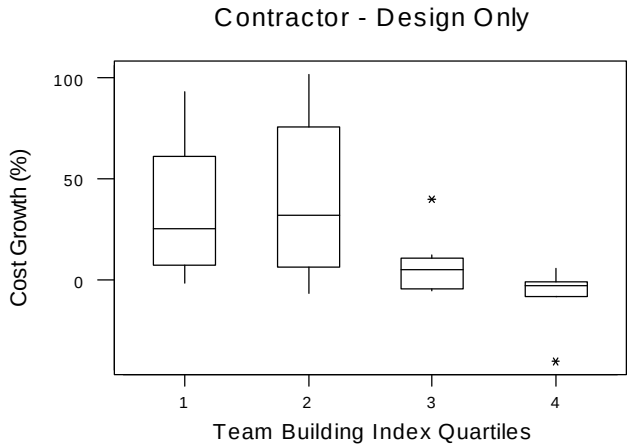

Figure 8.10.2-(2): Contractors' quartile distribution for design-only cost growth.

8.10.3 Contractors' Cost Growth for Design-and-Construct Function

The scatter plot for the design-and-construct group is shown in Figure 8.10.3-(1) along with the equation and statistics of the best-fit line. The slope of the line is moderate with a possible reduction in cost growth from 15.3% to 8.3% with an increase in the team building index from 0 to 10. Comparison of the medians in conjunction with the slope of the best-fit line would seem to override the findings of the mean comparison in Figure 8.10.-(1).

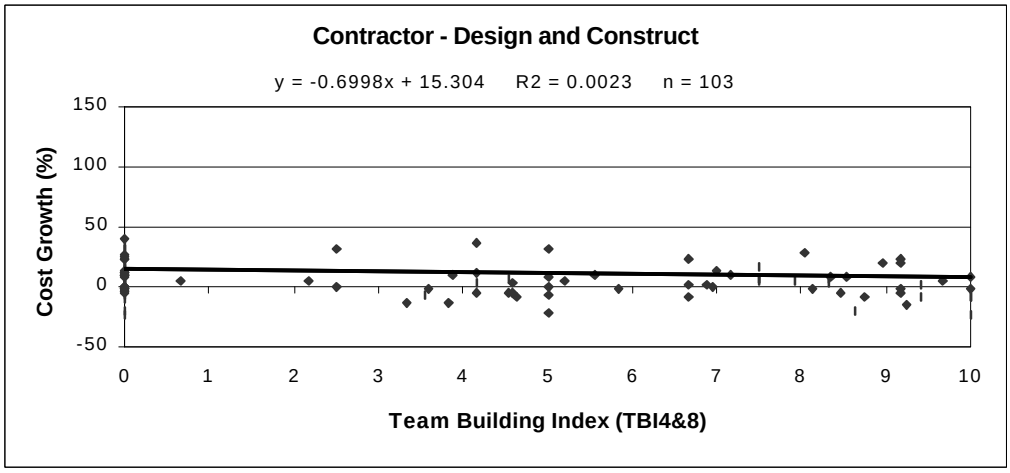

Figure 8.10.3-(1): Contractors' team building index versus cost growth for design-and-construct.

The Jonckheere-Terpstra Test supports the hypothesis that the quartiles are ordered. Shown in Figure 8.10.3-(2) are the whisker box-plots representing the quartile distributions. It can be seen that the two extreme values are in the design-and-construct group. These points may have been the cause of the unusual findings for the mean comparison of Figure 8.10-(1).

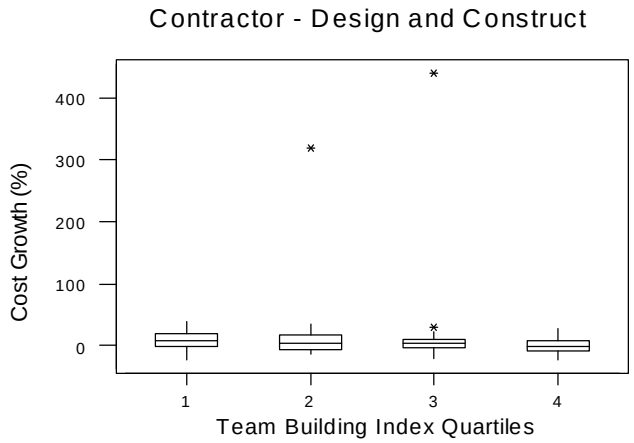

Figure 8.10.3-(2): Contractors' quartile distribution for design-and-construct cost growth.

8.11 Contractors' Cost Growth by Cost Category

The contractors' three-dimensional bar chart for the groups who did and did not implement a team building process is shown in Figure 8.11-(1) for each of the four cost categories. Projects in the less than $15 million category appear to be adversely effected by the team building process. The other three categories reveal a positive effect of team building on average cost growth with the smallest influence on the $50 to $100 million category. The $15 to $50 million and greater than $100 million categories have a reduction in average cost growth of 4.9% and 7.6% respectively.

The distribution of respondents among the categories is shown in Table 8.11-(1) along with a comparison of the cost growth medians. Examination of the medians supports the findings of the means, but according to the Wilcoxon Test, only the $15 to $50 million category was determined to have a statistically significant difference between the medians.

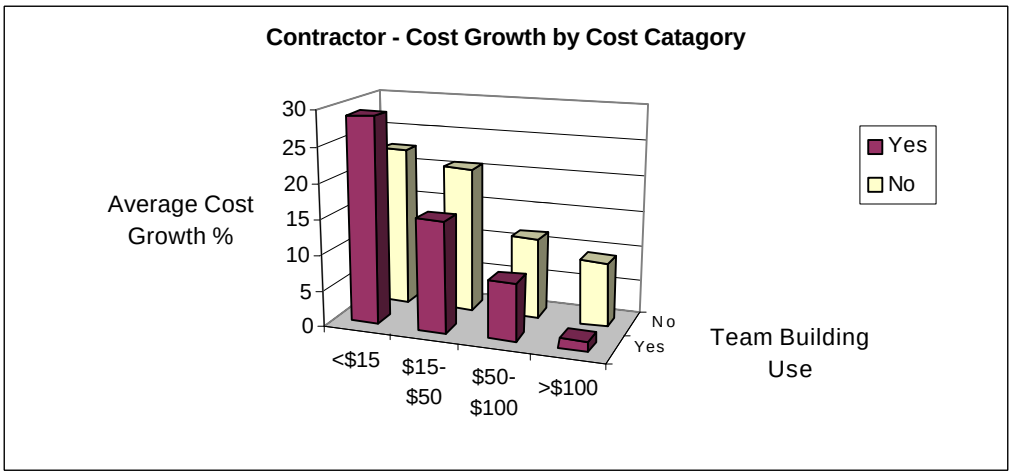

Figure 8.11-(1): Effect of team building on contractors' cost growth by cost category.

Table 8.11-(1): Contractor statistics for cost category cost growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	69	7.07E-12	27	42	12.5	10.9535	0.91677	0.4811
$15-$50 million	68	0	49	19	4.659	14.404	0.03189	0.0134
$50-$100 million	32	1.61E-06	21	11	5.5275	10.417	0.17962	0.1052
>$100 million	36	2.5E-15	28	8	1.0005	7.2495	0.1233	0.0203

8.11.1 Contractors' Cost Growth for < $15 mill. Cost Category

The contractors' scatter plot for the projects costing less than $15 million is shown in Figure 8.11.1-(1) along with the equation and statistics of the best-fit line. The meager negative slope of the line indicates that a positive relationship may exist. A notable characteristic of the plot is that out of 69 respondents, only a few had a team building index score greater than five. More than half of the respondents did not use any aspect of a team building process, while not one of them implemented a complete process. This may explain unusual findings of the mean and median comparisons.

The Jonckheere-Terpstra Test result for the projects costing less than $15 million shown in Table 8.11-(1) indicates that the quartiles are not ordered correctly. The whisker box-plots of Figure 8.11.1-(2) support the statistical test. It can be seen that the second quartile was consumed by the first in the quartile adjustments because of the large number of respondents with a team building index of zero.

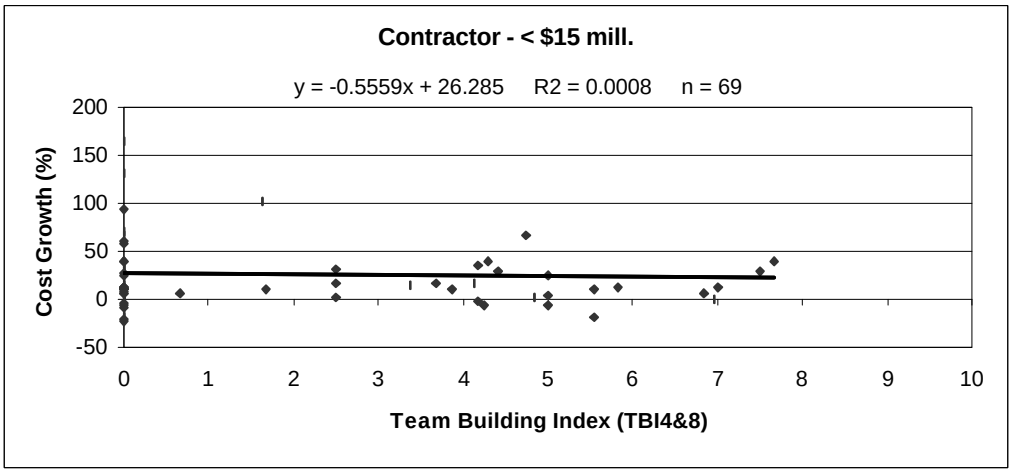

Figure 8.11.1-(1): Contractors' team building index versus cost growth for < $15 mill. projects.

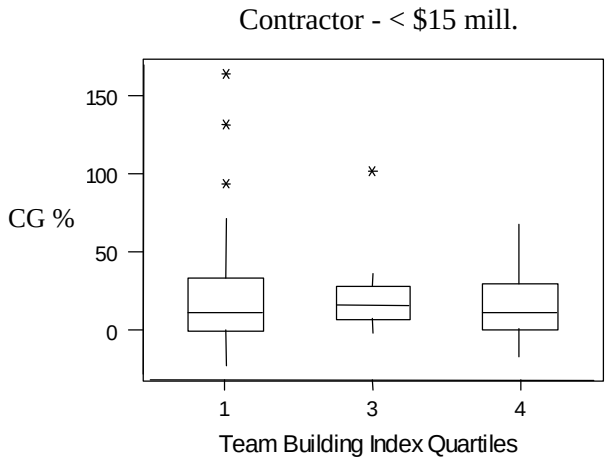

Figure 8.11.1-(2): Contractors' quartile distribution for < $15 mill. project cost growth.

8.11.2 Contractors' Cost Growth for $15 to $50 mill. Cost Category

A much better distribution across the team building scale exists for the contractor's $15 to $50 million category shown in Figure 8.11.2-(1). The slope of the best-fit line is by far the steepest for any of the contractors' cost categories. A reduction from 25.0% to 8.2% associated with an increase in the team building index from 0 to 10 creates a $5 million reduction in cost growth for a $30 million project. The relationship exhibited by the scatter plot supports the findings from the comparisons of the mean and median.

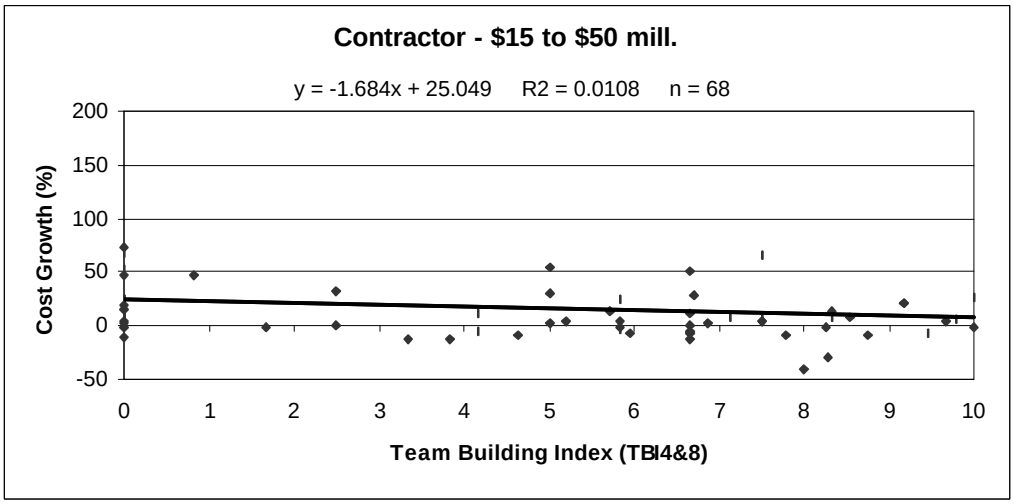

Figure 8.11.2-(1): Contractors' team building index versus cost growth for $15 to $50 mill. projects.

According to the Jonckheere-Terpstra Test of Table 8.11-(1), the quartiles are ordered correctly for the $15 to $50 million cost category. The whisker box-plots of Figure 8.11.2-(2) support the positive trend in the quartiles indicated by the statistical test. All of the charts and tests on the $15 to $50 million cost category indicate a positive relationship between increased use of the team building process and reduction in cost growth.

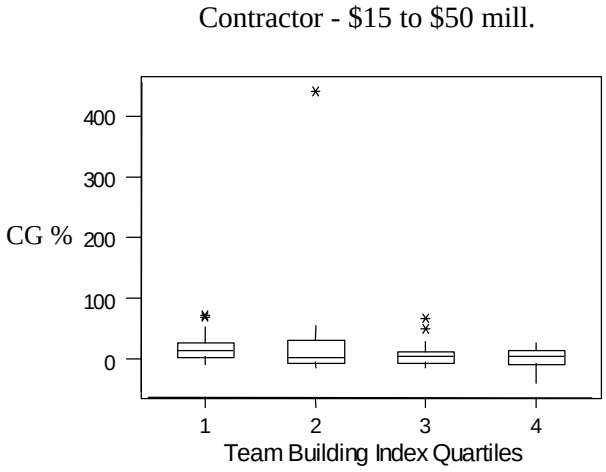

Figure 8.11.2-(2): Contractors' quartile distribution for $15 to $100 mill. project cost growth.

8.11.3 Contractors' Cost Growth for $50 to $100 mill. Cost Category

The scatter plot for the contractors' 32 projects in the $50 to $100 million cost category is shown in Figure 8.11.3-(1) along with the equation and statistics of the best-fit line. A moderate slope reveals a cost growth reduction from 12.3% to 5.9% with an increase in the team building index from 0 to 10. This results in a $4.8 million reduction in cost growth on a $75 million project which is actually less than the reduction of $5.0 million on the $15 to $50 million projects. Although the number of respondents is different for the two categories, it appears that the $15 to $50 million cost category is much more influenced by a team building process.

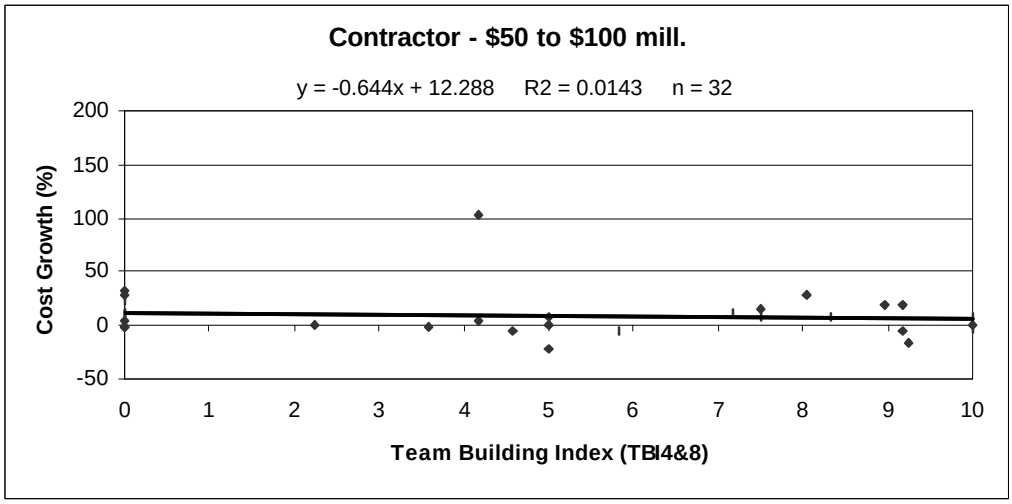

Figure 8.11.3-(1): Contractors' team building index versus cost growth for $50 to $100 mill. projects.

The Jonckheere-Terpstra results show that the quartiles are not ordered correctly. Figure 8.11.3-(2) supports this finding through the illustration of the medians and distributions for the quartiles. Not only is the second quartile out of order, so too is the fourth quartile. Reduction in the variability does not appear to be influenced by the increased use of team building.

The charts and tests for the $50 to $100 million cost category indicate that huge cost growth savings can be attained by the implementation of a team building process, bur the magnitude of the savings is much less than those of the $15 to $50 million cost category.

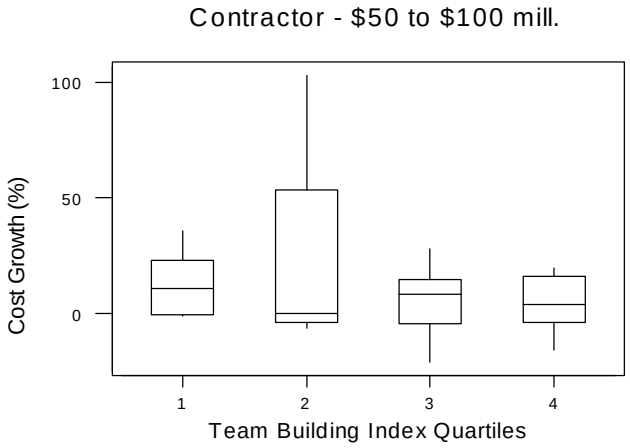

Figure 8.11.3-(2): Contractors' quartile distribution for $50 to $100 mill. project cost growth.

8.11.4 Contractors' Cost Growth for > $100 mill. Cost Category

The scatter plot of the contractors' 35 projects costing over $100 million is shown in Figure 8.11.4-(1) along with the equation and statistics of the best-fit line. The slope is similar to that of the $50 to $100 cost category. According to the best-fit line, a cost growth reduction from 7.7% to 0.1% is possible with an increase from 0 to 10 in the team building index. A reduction in cost growth of $7.6 million would result for a $100 million project.

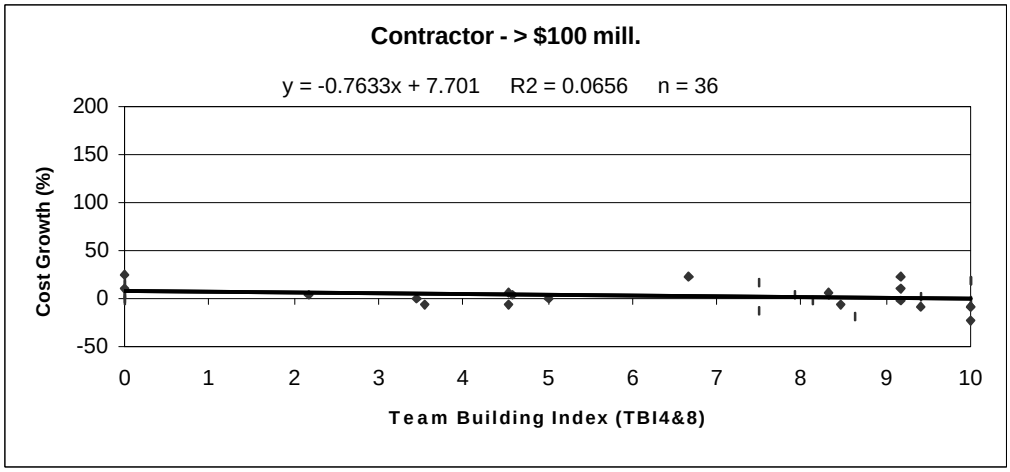

Figure 8.11.4-(1): Contractors' team building index versus cost growth for > $100 mill. projects.

The Jonckheere-Terpstra Test result of Table 8.11-(1) reveals that the quartiles of the projects costing more than $100 million are ordered to support the positive relationship. The whisker box-plots shown in Figure 8.11.4-(2) support the finding of the statistical test. The variability does not appear to be effected by the increased use of team building.

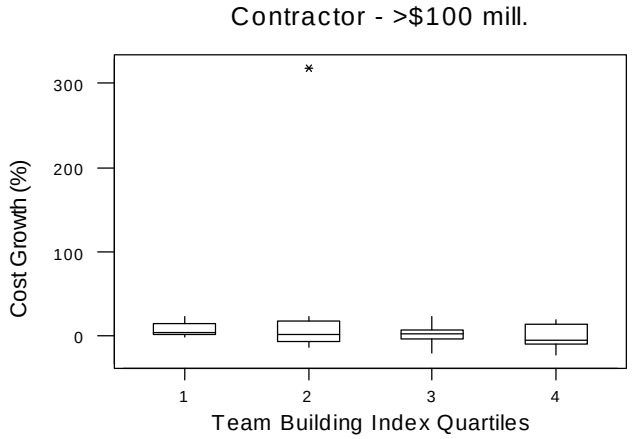

Figure 8.11.4-(2): Contractors' quartile distribution for > $100 mill. project cost growth.

8.12 Owners' Cost Growth by Cost Category

The slicing of the average cost growth by cost categories illustrated in Figure 8.12-(1) produced a somewhat different result for the owner class. In this case the $15 to $50 million category appeared to be resistant to the influences of team building. The projects costing less than $15 million revealed the greatest impact with a 6.3% reduction in average cost growth. The $50 to $100 million and greater than $100 million had an average cost reduction of 2.6% and 1.9% respectively.

The distribution of the respondents among the categories is shown in Table 8.12-(1) along with a comparison of the medians and the Wilcoxon Test results. The majority of the projects fell into one of the groups below $50 million. There were no statistically significant differences for any of the cost categories, according to the Wilcoxon results.

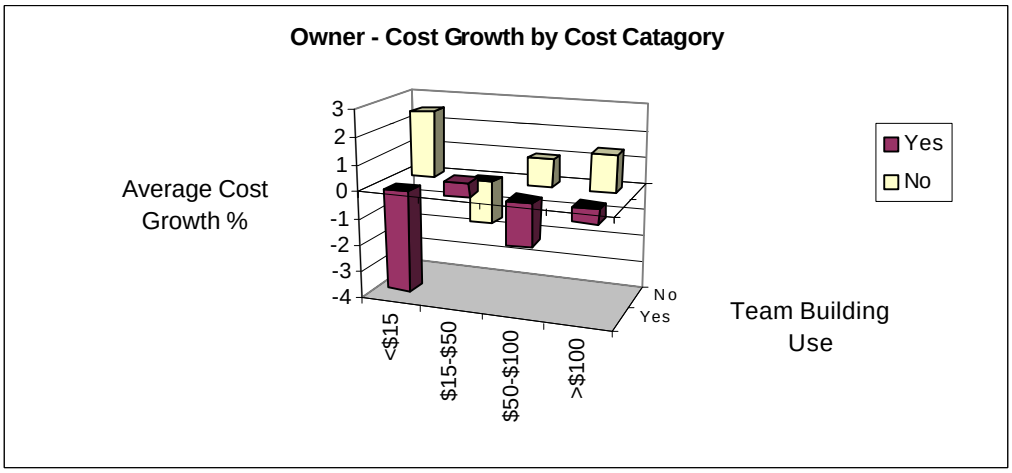

Figure 8.12-(1): Effect of team building on owners' cost growth by cost category.

Table 8.12-(1): Owner statistics for cost category cost growth.

Owner:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	76	0.247692	47	29	-1.6893	1.25	0.12266	0.1249
$15-$50 million	59	0.35692	41	18	0.3059	-2.3977	0.35231	0.9437
$50-$100 million	28	0.794603	23	5	-0.0167	-0.3597	0.76423	0.3334
>$100 million	24	0.000502	22	2	-2.5575	1.35835	0.37455	0.0611

8.12.1 Owners' Cost Growth for < $15 mill. Cost Category

The scatter plot for the 76 projects costing less than $15 million is shown in Figure 8.12.1-(1) along with the equation and statistics for the best-fit line. The slope of the line is the steepest for the owners' cost categories and this group represents the largest number of respondents. Comparison of the means and medians suggested that this category would be most effected.

Results of the Jonckheere-Terpstra Test of Table 8.12-(1) indicate that the quartiles are not ordered as suspected. The whisker box-plot shown in Figure 8.12.1-(2) illustrates the median locations and corresponding distributions of the quartiles for the projects costing less that $15 million.

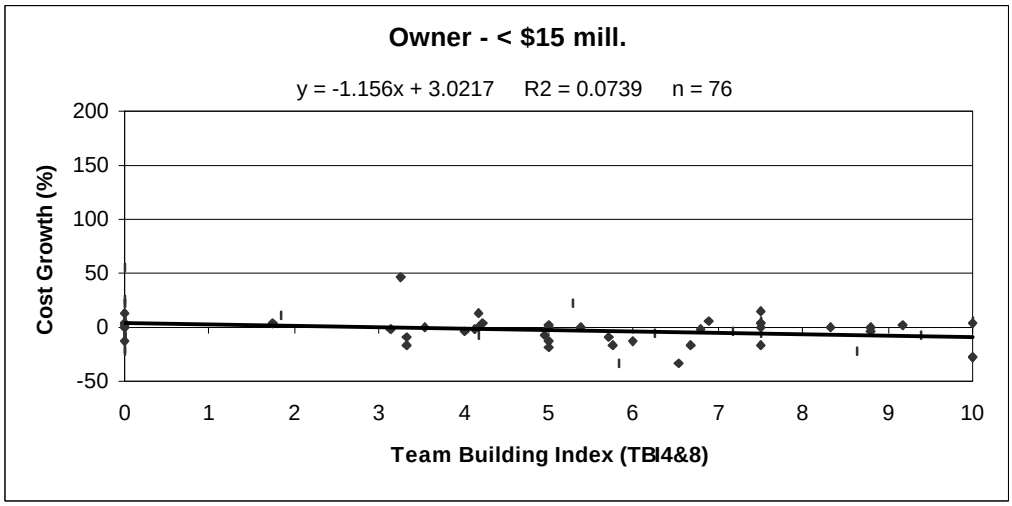

Figure 8.12.1-(1): Owners' team building index versus cost growth for < $15 mill. projects.

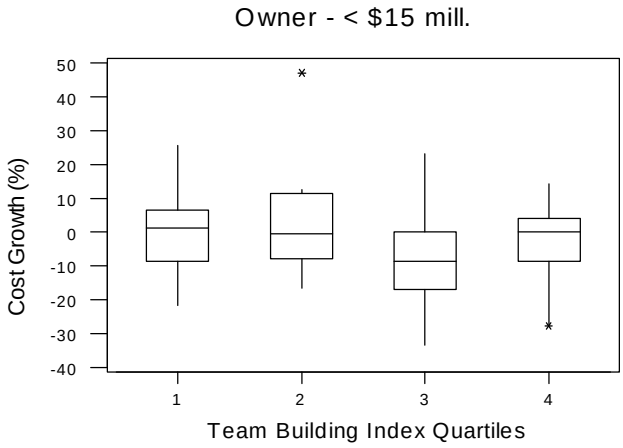

Figure 8.12.1-(2): Owners' quartile distribution for < $15 mill. project cost growth.

8.12.2 Owners' Cost Growth for $15 to $50 mill. Cost Category

Surprisingly, the scatter plot of the owner's 59 projects costing between $15 and $50 million supports the implications from the comparison of the means and medians. The slope of the line shown in Figure 8.12.2-(1) is the only positive slope in the entire cost growth analysis. This positive slope indicates an adverse effect of the team building process on cost growth reduction.

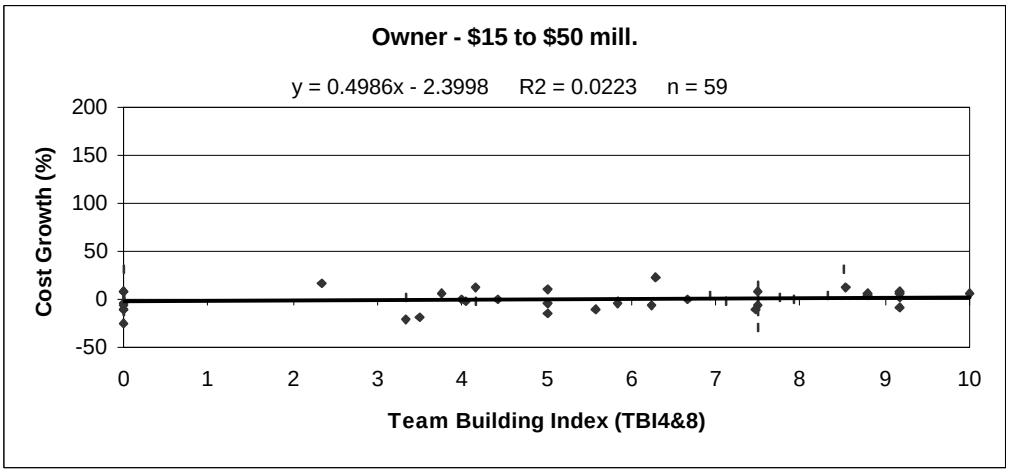

Figure 8.12.2-(1): Owners' team building index versus cost growth for $15 to $50 mill. projects.

As would be suspected, the Jonckheere-Terpstra Test of Table 8.12-(1) indicates that the quartiles are not ordered in a decreasing fashion. The whisker box-plots shown in Figure 8.12.2-(2) actually reveal that the quartiles may indeed be ordered in the opposite direction. With several slices taken for both the contractor and owner class, it should not be shocking to find one slice that does not support the existence of a positive relationship between team building and cost growth reduction.

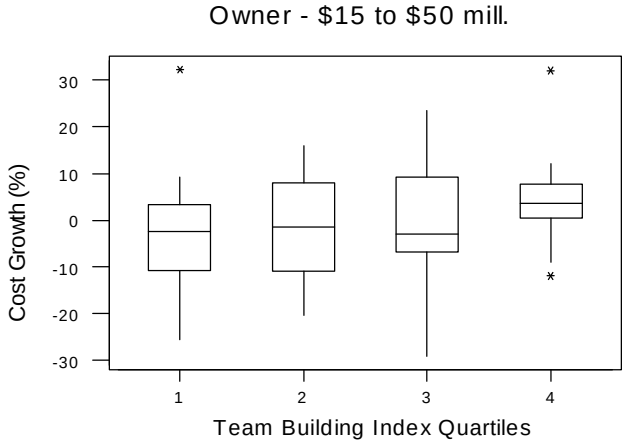

Figure 8.12.2-(2): Owners' quartile distribution for $15 to $50 mill. project cost growth.

8.12.3 Owners' Cost Growth for $50 to $100 mill. Cost Category

The scatter plot for the 28 owner projects costing between $50 and $100 million is shown in Figure 8.12.3-(1) along with the equation and statistics for the best-fit line. The slope of this line is moderate, indicating only a minor effect of team building on cost growth reduction.

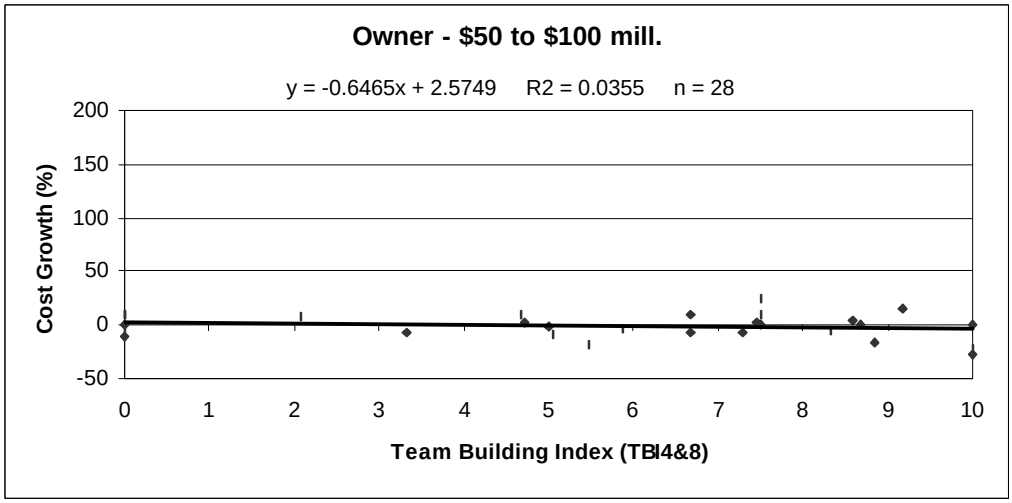

Figure 8.12.3-(1): Owners' team building index versus cost growth for $50 to $100 mill. projects.

Results of the Jonckheere-Terpstra Test indicate that the quartiles are not ordered to support the positive trend. The whisker box-plots shown in Figure 8.12.3-(2) support the statistical test and show no indications of variability decreasing with increased team building.

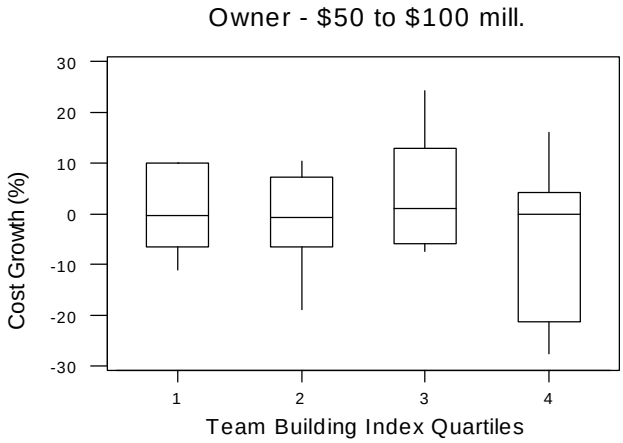

Figure 8.12.3-(2): Owners' quartile distribution for $50 to $100 mill. project cost growth.

8.12.4 Owners' Cost Growth for > $100 mill. Cost Category

Even fewer owner projects are represented in the category for projects costing over $100 million. The scatter plot in Figure 8.12.4-(1) shows the cost growth vs. team building index for the 24 projects along with the equation and statistics for the best-fit line. The mild slope indicates only a slight effect of team building on cost growth reduction.

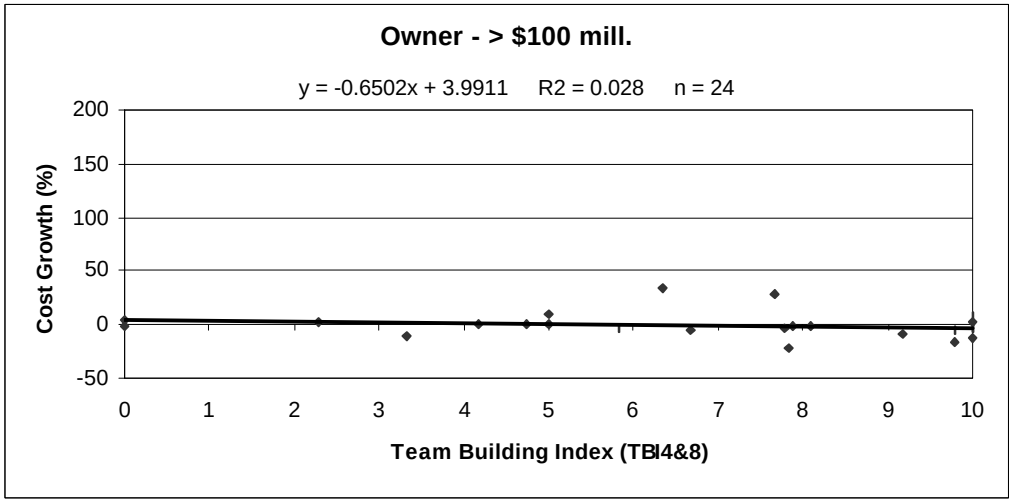

Figure 8.12.4-(1): Owners' team building index versus cost growth > $100 mill. projects.

The Jonckheere-Terpstra Test indicates that the quartiles are not ordered correctly. Whisker box-plots of Figure 8.12.4-(2) support the statistical test and do not indicate that increased team building decreases variability.

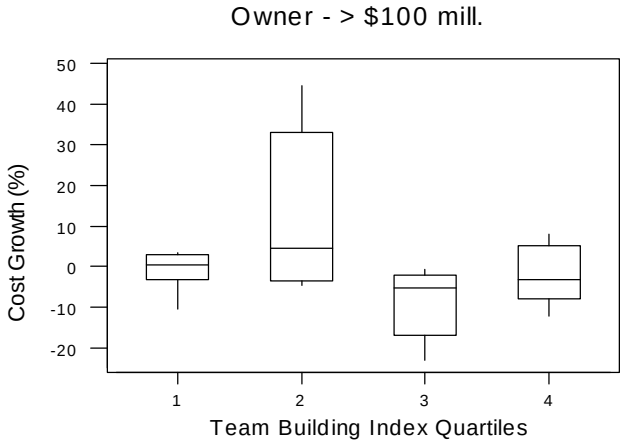

Figure 8.12.4-(2): Owners' quartile distribution for > $100 mill. project cost growth.

Chapter 9 - Results of Schedule Growth Analysis

9.1 Overview

The results of the schedule growth analysis are presented in a format similar to the cost growth analysis results. Analysis of the phases includes the three-dimensional bar charts, statistical tables, scatter plots, and whisker box-plots. Adjustments were made for the demographic slicing of the database because the schedule growth performance data did not include information about the total project schedule. Slices of the cost growth analysis were compared to the total project cost. The slices for the schedule growth analysis had to be compared to phase schedule growth information. The design, procurement, and construction phases were used in the analysis because they contain a significant number of respondents for both the owners and contractors. Scatter plots were not produced for the demographic slices because there would have been three for each element of every subset. Only a brief discussion of the charts, plots, and statistical tests is included because of the resemblance to the cost growth analysis results

9.2 Contractors' Schedule Growth by Phases

As illustrated in Figure 9.2-(1), the average schedule growth appears to be reduced by the use of team building for all of the contractors' phases except for the start-up phase.

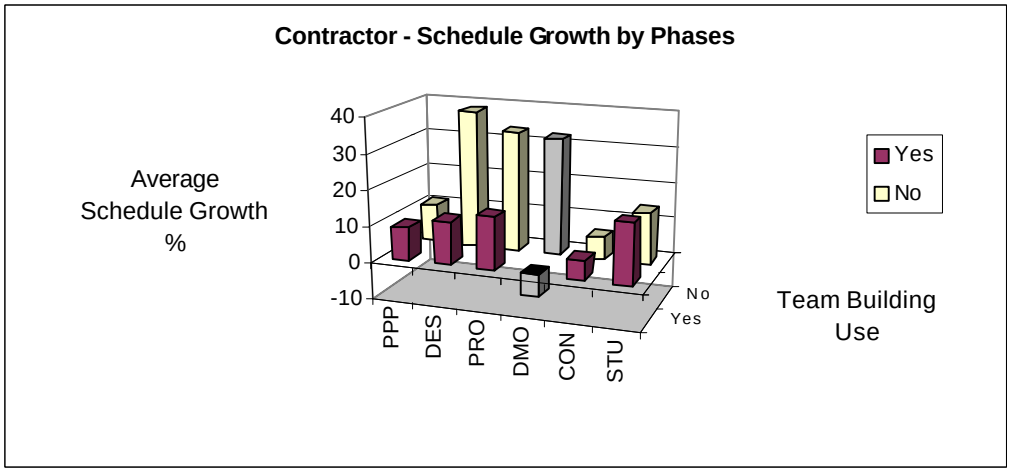

Figure 9.2-(1): Effect of team building on contractors' schedule growth by phases.

Comparison of the medians shown in Table 9.2-(1) supports a positive influence of team building on the reduction of schedule growth for all of the phases analyzed. Wilcoxon Test results only indicate a statistically significant difference between the medians of the yes-and-no groups for the design phase, though.

Table 9.2-(1): Contractor statistics for phase schedule growth.

Contractor:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Pre-Project Planning	66	0	45	21	0	1.613	0.19734	0.0667
Design	140	0	89	51	6.154	18.969	0.00012	2E-05
Procurement	124	0	83	41	6.601	16.423	0.06416	0.0466
Demolition	15	.	.	.	.	.	.	.
Construction	168	0	101	67	0	5.677	0.47977	0.3243
Start-Up	48	0.003216	29	19	3.279	11.688	0.78276	0.5261

9.2.1 Contractors' Pre-Project Planning Phase Schedule Growth

The slope of the best-fit line in Figure 9.2.1-(1) of the scatter plot for the contractors' pre-project planning phase reveals a positive effect of increased team building on schedule growth reduction.

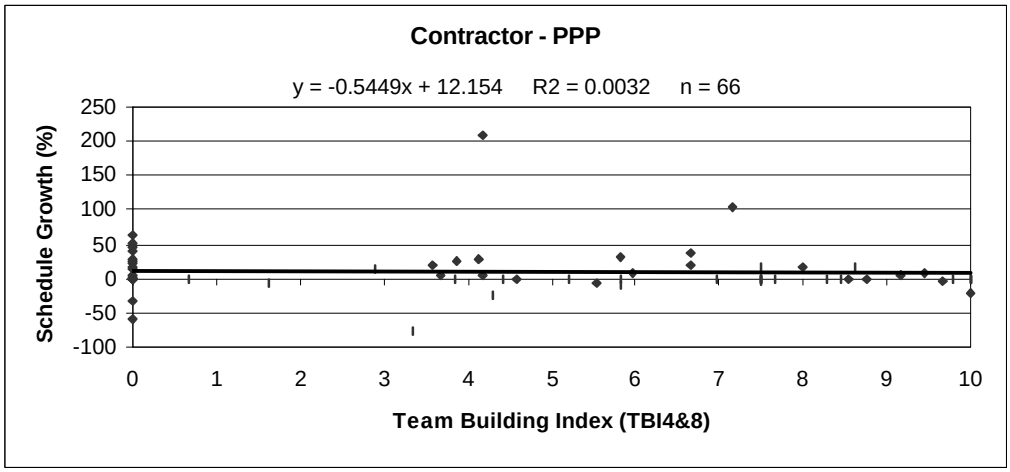

Figure 9.2.1-(1): Contractors' team building index versus pre-project planning schedule growth.

Results of the Jonckheere-Terpstra test reveal that the quartiles are not ordered to support a positive relationship. Although the statistical test fails, the whicker box-plots of Figure 9.2.1-(2) suggest that the positive relationship may exist.

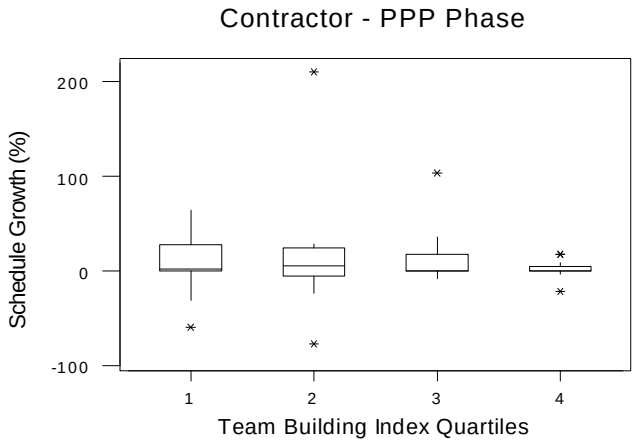

Figure 9.2.1-(2): Contractors' quartile distribution for pre-project planning schedule growth.

9.2.2 Contractors' Design Phase Schedule Growth

The slope of the best-fit line in Figure 9.9.9-(1) for the contractors' design phase scatter plot indicates an extremely strong relationship between team building and schedule growth reduction. According to the best-fit line, a 34.6% reduction in schedule growth is possible with an increase from 0 to 10 in the team building index. This outstanding result is supported with a relatively high number of respondents.

Results of the Jonckheere-Terpstra Test indicate that the quartiles are ordered as suspected. As shown in Figure 9.2.2-(2), the whisker box-plot also illustrates a positive relationship between team building and reduction of schedule growth.

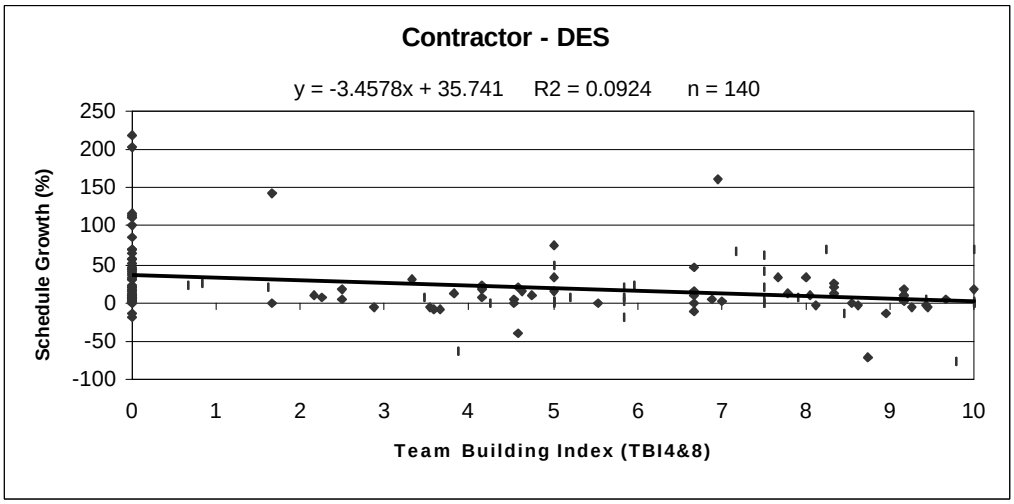

Figure 9.2.2-(1): Contractors' team building index versus design schedule growth.

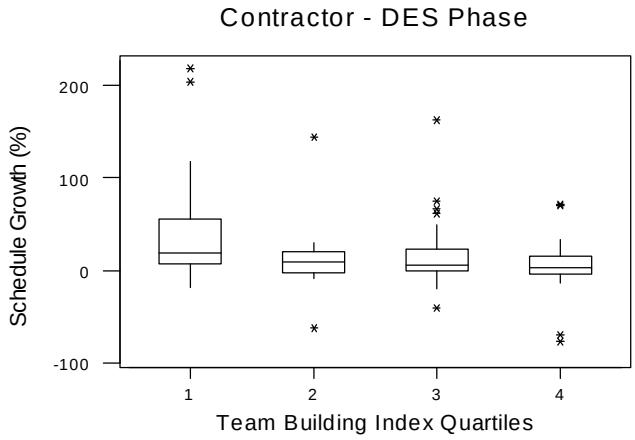

Figure 9.2.2-(2): Contractors' quartile distribution for design schedule growth.

9.2.3 Contractors' Procurement Phase Schedule Growth

Although not as dramatic as the design phase, the contractors' procurement phase scatter plot indicates a strong relationship between increased use of team building and reduction of schedule growth. The best-fit line of Figure 9.2.3-(1) suggests that an increase in the team building index from 0 to 10 can result in a decrease of 16.4% in schedule growth.

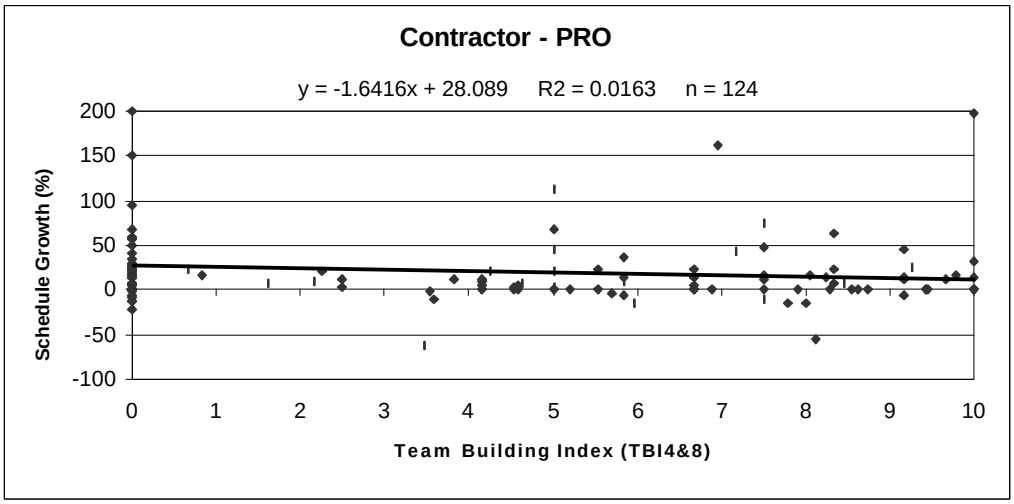

Figure 9.2.3-(1): Contractors' team building index versus procurement schedule growth.

According to the Jonckheere-Terpstra Test, the quartiles of the procurement phase schedule growth are ordered to support a positive relationship. The whisker box-plots shown in Figure 9.2.3-(1) support this finding except for the second quartile which is skewed by the quartile adjustments.

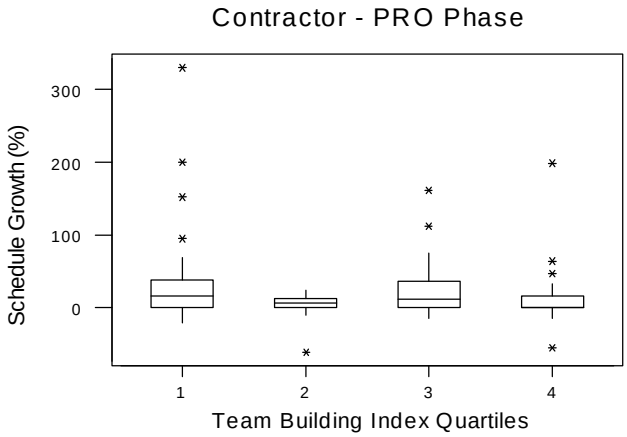

Figure 9.2.3-(2): Contractors' quartile distribution for procurement schedule growth.

9.2.4 Contractors' Construction Phase Schedule Growth

The slope of the best-fit line of Figure 9.2.4-(1) for the contractors' construction phase is relatively flat compared to the slope of the preceding phases. As indicated by the low r-squared value, a great deal of variability is associated with the best-fit line.

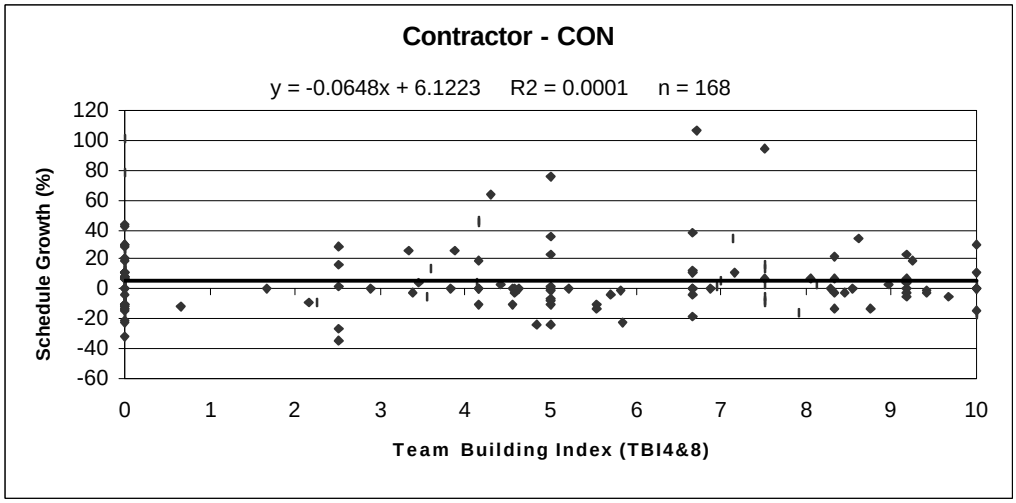

Figure 9.2.4-(1): Contractors' team building index versus construction schedule growth.

The Jonckheere-Terpstra Test indicates that the quartiles are not ordered as suspected. Observation of the whisker box-plots in Figure 9.2.4-(2) reveals that the medians appear to be uneffected by the increased team building.

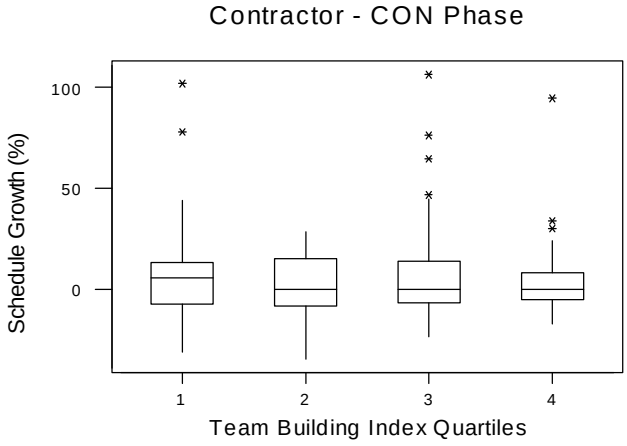

Figure 9.2.4-(2): Contractors' quartile distribution for construction schedule growth.

9.2.5 Contractors' Start-Up Phase Schedule Growth

A positive slope indicating a negative relationship exists for the contractors' start-up phase in Figure 9.2.5-(1). The scatter plot of the 48 respondents reveals an increase in schedule growth associated with an increase in the team building index and variability appears to be uneffected.

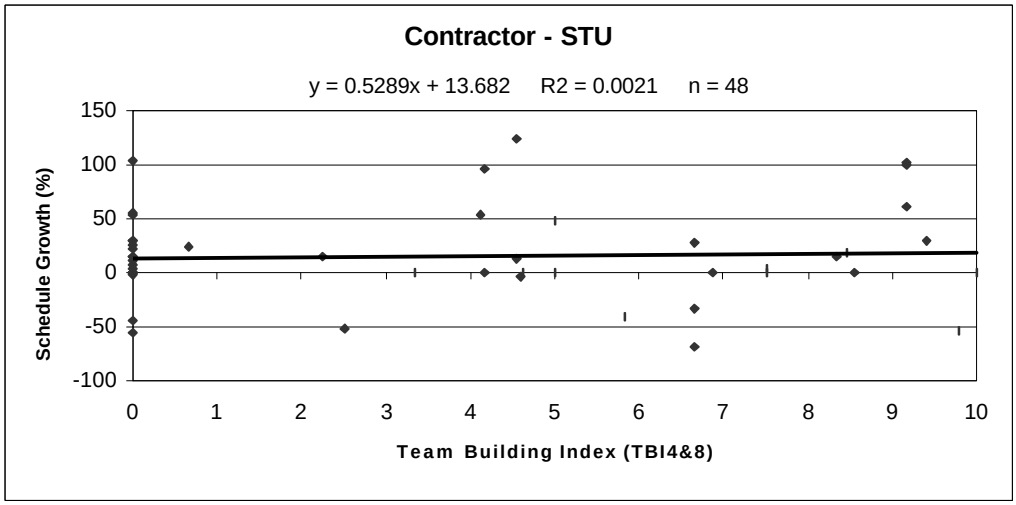

Figure 9.2.5-(1): Contractors' team building index versus start-up schedule growth.

Neither the Jonckheere-Terpstra Test nor the whisker box-plots of Figure 9.2.5-(2) support the existence of a positive relationship between team building and schedule growth reduction for the start-up phase.

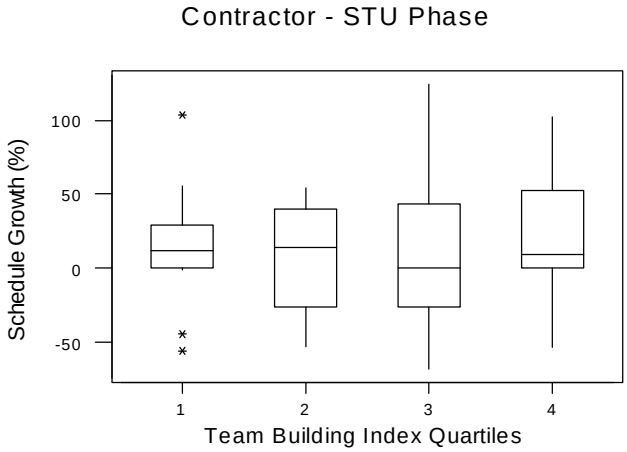

Figure 9.2.5-(2): Contractors' quartile distribution for start-up schedule growth.

9.3 Owners' Schedule Growth by Phases

As illustrated in Figure 9.3-(1), average schedule growth is reduced by the use of team building for every phase except the pre-project planning phase. The dramatic difference for the demolition phase is not substantiated with an acceptable sample size.

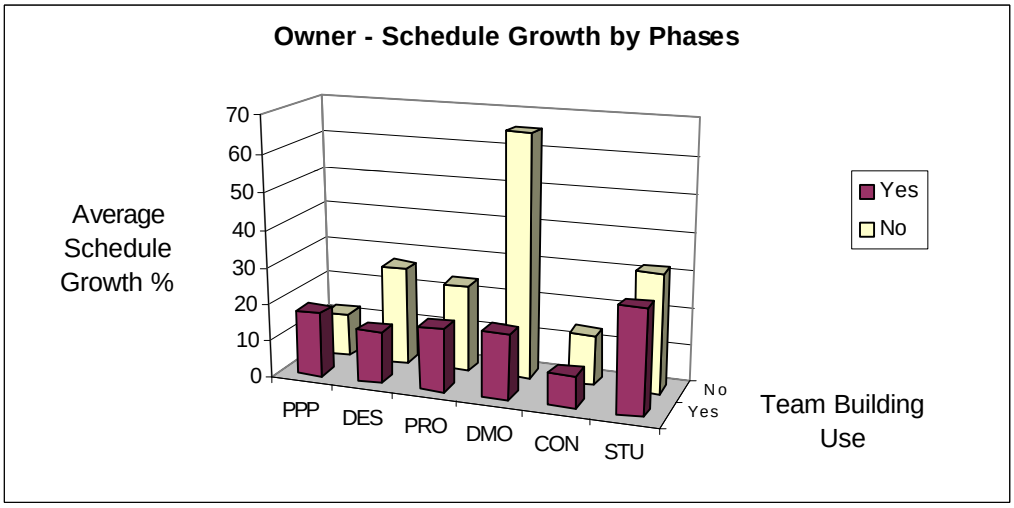

Figure 9.3-(1): Effect of team building on owners' schedule growth by phases.

All of the owners' phases except for the demolition phase have more than 100 responses. Comparison of the medians in Table 9.3-(1) reveals a positive influence of team building for all but the pre-project planning and start-up phases that revealed no differences. Wilcoxon Test results indicate a statistically significant difference only for the design phase.

Table 9.3-(1): Owner statistics for phase schedule growth.

Owner:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Pre-Project Planning	127	0	93	34	0	0	0.97704	0.3385
Design	159	0	113	46	4.737	13.3495	0.0419	0.0457
Procurement	134	0	98	36	5.9905	19.491	0.12074	0.1533
Demolition	27	6.38E-08	20	7	0	29.545	0.40618	0.1305
Construction	161	6E-10	114	47	1.8332	6.0606	0.20767	0.1872
Start-Up	111	0	80	31	0	0	0.6374	0.2082

9.3.1 Owners' Pre-Project Planning Phase Schedule Growth

The scatter plot of Figure 9.3.1-(1) indicates a negative relationship for the owners' pre-project planning phase. The 127 responses reveal an increase in schedule growth associated with increase team building. Also, variability associated with the best-fit line does not appear to decrease with increased team building.

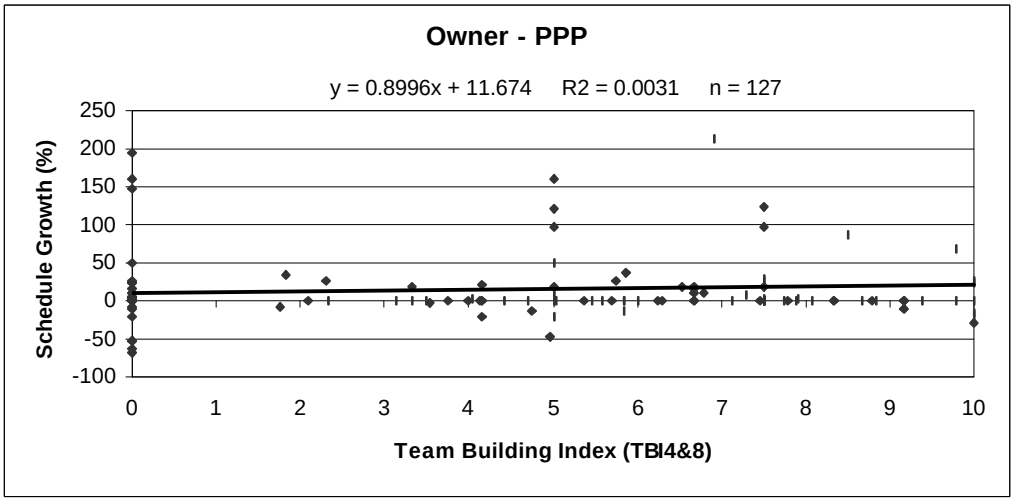

Figure 9.3.1-(1): Owners' team building index versus pre-project planning schedule growth.

Results of the Jonckheere-Terpstra Test and visual observation of the whisker box-plots in Figure 9.3.1-(2) do not reveal a positive relationship between increased team building and schedule growth reduction.

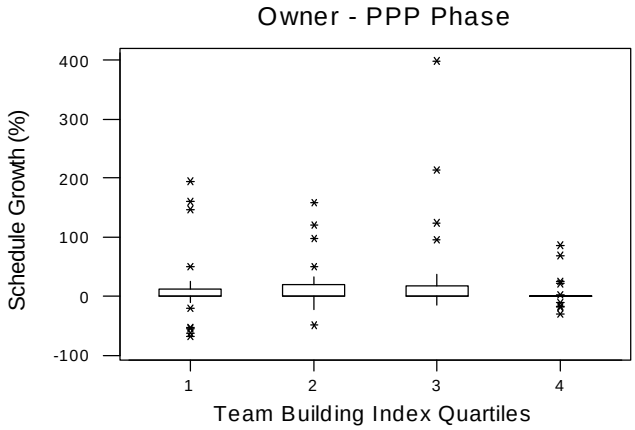

Figure 9.3.1-(2): Owners' quartile distribution for pre-project planning schedule growth.

9.3.2 Owners' Design Phase Schedule Growth

As illustrated in Figure 9.3.1-(1), the scatter plot of the159 respondents for the owners' design phase indicates a relatively strong positive relationship. The dramatic slope of the best-fit line for the phase reveals a reduction of 11.1% in schedule growth with an increase from 0 to10 in the team building index.

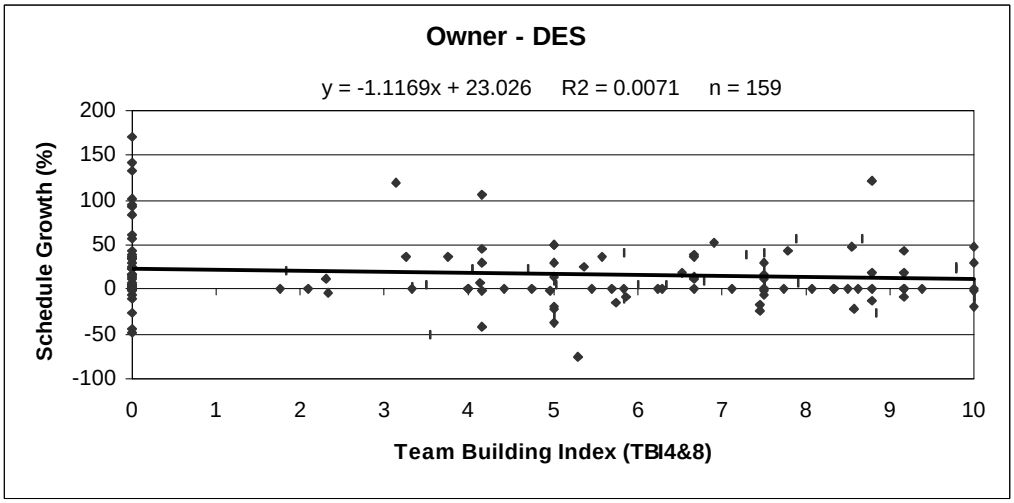

Figure 9.3.2-(1): Owners' team building index versus design schedule growth.

The Jonckheere-Terpstra Test results do indicate that the quartiles are ordered to support the positive relationship. Whisker box-plots shown in Figure 9.3.2-(2) suggest a positive relationship for all but the fourth quartile.

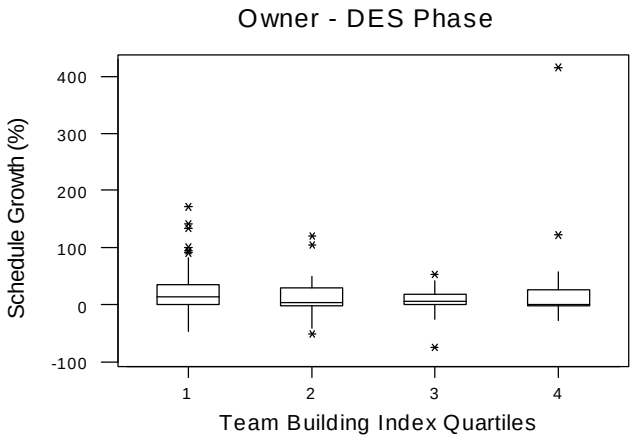

Figure 9.3.2-(2): Owners' quartile distribution for design cost schedule growth.

9.3.3 Owners' Procurement Phase Schedule Growth

A moderate slope of the best-fit line in Figure 9.9.3-(1) indicates that team building has a positive influence on schedule growth for the owners' procurement phase. An unusual amount of variability is present for the higher team building indexes.

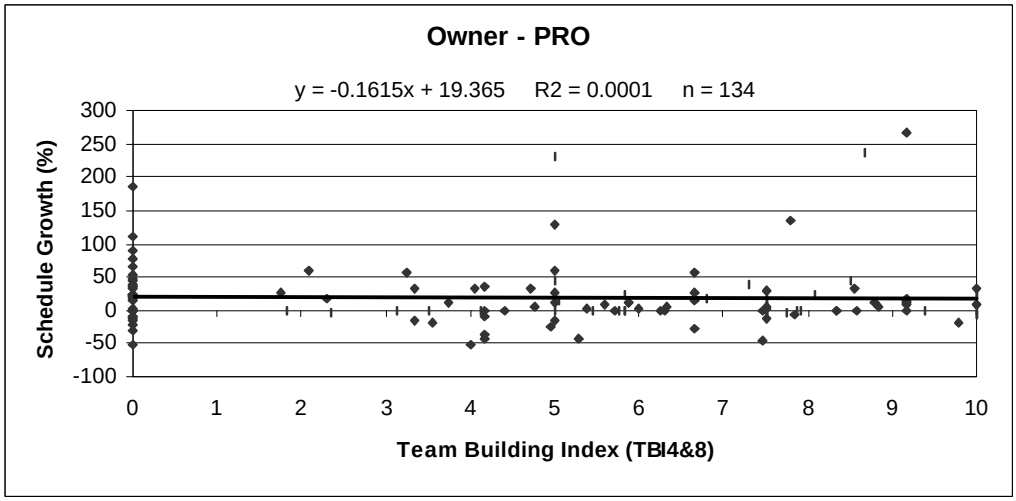

Figure 9.3.3-(1): Owners' team building index versus procurement schedule growth.

The Jonckheere-Terpstra Test results and the whisker box-plots shown in Figure 9.3.3-(2) fail to add support to the existence of a positive relationship for the owners' procurement phase.

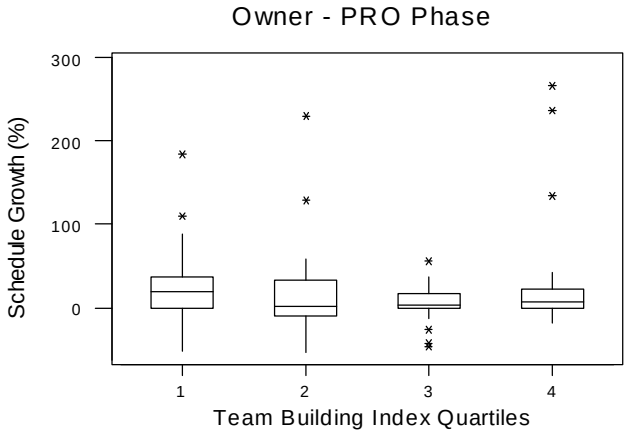

Figure 9.3.3-(2): Owners' quartile distribution for procurement schedule growth.

9.3.4 Owners' Demolition Phase Schedule Growth

The low sample size for the owners' demolition phase limits interpretations of the scatter plot in Figure 9.3.4-(1). The slope is tremendous but so is the variability. This plot should only be used as an indicator that a strong relationship may exist. Re-evaluation of the relationship is warranted upon the addition of more data.

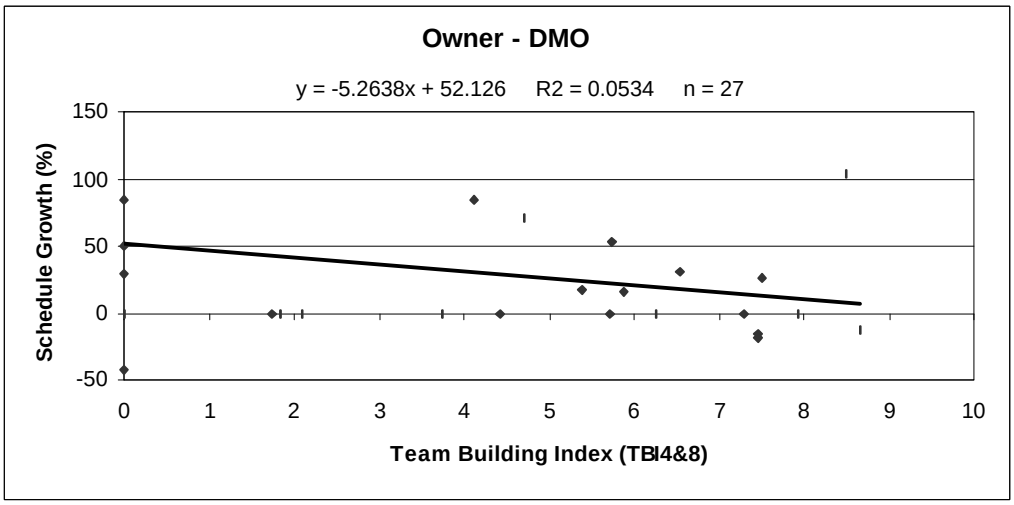

Figure 9.3.4-(1): Owners' team building index versus demolition schedule growth.

Neither the Jonckheere-Terpstra Test result nor the whisker box-plots of Figure 9.3.4-(2) provide support for a positive relationship between team building and schedule growth reduction.

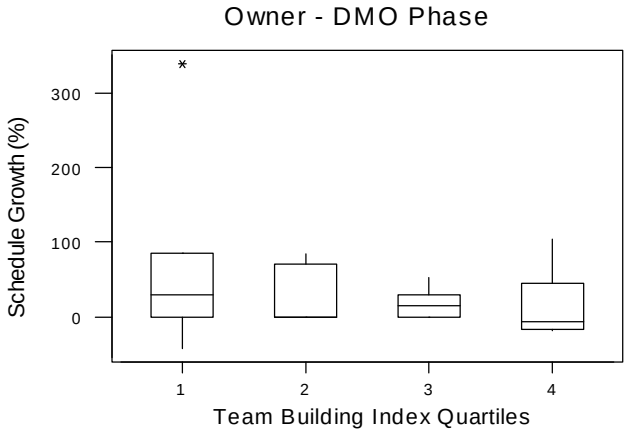

Figure 9.3.4-(2): Owners' quartile distribution for demolition schedule growth.

9.3.5 Owners' Construction Phase Schedule Growth

As shown in Figure 9.3.5-(1), the best-fit line in the scatter plot of the owners' construction phase indicates that a positive relationship exists between team building and schedule growth reduction. The variability does not appear to decrease with increased team building.

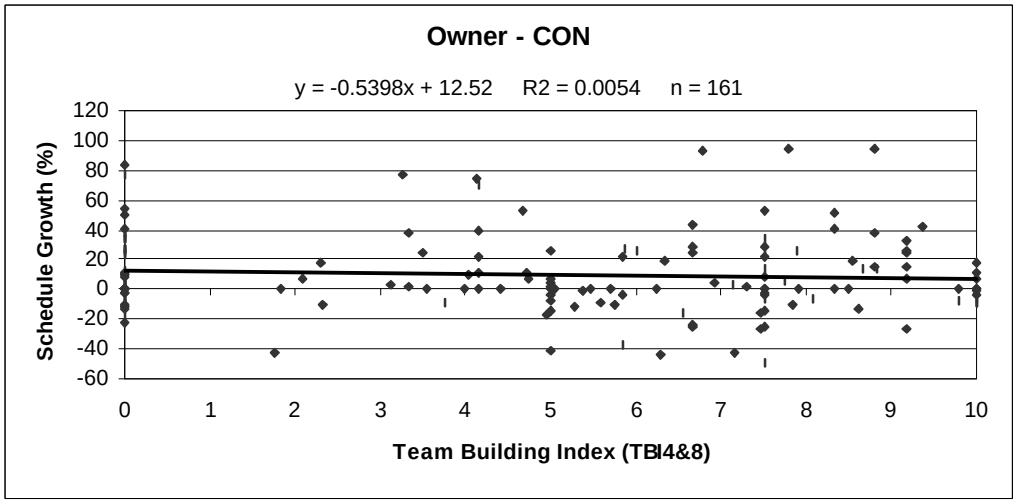

Figure 9.3.5-(1): Owners' team building index versus construction schedule growth.

The Jonckheere-Terpstra Test result and whisker box-plots of Figure 9.3.5-(2) do not indicate that team building has a positive relationship on the reduction of the construction phase schedule growth.

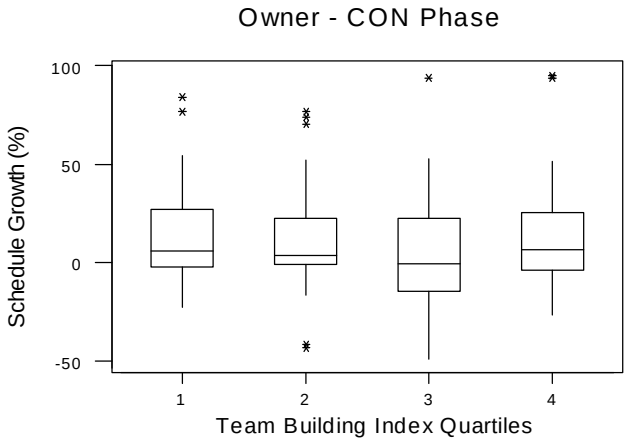

Figure 9.3.5-(2): Owners' quartile distribution for construction schedule growth.

9.3.6 Owners' Start-Up Phase Schedule Growth

The scatter plot for the owners' start-up phase in Figure 9.3.6-(1) resembles more of a shotgun pattern than a best-fit line. However, the negative slope does indicate the relationship is positive.

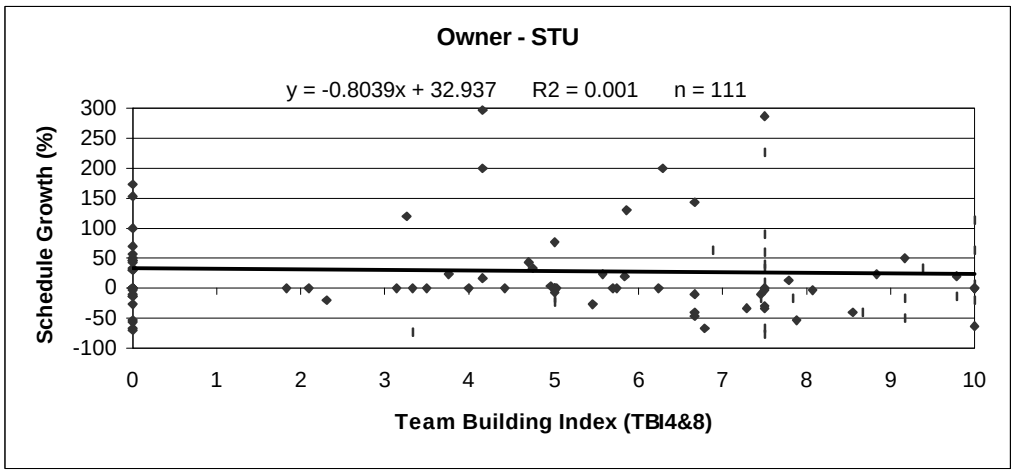

Figure 9.3.6-(1): Owners' team building index versus start-up schedule growth.

According to the Jonckheere-Terpstra Test results and observation of the whisker box-plots in Figure 9.3.6-(2), the quartiles are not ordered to indicate the existence of a positive relationship.

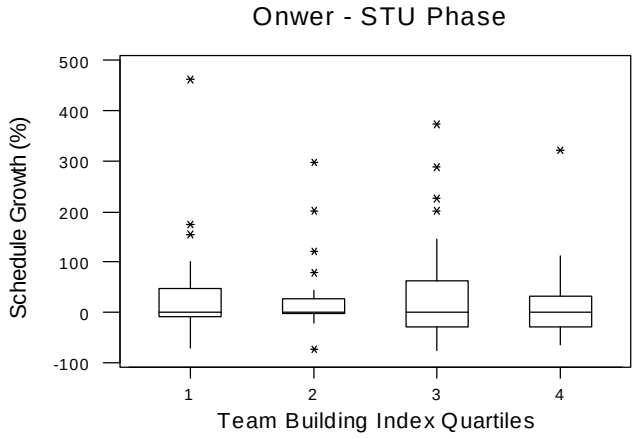

Figure 9.3.6-(2): Owners' quartile distribution for start-up schedule growth.

9.4 Contractors' Schedule Growth by Industry Group

This section and the succeeding sections represent the demographic slicing for the schedule growth analysis. Each slice is analyzed for the design, procurement, and construction phases because the information for the total project duration was not available. As previously mentioned, the scatter plots were not produced for the demographic slices of the schedule growth analysis. Whisker box-plots are only shown for those groups that pass the Jonckheere-Terpstra Test. The majority of the projects are of the heavy industrial group for all three phases analyzed.

9.4.1 Contractors' Design Phase Schedule Growth by Industry Group

As shown in Figure 9.4.1-(1), over 75% of the design phase respondents were of the heavy industrial group. The sample sizes for the other three categories were too small to substantiate a complete analysis. Design phase average schedule growth was reduced by more than 33% for those contractors who used a team building process. Likewise, the medians shown in Table 9.4.1-(1) reveal a reduction of almost 20% for the yes-group. The Wilcoxon Test indicates that a statistically significant difference exists between the medians of the yes-and-no respondents. The result of the Jonckheere-Terpstra Test indicates that the quartiles are ordered as suspected. Whisker box-plots illustrated in Figure 9.4.1-(2) support the statistical test result except for the second quartile that is skewed because of quartile adjustment. The design phase schedule growth appears to be significantly effected by the implementation of a team building process.

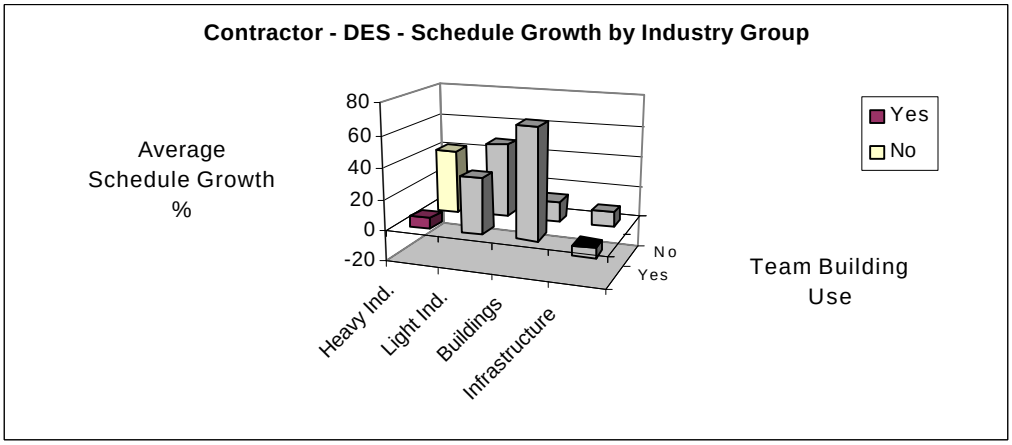

Figure 9.4.1-(1): Effect of team building on contractors' schedule growth by industry group for design phase.

Table 9.4.1-(1): Contractor statistics by industry group for design phase schedule growth.

Contractor, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	110	0	76	34	6.0695	25.832	7.4E-05	2E-06
Buildings (B)	12	.	.	.	.	.	.	.
Light Industrial (LI)	16	.	.	.	.	.	.	.
Infrastructure (I)	2	.	.	.	.	.	.	.

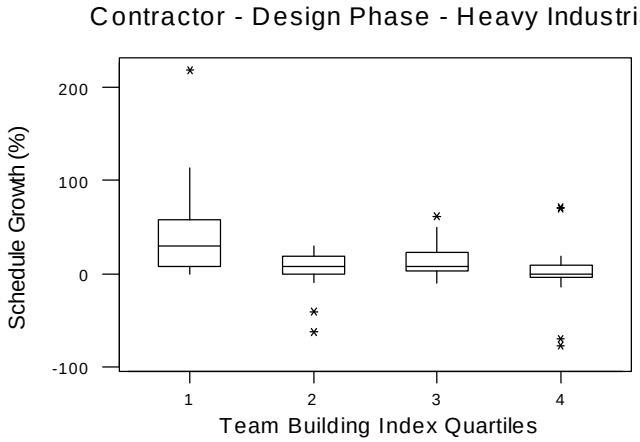

Figure 9.4.1-(2): Contractors' quartile distribution for heavy industrial schedule growth, design phase.

9.4.2 Contractors' Procurement Phase Schedule Growth by Industry Group

Similar to the design phase, the majority of the respondents for the procurement phase schedule growth were classified as heavy industrial projects. As shown in Figure 9.4.2-(1), average schedule growth is 7.7% lower for the respondents who implemented a team building process. Comparison of the medians in Table 9.4.2-(1) reveals a 4.6% reduction for the yes-group. Results of the two statistical tests were inconclusive. Effects of team building are suggested by the mean and median comparisons of the yes-group and no-group, but not supported by further investigation.

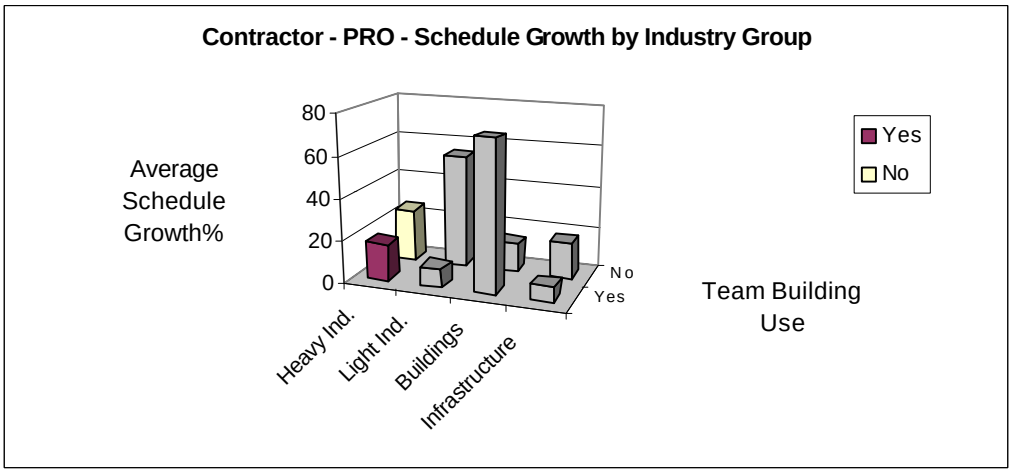

Figure 9.4.2-(1): Effect of team building on contractors' schedule growth by industry group for procurement phase.

Table 9.4.2-(1): Contractor statistics by industry group for procurement phase schedule growth.

Contractor, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	107	0	75	32	6.562	11.185	0.31165	0.1248
Buildings (B)	5	.	.	.	.	.	.	.
Light Industrial (LI)	9	.	.	.	.	.	.	.
Infrastructure (I)	3	.	.	.	.	.	.	.

9.4.3 Contractors' Construction Phase Schedule Growth by Industry Group

The majority of respondents are classified as heavy industrial projects for the contractors' construction phase. Enough responses exist for the infrastructure group to execute the analysis, but the poor results for mean and median comparisons are only supported by 23 respondents. As illustrated in Figure 9.4.3-(1), average schedule growth for the construction phase was reduced by 1.6% for those projects that implemented team building. Comparison of the medians in Table 9.4.3-(1) reveals a 5.7% reduction for the yes-group. The statistical tests fail to support a positive relationship for both the heavy industrial and infrastructure groups.

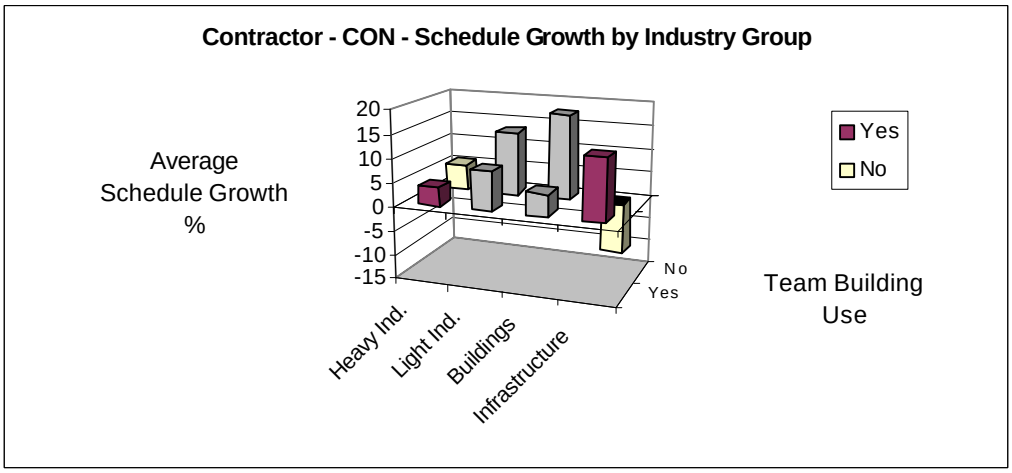

Figure 9.4.3-(1): Effect of team building on contractors' schedule growth by industry group for construction phase.

Table 9.4.3-(1): Contractor statistics by industry group for construction phase schedule growth.

Contractor, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	115	5.04E-11	74	41	0	5.696	0.25087	0.1174
Buildings (B)	17	.	.	.	.	.	.	.
Light Industrial (LI)	13	.	.	.	.	.	.	.
Infrastructure (I)	23	0.000121	16	7	1.7135	-7.474	0.06608	0.9507

9.5 Owners' Schedule Growth by Industry Group

The owners' projects were much more dispersed among the industry groups as compared to the contractors. The majority of the projects were still of the heavy industrial group, but an acceptable number of respondents were represented in the buildings and light industrial groups. Because public entities sponsoring infrastructure projects are typically not members of CII, it is not surprising that the number of infrastructure projects was low for the owner class.

9.5.1 Owners' Design Phase Schedule Growth by Industry Group

As shown in Figure 9.5.1-(1), comparison of the means reveals a distinct effect of team building on design phase average schedule growth for the heavy and light industrial groups. The comparison medians in Table 9.5.1-(1) indicates that the heavy industrial and buildings groups are positively effected by the team building process. Only the heavy industrial group shows

consistent support of the relationship for both comparisons. A reduction of 20% and 5.6% are indicated by the mean and median comparisons respectively for the heavy industrial group. The statistical tests fail to add support to the existence of the positive relationship.

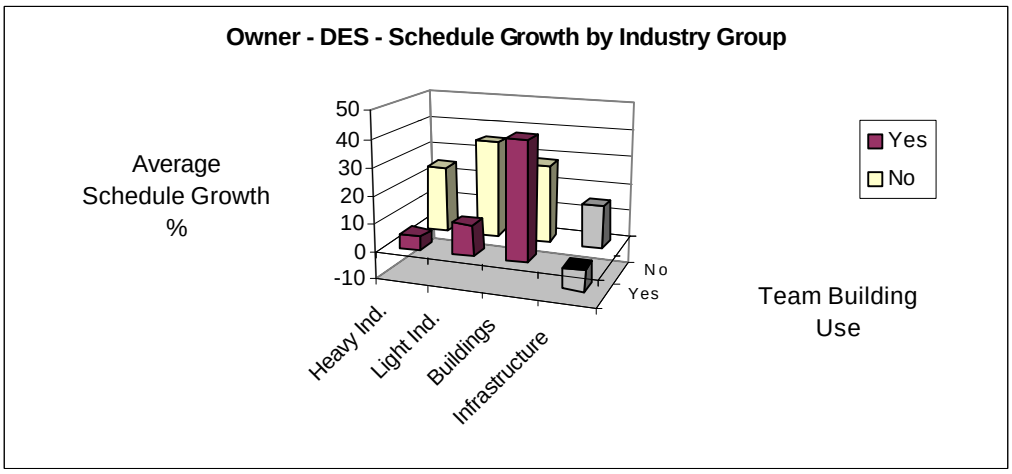

Figure 9.5.1-(1): Effect of team building on owners' schedule growth by industry group for design phase.

Table 9.5.1-(1): Owner statistics by industry group for design phase schedule growth.

Owner, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	91	4.88E-11	71	20	0	5.607	0.21797	0.1792
Buildings (B)	33	3.25E-10	24	9	18.717	33.88	0.44999	0.2551
Light Industrial (LI)	25	8.18E-05	14	11	8.76	7.957	0.60231	0.3273

9.5.2 Owners' Procurement Phase Schedule Growth by Industry Group

Both comparisons of the means and medians support a positive influence on schedule growth reduction for the owners' procurement phase. According to Figure 9.5.2-(1) and Table 9.5.2-(1), the buildings group appears to be negatively effected by the team building process. As with the owners' design phase, the majority of the respondents were of the heavy industrial group. The statistical tests are not supportive of a positive relationship between the team building process and schedule growth reduction.

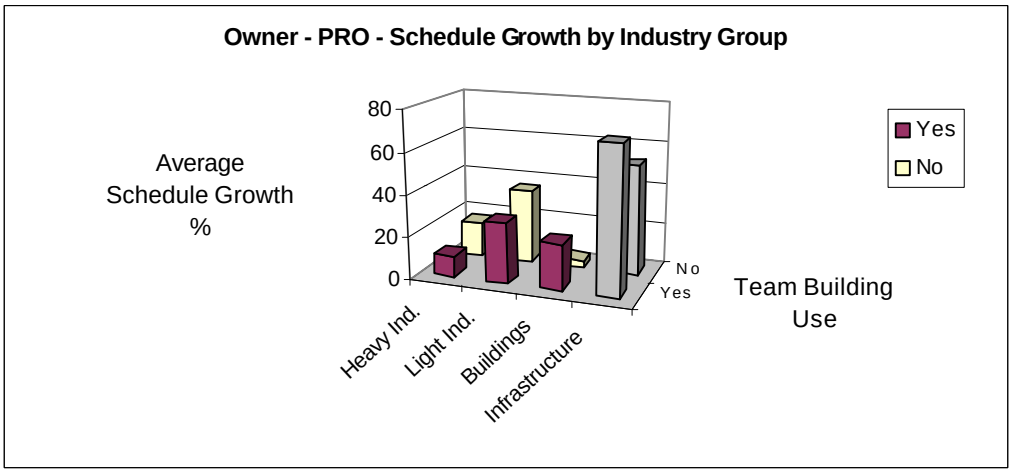

Figure 9.5.2-(1): Effect of team building on owners' schedule growth by industry group for procurement phase.

Table 9.5.2-(1): Owner statistics by industry group for procurement phase schedule growth.

Owner, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	84	0	66	18	1.3335	11.3465	0.28406	0.5963
Buildings (B)	20	9.64E-07	14	6	4.348	-5.224	0.56223	0.8441
Light Industrial (LI)	21	0.106715	14	7	16.236	22.951	0.43342	0.307

9.5.3 Owners' Construction Phase Schedule Growth by Industry Group

According to Figure 9.5.3-(1), the average schedule growth is not reduced for the heavy industrial group of the owners' construction phase. However, the average growths for the light industrial and buildings groups both indicate a substantial difference between the yes-group and no-group. Comparison of the medians in Table 9.5.3-(1) reveals a positive influence of team building on construction phase schedule growth for all of three of the groups. The statistical tests are not supportive of a positive relationship between the team building process and schedule growth reduction.

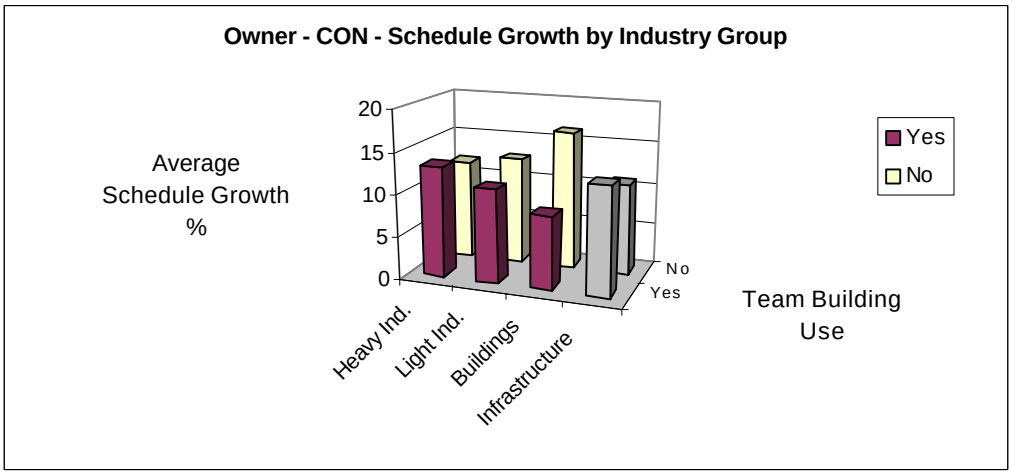

Figure 9.5.3-(1): Effect of team building on owners' schedule growth by industry group for construction phase.

Table 9.5.3-(1): Owner statistics by industry group for construction phase schedule growth.

Owner, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Heavy Industrial (HI)	95	0.024723	74	21	0	4.5455	0.20999	0.1674
Buildings (B)	31	0.125658	22	9	5.5263	13.2075	0.98264	0.708
Light Industrial (LI)	25	2.53E-05	14	11	1.9616	6.1508	0.97808	0.4407

9.6 Contractors' Schedule Growth by Project Nature

A much better distribution exists for the slicing of projects by nature than did for the industry groups. The number of respondents is well balanced among the three project types for all three of the project phases.

9.6.1 Contractors' Design Phase Schedule Growth by Project Nature

Observation of the contractors' design phase average schedule growth in Figure 9.6.1-(1) reveals a reduction of at least 22% for all three project types. The dramatic effect of team building on average schedule growth for the modernization and addition type projects is supported by the median comparison of Table 9.6.1-(1). Wilcoxon Test results indicate a statistically significant difference between the medians of the yes-and-no groups for the modernization and addition projects. The Jonckheere-Terpstra Test results reveal that the quartiles are ordered as suspected for all three of the project types. The whisker box-plots of

Figure 9.6.1-(2), Figure 9.6.1-(3), and Figure 9.6.1-(4) support the findings of the statistical test. Although each of the medians is not always decreasing with increased team building, the general trend measured by the test supports the existence of the positive relationship.

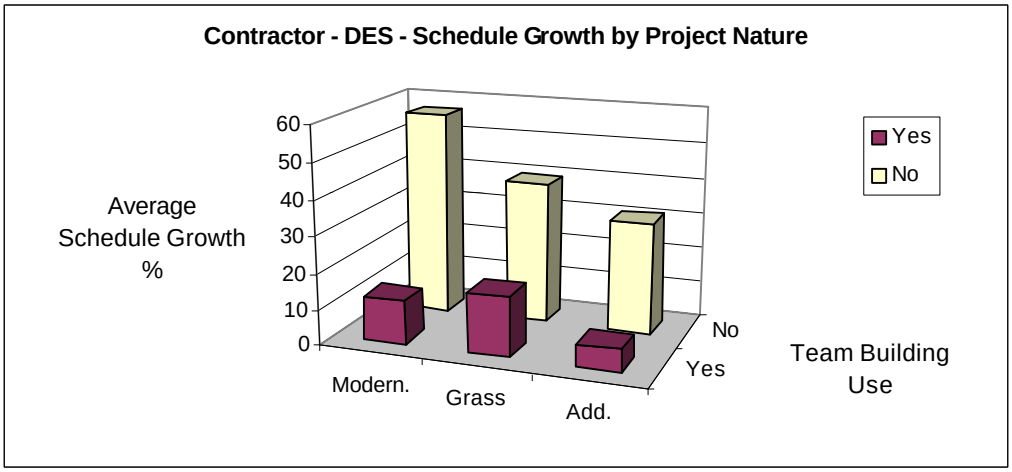

Figure 9.6.1-(1): Effect of team building on contractors' schedule growth by project nature for design phase.

Table 9.6.1-(1): Contractor statistics by project nature for design phase schedule growth.

Contractor, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	26	2.38E-05	14	12	3.3435	47.0905	0.00331	0.0106
Addition (A)	51	0.000329	32	19	6.0915	29.469	0.0415	0.0043
Grass Roots (GR)	63	6.55E-15	43	20	7.294	13.5135	0.07763	0.0337

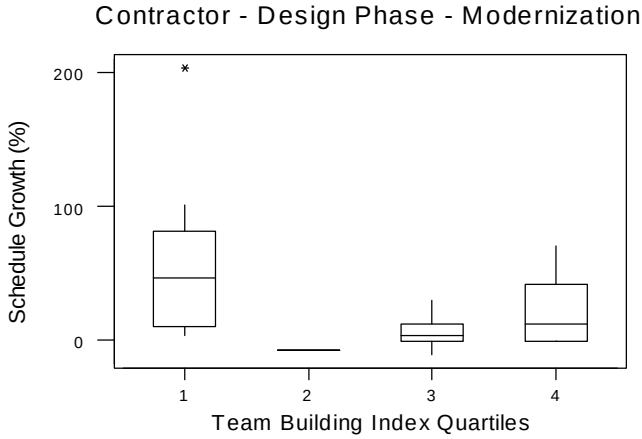

Figure 9.6.1-(2): Contractors' quartile distribution for modernization schedule growth, design phase.

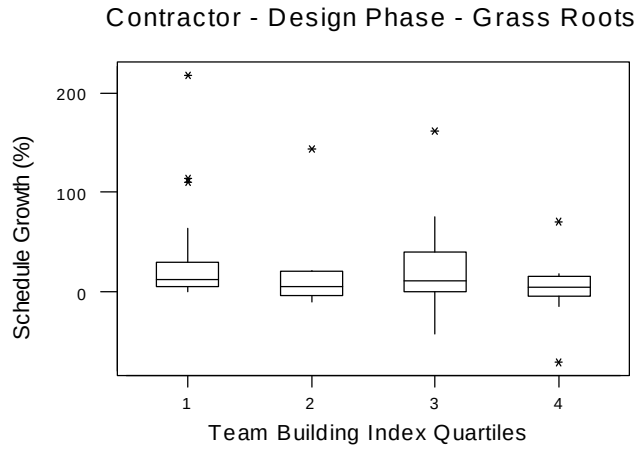

Figure 9.6.1-(3): Contractors' quartile distribution for grass roots schedule growth, design phase.

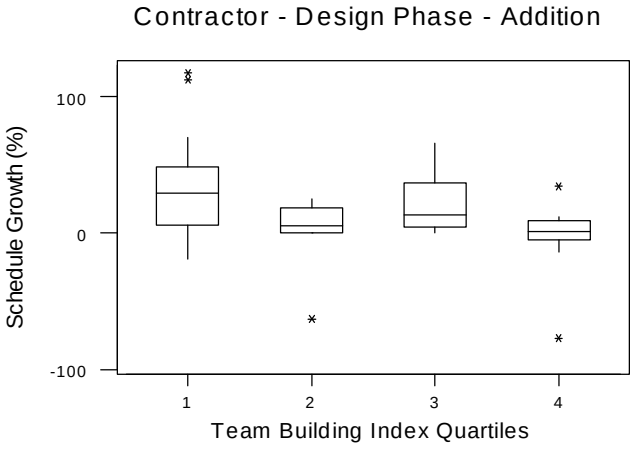

Figure 9.6.1-(4): Contractors' quartile distribution for addition schedule growth, design phase.

9.6.2 Contractors' Procurement Phase Schedule Growth by Project Nature

Team building appears to have relatively the same influence on the procurement phase average schedule growth for each of the contractors' project types. Figure 9.6.2-(1) reveals a reduction of about 10% for the contractors who implement team building regardless of the project nature. Comparison of the medians in Table 9.6.2-(1) reveals a similar result for the modernization and addition projects, but fails to support a positive relationship for the grass roots

projects. Wilcoxon Test results do not indicate that a statistically significant difference exists for any of the project types. Results of the Jonckheere-Terpstra Test suggest that the quartiles of the modernization projects are ordered. Whisker box-plots shown in Figure 9.6.2-(2) for the modernization projects illustrate the positive trend in the quartiles.

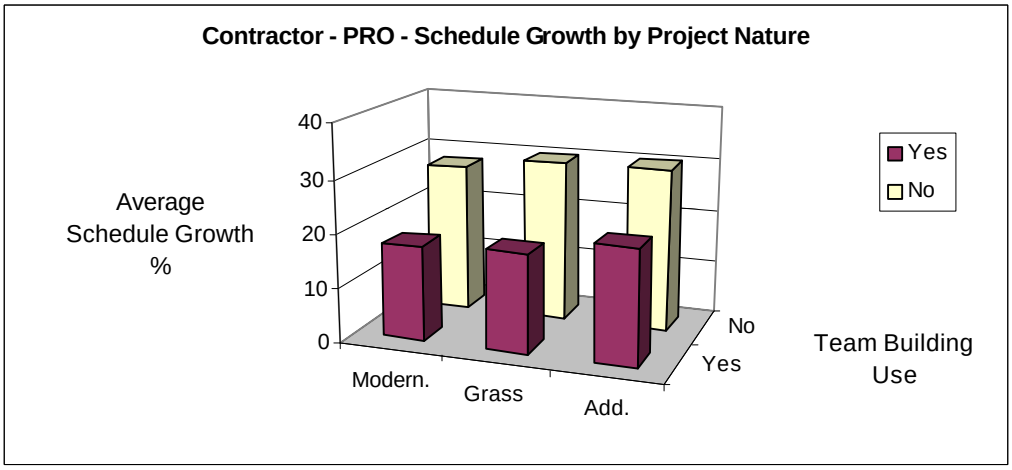

Figure 9.6.2-(1): Effect of team building on contractors' schedule growth by project nature for procurement phase.

Table 9.6.2-(1): Contractor statistics by project nature for procurement phase schedule growth.

Contractor, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	26	2.46E-06	12	14	8.6005	25.035	0.13346	0.0332
Addition (A)	44	1.82E-05	32	12	3.5835	15.422	0.25437	0.1521
Grass Roots (GR)	54	0	39	15	7.237	6.122	0.77827	0.8108

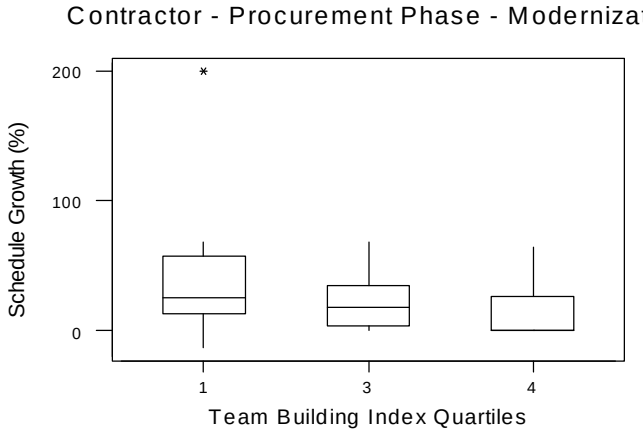

Figure 9.6.2-(2): Contractors' quartile distribution for modernization schedule growth, procurement phase.

9.6.3 Contractors' Construction Phase Schedule Growth by Project Nature

Unlike the procurement and design phases, the contractor's construction phase average schedule growth indicates mixed reactions to the implementation of team building. According to Figure 9.6.3-(1), modernization and addition projects appear to be adversely influenced, while the grass roots projects perform as expected. Comparison of the medians in Table 9.6.3-(1) reveals that team building has a negative impact on addition projects, a slight positive effect on modernization projects, and a definite improvement on grass roots projects. Wilcoxon Test results indicate that a statistically significant difference exists between medians of the yes-and-no groups for only the grass roots projects. The Jonckheere-Terpstra Test results and whisker box-plots of Figure 9.6.3-(2) indicate that increased team building reduces schedule growth for the grass roots projects.

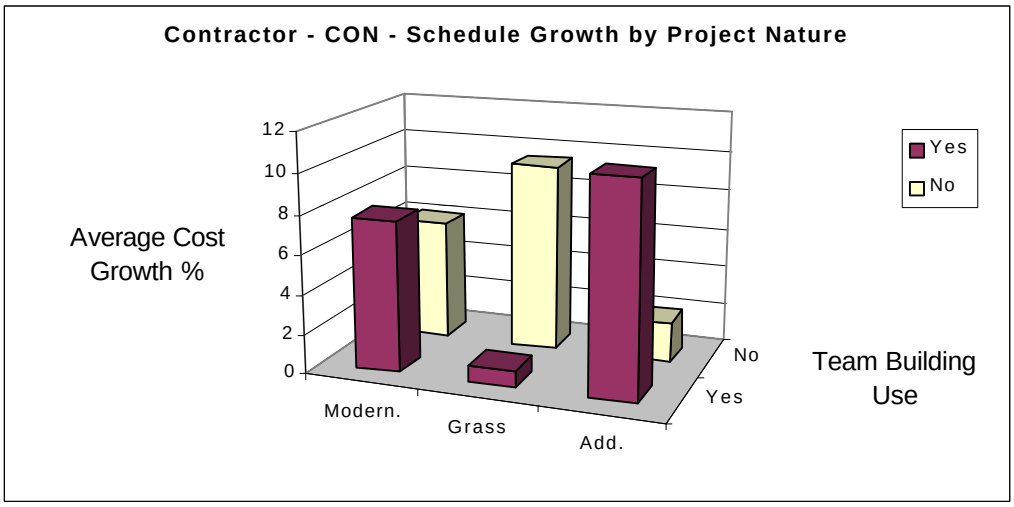

Figure 9.6.3-(1): Effect of team building on contractors' schedule growth by project nature for construction phase.

Table 9.6.3-(1): Contractor statistics by project nature for construction phase schedule growth.

Contractor, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	44	8.47E-06	21	23	3.333	5.677	0.77782	0.6841
Addition (A)	54	5.12E-10	35	19	1.548	0	0.28038	0.7908
Grass Roots (GR)	70	7.58E-06	45	25	-2.108	5.806	0.01021	0.0091

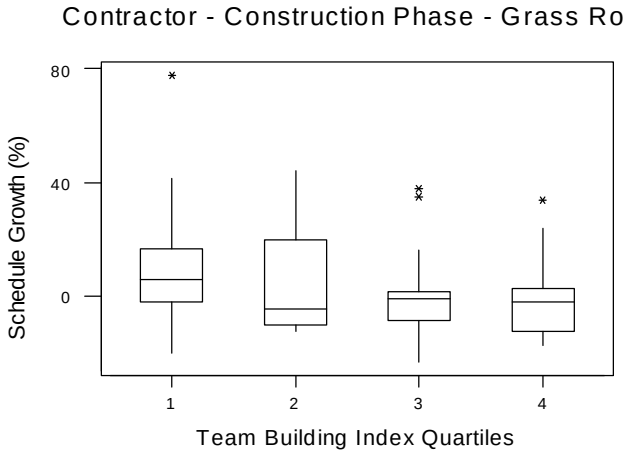

Figure 9.6.3-(2): Contractors' quartile distribution for grass roots schedule growth, construction phase.

9.7 Owners' Schedule Growth by Project Nature

The owner respondents were distributed fairly evenly among the project types for all three of the project phases analyzed. Support of the positive relationship between the use of a team building and schedule growth reduction varied for the addition, grass roots, and modernization projects.

9.7.1 Owners' Design Phase Schedule Growth by Project Nature

As shown in Figure 9.7.1-(1), team building positively influences the design phase average schedule growth for all of the owners' project types except for the grass roots projects. Comparison of the medians in Table 9.7.1-(1) reveals a positive impact of team building on all three of the project types. However, the statistical tests do not support the increased use of team building to reduce design phase schedule growth.

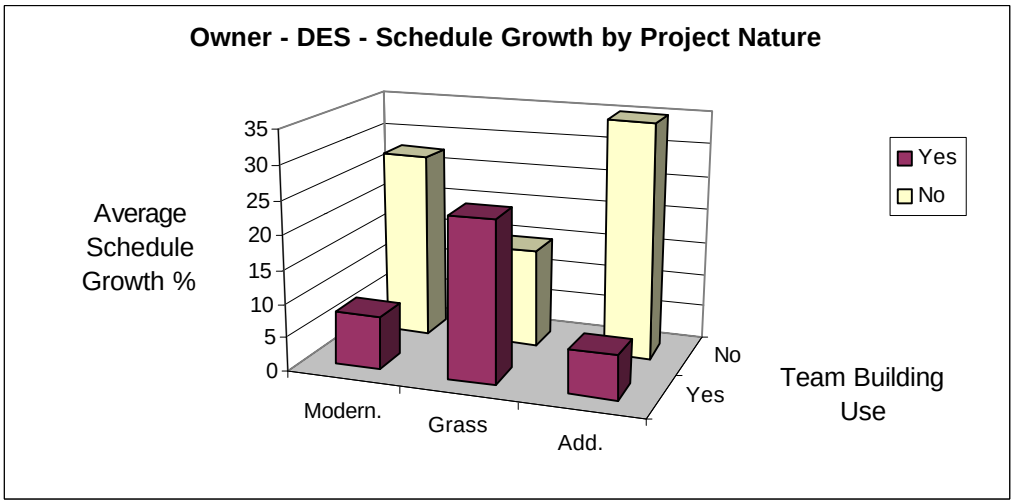

Figure 9.7.1-(1): Effect of team building on owners' schedule growth by project nature for design phase.

Table 9.7.1-(1): Owner statistics by project nature for design phase schedule growth.

Owner, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	55	0.000102	42	13	6.413	15.522	0.09342	0.2911
Addition (A)	50	2.26E-07	31	19	4.737	17.181	0.27622	0.1648
Grass Roots (GR)	54	0	40	14	0	2.201	0.44331	0.1297

9.7.2 Owners' Procurement Phase Schedule Growth by Project Nature

Like the design phase, the grass roots projects for the owners' procurement phase average schedule growth shown in Figure 9.7.2-(1) appear to be negatively impacted by the use of team building. However, the modernization and addition projects illustrate a procurement phase schedule growth reduction of 7% and 25% respectively. Comparison of the medians in Table 9.7.2-(1) supports the indications of the means. Although the difference between the medians is large for the addition projects, the Wilcoxon results do not reveal a statistically significant difference between the medians for either of the contract types. The Jonckheere-Terpstra Test and whisker box-plots of Figure 9.7.2-(2) indicate that the quartiles of the addition projects are ordered to support the positive relationship.

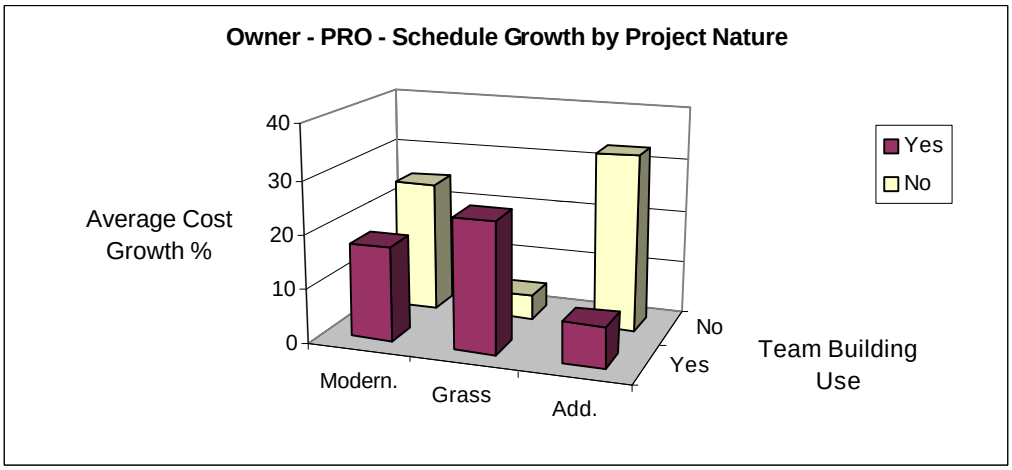

Figure 9.7.2-(1): Effect of team building on owners' schedule growth by project nature for procurement phase.

Table 9.7.2-(1): Owner statistics by project nature for procurement phase schedule growth.

Owner, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	48	7.58E-08	37	11	0	19.737	0.20443	0.1955
Addition (A)	45	2.18E-07	29	16	2.941	22.1905	0.09996	0.0331
Grass Roots (GR)	41	7.27E-14	32	9	8.9495	0.199	0.43033	0.7611

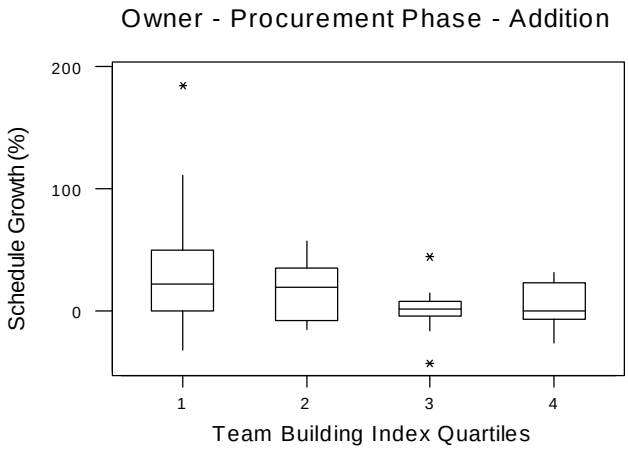

Figure 9.7.2-(2): Owners' quartile distribution for addition schedule growth, procurement phase.

9.7.3 Owners' Construction Phase Schedule Growth by Project Nature

Contrary to the contractors' design and procurement phases, the construction phase average schedule growth is shown in Figure 9.7.3-(1) to be positively influenced for all but modernization type projects. Comparison of the medians in Table 9.7.3-(1) reveals an improvement in schedule performance for all project types. Neither of the statistical tests supports the increased use of team building to reduce design phase schedule growth.

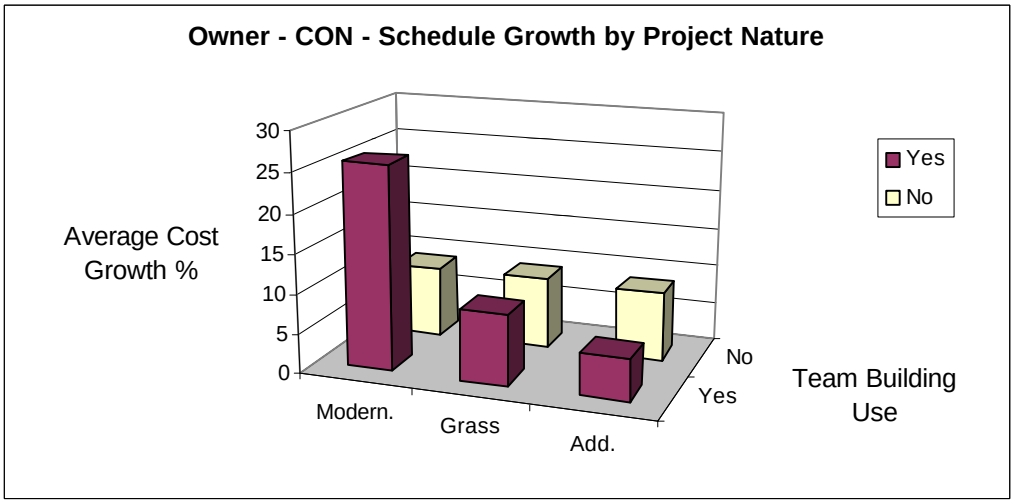

Figure 9.7.3-(1): Effect of team building on owners' schedule growth by project nature for construction phase.

Table 9.7.3-(1): Owner statistics by project nature for construction phase schedule growth.

Owner, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Modernization (M)	55	0.003244	43	12	4.2254	13.632	0.40817	0.3448
Addition (A)	53	0.014522	33	20	0	3.09705	0.44484	0.2788
Grass Roots (GR)	53	0.013476	38	15	2.8459	10.1307	0.27314	0.1313

9.8 Contractors' Schedule Growth by Remuneration

The majority of the contractors' contracts were either cost reimbursed or lump sum contracts for the design, procurement, and construction phases. Comparisons of the means and medians support the existence of a positive relationship between a team building process and schedule growth reduction for the two contract types across all three phases.

9.8.1 Contractors' Design Phase Schedule Growth by Remuneration

As illustrated in Figure 9.8.1-(1), the design phase average schedule growth for cost reimbursed contracts was more influenced by team building than for the lump sum contracts. Comparison of the medians in Table 9.8.1-(1) reinforces the suggestion that team building has a greater impact on the cost reimbursed contracts. Wilcoxon Test result indicates that a statistically significant difference exists between the medians of the yes-and-no groups for the cost reimbursed contracts. The Wilcoxon result for the design phase lump sum contracts is almost acceptable. Jonckheere-Terpstra Test results indicate that the quartiles are ordered as suspected for both contract types. Whisker box-plots of the quartiles shown in Figure 9.8.1-(2) and Figure 9.8.1-(3) illustrate the positive relationship between team building and design phase schedule growth reduction for the cost reimbursed and lump sum contracts. The second quartile, which is the only quartile not supportive of the trend, is skewed because of quartile adjustments.

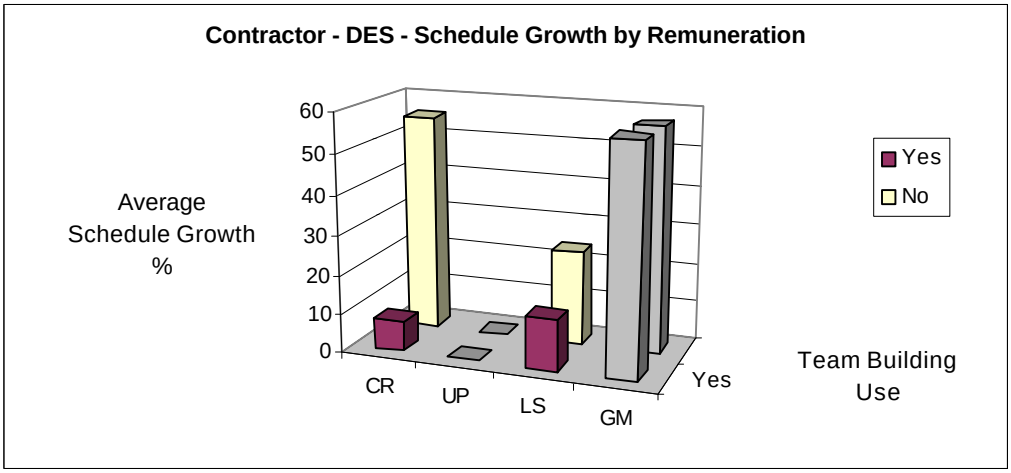

Figure 9.8.1-(1): Effect of team building on contractors' schedule growth by remuneration for design phase.

Table 9.8.1-(1): Contractor statistics by remuneration for design phase schedule growth.

Contractor, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Cost Reimbursement	83	1.67E-16	60	23	6.6205	29.781	9E-05	1E-05
Unit Price (UP)	1	.	.	.	.	.	.	.
Lump Sum (LS)	47	1E-07	23	24	4.252	9.3575	0.05021	0.0071
Guaranteed Maximum	9	.	.	.	.	.	.	.

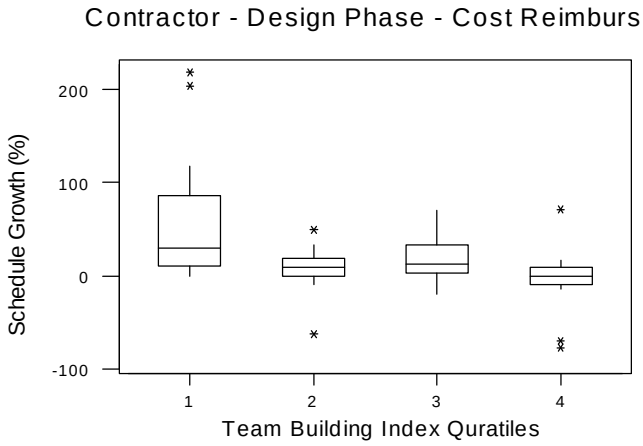

Figure 9.8.1-(2): Contractors' quartile distribution for cost reimbursed schedule growth, design phase.

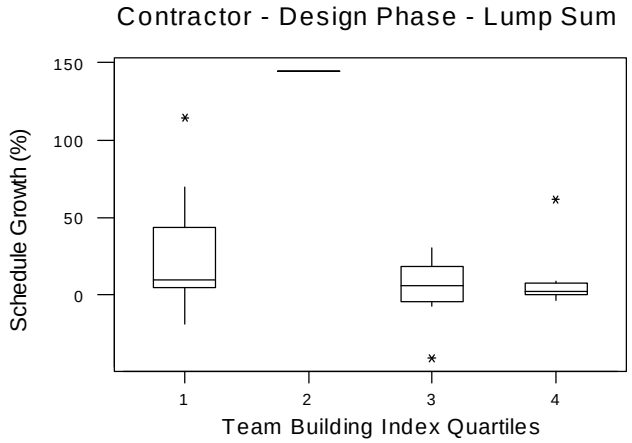

Figure 9.8.1-(3): Contractors' quartile distribution for lump sum schedule growth, design phase.

9.8.2 Contractors' Procurement Phase Schedule Growth by Remuneration

The effect of team building on average schedule growth for the procurement phase contracts shown in Figure 9.8.2-(1) appears to be relatively the same for the cost reimbursed and lump sum contracts. Comparison of the medians in Figure 9.8.2-(1) indicates that the lump sum contracts are more susceptible to the influences of team building. Wilcoxon Test results do not reveal a statistically significant difference between the yes-and-no groups for either of the two groups. The Jonckheere-Terpstra Test and whisker box-plots of Figure 9.8.2-(2) support a

positive relationship between team building and procurement phase schedule growth reduction for the lump sum contracts.

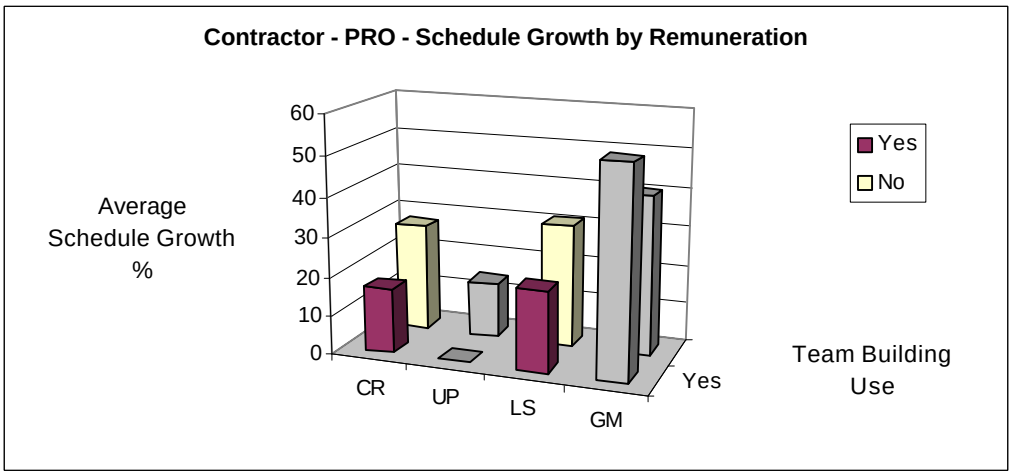

Figure 9.8.2-(1): Effect of team building on contractors' schedule growth by remuneration for procurement phase.

Table 9.8.2-(1): Contractor statistics by remuneration for procurement phase schedule growth.

Contractor, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Cost Reimbursement	78	0	56	22	8.1385	5.583	0.58704	0.3892
Unit Price (UP)	1	.	.	.	.	.	.	.
Lump Sum (LS)	39	8.06E-08	23	16	1.779	17.7945	0.10833	0.0436
Guaranteed Maximum	6	.	.	.	.	.	.	.

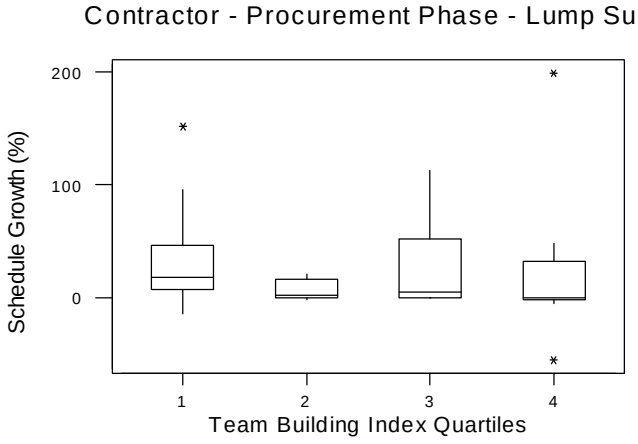

Figure 9.8.2-(2): Contractors' quartile distribution for lump sum schedule growth, procurement phase.

9.8.3 Contractors' Construction Phase Schedule Growth by Remuneration

According to Figure 9.8.3-(1), average schedule growth for the construction phase cost reimbursed contracts appears to be slightly more influenced by team building than for the lump sum contracts. This is supported by the comparison of the medians in Table 9.8.3-(1) for the yes-and-no groups. Wilcoxon Test results indicate that there is not a statistically significant difference between the medians of either contract type. The Jonckheere-Terpstra Test result reveals that the quartiles for the construction phase cost reimbursed contracts are ordered as suspected. The whisker box-plots for the cost reimbursed contracts shown in Figure 9.8.3-(2) illustrate the positive trend in the quartiles except for the second quartile that is skewed by quartile adjustments.

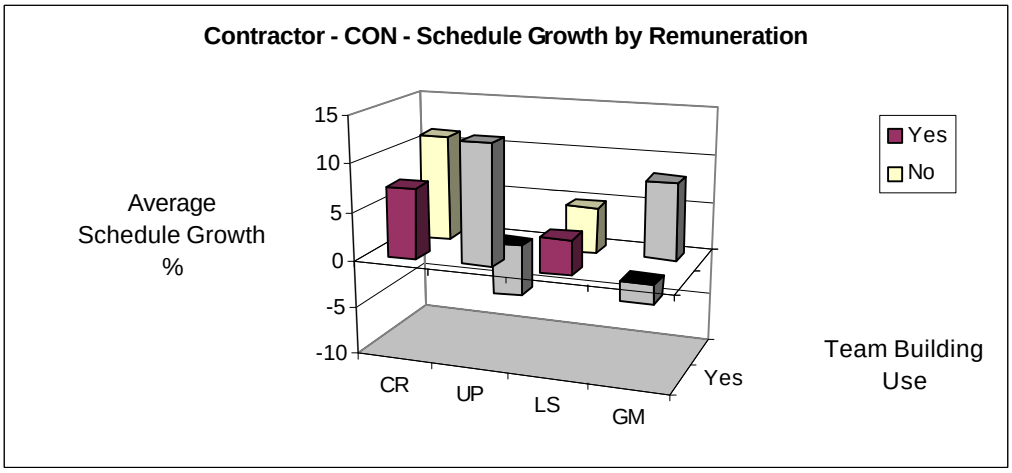

Figure 9.8.3-(1): Effect of team building on contractors' schedule growth by remuneration for construction phase.

Table 9.8.3-(1): Contractor statistics by remuneration for construction phase schedule growth.

Contractor, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Cost Reimbursement	75	1.42E-11	53	22	0	7.723	0.36672	0.0385
Unit Price (UP)	10	.	.	.	.	.	.	.
Lump Sum (LS)	72	9.67E-13	38	34	0	2.067	0.60361	0.7607
Guaranteed Maximum	10	.	.	.	.	.	.	.

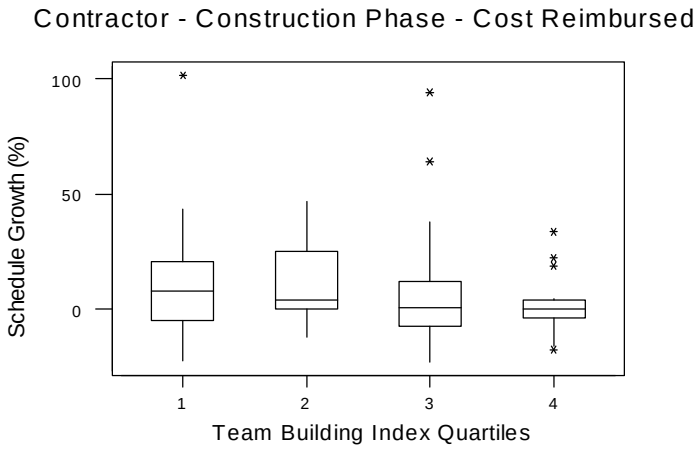

Figure 9.8.3-(2): Contractors' quartile distribution for cost reimbursed cost schedule growth, construction phase.

9.9 Contractors' Schedule Growth by Function

The majority of the contractors had the combined function of design-and-construct. As indicated by their titles, construct-only respondents did not respond for the design phase and the design-only respondents did not respond for the construction phase.

9.9.1 Contractors' Design Phase Schedule Growth by Function

According to Figure 9.9.1-(1), the design phase average schedule growth for the design-only function is much more impacted by a team building process than is the design-and-construct function. Comparison of the medians in Table 9.9.1-(1) supports the mean observation. Wilcoxon Test results indicate that there is a significant difference between the medians of the yes-and-no groups for both the design-only and design-and-construct functions. The Jonckheere-Terpstra Test results reveal that the quartiles are ordered as suspected. The whisker box-plots of Figure 9.9.1-(2) and Figure 9.9.1-(3) illustrate the positive influence of team building on the design phase schedule growth for both of the functions.

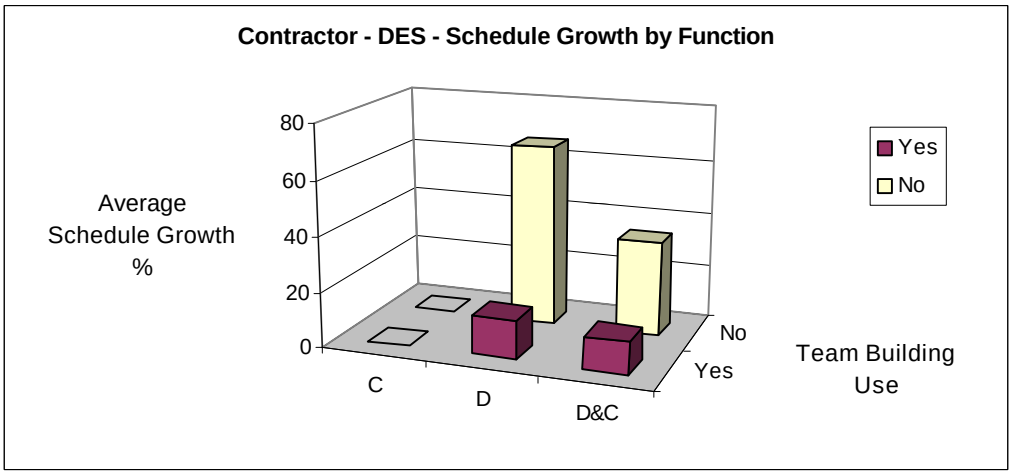

Figure 9.9.1-(1): Effect of team building on contractors' schedule growth by function for design phase.

Table 9.9.1-(1): Contractor statistics by function for design phase schedule growth.

Contractor, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Designer (D)	29	8.84E-05	20	9	7.2505	29.469	0.01514	0.0074
Builder (C)	0	.	.	.	.	.	.	.
Both (DC)	101	0	62	39	6.176	19.481	0.00246	0.0003

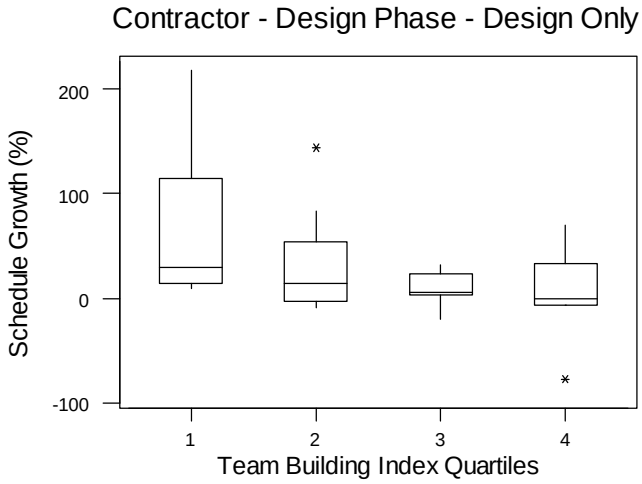

Figure 9.9.1-(2): Contractors' quartile distribution for design-only schedule growth, design phase.

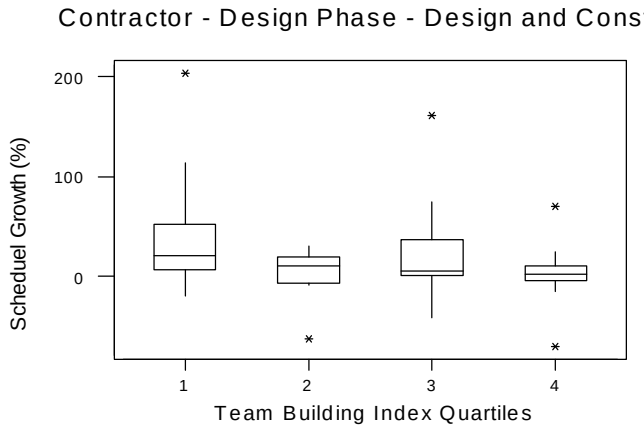

Figure 9.9.1-(3): Contractors' quartile distribution for design-and-construct schedule growth, design phase.

9.9.2 Contractors' Procurement Phase Schedule Growth by Function

Observation of Figure 9.9.2-(1) reveals that the contractors' design-only function average schedule growth for the procurement phase is much more impacted by the team building process than for the design-and-construct function. Examination of the statistical table reveals that the sample size is relatively low for the design-only contractor. Comparison of the medians in Table 9.9.2-(1) indicates that the design-and-construct group is actually more influenced by the team building process. Neither of the statistical tests supports the increased use of team building to reduce design phase schedule growth.

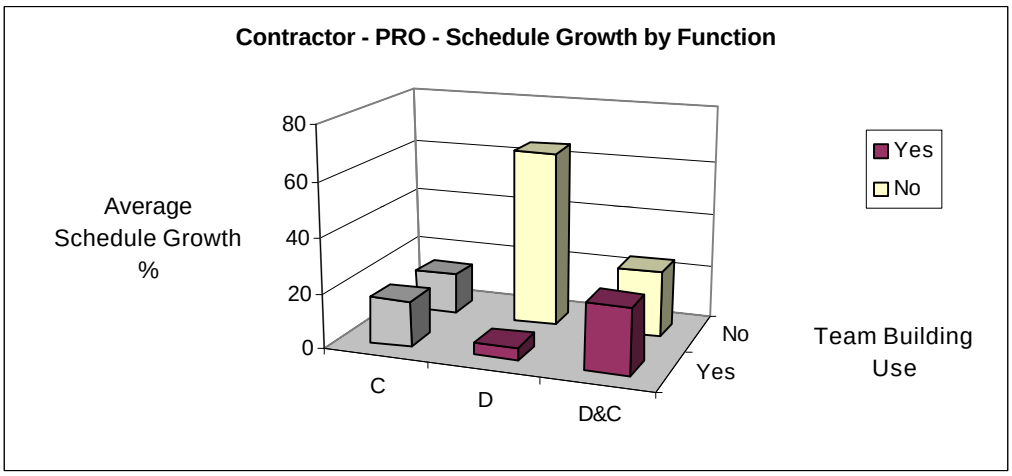

Figure 9.9.2-(1): Effect of team building on contractors' schedule growth by function for procurement phase.

Table 9.9.2-(1): Contractor statistics by function for procurement phase schedule growth.

Contractor, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Designer (D)	21	4.06E-09	15	6	6.562	11.1415	0.45662	0.1731
Builder (C)	18	.	.	.	.	.	.	.
Both (DC)	85	0	55	30	6.154	17.3105	0.08907	0.1136

9.9.3 Contractors' Construction Phase Schedule Growth by Function

The contractors' construction phase average schedule growth shown in Figure 9.9.3-(1) appears to be negatively influenced by the team building process for the construct-only function while the design-and-construct function is positively impacted. Comparison of the medians in Table 9.9.3-(1) indicates that team building reduces schedule growth for both functions. The design-and-construct function appears to be twice as susceptible to the team building process as is the construct-only function. Wilcoxon Test results do not reveal a statistically significant difference between the medians for either function. The Jonckheere-Terpstra Test result for the design-and-construct function indicates that the quartiles are ordered as suspected. Whisker box-plots of Figure 9.9.3-(2) illustrate the decreased schedule growth associated with increased use of team building for the contractor construction phase schedule growth.

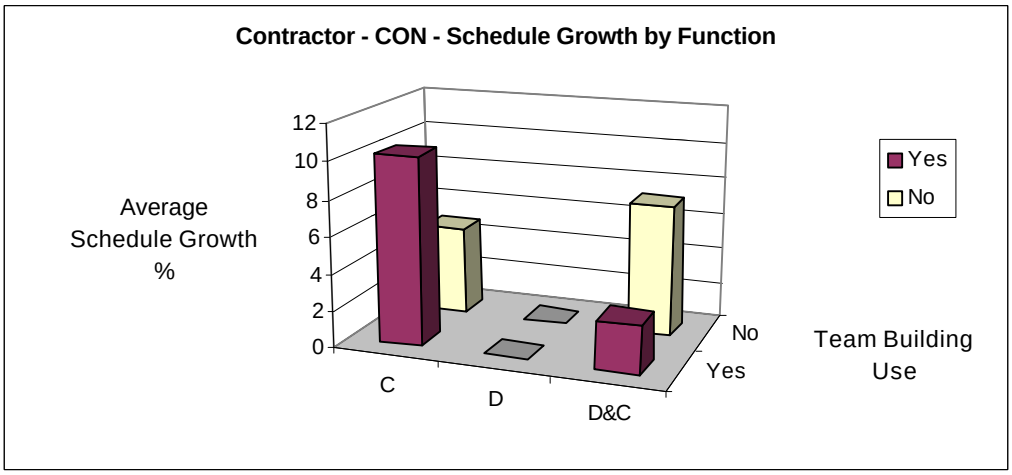

Figure 9.9.3-(1): Effect of team building on contractors' schedule growth by function for construction phase.

Table 9.9.3-(1): Contractor statistics by function for construction phase schedule growth.

Contractor, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Designer (D)	0	.	.	.	.	.	.	.
Builder (C)	67	4.65E-09	40	27	0	3.203	0.67304	0.8658
Both (DC)	101	4.72E-12	61	40	0	7.03	0.19484	0.0484

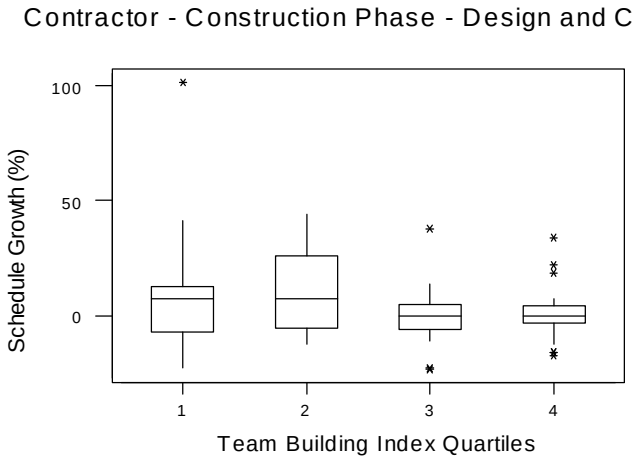

Figure 9.9.3-(2): Contractors' quartile distribution for design and construct schedule growth, construction phase.

9.10 Contractors' Schedule Growth by Cost Category

The contractors' projects are distributed relatively evenly among the cost categories for the three phases. The majority of the projects are in one of the two cost categories below $50 million.

9.10.1 Contractors' Design Phase Schedule Growth by Cost Category

As shown in Figure 9.10.1-(1), the contractors' design phase average schedule growth is positively influenced by the use of team building for all four cost categories. Projects costing between $15 and $50 million had a reduction in average schedule growth over 70%. Comparison of the medians in Table 9.10.1-(1) also indicates a strong influence of team building on this category. Wilcoxon Test results indicate that the $15 to $50 million category is the only group to have a statistically significant difference between the medians. Jonckheere-Terpstra Test results reveal that the quartiles are ordered for the $15 to $50 million and $50 to $100 million cost categories. Whisker box-plots of the two categories shown in Figure 9.10.1-(2) and Figure 9.10.1-(3) support the findings except for the second quartile that is skewed because of quartile adjustments.

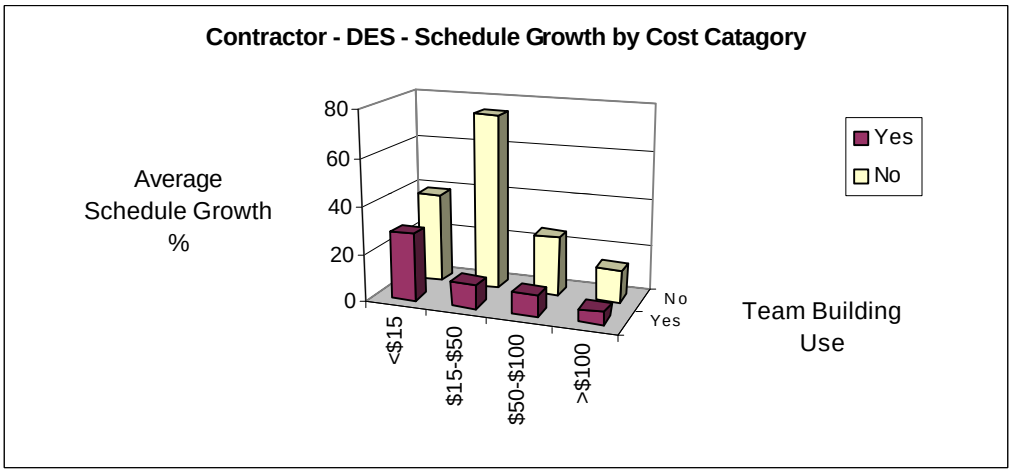

Figure 9.10.1-(1): Effect of team building on contractors' schedule growth by cost category for design phase.

Table 9.10.1-(1): Contractor statistics by cost category for design phase schedule growth.

Contractor, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	39	1.18E-05	14	25	18.798	17.143	0.7363	0.2875
$15-$50 million	43	4.02E-06	32	11	7.357	68.485	0.00047	0.0002
$50-$100 million	27	0.001619	18	9	5.8585	12.766	0.10466	0.0141
>$100 million	31	0.001054	25	6	2.237	6.1035	0.22039	0.4648

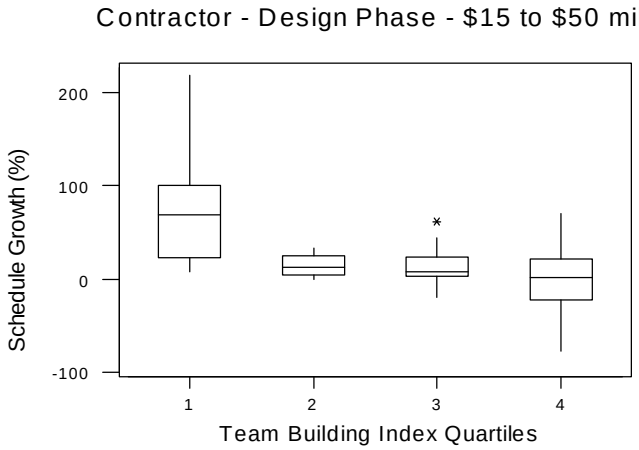

Figure 9.10.1-(2): Contractors' quartile distribution for $15 to $50 mill. project schedule growth, design phase.

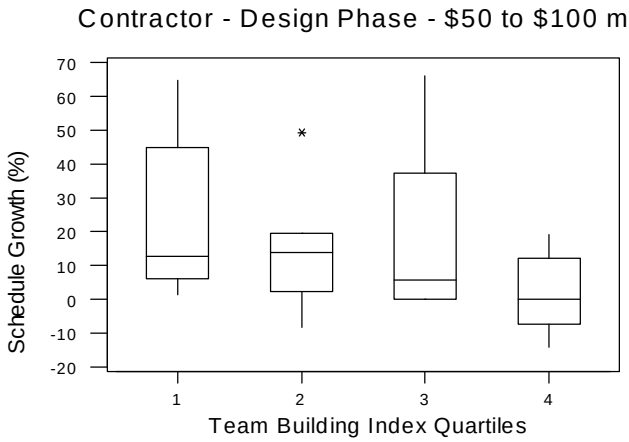

Figure 9.10.1-(3): Contractor's quartile distribution for $50 to $100 mill. project schedule growth, design phase.

9.10.2 Contractors' Procurement Phase Schedule Growth by Cost Category

Mixed effects of team building are apparent for the contractors' procurement phase average schedule growth shown in Figure 9.10.2-(1). Only the $15 to $50 million projects appear to be positively effected by the team building process. Comparison of the medians I in Table 9.10.2-(1) suggests that the $50 to $100 million category procurement phase schedule growth is also improved by the use of team building. Wilcoxon Test results fail to indicate that any of the cost categories posses a statistically significant difference between the medians of the yes-and-no groups. The Jonckheere-Terpstra Test and whisker box-plots of Figure 9.10.2-(2) reveal that the quartiles are ordered as suspected for the $15 to $50 million projects.

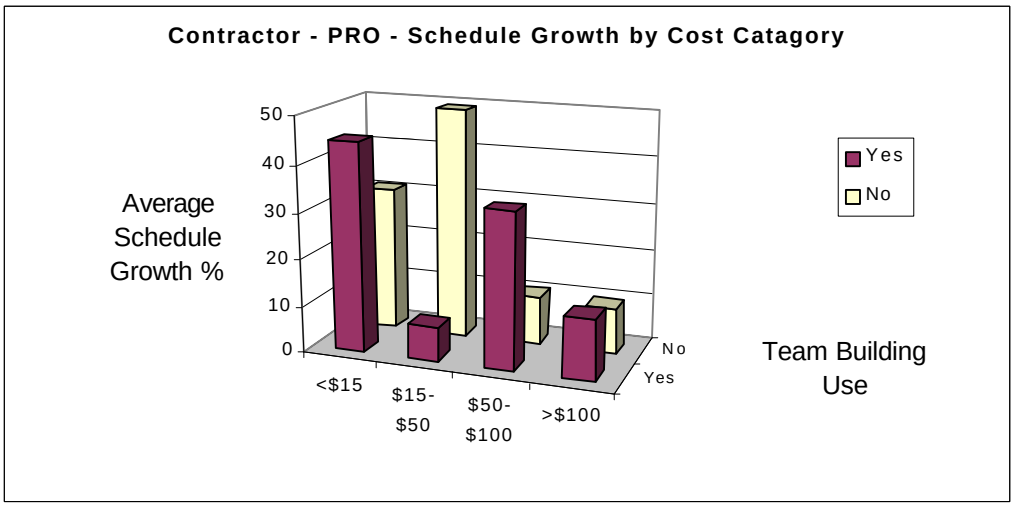

Figure 9.10.2-(1): Effect of team building on contractors' schedule growth by cost category for procurement phase.

Table 9.10.2-(1): Contractor statistics by cost category for procurement phase schedule growth.

Contractor, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	27	7.56E-05	10	17	22.703	22.283	0.82114	0.7046
$15-$50 million	42	9.99E-16	31	11	3.106	16.423	0.16586	0.0221
$50-$100 million	25	0.15312	17	8	6.601	10.2715	0.97651	0.5194
>$100 million	30	3.37E-08	25	5	4.976	4.251	0.86659	0.837

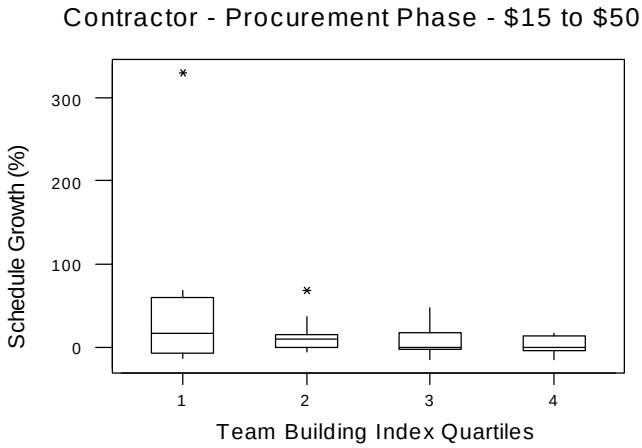

Figure 9.10.2-(2): Contractors' quartile distribution for $15 to $50 mill. project schedule growth, procurement phase.

9.10.3 Contractors' Construction Phase Schedule Growth by Cost Category

As illustrated in Figure 9.10.3-(1), team building appears to improve the contractors' construction phase average schedule growth for all of the cost categories except for projects costing between $50 to$100 million. Comparison of the medians in Table 9.10.3-(1) supports the indications of the means. Neither of the statistical tests supports the increased use of team building to reduce design phase schedule growth for any of the cost categories.

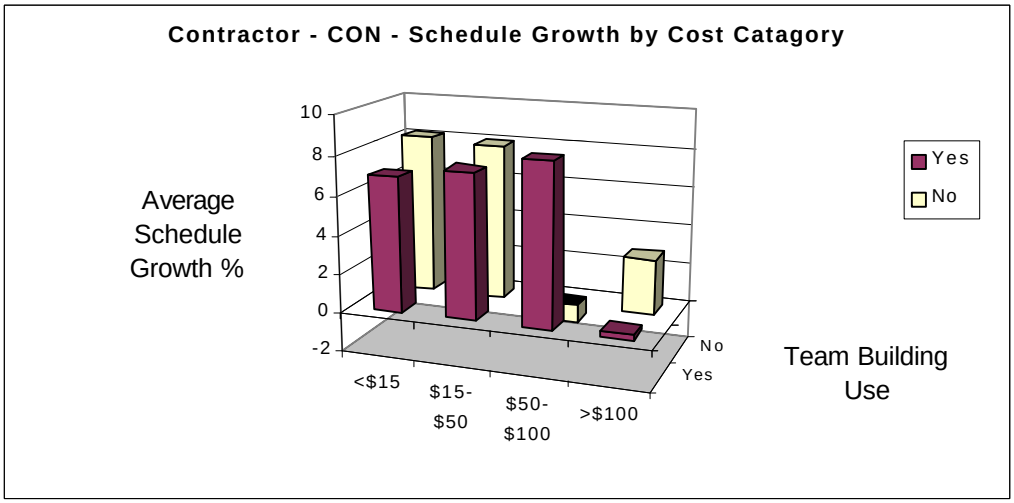

Figure 9.10.3-(1): Effect of team building on contractors' schedule growth by cost category for construction phase.

Table 9.10.3-(1): Contractor statistics by cost category for construction phase schedule growth.

Contractor, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	50	8.26E-06	18	32	0.7555	5.541	0.36307	0.2798
$15-$50 million	55	2.48E-09	37	18	0	7.723	0.31754	0.1228
$50-$100 million	27	0.141584	18	9	3.7745	-5.47	0.06769	0.9607
>$100 million	36	0.049059	28	8	-0.3	4.735	0.50537	0.2146

9.11 Owners' Schedule Growth by Cost Category

The owners' sample size is relatively small for the greater than $100 million cost category for all three of the phases. Like the contractors' cost category, the majority of the owners' projects were in one of the categories below $50 million.

9.11.1 Owners' Design Phase Schedule Growth by Cost Category

Observation of the design phase average schedule growth in Figure 9.11.1-(1) reveals that both categories below $50 million are improved by the team building process. Comparison of the medians in Table 9.11.1-(1) supports the indications from the means. Wilcoxon Test results do not support a statistically significant difference between the medians for any of the categories. The Jonckheere-Terpstra Test and whisker box-plots of Figure 9.11.1-(2) indicate that the quartiles for the projects costing less than $15 million are ordered as expected.

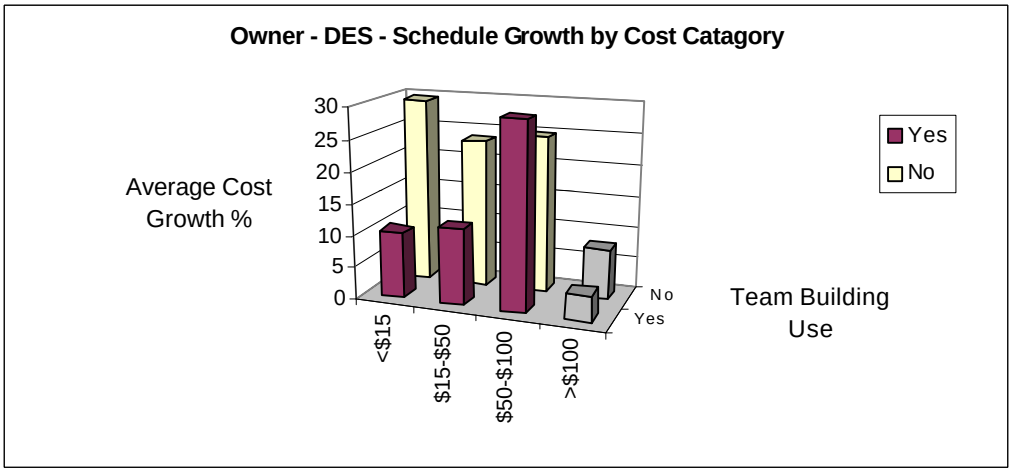

Figure 9.11.1-(1): Effect of team building on owners' schedule growth by cost category for design phase.

Table 9.11.1-(1): Owner statistics by cost category for design phase schedule growth.

Owner, DES:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	66	1.32E-06	40	26	5.9635	24.253	0.0853	0.0473
$15-$50 million	50	2.61E-07	36	14	3.107	10.045	0.76746	0.6192
$50-$100 million	24	1.04E-08	19	5	5.484	0.22	1	.
>$100 million	19	.	.	.	.	.	.	.

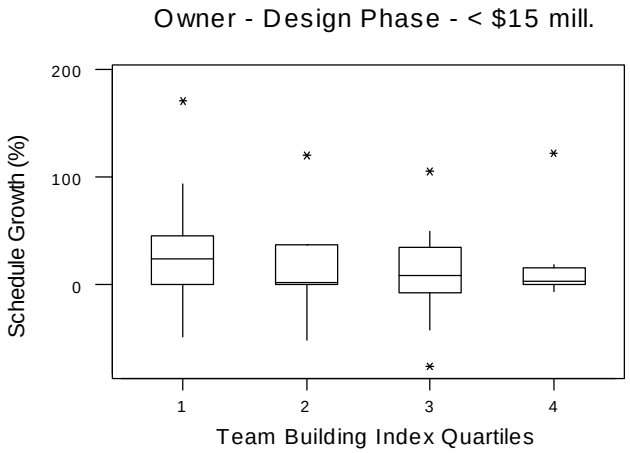

Figure 9.11.1-(2): Owners' quartile distribution for < $15 mill. project schedule growth, design phase.

9.11.2 Owners' Procurement Phase Schedule Growth by Cost Category

As illustrated in Figure 9.11.2-(1), the owners' procurement phase average schedule growth for the projects costing less than $15 million is improved by the use of a team building process. Comparison of the medians in Table 9.11.2-(1) supports this observation and suggests that the $50 to $100 million category is also improved. Neither of the statistical tests supports the increased use of team building to reduce the design phase schedule growth.

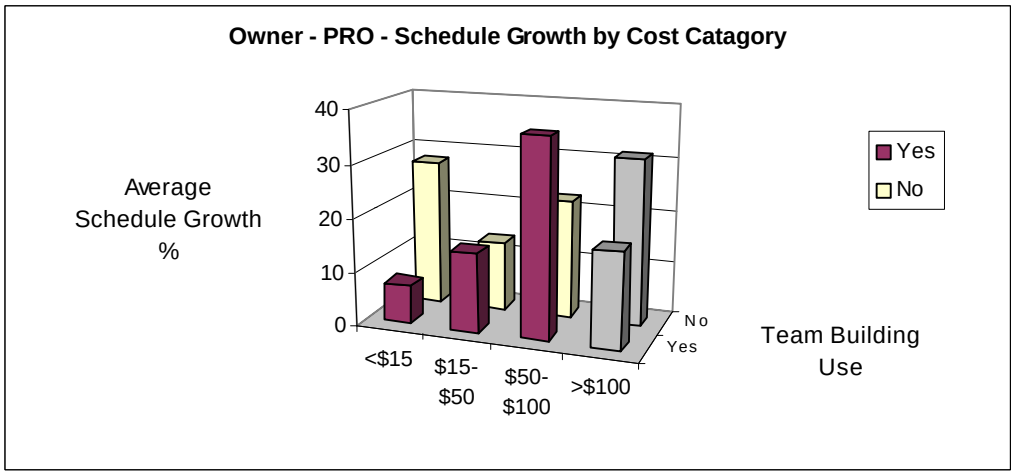

Figure 9.11.2-(1): Effect of team building on owners' schedule growth by cost category for procurement phase.

Table 9.11.2-(1): Owner statistics by cost category for procurement phase schedule growth.

Owner, PRO:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	55	3.4E-08	34	21	0	19.737	0.07817	0.2058
$15-$50 million	39	1.83E-09	30	9	4.24	0.415	0.98662	0.665
$50-$100 million	23	6.02E-07	18	5	12.337	22	0.76554	0.4239
>$100 million	17	.	.	.	.	.	.	.

9.11.3 Owners' Construction Phase Schedule Growth by Cost Category

Projects costing between $15 and $50 million are the only group in Figure 9.11.3-(1) representing an improvement in the owners' construction phase average schedule growth associated with the use of team building. According to the medians in Table 9.11.3-(1), the $50 to $100 million projects are the only projects not improved by the team building process. Neither of the statistical tests supports the increased use of team building to reduce design phase schedule growth.

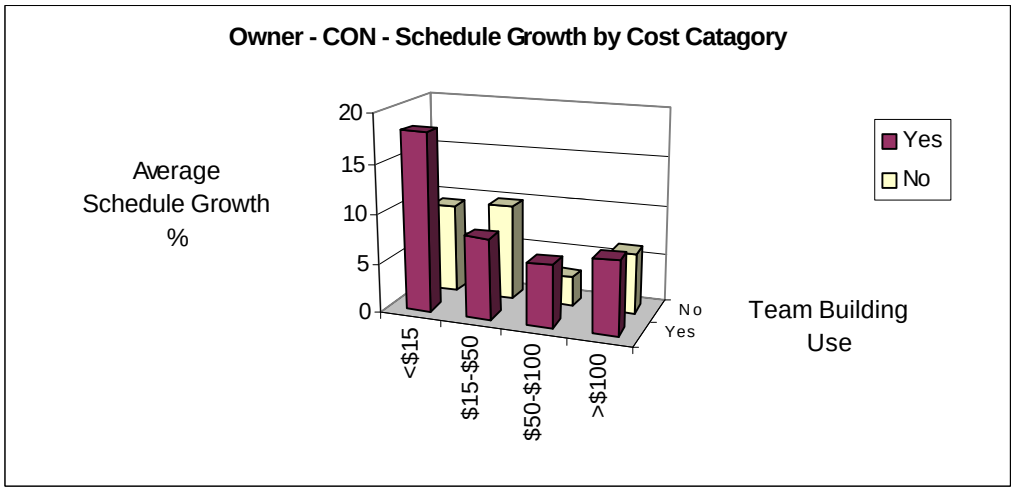

Figure 9.11.3-(1): Effect of team building on owners' schedule growth by cost category for construction phase.

Table 9.11.3-(1): Owner statistics by cost category for construction phase schedule growth.

Owner, CON:	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
<$15 million	66	0.003438	40	26	0	12.282	0.07068	0.0625
$15-$50 million	50	0.00724	35	15	4.936	5.0909	0.96618	0.394
$50-$100 million	25	0.396155	20	5	9.0787	0	0.23358	0.5863
>$100 million	20	0.000103	19	1	0.2347	6.1508	0.86232	.

Chapter 10 - Summary of Cost Growth Analysis Results

10.1 Overview

The results summary chapter was included to summarize the findings of the cost growth analysis. Included at the end of this chapter are Table 10.1-(1) and Table 10.1-(2) that summarize the cost growth analysis for the contractors and owners respectively. A summary of the statistical test results for the cost growth analysis is included in Appendix C. Both positive and negative results are included to fully represent the actual results. All of the statements made are supported in chapter 9. The following sections represent the summarized analysis results for each of the subsets.

10.2 Total Cost Growth

Analysis of the relationship between team building and total cost growth revealed a differing effect for the contractor and owner. The contractors' average cost growth is more effected by the influences of team building than is the owners' average cost growth. This is partially the case because the overall average cost growth for the contractor is about 10% higher than the overall average cost growth for the owner. According to the best-fit line of the scatter plots, a cost growth reduction of 17% and 4.3% are possible with an increase from 0 to 10 in the team building index for the contractor and owner respectively. The Wilcoxon Test for the contractor indicates that a statistical difference exists between the medians of those that did and did not implement the team building process. The Jonckheere-Terpstra Test for the contractors indicates that the quartiles are ordered to support a positive relationship between team building and cost growth reduction. Because the differences are much less for the owner, the statistical test results are less conclusive.

10.3 Contractor Phases

Separating the contractors' cost growth by phases yielded mixed results. Comparison of the average project phase cost growths for those who did and did not implement the process revealed both positive and negative influences. However, comparisons of the medians point to

the existence of a positive relationship for all of the phases. The Wilcoxon Test did not indicate a statistically significant difference between any of the medians. The design phase scatter plot reveals a prominent influence of team building on cost growth reduction associated with the best-fit line. A 21.5% decrease in design phase cost growth occurs with an increase from 0 to 10 in the team building index. Visual observation of the design phase scatter plot reveals a trend of decreasing variability with increased use of team building. The Jonckheere-Terpstra Test for the design phase indicates that the quartiles are ordered to support the positive relationship. The analysis of the start-up phase scatter plot implies that a tremendously strong relationship exists between team building and start-up cost growth reduction. Because of the low sample size, further investigation of the start-up phase is warranted before stern conclusions can be drawn.

10.4 Owner Phases

The owner is typically involved in almost all phases of the construction project. Therefore, it is of no surprise that the number of responses for each of the phases is much higher for the owner than for the contractor. Average cost growth comparisons for the owner were much more supportive of the positive relationship than for the contractor. Comparison of the medians also supports the positive relationship, but the Wilcoxon Test results do not reveal a statistically significant difference between the medians of those who implement and those who do not implement the process. Slopes of the best-fit lines for the scatter plots indicate a strong relationship between team building and cost growth reduction for the pre-project planning and construction phases. Only the pre-project planning phase is supported with a positive result for the Jonckheere-Terpstra Test. It should be noted that the slopes of the best-fit lines for the design and start-up phases are much flatter for the owner than for the contractor.

10.5 Contractor Industry Groups

The primary focus of this subset was on the heavy industrial group because about 70% of the respondents in the contractor class were of this group. Average cost growth was reduced by 50% for the heavy industrial projects that implemented a team building process. The medians were drastically reduced and the Wilcoxon Test results support a statistically significant

difference between the groups who did and did not implement the process. The best-fit line of the scatter plot for the heavy industrial group indicates a 27.2% possible reduction in cost growth associated with an increase from 0 to 10 in the team building index. Decreased variability is also associated with increased use of team building on the scatter plot. The Jonckheere-Terpstra Test reveals that the quartiles are ordered as suspected.

10.6 Owner Industry Groups

The owner projects were more distributed across the industry groups except for the infrastructure group whose sample size was still too small for analysis. Average cost growth for the heavy industrial, light industrial, and buildings groups were obviously reduced, but not near as much as was the contractor class. This is not surprising because the owner class typically has a much smaller cost growth. Comparison of the medians for the three groups supports a mild relationship, but a statistically significant difference is not indicated by the Wilcoxon Test results. It was noticed that the owners' heavy industrial group used team building to a much higher extent than most other subsets. The owners' subset for projects costing over $100 million, which probably contains many of the same projects as the heavy industrial group, was the only subset that rivaled the high extent of use of the team building process. On the contrary, the light industrial group appeared to implement a much lower degree of team building use.

10.7 Contractor Project Nature

Modernization type projects did not distinctly illustrate a positive relationship in the comparison of the means and medians. However, the comparison of means and medians for both the grass roots and modernization type projects support the positive relationship. According to the Wilcoxon Test, a statistically significant difference exists between the medians for both groups. The slopes of the best-fit lines for the scatter plots indicate a positive relationship for all three of the project types. Jonckheere-Terpstra Test results indicate that the quartiles of the grass roots and addition type projects are ordered. The contractors' addition type projects were noticeably susceptible to the positive influence of the team building process. The slope of the

best-fit line for the addition projects scatter plot is unquestionably the steepest for any significant sample size in the cost growth analysis.

10.8 Owner Project Nature

The use of team building appeared to reduce the average cost growth for all of the owners' project types. The grass roots type projects have a much more dramatic reduction than the other two types. Comparison of the medians for those who used and did not use the team building process mimicked the effects of team building on average cost growth. The Wilcoxon Test results did not reveal any significant difference between the medians. According to the Jonckheere-Terpstra Test, the quartiles were not ordered as suspected.

10.9 Contractor Remuneration

Slicing of the contractors' projects by contract type revealed that most of the contracts were either cost reimbursed or lump sum. Therefor, the cost growth analysis was limited to the cost reimbursed and lump sum contract types. The average cost growth was reduced by about 10% for the cost reimbursed contracts while the lump sum contracts were uneffected by the team building process. Median comparisons supported these findings, but did indicate that the lump sum projects were slightly effected by the team building process. The Wilcoxon Test results indicate that there is a statistically significant difference between the medians for the cost reimbursed contracts. The scatter plot for the cost reimbursed contracts also indicates a strong relationship between the use of a team building process and cost growth reduction. According to the best-fit line, a 27.3% reduction in cost growth is possible with an increase from 0 to 10 in the team building index. Only the contractors' addition group has a steeper slope for the best-fit line. The Jonckheere-Terpstra Test results indicate that the quartiles are ordered correctly for the cost reimbursed contract types.

10.10 Contractor Function

Comparison of the means and medians of the contractors' functions had mixed results. However, the design-only function cost growth values were consistent for both comparisons.

The mean and median was reduced by more than 20% for the contractors' design-only function. The Wilcoxon Test results indicate a statistically significant difference between the medians of the design-only function. Caution is warranted in the interpretation of the scatter plot because the design-only function sample size is somewhat small. The best-fit line for the design-only function reveals almost a 50% reduction in cost growth associated with an increase from 0 to 10 in the team building index. Jonckheere-Terpstra Test results for the design-only function indicate that the quartiles are ordered. Although the indications for the design-only function are tremendously supportive of the positive relationship, stern conclusions should not be made until the sample size is improved.

10.11 Contractor Cost Category

The average cost growth was positively influenced by the use of team building for all but the cost growth category for projects less than $15 million. Comparison of the medians indicates a similar effect for the cost categories. The scatter plot for the less than $15 million category reveals a lack of data points for the higher team building indexes which may explain the unusual results of the mean and median comparisons. Wilcoxon Test results indicate that there is a statistically significant difference in the medians for the $15 to $50 million cost category. Likewise, the Jonckheere-Terpstra Test results indicate the quartiles are ordered for this category.

10.12 Owner Cost Category

The mean and median comparisons for the owners' cost categories reveals a positive influence of team building for all but the $15 to $50 million category. Wilcoxon Test results indicate that the difference between the medians is not statistically significant for any of the cost categories. The slope of the scatter plot’s best-fit line for the $15 to $50 million cost category is positive indicating a negative relationship between the team building process and cost growth reduction. This is the only slope out of 42 subsets that indicated a negative relationship. The scatter plots for the other cost categories poses slopes more typical of the owners' total cost growth analysis. It should be noted that the owners' projects costing greater than $100 million appeared to have the highest degree of use of the team building process.

Table 10.1-(1): Summary of Contractors' Cost Growth Analysis.

	Does the **Mean** indicate a **positive relationship**?	Does the **Median** indicate a **positive relationship**?	Are the **Medians statistically different** at a 95% confidence interval according to the **Wilcoxon Test**?	Is the **extent of use of team building positively correlated to cost growth reduction according** to the **Jonckheere-Terpstra Test?**
CONTRACTOR:				
Cost Growth				
Total Cost Growth	YES	YES	YES	YES
Phases				
Pre-Project Planning	YES	NO	NO	NO
Design	YES	YES	NO	YES
Procurement	YES	YES	NO	NO
Demolition	NA	NA	NA	NA
Construction	YES	YES	NO	NO
Start-Up	NO	YES	NO	NO
Slices				
Industry Group				
Heavy Industrial	YES	YES	YES	YES
Buildings	NA	NA	NA	NA
Light Industrial	NA	NA	NA	NA
Infrastructure	NO	NO	NO	NO
Project Nature				
Modernization	NO	YES	NO	NO
Addition	YES	YES	YES	YES
Grass Roots	YES	YES	YES	YES
Remuneration				
Cost Reimbursed	YES	YES	YES	YES
Unit Price	NA	NA	NA	NA
Lump Sum	YES	YES	NO	NO
Guaranteed Maximum	NA	NA	NA	NA
Function				
Construct-Only	YES	NO	NO	NO
Design-Only	YES	YES	YES	YES
Design-and-Construct	NO	YES	YES	YES
Cost Category				
< $15 Million	NO	NO	NO	NO
$15 to $50 Million	YES	YES	YES	YES
$50 to $100 Million	YES	YES	NO	NO
> $100 Million	YES	YES	NO	YES

NA - Not Addressed

Table 10.1-(2): Summary of Owners' Cost Growth Analysis.

	Does the **Mean** indicate a **positive relationship**?	Does the **Median** indicate a **positive relationship**?	Are the **Medians statistically different** at a 95% confidence interval according to the **Wilcoxon Test**?	Is the **extent of use of team building positively correlated to cost growth reduction according** to the **Jonckheere-Terpstra Test?**
OWNER:				
Cost Growth				
Total Cost Growth	YES	YES	NO	NO
Phases				
Pre-Project Planning	YES	NO	NO	YES
Design	NO	NO	NO	NO
Procurement	YES	YES	NO	NO
Demolition	NO	YES	NO	NO
Construction	YES	YES	NO	NO
Start-Up	NO	NO	NO	NO
Slices				
Industry Group				
Heavy Industrial	YES	YES	NO	NO
Buildings	YES	YES	NO	NO
Light Industrial	YES	YES	NO	NO
Infrastructure	NA	NA	NA	NA
Project Nature				
Modernization	YES	YES	NO	NO
Addition	YES	YES	NO	NO
Grass Roots	YES	NO	NO	NO
Cost Category				
< $15 Million	YES	YES	NO	NO
$15 to $50 Million	NO	NO	NO	NO
$50 to $100 Million	YES	YES	NO	NO
> $100 Million	YES	YES	NO	NO

NA - Not Addressed

Chapter 11 - Summary of Schedule Growth Analysis Results

11.1 Overview

The schedule growth analysis was hindered by the fact that the schedule information was not available for the total project. Adjustments were made for the demographic slicing of the database to compensate for the lack data regarding the total project schedule. Whereas slices of the cost growth analysis were compared to the total project cost, the slices for the schedule growth analysis had to be compared to phase schedule growth information. The design, procurement, and construction phases were used in the schedule growth analysis because there were a significant number of respondents for both the owners and contractors. Included at the end of this chapter are Table 11.1-(1) and Table 11.1-(2) that summarize the schedule growth analysis for the contractors and owners respectively. A summary of the statistical test results for the schedule growth analysis is included in Appendix C. The limited schedule growth analysis suggests that team building may be an effective tool for reducing schedule growth in some cases.

11.2 Contractor Phases

Average schedule growth appeared to be reduced by the use of a team building process for all contractor phases except the start-up phase. Comparison of the medians adds support for this positive relationship. Wilcoxon Test results reveal a statistically significant difference between the medians of the groups that did and did not implement a team building process for the design phase. The best-fit lines of the scatter plots for the design and procurement phases indicate a strong relationship between increased use of team building and reduction in schedule growth. The slopes of the lines represent a decrease in cost growth of 34.6% and 16.4% associated with an increase from 0 to 10 in the team building index for the design and procurement phases respectively. According to the Jonckheere-Terpstra Test, the quartiles of the pre-project planning, design, and procurement phases are ordered to support a positive influence of team building.

11.3 Owner Phases

The owners' average schedule growth is reduced by the use of team building for all but the pre-project planning phase. A comparison of the medians supports the suggestion of the mean observations. There is a statistically significant difference between the design phase medians of those that did and did not use the process. Slopes of the scatter plot best-fit lines reveal a substantial influence of team building on schedule growth reduction for the design, construction, and start-up phases. The Jonckheere-Terpstra Test indicates that only the design phase quartiles are ordered to support a positive relationship.

11.4 Contractor Industry Groups

As previously mentioned the schedule growth analysis for the demographic slices was performed on the design, procurement, and construction phases because the schedule duration was not available for the total project. Of the four industry groups, only the heavy industrial group contained enough respondents for the three phases to substantiate a complete schedule growth analysis. The mean and median schedule growths were reduced for all three phases for those heavy industrial projects that implemented a team building process. Statistical tests on the heavy industrial group support the use of team building to reduce design phase schedule growth.

11.5 Owner Industry Groups

The distribution of owners' projects was spread more evenly over the heavy industrial, light industrial, and buildings projects. Comparison of the means and medians for the design phase and procurement phase schedule growths reveals that only the heavy industrial group consistently indicates a positive relationship. Construction phase average schedule growth does not appear to be improved by the use of the process for the heavy industrial group. However, medians for all three groups in the construction phase are positively influenced by team building. Statistical tests fail to support the positive relationship between team building and schedule growth reduction for the owner industry groups.

11.6 Contractor Project Nature

In all three project types, both the means and medians for the contractors' design phase schedule growths were improved for those projects that implemented the process. Team building drastically influenced the modernization and addition projects. Statistical tests and whisker box-plots also support a strong relationship between team building and design phase schedule growth reduction.

Procurement phase average schedule growth appears to be equally influenced by the process for all three project types. Comparison of the medians reveals that the modernization and addition projects are greatly improved while the grass roots projects appear to be uninfluenced. The Jonckheere-Terpstra Test indicates that only the quartiles of the modernization projects are ordered to support a positive relationship between team building and procurement phase schedule growth reduction.

The contractors' construction phase average schedule growth has mixed results related to the implementation of team building. Modernization and addition projects appear to be adversely influenced while the grass roots projects perform as expected. Comparison of the medians reveals that team building has a negative impact on addition projects and a positive effect on modernization and grass roots projects. Statistical test results support a positive relationship between team building and construction phase schedule growth reduction for the grass roots projects.

11.7 Owner Project Nature

Comparison of the owners' design phase average schedule growth reveals that team building has a positive influence on all of the owner project types except for the grass roots projects. Observation of the medians reveals a positive impact of team building on all of the project types. Neither the statistical tests nor the whisker box-plots support the increased use of team building to reduce design phase schedule growth.

The owners' procurement phase average schedule growth for grass roots projects appears to be negatively impacted by the use of team building. However, the design phase average schedule growths for the modernization and addition projects are improved by the process. Comparison of the medians supports the indications of the means. Wilcoxon results only reveal a statistically significant difference between the medians for the addition projects.

The construction phase average schedule growth is positively influenced for all but modernization type projects. The median comparison reveals an improvement in schedule performance for all project types. Neither the statistical tests nor the whisker box-plots support the increased use of team building to reduce design phase schedule growth.

11.8 Contractor Remuneration

The majority of the contractors' contracts were either cost reimbursed or lump sum contracts. Design phase average schedule growth for cost reimbursed contracts was more influenced by team building than for the lump sum contracts. Comparison of the medians reinforces the suggestion that team building has a greater impact on the cost reimbursed contracts. The Wilcoxon Test result indicates that a statistically significant difference exists between the medians of the yes-and-no groups for the cost reimbursed contracts. Jonckheere-Terpstra Test results and whisker box-plots indicate that the quartiles are ordered as suspected for both contract types.

The effect of team building on procurement phase average schedule growth appears to be relatively the same for the cost reimbursed and lump sum contracts. Comparison of the medians indicates that the lump sum contracts are more susceptible to the influences of team building. The Jonckheere-Terpstra Test and whisker box-plots for the lump sum contracts support a positive relationship between team building and procurement phase schedule growth reduction.

Average schedule growth for construction phase cost reimbursed contracts appears to be slightly more influenced by team building than for the lump sum contracts. This is supported by

the comparison of the medians for the yes-and-no groups. The Jonckheere-Terpstra Test result and whisker box-plots reveal that the quartiles for the construction phase cost reimbursed contracts are ordered as suspected.

11.9 Contractor Function

The majority of the contractors had the combined function of both design-and-construct. According to the design phase average schedule growth, the design-only function is much more impacted by the team building process than is the design-and-construct function. Comparison of the medians supports the mean observation. Wilcoxon Test results indicate that there is a significant difference between the medians of the yes-and-no groups for both the design-only and design-and-construct functions. The Jonckheere-Terpstra Test results and whisker box-plots reveal that the quartiles are ordered as suspected.

The contractors' procurement phase average schedule growth for the design-only function appears to be much more impacted by team building than the design-and-construct functions. Comparison of the medians of the yes-and-no groups indicates the design-and-construct group is actually more influenced by team building. Neither the statistical tests nor the whisker box-plots support the increased use of team building to reduce design phase schedule growth.

The contractors' construction phase average schedule growth for the construct-only function appears to be negatively influenced by team building while the design-and-construct function is positively impacted. Medians of the yes-and-no groups indicate that team building reduces schedule growth for both functions. The Jonckheere-Terpstra Test result and whisker box-plots for the design-and-construct function indicate that the quartiles are ordered as suspected.

11.10 Contractor Cost Category

The contractors' projects are distributed relatively evenly among the cost categories for the three phases. The Design phase average schedule growth for the contractor is positively

influenced by the use of team building for all four cost categories. Projects costing between $15 and $50 million had a reduction in average schedule growth over 70%. Comparison of the medians also indicated a strong influence of team building on this category. Wilcoxon Test results indicate that the $15 to $50 million category is the only group to have a statistically significant difference between the medians. Jonckheere-Terpstra Test results and whisker box-plots reveal that the quartiles are ordered for the $15 to $50 million and $50 to $100 million cost categories.

Mixed effects of team building are apparent for the contractors' procurement phase average schedule growth. Only the $15 to $50 million projects appear to be positively effected by the team building process. Comparison of the medians suggests that the $50 to $100 million category procurement phase schedule growth is also improved by the use of team building. The Jonckheere-Terpstra Test and whisker box-plots reveal that the quartiles of the $15 to $50 million category are ordered as suspected.

Team building appears to improve the contractors' construction phase average schedule growth for all of the cost categories except for the projects costing between $50 to$100 million. The medians of the yes-and-no groups support the indications of the means. Neither the statistical tests nor the whisker box-plots support the increased use of team building to reduce construction phase schedule growth.

11.11 Owner Cost Category

The owners' sample size is relatively small for the greater than $100 million cost category for all three of the phases. Observation of the design phase average schedule growth reveals that both categories below $50 million are improved by team building. Comparison of the medians for the yes-and-no groups supports the indications from the means. The Jonckheere-Terpstra Test and whisker box-plots indicate that the quartiles for the projects costing less than $15 million are ordered as expected.

The owners' procurement phase average schedule growth for the projects costing less than $15 million is improved by the use of team building. Comparison of the medians supports this observation and suggests that the $50 to$100 million projects are also improved. Neither the statistical tests nor the whisker box-plots support the increased use of team building to reduce construction phase schedule growth.

Improvement in the owners' construction phase average schedule growth is only indicated for the projects costing between $15 and $50 million. Observation of the medians reveals that the $50 to $100 million projects are adversely impacted by the team building process. Neither the statistical tests nor the whisker box-plots support the increased use of team building to reduce design phase schedule growth.

Table 11.1-(1): Summary of Contractors' Schedule Growth Analysis.

	Does the **Mean** indicate a **positive relationship**?			Does the **Median** indicate a **positive relationship**?			Are the **Medians statistically different** at a 95% confidence interval according to the **Wilcoxon Test**?			Is the **extent of use of team building positively correlated to cost growth reduction according** to the **Jonckheere-Terpstra Test?**		
CONTRACTOR:												
Schedule Growth												
Phases												
Pre-Project Planning	YES			YES			NO			NO		
Design	YES			YES			YES			YES		
Procurement	YES			YES			YES			YES		
Demolition	NA			NA			NA			NA		
Construction	YES			YES			NO			NO		
Start-Up	NO			YES			NO			NO		
Slices												
Industry Group	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
Heavy Industrial	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES	NO	NO
Buildings	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Light Industrial	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Infrastructure	NA	NA	NO	NA	NA	NO	NA	NA	NO	NA	NA	NO
Project Nature	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
Modernization	YES	YES	NO	YES	YES	YES	YES	NO	NO	YES	YES	NO
Addition	YES	YES	YES	YES	YES	NO	YES	NO	NO	YES	NO	NO
Grass Roots	YES	YES	NO	YES	NO	YES	NO	NO	YES	YES	NO	YES
Remuneration	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
Cost Reimbursed	YES	YES	YES	YES	NO	YES	YES	NO	NO	YES	NO	YES
Unit Price	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lump Sum	YES	YES	YES	YES	YES	YES	NO	NO	NO	YES	YES	NO
Guaranteed Maximum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Function	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
Construct-Only	NA	NA	NO	NA	NA	YES	NA	NA	NO	NA	NA	NO
Design-Only	YES	YES	NA	YES	YES	NA	YES	NO	NA	YES	NO	NA
Design-and-Construct	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES	NO	YES
Cost Category	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
< $15 Million	YES	NO	YES	NO	NO	YES	NO	NO	NO	NO	NO	NO
$15 to $50 Million	YES	YES	NO	YES	YES	YES	YES	NO	NO	YES	YES	NO
$50 to $100 Million	YES	NO	YES	YES	YES	NO	NO	NO	NO	YES	NO	NO
> $100 Million	YES	NO	YES	YES	NO	YES	NO	NO	NO	NO	NO	NO

NA - Not Addressed

Table 11.1-(2): Summary of Owners' Schedule Growth Analysis.

	Does the **Mean** indicate a **positive relationship**?	Does the **Median** indicate a **positive relationship**?	Are the **Medians statistically different** at a 95% confidence interval according to the **Wilcoxon Test**?	Is the **extent of use of team building positively correlated to cost growth reduction according** to the **Jonckheere-Terpstra Test?**
OWNER:				
Schedule Growth				
Phases				
Pre-Project Planning	NO	NO	NO	NO
Design	YES	YES	YES	YES
Procurement	YES	YES	NO	NO
Demolition	YES	YES	NO	NO
Construction	YES	YES	NO	NO
Start-Up	YES	NO	NO	NO

Slices												
Industry Group	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
Heavy Industrial	YES	YES	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Buildings	YES	YES	YES	YES	NO	YES	NO	NO	NO	NO	NO	NO
Light Industrial	NO	NO	YES	NO	YES	YES	NO	NO	NO	NO	NO	NO
Infrastructure	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Project Nature	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
Modernization	YES	YES	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Addition	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	YES	NO
Grass Roots	NO	NO	YES	YES	NO	YES	NO	NO	NO	NO	NO	NO
Cost Category	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON	DES	PRO	CON
< $15 Million	YES	YES	NO	YES	YES	YES	NO	NO	NO	YES	NO	NO
$15 to $50 Million	YES	NO	YES	YES	NO	YES	NO	NO	NO	NO	NO	NO
$50 to $100 Million	NO	NO	NO	NO	YES	NO	NO	NO	NO	NA	NO	NO
> $100 Million	NA	NA	NO	NA	NA	YES	NA	NA	NO	NA	NA	NA

NA - Not Addressed

Chapter 12 - Early Implementation Analysis

12.1 Background

Upon review of the literature and completion of the primary data analysis, it appeared obvious that there must be a correlation between the early implementation of team building and better project performance. The subjects of the Team Building Task Force Studies commonly believed that the team building process should be implemented early in the project to reap the maximum benefits. Common sense would also suggest that the earlier the process is started, the more effect it will have on the project.

12.2 Definition of Early Implementation

For this analysis, early implementation was defined as implementing the team building process in either the pre-project planning phase or design phase. This information was acquired by question 36g of the Benchmarking and Metrics Completed Project Questionnaire. The subjects were simply asked to mark the project phases in which they were involved in a team building process. Version 1.0 of the Questionnaire did not include question 36g; therefore, only the data from Version 2.0 could be used in this analysis.

12.3 Methodology of Analysis

The graphical and statistical methods used for the cost growth analysis were utilized to investigate the effect of early implementation of the team building process. Adjustments were made to the methodology to compensate for the modified analysis. The variable used to measure project performance for the analysis was total cost growth for both the contractor and owner.

The first adjustment was to replace the yes-or-no question "Was Team Building Used?" with the yes-or-no question "Was Team Building Implemented Early?". All of the respondents were asked if they implemented the process early, including those who did not implement the process. A three-dimensional bar chart was produced for the modified analysis using the yes-or-

no responses. Means and medians of the yes-group and no-group were compared and the Wilcoxon Test was performed just as in the primary analysis.

The next step of the analysis required some distinct adjustments. To evaluate the difference between implementing early or not, it was necessary to maintain separation of the yes-and-no groups for the scatter plots, Jonckheere-Terpstra Test, and whisker box-plots. The key difference between this approach and the previous analyses is that the yes-and-no groups were not separated in those analyses because of the content of the question being analyzed. The question of the previous analyses simply asked if team building was used; therefore isolating the respondents that had a score of 0 for the team building index. It made logical sense to merge the yes-and-no groups for the scatter plots, Jonckheere-Terpstra Test, and whisker box-plots sense the purpose of the analysis was to evaluate the effects of varying degrees of use of the team building process. The question of the modified analysis regarding early implementation separated the respondents into two groups, both of which used varying degrees of team building. These two groups were analyzed separately to illustrate the effect implementing early versus implementing late.

12.4 Results

The modified analysis results should be viewed as exploratory because of the low sample size. As previously mentioned only the data for Version 2.0 could be used in the analysis. Figure 12.4-(1) illustrates the average cost growths for the groups that did (Yes) and did not (No) implement the team building process early. The average cost growth is reduced by 5.4% and 3.4% for the contractors and owners respectively.

The number of yes-and-no respondents and the medians associated with each group are shown in Table 12.4-(1) along with the results of the Wilcoxon Test. Comparison of the medians supports the relationship indicated by the means. A statistically significant difference exists between the medians of the contractors' yes-and-no groups.

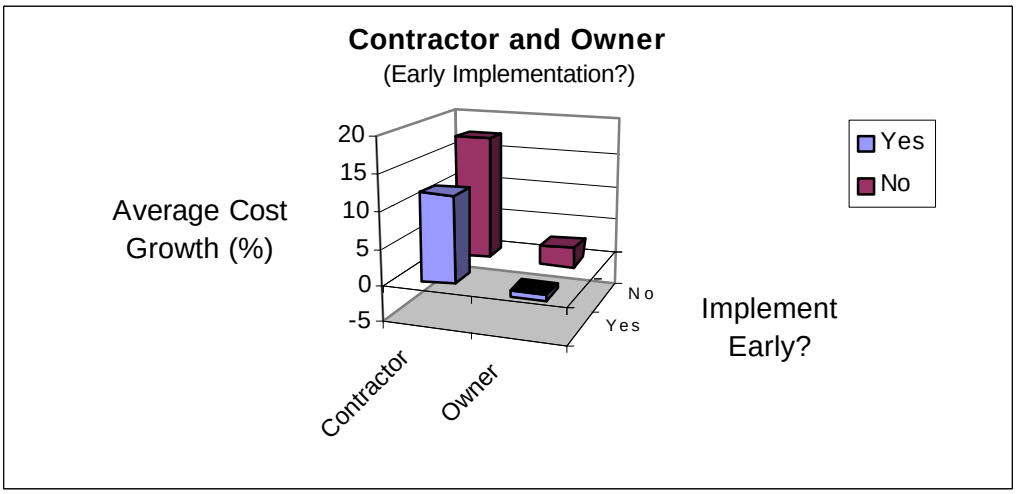

Figure 12.4-(1): Effect of early implementation on contractors' and owners' total cost growth.

Table 12.4-(1): Summary of contractor and owner statistics for Early Implementation Analysis.

Total Cost Growth --- Was Team Building Implemented Early? (Y / N)

	Number	# of Y's	# of N's	MED(Y)	MED(N)	Wilcoxon	JT (Y)	JT (N)
Contractor	90	45	45	1.3608	10.4167	0.00793	0.93196	0.86056
Owner	93	56	37	-1.5947	2.0585	0.11462	0.90733	0.49321

The scatter plot for the contractors who implemented the team building process early on in the project is shown in Figure 12.4-(2). Few points are located between the 0 and 3 indexes because respondents with a low team building index rarely implemented the process early. The slope of the best-fit line is the most dramatic slope of the entire research analysis. According to the line, a decrease in cost growth from 38.3% to -14.3% is possible with an increase from 3 to 10 in the team building index. Because the point above 300% cost growth heavily skews the slope of the line, a slope was also calculated omitting the extreme point. The resulting slope of -3.2074 still represents a substantial relationship between increased use of team building and cost growth reduction.

Figure 12.4-(3) shows the scatter plot for the contractors who did not implement the team building process early. As expected, the majority of the points are below the 3 index for this group. The purpose of the showing the scatter plots for both the early and late respondents is to

compare the slopes of the best-fit lines. Since the slopes represent the effect of increased team building on cost growth, comparison of the two slopes would reveal if early implementation improves the effect of team building. It can be seen that the slope, -7.5235 or -3.2074, for the early respondents is much steeper than the slope, -2.8317, for the late respondents. This indicates that the effect of team building is stronger for those who implement the process early.

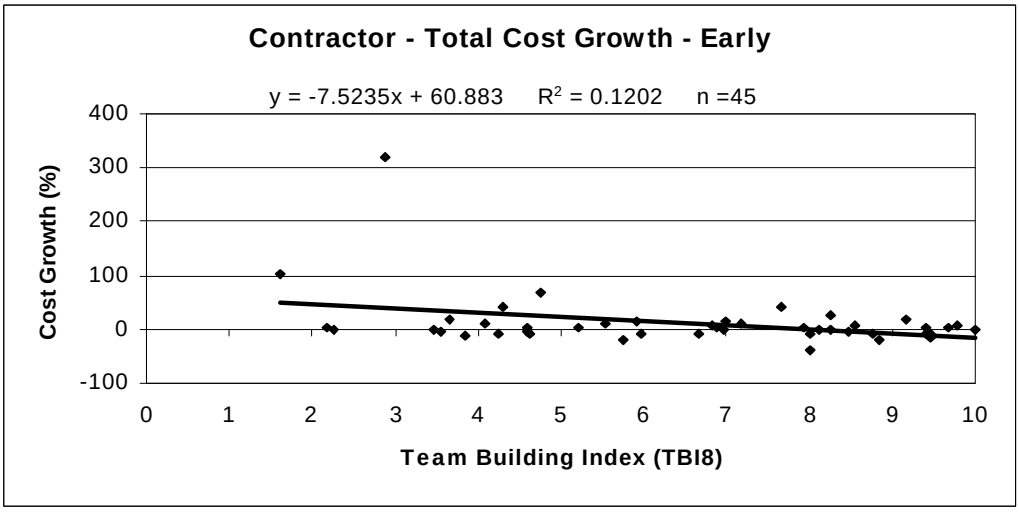

Figure 12.4-(2): Contractor early implementation scatter plot.

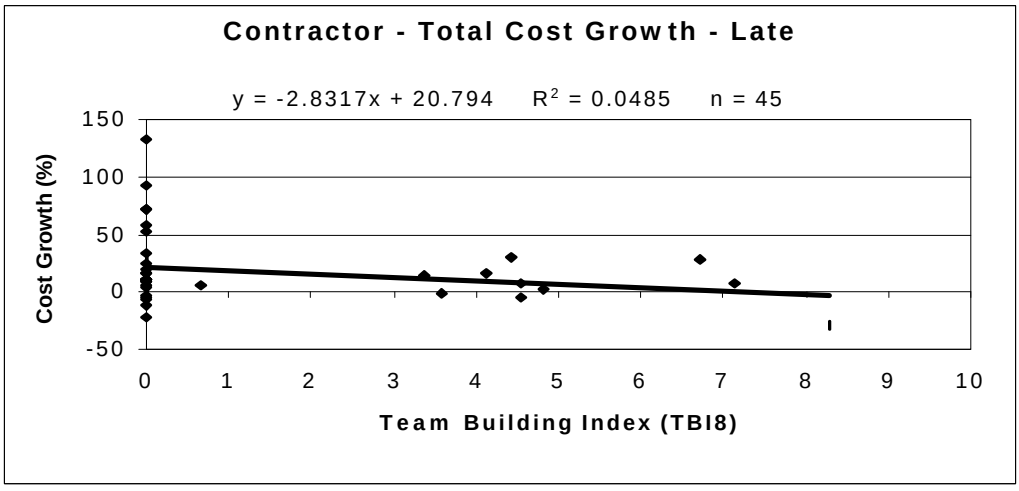

Figure 12.4-(3): Contractor late implementation scatter plot.

The Jonckheere-Terpstra Test does not indicate that the quartiles are ordered for either of the early or late contractor groups. Whisker box-plots are shown in Figure 12.4-(4) and Figure

12.4-(5) for the early and late groups respectively. Although the statistical test indicates that early group quartiles are not ordered, a positive trend does exist for all but the second quartile. The quartile analysis is ineffective for representing the late respondents because the majority of the respondents were of the 0 index.

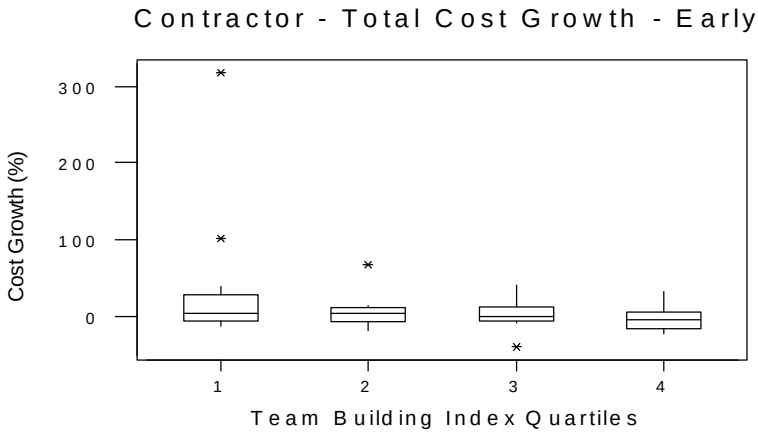

Figure 12.4-(4): Contractor quartile distribution for early implementation.

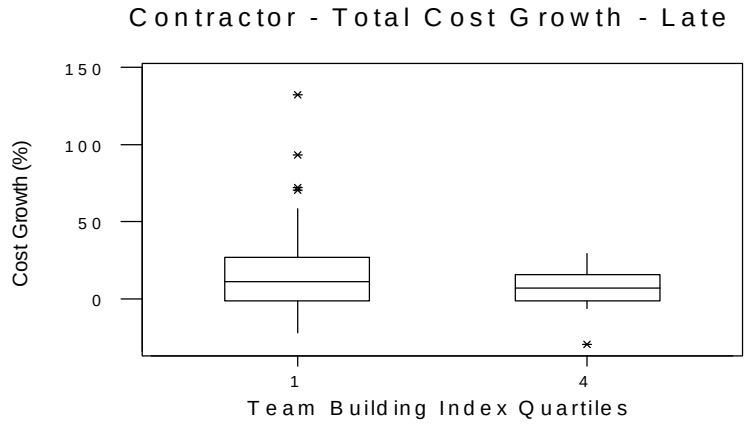

Figure 12.4-(5): Contractor quartile distribution for late implementation.

The scatter plot for the owner respondents who implemented the process early is shown in Figure 12.4-(6) along with the best-fit line. Similar to the contractors' early group, few of the data points are below the 3 index. A decrease from 3.3% to -5.9% is associated with an increase

from 3 to 10 in the team building index. The data points are not as dispersed as they appear because of the small scale on the y-axis.

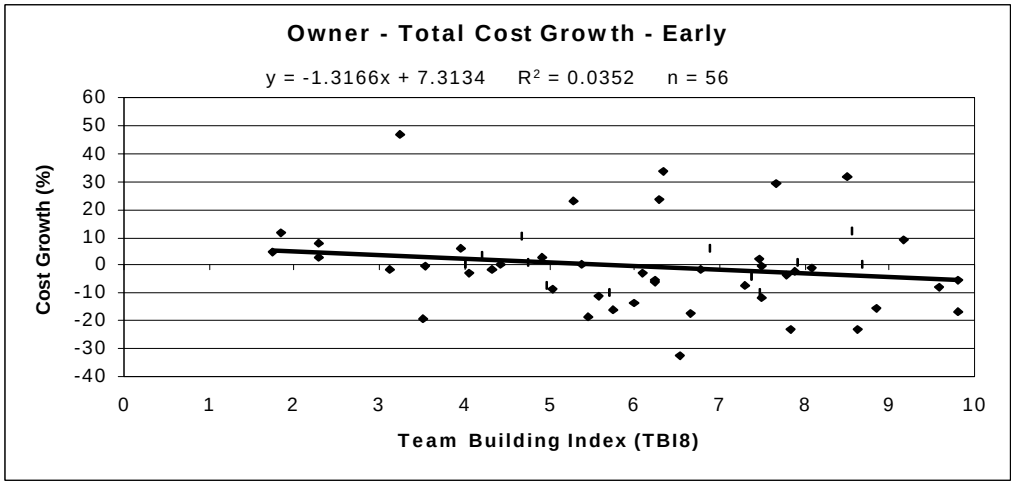

Figure 12.4-(6): Owner early implementation scatter plot.

The scatter plot and best-fit line for the owner respondents who did not implement the process early are shown in Figure 12.4-(7). As expected, the majority of the data points are of the 0 index. The slope of the best-fit line, -0.1376, is much flatter than the slope, -1.3166, for the early implementation group. This indicates that the effects of team building are stronger if the process is implemented early.

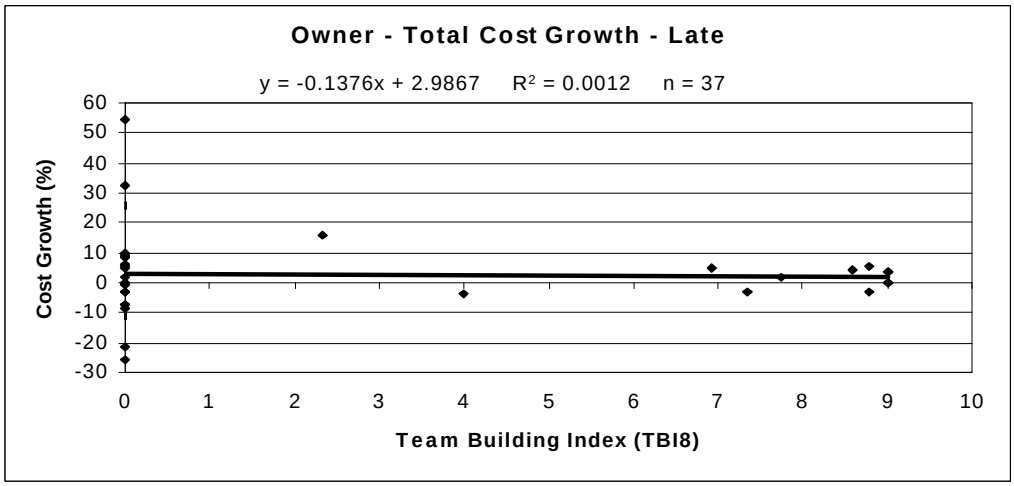

Figure 12.4-(7): Owner late implementation scatter plot.

The Jonckheere-Terpstra Test does not indicate that the quartiles are ordered for either of the early or late owner groups. Whisker box-plots shown in Figure 12.4-(8) and Figure 12.4-(9) for the early and late groups respectively fail to indicate that the quartiles are ordered.

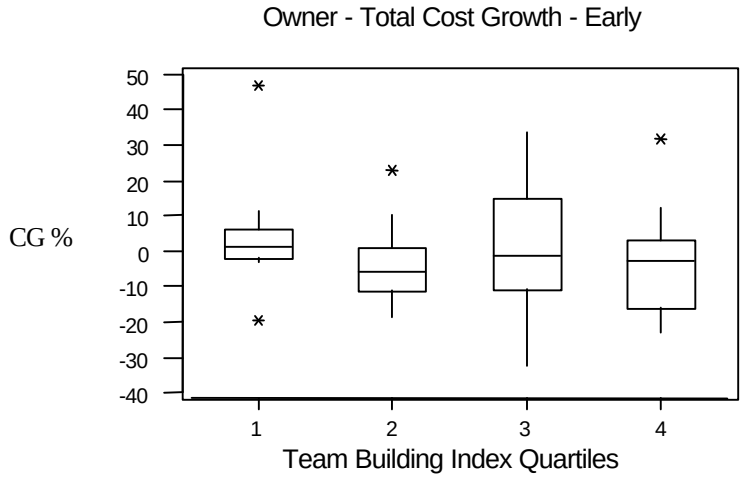

Figure 12.4-(8): Owner quartile distribution for early implementation.

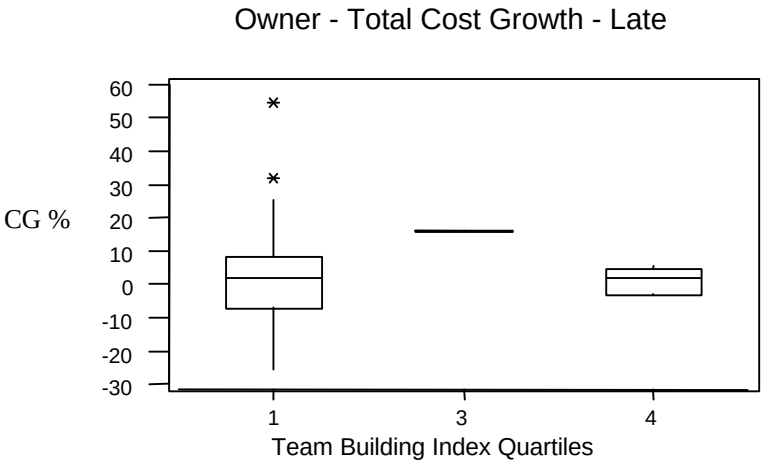

Figure 12.4-(9): Owner quartile distribution for late implementation.

12.5 Summary of Results

Although this analysis should be considered exploratory, it overwhelmingly indicates that implementing the team building process early in the project improves the overall effect of the process on total cost growth. Both the mean and median cost growth were lower for the respondents who implemented the process early. The slopes of the scatter plot best-fit lines indicate that the effects of increased team building are stronger if the process is implemented early.

Chapter 13 - Findings and Conclusions

13.1 Research Summary

Benefits of the team building process have been examined for many years by several organizations. The Army Corp of Engineers, Project Management Institute, and Construction Industry Institute studies provided the foundation of this research. Cost growth and schedule growth are two areas that were suspected to be improved by the use of team building. A thorough investigation was conducted as to the effects of the team building process on cost growth and schedule growth. The project phases and demographic slices were examined for both the contractors and owners. The research findings and conclusions are presented in the succeeding sections.

13.2 Key Findings

Three key findings resulted from the Cost Growth Analysis, Schedule Growth Analysis, and Early Implementation Analysis. The analysis summary tables of Chapter 10 and 11 were used to identify subsets that consistently revealed a positive influence of team building on the growth variables. The subsets labeled "YES" for all four inquiries, or the subsets that revealed a positive influence of team building for the two comparisons and two statistical tests, are classified as "noticeably improved."

Because the sample size was small for the Early Implementation Analysis, the statistical tests were inconclusive and the results should be considered exploratory. However, comparison of the means, medians, and slopes of the scatter plot best-fit lines all suggest that a relationship exists between early implementation and reduction of the growth variables.

1) The cost growth analysis indicates that the team building process has varying positive effects for the respondent classes, project phases, and demographic slices.

- As indicated by Table 10.1-(1), cost growth was "noticeably improved" by the team building process for the following contractors' subsets:

  - Total Project Cost
  - Heavy Industrial Projects
  - Addition Projects
  - Grass Roots Projects
  - Cost Reimbursed Contracts
  - Design-Only Function
  - $15 to $50 Million Cost Category

- As indicated by Table 10.1-(2), cost growth was not "noticeably improved" by the team building process for any of the owners' subsets.

  - This result may be explained by a dampering effect on the influences of team building caused by those owners using lump sum contracts. In theory, the owner will have zero cost growth with a lump sum contract.

2) The schedule growth analysis was hindered by the lack of total project schedule information, but the modified project phase analysis results resembled those of the cost growth analysis.

- As indicated by Table 11.1-(1), schedule growth was "noticeably improved" by the team building process for the following contractors' subsets:

  - Design Phase Cost
  - Procurement Phase Cost
  - Heavy Industrial Projects (design phase)
  - Modernization Projects (design phase)
  - Addition Projects (design phase)
  - Cost Reimbursed Contracts (design phase)
  - Design-Only Function (design phase)
  - Design-and-Construct Function (design phase)
  - $15 to $50 Mill. Category (design phase)

- As indicated Table 11.1-(2), schedule growth was "noticeably improved" by the team building process for the owners' Design Phase subset.

3) Early Implementation of the team building process appears to be crucial in maximizing the benefits of the team building process.

- Comparison of the means, medians, and slopes of the scatter plot best-fit lines indicate that early implementation is crucial for both the owners' and contractors' total project cost growth.

13.2.1 Cost Growth Analysis

According to the best-fit line of the scatter plots, a positive relationship between the team building process and cost growth reduction was indicated for 36 out of 37 subsets. The contractors' cost growth was more effected by team building than was the owners', probably because the contractors had a higher average cost growth which presented more room for improvement.

The contractors' design phase cost growth revealed the greatest influences of team building of contractors' phases. Start-up phase cost growth was much more impacted by the process but the findings were undermined by a low number of respondents. Effects of team building on the owners' phases were less dramatic but more consistent. The start-up and construction phases indicated the strongest positive relationship with team building.

The combined graphical and statistical results advocate the contractors' heavy industrial group as the subset with the most prominent influences of team building on cost growth reduction. The owners' heavy industrial group appeared to have the highest degree of use of the team building process for all of the subsets.

Addition projects illustrated the greatest improvements resulting from the use of the team building process for the contractors' project types. The grass roots projects were the most susceptible of the owners' project types.

Contrary to the findings of the PMI and CII studies, which indicated that team building had the same effect for low-bid and non-low-bid contracts, the contractors' cost reimbursed contracts were much more influenced by team building than the lump contracts.

The design-only group was the contractors' function most improved by the team building process.

A positive influence between team building and cost growth reduction was revealed for all of the contractors' cost categories except for the less than $15 million category and for all of the owners' except the $15 to $50 million category. The extent of use of team building grew with the increasing size (cost) of projects for both contractors and owners.

13.2.2 Schedule Growth Analysis

The total schedule growth analysis was not performed because of the lack of information regarding the total project schedule. Project phase analyses were performed as in the cost growth analysis and the demographic slices were analyzed in terms of the design, procurement, and construction phases.

Design phase schedule growth appeared to be the phase most improved by the team building process for both the contractors' and owners'.

The contractors' heavy industrial projects revealed a conservative positive effect of team building on schedule growth reduction for all three phases analyzed. Statistical tests of the owners' industry groups failed to support the relationship, but the graphical analysis revealed a positive trend between the use of team building and reduction of schedule growth for the heavy industrial projects.

The contractors' modernization and addition projects were improved by team building for the design and procurement phases while the grass roots projects revealed the greatest influence

for the construction phase. Findings for the owner class were similar to the contractor class except that the addition projects were also improved in the construction phase.

The contractors' procurement phase schedule growth was slightly more improved for the cost reimbursed contracts as compared to the lump sum contracts. The effect of team building was much more influential for the cost reimbursed contracts as compared to the lump sum contracts for both the design and construction phases.

The contractors' function of design-only appears to be the most influenced function for the design and procurement phases while the design-and-construct function reveals the greatest influence for the construction phase.

Results of the contractors' cost category analysis were mixed for the procurement phase but support a positive relationship across all four categories for the design and construction phases. The owners' cost category analysis revealed mixed results. The two categories below $50 million support a positive relationship for the design phase and the two categories between $15 and $100 million revealed improvements for the construction phase.

13.2.3 Early Implementation Analysis

Although this analysis should be considered exploratory because of the small sample size, it overwhelmingly indicates that implementing the team building process early on in the project improves the overall effect of the process on total cost growth. The statistical analyses was inconclusive because of the low number of respondents, but the graphical analyses revealed overwhelming indications to support the importance of early implementation for both the owner and contractor classes.

13.3 Conclusions

The thorough graphical and statistical analyses of the relationship between the team building process and reduction of cost growth and schedule growth provides overwhelming

support for extensive use of team building on construction projects. Although results of particular projects are not always supportive, the overall trends indicate that both budget overruns and schedule extensions can be reduced by the use of a team building process. Particular subsets of the data have been identified as projects that are very susceptible to the positive influences of the team building process. Early implementation appears to be crucial in maximizing the benefits of the team building process. CII's Benchmarking and Metrics Database should be reevaluated yearly to confirm or refute the findings of this research.

To conclude, it is important to apply the findings to actual companies so as to realize the potential cost growth improvement. The heavy industrial subset is the focus of this example because it is undoubtedly the most notable. As discussed earlier, the slope of the best-fit line for the scatter plot represents the possible improvement in cost growth as related to the extent of use of the team building process. According to the slope of -2.76 in Figure 8.5.1-(1), shown below as Figure 13.3-(1), a reduction in cost growth of 13.6% is the result of an increase in the team building index from 3 to 8. The increase from 3 to 8 in the team building index represents a moderate improvement in team building practices.

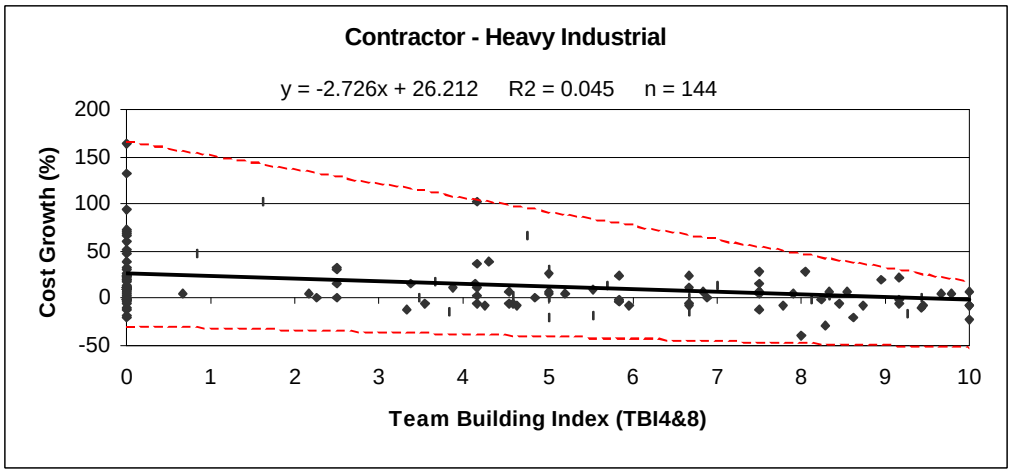

Figure 13.3-(1): Contractors' team building index versus cost growth for heavy industrial.

A direct product of the team building process is positive interaction among project participants, which in turn results in better "scope definition," among other things. Improved

scope definition is crucial in reducing variability of costs. The red lines in Figure 13.3-(1) illustrate the convergence of data points towards the best-fit line and represent a reduction in cost variability associated with increased use of team building. As shown in Table 13.3-(1), applying a reduction in cost growth of 13.6% to the top 7 Heavy Industrial contractors in ENR's Top 400 Contractors for 1997 yields dramatic results.

Table 13.3-(1): "Value" of possible reduction in cost growth (ENR 1997, pg. 65).

Contractor's from ENR's Top 400	Total Revenue from Industrial - Petroleum Projects (billions of dollars)	Possible Cost Growth Improvement from Team Building (billions of dollars)
Fluor Daniel Inc., Irvine, Calif.	$4.43	$0.60
Becthel Group Inc., San Fransisco, Calif.	$5.22	$0.71
Brown & Root Inc., Houston, Texas	$2.06	$0.28
Foster Wheeler Corp., Clinton, N.J.	$1.67	$0.23
Raytheon Engi. & Contr. Int'l, Lexington, Mass.	$1.08	$0.15
McDermott International Inc., New Orleans, La.	$1.49	$0.20
The M.W. Kellogg Co., Houston, Texas	$1.58	$0.22

It is important to note that the above example arbitrarily assumes that the listed contractors would currently have at team building index of 3 and that the results are associated with increasing the team building index to 8. This is purely an academic exercise to make a point since we have no factual data describing the use of team building among these companies. The hypothetical dollar values shown above represent reductions in cost growth associated with the improved team building index. This increased used of team building would have resulted in a much-improved "scope definition" and in a much-reduced "risk." Therefore, these dollar values can be indirectly related to the value of "scope definition" and/or the value of mitigated "risk" as a result of using more team building practices. That these dollar values represent actual reductions in the Total Installed Cost would be an incorrect interpretation.

13.4 Areas for Future Research

This thesis investigated the relationship between the team building process and the cost growth and schedule growth variables. As illustrated in Figure 13.4-(1), the overall cost growth

variable used in this research is affected by many other factors. Further research should be conducted to examine the individual relationships and their effect on the overall cost growth.

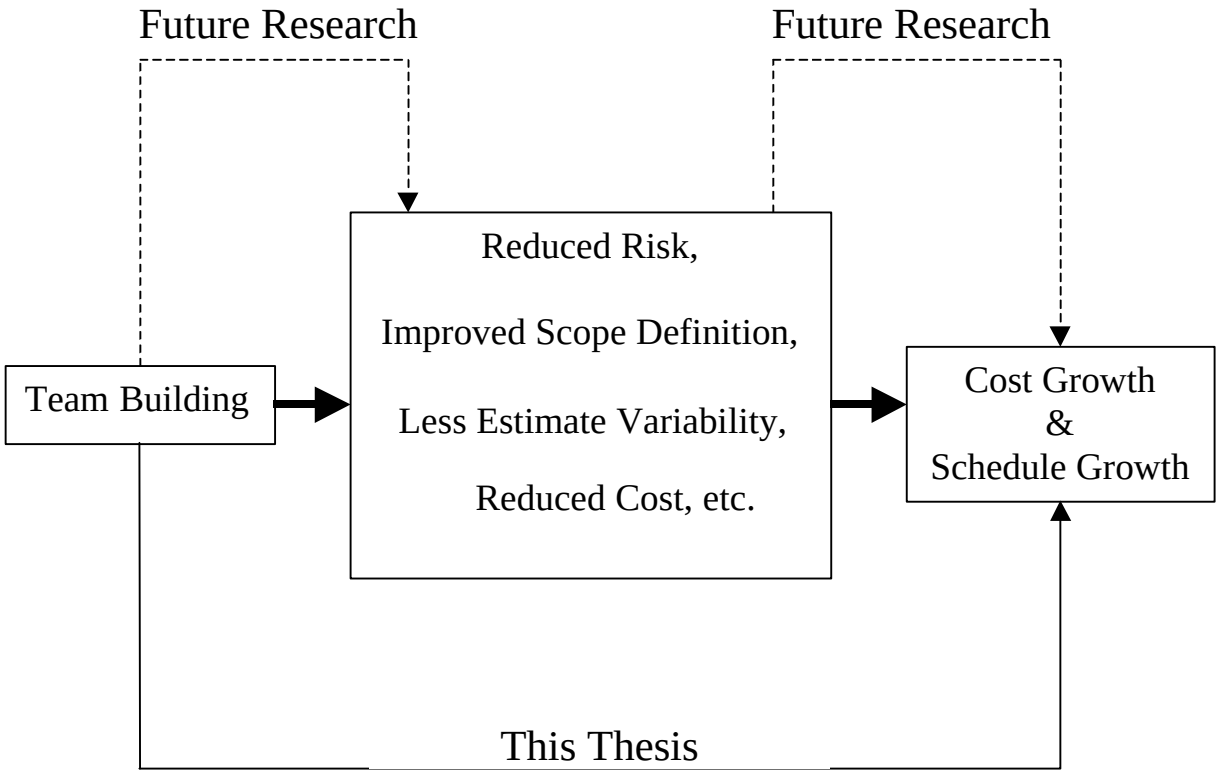

Figure 13.4-(1): Areas of Future Research

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Appendix A

CII's Project Phase Definitions
(Benchmarking 1997, Appendix D 1-2)

1. Pre-Project Planning: Starts with a need for a facility and ends when total budget is approved.
2. Detail Design: Starts with the basis of design and ends when approved drawings and specs are released for construction.
3. Demolition / Abatement: Starts with mobilization for demolition and ends at completion of the demolition.
4. Procurement: Starts with procurement plan for engineered equipment and ends upon delivery to the site.
5. Construction: Starts at the beginning of continuous substantial construction activity and ends with mechanical completion or start-up of the facility.
6. Start-up / Commissioning: Starts upon mechanical completion and ends when facility turned over to owner.

Appendix B

CII's Benchmarking and Metrics Completed Project Data Questionnaire (Version 2.0)

7. Principal type of project (Check only one. If you feel the project does not have a principal type, but is an even mixture of two or more of those listed, please attach a short description of the project. If the project type does not appear in the list, please describe in the space next to "Other."):

Light Industrial	Heavy Industrial	Infrastructure	Buildings
_Pharmaceuticals Mfg.	_Electrical (Generating)	_Electrical Distribution	_Lowrise Office
_Microelectronics Mfg.	_Oil Explor./Prod.	_Highway	_Highrise Office
_Consumer Product Mfg.	_Oil Refining	_Navigation	_Warehouse
_Automotive Mfg.	_Pulp and Paper	_Flood Control	_Hospital
_Foods	_Chemical Mfg.	_Rail	_Laboratory
	_Environmental	_Water/Wastewater	_School
	_Metals Refin./Proc.	_Airport	_Prison
	_Mining	_Tunneling	_Hotel
	_Natural Gas Proc.	_Marine Facilities	_Maint. Facilities
		_Parking Garage	_Retail

__Other (Please describe)_____
_____

8. The project was (check only one): grass roots__ modernization__ addition__

Grass roots - a new facility from the foundations and up. A project requiring demolition of an existing facility before a new construction begins is also classified as grass roots.

Modernization - a facility for which a substantial amount of the equipment, structure, or other components is replaced or modified, and which may expand capacity and/or improve the process of facility.

Addition - a new addition that ties in to an existing facility, often intended to expand capacity.

__Other (Please describe)_____
_____

CII's Questionnaire
(cont.)

10. Please indicate in the table below the function(s) **your company** performed on this project and the approximate percent of each to the nearest 10%. For each function, indicate the principle form of remuneration in use at the completion of the work. Also indicate if your contract contained incentives. Use a separate line for each function your company performed.

    Please use the following codes to identify the **Function(s)** performed by your company.

PPP	Pre-Project Planner	DM	Demolition/Abatement Contractor
PPC	Pre-Project Planning Consultant	GC	General Contractor
D	Designer	PC	Prime Contractor
PE	Procurement - Equipment	SC	Subcontractor
PB	Procurement - Bulks	PM	Project Manager
		CM	Construction Manager

    Percent of Function refers to the percent of the overall function contributed by your company. Estimate to the nearest 10 percent.

    Type of Remuneration refers to the overall method of payment. Unit price refers to a price for in place units of work and does not refer to hourly charges for skill categories or time card mark-ups. Hourly rate payment schedules should be categorized as cost reimbursable. Please use the following codes to identify remuneration types.

LS	Lump Sum	CR	Cost Reimbursable/Target Price (Including Incentives)
UP	Unit Price	GP	Guaranteed Maximum Price

    If **Incentives** were utilized in your company's contract, please indicate whether those incentives were positive (a financial incentive for attaining an objective), negative (a financial disincentive for failure to achieve an objective), or both. Circle "+" to indicate positive incentive and circle "-" to indicate negative incentive.

Function	Approx. Percent of Function (Nearest 10%)	Type of Remun. (Contract End)	Contract Incentives (circle as many as apply)			
			Cost	Schedule	Safety	Quality
			+ or -	+ or -	+ or -	+ or -
			+ or -	+ or -	+ or -	+ or -
			+ or -	+ or -	+ or -	+ or -
			+ or -	+ or -	+ or -	+ or -
			+ or -	+ or -	+ or -	+ or -

CII's Questionnaire
(cont.)

11a. **Your company's <u>Project Budget at Authorization to Proceed</u>.**

- This is the estimated cost at authorization to proceed for your company's portion of the project only (not the budget for the entire project). If possible, do not include corporate overhead.
- Do not include profit.
- Be sure to include the cost of work performed by you subcontractors.
- **Do not** include the estimated cost of change orders granted while the project was underway (these are examined in question 15).
- State your company's project budget in U.S. dollars to the nearest $1000. (You must use a "k" to indicate thousands in lieu of "….000".)

$_____

12. **Your company's <u>Total Actual Project Cost</u>:**

- This is the actual cost of your company's portion of the project only (not the total cost of the entire project). If possible, do not include corporate overhead.
- Do not include profit.
- **Include** the cost of executing change orders.
- State your company's Total Actual Project Cost in U.S. dollars to the nearest $1000. (You may use a "k" to indicate thousands in lieu of "….000".)

$_____

CII's Questionnaire
(cont.)

13. Please indicate **your company's** budget and actual costs by project phase

- Phase budget amounts should correspond to **your company's budget** at authorization to proceed. Do not include the estimated cost of change orders in the "Phase Budget" column. These are addressed in question 15. However, the "Actual Phase Cost" column should include all project costs, including those attributed to change orders.
- Refer to the table on pages 2 and 3 for phase definitions and typical cost elements.
- Include the cost of bulk materials in construction and the cost of engineered equipment in procurement.
- If your company did not perform any function during a project phase, check "NA" for that phase.
- The sum of phase budgets should equal your company's budget at authorization to proceed and the sum of actual phase costs should equal your company's total actual cost reported in questions 11a & 12 above.)

Project Phase	Phase Budget (Including Contingency)	Amount of Contingency in Budget	Actual Phase Cost	NA
Pre-Project-Planning	$	$	$	
Detail Design	$	$	$	
Procurement	$	$	$	
Demolition/Abatement	$	$	$	
Construction	$	$	$	
Startup	$	$	$	
Totals	$	$	$	

14. Please indicate **your company's** Planned and Actual Project Schedule

- The dates for the planned schedule should be those in effect when you were authorized to proceed. If you cannot provide an exact day for either the planned or actual, estimate to the nearest week in the form mm/dd/yy; for example, 1/8/96, 2/15/96, or 3/22/96.)
- Refer to the chart on pages 2 and 3 for a description of starting and stopping points for each phase.
- If your company did not perform any function during a project phase, check "NA" for that phase.

Project Phase	Planned Schedule		Actual Schedule		
	Start mm/dd/yy	Stop mm/dd/yy	Start mm/dd/yy	Stop mm/dd/yy	NA
Pre-Project-Planning	/ /	/ /	/ /	/ /	
Detail Design	/ /	/ /	/ /	/ /	
Procurement	/ /	/ /	/ /	/ /	
Demolition/Abatement	/ /	/ /	/ /	/ /	
Construction	/ /	/ /	/ /	/ /	
Startup	/ /	/ /	/ /	/ /	

CII's Questionnaire
(cont.)

Team Building Practices

Team Building is a process that brings together diverse groups of project participants and seeks to resolve differences, remove roadblocks and proactively build and develop the group into an aligned, focused and motivated work team that strives for a common mission and for shared goals, objectives and priorities.

36. Was your company involved in a team building process that included other personnel on this project?

Yes__ No__

If yes, answer questions 36a - 36h. If no, go to question 37.

	Yes	No	
36a.	__	__	Was an independent consultant used to facilitate the team building process?
36b.	__	__	Was a team-building retreat held early in the life of the project?
36c.	__	__	Did this project have a documented team-building implementation plan?*
36d.	__	__	Were objectives of the team building process documented and clearly defined?*

36e. Were team building meetings held among team members throughout the project?

__regularly __sometimes __seldom __ never

36f. Were follow-up sessions held to integrate new team members and reinforce concepts?

__regularly __sometimes __seldom __ never

36g. Please indicate the project phases in which your company was involved in the team building process.* (Check all that apply)

__Pre-Project Planning __Construction
__Design __Startup
__Procurement

36h. Please indicate the parties involved in the team building process.*

__Owner __Designer
__Contractor __Suppliers
__Subcontractors __Construction manager
__Other. If other, please specify _____

*Note: Questions 36c, 36d, 36g, and 36h were not included in the Version 1.0 Questionnaire.

Appendix C

Statistical Analysis Summary

(Part I)

Contractors'

Category	Subset	*Cost Growth* Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Overall	n/a	204	0	124	80	4.8555	10.9535	0.003799	0.00062
Phase	Pre-Project Planning	66	2.09E-14	41	25	0	0	0.089076	0.01084
	Detail Design	131	0	81	50	8.511	12.5085	0.134311	0.00459
	Procurement	120	0	78	42	-2.9485	0	0.202732	0.06851
	Demolition/Abatement	18	.	.	.	.	.	.	.
	Construction	166	0	97	69	8.112	11.579	0.086891	0.06035
	Startup	36	5.68E-08	20	16	3.111	27.34	0.23221	0.17936
		CGTOT Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	144	0	92	51	3.452	11.579	0.000511	5.5E-06
	Buildings (B)	18	.	.	.	.	.	.	.
	Light Industrial (LI)	19	.	.	.	.	.	.	.
	Infrastructure (I)	24	2.37E-10	16	8	18.723	6.819	0.043252	0.87778
Project Nature	Modernization (M)	52	1.67E-16	27	25	7.816	14.544	0.59533	0.29218
	Addition (A)	71	8.71E-13	44	26	4.8955	11.0365	0.029125	0.00339
	Grass Roots (GR)	82	0	53	29	4.31	10.619	0.040712	0.00297
Cost	<$15 million	69	7.07E-12	27	42	12.5	10.9535	0.916765	0.48115
	$15-$50 million	68	0	49	19	4.659	14.404	0.031887	0.01339
	$50-$100 million	32	1.61E-06	20	11	5.5275	10.417	0.179617	0.10518
	>$100 million	36	2.5E-15	28	8	1.0005	7.2495	0.123301	0.02031
Remuneration	Cost Reimbursement (CR)	107	0	73	33	4.659	16.913	0.008112	6.1E-05
	Unit Price (UP)	10	.	.	.	.	.	.	.
	Lump Sum (LS)	75	0	39	36	4.682	9.381	0.361761	0.28078
	Guaranteed Maximum (GP)	12	.	.	.	.	.	.	.
Function	Designer (D)	31	0.001692	21	10	4.935	25.5755	0.023772	0.00026
	Builder (C)	71	6.33E-12	41	29	13.57	12.083	0.262389	0.14973
	Both (DC)	103	0	62	41	3.452	9.254	0.04724	0.0156

Statistical Analysis Summary

(Part II)

Contractors'

Category	Subset	*Schedule Growth* Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Overall	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Phase	Pre-Project Planning	66	0	45	21	0	1.613	0.197335	0.06668
	Detail Design	140	0	89	51	6.154	18.969	0.000115	1.9E-05
	Procurement	124	0	83	41	6.601	16.423	0.064161	0.04656
	Demolition/Abatement	15	.	.	.	.	.	.	.
	Construction	168	0	101	67	0	5.677	0.479769	0.32435
	Startup	48	0.003216	29	19	3.279	11.688	0.782763	0.52614
		Design Phase Schedule Growth Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	110	0	76	34	6.0695	25.832	7.38E-05	2.2E-06
	Buildings (B)	12	.	.	.	.	.	.	.
	Light Industrial (LI)	16	.	.	.	.	.	.	.
	Infrastructure (I)	2	.	.	.	.	.	.	.
Project Nature	Modernization (M)	26	2.38E-05	14	12	3.3435	47.0905	0.003311	0.01062
	Addition (A)	51	0.000329	32	19	6.0915	29.469	0.041503	0.00429
	Grass Roots (GR)	63	6.55E-15	43	20	7.294	13.5135	0.077632	0.03373
Cost	<$15 million	39	1.18E-05	14	25	18.7975	17.143	0.736303	0.28748
	$15-$50 million	43	4.02E-06	32	11	7.357	68.485	0.000474	0.00021
	$50-$100 million	27	0.001619	18	9	5.8585	12.766	0.104661	0.01413
	>$100 million	31	0.001054	25	6	2.237	6.1035	0.220389	0.46484
Remuneration	Cost Reimbursement (CR)	83	1.67E-16	60	23	6.6205	29.781	9.02E-05	1.4E-05
	Unit Price (UP)	1	.	.	.	.	.	.	.
	Lump Sum (LS)	47	1E-07	23	24	4.252	9.3575	0.05021	0.00714
	Guaranteed Maximum (GP)	9	.	.	.	.	.	.	.
Function	Designer (D)	29	8.84E-05	20	9	7.2505	29.469	0.015143	0.00742
	Builder (C)	0	.	.	.	.	.	.	.
	Both (DC)	101	0	62	39	6.176	19.481	0.002461	0.00029

Statistical Analysis Summary

(Part III)

Contractors'

Category	Subset	*Procurement Phase Schedule Growth* Number	Normality	Q_36(Y)	Q_36(N)	MEAN(Y)	MEAN(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	107	0	75	32	6.562	11.185	0.311651	0.12477
	Buildings (B)	5	.	.	.	.	.	.	.
	Light Industrial (LI)	9	.	.	.	.	.	.	.
	Infrastructure (I)	3	.	.	.	.	.	.	.
Project Nature	Modernization (M)	26	2.46E-06	12	14	8.6005	25.035	0.133458	0.03315
	Addition (A)	44	1.82E-05	32	12	3.5835	15.422	0.254371	0.15214
	Grass Roots (GR)	54	0	39	15	7.237	6.122	0.778272	0.81078
Cost	<$15 million	27	7.56E-05	10	17	22.703	22.283	0.821138	0.70457
	$15-$50 million	42	9.99E-16	31	11	3.106	16.423	0.165863	0.02214
	$50-$100 million	25	0.15312	17	8	6.601	10.2715	0.976509	0.51942
	>$100 million	30	3.37E-08	25	5	4.976	4.251	0.866587	0.837
Remuneration	Cost Reimbursement (CR)	78	0	56	22	8.1385	5.583	0.587044	0.38921
	Unit Price (UP)	1	.	.	.	.	.	.	.
	Lump Sum (LS)	39	8.06E-08	23	16	1.779	17.7945	0.108328	0.04362
	Guaranteed Maximum (GP)	6	.	.	.	.	.	.	.
Function	Designer (D)	21	4.06E-09	15	6	6.562	11.1415	0.45662	0.17315
	Builder (C)	18	.	.	.	.	.	.	.
	Both (DC)	85	0	55	30	6.154	17.3105	0.089071	0.11364

Statistical Analysis Summary

(Part IV)

Contractors'

		Construction Phase Schedule Growth							
Category	Subset	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	115	5.04E-11	74	41	0	5.696	0.250873	0.11742
	Buildings (B)	17	.	.	.	.	.	.	.
	Light Industrial (LI)	13	.	.	.	.	.	.	.
	Infrastructure (I)	23	0.000121	16	7	1.7135	-7.474	0.066081	0.9507
Project Nature	Modernization (M)	44	8.47E-06	21	23	3.333	5.677	0.777819	0.68411
	Addition (A)	54	5.12E-10	35	19	1.548	0	0.280377	0.79079
	Grass Roots (GR)	70	7.58E-06	45	25	-2.108	5.806	0.010209	0.00911
Cost	<$15 million	50	8.26E-06	18	32	0.7555	5.541	0.36307	0.27977
	$15-$50 million	55	2.48E-09	37	18	0	7.723	0.317544	0.12275
	$50-$100 million	27	0.141584	18	9	3.7745	-5.47	0.067694	0.96074
	>$100 million	36	0.049059	28	8	-0.3	4.735	0.505371	0.21455
Remuneration	Cost Reimbursement (CR)	75	1.42E-11	53	22	0	7.723	0.366722	0.03852
	Unit Price (UP)	10	.	.	.	.	.	.	.
	Lump Sum (LS)	72	9.67E-13	38	34	0	2.067	0.603609	0.76066
	Guaranteed Maximum (GP)	10	.	.	.	.	.	.	.
Function	Designer (D)	0	.	.	.	.	.	.	.
	Builder (C)	67	4.65E-09	40	27	0	3.203	0.673041	0.86582
	Both (DC)	101	4.72E-12	61	40	0	7.03	0.19484	0.04837

Statistical Analysis Summary

(Part V)

Owners'

Category	Subset	*Cost Growth* Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Overall	n/a	185	0.001504	132	53	-0.5861	-0.3597	0.530594	0.21158
Phase	Pre-Project Planning	118	0	87	31	0	0	0.097422	0.01384
	Detail Design	163	0	117	46	1.363	-0.4125	0.212625	0.73935
	Procurement	138	8.65E-07	100	38	-7.7673	-4.5634	0.225079	0.4402
	Demolition/Abatement	40	4.24E-07	32	8	1.3335	2.837	0.959512	0.36772
	Construction	166	0	117	49	1.89	3.111	0.183136	0.10765
	Startup	82	0	63	19	0	0	0.670808	0.62199
		CGTOT Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	103	0.131944	79	23	-0.0167	3.588	0.130175	0.05744
	Buildings (B)	40	0.06542	30	9	-2.713	-0.8646	0.701458	0.90592
	Light Industrial (LI)	29	0.00519	18	11	-0.7656	-0.3597	0.753016	0.26465
Project Nature	Modernization (M)	62	0.125386	47	14	1.029	1.1905	0.830239	0.42006
	Addition (A)	61	0.066962	38	23	-1.1686	-2.2147	0.875834	0.42499
	Grass Roots (GR)	64	0.124594	47	16	-3.125	-0.4368	0.272448	0.28241
Cost	<$15 million	76	0.247692	46	28	-1.6893	1.25	0.122662	0.12485
	$15-$50 million	59	0.35692	41	18	0.3059	-2.3977	0.352313	0.9437
	$50-$100 million	28	0.794603	23	5	-0.0167	-0.3597	0.764234	0.33342
	>$100 million	24	0.000502	22	2	-2.5575	1.35835	0.374547	0.06114

Statistical Analysis Summary

(Part VI)

Owners'

Category	Subset	*Schedule Growth* Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Overall	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Phase	Pre-Project Planning	127	0	93	34	0	0	0.977036	0.33855
	Detail Design	159	0	113	46	4.737	13.3495	0.041898	0.04572
	Procurement	134	0	98	36	5.9905	19.491	0.12074	0.1533
	Demolition/Abatement	27	6.38E-08	20	7	0	29.545	0.406179	0.13047
	Construction	161	6E-10	114	47	1.83315	6.0606	0.207668	0.18722
	Startup	111	0	80	31	0	0	0.637396	0.20817
		Design Phase Schedule Growth Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	91	4.88E-11	71	20	0	5.607	0.21797	0.1792
	Buildings (B)	33	3.25E-10	24	9	18.717	33.88	0.44999	0.25513
	Light Industrial (LI)	25	8.18E-05	14	11	8.76	7.957	0.602311	0.32734
Project Nature	Modernization (M)	55	0.000102	42	13	6.413	15.522	0.093417	0.29115
	Addition (A)	50	2.26E-07	31	19	4.737	17.181	0.276217	0.16482
	Grass Roots (GR)	54	0	40	14	0	2.201	0.443313	0.12973
Cost	<$15 million	66	1.32E-06	40	26	5.9635	24.253	0.085295	0.04727
	$15-$50 million	50	2.61E-07	36	14	3.107	10.045	0.767463	0.61915
	$50-$100 million	24	1.04E-08	19	5	5.484	0.22	1	.
	>$100 million	19	.	.	.	.	.	.	.

Statistical Analysis Summary

(Part VII)

Owners'

		Procurement Phase Schedule Growth							
Category	Subset	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	84	0	66	18	1.3335	11.3465	0.284058	0.59629
	Buildings (B)	20	9.64E-07	14	6	4.348	-5.224	0.56223	0.84411
	Light Industrial (LI)	21	0.106715	14	7	16.236	22.951	0.433422	0.30703
Project Nature	Modernization (M)	48	7.58E-08	37	11	0	19.737	0.204434	0.19548
	Addition (A)	45	2.18E-07	29	16	2.941	22.1905	0.099963	0.03311
	Grass Roots (GR)	41	7.27E-14	32	9	8.9495	0.199	0.430329	0.76107
Cost	<$15 million	55	3.4E-08	34	21	0	19.737	0.078173	0.20583
	$15-$50 million	39	1.83E-09	30	9	4.24	0.415	0.986621	0.66499
	$50-$100 million	23	6.02E-07	18	5	12.337	22	0.765538	0.42395
	>$100 million	17	.	.	.	.	.	.	.

Owners'

		Construction Phase Schedule Growth							
Category	Subset	Number	Normality	Q_36(Y)	Q_36(N)	MED(Y)	MED(N)	Wilcoxon	JT
Industry Group	Heavy Industrial (HI)	95	0.024723	74	21	0	4.5455	0.20999	0.16743
	Buildings (B)	31	0.125658	22	9	5.5263	13.2075	0.98264	0.70801
	Light Industrial (LI)	25	2.53E-05	14	11	1.96155	6.1508	0.978078	0.44074
Project Nature	Modernization (M)	55	0.003244	43	12	4.2254	13.632	0.408169	0.34482
	Addition (A)	53	0.014522	33	20	0	3.09705	0.44484	0.27881
	Grass Roots (GR)	53	0.013476	38	15	2.84585	10.1307	0.273137	0.13127
Cost	<$15 million	66	0.003438	40	26	0	12.282	0.070678	0.06246
	$15-$50 million	50	0.00724	35	15	4.936	5.0909	0.966182	0.39401
	$50-$100 million	25	0.396155	20	5	9.07865	0	0.233581	0.5863
	>$100 million	20	0.000103	19	1	0.2347	6.1508	0.86232	.

Vita

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I received a Bachelor of Science in Civil Engineering from West Virginia University in May of 1997. I have spent the last few summers working in the construction department for the West Virginia Department of Highways. Graduate study at Virginia Tech has propelled me into a career that I truly enjoy. I am currently employed by Allan A. Myers Inc., a heavy civil construction company located in southeastern Pennsylvania.