DISSERTATION

AN EVIDENCE-BASED COMPARISON OF CONSTRUCTION PROJECT DELIVERY

Submitted by:

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY PHILIP WARREN PLUGGE ENTITLED *AN EVIDENCE-BASED COMPARISON OF CONSTRUCTION PROJECT DELIVERY* BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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ABSTRACT OF DISSERTATION

AN EVIDENCE-BASED COMPARISON OF CONSTRUCTION PROJECT DELIVERY

Medical professionals use evidence-based decision theory to identify uncertainty and knowledge about a problem through research and practical knowledge. Doctors use a gestalt process to synthesize the information available, weighting individual pieces of information related to patient condition, resources, budget, experiential knowledge, and econometrics, to analyze potential risks to a patient.

As with a patient, construction projects are all unique and take on their own characteristics throughout the life of the project. This research used the analysis-of-variance (ANOVA) method to analyze the risks associated with economics, environment, project, and technology on the project delivery methods of design-bid-build and design-build from the perspective of professionals in the construction industry. Data collected from this research was used to develop an evidence-based risk model related to the constructs of economics, environment, project, and technological risk and compare them between the two project delivery method variables of design-bid-build and design-build. Findings included significant differences across the constructs of project and technology. Additional findings on cost and time exposed differences associated with expectations of change and the understanding of costs within the design-build delivery method. For the design-bid-build project delivery method, the research confirmed the concern about cost growth through change orders. With design-build, the research supported the concept of improved quality and a better understanding of cost during the design process.

Significant findings were categorized around the constructs of project and technology. Conclusions from this research provide construction managers associated with

the ownership, design, and construction of projects with information about areas and magnitudes of potential risk concerning the two project delivery methods investigated.

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DEDICATION

To Mom, Pop, Grandma, and Grandpa. Thanks!

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER 1: INTRODUCTION AND BACKGROUND

The construction industry is a multi-faceted business which organizing large consumptions of money, time, resources, and people. It is one of the largest single most economically productive activities in the United States with an expected annual gross domestic product (GDP) of over $1 trillion by the year 2007 (Goodrum & Gangwar, 2004). In the next ten years, factors that will influence the construction market will be customer sophistication, construction skills, construction services, globalization, consolidation, construction diversity, capital supply, restoration, governance, and technology (Fails Management Institute [FMI], 2005).

Owners are seeking to find a one-stop-shop opportunity to provide all of the services offered in the construction process, which include architectural services, financing, engineering, supply, regulation, and construction for their projects. Constructors have begun to exert more control over the cost and schedule on a project by taking on additional responsibilities on the project, due to greater demands from the customer (Kasturi & Gransberg, 2002). This means the constructor is assuming more and more of the responsibility on the project due to greater demands from owners. Therefore, the constructor has to be prepared for an increased level of customer sophistication, construction skills, construction services, and diversity (FMI, 2005; Kasturi & Gransberg, 2002).

The customer (owner, user, general public) is demanding more from the services offered during the construction process. Typically, these demands require the constructor to deliver a project by expanding construction services within the framework of cost and time while maintaining a high-quality, safe product and reducing risk. Hall and Wiggins (2000) argue risk decision making involves six general factors including “social, technical, administrative, political, legal, and economic factors” (p. 180).

The architect/engineer within construction is faced with newer management challenges in business. Many of these challenges are driven by technology associated with building materials, newer design methodologies, design economics, and greater sophistication, along with the client's requirement to receive a low-cost, quickly constructed, high-quality, and safe project (Beard, Loulakis, & Wundram, 2001; Konchar & Sanvido, 1998).

The challenge for the constructor is bringing together and balancing all facets of the construction process. A part of this includes working with the customer's sophistication with construction practices. A knowledgeable costumer challenges both the skills of the constructor and the professional construction abilities of other individuals involved with the project. Constructors must provide the necessary skills to construct the project at the level and quantity to meet the customer's expectations while also meeting their own needs by keeping an eye on globalization's effects on the construction process. This should be done by maintaining an understanding of the global interface with their specific project and the construction industry as a whole (FMI, 2005).

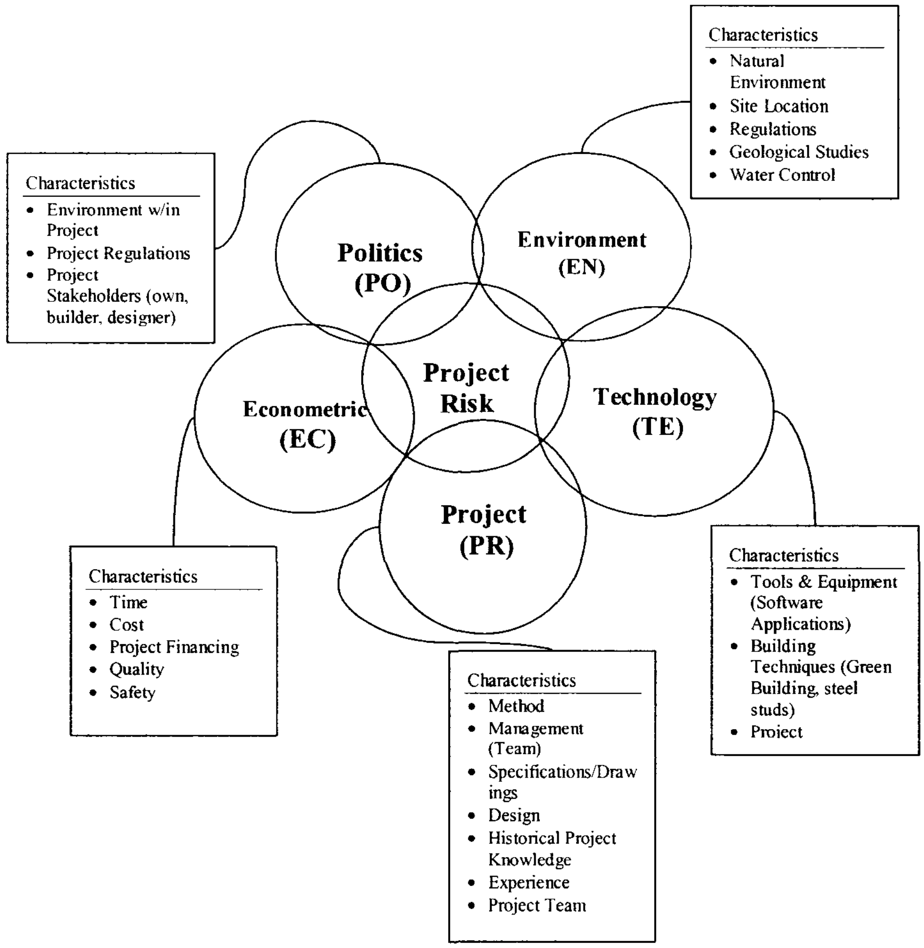
This is not the only challenge a constructor has to work with. Corporate expansion and consolidation affect the delivery and consumption of services related to materials, labor, and equipment. The constructor needs to manage a diverse set of projects, skills, language barriers, capital supply, continuous supply of material, restoration, governance (laws, rules, and regulations construction conforms to) and technology (change in tools and materials), while still providing a quality product under budget and within the allotted contract time (FMI, 2005). Also, the physical products the constructor is providing the customer are often one of a kind, large in size, high in cost, require large amounts of time to produce, consume many resources, and are very complex (Barrie & Paulson, 1992).

As projects grow larger and more complex, the uncertainty and services associated with them increase as well. Warsawski and Sacks (2004) state that "uncertainty is the state of incomplete knowledge about a decision variable" (p. 357). Uncertainty and decisions related to construction projects are becoming more complex as the knowledge of owners, architects, engineers, and constructors increase. With this knowledge the complexity, variability, and risk associated with construction projects increase as factors associated with the economy, environment, politics, project, and technology are analyzed within construction projects. More and more owners are seeking to find different methods to deliver projects under budget, and time, while maintaining high quality and safety standards (Warsawski & Sacks, 2004).

Project Complexity

Construction projects by their nature are complex operations. Many different individuals and factors interact during the construction process. The analysis of project complexity is the consideration "of the innumerable individuals involved in the process starting with the builder, the design professional, construction representative, subcontractor, supplier, and the entire professional and non-professional team members working under these responsibilities" (Kasturi & Gransberg, 2002, p. 17). Each professional constructor on a project will manage multiple factors related to the econometrics, politics, environment, technology, and the project. Davies (2004) argues with respect to complex environments, "there is a very strong need for more and better implementation studies that can identify the particular conditions under which successful implementation and delivery takes place or fails to take place" (p. 13). Figure 1 shows the complex conceptual risk framework with some of the interrelationships of these factors on a single project in construction.

Figure 1. Conceptual Model of Project Complexity



Adapted from Davies, (2004, February).

Econometrics

Cyert and Degroot (1986), Heij, De Boer, Franses, Kloek, and Dijk (2004), and Watson and Telucksingh (2002) argue that econometrics uses statistical and mathematical concepts to explain the various decision functions of uncertainty within the economy. More importantly, construction econometrics can be used as the economic framework for the decisions made with respect to the project cost, schedule, financing, quality, and safety based on the current economy. Econometrics assists in the definition of cost-effective and cost-beneficial interventions on a single project (Davies, 2004). Davies (2004) recommends that econometrics set the stage for sensitive and appropriate targets within the project. These targets are important because they provide the supportive background to the level of risk associated with a project for the owner, architect, engineer, and constructor. These targets are mostly based on time, cost, quality, and safety.

Environment

Some environmental aspects of the project include characteristics such as natural environment, site location, site regulations, geographic reports, geologic reports, and water. On all projects, site characteristics change based on the location. Some of these characteristics include the management of the soil, water supply and treatment, erosion and sediment control (Paleologos & Fletcher, 1999). Depending on the location, building codes and local environmental regulations will also be important factors (Drewnowski, 1996). These codes are necessary to assure the owner and constructors build the project to maintain the local environment and safety of the users. Environmental regulations exist to protect human health and the environment by placing value on human health and the environmental aspects of the project (Cothern, 1996; Dewberry & Champagne, 2002).

Politics

Politics is the sum of factors related to the project that include environment, regulations, and project stakeholders. In many cases legislative and regulatory codes, along with environmental concerns, set the guidelines for project construction. With respect to politics, Davies (2004) asserts that "governments make daily decisions that involve trade-offs between one policy and another, or one group and another" (p. 14). These decisions have an effect on the project's management environment, regulations, and the stakeholders involved. The management environment incorporates the interrelationships of the various stakeholders on the project with the decisions that need to be made. Regulations set the standards or boundaries by which a project is constructed. These are typically defined by state and local building codes which the project has to follow for basic human safety (Dewberry & Champagne, 2002). Political decisions with respect to the politics could have an adverse effect on the project's econometric factors related to the project.

Project

Construction projects are a complex and multifaceted, and influenced in many ways by various stakeholders and conditions (Harrison, 1932). Characteristics that influence the project delivery method include the management team, specifications and drawings, design, historical project knowledge, and the project team. The project delivery method could have an effect on the cost and schedule of the project (Barrie & Paulson, 1992; Mincks & Johnston, 1999). Depending on the project delivery method, the management team organizing the efforts could impact the project based on working relationships among the stakeholders (Kasturi & Gransberg, 2002).

Drawings and specifications define the actual components and complexity of the project (Simmons & Olin, 2001). If the drawings and specifications are not clear, the resulting uncertainty can complicate the project further. Historical project knowledge is an asset, because this provides a framework of experience that allows the manager to manage the project efficiently. A project team who has had a successful working relationship can also decrease the complexity factor because roles are more formally or informally understood and established within the team.

Technology

Technological characteristics involve the management of a project and its physical components. More specifically, technological characteristics involve the integration of tools and equipment, building technologies, and project management software should be integrated to assist in important decisions (Webb, Smallwood, Haupt, 2004). More technologically advanced equipment in construction provides labor with tools to be safer and more efficient

(Goodrum & Gangwar, 2004). However, the efficiency of a project could be affected by the lack of or type of equipment required by the conditions of the project.

Building technology is changing as we learn new ways to assemble construction projects. Different building materials have emerged, due to the rising interest in sustainable building practices (Myers, 2002). Sophisticated management software allows for more precise documentation of construction projects. Kerzner (2003) asserts that with respect to technology on projects, "most project management professionals seem to agree that the most serious risks, and the ones about which we seem to know the least, are the technical risk" (p. 694). Modern construction activities often involve the interaction of multiple technological components, which creates risk. Kerzner (2003) claims there are multiple technical aspects to a project, but "the worst situation is to have multiple technical risks that interact in an unpredictable or unknown manner" (p. 694).

Project Delivery

Construction projects are complex organizations of people and resources to achieve one common goal, namely a building, road, bridge, or other human-designed structure. Project delivery is the invisible part of the project's construction. It is more of a management process involving complex integration of technical, political, environmental, economical, and project components, conducted by many professionals to reach the common goals of completing projects under budget and within tight time frames (Barrie & Paulson, 1992; Cothern, 1996; Davies, 2004; Dewberry & Champagne, 2002; Heij et al., 2004, Kasturi & Gransberg, 2002; Simmons & Olin, 2001; Watson & Telucksingh, 2002).

To bring this notion of project delivery into context, a computer system is much like a project. As soon as the user pushes the button to turn on the computer, inside there is an organized operating system that is providing specific instructions about what the user will see on the screen, how the computer functions, how the mouse functions, and how the keyboard functions. These specific instructions are generally not known to the end user, but the user knows they exist and should be familiar with which operating systems are available. Each operating system achieves a similar outcome and there are many operating systems the user can choose from that would best suit their needs.

In construction, similar to an operating system, there are different project delivery methods that can be used to manage the construction of a project. Each project delivery method will achieve the same primary outcome, which is a completed project for use by the owner. Fisk and Reynolds (2006) identify project delivery as the organization of:

> People, relations with the contractor, communications, business systems, procedures, responsibility, authority, and duties of all the parties, documentation requirements, construction operations, planning, and scheduling, coordination, materials control, payment administration, change orders and extra work, dispute and claim handling, negotiations, and all project closeout functions, including punch list inspections, final cleanup, and administrative closeout (p. 3).

Project Delivery Methods

Common types of project delivery methods include design-bid-build, construction management, construction management at risk, and design-build. Each of these project delivery methods is unique in its management structures, organization, and the influence the stakeholders have on the project (Blayse & Manley, 2004; Konchar & Sanvido, 1998).

Design-bid-build

Design-bid-build (DBB) is the most prevalent delivery method in the construction industry, but was not the first delivery method to be used (Cushman & Loulakis, 2001). This system allows the owner to contract separately with the designer or engineer and the constructor. With this project delivery method, responsibilities are clearly divided among the owner, engineer, designer, and constructor (Cushman & Loulakis, 2001; Beard, Loulakis, & Wundrum, 2001). As previously stated, this is not the oldest project delivery method. Cushman and Loulakis (2001) state that this delivery method is a relatively recent concept that has been in use for approximately 150 years. Under this method, the design is complete before it goes to bid and before construction begins. For the constructor, many of the construction variables are known since they are documented in drawings and specifications or what are commonly known as contract documents. More importantly these contract documents serve as an accurate depiction of the actual scope and size of the project (Konchar & Sanvido, 1998; Ling, Chan, Chong, & Ee, 2002).

Construction management

Construction management (CM) is similar to DBB because it "treats the project planning, design, and construction phases as integrated tasks" (Barrie & Paulson, 1992, p. 35). This delivery method combines the project team of the owner, designer, and contractor. The key difference between this system and DBB is that the construction manager is in a non-adversarial or consultant relationship with the owner, designer, and constructor, allowing the owner to participate in the design and construction process. Contracts are generally written between the owner, designer, constructor, and construction manager (Barrie & Paulson, 1992, Fisk & Reynolds, 2006).

Much like DBB, CM is a well-established form of project delivery. More specifically, Fisk and Reynolds (2006) identify a construction manager as the one that works with the owner and design organization from the beginning to end; proposes construction guidance during planning with respect to cost, schedule, and constructability issues; advises and coordinates procurement of material, equipment, subcontractors, quality-control services; and provides current cost and schedule information to the project team.

Construction management at risk

The construction management at risk (CMR) is similar to the CM project delivery method. This method allows the owner to contract separately with the designer and contactor. The contractor has significant input into the design process and will guarantee a maximum construction price and time. CMR removes the non-adversarial relationship from the construction manager and places more responsibility with respect to cost and time on the construction manager (Konchar & Sanvido, 1998).

Design-build

Design-build (DB) is a different project delivery method than DBB, CM, and CMR, yet adopts some of the management responsibilities from CMR and removes the contractual design responsibility from the owner. With DB the owner will contract with a single entity for design and construction services. Through the DB project delivery method, the design-builder can contract with a different entity for design or they can provide the design as part of a single company. A key to this method is that the designer and constructor will work together as a single entity. Under this delivery method, construction could start before all of the design documents are 100% complete. This is different than DBB in that the contractor usually does not have a completed set of construction documents prior to the start of construction (Beard, Loulakis, & Wundram, 2001; Konchar & Sanvido, 1998).

As the complexity of construction projects increases, selecting a project delivery system has become a way to accommodate the owners' demands of decreased budgets and shorter building schedules. Different project delivery methods have been adjusted and used on the assumption that they decrease the cost and time on a project (Barrie & Paulson,1992; Konchar & Sanvido, 1998; Mincks & Johnston, 1999; Songer & Molanaar, 1997). Project delivery methods have been a way to divide the complexity of the project up into manageable parts and to spread or diversify the risk among many different professional specialties. Therefore, the type of project delivery method an owner adopts will define the relationship among those involved with the construction project.

Comparative Risk Analysis

At any point in a construction project continuum, stakeholders are constantly making comparisons and decisions about the cost and schedule of the individual components of the project; much like managing a portfolio of stocks. In a diversified stock portfolio, the portfolio is "composed of different assets with small mutual correlations, is less risky because the gains of some of the assets more or less compensate for the loss of others" (Bouchaud & Potters, 2000, p. 102). Portfolio managers adjust the portfolio as stocks rise or fall, in order to increase efficiency. The compare stocks to determine which ones carry the most risk.

Construction projects and project delivery are very similar to stock portfolios. Construction projects can be defined as a portfolio of work packages that can be affected by the management structure of the project (Minato & Ashley, 1998). Success or failure is determined by the performance of these work packages, due to the factors of econometrics, environment, politics, project, and technology (Konchar & Sanvido, 1999).

Empirical Project Delivery Comparisons

The comparison of project delivery risk can be analyzed through many different metrics. Minato and Ashely (1998) formulated a risk-analysis methodology to explain the interaction of risk factors inherent in multiple projects by the same corporation, using cost control data. This analysis used modern portfolio theory (MPT) to develop the concept of corporate risk. A model was then constructed to identify a beta for the regression coefficient relating the performance of a cost element relative to the overall performance of the completed project. This beta coefficient, a formula commonly used to describe financial portfolio risk, was developed to create a baseline for corporate risk. Once the model was created, Minato and Ashely (1998) used the beta coefficient in conjunction with actual historical cost-control data from a contractor to illustrate the project variability and performance risk factors associated with the sample of projects studied. The key finding from this study was that the beta used to predict and identify the magnitude of uncertainty with a portfolio of dependent risks found on a series of projects over a period of time.

Konchar and Sanvido (1998) empirically compared three project delivery systems on cost, schedule, and quality performance. The delivery methods studied included CMR, DB, and DBB. They compared these three delivery methods to develop an understanding of the benefits commonly obtained in project delivery. The authors were interested in variables of project scope, definition, team communication, information sharing, and presence of constructability in relationship to cost and schedule through a survey questionnaire. Using the survey sampling technique, Konchar and Sanvido (1998) built multivariate linear regression models for cost and schedule performance metrics using a series of projects from multiple construction companies. The objective was to analyze three project delivery methods on performance related to cost, schedule, and quality in relationship to unit cost, construction speed, delivery speed, cost growth, and schedule growth (Konchar & Sanvido, 1998).

Project Delivery and Risk

Other researchers have compared the use of project delivery methods. Molanaar and Songer (1998) used a multi-attribute regression-analysis model to identify the characteristics associated with DB project success. Songer (1988) sampled project directors to identify the performance factors associated with cost and schedule growth, conformance to expectations, administrative burden, and overall user satisfaction. Molenaar and Songer (1998) were able to develop models and equations that could be used to predict the performance of future projects.

Ling, Chan, Chong, and Ee (2002) have added to the body of knowledge on project delivery and risk by developing models of risk performance for projects using DBB and DB delivery methods. Ling et al. (2004) set out to find explanatory variables that significantly affect project performance and then constructed models to predict the project performance on

DB and DBB projects. Ling et al. (2004) argue that with explanatory variables "contractors will know the important variables that they must pay very close attention to in order to complete a project under budget, within schedule, with high quality, and bring satisfaction to the owner" (p. 75). Their study is important because these project performance models can help owners, contractors, architects, and engineers predict the likely key project-performance variables that need to be controlled. Ling et al. (2004) were able to group variables into four basic categories of cost, time, quality, and others on both public and private projects. This study added to the body of knowledge related on the comparisons and performance of project delivery methods by Konchar and Sanvido (1998), Minato and Ashely (1998), and Molenaar and Songer (1998).

With respect to project delivery, construction projects, complexity, and risk-analysis comparisons, Griffin (1996) argues "the mix of project requirements, contractor skills and experience, management tools, people, and owner expectations is constantly changing and so complex we may never understand all the variables" (p. 58). Because these variables are so complex, it becomes necessary to understand and study factors associated with the way risks are determined, even though all of the variables and outcomes may never be fully known. This is because "risk management techniques are not well developed in the construction industry, and almost all participants approach risk management in terms of intuition, judgment, and experience gained from previous contracts" (Kapila & Hendrikson, 2001, p. 186).

Through the work of Bouchaud and Potters, (2000), Kapila and Hendrikson (2001), Griffin (1996), Konchar and Sanvido (1999), Minato and Ashley (1998), and Molenaar and Songer (1998) we see that there are many variables that can affect a project, which are susceptible to cost and schedule variations on construction projects.

Study Context

There have been many studies related to construction project risk, that have looked at risk management, schedule risk, cost risk, risk communication, and risk modeling (Konchar & Sanvido, 1999; Minato & Ashley, 1998; Plugge, 2003; Tah & Carr, 2000). Tah and Carr (2000) state "construction projects are becoming increasingly complex and dynamic in their nature, and the introduction of new procurement methods means many contractors are having to rethink their approach to the ways risks are treated within their projects and organizations" (p. 170). Intelligent decision making requires understanding the risks associated with construction projects. The need was identified by Warszawski and Sacks (2004) as a challenge because:

> In risk assessment there exists a difficulty of obtaining information about the variability of the risk factors. Construction projects are generally unique, and design and construction teams change from project to project. Records are seldom kept in a retrievable manner; and when they are, the differences in project teams and the unique technical makeup of any new individual project, make the application of historic data difficult. Intensive investment efforts to establish the nature and scale of the risk factors with any precision, as is common in large scale capital projects, are typically well beyond the financial means of the majority of commercial, civil, or residential building construction project teams (p. 358).

Because of the demand for construction projects that are efficient and economical, using new technology and are environmentally conscious and politically compliant, the owners of these projects need to use the best means and methods to complete the project. Tah and Carr (2000) argue this presents an adversarial relationship with contractors because "project participants do not have a 'shared' understanding of the risks that threaten a project" (p. 170). Because each construction project is unique, there is a need to understand construction risk which is inherent to projects in general. An understanding of the factors related to project risk can explain the complex environments commonly found in construction.

Statement of Research Problem

Due to the variability and complexity of projects, there has been a move to use alternative project delivery methods to build projects with fewer resources and increased complexity (Chan, Scott, & Lam, 2002; Kasturi & Gransberg, 2002). The interrelationship of econometrics, environmental issues, political concerns, project and technological aspects of different projects is what distinguishes project delivery methods (Cooper, Grey, Raymond, & Walker, 2005).

The stability of the traditional design-bid-build delivery method means many companies can profitably estimate their project costs. The design-bid-build process is a relatively complete process because most of the information is generally known by the stakeholders. A contractor can be reasonably assured that what is in the drawings and specifications at the bidding stage is a true representation of what is intended to be constructed.

With alternative delivery methods such as DB, many of the critical variables such as the project design or cost are not well defined at the beginning of the project and can change during the course of design and construction. A common feature of the DB process is the control the architect, engineer, and constructor have over the design and construction of the project. Barrie and Paulson (1992) argue, even though there is greater control, there is less detailed information with respect to the design and finance information on the project.

Research Questions

This research will gather and use experiences of professionals who have worked in the design-bid-build (DBB) and design-build (DB) method of project delivery. This study will attempt to compare risks associated with econometrics, environment, politics, project, and technology as it relates to DBB and DB. Information collected from the experiences of professionals will be used to populate an evidence-based model on construction project risk.

The research questions are designed to examine risk exposure within the five main constructs of economics, environment, politics, project, and technology on the independent variables of the project delivery methods. Differences between the two project delivery methods were identified from well established professionals in the fields of architecture, engineering, and construction through a survey instrument. Research questions for differences between two project delivery methods across the constructs of interest included:

1. Do differences exist between the two project delivery methods of design-bid-build and design-build?

    a. Where do the differences occur econometrically between the two project delivery methods?

    b. Where are the differences in environmental-management factors in the two project delivery methods on projects?

    c. At the project level, what are the most important risk considerations in each of the two project delivery methods?

    d. What technological factors are important across the two project delivery methods?

Hypotheses

There are many variables associated with the delivery of a construction project. Many of these are influenced by factors such as the economy, the environment, politics, project, and technology. The purpose of this study is to compare the DBB and DB across economic, environment, politics, project, and technology factors to build an evidence-based model on risk in construction management. In addition to comparing the project delivery methods of DBB and DB, this research will attempt to explain or organize the complexity of project delivery. Therefore, these differences can be stated within the following null hypotheses H_O:

1. There are no significant differences between the two project delivery methods of design-bid-build and design-build.
    a. There are no significant differences in econometric factors between the two delivery methods.
    b. There are no significant differences in environmental management factors between the two project delivery methods.
    c. At the project level the there are no significant differences that exist across the two project delivery methods.
    d. There are no significant differences that exist across the two project delivery methods on technology.

Definition of Terms

For the purposes of this study, the following terms are defined to operationalize the terms used within this research:

Decision Analysis: The recognition that uncertainties exist regarding desirable and undesirable consequences and all such uncertainties influence decisions (Lifson & Shaifer, 1982, p. 133).

Design-bid-build (DBB): Also known as the traditional project delivery method where the owner contracts separately with a designer and constructor to design and construct a project (Fisk & Reynolds, 2006;Ling et al., 2002). The owner normally contracts with a design company to provide "complete" design documents. Then the owner or owner's agent usually solicits fixed-price bids from construction contractors to perform the work. One contractor is usually selected and enters into an agreement with the owner to construct a facility following the plans and specifications (Konchar & Sanvido, 1998, p. 435).

Design-Build (DB): An effort by the owner of a project to combine the design and construction of a project to coordinate cost, time, quality, and safety on a construction project (Beard, Loulakis, & Wundrum, 2001). The owner contracts with a single entity to perform both design and construction under a single design/build contract. Contractually, design-build offers the owner a single point of responsibility for design and construction services. Portions or all of the design and construction may be performed by a single design-build entity or selected specialty work, or in some cases, all may be subcontracted to other companies (Abdou, 1996; Konchar & Sanvido, 1998).

Project Delivery: A method to establish the working relationships between the owner, architect, engineer, and constructor on a construction project. Methods include are design-bid-build (DBB), design-build (DB), construction management (CM), or construction management at risk (CMR) (Dorsey, 1999).

Risk: For the purposes of this study, risk is defined as the variability in cost, time, and quality associated with the 16 Construction Specifications Institute (CSI) divisions in construction. Associated with cost is the variability between the project's estimated and actual cost across the 16 divisions. Time risk is defined as the variability between the planned duration and the actual duration across the sixteen divisions.

Risk Analysis: Identifying the "right" data for a particular decision and properly processing the data to identify the "best" course of action consistent with available resources (Lifson & Shaifer, 1982, pg. 4).

Delimitations

Creswell (1994) states delimitations, "address how the study will be narrowed in scope" (p. 110). The delimitations for this study are:

- This study will be limited to comparing the risks associated with projects procured under the design-bid-build and design-build project delivery methods.
- Data will be extracted using only a questionnaire to be emailed to selected individuals in professional organizations and companies.
- Only professionals working with these project delivery methods on a daily basis will be used as the sample to providing the data needed to compare design-bid-build and design-build.

Assumptions

The assumptions of the study are based on the requirements for statistical analysis using the analysis of variance (ANOVA) method to compare differences that may exist across the five constructs of interest. Factors exist that are beyond the researcher's control, as defined by the limitations of the study. Limitations are "the potential weaknesses of the study" (Creswell, 1994, p. 110). The conceptual framework for the assumptions in this study follows guidelines defined by Anderson (2001), Huck (2004), Snow (1974) and Tromchin (2004) in the context of random sampling, statistical independence, normality, and homogeneity of variances. Although some of these assumptions may be violated in this study, this is inherent to quasi-experimental research conducted in natural settings. Research in construction represents the natural ebb and flow of activities that occur in the context of a construction project (Snow, 1974). Because experienced professionals working with the two project delivery methods are the data source, the researcher will be relying on their experiences with these delivery methods, and their willingness to provide information. Additional assumptions and limitations of the study are defined below.

The groups of professionals who work with DBB and DB projects could have little independence. Anderson (2001) states that "independence is violated when one score carries information about some other score" (p. 69). Independence could be affected because a single econometric, environmental, political, project, and technological factor could influence a project at any point in relation to the cost and schedule of the project. Anderson (2001) further explains that a common source of "nonindependence can occur when groups are naturally occurring, subjects' responses may expect to be more similar within groups than between groups, thereby violating independence. " (p. 69). Because the data for this study will be gathered from experienced professionals, the researcher will be relying on the participant's previous knowledge and experience as data to develop the comparative model.

Current market conditions also affect the cost data. These conditions reflect the fluctuating economical, financial, and inflationary metrics of the economy. Financial aspects and change over time on projects are sensitive areas, therefore the researcher will not be able to access detailed financial records. Additionally, schedule components are also sensitive areas for this research, because many architecture, engineering, and construction companies consider this information as proprietary. Again, the researcher will be relying on the experience and knowledge of the professionals through the use of a survey methodology using a self-made questionnaire.

Significance of the Study

Many construction project delivery methods and variations exist to organize and complete the activities required on a construction project. The most dominant project delivery method today is still the design-bid-build method (Konchar & Sanvido, 1998). The literature on this project delivery method asserts that it is a well-established practice in the construction industry. Therefore, the risks associated with this delivery method are also well-established (Barrie & Paulson, 1992; Gould & Joyce, 2004).

The use of design-build as a delivery method to manage projects does provide many challenges for project teams. For the owner, the design-build delivery method allows a single point of contact for the design and construction of a project. This is unlike the design-bid-build method, where the owner contracts separately with an architect and/or engineer to manage the design of the project, and with a constructor to manage the physical construction (Barrie & Paulson, 1992; Beard, Lulakis, & Wundram, 2001; FMI, 2004; Ling et al., 2004; Mincks & Johnston, 1999).

In comparing these two delivery methods, the literature suggests that there are inherent risks associated with cost and time related to both design-bid-build and design-build (Beard, Lulakis, & Wundram, 2001; Konchar & Sanvido, 1998; Ling et al. 2004). Statistical-analysis procedures show there are inherent differences between the two delivery methods (Minato & Ashley, 1998). Therefore, the significance of this study is that it measures and compares potential risks associated with these two project delivery methods across the five constructs of interest, through measuring the perceptions of experienced professionals in architecture, engineering, and construction disciplines.

Researcher's Perspective

The researcher developed an interest in the decision analysis strategies used in construction while researching and working on several large construction projects. Experiential knowledge is an important factor in the success or failure of any future project. More importantly, experience provides the manager with greater insights about what risks are inherent to a particular project. This knowledge guides decisions that need to be made on problems or conditions which could expose a project to various types of risk.

It is the opinion of the researcher; a successful construction project depends on the ability of a manager to use research and experiential knowledge to make calculated decisions. Doggett (2003) argues with respect to solving problems and making decisions; that "systematic analysis helps professionals make decisions based on logic rather than emotion" (p. 11). The logic in most construction applications is based on field experience and knowledge gained from prior projects. There is little documentation from actual research on how decisions are made or risk is identified across project delivery methods. My interest in this subject comes from several years of working within construction under both project delivery methods in the areas of construction estimating and field management. I observed how key personnel made the decisions that could positively or negatively affect a project. I wanted to see if there was a way to create a model using a statistical approach to define the variability in decisions on risk associated with construction projects.

Original research related to construction management is important to me as a construction professional and construction management faculty member. Advancing research in this area is also extremely important as costs are becoming a more critical component in the construction process. Identifying areas of potential risk only seem to reason that they could be assistive in reducing costs and delivering a better quality project. Therefore, if we could perform research that expose elements of delivering a project safely, with acceptable quality, within time, and under budget we have met a criteria of understanding risks inherent on many projects.

CHAPTER 2: LITERATURE REVIEW

Introduction

The built environment is a collection and progression of technology developed over many years, influenced by social, economic, political, environmental, and technological events. Humans instinctually create shelter for living and working. Years of building technology, research, education, testing, and trials and errors, have gone into making the human built environment habitable. What we build changes the natural environmental landscape and how we build changes the relationship between nature and our world (Bartuska & Young, 1994). Fiori and Kovaka (2005) have stated in relation to construction that:

> Construction of the built environment is one of the oldest and most globally-pervasive human activities. Over the past century the volume and scope of construction projects worldwide has increased exponentially in response to cultural, economic, and technological globalization (n.p.).

Anthropologists have researched the human endeavor to design and construct various structures to assist and sustain the existence of human life. As Matthews (1994) has illustrated "the human animal has created an endless variety of products, structures, and settlements which adapt to widely different circumstances, indulging (often wildly) in original expression and unique design ideas" (p. 13). Anthropologic studies show the existence of construction from ancient times to present.

Armi (2004) documented through the works of scholars such as Guy Bois, Pierre Bonnassie, Georges Duby, Robert Frossier, and Jean-Pierre Ply issues of population, economy, environment, politics, religion, and technology were part of the complexity of construction of numerous churches and buildings in the Roman Empire. Van De Mieroop (2005) and Rowland and Howe (1999) assert that ancient Roman architectural philosophers such as Hammerabi, Vitruvius, and Alberti documented the complexities of construction through codes and handbooks used by the builders of their time. These codes and handbooks were instrumental in defining the roles of architects, engineers, and constructors (Rowland & Howe, 1999; Van De Mieroop, 2005). As Rowland and Howe (1999) argued, artists used the gaps left in these codes and handbooks to provide greater input into design and construction of projects.

Construction methods developed during the Renaissance, due to changes in econometrics, environment, politics, technology, and project delivery methods. Professional and managerial roles adapted to fit these new approaches (Armi, 2004; Carty, 1995; Jackson, 2004). Konchar and Sanvido (1998) argue that:

> Project delivery systems have evolved over the years. The medieval master builder was hired by an owner to design, engineer, and construct an entire facility. This system was common until early in the 20th century. Continuous changes in technology and increasing sophistication in buildings required specialization of design and construction services. Designers and constructors began to specialize in design, fabrication, and/or construction of particular building systems. This led to the traditional design-bid-build delivery system which offered clients a sequential 'design, bid, then build approach' (p. 435).

As technology advanced and sophistication increased, there was a need for further professional specialization. Condit (1982) contends that construction industry within the United States became more organized in 1724 by the Carpenters Company in Philadelphia; this was one of the first adoptions of the master builder concept in the U.S. The master builder concept, described by Rowland and Howe (1999), Yates and Battersby (2003), and Van De Mieroop (2005) is the idea that the builder is responsible for designing, surveying, laying out, and managing of construction projects according to the construction documents for the project. Beard, Loulakis, and Wundram (2001) and Yates and Battersby (2003) also argue that the master builder was the architect, engineer, and job superintendent for each project.

During the twentieth century, the complexity of projects increased. Roles of the designer and constructor began to fragment, creating the traditional or design-bid-build project delivery method (Yates & Battersby, 2003). Yates and Battersby (2003) assert there are two areas of fragmentation: "the first area of fragmentation is caused by the separation of the master builder function into separate design and construction functions, and the second results from the specialization of designers and builders into more specific fields of operation" (p. 637). In the design-bid-build project delivery method fragmentation created "significant gaps between individuals and organizations working on the same project" (Pocock, Hyun, Liu, & Kim, 1996, p. 165).

To understand the differences between design-bid-build and design-build, this review of literature will discuss some of the history and background of construction and its project delivery methods. Through the historical background of the two delivery methods the literature review will review the advantages and disadvantages of each project delivery method and develop the concept of risk associated with cost and time with each of the two project delivery systems.

Discussing the history and background of construction sets the stage to understand the relationship of construction as it relates to design-bid-build (DBB) and design-build (DB) and the influences each has on the metrics of cost and time. The importance of the relationship between the two methods, cost, and time, is that each delivery method and project has its own inherent unique characteristics. One method (DBB) has a fragmented management system and the other (DB) is an integrated management system (Konchar & Sanvido, 1998; Pocock et. al, 1996; Yates & Batersby, 2003).

These characteristics change with every project and project team. Conditions beyond the control of the stakeholders involved with the project also play a part. Managing risk is a challenging job, especially when project costs and durations are taken into account. Yates and Battersby (2003) believe “the changes that have taken place in project delivery methods during the later part of the 20^{th} century may have affected the construction industry” in terms of cost, quality, and schedule (p. 637). Therefore, decreasing the level of uncertainty or risk associated with a project requires stakeholders to acquire detailed information for the minimization of risks related to the specific project. The minimization of risks requires management to access historical information for analysis from which, to draw conclusions, minimize uncertainty, and guide decisions with respect to the construction process and the project delivery method on factors such as econometrics, environment, politics, technology, and the project (Takayuki, 1994).

Project Delivery

Project delivery methods provide an organizational structure for construction projects. As Mincks and Johnston (2004) state, project delivery methods are “a structure or matrix, with formal and informal contractual relationships between participants” (p. 14). The selection of the delivery method “is governed to a large extent by risk but also by the owner’s desire to find a method that will deliver the project on time, within budget, and in a form that will meet the owner’s needs most effectively” (Gould & Joyce, 2003, p. 100).

Project delivery methods are used to identify and establish the primary parties taking contractual responsibility for the work. AGC (2004) argues that the essential elements of a project delivery method revolve around cost, quality, time, and safety. More importantly, the people on the project will also determine the project’s success or failure. Therefore, success or failure of the delivery method depends on the performance, trust, and cooperation among the parties involved (AGC, 2004). The delivery method process includes:

- The scope and requirements of a project
- Procedures, actions, and sequences of events
- Contractual requirements, obligations, and responsibilities of the parties
- Interrelationships among the participants
- Mechanisms for managing time, cost, safety, and quality
- Forms of agreement and documentation of activity (AGC, 2004, p. 3)

The project delivery process combines many different tasks and activities performed at all levels of the project. Generally, definition of scope and requirements of the project will be defined by the owner of the project. Gould (2005) asserts, "the owner is responsible for determining what the project will include, when the project can begin and must end, and how much he or she can afford to spend" (p. 11). To determine these parameters, the owner will rely on many people including facility engineers, planners, outside consultants, project managers, design professionals, and construction managers (Gould, 2005).

The procedures, actions, and sequencing of events are generally determined during the planning stage of the project. Kerzner (2003) contends that planning "is determining what needs to be done, by whom, and by when, in order to fulfill one's assigned responsibility" (p. 380). Planning requires the participants to document the work required to complete the necessary objectives of the project.

In the planning stage, contractual requirements, obligations, and responsibilities of the parties are determined. The contractual requirements establish the obligations of each party involved with the project. This is crucial for determining project risk (Gould, 2005). A contract is defined by Ansley, Kelleher, Lehman (2001) as the "foundation of virtually every relationship in the construction industry" (p. 35). Contract terms establish the relationship among parties, define technical terms within various industries and trades, and identify the general terms defining the project (Ansley, Kelleher, T.J., Lehman, 2001).

Interrelationships among the parties are also established through the organization of the project. Barrie and Paulson (1992) argue that "organization is the process used by managers to relate tasks to people, other firms, regulatory agencies and other interested groups in order to achieve an economical and timely performance" (p. 20). More importantly, in construction the manager "must deal with the design of the structure, delegation of responsibility, working relationships between individuals and groups, and creation of a communications program designed to keep everyone fully informed" (Barrie & Paulson, 1992, p. 20).

Mechanisms for managing time, cost, safety, and quality specify the control aspects of project delivery. Kerzner (2003) identifies three steps to controlling a project: measuring, evaluating, and correcting the project. Kerzner (2003) further defines these steps as:

- *Measuring:* determining through formal and informal reports the degree to which progress toward objectives is being made.
- *Evaluating:* determining the cause of and possible ways to act on significant deviations from planned performance.
- *Correcting:* taking control action to correct an unfavorable trend or to take advantage of an unusually favorable trend (p. 193).

Using these concepts, Barrie and Paulson (1992) argue that controlling requires monitoring, influencing, and achieving the objectives of the project thoughout the project's performance. More specifically, they state "control requires an awareness of the current status of cost, schedule, safety, and quality performance" (Barrie and Paulson, 1992, p. 21).

Forms of agreement and documentation of activities are systems that inform managers on the condition of the project delivery method. Barrie and Paulson (1992) emphasize, to be informed of the project's condition, the project should have a "budget; its designs should be on paper; it should have a schedule which in turn forecasts the requirements for resources of labor, equipment, and materials; but it also needs a dynamic and responsive feedback-control system to cope with the operations underway" (p. 183).

Forms of agreement and documentation include inspection reports, correspondence, cost worksheets, quality/materials testing, changes and extra work, payment for work and materials, work progress reports (schedules), daily reports, contractor submittals, record drawings, photos, claims information, and safety records (Fisk & Reynolds, 2006). What Barrie and Paulson (1992), Fisk and Reynolds (2006), and Kerzner (2003) are suggesting is that project documentation is important for measuring, evaluating, and correcting risks associated with project delivery.

Project Framework

Griffin (1996) and Kerzner (2003) claim there are various mechanisms to control a project. An important factor is the management information system that allows a manager to communicate, capture, organize, measure, evaluate, and correct information exchange on a project. Typically, with costs and schedule, a project is organized by the sequential activities as they occur, defined by the work breakdown structure (WBS) (Haugan, 2003). The basic concept of the WBS is an organizational structure that breaks down the project into specific parts that can be coordinated, controlled, designed, and budgeted (Gould, 2005; Haugan, 2003).

Construction projects are typically organized using a WBS developed by the Construction Specifications Institute (CSI). CSI was established in 1948 to organize the specifications required for a project (Simmons, 2001). A WBS is necessary due to the size and complexity of most construction projects (Feigenbaum, 2002). CSI divisions are organized categorically from divisions 1-16 starting with the general requirements of the project and ending with electrical. This structure follows the basic construction sequence of a typical project. The basic descriptors are Division 1- General Requirements, Division 2- Site Construction, Division 3- Concrete, Division 4- Masonry, Division 5- Metals, Division 6- Wood and Plastics, Division 7- Thermal and Moisture Protection, Division 8- Doors and

Windows, Division 9- Finishes, Division 10- Specialties, Division 11- Equipment, Division 12- Furnishings, Division 13- Special Construction, Division 14- Conveying Systems, Division 15- Mechanical, and Division 16- Electrical (Simmons, 2001).

Much like the framing for a building or a house the 16 divisions provided by CSI and described by Simmons (2001) provide a structure for organizing and controlling the costs and schedule of a construction project. The 16 divisions are constant, and are common elements of most construction projects. A WBS and the 16 divisions can provide "valuable historical data that can be accumulated and used to verify current project performance and productivity" for both cost and schedule metrics (Feigenbaum, 2002, p. 6).

CSI Divisions

The 16 divisions are used to describe the entire project, and specify the types of material, labor, and equipment to be installed, each division has its own unique characteristics to help organize a project. Each division one is unique because it sets the boundaries or the general requirements of the project. Section one describes the building design, construction documents, bidding and negotiation, construction contract administration, industry standards, codes, barrier-free design, systems of measurement, land surveys and descriptions, and properties of materials (Simmons, 2001). Many division one activities can occur throughout the duration of the project.

Division two, or site construction, describes how the physical is to be constructed. It describes the project's soils, site preparation, earthwork surface and groundwater considerations, and lawns and landscaping (Simmons, 2001). These activities can also occur in several different stages throughout the project.

Division three is associated with the concrete activities on the project. More specifically, it contains the concrete materials, formwork, reinforcement, accessories, joints, mixtures, handling, finishing, curing and protection, foundation types, precast concrete, architectural, and structural concrete activities (Simmons, 2001). Depending on the stage of the project concrete activities can occur throughout the duration of the project.

Division four describes the installation and the material application of masonry on the project. Masonry can be used in structural or architectural applications. This involves activities associated with installing and placing mortar and grout, reinforcement, ties, anchors, and flashing, clay masonry, concrete masonry, masonry design, erection, stone, glass masonry, and the properties of masonry walls (Simmons, 2001).

Division five describes the metals to be installed on the project, which can have structural and architectural elements. More specifically, division five identifies the iron and steel design and construction, iron and steel material properties, miscellaneous iron and steel, aluminum, and specialty metals (Simmons, 2001). Division five will specifies how each of the metals is to be fabricated and installed.

Division six identifies the wood and plastics to be installed on the project. Many of the woods and plastics can be structural and architectural. This division specifically describes the manufacturing and installation of lumber, plywood and other wood panels, and treated wood, as well as framing requirements, finish carpentry, and plastic fabrications (Simmons, 2001).

Division seven describes thermal and moisture protection. Within this division, the specifications explain moisture control, waterproofing and dampproofing, building insulation, exterior insulation and finish systems, roofing, siding, flashing and sheet metal, metal roofing, fireproofing, and joint sealing (Simmons, 2001).

Division eight provides information on the door and window installation. It specifies metal doors and frames, wood doors, aluminum entrances and storefronts, aluminum windows and sliding glass doors, wood windows, storm windows and doors, door hardware, glazing (glass), and glazed aluminum curtain walls (Simmons, 2001). Division eight activities can occur at many different stages of a project.

Division nine specifies the finishes to be applied, such as plaster materials, plaster support systems, bases, and accessories, gypsum board application, tile, terrazzo, acoustical treatment, wood flooring, tile flooring (ceramic, vinyl, etc.), carpet, resinous floorings, paints, and wall coverings (Simmons, 2001).

Division ten describes the specialty items installed on a project. Some of the specialty items included are visual display boards, toilet compartments, louvers, equipment screens, high impact wall coverings, manufactured fireplaces, gas-stove inserts, flagpoles, signage, lockers, operable partitions, shelving, and bath accessories (McGraw Hill Construction Network for products, n.d.).

Division eleven specifies the equipment to serve the functional purposes of the project requirements. The equipment specifications will include traffic-control equipment, vault equipment, computers, banking accessories, kitchen units, food-service equipment, walk-in freezers, laboratory equipment, theater and stage equipment, recreational equipment, healthcare equipment, and waste handling equipment ((McGraw Hill Construction Network for products, n.d.; Simmons, 2001).

Division twelve identifies the furnishings to be installed on the project. Typical furnishings to be installed include artwork, curtains, window treatments, casework, countertops, clocks, rugs, mats, furniture, seating, site furnishings, pews and benches, planters, and bike racks (McGraw Hill Construction Network for products, n.d.).

Division thirteen is special construction. Items related to this division would include special purpose rooms, precision-controlled environments, computer rooms, shelters and booths, bullet-resistant protection, vibration and seismic control, radiation protection, pre-engineered buildings, glazed structures, mezzanine systems, equipment storage systems, swimming pools, ice rinks, chemical storage equipment, athletic structures, solar energy systems, security systems, and fire protection systems (McGraw Hill Construction Network for products, n.d.).

Division fourteen identifies the conveying systems on projects. Typical conveying systems include elevators, passenger cabs, escalators, moving walks, people lifts, wheelchair lifts, vehicle lifts, hospital transport equipment, conveyors, hoists and cranes, and powered scaffolding (McGraw Hill Construction Network for products, n.d.).

Division fifteen contains the mechanical components on the project. Mechanical components can include ventilation equipment, ducts, piping, floor and roof drains, process air and gas piping, plumbing fixtures, water coolers and drinking fountains, fountains, water conditioning and filtration equipment, heating boilers, heating, ventilation, and air-conditioning equipment (McGraw Hill Construction Network for products, n.d.).

Division sixteen contains all electrical items pertaining to a project. Typical electrical items include wiring devices, lighting, roadway and parking lighting, navigation lighting, emergency lighting, medical lighting, light poles, communication equipment, sound and video wiring, and multimedia equipment (McGraw Hill Construction Network for products, n.d.).

The description of each of each division shows the complexity that must be controlled and managed with respect to the labor, material, and equipment on a construction project. In many cases, there may be multiple entities that will design, build, manage, and control each of these sixteen divisions for the owner.

Because there are so many tasks that must be managed on a project, specifying the appropriate project delivery method is important. Gould and Joyce (2004) claim the dilemma for the owner in choosing a project delivery method is that it is a function of "price versus performance"(p. 98). Additionally, with respect to problem solving, "each project has distinctive requirements for problem solving, and some methods work better than others in solving problems" (p. 98). Since projects come in all different shapes and sizes there are multiple types of project delivery methods. Three types of project delivery methods commonly used and studied include design-bid-build (DBB), design-build (DB), and construction management (CM) (AGC, 2004; Jackson, 2004; Joyce & Gould, 2003; Gould, 2005; Konchar, 1997; Konchar & Sanvido, 1999; Mincks & Johnston, 2004). The project delivery methods of DBB and DB will be further defined in the next sections to establish the current and historical differences between these two delivery methods.

Design-Build

History

The concept of the design-build project delivery method is not new. The Greeks had a term which encompassed the major concepts of the design-build process, a single source of responsibility or seamless service called *arkitekton*. Arkitekton, when translated, means "first or principal builder or craftsperson, and from which we have derived the modern word architect" (Beard, Loulakis, & Wundram, 2001, p. 13). Besides the Greeks, other ancient philosophers commingled the ideas of design and construction. In Mesopotamia, the Babylonian Code of Hammurabi (1800 BC) also placed design and construction under one single source of responsibility, the "master builder." With this title, came specific responsibilities and liabilities for and knowledge of drafting, engineering, aesthetic design, architectural design, and construction methods (Cushman & Loulakis, 2001). Codes established by Hammurabi were an attempt to provide central organization to the building and construction of many cities which fell under his control. Much like other rulers of this time, Hammurabi was "careful to portray himself as a central cog in a system that only worked when all parts fit together" (Van De Mieroop, 2005, p. 85).

The codes developed by Hammurabi described how the builder must know the appropriate design for the required structure. Parts of the code address the work of the builder, but little of the design. This was based on the assumption that many of the structures were designed and built based on trial and error means and methods. Beard, Loulakis, & Wundram (2001) identified six of Hammurabi's numerous codes:

> 228 If a builder build a house for someone and complete it he shall give him (the builder) a fee of two shekels in money for each sar of surface.
>
> 229 If a builder build a house for someone, and does not construct it properly, and the house, which he built, fall in and kills its owner, the that builder shall be put to death.
>
> 230 If it kill the son of the owner, the son of that builder shall be put to death.
>
> 231 If it kill a slave of the owner, then he shall pay slave for slave to the owner of the house.
>
> 232 If it ruin goods, he shall make compensation of all that has been ruined, and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means.
>
> 233 If a builder build a house for someone, even though he has not yet completed it; if then the walls seem toppling, the builder must make solid from his own means (p. 15).

Under Hammurabi's rule, using accepted practices in design, construction, building materials and forms was important to building ideology and the laws governing the people of the city. If these practices were not followed, the builder would risk life and limb and face strict penalties (Horne, 2005). Under these codes, the designer and builder had to accept design and construction responsibilities in order to be paid. As Horne (2005) and Beard, Loulakis, and Wundram (2001) imply, the laws or codes under Hammurabi were the first recorded penalties that made master builders liable if the client or owner was harmed physically or monetarily. What these codes established were the first elements of risk, the builder's human life, as it applied to architecture, engineering, and construction management (Beard, Loulakis, and Wundram, 2001; Horne, 2005).

Hammurabi was a building philosopher who developed rules or codes architects or builders had to follow for the protection of human life. Vitruvius is responsible for writing, organizing, documenting, and disseminating the concepts behind architecture and engineering design. These concepts were captured in Vitruvius' writings of 10 handbooks (10 books on Architecture) called *De architectura libri decem* or *De architectura*. These were extensions of handbooks used during the time of Roman Emperor Augustus. In each of the 10 books of *De architectura,* Vitruvius consistently refers to architecture and construction as centered on nature, the human body, and the synergy of humans with the built environment (Beard, Loulakis, & Wundram, 2001; McEwen, 2003).

As Vitruvius wrote his 10 handbooks, each handbook he developed further knowledge on architecture, engineering, and construction methods. Various authors have argued that *De architectura* was successful in establishing design and construction management as learned professions (Beard, Loulakis, & Wundram, 2001). More importantly, as Beard, Loulakis, & Wundrum (2001) state, Vitruvius' writings established "responsibilities for what we now call design and construction was vested in a single individual or *arkhitekton*" (p. 16). In a time when the world was being remade, Vitruvius' handbooks were the first attempt to organize architecture, engineering, and construction as a professional discipline. Each of the ten handbooks has been translated from the Latin and Greek language to cover a wide range of architecture, engineering, and construction subjects. According to Rowland and Howe (1999), the titles of the ten handbooks are translated as follows:

Book 1: First Principles and the Layout of Cities
Book 2: Building Materials
Book 3: Temples
Book 4: Corinthian, Doric, and Tuscan Temples
Book 5: Public Buildings
Book 6: Private Buildings
Book 7: Finishing
Book 8: Water
Book 9: Sundials and Clocks
Book 10: Machines

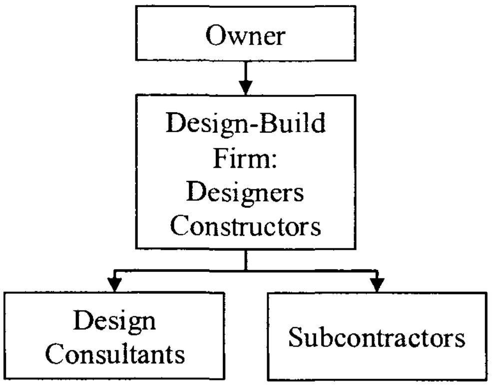
Vitruvius describes in great detail the architectural, engineering, and construction processes needed to construct various types of Roman structures. Each book explains the factors that control the engineering and construction process as they are relate to politics, science, mathematics, philosophy, biology, and the environment (Rowland & Howe, 1999). The descriptions and drawings were detailed to a certain point, but also left incomplete, since "gaps and ambiguities in the drawings were left because that is probably the way he intended them to be understood" (Rowland & Howe, 1999, p. xvi). Rowland and Howe (1999) claim that these gaps and ambiguities were probably left until the final execution of construction to allow other artisans to provide further input and collaboration into the design and construction of the project, hence the birth of the design-build process.

Design-Build Management Structures

The examples of Hammurabi and Vitruvius show that the design-build concepts use a single point of contact for the design and construction of a project. The management structure of a design-build project is designed to use this single point of contact from concept through design and construction (Barrie & Paulson, 1992; Mincks & Johnston, 1999).

There are four basic forms of management structures in design-build. These are variations on the concept of allowing the owner to have a single source of contact during the design and building process. Each management structure is suited to different types of projects. Figure 2 shows the organizational structure of the traditional design-build organization. This structure allows the constructors internal control over the design and construction, which may result in a high value package for the owner (Mincks & Johnston, 1999).

Figure 2. Integrated Design-Build Organization

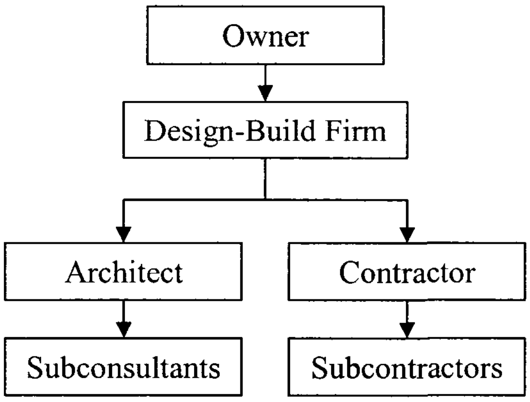


Adapted from: Mincks, W.R. & Johnston, H. (2004).

In this organizational model, both the designers and constructors are organized as a single entity. Generally, if the two companies, the designer and constructor, are two separate companies, they will form as a single company much like a joint venture (Mincks & Johnston, 1999; Yates & Battersby, 2003). Typically, under this relationship, the owner will "contract directly with the designer who is an in-house employee of the integrated firm" (Cushman & Loulakis, 2001). Cushman and Loulakis (2001) argue that the "designer is an employee who may not have the degree of independence to exercise its discretion over what is in the best interests of the owner" (p. 17).

Developers who have their origins in architecture/engineering, construction, or property development often use the design-build firm organization, shown in Figure 3.

Figure 3. Design-Build Firm Organization

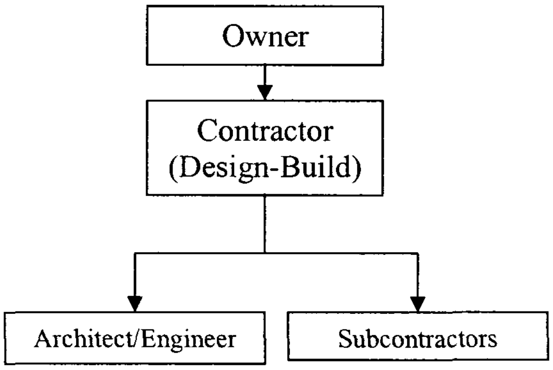


Adapted from: Mincks, W.R. & Johnston, H. (2004).

A design-build firm acts as a single entity that contract out both the architectural and construction services to two separate entities (Mincks & Johnston, 1999).

The next organizational structure is an adaptation to the designer-led design-build format. This is the contractor lead joint venture shown in Figure 4, the contractor led design-build organization.

Figure 4. Contractor Led Design-Build Organization

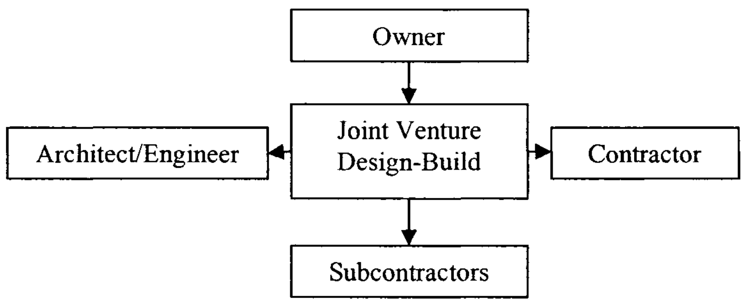


Adapted from: Mincks, W.R. & Johnston, H. (2004).

In this design-build management format, the owner hires the contractor who becomes the contracting entity that will hire the architects/engineers and the subcontractors. The determination by the owner to use this design-build contractual management format is based on successful bids from contractors (Mincks & Johnston, 1999). This relationship for owners can create a certain amount of discomfort, because "they feel uncomfortable with having the design professional under the contractor and not in privity with the owner" (Cushman & Loulakis, 2001, p. 17).

The fourth design-build management format is a combination of all three. This is the joint venture design-build format, shown in Figure 5.

Figure 5. Joint Venture Design-Build Organization



Adapted from: Mincks, W.R. & Johnston, H. (2004). *Construction Jobsite Management.* Clifton Park, NY: Thomson Learning, Inc. (p. 35-37).

Under this management structure, both the architect/engineer and contractor form a partnership for a single project. In some cases, this structure allows the two entities to use resources from both companies (Mincks & Johnston, 1999). This form of DB organization is very similar to the designer-led design-build organization. Cushman and Loulakis (2001) state that the designer still has an economic interest with the project. Additionally, the designer "has a fiduciary duty to its partner, the contractor, which potentially impacts its ability to act in the owner's best interests if the joint venture would be adversely affected" (Cushman & Loulakis, 2001, p. 17).

What each of these design-build management structures provide is a range of options owners can choose in the management of the DB project. Many of these DB management structures "were derived through the organizational constraints on the practice of architecture and engineering" (Cushman & Loulakis, 2001, p. 16), by the fact that contractors cannot perform design services (Cushman & Loulakis, 2001). The management structures shown in Figures 2 through 5 provide a specific purpose for the construction of a project by accessing the design-builder's knowledge, expertise, and resources necessary to function as a project team and provide the best product for the owner (Mincks & Johnston, 1999; Yates & Battersby, 2003).

Other Contract Types in Design-Build

The management structure of design-build also depends on the level of risk the owner would like to accept. Other terms for design-build include design-construct turnkey or design manage (DCT), design/build/operate (DBO), and design/build/finance/operate (DBFO). In DCT the constructor acts as the general contractor with single-firm control over all subcontractors. This type of arrangement will usually require some type of negotiated contract between the design-constructor and the owner (Barrie & Paulson, 1992). The DBO method integrates the operation with the tasks of design and construction. The owner selects a single contractor to design, build, and operate the project for a specified period of time. Once construction is complete, the procurement of maintenance and repair responsibilities is re-bid to another company or the same company (Barrie & Paulson, 1992). With the DBFO project delivery method, financing is assumed by the contractor, typically at the contractor's risk (Barrie & Paulson, 1992). Control of the project is returned to the owner at the end of the contract period (Miller, Garvin, Ibbs, & Mahoney, 2000, p. 59).

Professional Roles in Design-Build

Key points in the literature identify that management structures and stakeholders involved in the design-build process take on different roles depending on the project (Beard, Loulakis, & Wundram, 2001; Cushman & Loulakis, 2001; Molaanar & Songar, 1998). The difference in the management structure with design-build assumes "there is more pressure on owners and construction service providers to be cost effective and deliver faster" (FMI, 2004,

p. 65). In relation to the roles assumed and the design-build delivery method, Beard, Loulakis, and Wundram (2001) through insight provided by Anthoney Songer and Keith Molanaar assert that "design–build does require practicing professionals to comport themselves differently, to assume greater or different responsibilities, and work at understanding more of the entire design and construction process" p. (501).

The demand to be more cost effective and deliver the finished product more quickly can be driven by the owner, but also can be driven by the constructor (i.e., architect/engineer and contractor). The owner's role within the design-build process is not only to provide financial assistance, but also to provide input into the functionality and end use of the project through collaboration with the various construction professionals. In design-build, much of this collaboration occurs through the partnering process. The Construction Industry Institute (2005) defines this partnering process as:

> a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organizational boundaries. The relationship is based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services (Construction Industry Institute).

Insight to how partnering, collaboration, and the design-build project delivery method work together is provided in a study of two highway projects, Interstate 25 (TREX) Denver, Colorado and Interstate 15 in Salt Lake City, Utah, by Plugge (2003). This study determined that the partnering process helped define flexibility from contract development to the overall management of the project. This flexibility could only be achieved through the maturation of the owner's team and general contractor's or constructor's (i.e., engineer and general contractor) ability to understand the concept of design-build. Knowledge gained on previous projects was crucial to completing the project below cost, under schedule, safely, and with high quality.

Design-led design-build

Switching from traditional project delivery methods means designers (i.e., architects and engineers) also have to change their roles and ways of thinking (Beard, Loulakis, & Wundram, 2001; Yates & Battersby, 2003). Many of these role changes are cultural changes and can be challenging for traditional design firms. In designer-led design build, designers are concerned with the following factors, discussed by Beard, Loulakis, and Wundram (2001):

- Contact with and access to the owner.
- An opportunity to provide design solutions.
- Recognition for design contributions.
- Ability to land the work and earn a fee.
- Ways to achieve quality, safety, and reliability.
- Limits on risks (p. 501).

For the designer, contact with and access to the owner is an important relationship because it provides the designer and the owner opportunities to develop consistent design solutions. Cushman and Loulakis (2001) make a point that caution should be taken, since "excessive involvement by the owner can influence the design-builder's quality, cost, and schedule goals" (p. 21). As the designer develops the solutions, the designer should be recognized not only monetarily, but also through recognition of their design efforts.

Much of this debate is over the ownership of documents during the preliminary design phase of the project and the degree of access the owner has to the design (Cushman & Loulakis, 2001). Flexibility in thinking about quality, safety, and reliability is important through the design process because, as the constructor gets involved with the design, his/her experience can contribute to a higher-quality, safer, and more reliable product. Limiting risk is the determination and allocation of risk through the contract. Findings by Plugge (2003) and Cushman and Loulakis (2001) suggest that when the owner and design-builder work closely together to develop the contract, their relationship is enhanced, especially when the designer participates with the builder in procuring and negotiating the design-build agreement with the owner.

Contractor led design-build

For the constructor, this requires a change in how they manage a project (Beard, Loulakis, & Wundram, 2001). Motivational factors for a constructor in contractor led design-build are identified by Beard, Loulakis, and Wundram (2001) as:

- Control over the cost and schedule aspects of the process.
- Increased volume of work and/or satisfying working relationships.
- Satisfaction of managing the entire design and construction process (the same satisfaction can accrue to the designers in designer-led design-build).
- Profit margins commensurate with risks (p. 501).

Cushman and Loulakis (2001) assert that it is important for designers to have control of the design on the project. Fahmy and Jergeas (2004) and Konchar and Sanvido (1998) argue that the contractor should have control over the cost and schedule aspects of the design-build process. As the owner defines the design of the work, the contractor "is typically at the forefront of formulating responses to requests for proposals (RFP's) and cost, not quality, is the main concern" (Fahmy & Jergeas, 2004, p. 3). Konchar and Sanvido (1998) found in their research of alternative project delivery methods that when the owner was satisfied with the work of the design-builder, the volume of work increased. This could also apply to the designers (Beard, Loulakis, & Wundram, 2001). Finally, in the contractor-led approach, the contractor seeks to find satisfaction in managing the entire design and construction process, and hopes to be compensation for acquiring the risks (Beard, Loulakis, Wundram, 2001; Fahmy & Jergeas, 2004; Konchar & Sanvido, 1998; Molenaar, 2004).

Owners, architects, engineers, and constructors must assume new roles, risks, and different ways of thinking in the process of delivering a project from the design-bid-build concept to the design-build project delivery method. Table 1 shows the roles and responsibilities for design-build projects for the owner and the design-build contractor as defined by Warne and Associates (2005).

Table 1.

Contrast of Roles and Responsibilities for Design-Build

Owner	Design-Build Contractor
• Design oversight • Initial coordination with governmental entities • Preliminary design • Independent quality assurance • Public information/relations- strategic • Environmental analysis and approvals • Government relations- strategic • Right-of-way acquisition • Definition of project attributes and characteristics • Finance planning and management	• Project construction • Project management • Design • Design management • Public information/relations- tactical • Environmental mitigation and compliance • Detailed coordination with governmental entities • Quality assurance and quality control • Right of way acquisition • Coordination between designer and the constructor • Quantity management • Performance management • Utility coordination • Site safety • Coordination and management of subcontractors • Financial management and cash flow

Adapted from: Tom Warne and Associates. (2005, May).

Table 1 shows the differences in roles and responsibilities within the design-build process for the owner and design-build contractor. Many of these roles bring together the variables that have to be managed throughout the design and construction process that are related to econometric, political, environmental, technological, and project factors between the owner and design-builder.

Advantages and Disadvantages of Design-Build

The use of the design-build project delivery method has been on the increase in recent years (Molanaar & Saller, 2003). Molanaar and Saller (2003) state "the use of design/build delivery has seen a dramatic increase, as indicated by growth in the private sector market share and evolution of federal, state, and local laws that specifically authorize design/build delivery" (p. 106). Throughout the process of design-build there are certain advantages and disadvantages to this type of delivery method. Many are related to performance measures, cost, time, and the single point of contact for both the design and construction phases. Others involve changes in how the owner, architect, engineer, constructor, and others associated with the project perform their business (Beard, Loulakis, & Wundram, 2001; Cushman & Loulakis, 2001; Konchar & Sanvido, 1998; Molaanar, 2004; Songer & Molenaar, 1997).

Advantages

The advantages of the design-build delivery method have been documented over recent years. These include: the reductions in cost, shorter construction schedules, a higher-quality product, innovation, and a single point of contact. Fiedlander and Roberts (2005) state owners prefer design-build because it reduces the overall costs and shortens the construction schedule. Konchar and Sanvido (1998) further supported this when they compared several metrics related to the delivery processes of construction-management-at-risk, design-build, and design-bid-build. The metrics compared for the three delivery methods included of cost, schedule, and quality. Fiedlander and Roberts (2005) found a significant difference between design-build and design-bid-build where 50% of the design-build projects showed a 0% schedule growth. As for cost, the study identified a 6.1% decrease in cost using the design-build method.

The single point of contact in DB is considered an important advantage. By having a single point of contact the communication goals, objectives, and scope of work can be more effective (Fahmy & Jergeas, 2004; Fiedlander & Roberts, 2005). Beard, Loulakis, and Wundram (2001) and Cushman and Loulakis (2001) state that the design and construction coordination under one single entity, the design-builder as a single entity is responsible for quality, budget, schedule, and performance of the completed facility. The owner can then "concentrate on definition of needs (scope of work) and timely decision making, rather than on coordination between designer and builder" (Beard, Loulakis, & Wundram, 2001, p. 38).

Design-build is also often cheaper, due to communication and teamwork (Cushman & Loulakis, 2001; Plugge, 2003). This is an advantage because "design and construction personnel working and communicating as a unit can evaluate alternatives, choosing systems, methods, and materials that enhance the project" (Beard, Loulakis, and Wundram, 2001, p. 38). For the owner, this is an advantage because he or she can have early knowledge of costs, when the designer and contractor work together as the project is designed (Fahmy & Jergeas, 2004).

Design-build also takes less time. The DB method allows both design and construction to progress at the same time (Barrie & Paulson, 1992). Beard, Loulakis, and Wundram (2001) also assert bidding periods and redesign time are reduced and eliminated because "materials and equipment procurement, and advance construction work, may progress before construction documents are completed" (p. 38).

A key issue with any construction project is quality. Quality is defined by Gransberg and Molanaar (2004) as the "program of policies, procedures, and responsibilities required to provide confidence that the desired characteristics have been obtained to help ensure the project will perform its intended function over its design life" (p. 165). Increased quality is an advantage because the "design-builder has total responsibility for the finished product, and cannot afford to shift design errors or construction defects to another party" (Beard, Loulakis, and Wundram, 2001, p. 38).

Another advantage to design-build is a decrease in claims and litigation (Fiedlander & Roberts, 2005). Because the designer and builder are the same entity, changes that would occur due to errors or omissions in the design process cannot be redirected back to the designer (Beard, Loulakis, & Wundram, 2001; Fiedlander & Roberts, 2005). Finally, design-build is innovative. Beard, Loulakis, and Wundram argue that this project delivery method "elicits creative responses from project teams" (p. 38). Innovation is encouraged because at the request for proposal stage, performance requirements provided by the owner are established. This allows the design-builder to use different solutions to meet the goals of the owner's needs (Beard, Loulakis, & Wundram, 2001). This is important because "higher levels of innovation arise when a more innovative project delivery method is chosen" (Blayse and Manley, 2004, p. 149). Walker, Hampson, and Ashton (2003) also contend the presence of a well-integrated team is an important advantage.

Disadvantages

Although the design-build process has many advantages that are related to cost, time, and quality, its disadvantages are related to the various business practices that surround it. Some these disadvantages include the loss of checks and balances, less owner control, difficulty obtaining competitive bidding, and institutional obstacles (Beard, Loulakis, & Wundram, 2001; Cushman & Loulakis, 2001; Fiedlander & Roberts, 2005).

Beard, Loulakis, and Wundram (2001) identified the disadvantages related to selecting a design-builder instead of using competitive building practices. These include industry complaints about the bundling of contracts and the use of subjective evaluation requirements. Also, they feel there is a transition process design-bid-build practitioners must make to the idea of "shared goals and performance attainment" (p. 502). Because the industry is slow to adopt change, management should find individuals or personnel who can think collaboratively (Beard, Loulakis, & Wundram, 2001; Cushman & Loulakis, 2001).

Another disadvantage is the availability of insurance. Because of the complex nature of some design-build projects, insurance companies may not be readily equipped or well educated to handle design-build types of contracts. Therefore, insurance providers also have to be progressive in the adopting design-build because it requires additional training to identify "risk mitigation measures (such as adequate insurance for design and omissions) as a condition for underwriting" (Beard, Loulakis, & Wundram, 2001, p. 503). Building product manufacturers have also been slow to adopt the design-build concept in developing and marketing their products. Loulakis, Beard, and Wundram (2001) state:

> Firms that produce single product lines such as lighting fixtures, gypsum wallboard, or brick have not necessarily discovered the demand for integrated solutions: that is, how their products fit within an assembly or element that contributes to the overall performance of the building or a functional part of a building. Information and technology is expected to drive demand for systems-based products that can be quickly analyzed, costed, selected, and implemented by the integrated design-build team (p. 503).

It is implied by the literature that disadvantages associated with the design-build process can be related to checks and balances, owner control, competitive bidding, institutional obstacles, insurance, materials, labor, and equipment (Beard, Loulakis, and Wundram, 2001; Cushman & Loulakis, 2001; Fiedlander & Roberts, 2005).

Design-Bid-Build

History

As projects became more complex the construction disciplines required a separation of techniques. During the Roman Empire and the Middle Ages the concept of architecture and construction was sought to be controlled under one individual the "Master Builder" according to great Roman Architects like Hammurabi the King from Babylon and Vitruvius (Rowland & Howe, 1999). During the Renaissance the concept of the Master Builder, changed. Leone Battista Alberti challenged the idea of a single source of responsibility for the architecture, engineering, and construction. Unlike Vitruvious, he divided the roles of architecture and construction. Kruft (1994) illustrates Alberti's conceptual view of architecture and construction:

> In the formation of an architect are painting and mathematics. Painting- or rather drawing- is of particular importance in his eyes, because he believes that the architectural idea is crystallized in the drawn design. In both his theory and practice, design and execution were divorced from one another (p. 49).

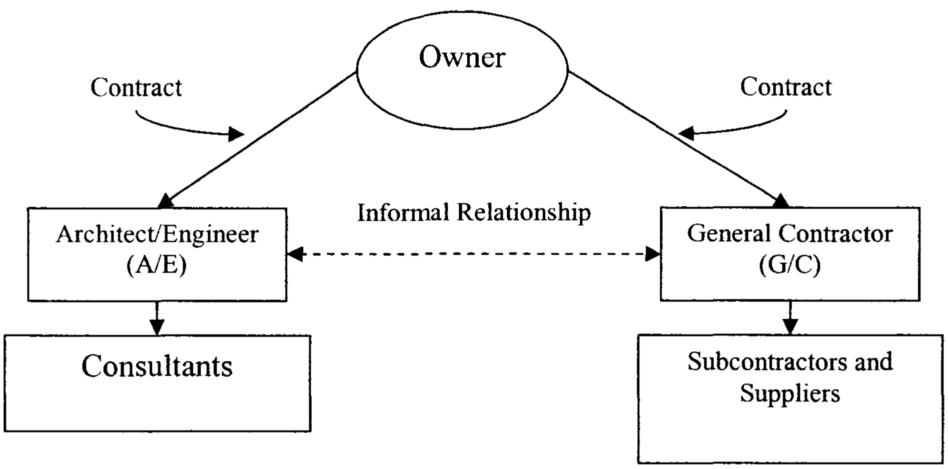
This division between the theory of architecture and actual construction was developed in Alberti's treatise (or handbooks). Interestingly enough, these handbooks were "not primarily for architects, but for the circle of patrons desiring a set of criteria for their building projects" (p. 44). In his treatise he builds the theory of architecture and construction starting with Book I- Definitions (design), Books II and III: Firmitas (materials and construction), Books IV and V: Utilitas (building types and their uses), Books VI-IX: Venustas (ornament; sacred, public and private buildings; the theory of proportion), and Book X: General Conclusions (Kruft, 1994).

Alberti started the division of architecture and construction as separate professions and the theory behind the design-bid-build contractual relationship. Architects were supposed to concentrate on the theory of architecture creating "drawings and models as a way to direct master craftsmen without actually being involved in the building process" (Jackson, 2004, p. 7). It wasn't until the industrial revolution that the roles of the building profession became more defined using separate theories of architecture, the science of engineering, and building as a craft (Jackson, 2004; Kruft, 1994).

Management Structure

The historical context behind the DBB concept explains its management structure. The management structure of DBB is also commonly known as the traditional delivery method. The presence of two separate contracts, and an owner that has informal communication relationships with the designer or architect/engineer best define it. The management structure for the design-bid-build project delivery method is shown in Figure 6.

Figure 6. Design-Bid-Build Management Structure



Gould, F.E. & Joyce, J.A. (2003).*(p. 45).*

More specifically, “the owner enters into a contract with the designer for a complete design and then enters into a separate contract with the constructor” (AGC, 2004, p. 75). For DBB, contractual relationships are signified by the solid lines between the owner and architect/engineer and owner and the contractor. The relationship between the architect/engineer and constructor is an informal communication relationship, indicated by the dashed line (Fisk & Reynolds, 2006; Mincks & Johnston, 2004). Under the traditional DBB management structure more information is known prior to the start of the project unlike its predecessor DB. Therefore, drawings and specifications are nearly complete, the schedule is known, and the cost for the overall project has been established when the project has begun (AGC, 2004; Fisk & Reynolds, 2006; Minks & Johnston, 2004).

Professional Roles in Design-Bid-Build

The owner is the intermediary between the A/E and contractor. During the design phase the owner will give the A/E the design requirements for the project. Based on these requirements the A/E will work with the owner to determine the "legal, financial, and other constraints on project design, program and design the project, produce contract documents, provide professional services during the bidding or negotiation phase, and provide construction contract administration services" (Simmons, 2001, p. 2). In the construction phase the owner is responsible for reviewing the contractor's submittals, requests for information, and proposed changes and claims with the architect. The owner will also interpret the requirements of the contract, drawings and specifications. During the bidding phase, "the owner's most important duties are to accept bids and select the constructor" (AGC, 2004, p. 83).

For the A/E, their primary responsibility is to the owner. The A/E also has a communication link with the constructor, but no contractual relationship. The A/E will design a project to meet the owner's needs while meeting structural, code, and governmental requirements. It is the A/E's responsibility to maintain these municipality requirements as an architect and engineer (AGC, 2004; Gould & Joyce, 2004).

The contractor's responsibility is to provide a single product which meets the requirements of the contract with the owner. AGC (2004) states that the constructor has "an obligation to satisfy the minimum requirements of the drawings and specifications as stipulated by the lowest or best price to perform the requirements" (p. 83). The contractor may subcontract portions of the work to specialty contractors or suppliers in order to accomplish his or her goal. When the contractor uses subcontractors, they are usually the communication link between the owner, architect and the engineer (AGC, 2004). Table 2 compares the contrast in the roles and responsibilities in design-bid-build project delivery method as defined by Tom Warne and Associates (2005):

Table 2

Comparison of Responsibilities for Design-Bid-Build

Owner	Contractor
• Design • Environmental analysis and approvals • Coordination with other governmental entities (if needed) • Design standards • Finance planning and management • Quality assurance and quality control • Independent quality assurance • Coordination between the designer and the constructor • Management oversight • Utility coordination • Public information/relations- strategic and tactical	• Project construction • Project management • Site safety • Coordination and management of subcontractors

Adapted from: Tom Warne and Associates. (2005, May).

This table also illustrates how the design-bid-build project delivery method differs from design-build. Here, two separate entities are responsible for the design and the construction, the owner and contractor (Barrie & Paulson, 1992). With design-bid-build, the processes of design and construction cannot be performed concurrently, which could increase cost and time associated with the project (Barrie & Paulson, 1992; Konchar & Sanvido, 1998). The issues of concurrent design and construction are associated with some of the advantages and disadvantages of using the design-bid-build process.

Advantages and Disadvantages to Design-Bid-Build

The advantages and disadvantages associated with DBB vary. A key advantage cited by Gould and Joyce (2004) is the historical documentation of the DBB method in legal references, management procedures, and past projects. On the other hand, Konchar and Sanvido (1998) argue:

> As specialization of services increased, design and construction entities were sharing information only at the end of design and during the construction process. Interaction, particularly during the design phase, was extremely low. This resulted in inefficient designs, increased errors and disputes, higher costs, and ultimately longer schedules (p. 435).

Advantages and disadvantages all play an important role in the decisions made by owners, designers and constructors. The advantages and disadvantages cited by Barrie and Paulson (1992), Konchar and Sanvido (1998) and Pocock, Hyun, Liu, and Kim (1996) are all related to cost, time, quality, and safety.

Owner advantages

One advantage of the DBB method is that it has been used for a long time. Gould and Joyce (2004) state this method "is a known quantity to owners, designers, and constructors" (p. 101). There is considerable contractual protection where systems are accepted and historically know (Barrie & Paulson, 1992; Gould & Joyce, 2004).

The allocation of risk in DBB solely on the contractor. The owner is protected from cost overruns due to labor inefficiencies, nonperforming subcontractors, inflation, and other economic factors (Barrie & Paulson, 1992). More importantly, the accepted rules that have developed over time with this method provide a clearly defined relationship that reduces risk and uncertainty. In some cases, this relationship provides the opportunity for a project to proceed successfully from beginning to the end, but does not happen in every case. (Barrie & Paulson, 1992; Gould & Joyce, 2004). The owner knows the final cost at the beginning of the construction and can benefit from price and open market competition (Barrie & Paulson, 1992).

Another advantage is the fact that while the owner does not have to be involved with the construction process, he or she is involved in the design process, and decides whether or not to accept the design (AGC, 2004; Barrie & Paulson, 1992; Gould & Joyce, 2004). During construction, the owner allows the constructor to make decisions on his or her behalf limiting the amount of day-to-day interaction (AGC, 2004; Barrie & Paulson, 1992).

Another advantages this project delivery method offers owners is the ability to use incentives, such as bonuses and liquidated damages as motivation to improve the contractor's performance (Barrie & Paulson, 1992). Cost can also be controlled through creating accurate and complete drawings (AGC, 2004; Gould & Joyce).

Contractor advantages

The design-bid-build method offers contractors their own set of advantages. Barrie and Paulson (1992) define these as:

- Can name his or her own price for the work as well and estimate profits in the bid.
- Minimum involvement of the owner or architect/engineer in the details of the building process other than for quality, schedule, and change control.
- Innovation provides an opportunity to maximize profits through creativity and experience.
- Administrative requirements are based upon applicable law, the contract and the contractor's own determination.
- May pass on much of the risk to lower-tier specialty contractors when feasible (Barrie & Paulson, 1992, p. 29).

Advantages to both the owner and contractor can change based on the structure of the contract and the level of detail it specifies (Barrie & Paulson, 1992). As Barrie and Paulson (1992) and Cushman and Loulakis (2001) concur, there is little involvement of the owner and A/E have little involvement in the details of actual construction, unless there are issues that arise in relationship to cost, time, quality, or safety. This is an opportunity for the contractor to maximize profits due to historical knowledge and innovation. The contractor can also take advantage of specialized skill sets through the use of specialty contractors for difficult construction processes (Barrie & Paulson, 1992; Gould & Joyce, 2004).

Disadvantages

There are disadvantages to using the design-bid-build (DBB) project delivery method for the owner and contractor. These involve conflict resolution, time, cost, and collaboration. The disadvantages to the owner as outlined by AGC (2004), Barrie and Paulson (1992), and Gould and Joyce (2004) are:

- Design limits input from construction expertise during design which limits opportunities for value engineering and constructability analysis prior to the contract development and award.
- The time required to design and construct the project occur linearly. These processes cannot be overlapped to reduce overall time.
- The owner is in an adversarial relationship with the general contractor and the designer, which places the owner in the position to be a referee between the two parties.
- Unforeseen conditions and changes in the contract documents can lead to disputes which increase cost and time.
- Minimal control and input to the work.
- Linear relationship between design, estimating, and construction provides little collaboration and team-building between the stakeholders which lead to conflicts.

Expenses can increase using the DBB method, due to the increased time it takes to complete projects, and also, perhaps because of the lack of collaboration between parties involved with the project (Gould & Joyce, 2004). This reduces the benefits to the owner of knowing costs before construction begins. Blayse and Manley (2004) and Kurmaraswamy and Dulami (2001) agree that disadvantages to DBB involve high cost risk for contractors, increased likelihood of adversarial relationships, low levels of integration, and reduced innovation.

Many of the disadvantages to the owner can also be disadvantages to the contractor. From the contractor's perspective, Barrie and Paulson (1992) have identified these disadvantages as:

- To be competitive, the builder must often use marginal subcontractors who may have problems performing the work.
- Too many bidders may make it difficult to obtain the work for a fair price and in weak markets the cumulative cost of preparing the proposal by all contractors may exceed the profit potential of the successful bidder.
- Owner controls the funding on disputed extra work or changed conditions, and the contractor must often resort to expensive arbitration or litigation with no assurance that it will recover the additional costs.
- Contractor usually bears the economic risk of unusual weather conditions, strikes, or other external factors that influence a contractors cost but which may not be directly under its control.
- Last-minute telephone quotations may contribute to misunderstandings with material suppliers and subcontractors (p. 29).

The disadvantages for the contractor are due in some cases to competition and variable market forces. Contractors may have to use marginal subcontractors who may have problems performing the work. A key disadvantage for the contractor is that the owner controls funding for extra work or changed conditions where the contractor must bear the costs (Barrie & Paulson, 1992). These conditions not only arise through extra work, but also through changing economic conditions, unusual weather, strikes, politics, and the environment. As Cushman and Loulakis (2001) state "predictability is a significant characteristic in the design-bid-build approach; experience shows that claims and disputes among team members are a common byproduct of the separation of design and construction" (p. 8).

Risk in Construction

Exposure to risk can be caused by many different factors on a construction project. These factors include time, cost, quality, safety, econometrics, the environmental, the type of project delivery method, political and technical factors, and people. These factors are interrelated. To determine which factor exposes the project to the most risk, constructors can use decision analysis techniques based on experience, historical information, and previous studies in construction to make clear decisions about financial and time factors related to the project. This next section will attempt to define risk as it relates to the delivery methods of DBB and DB, provide examples of various risk decision analysis models, and explain how other researchers have used decision analysis to identify various risk factors of time, cost, quality, safety, and delivery method.

Risk Defined

The concept of risk is the variability of decisions, problems, or situations related to a single outcome. Webster's Dictionary defines risk as the variability of returns from an investment of time, money, effort and a factor, thing, element, or course involving uncertain danger (Websters Online). Hertz and Thomas (1983) and Jannadi and Almishari (2003) state risk involves some type of damage or loss which can be written symbolically as "Risk = Uncertainty + Damage" (p. 493). Hertz and Thomas (1983) and Jannadi and Almishari argue that risk "is a broad concept with many dimensions, and only through the ability to structure the decision problem can a meaningful assessment of risk be obtained" (p. 493). Understanding risk and the nature of problems are important to mitigating risk. Abdou (1996) suggests there are a number of steps in the process of analyzing and managing construction risk. These steps include:

1. Understanding the types and phases of risk.
2. Assessing the risks of a particular construction project.
3. Matching risks with in-house capabilities and building a construction team.
4. Defining a building strategy.
5. Understanding the bidding process.
6. Selecting the right kind of construction contract.
7. Selecting the contractor.
8. Monitoring construction (p. 3).

Risk in construction has been studied from many different perspectives. Researchers have studied risk in construction related to time, cost, work package, base risk control, schedule risk, etc. Construction risk can be associated with any number of different factors depending on the type of project and the relationships of the people involved with the project. A common theme among these studies is that risk is related to uncertainty and the definition of problems that could occur.

Research in Construction Risk

Each of the following studies show how researchers have come to conclusions on risk by studying historical corporate-cost data, analyzing project delivery methods on cost, schedule, safety, quality metrics, and the identification of the relationship of time and cost on construction projects (Kenley, 2003; Konchar & Sanvido, 1998; Kumar, 2003; Minato & Ashely, 1998; NIST GCR 02840).

Data-Driven Analysis of "Corporate Risk" Using Historical Cost-Control Data

Each project has its own history of problems, and the ways these problems have been solved. This historical background can be used as a framework to assess risk for future projects. In some cases, project executives will use some type of cost structure to identify the necessary components of the project, to use as a control basis as the project progresses. This structure consists of cost codes or a code of accounts. Many cost code structures are based on a work-breakdown structure (WBS) defined by the project executives and estimators. The WBS identifies who has responsibility for work assigned and actual direct labor, material, equipment, and other direct costs (Kerzner, 2003).

Minato and Ashley (1998) studied risk in construction by analyzing risk from a corporate perspective. To identify risk, the researchers divided their study into three stages. The first part identified risks through multiple projects using the insights from the modern portfolio theory (MPT). Next, the researchers used MPT to create an indexing system to obtain a beta for their identification of risk based on costs related to the performance of the overall project. In the third stage, researchers used actual cost-control data from a Japanese contractor to test their methodology.

Cost data was used to define dependent risk which "arise[s] from combinations of political, economic, industrial, and company conditions common to multiple projects, as well as from conditions specific to individual projects" (Minato & Ashley, 1998, p. 43). Combinations of politics, economics, industry conditions, company conditions, and project conditions are all underlying components of economic principles and financial theory related to risk. In an effort to explain how these components react with each other, beta, or systematic risk, places a weighted value on each of the risk components based on their market value (Fabazzi, Modigliani, & Ferri, 1997). Minato and Ashley (1998) used beta, based on the Capital Asset Pricing Model and single indexed-market model, to estimate the covariability among the performances of individual components of a project-to-project performance of the overall project. By using the beta, the researchers were able to correlate it to the concept of systematic risk, where changes that occur in the macroeconomic environment to some degree equally affect individual securities. Applying this concept to construction, they state "the effect of multiple risk factors on various cost elements of a project can be measured through the beta value tied to the overall project performance" (Minato & Ashley, 1998, p. 44).

Minato and Ashley's (1998) methodology provides a base for analyzing uncertainty using historical project-cost data from the work-breakdown structure. This research identified the need to study risk in a context where covariable risk exists among a company's project portfolio. The project portfolio contains the cost-coded breakdown of material, labor, and job indirects (salaries, temporary construction, general expenses, and insurance). Their hypothesis shows that risks could be diminished efficiently at the corporate level rather than at the project level. This research provided a theoretical methodology for analyzing project risk at a corporate level through the use of regression analysis and using cost data from a Japanese construction company. Using a historical database of 88 completed projects, expected and actual costs were used to identify a performance metric. Results of the study identified that indirect costs, salaries, temporary construction, general expenses, and insurance showed an estimated performance deviation of 15%. This translated to an assumed $\pm$ \$0.45 million of uncertainty due to corporate risk for indirect costs where the true beta was between 3.77 ± 0.19 on the 88 referenced projects. For material and labor, the betas were low at 0.64 ± 0.05 and 0.14 ± 0.04 with correlation coefficients of 0.05 and 0.11 (Minato & Ashley, 1998, p. 46). This study contributes to the field of construction management by showing how projects can be analyzed using the cost structure of several projects to predict future performance uncertainty.

Construction Industry Institute

Project delivery methods have developed over the course of construction history. As projects are completed using different delivery methods, new techniques and ideas develop based on practical experience.

One organization that has identified project performance metrics for project delivery systems is the Construction Industry Institute (CII). CII aims to collect contract data from contractors and owners on construction projects that identify how project delivery systems affect project outcomes and practices. The CII database contains over 1,000 projects with self-reported information from owners and contractors. Data collected can be analyzed from a multivariate perspective based on a self-reported questionnaire. In the last ten years, newer versions of the questionnaire have been developed to collect additional data on construction practices and performance metrics (NIST GCR 02-840). The performance metrics measured within the report are cost, schedule, safety, changes, rework, and productivity. Practice use metrics analyzed include pre-project planning, constructability, team building, zero accident techniques, project change management, design/information technology, materials and management, planning and startup, and quality management. The study included 617 as either domestic or international projects categorized by either DBB or DB. Responses were further classified by owner and contractor and by project delivery method. Industry groups were categorized by building type (civil or heavy construction), industrial (heavy and light industrial), and buildings. Each project was also categorized by its cost of less than $15 million, $15 million to $50 million, and greater than $50 million. Once cost categories were established, the projects were also analyzed by project nature, which included grass roots (new construction), additions, and modernizations (NIST GCR 02-840).

Owners and contractors established outcomes by project delivery system. T-tests were performed to determine the significant differences between the delivery methods on cost and time. It should be noted that DB projects, from the owners' perspectives, outperformed DBB projects in schedule-related issues. DB projects cost an average of 3.5 times more, and took on average, three weeks longer to complete. To explain this discrepancy, CII stated that from an owners' perspective, "there clearly must be construction schedule benefits that can be attributed to the DB delivery method" (NIST GCR 02-840, p. 17).

On cost, from the contractors' perspective, DB projects performed worse than DBB projects. For the contractors' schedule-related metrics, DBB projects did better than DB projects. There were also significant differences in performance for DBB. Design-bid-build performed better than DB projects on construction schedule growth, project schedule factor, and construction phase duration. There was no significant difference in project schedule growth for the contractor (NIST GCR 02-840). The CII study found differences in the cost and schedule for both project delivery methods and other metrics studied.

In a separate study Konchar and Sanvido (1998) used CII's data to empirically compare three project delivery methods; construction management at risk, design-bid-build, and design-build. They compared the performance metrics of cost, schedule, and quality of

U.S. building projects. The researchers were interested in quality performance, project turnover, and project performance of the principal facility systems. Quantitative measures were analyzed on unit cost, cost growth, and intensity (a hybrid of cost and schedule measures). Comparisons were also made to the as-built design (planned start of design) with the construction end date. There were also three schedule measures analyzed within this study that include construction speed, delivery speed, and schedule growth (Konchar & Sanvido, 1998). Konchar and Sanvido's (1998) study is important because it frames how projects can be compared econometrically across several metrics of cost, time, quality, and safety.

Results of this study were broken into univariate and multivariate cost and schedule results. Konchar and Sanvido (1998) found univariate results on cost and schedule indicated "50% of all construction management at risk and design-build projects fall below a 50% schedule growth. On the other hand, there was a significant difference over the performance of design-bid-build where 50% were more than 4% late in completion" (p. 438).

Multivariate results for unit cost is a function of final project-cost-per-square-area divided by a Means© historical cost index. The study results concluded that design-build projects cost 6.1% less than design-bid-build projects. Konchar and Sanvido (1998) found the four variables with the most variability were contract unit cost, facility type, project size, and project delivery system. For construction speed, a function of the construction area, start date, and end date, Konchar and Sanvido (1998) identified that design-build was 12% faster than design-bid-build. The model used to calculate construction speed indicated a high level of variation in "project size, contract unit cost, project delivery system, percent design complete before the construction entity joined the project team, project communication, and project complexity" (Konchar & Sanvido, 1998, p. 441). Findings from this study showed an increase in cost and schedule growth in design-bid-build. For design-build there was a decrease in cost and schedule duration (Konchar & Sanvido, 1998).

As an extension of the study provided by Konchar and Sanvido (1998), Ling et al. (2002) sought to find explanatory variables that significantly affect project performance and to construct models to predict the performance of design-bid-build and design-build. The first objective was important to Ling et al. (1998) because the explanatory variables are those that contractors analyze to assure their projects are completed under budget and within schedule, while maintaining high quality to the satisfaction of the project team. For the second objective Ling et al. (2002) felt that "project performance models developed in the study can help owners, contractors, and architects and engineers (A/E) predict what the likely project performance level would be" (p. 75). Additionally, the prediction equations assisted the researchers by informing the A/Es to make decisions on whether the use of DBB versus the use of DB method would provide the desired results.

Time-cost Relationship

Cost and time issues are inherent in any construction project. To manage this relationship "an effective cost and schedule control system must be established in order to deliver construction projects on time and within budget" (Kumar, 2005, p. 14). Such a system can only be effective if there is some type of organization established to manage the cost and schedule of the construction project. Organizing costs and schedule requires the concepts of cost codes, activity codes, and the work breakdown structure (WBS) to organize the specific cost components and schedule activities of the project. Typically these codes are organized using the 16 Construction Specifications Institute (CSI) index, which provides the structure to track cost and time on the project (Clark & Laronzoni, 1997; Feihgenbaum 2002; Halpin, 1985; Simmons, 2001). The organization and the relationship of cost and time are important, given that "governments around the world are seeking to improve the productivities of their construction industries, particularly as they play such a large role in the gross domestic product of the nation (GDP)" (Kenley, 2003, p. 137).

Kenley (2003) states the "time-cost relationship directly correlates project value with project time" (p. 137). Project value can be a relationship of the original contract sum and the final contract sum. An original contract sum or contract estimate is the ability of the contracting party to identify the cost of a project based on an estimate provided by the architect or engineer for design, and the contractor for construction. An architect or engineer's cost estimate is usually defined by the total number of hours necessary to perform the design objectives on a particular job. These estimates include design development, engineering, drafting, material procurement, scheduling, and specification writing (Clark & Lorenzoni, 1997).

A contractor's estimate is created based on the level of detail provided in the contract documents by the owner and the architect/engineer (Holme, Schaufelberger, Griffin & Cole, 2005). There are three levels of detail in the estimate: can be characterized as the conceptual, semi-detailed, and detailed cost estimates. These are defined by Holme et al. (2005) as:

- Conceptual cost estimates: developed using incomplete project documentation, during programming and schematic design.
- Semi-detailed cost estimates: prepared when parts of the project have been completely designed, while other aspects have not, usually during the design development.
- Detailed cost estimates: prepared based on fully developed construction drawings and specifications (p. 6).

The importance of the estimate is that it provides a cost baseline for the project. Estimates are used for many purposes including developing the initial budget for the owner, determining project feasibility, evaluating alternative design concepts and project components, preparing subcontract bids, preparing cost proposals, establishing cost and project budgets, defining cost impacts of change orders, substantiating claims and disputes, preparing a schedule of values, creating historical cost databases, and assisting in the development of the schedule (Holme et al., 2005). Actual project cost data is built from the estimate, depending on decisions made during the project's completion. The owner, A/E, and construction team on the project can make decisions that could affect the cost and time of the design and construction. (Clark & Lorenzoni, 1997; Holme et al., 2005).

Items affecting the actual cost of a project during the design phase would include design work hours and office costs, equipment purchases, detailed design of bulk materials (i.e., design of concrete foundations and structural steel), design research, and project changes. The items that should be controlled in the field with respect to the estimate versus actual cost would include direct labor, materials, subcontracts, field labor overhead (temporary construction, consumables, supervision and office expenses, construction tools and equipment), other overheads (surveyors, job cleanup, construction utilities, security, and disposal of construction waste), commissioning and start-up. These general categories could have an effect on the overall project cost. Between architectural engineering and field construction, these components define the actual cost or schedule components that could affect the project (Clark & Lorenzoni, 1997).

The original and final contract values differ because of changes that occur during construction, often related to the time required to complete the project. Variables that affect the time needed to complete a project include: available resources, technological and managerial innovations, project delivery method, type of construction, and complexity of the project (Abdou, 1996; Knoke, 2003; Kumarswamy & Chan, 1995; Li & Carter 2005; Towill, 2003).

The success of a project is often related to its cost and time parameter. Therefore, successful construction is the ability of the project team comprised of the owner, designer, contractor, trades, manufacturers, suppliers, etc. to function as a team. Abdou (1996) identifies three success criteria for construction projects as "on-time completion, final cost within budget, and final product satisfies the owner's needs" (p. 9).

Managing a successful construction project requires frequent decision making, but many "decisions in project risk management are made using incomplete or uncertain information" (Tah & Carr, 2001, p. 171). Each decision carries potential risks that could affect the cost and time on a project. Like risk management, many decisions are made in terms of "intuition, judgment, and experience gained from previous experiences" (Kapila & Hendrickson, 2002, p. 186). Although many decisions can be made through intuition, judgment, and experience there are other techniques that use data and information to inform decisions.

Literature Review Summary

This literature review explains the many areas of risk that are relevant to this study. The literature shows that differences between the two project delivery methods existed as far back as the Roman Empire, where the concept of risk was inherent to architecture and construction. Then, a builder's life was at risk if the building was not constructed properly or failed to meet the owner's expectations (Van De Mieroop, 2005).

Today, construction risk is analyzed based on cost, time, quality, and safety. As Kenley (2003) states, "the relationship between cost and time where one can be derived from the other, is less understood" (p. 138). This is based on the assumption that cash flow modeling is usually conducted in the absence or presence of detailed project schedules. There is a need, however, to study cost and schedule risk exposure for the two project delivery methods (Kangari, 1995; Kenley, 2003).

This literature review investigated risk and differences in project delivery methods through the use of secondary information provided by industry professionals. Other studies identified risk variability with respect to a Beta coefficient, using historical project data for materials, labor, and job indirects (i.e., salaries, temporary construction, general expenses, and insurance) to develop a predictive function to calculate risk exposure. Furthermore, the literature provides a comparison of two project delivery methods based on cost and schedule with various performance metrics. In addition, this literature review revealed studies that focused on the unit construction productivity metrics of concrete, structural steel, electrical, piping, instrumentation, equipment, and insulation. There are studies that identify ways to predict the risk of cost and time upon a design-bid-build and design-build project using the explanatory variables that significantly affect project performance.

Research provided by CII was used to develop an evidence-based risk model in construction. CII has the largest database on industry performance norms through quantitative analysis on best practices in the construction industry. A goal of the CII Benchmarking & Metrics (CIIB&M) program is to "assist member companies in the statistical measurements that can improve capital project effectiveness" (Construction Industry Institute, n.d.). The CII research method uses administrated questionnaires to populate the database. Information acquired from contractors and owners identifies general information about the construction projects, performance, practice, engineering productivity, construction productivity, and project closeout metrics (Construction Industry Institute, n.d.).

The study performed by CII for the National Institute of Technology (NIST) uses information from contractors and owners to draw comparisons between DBB and DB projects. Its goal was to inform industry stakeholders, owners and contractors, on the "merits" of the two project delivery methods with respect to cost, time, quality, and safety (NIST GCR 02-840, p. iii). In comparison of owner and contractor submitted projects, the latter performed better in cost, schedule, changes, rework, and practice use. For the contractor submitted projects "DBB projects outperformed DB projects in schedule, but contractor submitted DB projects had better performance in changes, rework, and practice use" (NIST GCR 02-840, p. 49).

The CII study provides considerable and valuable information on cost, schedule, quality, and safety, with respect to the project delivery methods. This information provided by CII heavily favors many of the processes found in the general conditions portion of the work found on a construction project. Also, CII takes a more general overview of the cost and schedule metrics with respect to the large-dollar work-package items including concrete, structural steel, electrical, piping, instrumentation, equipment, and insulation.

CII and Knonchar and Sanvido (1998) conducted studies taking a broad approach to evaluating project delivery methods at many different levels. While many other delivery methods could have been studied, the decision to look at issues surrounding DBB and DB delivery methods were based on historical background and the frequency in which these two delivery methods are used to deliver projects. More importantly, many other delivery methods are derived from these two delivery methods. Therefore, issues and significant findings pertaining to the DBB and DB methods could be applied to other delivery methods.

While the CII study is important to the field of construction management research, there are questions that require further investigation. For example, could there be a way to view or organize a project based on its project delivery method, in light of key risk factors associated with the politics, environment, technology, project, and econometric factors? Also, could we look at project specific risk factors with respect to the work-breakdown structure and work packages that describe the cost and schedule factors associated with DBB and DB projects? To advance the CII findings it would be necessary to take a more detailed approach in the analysis of cost, time, and quality in how projects are delivered. Similar to the CII study, this research explores a model that organizing data and the perceptions of risk factors associated with political, environmental, technological, project, and econometrical factors on

DBB and DB projects. To date, there are few studies that examine the perceptions of risk related to the two project delivery methods of DBB and DB from experienced industry professionals.

CHAPTER 3: METHODOLOGY

Introduction and Research Rationale

The purpose of this study is to develop an evidence-based model for potential use in construction risk management. More specifically, this research compares characteristics associated with economics, environment, politics, project, and technology associated with construction project delivery. This chapter discusses the research design, rationale, measures, and analysis, including their reliability and validity within the context of the study. A procedure section is included to explain how the research data was collected and analyzed.

Construction science takes place within the natural elements of the construction environment. Because construction is a carefully planned series of events executed in the field, it is necessary for a researcher to study risk in construction within its natural environment; where activities occur. Construction activities include cost, time, safety, and quality factors that change depending on the human and natural elements on a construction project. Anderson (2001) argues that "field science refers to investigations 'in the field,' that is, in ongoing natural situations" (p. 464).

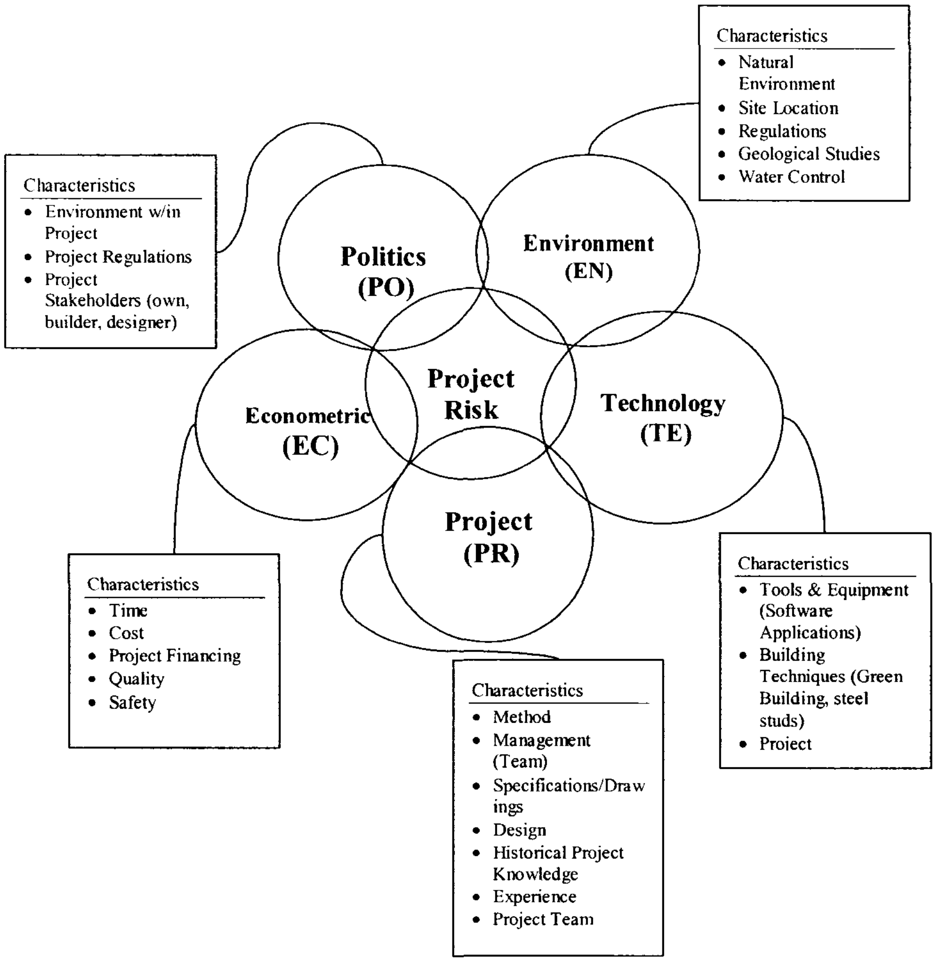
When construction field science investigates situations in the field, it is not always convenient or appropriate for a researcher to be involved in the daily progress of activities as they naturally occur. Information and key observations on most construction projects develop over a long span of time. To obtain this information, it is necessary to identify important personnel and documentation. The stakeholders who have key field data include construction managers, project managers, field superintendents, project engineers, and field engineers. These personnel use important documents such as estimates, schedules, and various project reports to make decisions and assure that labor, material, equipment, and subcontractors are within the estimated cost and schedule defined at the beginning or within the progress of the project. In addition, these stakeholders have experience regarding the construction process that may or may not be documented.

Davies (1999) reminds us that evidence-based education operates under two continuums. He states "the first is to use existing evidence from worldwide research and literature on education and associated subjects" (Davies, p. 109). The second continuum he claims is to "establish sound evidence where existing evidence is lacking or of a questionable, uncertain, or weak nature" (p. 10). Additionally, McMillan and Schumacher (2006) also contend that evidence based inquiry:

> Is the search for knowledge using systematically gathered empirical data. Unlike opinion or ideology, evidence-based inquiry is conducted and reported in such a way that the logical reasoning can be painstakingly examined. The term evidence-based does not refer to ritualization and using narrow forms of investigation, nor does it necessarily refer to following formal procedures. A study is evidence-based when investigators have anticipated the traditional questions that are pertinent and instituted techniques to avoid bias at each step of data collection and reasoning (p. 7).

The design of this research used the two continuums established by Davies (1999) and the concepts on evidence-based inquiry provided by McMillan and Schumacher (2006) to validate and expand upon its conceptual model, shown in Figure 7. Figure 7 illustrates how the five factors that drive this research interact, affect construction project delivery, and potentially impact construction risk. The hypothesis of this study is that these factors vary, depending on the project delivery method. The initial model that informing the conceptual model in Figure 7, originates in medical and political models. This study attempts to apply this knowledge to construction project management. A need exists within construction management for applied models to evaluate project risk within different project delivery methods.

Figure 7. Conceptual Model of Project Complexity

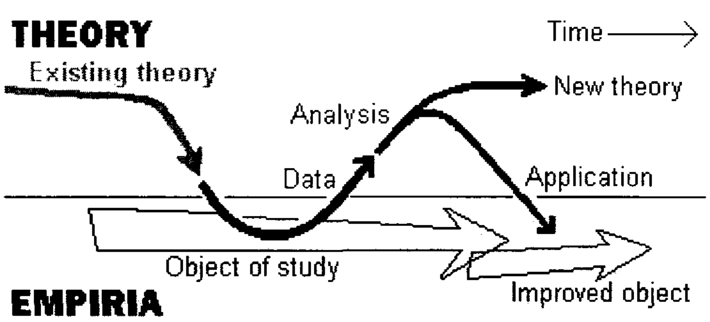


Adapted from Davies, P. (2004, February). "Is Evidence-Based Government Possible?" Paper presented at Campbell Collaboration Colloquium, London, England

Exploratory Research

This model is unique to construction and reflects many concepts contained in exploratory research. Routio (2006) explains that the researcher starts with a vague idea as to the notion of the project and through the exploratory research process, develops a clearer picture of ideas and concepts. Schindler and Cooper (2001) state that "through exploration researchers develop concepts more clearly, establish priorities, develop operational definitions, and improve the final research design" as studies are developed (p. 139). Figure 8 provides a pictorial view of the exploratory research process and how the research in this study was developed.

Figure 8. Exploratory Research Process



Adopted From: Routio, P. (2006, May 19). Methods of Arteology. http://www2.uiah.fi/projects/metodi/177.htm and http://www2.uiah.fi/projects/metodi/ .

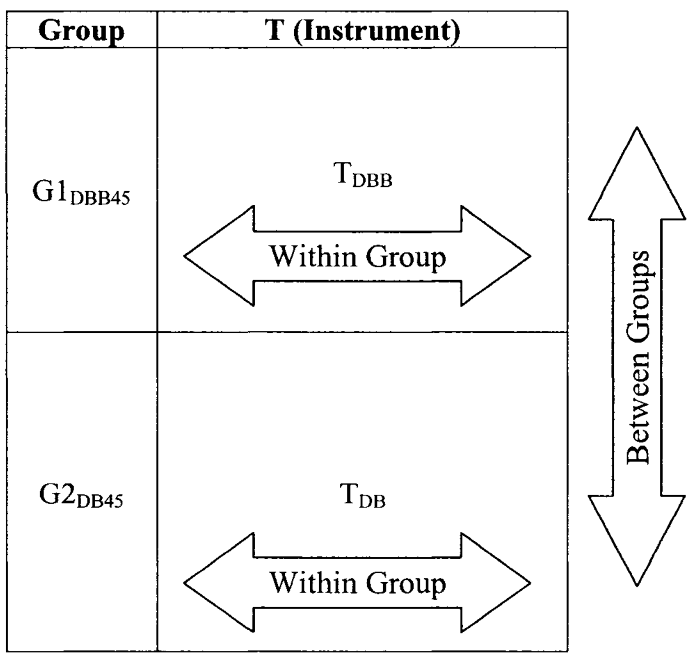
Routio's (2006) figure shows how experienced based surveys could be used to develop the evidence-based model in Figure 7 for construction project delivery. Cooper and Schindler (2001) state "while published data are a valuable resource, it is seldom that more than a fraction of the existing knowledge in a field is put into writing" (p. 141). This holds true for knowledge and practices in the construction field and construction research. Therefore, this study was designed to seek this information from professionals in the areas of architecture, engineering, and construction. It attempts to tap into their collective knowledge and experiences regarding project delivery methods. An experiential survey will "seek ideas about important issues or aspects of the subject and discover what is important across the subject's range of knowledge" in project delivery methods on the constructs of econometrics, environment, politics, project, and technology (Cooper and Schindler, 2001, p. 141).

Design of Study

The independent variables for this study are included the two project delivery methods: DBB and DB. Participants in this study voluntarily selected surveys on DBB or DB, depending on their experience with these methods, such as the number of years they have worked with these methods, or the amount of projects they have built with either DBB or DB. Participants that had extensive experience with and knowledge of both delivery methods were asked to complete both surveys.

Dependent measures include the five constructs of economics, environment, politics, project, and technology. Items related to the five constructs were randomly organized throughout each of the two questionnaire forms. Responses depended on each participant's experience with the particular delivery method. The research design model for this study is shown in Figure 9.

Figure 9. Conceptual Model- Between and Within Groups Design



The conceptual model of this between and within groups design represents participant groups that were randomly assigned (G_{DBB45} and G_{DB45}). T represents the survey instrument (DBB or DB) the participants completed based on their experience. Each participant answered a survey instrument. O_{1A} form A was devoted to the DBB project delivery method and O_{1B} form B asked questions about the DB project delivery method.

Quantitative Research

This study was grounded in the quantitative experimental research tradition. It holds many characteristics associated with exploratory quasi-experimental research. Because this study was exploratory and quasi-experimental in nature, it used factorial loading, dependent on nonequivalent groups that could be compared with each other in various ways (Cook & Campbell, 1974). A quantitative approach allowed the researcher to ask confirmatory and exploratory questions to generate theories. Questions were based on the evidence-based model proposed originally by Davies (2004) and adapted to construction management in a naturalistic setting. Snow (1974) advocates that this type of design in naturalistic settings is important to build "detailed descriptions of variables within their own contextual boundaries" (p. 288). It is important to note that this research is not causal in nature. It merely provides a sense of informed reasoning from a naturalistic group of experienced participants on risk analysis with respect to project delivery methods. Participants were grouped based on their years of experience and knowledge on the delivery methods of design-bid-build and design-build.

The purpose of the study was to compare the experiences of professionals on DBB and DB and apply these experiences to an evidence-based model describing the econometric, environmental, political, project, and technological factors commonly found within these delivery methods. Another purpose of this research is to identify when or where differences exist between these constructs, or, if differences exist at all. Comparing the independent variables of these two project delivery methods using this model could give a construction executive an idea of how two project delivery methods might differ, besides time and cost. Comparing the data applied to the evidence based model generated a different set of comparative theories associated with the project delivery methods being studied.

Therefore, the importance of this study was to identify the strength and patterns among the variables on economy, environment, politics, project, and technology as they relate to the use of the two project delivery methods. An evidence-based conceptualizes different principles and practices related to the complexities of project delivery and the practice of construction. Constructors can use this model to make decisions related to project delivery. A model such as the one proposed by Davies (2004) could also document the best available evidence of skills, practices, and factors construction professionals use to deploy their expertise when making decisions about projects. For the construction professional, this model could provide greater information from experienced professionals in the construction management of DBB and DB project delivery.

Instrument Design and Construction

The next two sections discuss the quantitative research design in two different phases. The first phase is the pilot test, followed by the second phase, described as the test phase. The basic design used was a two-group between and within subjects multivariate design. This design was used because it takes advantage of providing information on the influence of each independent variable separately and how the effects of the variables react when they were combined. More importantly this design provides a "richer, more revealing, multidimensional" view of project delivery from an evidence-based model (Keppel & Wickens, 2004, p. 10). The research design will be further discussed within the study phase of the methodology. Each phase followed the same basic research process from sample selection to analysis.

Phase 1: Pilot Test Method and Procedure

Phase 1 of the design discusses the processes required to develop the pilot questionnaire and establish reliability, validity, content validation, internal validity, external validity, and factor analysis.

Pilot Questionnaire Development

The survey instrument was developed in multiple stages, beginning with research questions, sub-questions, and item development. Questions were developed to address the characteristics of the two project delivery methods being investigated. Sub-questions were then developed to reflect the model elements that examined the major constructs of economics, environment, politics, project, and technology for the two project delivery methods. From these sub-questions, items were developed that tied back to the sub-questions, which were used to analyze differences associated with the constructs of economics, environment, politics, project, and technology.

Item development

Items for this research were developed based on the CII study questions. A total of 93 items with 5 demographic questions were developed. Components of questions from the CII study served as the platform for the item development. The CII study was only used to organize and inform the items on project performance, practice, engineering productivity, construction productivity, and project closeout metrics and relate these to the constructs for this study (Construction Industry Institute [CII], n.d.).

A goal of this research was to examine the strengths of the risk constructs if differences exist, and to specify where these differences exist. Embedded in each question was an identifier for each of the construct questions characterized by a key word or phrase. Identifiers for each question were assigned using a code of "W" for questions related to *where* differences existed in relation to the 16 construction divisions (Simmons, 2001). The intent was also to explore if within the construction continuum differences would exist. A code of "D" was then used to establish if *differences* existed between the two project delivery methods.

During the item development phase, a unique 5 point likert scale was developed for each item. Each item a likert scale was tailored with a range of descriptors that fit each question. The purpose for developing this type of scale was to associate the item scale with each item. Using these descriptors would be more relevant to the actual item than a numeric code. There were no qualitative questions asked within the item development stage. However, participants were free to provide feedback and comments through email that would be used in the development of the final survey instrument.

To differentiate the construct differences between the two project delivery methods, based on responses from industry professionals, two different survey instruments were developed. The pilot test survey instrument labeled Form A contained questions about the DBB project delivery method across the five constructs (Appendix A). The pilot test survey instrument labeled Form B contained questions about the DB method across the five constructs (Appendix B). The pilot survey instruments were used to inform the researcher of their reliability and validity.

Reliability and Validity Procedure

This section establishes the reliability and validity of the survey instrument, and discusses content validity, pilot testing, internal validity, and external validity. This section shows how a factor analysis process was used to establish the content validity and reliability of the survey instrument.

Reliability

Reliability is a measure of consistency. To ensure reliability, the following questions must be answered:

1. To what extent can we say that the data are consistent?
2. To what extent do the individual items that go together make up a test or inventory consistently measure the same underlying characteristic? (Huck, 2000, p. 76).

It is suggested by Cook and Campbell (1979) that reliability plays a crucial role in inferring differences between the means of the treatment groups. They suggest the following methods for controlling unreliability, consistency in the data, and ensuring items that make up a test measure the same characteristic by:

1. Using longer tests for which items or measures have been carefully selected for their high intercorrelations.
2. Using more aggregated units e.g., groups instead of individuals, since a group mean will be more stable than an individual mean. (Cook & Campbell, 1979, p. 43).

Reliability was established by asking multiple questions under each major construct to establish high intercorrelations. Each individual question was related to one aggregated construct of economics, environment, politics, projects, and technology to establish whether variability exists within the constructs. Questions were then developed and compared based on their group means. Additionally, some questions were repeated, but formatted differently. Reliability was established through the systematic development of the survey instrument through the item development process.

Validity

If reliability is the measure of consistency in the data, validity is a measure of accuracy in the data (Huck, 2000). The two components of validity include internal validity and external validity. This section discusses content validity, pilot testing, internal validity, and factor analysis as methods to ensure the accuracy of the data collection instrument (Gorsuch, 1983; Huck, 2000).

Internal validity

Because the participants' responses were randomly assigned into groups (DB and DBB) there were some threats to the internal validity of the study. One of the main threats to internal validity in this study was the presence of participants that had experience in both the

DBB and DB project delivery methods. It was difficult to determine if the participants had experience using the DBB or DB project delivery method. In addition, a threat to selection, what Gliner and Morgan (2000) consider as participant assignment, was present. Because the participants were randomly selected, no background checks were conducted to determine whether participants had the professional experienced they claimed. Also, the researcher relied on the participants to select the survey instrument in which they had the most amount of experience. Experience here was defined by the total number of projects or the years of experience under the associated project delivery method.

External validity

External validity is the application of research to real world conditions. External validity is defined as the "extent to which the results of a study can be generalized (applied) to the circumstances outside the specific research setting in which a particular study was conducted" (Siegle, n.d., p. 1). The main threats to external validity are generalizability, sample selection, and ecological validity.

There are multiple types of project delivery methods used within construction project procurement. Therefore, a threat to the external validity is how applicable it is to project delivery methods other than DB and DBB. There exists a potential threat to the sample size. The sample size also poses a problem. The sample size for either project delivery method, DBB or DB, was smaller than what is typically acceptable in social science research. This low sample size resulted because it was difficult to get a group of 100 to 200 architects, engineers, and construction managers into a single area because of the geographic distribution of where their projects are located. To counter the small sample size, the researcher selected equal numbers of participants to participate in the research groups.

Content validation

To validate the content within the survey instrument, a pilot test was conducted. Oppenhiem (1992) states that content validity "establishes the items or questions are a well balanced sample of the content domain to be measured" (p. 162). The content validation process allowed the researcher to verify that the questions asked aligned with current industry practices. The researcher worked to determine if the right questions were asked and if they were consistent with decisions made in the process of risk analysis in design-bid-build and design-build project delivery. The pilot test instrument can be found in Appendices A and B. A conceptual factor analysis procedure was also developed to reduce the number of items to be used in the final instrument.

Conceptual Factor Analysis

In an effort to establish internal consistency and further ground the content within the survey instrument, a conceptual factor analysis process was used. Conceptual factor analysis is a statistical technique used in test development and evaluation for item analysis, scale development, and theory testing (DeMiranda, 2006; Gorsuch, 1983). Gliner and Morgan (2000) state that factor analysis is useful in two ways: "to combine a number of items or variable to form a smaller number of composite variables or factors (constructs) and look for latent or unobservable variables or constructs from observed variables" (p. 300). Gorsuch (1983) also contends, in "parsimoniously describing data, factor analysis explicitly recognize that any relationship is limited to a particular area of applicability" (p. 2). These authors recognize that each area or factor represents an area of generalization that is different from any other factors within the study. The researcher established the amount of generalizability and the cohesiveness that can be applied to each factor, due to the constructs of economics, environment, politics, project, and technology. Simply put, how closely related are the items to be analyzed?

Gorsuch (1983) states that "a measure of the degree of generalizability between each variable or item and each factor is calculated and referred to as a factor loading" (p. 3). Factor loadings identify quantitative relationships between the factors to be measured. Therefore, the researcher looked for is how far from zero the factor load exists within the data. If the factor loading is large, then greater generalizability can be assumed about the specific factor. In this study, conceptual factor analysis was used to determine the item factor loadings across the five variables of economics, environment, politics, project, and technology. Because of this process, five of the factors could be reduced or measured to similar or different categories (Gorsuch, 1983). Most importantly, factor analysis as used in this study provided a statistical grounding for the development of the evidence-based model.

A factor analysis table was built to best show how the factors would align based on their component loadings. Table 3 shows sample component factor patterns for two variables.

Table 3

Sample Component Factor Patterns for Two Variables

	Factors				
Variables	Economics	Environment	Politics	Projects	Technology
DBB					
DB					

The equation used to determine the factor loadings was:

$$X_{DBB} = w_{vDBB}F_{ec} + wv_{DBB}F_{en} + wv_{DBB}F_{po} + wv_{DBB}F_{pr} + wv_{DBB}F_{te} \quad \text{(Eq. 1)}$$

$$X_{DB} = w_{vDB}F_{ec} + wv_{DB}F_{en} + wv_{DB}F_{po} + wv_{DB}F_{pr} + wv_{DB}F_{te} \quad \text{(Eq. 2)}$$

Where X_v represents the variable's loading, w_{vDBB} is the weight for the variable or the project delivery method and F_{ec} represents the factor loading on each individual factor. This table will be used later in the study (see page 94) to describe the factor loadings for each of the factors as calculated in Equations 1 and 2

Pilot Testing

Pilot testing the instrument allowed the researcher to test for the item reliability of the self-made instrument to further fine tune it. Pilot testing established a Cronbachs alpha reliability coefficient of .64 or higher for the self-made instrument. Additionally, each of the constructs were tested to achieve a Cronbach's Alpha reliability coefficient of .64 or higher for each of the questions within the construct areas of econometrics, environment, politics, project, and technology (Gliner & Morgan, 2000). Further discussion of the Cronbach's alpha will be discussed in the pilot test findings. During this same process, the survey instrument was tested to establish a Flecsh-Kincaid reading level between 7 and 8. The Flecsh-Kincaid reading level for each of the pilot tests is given in Table 4.

Table 4

Pilot Test Grade Level and Reading Ease Scores

Pilot Test Type	**Grade Level**	**Reading Ease**	**Word Count**
DBB0636	13.2	32.2	1317
DBB3767	13.2	32.6	1355
DBB6898	12.7	34.4	1293
DB0636	13.2	32.2	1317
DB3767	13.2	32.6	1355
DB6898	12.7	34.4	1293

Scores for the reading level were slightly higher than desired. This is due to the total length of the survey instrument and the complexity of the questions proposed within the pilot test. It was also assumed that many of the professionals to receiving the pilot test had the experience to handle complex survey instrument. An example of the pilot test for both project delivery methods can be found in Appendices A and B.

Pilot Test Participant Recruitment

Pilot test participants were recruited through several methods. The first initial participant recruitment took place at the Society of American Military Engineers (SAME) conference held in New Orleans, Louisiana, from May 30, 2006 through June 2, 2006. The researcher supplied participants with forms that informed the participant about the research being conducted and asked participants to complete the pre-survey form found in Appendix C. The pre-survey form recorded the participant's name and address. Participants also filled out forms that included the Colorado State University Human Subjects consent form (Appendix D).

Since there were very few participants recruited at the SAME conference, the researcher then called individuals who had attended the conference to ask them to participate in the research. The phone script used can be found in Appendix E. The researcher collected the participant's name, email address, and phone number, in order to send the pilot instrument to the participant. Participants were also informed through the phone contact that by providing their contact information they agreed to participate in the research. Additionally, participants were recruited by through phone lists provided by the Colorado State University's Construction Management Internship Recruitment Office, American General Contractors of Colorado and Washington, and through the identification of companies using the Internet. Phone numbers were also collected through the Construction Management Association of America (CMAA) Denver Chapter and the Rocky Mountain American Association of Cost Engineers (RMAACE).

Data Collection

Emails and personal phone calls were used to inform and notify the participants that they would receive a survey questionnaire. The researcher sent the questionnaire to each participant after they agreed to receive it. The participants were provided specific instructions with the pilot test found in Appendix F on how to complete the instrument. They were told to send it back to the researcher to a secure database using the Internet and email. Each participant received either a DBB or DB pilot test instrument based on the participant groupings shown in Table 6. If the participant had extensive experience in both project delivery methods, the participant was able to complete both survey instruments. All participants were assured that any information they provided during this pilot test phase would be secure. Instructions used for this phase of the study can be found in Appendix F.

Pilot test item partitioning

To pilot test the instrument, key participants within industry and education were identified. Participants from industry were predominantly used to validate the instrument. Because industry participants do not have time to read through a 93-item instrument, the researcher created three different 30- to 31-item instruments. The instrument was distributed to 5 participants in each group that received 30 to 31 questions. There were 15 total participants for DBB and 15 total participants for DB, for a total of 30 in the pilot test sample. Table 5 describes how the 93-item instrument was partitioned to each of the participants.

Table 5

Pilot Test Item Partitioning

Participant	Project Delivery Method (PDM)	Items
1-5	DBB	1-31
6-10	DBB	32-63
11-15	DBB	64-93
16-20	DB	1-31
21-25	DB	32-63
26-30	DB	64-93

Table 5 shows how the instrument was shortened to include 5 demographic questions and 30 to 31 item questions for each of the 15 participants for each delivery method (DBB=15 and DB=15). Each participant was contacted by telephone to verify their email address and to notify them that the researcher would be sending them a survey instrument. Follow-up calls and emails were used to assure the participant completed the survey instrument. As the participant completed the survey instrument they would send it to a secure MSN database, only to be accessed by the researcher. The researcher would then download, file, print, and code each survey instrument to identify the completion time, date, and pilot test type (DBB or DB). Coding each of the surveys assured that no individual information could be tracked back to the participants completing the surveys. Allowing this group of professionals to pilot test the instrument, helped establish the construct validity for the study, which informs "how well the test links up with a set of theoretical assumptions" about the constructs (Oppenhiem, 1992, p. 162).

Pilot test grouping

As surveys were completed each of the items that were previously partitioned (items-1-31, 32-63, and 64-93) would be randomly combined to make up the responses for one single test instrument of items 1-93. Once the pilot test instrument was combined to include all 93 responses from each of the participants, the data was entered into SPSS for each of the aggregated pilot tests. The total number of pilot tests acquired using this process was n= 10 (5 DBB and 5 DB) test instruments. Table 6 shows how each item from the partitioning section was combined to create a completed pilot test with an n = 10.

Table 6

Pilot Test Participant Groupings

Pilot Test	Project Delivery Method (PDM)	Participant			Pilot Test Items		
1	DBB	1	6	11	1-31	32-63	64-93
2	DBB	2	7	12	1-31	32-63	64-93
3	DBB	3	8	13	1-31	32-63	64-93
4	DBB	4	9	14	1-31	32-63	64-93
5	DBB	5	10	15	1-31	32-63	64-93
6	DB	16	21	26	1-31	32-63	64-93
7	DB	17	22	27	1-31	32-63	64-93
8	DB	18	23	28	1-31	32-63	64-93
9	DB	19	24	29	1-31	32-63	64-93
10	DB	20	25	30	1-31	32-63	64-93

Although few pilot tests were analyzed, Gliner and Morgan (2000) state that the pilot test "involves trying out procedures or fine tuning a questionnaire with a *few* acquaintances or knowledgeable persons in the field" (p. 353). In order to prevent test fatigue by providing a single 1-93 item test to one participant, the researcher divided pilot tests among 30 (n = 30) participants. Therefore, each of these 30 participants could take the time necessary to answer the questions. This also provided the researcher a greater knowledge pool of people to provide additional comments and feedback. Participants submitted comments and feedback to the researcher via email. These helped develop the final survey instrument. The pilot test provided a means for the researcher to collectively address each question from experienced industry participants and assess its validity to assure the questions reflected how the final test was going to perform under test conditions.

Pilot Test Findings

The pilot test was a way to test drive the instrument before the actual test was performed. After the data was received, combined, and synthesized it was cleaned and checked for any missing data. Cronbach's alpha was used to determine the internal consistency within the questionnaire (Andersen, 2001; Huck, 2004; Gliner & Morgan, 2000). For the pilot test, the researcher was anticipating a minimum alpha level of $\alpha = .64$ (Gliner & Morgan, 2000). A reliability test for internal consistency was run for the overall test instrument. The coefficient alpha of .84 suggested that the survey instruments were internally consistent. The alpha was measured for each delivery method and the alphas for DBB and DB are shown in Table 7.

Table 7

Pilot Test Reliability

Project Delivery Method	M	α
DBB	3.17	.67
DB	3.46	.79

To determine the inter-item consistency within the constructs, a minimum alpha level of .64 was used to gauge consistency in the constructs. The importance of determining the inter-item consistency using alpha was to determine which items could be eliminated while keeping the alpha level at a reasonably high level of .64 or above for the final self made instrument. The Cronbach's alpha for construct reliability is shown in Table 8.

Table 8

Construct Reliability

Construct	M	α
Econometrics	3.22	.85
Environment	3.20	.87
Politics	3.34	.53
Project	3.29	.56
Technology	3.65	.59

The constructs for econometrics and environment proved to be internally consistent using the alpha measure. But, constructs for politics, project, and technology fell below the standard measurement for internal consistency of .64. To analyze the interitem correlation between each of the constructs a conceptual component analysis was used to reduce the total number of items.

Conceptual component analysis- item reduction

To reduce the total number of items for the final test, the researcher systematically tested each of the constructs. This was designed to remove and replace items until the alpha level stabilized above .64. For each construct, Cronbach's alpha statistics were run in relation to the questions of; 1. *Do* differences exist (D)? and 2. *Where* do differences exist (W)? This reduction framework, as suggested by Cook and Campbell (1979), was a way to determine the strength of the intercorrelations across the aggregated units of econometrics, environment, politics, project, and technology.

The researcher created a conceptual component matrix within SPSS using the output from the corrected item total correlation column to limit the items used in the final study questionnaire. To eliminate an item, the researcher searched for items that maintained an intercorrelation level of .40 or higher, but less than .90. If the correlation for the individual item was measuring .90 or higher it was determined that the item was measuring equally as another item within the matrix. If the item correlation was too low, around .1, then one or more of the items was loaded on one component. These assumptions were used as the criteria for eliminating items within the survey instrument (UCLA Academic Technology Services, 2006).

Table 8 shows the alpha levels as items were removed and added to the survey. The alpha initial (α_i) was the measure of alpha when all items were included in the analysis. By removing and adding items to the survey instrument, this process caused fluctuations in the alpha level indicating that various items were measuring the same outcome. Alpha adjusted (α_a) was used to determine the agreement between each of the items within the survey instrument, when they were categorized on *where* differences existed (W) and if differences (D) within each of the constructs on the variables of DBB and DB. Table 9 shows the adjusted alpha (α_a) for the internal consistency of the instrument.

Table 9

Conceptual Component Analysis- Item Reduction

Econometrics				Environment				Politics				Project				Technology			
W		D		W		D		W		D		W		D		W		D	
1		2	*	29		27		52	*	43		56	*	57	*	85	*	80	
3	*	4	*	30		28	*	53		44		60	*	58		90	*	81	
5		8	*	31	*	35		54	*	45		68		59		91		82	*
6	*	9	*	32		36	*	55	*	46		69	*	61				83	
7	*	10	*	33	*	37	*			47		70		62				84	
15	*	11	*	34	*	38	*			48	*	71		63	*			86	
16	*	12		41		39	*			49	*	72	*	64	*			87	
17	*	13				40	*			50		78		65	*			88	
18	*	14				42	*			51		79	*	66				89	*
19	*	15												67				92	
20	*	26	*											74				93	*
21	*													75					
22	*													76					
23	*													77					
24																			
25																			
α_i	**.84**	α_i	**.52**	α_i	**.68**	α_i	**.82**	α_i	**.66**	α_i	**-.19**	α_i	**.59**	α_i	**.24**	α_i	**.36**	α_i	**.46**
α_a	**.87**	α_a	**.70**	α_a	**.71**	α_a	**.87**	α_a	**.76**	α_a	**.58**	α_a	**.70**	α_a	**.67**	α_a	**.57**	α_a	**.71**

Legend	
α_i	Alpha initial
α_a	Alpha adjusted
*	Items selected to be in survey instrument.
Note:	All items without "*" were not used in the survey instrument

Test Instrument Development

A pilot test was developed and performed to reduce the number of questions within the survey instrument and identify which questions would be most valid for the study (Gliner & Morgan, 2000). In the initial item reduction process the researcher was able to reduce the 93 questions to 48 questions, using the conceptual component analysis process that provided an internal consistency factor of .80 for all 48 questions. The researcher then determined that further item reduction was needed to minimize test fatigue on the participants. The 48 item analysis in Table 10 provides the construct alphas within the questions for each delivery method.

Table 10

48 Item Analyses

	Constructs									
Variables	Economics		Environment		Politics		Projects		Technology	
	α	M	α	M	α	M	A	M	α	M
DBB	.70	55.4	.93	29.8	.87	13.2	.78	29.8	.67	18.8
DB	.89	61.6	.83	36.2	.77	11.2	.66	34.8	.82	19.8

α = alpha, M = mean, DBB = Design-bid-build, DB = Design-build

Table 10 shows the alpha measures for each of the delivery methods and constructs. The average responses for the subscales of DBB and DB were .64 (M = 150.4) and .83 (M = 167.2). This information was used to identify where the researcher could further reduce the number of items in the instrument. As shown in the above table, all measures indicated an alpha level above the .64 minimum.

A goal of the conceptual component analysis was to reduce the number of items to minimize test fatigue while maintaining a stable alpha. Using the information provided in the previous two tables, the researcher made a decision to remove the group of questions within politics. Although the group of questions within politics had a higher alpha in the second test when grouped by DBB and DB ($\alpha = .87$, M = 13.2 and $\alpha = .77$, M = 11.2), they had a much lower adjusted alpha when they were grouped by the construct category of politics ($\alpha = .76$ and $\alpha = 56$). Even though these questions hold a relatively high alpha, their intercorrelations would affect the overall alpha. Removing the group of politic questions reduced the number of questions to 42.

The decision to remove the politics category from the model was based on low alpha loadings. As the researcher removed or added items within the politics category, the low statistical loadings continued to exist. The reasons for large variations within the mean statistic might be poorly developed questions, or a participant's opinion toward a certain subject matter within the question being posed.

The researcher determined, through a qualitative review of the questions in the 42-item instrument, that the structure of two questions was similar to other questions asking for similar responses. These questions were removed, resulting in a 40-item instrument. Analyzing this 40 item instrument provided an increased alpha level of .82.

Table 11

40 Item Analyses

	Constructs							
Variables	Economics		Environment		Projects		Technology	
	α	M	α	M	α	M	α	M
DBB	.72	48.2	.93	29.8	.67	22.6	.67	18.8
DB	.87	53.2	.83	36.2	.63	27.4	.82	19.8

α = alpha, M = mean, DBB = Design-bid-build, DB = Design-build

Table 11 shows alpha levels for each of the delivery methods and constructs for the 40-item instrument. Eliminating the questions on politics slightly raised the alpha level of DBB to .65 and decreased the alpha for DB to .81. Although these are slight adjustments in the alpha levels for the instrument, they contributed to a higher and more stable overall alpha of .82 sufficient for a self-made instrument.

Phase 2: Test Phase Method and Procedure

Sample

The target population for this study was a intact group of construction professionals who had experience or knowledge of building and managing projects using the design-bid-build (DBB) and/or design-build (DB). This sample was chosen to get a good cross section of construction professionals with actual working knowledge of the two project delivery methods; design-bid-build (DBB) and design build (DB).

The initial search for participants started with a population of construction companies that perform DBB and DB projects. Typically, these were companies would be larger companies found among Engineering News Record's (ENR) top 400 constructors. These companies were chosen because of their dollar volume and the types of projects they perform. In order to gain access to participants within these companies, the researcher used the human resources (HR) director as a gatekeeper to identify the project management staff within the company. In cases where there was no HR director, the researcher would ask for a high ranking member within the organization to help distribute surveys to qualified participants.

Participants for this study were carefully selected based on their experience and knowledge of the two project delivery methods DBB and DB. The HR director or company representative was used to select the participants because they would have the best knowledge of the participants' company position and experience level with the project delivery method of interest.

For each type of project delivery method the researcher searched for participants who had upper level management positions. These two criteria were selected to secure participants with real world experience with these two project delivery methods. The researcher hoped they would reflect on their experiences with these types of projects. Therefore, the total number of projects each participant had worked on was important. The total quantity of projects could vary, because participants could have worked for several years on a specific project, especially if it was complex.

Another important classification factor in the comparisons would be the construction industry type the participant worked under (i.e. civil, buildings, industrial). It would seem that there could be differences that would exist between the types of construction industries with respect to the project delivery methods. The researcher also tried to identify the quantity of projects the participants were involved with under a certain delivery method.

The actual sample used for this study was 108 total participants (54- DBB and 54- DB). Under survey research standards, this sample size was relatively low. Conducting research in construction is difficult because participants seem reluctant to share information that might help another competitor. Another factor that affected the sample size was the time period in which the study was conducted; many constructors were inundated with large volumes of work all across the country. Participation in the project diverted from revenue generating activities. The effects of a low sample size may not accurately represent the total population. Therefore, the two samples for DBB and DB were analyzed using equal participants for each delivery method.

A contributing factor to the low sample size in this study was the difficulty in which the researcher was able to secure reliable commitments to participate in the study from the construction professionals selected to participate in the study. The sample responses were often inconsistent, commitments to reply were not kept by the sample participants, and multiple attempts to follow up via electronic communication and direct personal telephone were often met with diversionary reaction in a less than desirable attempt to contribute to this research. Sample participants often cited lack of time or "too busy schedule," to contribute to the knowledge base in construction management. This response can be characterized a symptomatic of an already overworked population. Because of the exploratory nature, empirical research in construction management is not an accepted practice of the professional culture. However, research such as this and the teaching of empirically based research in construction management programs could help change and affect this culture in the future.

Final Test Instrument

The final test instrument used in the study was a 40-item instrument. All 40 items were tested, resulting in an alpha of .82. This indicated that the test instrument was acceptable for internal consistency for a self-made instrument. The test instrument was developed to address differences between four constructs, econometrics, environment, project, and technology across the project delivery methods of DBB and DB. The instrument measured differences between the constructs, but it also was designed to measure *where* differences existed and *if* (Do) differences existed between the two treatment variables of design-bid-build and design-build.

Data Collection

Data were collected using the Microsoft Word form survey instrument found in Appendix G and Appendix H. The two survey instruments (DBB and DB) were distributed by email through a gatekeeper within a company or organization. As the survey instrument was distributed, the participants were instructed to complete the survey and send it back to a secure email address. Once the survey instruments were received, all survey instruments were filed into a Microsoft Network (MSN) service provider database to be collected by the researcher at a later date.

As the researcher collected the data within the MSN database, the survey instruments were downloaded, printed, and coded with an identification number that corresponded to the type of survey instrument (DBB or DBB), time, and date the instrument was received. Each of the instruments was coded to remove any identifying information linking the survey instrument to the participant.

Data Analysis

Treatment of Data

Coded surveys that were downloaded from the secure email system were organized based on the delivery methods; DBB or DB. Data from the survey instruments was entered into an Excel worksheet template developed in SPSS. Once the data was in the worksheet, it was visually reviewed to assure there were no inconsistencies or missing values. The data was then exported from the Excel spreadsheet to the SPSS software. Once the data set was imported into the SPSS software all data was cleaned to identify any data entry errors that may have occurred in the data transfer process. This process was necessary to assure the data set was accurate and complete.

Method of Analysis

To compare the two project delivery methods, a two-way analysis of variance (ANOVA) was conducted. A two-way ANOVA was selected because the study is comparing the independent variable of the project delivery methods design-bid-build and design-build on the four dependent variables of econometrics, environment, project, and technology (Huck, 2000). These comparisons would be used to populate the evidence-based model for comparative analysis.

More specifically, the ANOVA searched for differences between the independent variables of project delivery across the four main constructs of economics, environment, project, and technology. The two-way ANOVA analysis structure for this study is shown in Table 12. This two-way ANOVA analysis was used to identify if differences that existed between the two delivery methods.

Table 12

Two-Way ANOVA Analysis Structure

Project Delivery Method	Economy EC	Environment EN	Project PR	Technology TE
DBB				
DB				

The two-way ANOVA analysis structure reveals statistically significant main affects between each of the project delivery methods and constructs. The researcher will be looking for differences between the means of the project delivery method and the construct. Differences between delivery methods and the constructs are further explained in the next section.

Assumptions

The assumptions of independence, randomness, normality, and homogeneity of variance were applied to the two-way ANOVA. To assure independence, the data was tested to assure that one participant's performance did not affect another. The method of administering the questionnaire during the testing process also assured independence. An additional assumption within the ANOVA was randomness. To assure this, the researcher selected participants based on their level of experience related to the project delivery methods of DBB and DB. Also, the researcher used gatekeepers to select participants and distribute the survey instrument. Prior to data analysis, the data was screened for the assumption of normality to assure there were no outliers and that the skewness and kurtosis were close to zero among the data. The samples were also tested for homogeneity of variance to assure normality.

CHAPTER 4: FINDINGS

This chapter will present the findings of this research by showing the descriptive data for the dependent constructs of econometrics, environment, politics, technology, and sample characteristics. Additional findings will illustrate some of the differences found with time and cost between the two project delivery methods associated with risk.

Descriptive Findings

Sample

A sample of 108 participants took part in this study. They were selected based on their current employment position, number of years in the construction industry, duration of projects they have participated on based on delivery method, type of construction, and the number of projects they have worked on within the delivery methods of design-bid-build and design-build. Sample data were screened for missing values and outliers, and test for normality. Missing value cases were replaced with the sample mean response for the question. Screening indicated the data was normally distributed and met the assumptions for parametric tests. A strong Cronbachs alpha of .88 was achieved with an inter-item mean of M = 3.34. Table 13 shows the reliability analysis for each project delivery variable.

Table 13

Project Delivery Reliability Analysis

Delivery Method	N	α	M
DBB	54	0.85	3.31
DB	54	0.90	3.45

There was a strong Cronbachs alpha for DBB (N = 54, α = 0.85, M = 3.31) and for DB (N = 54, α = 0.90, M = 3.45). The alphas for these two variables provide an assessment of the internal consistency and reliability of the multiple item scales for the two questionnaires.

Descriptive statistics were also run on the sample of 108 participants, which are shown in Table 14. The majority of the participants in this study were project managers, upper level management, or held other types of positions, such as consultants, architects, or higher level management with multiple responsibilities with in-depth knowledge of project delivery methods.

Table 14

Industry Current Position

Industry Position	N	%
Field Supervision (Field Engineer, Superintendent)	3	2.8
Project Manager	39	36.1
Upper Level Management (Area Manager, V.P., CEO)	21	19.4
Other (Architects, Engineer, Consultants)	45	41.7

Each participant was asked to provide information on the total number of years they had been in the construction industry. This data is shown in Table 15.

Table 15

Industry Experience

Years of Experience	N	%
0-5	2	1.9
6-10	6	5.6
11-15	20	18.5
16-20	18	16.7
21-25	15	13.9
26-35	33	30.6
36 or more	14	13.0

This table shows that the majority of the participants had more than ten years of experience within the construction industry. They were qualified to provide their expertise and knowledge on the two delivery methods being investigated. Table16 shows the average duration of projects participants typically manage with respect to project delivery type.

Table 16

Average Project Duration

Years	N	%
Less than 1 year	5	4.6
1	15	13.9
2	52	48.1
3	20	18.5
4	5	4.6
5	1	.9
6	2	1.9
Other	8	7.4

Table 16 shows the majority of the DBB and DB projects lasted between one and four years. Table 17 shows the areas of construction participants worked in.

Table 17

Area of Construction

Construction Area	N	%
Civil	30	27.5
Commercial (Buildings)	39	36.1
Industrial	4	3.7
Architect./Engineer	7	6.5
Residential/Developer	1	0.9
Vendor/Supplier	1	0.9
Other (multiple areas of construction)	26	24.1

Most of the participants were from the civil (27.5%, N = 30), commercial (36.1%, N = 39), and multiple areas of construction (24.1%, N = 26). Therefore, the responses from the participants provided a good cross-section of data with which to compare the delivery methods being tested. Table 18 shows the number of projects participants have performed under each of the project delivery methods of interest.

Table 18

Number of Projects Per Delivery Method

Number of Projects	**N**	**% DBB**	**N**	**% DB**
1-10	18	33.3	31	57.4
11-20	9	16.7	10	18.5
21-30	10	18.5	4	7.4
31-40	4	7.4	3	5.6
41-50	13	24.1	6	11.1

What can be determined from this table is that most participants had more experience with the DBB method of project delivery, at 41-50 projects (24.1%, N = 13). An interesting finding is that many of the participants have participated between one and ten projects per delivery method (DBB = 33.3%, N = 18 and DB = 57.4%, N = 31). This information suggests that the actual project knowledge level of the sample participants on the type of delivery methods is quite high.

What the findings help show is the depth of industry experience and knowledge of the participants in this study on the two project delivery methods within the four constructs of econometrics, environment, project, and technology. The next section will explain the descriptive statistics for the constructs identified in this study. The next few sections of this analysis discuss the findings of the comparative analysis on the research question, sub-questions, and constructs.

Construct Item Descriptive Analysis

The construct descriptive analysis in Table 19 shows the descriptive statistics for the questions as they were grouped in their respective constructs by project delivery method. Overall, these statistics show significant differences in the null hypothesis (H_0). Therefore, the null hypothesis (H_0) was rejected, since there were significant differences between the constructs of project F (1, 107) = 4.27 $p < .05$ and technology F (1, 107) = 4.72, $p < .05$.

Table 19

Construct Descriptive Statistics

Construct/Dependent Variable	Delivery Method	N	*M*	*SD*	S.E	95% Confidence Interval for Mean Lower	Upper	Minimum	Maximum	P	*F*	*d*
Econometrics	DBB	54	62.65	7.67	1.04	60.56	64.74	48.00	79.00			
	DB	54	63.07	8.60	1.17	60.73	65.42	41.00	87.00			
	Total	108	62.86	8.11	0.78	61.31	64.41	41.00	87.00	.786	.074	0.05
Environment	DBB	54	31.26	7.31	0.99	29.27	33.25	13.00	47.00			
	DB	54	33.28	7.93	1.08	31.11	35.44	12.00	48.00			
	Total	108	32.27	7.66	0.74	30.81	33.73	12.00	48.00	.172	1.89	0.26
Project	DBB	54	25.19	4.77	0.65	23.88	26.49	16.00	36.00			
	DB	54	27.19	5.23	0.72	25.75	28.63	15.00	39.00			
	Total	108	26.19	5.11	0.49	25.21	27.16	15.00	39.00	.042	4.27	0.40
Technology	DBB	54	13.46	2.30	0.31	12.84	14.09	8.00	18.00			
	DB	54	14.48	2.57	0.35	13.78	15.18	8.00	19.00			
	Total	108	13.97	2.48	0.24	13.50	14.45	8.00	19.00	.032	4.72	0.42

Although the null hypothesis was rejected for the overall research question, within each construct, significant differences were also found. Effect sizes were also calculated for each of the constructs to determine the differences between the two means for each of the constructs of interest. As the reader will see in Table 18 there was a small effect shown for econometrics ($d = .05$) and a relatively small effect for environment ($d = .26$). There was also a medium effect with the constructs of project (d = .40) and technology (d = .42) (Cohen, 1998). Further discussion and analysis of each construct can be found within this chapter's findings.

Quantitative Dependent Variable Findings

The dependent variables consisted of scaled scores for four constructs: econometrics, environment, project, and technology. Each construct measured several variables to determine if differences existed between the two delivery methods. If differences did exist, what and where they were within each of the constructs had to be determined, as well. Post-hoc tests were not necessary because there were only two study variables being tested, DBB and DB.

Econometrics

Econometrics was defined within the context of this study as the decisions made regarding the project cost, schedule, financing, quality, and safety based on the current economy. A between groups ANOVA was conducted to determine if differences existed econometrically between the two project delivery methods of DBB and DB. Multivariate normality showed some tendency for non-normality. However, none of the skewness statistics were high and the ANOVA method is robust enough. Therefore it was decided to keep extreme values (outliers) in the analysis and no transformations were necessary. Table 20 shows the differences between the two project delivery methods when grouped under the econometrics construct.

Table 20

ANOVA Source Table for Differences Between DBB and DB on Econometrics

Variable	Source	df	SS	MS	F	P
Cost Known	Between groups	1	7.26	7.26	6.29	.014
	Within groups	106	122.41	1.12		
Change Order per Delivery Method	Between groups	1	41.57	41.57	29.5	<.001
	Within groups	106	149.35	1.41		
Quality During Design	Between groups	1	13.37	13.37	10.27	.002
	Within groups	106	138.04	1.41		
Quality During Feasibility	Between groups	1	32.23	32.23	24.29	<.001
	Within groups	106	140.69	1.33		
Schedule Change During Construction	Between groups	1	9.48	9.48	5.45	.021
	Within groups	106	184.26	1.74		

This data suggests that cost known at the design phase between the two delivery methods is significant $F\,(1,107) = 6.23, p < .05$. There was a significant difference observed between delivery methods on the expectation of change orders between the two project delivery methods $F\,(1, 107) = 29.5, p < .001$. The data also suggests significance on quality during design $F\,(1, 107) = 10.27, p < .05$. Data collected suggested a significant difference in the expectation of change within schedule $F\,(1, 107) = 5.45, p = .021$. Finally, the data shows a significant differences between delivery methods on quality during the feasibility stage $F\,(1, 107) = 24.29, p < .001$.

Based on the data collected for this sample, the null hypothesis (H_0) for econometrics was rejected. There were significant differences between delivery methods that existed due to the knowledge of costs during design, the expectation of change orders between project delivery methods, the consideration of quality during the design phase, expectations of changes in the schedule, and concern over quality during the feasibility stage.

Environment

Environmental factors, within the context of this study, are characteristics related to the natural environment, site location, site regulations, geographic documentation, and water. Multivariate tests for normality showed no indication of non-normality. Skewness statistics were within the acceptable limits of the study. A between groups ANOVA was conducted on environmental factors related to project delivery. However, the null hypothesis (H_0) was rejected and there were significant differences found within this construct. Participants were asked for their involvement with environmental considerations at the feasibility stage (project formulation, strategy design, and approval) of the project. Table 21 shows the significant difference that existed within the environmental construct by project delivery method.

Table 21

ANOVA Source Table for Differences Between DBB and DB on Environment

Variable	Source	df	SS	MS	F	P
Environmental Considerations During Design	Between groups	1	24.08	24.08	15.0	<.001
	Within groups	106	170.24	1.60		

Under the environmental construct, participants indicated a significant difference F (1, 106) = 15.0, $p < .001$with their involvement in the environmental considerations at the feasibility stage of the project. The feasibility stage of the project includes the processes of project formulation, strategy design, and approval. This is an interesting finding because many of the participants may not be involved in these processes at the feasibility stage due to their current position and where their integration into the construction process.

Project

Project characteristics are those factors associated the project delivery method, such as the management team and project teams, specifications and drawings, design, and historical project knowledge and the project team. Multivariate tests of normality showed no sign of non-normality. Skewness statistics were reasonably within the acceptable limits for an ANOVA, which was conducted to determine what differences exist between the project delivery methods on project risk. Table 22 shows the data on risk considerations at the project level.

Table 22

ANOVA Source Table for Differences Between DBB and DB on Project

Variable	Source	df	SS	MS	F	P
Collocation of Stakeholders	Between groups	1	9.48	9.48	7.97	.006
	Within groups	106	126.04	1.18		
Inspection During Planning	Between groups	1	14.08	14.08	8.99	.003
	Within groups	106	166.02	1.57		
Inspection During Feasibility	Between groups	1	6.26	4.35	4.35	<.05
	Within groups	106	152.41	1.44		

Significant factors associated with the project construct included the collocation of stakeholders, inspection during planning, and inspection during the feasibility stages of the project. A significant difference between the project delivery methods was the collocation of stakeholders $F\,(1, 106) = 7.97, p = .006$. Data also indicated a significant factor related to the participants' involvement with the formal inspection process during the planning and design of the project (including base design, cost and schedule, contract development, and planning) $F\,(1, 106) = 7.97, p = .006$. Another significant factor was the inspection process during the feasibility stage (project formulation, strategy design, and approval) between the project delivery methods $F\,(1, 106) = 4.35, p < .05$.

Technology

The technology construct investigates the differences among characteristics of the integration of tools and equipment, building technologies, and project management software for the two project delivery methods of interest. Multivariate tests of normality showed no sign of non-normality. Skewness statistics were within the acceptable limits of the study for an ANOVA, which was conducted to identify the factors associated with technology between the two project delivery methods. Table 23 shows the significant differences that exist within the technology construct.

Table 23

ANOVA Source Table for Differences Between DBB and DB on Technology

Variable	Source	df	SS	MS	F	P
Technology use on means and methods	Between groups	1	21.33	21.33	17.56	<.001
	Within groups	106	128.74	1.22		

Data collected from study participants showed there was a strong difference in their ability to use modern technology on construction means and methods to improve the overall project functionality $F(1, 106) = 17.57, p < .001$. Therefore, the null hypothesis was rejected (H_0) for this construct, due to the differences associated with technological factors with these project delivery methods.

Additional Findings

Findings on econometrics, environment, project, and technology helped expose some of the potential risk factors within the major constructs of this study. Additional data was collected to identify differences within the continuum of the project delivery method. The researcher was interested in explaining where along the project continuum differences existed between the project delivery methods. Further analysis of the data determined if differences existed on cost and schedule items associated with the two project delivery variables.

To observe where differences existed between the two delivery methods an ANOVA was conducted. Questions were grouped based on their syntax structure. For example, the questions were sorted by language, if they stated *where* or *what* differences existed. These *where* or *what* questions were purposely designed to identify the differences within the project delivery continuum. This defined the locations of risk in the project delivery method. Multivariate normality showed no sign of non-normality. Skewness statistics were within the acceptable limits for the conduct of an ANOVA. Table 24 shows the differences that exist between the two delivery methods with respect to *where* and *what* differences exist along the project continuum for the delivery methods.

Table 24

ANOVA Source Table for Where Differences Exist Between Project Delivery Methods

Variable	Source	df	SS	MS	F	P
Technology to Improve Functionality	Between groups	1	21.33	21.33	17.57	<.001
	Within groups	106	128.74	1.22		
Quality During Design	Between groups	1	13.37	13.37	10.27	.002
	Within groups	106	138.04	1.30		
Inspection During Planning	Between groups	1	14.08	14.08	8.99	.003
	Within groups	106	166.02	1.57		
Inspection During Feasibility	Between groups	1	6.26	6.26	4.35	.039
	Within groups	106	152.41	1.44		
Environmental Considerations During Design	Between groups	1	24.08	24.08	15.00	<.001
	Within groups	106	170.24	1.61		
Quality During Feasibility	Between	1	32.23	32.23	24.29	<.001
	Within	106	140.69	1.33		

The data suggest that all of the significant differences exist within the beginning stages of the project, in the feasibility, planning, design, and construction stages. There were also pronounced differences in the participants' ability to use modern means and methods to improve the overall project functionality during construction $F(1, 106) = 17.57, p < .001$. Significant differences were also observed in the consideration of quality during design F (1,

106) = 10.27, $p = .002$. Differences were observed in the participants' involvement in formal inspection processes during both of the planning and design stages $F(1, 106) = 8.99$, p .003 and the feasibility stage $F(1, 106) = 4.35$, p .039. Their involvement in environmental considerations during design and their concern with quality during the feasibility stage both showed high statistical significances, $F(1, 106) = 15.00$, $p < .001$ during the beginning phases of the project.

Another research item of interest is shown in Table 25. This is a project delivery means comparison table between each of the two project delivery methods and the significant items on where differences existed between the two project delivery methods.

Table 25

Project Delivery Means Comparison

Item	**Project Delivery Method**	**N**	**M**	**SD**	***d***
Technology to Improve Functionality	DBB	54	3.15	1.22	
	DB	54	4.04	0.97	
Total		108	3.59	1.18	.37
Quality During Design	DBB	54	3.72	1.28	
	DB	54	4.43	0.98	
Total		108	4.07	1.19	.29
Inspection During Planning	DBB	54	2.43	1.19	
	DB	54	3.15	1.31	
Total		108	2.79	1.30	.28
Inspection During Feasibility	DBB	54	2.31	1.24	
	DB	54	2.88	1.16	
Total		108	2.56	1.22	.23
Environmental Considerations During Design	DBB	54	2.37	1.26	
	DB	54	3.31	1.27	
Total		108	2.84	1.35	.34
Quality During Feasibility	DBB	54	3.15	1.43	
	DB	54	4.24	0.78	
Total		108	3.69	1.27	.42

This means comparisons table provides a descriptive analysis for each project delivery method and the means associated with the significant items on *where* or *what* significant differences exist across the two project delivery methods. Between the two project delivery methods DB had the greater mean for each condition. What this may suggest is that there was greater collaboration and communication among the participants on DB projects during the design and construction phases.

Data was also analyzed by grouping *cost* and *schedule* factors together between the two project delivery methods. An analysis of cost and schedule between the two project delivery methods is important to expose the difference between the delivery methods. A between groups ANOVA was conducted to make these comparisons. Skewness and kurtosis were within the acceptable limits for the conduct of an ANOVA. In the questionnaire, the researcher categorized each question as to whether it related to *cost* or *schedule.* Table 26 is the ANOVA summary table for the comparison of *cost* and *schedule* across each project delivery method.

Table 26

ANOVA Source Table on Cost and Schedule

Variable	Source	df	SS	MS	F	P
Cost Known	Between groups	1	7.26	7.26	6.29	.014
	Within groups	106	122.41	1.12		
Change Orders Per Delivery Method	Between groups	1	41.57	41.57	29.5	<.001
	Within groups	106	149.35	1.41		
Schedule Change During Construction	Between groups	1	9.49	9.49	5.45	.021
	Within groups	106	184.26	1.74		

The data reflects whether costs are known during design, the expectations for change orders, and the expectations of schedule change during construction. For cost known during design, there was a significant difference between DBB and DB $F(1, 106) = 6.29, p = .014$.

Expectations of change orders provided a relatively high significant difference between the two delivery methods of DBB and DB $F\ (1, 106) = 29.5, p < .001$. Comparing expectations of the schedule to change between the delivery methods also yielded a significant difference of $F\ (1, 106) = 5.45, p = .021$. Although there were significant differences within these areas, the strengths of these differences can be observed in the cost and schedule means comparison in Table 27 below.

Table 27

Cost and Schedule Means Comparison

Item	Proj. Delivery Method	N	Mean	S.D.	*d*
Costs Known During Design	DBB	54	3.02	1.02	
	DB	54	3.54	1.13	
Total		108	3.28	1.10	0.48
Change Orders Per Delivery Method	DBB	54	3.76	1.27	
	DB	54	2.52	1.09	
Total		108	3.14	1.34	0.20
Schedule Change During Construction	DBB	54	3.06	1.37	
	DB	54	2.46	1.27	
Total		108	2.76	1.35	0.45

This table shows the means associated with the significant differences between the two delivery methods. Therefore, what the researcher noted from this comparison is that the mean (M = 3.54) was greater for DB, suggesting that costs are relatively known under this delivery method during the design phase $F\ (1, 106) = 6.29, p = .014$. For DBB the mean (M = 3.76) was greater for the expectation of change orders $F\ (1, 106) = 29.5, p < .001$. Finally, the mean (M = 3.06) for expectation of schedule to change was greater in DBB $F\ (1, 106) = 5.45$, $p = .021$. The data suggests that a construction professional managing a project under the DBB method should expect the schedule to change.

Summary of Findings

The purpose of these findings was to show the differences between the two project delivery methods on risk. It is interesting to see that the findings failed to satisfy the null hypothesis (H_0) that there were no differences that existed between the two on the four construct factors of econometrics, environment, project, and technology.

There were several key significant factors observed within this study. One important factor is costs known during the design for the delivery method being studied. The cost known during design was more significant under the DB method than the DBB method with a mean of (M = 3.54) F (1, 106) = 6.29, p = .014. Another issue is the expectation of change orders had a higher mean under the DBB project delivery method (M = 3.76) than with the DB method, with a mean of (M = 2.52) F (1, 106) = 29.5, p <.001. In addition to change orders, the research showed a stronger mean of (M = 4.43) for quality during the design stage F (1, 106) = 10.27, p <.002. Quality during the feasibility stage between the two delivery methods maintained a stronger mean under the DB (M = 4.24) delivery method than the mean (M = 3.15) within the DBB method F (1, 106) = 24.29, p <.001.

Because environmental considerations are important during the design of a project, there was a stronger mean in the environmental construct with DB (M = 3.31) compared to the mean in DBB (2.72) F (1, 106) = 14.00, p <.001. With the project construct, risk factors that tended to have a stronger significance included the factor of inspection during planning, which had a greater mean (M= 2.80) in the DB project delivery method compared to the mean in DBB (M = 2.31) F (1, 106) = 8.99, p =.003. More importantly with the project construct, there was also a strong significance with the collocation of stake holders where the mean for DB (M = 4.09) compared to DBB's mean (M = 3.50) F (1, 106) = 7.97, p <.006. Finally, under the technology construct, the significance of a participant's ability in selecting the most modern construction means and methods to improve the overall project functionality was greater with the DB (M = 4.04) than DBB (M = 3.15) $F(1, 106) = 17.57, p < .001$.

In summary, the additional findings provided interesting results with respect to *where* construction professionals can expect risk. The additional findings also provided information on which project delivery method construction professionals could expect change orders and varying schedules. An unexpected finding was that costs are better understood under the DB method. This finding is particularly interesting because it competes with the conventional theory of the DB project delivery method, because most design within the DB is relatively incomplete.

CHAPTER 5: DISCUSSION

Introduction

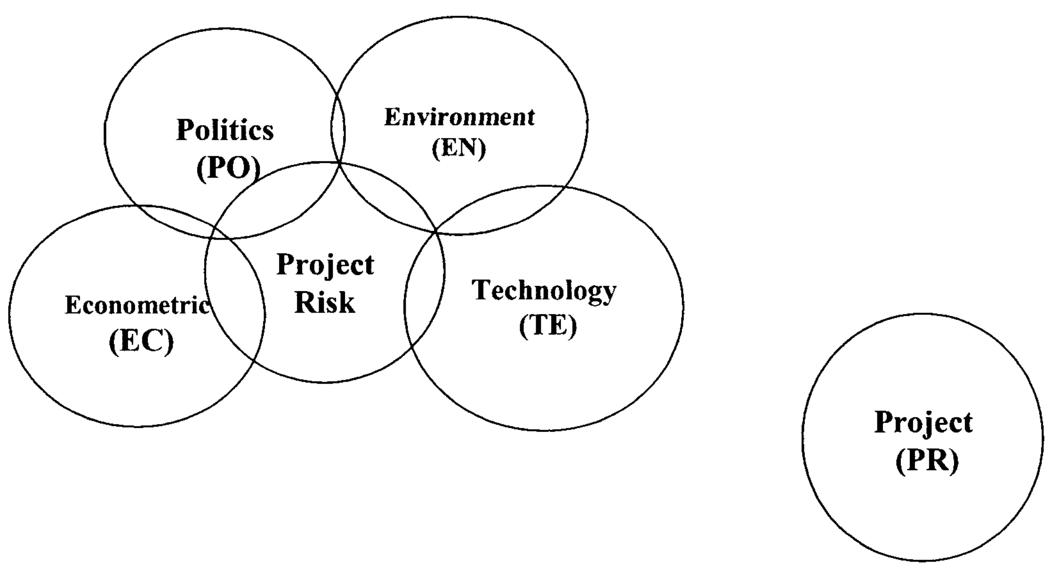
What this inquiry provided was an in-depth investigation into construction project delivery from an industry perspective. In the historical context of construction project delivery we have built many different management systems to handle the complex nature of construction. The works of Hammurabi, Vitruvius and Alberti remind constructors that at one time, builders risked losing their life if their projects failed and caused harm to others. In addition to the concept of life, death, and the concept of risk, the works of scholars such as Guy Bois, Pierre Bonnassie, Georges Duby, Robert Frossier, and Jean-Pierre have documented the notion that issues of population, economy, environment, politics, religion, and technology have created complexity in the construction project delivery process.

Recently, researchers have studied the construction process in further depth. They have shown that fragmentation has increased as time has passed and projects have become more complicated. This fragmentation is created when roles and responsibilities are broken up into individual components, where communication is needed to complete the task of delivering a project on time and under budget. Through the progression of time, what constructors initially evolved toward was more of a DB project delivery method where the master builder assumed the risk on the project. As constructors became more educated in the concepts of construction, constructors decided to divide the construction process into design and construction functions. This division of labor has created what we know today as the DBB delivery method.

As we examine the delivery methods of DBB and DB, we are reminded by Davies (2004) that for complex environments to succeed, there must be studies that can identify the conditions that make projects successful or unsuccessful. One way to do this is to develop a model which explains the complex environments construction managers face when making daily decisions with input from a population of constructors. In this study, a preliminary model was developed to identify the various components that exist in construction project delivery. This study used that preliminary model within a two-phase research design to further refine the model to reflect conditions that exist within the construction industry for the two project delivery methods.

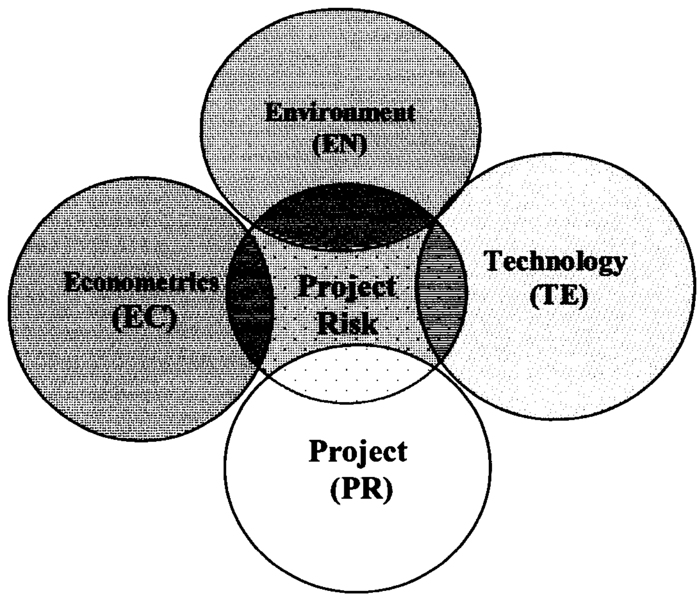
The first phase of the study took the preliminary model shown in Figure 1 and examined perceptions of industry professionals on the factors of econometrics, environment, politics, project, and technology within the concepts of the DBB and DB project delivery methods. The adjusted study conceptual model shown in Figure 10 represents the constructs most susceptible to risk elements based on the data collected for this study.

Figure 10. *Adjusted Conceptual Model of Project Delivery*



This model was the base for the development of this research on evidence-based project delivery. Using this conceptual model, it was determined through the factor analysis process that the construct of "Politics" was weak compared to the other constructs on risk. Therefore, it was removed from the model. The factor analysis conducted during the first phase of this study adjusted the conceptual model of project delivery shown in Figure 10. This does not mean to say that the construct of politics is not a part of risk, but under the context of the questions asked within this study, the politics construct would not add significant value to the findings. Figure 11 shows the new study conceptual model which was used to develop the notion of risk during the final phase of this study.

Figure 11. New *Study Conceptual Model*



The new evidence-based risk model for the project delivery elements of design-bid-build and design-build show the constructs that are more susceptible to the overall concept of risk. This model was used to develop and categorize evidence-based risk analysis by using the ANOVA statistical method to compare the two groups of delivery methods, DBB and DB.

Discussion of Findings

The results of this research indicated that differences were observed between the two delivery methods of DBB and DB. Because of these differences, the null hypothesis (H_0) was rejected for the overall research question, especially with the constructs of project and technology. For each of the four construct sub-questions, the null hypothesis (H_0) was also rejected because differences were found among the constructs of econometrics, environment, project, and technology between the project delivery methods.

Econometrics

Econometrics is the examination of the project cost, schedule, financing, quality, and safety based on the current economy. Through the inquiry into this construct, the researcher was interested in the differences that could exist between the two delivery methods. What the results of the test on econometrics show is that the null hypothesis (H_0) was rejected, thus indicating that there are differences that existed between project delivery methods in econometrics. It was not particularly surprising that differences that exist, since they support the conventional project delivery theory, with costs not entirely known during design, expectations of change orders, consideration for quality during design, and schedule change during construction.

A finding that is important is that design-builders tend to better understand their costs within the design phase. This was supported by the data where design-builders stated that they more often know the costs during the design of the project. Under conventional theory, this should be true because the design-builder and constructor work together to develop the design. Costs become known as the design is developed. For design-bid-builders, costs should be known after design is complete when a project is estimated and procured.

The expectation of change orders was also greater in the DBB method. Again, this finding was not a surprise because on any project, there are some conditions that change. Therefore, what this statistic provides is the design-bid-builder's expectation of change that occurs on the projects. This finding does suggest that under the DBB method, an owner and constructor could expect change orders.

The finding about quality during the feasibility and design phase supports the view that quality is a consideration during the design of the project under the DB method. A finding such as this differs from DBB because much of the quality component is the contractor's responsibility as work is put in place. This result, again, is not surprising. When designers collaborate with construction personnel from the beginning of a project, a better project should result, with both time and cost savings. Finally, under econometrics, the finding show there are higher risks associated with schedule change during the construction process with DBB. The data supports the suggestion that schedules do increase due to change orders that arise on DBB projects. Therefore, a constructor or an owner can expect higher risks of delays under the DBB project delivery method due to change orders. These findings show that a better balance between quality and efficiency is needed, one that does not sacrifice the former pursuit of the latter.

What this research suggests within the econometrics component of the study is that considerations of cost, changes, quality, and schedule are significant risk considerations. For an owner selecting the DB process, there is a good potential that costs can be better identified and understood during the design. Also, what the findings suggest for owners and construction managers is, there is less risk with the DB process for the potential of change orders which would adversely affect the schedule during construction. Again, many of these findings are not surprising, but they do support how factors associated with the econometrics of a project entail well-defined risks related to cost, changes, quality, and schedule defined by professionals within the industry.

Environment

The environmental factor grouped together concepts of natural environment, site location, geological conditions, site regulations, geographic documentation, and water conditions. The results of the test on the environment construct show that the null hypothesis

(H_0) was rejected; a difference exists between project delivery methods in the area of environment. This was the increased involvement of the constructor in environmental considerations at the design stage of the project. The data did show most involvement by the contractor during the design stage was observed within the DB project delivery method. Again, this was not a surprise, as both engineers/architects and constructors would have a greater opportunity for input using this method. As for risks within this construct, it seems that it is important for the owner, engineer, architect, and constructor to be involved with the environmental considerations at the beginning of the project. Although cost considerations regarding the environment and the mechanical systems were not a significant factor, cost concerns associated with the environmental and mechanical components were relatively significant with the design-build group of participants.

Project

The characteristics that make up the construct of project included project delivery, the management and project teams, specifications and drawings, design, and historical project knowledge, and the project team. Significant factors associated with the project construct included collocation of stakeholders on the project, inspection during the planning stage, and inspection during the feasibility stage. Participants associated with the DB projects saw collocation with the major stakeholders on their projects as a benefit. Collocation may not be a risk category, but it does illustrate the importance of maintaining a stakeholder presence on the site with design-build projects. This does not mean to say that collocation is not important in DBB projects, but the research supports the idea that collocation of all design, engineering, and construction professionals is important for the communication efforts associated with the project and works better with DB than with DBB.

Construction professionals' involvement in the inspection process during the planning and feasibility stage of the project was also significant. Design-builders were more involved with the inspection process during the planning and feasibility stages of the project. The data supports the idea that it would be easier for the construction professionals to be involved during the DB planning and feasibility stages since construction would take place within the same timeframe as design.

Technology

Characteristics associated with the construct of technology investigated the integration of tools and equipment, building technology, and project management software. The most significant factor associated with technology was the participant's ability to use the most modern construction means and methods to improve the overall project functionality. What can be inferred from this finding is the participants can use their own judgment or experience on the types of tools and equipment, building materials, and management processes to manage the project delivery process. Participants feel they can contribute more within the DB process rather than the DBB process. This finding also suggests that constructors are more able to provide their input into the building process, but more willing to use more technologically advanced means and methods.

Additional Findings

Additional information was collected in this study to help describe some of the potential risk factors within the major constructs of the study. More specifically, the additional findings investigated where and what differences existed along the project continuum and the cost and schedule differences between the two project delivery methods.

What these additional findings suggest is that they support the literature by confirming that one of the main benefits of the DB project delivery method is a sense of increased quality. It is not a surprising that participants felt they had more opportunity to use modern construction means and methods to improve the overall functionality of the project when using the DB project delivery method. Another conclusion that can be drawn from the additional findings is there was a significant relationship to the participants' concern with quality during the project formulation stages. Findings on the cost and schedule data did not reveal new information. Contrary to what the literature supports, the data supported the idea that construction professionals could be relatively assured that costs would be known during the DB project delivery method. These findings also provided strong confirmation that there is a greater potential for change orders associated with the DBB process. Also, related to change orders, participants in this study confirmed that schedule growth can be more commonly observed on DBB projects.

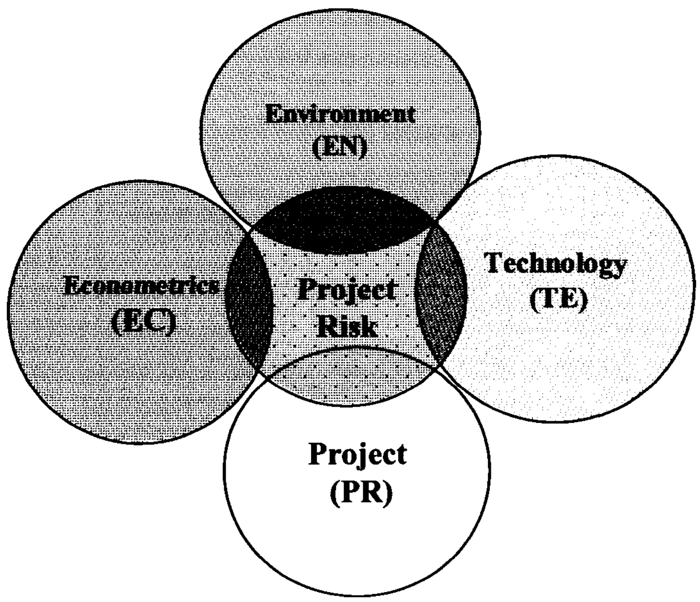
Summary of Findings

One might ask what this research means for project delivery? What these study findings provide is confirmation and more definition of existing information related to the two project delivery methods studied. What the findings from this study helped to confirm, is information related to the areas that were often thought of as contributing to project risk. This study confirmed that indeed the constructs within the project risk model discussed emerge as risk indicators according to professionals in the field. The knowledge contribution from this work demonstrates to constructors that an evidence-based decision system can be created to map risk in project delivery. These findings provide further insight into project delivery from an applied-research focus using many highly skilled participants from different sectors of the construction industry. Regardless of what sector of the industry we analyze, it appears that the same factors tend to emerge as significant factors across the project delivery continuum.

This was supported by the project's findings that typical risk components related to cost, time, and quality do exist. These findings support the idea that there are cost, time, and quality components in each of the constructs of econometrics, environment, project, and technology. Therefore, based on the data and the findings, this research identifies that there are significant differences that exist between the two project delivery methods. What has emerged out of these findings is that construction professionals recognize the project cost, schedule, and quality factors can be organized in the framework of econometrics, environment, project, and technology for project delivery methods.

What the evidence-based project delivery model shows in Figure 12 below is the variation on where significant risks exist in the project delivery continuum. Holistically, this model shows the complexities involved in delivery of construction projects.

Figure 12. *Evidence-Based Project Delivery Model*



When the individual components of econometrics, environment, project, and technology were researched, they all had significant factors associated with them. For econometrics it was interesting to see the participants confirm the fact that schedules could be extended due to change orders commonly found using this delivery method. What this finding helps support is that lengthen the duration of a project. It was interesting to see environmental factors were significant. The model shows the construct of environment is an important part of how constructors think about projects, regardless of the type of delivery method. The project component provided interesting findings with respect to the teamwork aspect of construction. The model mostly exposed the importance of collocation of project participants and the confirmation that communication is a major risk management component in regards to the differences between the two project delivery methods. Finally, with technology it was fruitful to see the participants' concern in using technology to adversely affect a project. This is an important aspect to the model because various influences of technology whether in the material, labor, and equipment aspects can have an effect on how risk is distributed within the rest of the model between each of the delivery methods. These influences can only be placed into the project with the various experience levels of participants associated with delivering projects.

In summary, when we take a look at the whole model shown in Figure 12, this research points to the fact that risk is mainly a function of econometric, environmental, project, and technological components that have to be managed at many different levels. What the model does not leave out is the importance of managing risk requires the abilities of many experienced professionals. In simple terms, the differences that exist between delivery methods are there because of variations in the decision points constructors' use. This research helped confirm that econometric, environmental, project, and technological factors covary within projects and delivery methods. They covary in projects and project delivery methods to help decision makers identify risk as project conditions change.

Discussion and Recommendations

Why would someone want to study the risk components associated with project delivery from an industry perspective? What this study attempted to do was to reach into the professional knowledge base to categorize and evaluate risk and develop a model to explain the differences that exist. If we look back into the history of project delivery, the differences with project delivery exist because project delivery systems were created to segment the work and streamline the construction process to meet needs of the time. The mechanisms that control this process exist in the cost, schedule, and quality factors that can be observed within each project delivery methods. I believe these differences exist because project delivery is a complex network of econometric, environment, project, and technology factors. In each of these constructs there are cost, schedule, and quality factors that could be shared within each of the constructs. It is then up to the construction manager to make sense of all the items as a function of econometrics, environment, project, and technology as they relate to the project. Many of these cost, schedule, and quality factors associated with these factors may not be fully understood at the point of delivering the project. But they should be exposed to improve communication and discussion.

Design-Bid-Build Risk Points

What should be understood is that each project delivery method has its own significant risk points. This research has identified and evaluated those risk points with respect to each project delivery method of interest. This research has shown that DBB is limited to a certain element of cost, time, and quality variability. The data supports the idea that there is a concern of cost growth through increased change orders. Then as change orders increase the cost there is also a function of time that is increased because labor, material, and equipment needs to be scheduled within a limited cost and time parameter. Therefore, differences that exist between project delivery methods support the fact that project performance is a greater concern or risk that should be considered when engaged in DBB projects.

Design-Build Risk Points

For DB the risk points tend to be different. The reader should not conclude that project performance is not a concern under the DB delivery method. Instead, related to project performance, what this study found was that the risk points for DB focused more on the quality aspect of the delivery method. The data did support the idea that there was more of a focus on quality in the DB method; this was supported through the significances that were observed with inspection processes during the feasibility and design processes. There were very few significant differences that existed with respect to cost and time when the DB delivery method was analyzed.

Recommendations for Future Research

What this research has advanced in the construction management body of knowledge is a paradigm for future research projects in project delivery and construction management. The model that contains the constructs of econometrics, environment, project, and technology could be expanded through smaller research studies that would focus on each of the individual constructs. Then, for each of the individual constructs, the risk components could be identified within the constructs with a focus on industry. An example of this would be to identify risk components that exist in econometrics searching for a deeper meaning into the components of cost, time, quality, and safety. During the preliminary stages of this research, the construct of politics was eliminated as a construct to be compared. A suggestion for future research would be to further investigate and define the politics construct.

In order to draw accurate comparisons of project delivery, the components of cost and schedule need to be further investigated. More importantly, researchers need to find a way to break the barriers within the industry to identify the factors as they relate cost and time. What is desperately needed from industry is relevant cost and schedule data. Somehow, there has to be a way to be able to access this data. It is the assumption of the researcher that we will never fully know the risk components in construction until we can really investigate the cost and time factors. The people who hold these data and those that would like to research it need to find a way for it to be studied without exposing financial or trade secrets. A qualitative study of this information is necessary and could be achieved without exposing the interests of the construction companies, owners, or designers.

The difficulty with doing this type of research is that the data would be different for each construction industry, company, and individual who maintains the data. An additional factor, associated with any construction research, and which could significantly hinder advances in our understanding, is that the construction industry is a bit stubborn and does not like to share for many of the reasons stated above. Therefore, careful explanation in the use and distribution of the data is certainly needed.

To further the area of evidence-based project delivery, construction researchers could apply the information contained in this study to observation within the field. Much of the research that is studied in construction management is theoretically based and has no real live application within the field. Therefore, researchers in construction management need to find ways to apply their work to actual working conditions. This would provide an opportunity for educators to work closely in the construction management environment. Construction management educators need to make an effort to inform their industry counterparts on the importance of applied research in construction.

Empirical research within the construction management industry is in its infancy. We must not, as construction researchers, become discouraged by the seeming lack of interest in those practicing in the field to participate and contribute to research activities. This indifference to research is not because of their lack of interest, but more of a cultural or educational problem in the industry. We as construction management professionals must constantly educate our owners, engineers, architects, and constructors to the value of construction management education and research to advance the field. Trial and error or experimental methods with materials, management practices, technology, is a costly method in which to improve a field. We must turn and develop a culture of construction management research that is currently in its infancy. When the importance of research is enhanced and explored it will gently provide a shift in the recognition by practicing professionals that research is an important element in changing the construction management culture. This change in culture would then open doors for future researchers in construction to expand upon old research ideas and explore new problems being developed in the profession of construction management.

Discussion and Conclusion

What this research set out to investigate were differences that existed between the two project delivery methods of DBB and DB. Differences were observed between the two project delivery methods within the constructs of econometrics, environment, project, and technology. The differences observed were related to cost, quality, and time. These differences seem to be fairly synonymous with what has been previously researched by the Construction Industry Institute (CII) and others. Many of the same factors related to the differences in project delivery performance on cost, time, and quality were observed. I believe what industry participants are suggesting in this study is factors of cost and time seemed to be more prevalent in the DBB method and the factor of quality seemed to be greater in the DB method. What is different about this research was the method of data extraction.

Although there were many similarities observed with this research to previous studies, it is important to understand that data for this research relied on industry experts who have worked in the construction industry for many years. These individuals have rich experience that needs to be captured and documented in further studies to advance the construction profession. Documentation of this research is the key component to expanding objective knowledge and eliminating tribal knowledge education in construction management education and construction project administration.

Advancing research in construction management is very important. Original research related to construction management helps inform and provide insight to professionals in education and industry who are searching for knowledge to become better managers in all areas of construction. Identifying areas of potential risk are assistive in reducing time and cost while providing a safer and better quality project. Performing and adding to the construction management body of knowledge will only create additional opportunities for future research to be conducted and main stream the value of research in construction management.

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APPENDIXES A-H

APPENDIX A and APPENDIX B

Pilot Test
Design-Bid-Build (Form A) and Design-Build (Form B)
0636, 3767, and 6898

Note: The same test was used for both Form A Design-Bid-Build and Form B Design-Build.

Dear Colleague,

Thank you for agreeing to participate in this pilot test. You may wish to allow approximately 30 minutes to complete the survey. Your responses to this survey will be used to reduce the total number of questions so that the actual survey will take only 15 to 20 minutes.

Most important, I would like to thank you in advance for taking the time to provide your expertise related to project delivery methods. Because of your experience you have been selected from 500 of your peers to provide your knowledge and feedback. Your knowledge is very important for the understanding of risk associated with project delivery methods. Information you provide will benefit the construction industry with ideas that can assist owners, architects, engineers, and constructors in making decisions related to risk and project delivery.

The purpose of this pilot test process is to assist us in identifying the best questions that can be used to develop a risk model for project delivery methods. The survey you are about to complete will have 36 questions. Although there are many questions, it is important that you answer each question to the best of your knowledge considering the design-bid-build project delivery method.

Please select the answer that best answers the question for the *(design-bid-build/design-build)* project delivery method.

I value your time and knowledge; your participation in this pilot test process is appreciated in the development of this research. If you have additional questions regarding this pilot test feel free to contact me at 970-481-8948 (wplugg@msn.com) or my advisor Dr. Michael A. De Miranda at 970-491-5805 (mdemira@CAHS.Colostate.edu).

Thanks again for your time,

P. Warren Plugge, M.S.

Directions: To select your response, simply click the box beside the best answer that matches/reflects your experience in design-bid-build project delivery method. Please disregard the Code Column, it simply assists us in tracking question types.

Demographics

1. Which of the following best describes your current position?

- ☐ Field Engineer
- ☐ Field Superintendent
- ☐ Assistant Project Manager
- ☐ Project Manager
- ☐ Area or Division Manager
- ☐ Vice President
- ☐ Sales
- ☐ CEO
- ☐ Other, please state (type in box)

2. How many years have you worked in the construction industry?

- ☐ 0-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21-25
- ☐ 26-35
- ☐ 36 or more

3. Under the design-bid-build project delivery method, the average duration of the projects you have worked on has been?

- ☐ Less than 1 year
- ☐ 1 Yr
- ☐ 2 Yrs
- ☐ 3 Yrs
- ☐ 4 Yrs
- ☐ 5 Yrs
- ☐ 6 Years
- ☐ Other, please explain, (type in box)

4. Which of the following best describes the area of construction you work in the most?

- ☐ Civil
- ☐ Commercial (Buildings)
- ☐ Industrial
- ☐ Architect/Engineer
- ☐ Residential/Developer
- ☐ Subcontractor
- ☐ Vendor/Supplier
- ☐ Other (Type in box):

5. To the best of your ability, please estimate the number of projects you have worked on under the design-bid-build delivery method?

☐ 1-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41- 50 Other (please specify)

Pilot Test 0636

When responding to the following questions, please frame your response in light of your experience using the design-bid-build project delivery method.

Number	Code	Question
6.	W	Cost was often a concern when using the design-bid-build delivery method? ☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
7.	D	Cost was known during design on design-bid-build projects? ☐ Never ☐ Somewhat ☐ Usually ☐ Often ☐ Always
8.	W	Schedule was known during design on design-bid-build projects? ☐ Never ☐ Somewhat ☐ Usually ☐ Often ☐ Always
9.	D	Schedule was often a concern when using the design-bid-build project delivery method? ☐ Never ☐ Somewhat Often ☐ Usually ☐ Often ☐ Always
10.	W	Considering the design-bid-build delivery method, changes associated with the physical elements of the project more often occur during design. ☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
11.	W	Considering the design-bid-build delivery method, changes associated with the physical elements of the project more often occur during construction. ☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
12.	W	Considering design-bid-build project delivery method, schedule was often a concern at the beginning of the project (s)? ☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
13.	D	Quality often changed from the beginning to the end of construction on my design-bid-build project (s)? ☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
14.	D	Cost on design-bid-build project (s) was expected to change at the beginning of the project (s). ☐ Never Expected ☐ Somewhat expected ☐ Expected ☐ Usually expected ☐ Always expected
15.	D	Did you expect cost to change on your design-bid-build project (s) during design? ☐ Not Expected ☐ Some change ☐ Remains the same ☐ Often ☐ Always
16.	D	Did you expect the schedule on your design-bid-build project (s) to change during construction? ☐ Not Expected ☐ Some change ☐ Remains the same ☐ Often ☐ Always
17.	D	Did you know the durations of activities at the beginning of your design-bid-build project (s)? ☐ Not known ☐ Somewhat known ☐ Known ☐ Often known ☐ Always known
18.	D	Considering the design-bid-build project delivery method, you were informed of changes to the cost on the project. ☐ Never informed ☐Somewhat informed ☐ Informed ☐Usually informed ☐ Always informed

19.	D	Considering the design-bid-build project delivery method, you were informed of changes to the schedule on the project. ☐ Never informed ☐Somewhat informed ☐ Informed ☐Usually informed ☐ Always Informed
20.	W	Considering the design-bid-build project delivery method, you take into account quality during the design phase of the project. ☐Not considered ☐Somewhat considered ☐Considered ☐Usually considered ☐Always considered
21.	W	During the beginning phases of the project (estimating, preconstruction), I can determine physical costs on design-bid-build project (s) through historical cost data? ☐Unknown ☐Somewhat known ☐Known ☐Usually known ☐Always Known
22.	D	I could estimate costs associated with general conditions from historical cost data or my experience on design-bid-build project (s). ☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
23.	D	Costs associated with the structural components of the project (s) (includes sitework, concrete, masonry, metals, woods and plastics, and thermal and moisture protection) were known from historical cost information or my experience. ☐Unknown ☐Somewhat known ☐Known ☐Usually known ☐Always Known
24.	W	I could determine costs associated with mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical, and electrical) installed on my design-bid-build project (s) from historical cost information or from my experience. ☐Unknown ☐Somewhat known ☐Known ☐Usually known ☐Always known
25.	W	I could determine the durations associated with general conditions from historical schedule data or from my experience on my design-bid-build project (s). ☐ Never ☐ Sometimes ☐ Usually ☐ Often ☐ Always
26.	W	I could determine the durations associated with architectural components (includes doors and windows, finishes, specialties, furnishings) from historical cost information or from my experience on my design-bid-build project (s). ☐ Never ☐ Sometimes ☐ Usually ☐ Often ☐ Always
27.	W	I could determine durations associated with mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical, and electrical) installed on my project from historical cost information or from my experience. ☐Unknown ☐Somewhat known ☐Known ☐Usually Known ☐Always Known
28.	W	I take into account quality during the feasibility stage on design-bid-build project (s) (project formulation, feasibility studies, strategy design and approval). ☐Never ☐Somewhat ☐ Depends ☐Usually ☐Always
29.	W	I take into account quality during the planning and design stage on design-bid-build my project (s) (base design, cost and schedule, contract development, and planning). ☐Never ☐Somewhat ☐ Depends ☐Usually ☐Always

30.	W	I take into account quality during the production stage on design-bid-build my project (s) (construction, delivery, installation, testing). ☐Never ☐Somewhat ☐ Depends ☐Usually ☐Always
31.	D	Using the design-bid-build delivery method I expect to have change orders on a project? ☐ Never Expected ☐ Somewhat expected ☐ Expected ☐ Usually expected ☐ Always expected
32.	D	Considering the design-bid-build delivery method, to what degree are you involved with the environmental agencies (Ex. Environmental Protection Agency (EPA), City, State, or Local Agencies)? ☐Not involved ☐Somewhat involved ☐Involved ☐Usually involved ☐ Always involved
33.	D	To what degree are the physical site characteristics known prior to the start of your projects (Ex. Land topography, geology). ☐Unknown ☐Somewhat known ☐Known ☐Usually Known ☐Always known
34.	W	I often spend ______ time trying to understand the environmental requirements at the planning and design stage of the project. ☐ No ☐Some ☐ Enough ☐More than usual ☐ Too much
35.	W	I typically find environmental regulations provided within the specifications and drawings clear and understandable. ☐Never ☐Somewhat ☐ Neutral ☐Usually ☐Always
36.	W	I was involved with environmental considerations at the feasibility stage (project formulation, strategy design, and approval) of the project? ☐ Never ☐Somewhat ☐Neutral ☐Usually ☐Always

Pilot Test 3767

Number	Code	Question
37.	W	I was involved in environmental activities during the planning and design stage of my design-bid-build project (s) (base design, cost and schedule, contract development, and planning). ☐Never ☐Somewhat ☐ Neutral ☐Usually ☐Always
38.	W	I was involved in the environmental activities during the production stage on design-bid-build project (s) (construction, delivery, installation, testing). ☐Never ☐Somewhat ☐ Neutral ☐Usually ☐Always
39.	W	I was involved in environmental activities during the close out or turnover and startup stage of design-bid-build project (s) (punch list, final testing, maintenance, lifecycle development). ☐Never ☐Somewhat ☐ Neutral ☐Usually ☐Always
40.	D	I consider environmental activities associated with the structural components (includes sitework, concrete, masonry, metals, woods and plastics, and thermal and moisture protection) of design-bid-build project (s) a cost issue? ☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
41.	D	I consider environmental activities associated with the architectural components (includes doors, windows, finishes, specialties, furnishings) of design-bid-build project (s) a cost issue? ☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
42.	D	I consider environmental activities associated with the mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical and electrical) of design-bid-build project (s) a cost issue? ☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
43.	D	I consider environmental activities associated with the structural components (includes sitework, concrete, masonry, metals, woods and plastics, and thermal and moisture protection) of design-bid-build project (s) a schedule issue? ☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
44.	D	I consider environmental activities associated with the architectural components (includes doors, windows, finishes, specialties, furnishings) of design-bid-build project (s) a schedule issue? ☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
45.	D	I consider environmental activities associated with the mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical and electrical) of design-bid-build project (s) a schedule issue? ☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
46.	W	From my experience, environmental innovations are considered more at the ______ stage of the project delivery process? ☐Project Formulation ☐Design ☐ Estimating ☐ Construction ☐Closeout

47.	D	How much experience do you have with green building techniques? ☐ No experience ☐ Some experience☐ Experienced ☐Very experienced ☐ Highly experienced
48.	D	On design-bid-build project (s), I was involved in partnering or team building to help communicate the goals and objectives of the project from the various stakeholders involved with the project? ☐Never helps ☐Somewhat helps ☐Helps ☐Usually helps ☐Always helps
49.	D	I was involved in some form of team building on design-bid-build projects. ☐Never involved ☐Somewhat involved ☐Involved ☐Usually involved ☐ Always involved
50.	D	The project architect was involved in meetings on my design-bid-build project (s). ☐Never involved ☐Somewhat involved ☐Depends ☐More involved ☐ Always involved
51.	D	The owner on the project was involved in meetings on my design-bid-build projects. ☐Never Involved ☐Somewhat Involved ☐Involved ☐Usually Involved ☐ Always involved
52.	D	I was involved with the daily design activities related on my design-bid-build projects? ☐Never involved ☐Somewhat involved ☐Involved ☐Usually involved ☐ Always involved
53.	D	I was involved with the daily construction activities on my design-bid-build project (s)? ☐Never involved ☐Somewhat involved ☐Involved ☐Usually Involved ☐ Always involved
54.	D	On my design-bid-build project (s), specifications were prescriptive (provide well defined instructions on products or processes, with very few options for innovation)? ☐Never ☐Somewhat ☐Neutral ☐Mostly ☐Always
55.	D	On my design-bid-build project (s), project specifications were performance based (more open to innovation in materials and methods to be used on the project)? ☐Never ☐Somewhat ☐Neutral ☐Mostly ☐ Always
56.	D	On my design-bid-build project (s), political and community support was involved. ☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐ Always involved
57.	W	On my design-bid-build project (s), partnering or team building took place at the feasibility stage (project formulation, strategy design, and approval) of the project. ☐Never ☐Sometimes ☐Often ☐Most Often ☐All the Time
58.	W	I have been involved with partnering or team building at the planning and design stage of design-bid-build project (s) (base design, cost and schedule, contract development, and planning). ☐Never ☐Sometimes ☐Often ☐Most often ☐All the time
59.	W	I have been involved in partnering or team building during the production stage on design-bid-build project (s) (construction, delivery, installation, testing).

		□Never □Sometimes □Often □Most often □All the time
60.	W	I have been involved in partnering or team building during the close out or turnover and startup stage on design-bid-build project (s) (punch list, final testing, maintenance, lifecycle development). □Never □Sometimes □Often □Most Often □All the Time
61.	D	On design-bid-build project (s), I was involved in a comprehensive risk management development plan? □Never involved □Somewhat involved □Involved □Most involved □ Always involved.
62.	W	Under the design-bid-build project delivery method, historical project knowledge and experience was used to develop the estimate for the project? □Never used □Somewhat used □Used □Mostly used □Always used
63.	W	At the project level I was involved in providing my expertise during the design of the project on design-bid-build project (s). □Never involved □Somewhat involved □Involved□ Mostly involved □ Always involved
64.	W	At the project level, I was involved providing my expertise during the construction of my design-bid-build project (s)? □Never involved □Somewhat involved □Involved□ Mostly involved □ Always involved
65.	D	Collocation of all of the major stakeholders on design-bid-build project (s) was beneficial? □ Never beneficial □ Somewhat beneficial □ Beneficial □ Mostly beneficial □ Always beneficial
66.	W	I attended collaborative design meetings with design-bid-build project (s). □ Never □ Sometimes □ Can be □ Usually □ Always
67.	W	I dealt with constructability issues through on-site meetings on design-bid-build projects. □ Never □ Sometimes □ Can be □ Usually □ Always

Number	Code	Question
68.	W	I was involved in formal inspection processes during the feasibility stage (project formulation, strategy design, and approval) of the project? ☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐ Always involved
69.	W	I was involved in formal inspection processes during the planning and design stage of design-bid-build project (s) (base design, cost and schedule, contract development, and planning). ☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐ Always involved
70.	W	I was involved in formal inspection processes during the production stage on design-bid-build project (s) (construction, delivery, installation, testing). ☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐ Always involved
71.	W	I was involved in formal inspection processes during the close out or turnover and startup stage of design-bid-build project (s) (punch list, final testing, maintenance, lifecycle development). ☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐ Always involved
72.	W	I have offered construction knowledge at feasibility stage on design-bid-build project (s) (project formulation, strategy design, and approval)? ☐Never offered ☐Somewhat offered ☐Neutral ☐Most of the time ☐Always offered
73.	D	Production activities were based on my experience for scheduling the project on design-bid-build project (s)? ☐Unknown ☐Somewhat known ☐Known ☐Mostly known ☐Always known
74.	D	On my design-bid-build project (s), information was provided in a directive format. ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
75.	D	On my design-bid-build project (s), information was provided in a format which encourages judgment and evaluation? ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
76.	D	The organizational structure of my design-bid-build project (s) affected the decisions that needed to be made on the project. ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
77.	D	Considering the design-bid-build delivery method, information was presented in a simple and clear way, without distortion or bias. ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
78.	W	On my design-bid-build project (s) innovative scope changes occurred during the feasibility stage (project formulation, strategy design, and approval) of the project. ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
79.	W	On my design-bid-build project (s), scope changes occurred during the planning and design stage (base design, cost and schedule, contract

		development, and planning). ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
80.	W	On my design-bid-build project (s), scope changes occur during the production stage (construction, delivery, installation, testing). ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
81.	W	On my design-bid-build project (s), scope changes have occurred during the close out or turnover and startup stage of a project (punch list, final testing, maintenance, lifecycle development). ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
82.	W	On my design-bid-build, critical information about finishes was known at the beginning of the project? ☐Unknown ☐Somewhat known ☐Known ☐Mostly known ☐Always known
83.	D	On design-bid-build my project (s), critical information about the electrical and mechanical components was known at the beginning? ☐Unknown ☐Somewhat known ☐Known ☐Mostly known ☐Always known
84.	D	On design-bid-build my project (s), critical information about structural components of the project were known at the beginning of the project? ☐Unknown ☐Somewhat known ☐Known ☐Mostly known ☐Always known
85.	D	Technology has increased cost on my design-bid-build project (s)? ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most Often
86.	D	Technology has increased schedule durations on my design-bid-build project (s). ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most Often
87.	D	Technology has increased quality on my design-bid-build project (s)? ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most Often
88.	D	Technology has assisted me when making decisions about the schedule on design-bid-build project (s). ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
89.	D	Technology has assisted me in making decisions about the cost on design-bid-build project (s). ☐Never ☐Sometimes ☐Usually ☐Most of the time ☐Always
90.	W	On design-bid-build project (s), I was free to use technology (use of value engineering etc) to improve project functionality while constructing the project. ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often
91.	D	On design-bid-build project (s), I have used management tools (computers, software, etc.) for project documentation (includes financial, schedule, safety, quality documentation). ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most Often
92.	D	On design-bid-build project (s), technology increased the productivity of the construction management team. ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often
93.	D	On design-bid-build project (s), technology increased the productivity of the workers (subcontractors, laborers, etc.) installing the physical components of the project? ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often

94.	D	More technologically developed products or materials have affected the schedule on my design-bid-build projects. ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often
95.	W	Technology has increased communication on my design-bid-build project (s). ☐ Never ☐ Sometimes ☐ Often ☐ Somewhat often ☐ Most often
96.	W	It was beneficial to use an outside consultant to manage green building techniques and technologies on design-bid-build project (s). ☐ Not Beneficial ☐ Potentially Beneficial ☐ Beneficial ☐ Somewhat Beneficial ☐ Most beneficial
97.	D	Technology has increased the labor demand on design-bid-build projects? ☐ Never ☐ Somewhat increases ☐ Remains the same ☐ Increases ☐ Always increases
98.	D	The most technologically advanced materials available have affected my project costs and time on design-bid-build project (s). ☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often

APPENDIX C
PRE-SURVEY FORM

1. Under what discipline has most of your experience in construction management been in?

   Architecture □
   Engineering □
   Construction □
   Education □
   Other ________________________________

2. How many years have you worked under this discipline?

   Number of years: ______yrs

3. Do you have experience working within the design-bid-build project delivery method?

   Yes □
   No □

4. How many years have you worked under the design-bid-build project delivery method?

   Number of years: ______yrs

5. Do you have experience working within the design-build project delivery method?

   Yes □
   No □

6. How many years have you worked under the design-build project delivery method?

   Number of years: ______yrs

APPENDIX D
Consent Form

Consent to Participate in a Research Study
Colorado State University

TITLE OF STUDY: *A Comparative Analysis of Two Project Delivery Methods: Design-Bid Build and Design-Build*

PRINCIPAL INVESTIGATOR:

Dr. Michael DeMiranda
School of Education Box 1588
Colorado State University
Fort Collins, CO 80523
970-491-5805
mdimira@cahs.colostate.edu

CO-PRINCIPAL INVESTIGATOR:

Philip Warren Plugge
1645 Robertson Unit D.
Fort Collins, CO 80525
970-481-8948
wplugge@lamar.colostate.edu

WHY AM I BEING INVITED TO TAKE PART IN THIS RESEARCH?
You are being invited to take part in this research because your firm constructs projects under the design-bid-build and design-build project delivery methods.

WHO IS DOING THE STUDY?
Colorado State University's School of Education and the Construction Management Department.

WHAT IS THE PURPOSE OF THIS STUDY?
Purpose of this study is to develop an understanding of the risks associated with the design-bid-build and design-build project delivery methods through an evidence based model.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?
Data collection will take place at within actual construction companies and at the Society of American Military Engineers (SAME) Educational conference in New Orleans, Louisiana. Each participant should take only 20 minutes to complete the survey instrument.

WHAT WILL I BE ASKED TO DO?
The information you will be asked is about your experience in the areas of economics, environment, politics, project, and technology on design-bid-build or design-build projects.

ARE THERE REASONS WHY I SHOULD NOT TAKE PART IN THIS STUDY?
There are no known reasons why you should not take part in this study.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?
There are no known risks or discomforts in the information you will provide to the researcher.

- It is not possible to identify all potential risks in research procedures, but the researcher(s) have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

WILL I BENEFIT FROM TAKING PART IN THIS STUDY?
The benefits from taking part in this study will be extending the body of knowledge in construction of risk in the areas of economics, environment, politics, project, and technology with respect to the project delivery methods of design-bid-build and design-build.

DO I HAVE TO TAKE PART IN THE STUDY?

Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

WHAT WILL IT COST ME TO PARTICIPATE?
There are no known costs to you for your participation in this study.

WHO WILL SEE THE INFORMATION THAT I GIVE?
I will keep private all research records that identify you, to the extent allowed by law. Your information will be combined with information from other people taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be identified in these written materials. We may publish the results of this study; however, we will keep your name and other identifying information private.

I will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. For example, project names and any other identifiers will be kept separate from your research records and these two things will be stored in different places under lock and key. You should know, however, that there are some circumstances in which we may have to show your information to other people.

WILL I RECEIVE ANY COMPENSATION FOR TAKING PART IN THIS STUDY?
No.

WHAT HAPPENS IF I AM INJURED BECAUSE OF THE RESEARCH?
The Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

Page_2_ of_3_ Participant's initials _______ Date _______

WHAT IF I HAVE QUESTIONS?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, P. Warren Plugge at 970-481-8948. If you have any questions about your rights as a volunteer in this research, contact Janell Meldrem, Human Research Administrator at 970-491-1655. We will give you a copy of this consent form to take with you.

Your signature acknowledges that you have read the information stated and willingly sign this consent form. Your signature also acknowledges that you have received, on the date signed, a copy of this document containing _3_ pages.

____

Signature of person agreeing to take part in the study. Date

____

Printed name of person agreeing to take part in the study.

____

Name of person providing information to participant . Date

____

Signature of Research Staff

APPENDIX E
Phone Script

Participant
Data Collection Recruitment Phone Script

- Hello my name is Warren Plugge, I am a Ph.D. candidate with the Construction Management department at Colorado State University.

- The purpose of my phone call today is to identify key people within your organization who would be able to provide economic, environment, political, project, and technology information about design-bid-build and design-build projects. Who might I be able to speak to with regards to this type of information?

- I am conducting research to determine the risks associated with design-bid-build and design-build projects.

- [Phone conversation will transition to actual contact or leave a message with the phone administrator or voice mailbox to call the researcher back at a later time and date.]

- [Conversation with key contact]. Hello my name is Warren Plugge with the Construction Management department at Colorado State University. I am conducting research to develop a model on design-bid-build and design-build risk.

- More specifically you would provide this information by completing a Microsoft Word survey instrument form distributed by email. This survey would only take 10-15 minutes to complete What is your email?

- If you could complete the survey within the two weeks I would greatly appreciate it.

- I thank you for your time and should you need any further information you may contact me at 970-481-8948 or my advisor Dr. Michael DeMiranda at 970-491-5805.

APPENDIX F
Email Recruitment Letter

To Whom It May Concern:

Thank you for taking the time to discuss my research with me today/yesterday. As we spoke earlier, attached is the survey instrument on DB or DBB I would like you to complete.

To complete the survey, simply download the survey as a file to your C: drive, open the file, select the answer that best fits the question (click on the grey box and an "x" should appear), save the file, and send it back to my email address at wplugg@msn.com. This process should take less than 15 minutes to complete.

Information you provide will be used to compare differences between the two project delivery methods of design-bid-build and design-build for the development of a project delivery model.

If you know of anyone else within your organization that would be willing to complete the survey feel free to forward the survey to them. Your experience and knowledge is very important to the development of this research on project delivery. Any information you provide during this survey process will be kept confidential.

I sincerely appreciate your help and look forward to your response. If you should have any questions regarding this survey feel free to contact me at 555-555-5555.

Regards,

P. Warren Plugge
Ph.D.Candidate
Colorado State University
Fort Collins, Colorado
555-555-5555

APPENDIX G
DBB Test Instrument
And
APPENDIX H
DB Test Instrument

Note: The same instrument was used for both DBB and DB test instrument. The words "Design-Bid-Build" and "Design-Build" were replaced depending on which survey was distributed to the participant.

Design-Bid-Build/Design-Build
Survey Instrument

Dear Colleague,

Thank you for agreeing to participate in this research project. You may wish to allow approximately 15 minutes to complete the survey. Your responses to this survey will be used to compare the differences between the two project delivery methods of design-bid-build and design-build.

Most important, I would like to thank you in advance for taking the time to provide your expertise related to project delivery methods. Because of your experience you have been selected from 500 of your peers to provide your knowledge and feedback. Your knowledge is very important for the understanding of risk associated with project delivery methods. Information you provide will benefit the construction industry with ideas that can assist owners, architects, engineers, and constructors in making decisions related to risk and project delivery.

The survey you are about to complete will have 40 questions. Although there are many questions, it is important that you answer each question to the best of your knowledge considering the *design-bid-build project delivery* method.

Please select the answer that best answers the question for the design-bid-build project delivery method.

I value your time and knowledge; your participation in this research process is appreciated. If you have additional questions regarding this research feel free to contact me at 555-555-5555 (wplugg@msn.com) or my advisor Dr. Michael A. De Miranda at 970-491-5805 (mdemira@CAHS.Colostate.edu).

Thanks again for your time,

P. Warren Plugge, M.S.

Directions: To select your response, simply click the box beside the best answer that matches/reflects your experience in design-build project delivery method.

Demographics

Which of the following best describes your current position?

- ☐ Field Engineer
- ☐ Field Superintendent
- ☐ Assistant Project Manager
- ☐ Project Manager
- ☐ Area or Division Manager
- ☐ Vice President
- ☐ Sales
- ☐ CEO
- ☐ Other, please state (type in box)

How many years have you worked in the construction industry?

- ☐ 0-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21-25
- ☐ 26-35
- ☐ 36 or more

Under the design-bid-build project delivery method, the average duration of the projects you have worked on has been?

- ☐ Less than 1 year
- ☐ 1 Yr
- ☐ 2 Yrs
- ☐ 3 Yrs
- ☐ 4 Yrs
- ☐ 5 Yrs
- ☐ 6 Years
- ☐ Other, please explain, (type in box)

Which of the following best describes the area of construction you work in the most?

- ☐ Civil
- ☐ Commercial (Buildings)
- ☐ Industrial
- ☐ Architect/Engineer
- ☐ Residential/Developer
- ☐ Subcontractor
- ☐ Vendor/Supplier
- ☐ Other (Type in box):

To the best of your ability, please estimate the number of projects you have worked on under the design-build delivery method?

☐ 1-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41- 50 Other (please specify)

When responding to the following questions, please frame your response in light of your experience using the design-bid-build project delivery method.

1. Schedule is a concern of mine at the beginning of DESIGN-BID-BUILD project (s)?
☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
2. Cost is known during design on DESIGN-BID-BUILD projects?
☐ Never ☐ Somewhat ☐ Depends ☐ Often ☐ Always
3. I expect to have change orders on DESIGN-BID-BUILD project (s)?
☐ Never Expected ☐ Somewhat expected ☐ Expected ☐ Usually expected
☐ Always expected
4. I know the physical site characteristics prior to the start of DESIGN-BID-BUILD projects (Ex. Land topography, geology).
☐Unknown ☐Somewhat known ☐Known ☐Usually Known ☐Always known
5. I was involved in a comprehensive risk management plan (s) on my DESIGN-BID-BUILD project (s)?
☐Never involved ☐Somewhat involved ☐Involved ☐Most involved
☐Always involved.
6. Technology increased **quality** on my DESIGN-BID-BUILD project (s)?
☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most Often
7. I can estimate costs associated with general conditions from historical cost data or my experience on DESIGN-BID-BUILD project (s).
☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
8. I consider environmental activities associated with the architectural components (includes doors, windows, finishes, specialties, furnishings) of DESIGN-BID-BUILD project (s) a schedule issue?
☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered
☐Always considered
9. I use historical project knowledge and experience to develop the estimate for DESIGN-BID-BUILD project (s)?
☐Never used ☐Somewhat used ☐Used ☐Mostly used ☐Always used
10. I was free to use the most modern construction means and methods to improve the overall project functionality on my DESIGN-BID-BUILD project (s) during construction.
☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often
11. I observed changes associated with the physical components of the project during construction on DESIGN-BID-BUILD project (s).
☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
12. I expect cost to change on DESIGN-BID-BUILD project (s) during design?
☐ Not Expected ☐ Some change ☐ Remains the same ☐ Often ☐ Always
13. I consider environmental activities associated with the mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical and electrical) of DESIGN-BID-BUILD project (s) a cost issue?
☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered
☐Always considered

14. How much experience do you have with green building techniques?
☐ No experience ☐ Some experience☐ Experienced ☐Very experienced ☐ Highly experienced
15. The most modern products and materials have affected the **schedule** on my DESIGN-BID-BUILD projects.
☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often
16. I consider quality during the design phase of the project on DESIGN-BID-BUILD project (s).
☐Not considered ☐Somewhat considered ☐Considered ☐Usually considered ☐Always considered
17. I can determine costs with the mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical, and electrical) from historical cost information or my experience on DESIGN-BID-BUILD project (s).
☐Unknown ☐Somewhat known ☐Known ☐Usually known ☐Always known
18. I was involved in the environmental activities during the production stage on DESIGN-BID-BUILD project (s) (construction, delivery, installation, testing).
☐Never ☐Somewhat ☐ Neutral ☐Usually ☐Always
19. Collocation of all of the major stakeholders on DESIGN-BID-BUILD project (s) was beneficial?
☐ Never beneficial ☐ Somewhat beneficial ☐ Beneficial ☐ Mostly beneficial ☐ Always beneficial
20. The most modern products and materials available have affected my project **cost** on DESIGN-BID-BUILD project (s).
☐ Never ☐ Sometimes ☐ Neutral ☐ Often ☐ Most often
21. I can determine physical costs on DESIGN-BID-BUILD project (s) at the beginning phases of the project (estimating, preconstruction) through historical cost data?
☐Unknown ☐Somewhat known ☐Known ☐Usually known ☐Always Known
22. Schedule is a concern on my DESIGN-BID-BUILD project (s)?
☐ Never ☐ Somewhat Often ☐ Usually ☐ Often ☐ Always
23. I expect cost to change on DESIGN-BID-BUILD project (s) at the beginning of the project (s).
☐ Never Expected ☐ Somewhat expected ☐ Expected ☐ Usually expected ☐ Always expected
24. I was involved with the environmental activities during the close out or turnover and startup stage of DESIGN-BID-BUILD project (s) (punch list, final testing, maintenance, lifecycle development).
☐Never ☐Somewhat ☐ Neutral ☐Usually ☐Always
25. I consider environmental activities associated with the mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical and electrical) on DESIGN-BID-BUILD project (s) a schedule issue?
☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered

26. I was involved in formal inspection processes during the planning and design stage of DESIGN-BID-BUILD project (s) (base design, cost and schedule, contract development, and planning).
☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐Always involved
27. On DESIGN-BID-BUILD project (s) I know the costs of the structural components (includes sitework, concrete, masonry, metals, woods and plastics, and thermal and moisture protection) from historical cost information or my experience.
☐Unknown ☐Somewhat known ☐Known ☐Usually known ☐Always Known
28. I can determine durations associated with mechanical components (includes equipment, furnishings, special construction, conveying systems, mechanical, and electrical) installed on my project from historical cost information or from my experience on DESIGN-BID-BUILD project (s).
☐Unknown ☐Somewhat known ☐Known ☐Usually Known ☐Always Known
29. I consider environmental activities associated with the architectural components (includes doors, windows, finishes, specialties, furnishings) of DESIGN-BID-BUILD project (s) a cost issue?
☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
30. Critical information about structural components of the project were known at the beginning of the project on my DESIGN-BID-BUILD project (s)?
☐Unknown ☐Somewhat known ☐Known ☐Mostly known ☐Always known
31. I was involved in formal inspection processes during the production stage on DESIGN-BID-BUILD project (s) (construction, delivery, installation, testing).
☐Never involved ☐Somewhat involved ☐Involved ☐Mostly involved ☐Always involved
32. Technology increased communication on my DESIGN-BID-BUILD project (s).
☐ Never ☐ Sometimes ☐ Often ☐ Somewhat often ☐ Most often
33. I was involved in formal inspection processes during the feasibility stage (project formulation, strategy design, and approval) on my DESIGN-BID-BUILD project (s)?
☐Never invovled ☐Somewhat involved ☐Involved ☐Mostly involved ☐Always involved
34. I consider environmental activities associated with the structural components (includes sitework, concrete, masonry, metals, woods and plastics, and thermal and moisture protection) of DESIGN-BID-BUILD project (s) a schedule issue?
☐Never considered ☐Somewhat considered ☐ Considered ☐Usually considered ☐Always considered
35. I was involved with environmental considerations at the feasibility stage (project formulation, strategy design, and approval) of the project?
☐ Never ☐Somewhat ☐Neutral ☐Usually ☐Always
36. I can determine the durations associated with architectural components (includes doors and windows, finishes, specialties, furnishings) from historical cost information or from experience on DESIGN-BID-BUILD project (s).
☐ Never ☐ Sometimes ☐ Usually ☐ Often ☐ Always

37. I am concerned with quality during the feasibility stage on DESIGN-BID-BUILD project (s) (project formulation, feasibility studies, strategy design and approval).
☐Never ☐Somewhat ☐ Depends ☐Usually ☐Always
38. I can determine the durations associated with general conditions from historical schedule data or from my experience on DESIGN-BID-BUILD project (s).
☐ Never ☐ Sometimes ☐ Usually ☐ Often ☐ Always
39. Quality often changed from the beginning to the end of construction on my DESIGN-BID-BUILD project (s)?
☐ Never ☐ Somewhat often ☐ Usually ☐ Often ☐ Always
40. I expect schedule to change on DESIGN-BID-BUILD project (s) during construction?
☐ Not Expected ☐ Some change ☐ Remains the same ☐ Often ☐ Always