IMPACT TO ALTERNATIVE CONTRACTING METHODS USING MULTIVARIATE ANALYSIS IN THE REGULATORY ENVIRONMENT

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IMPACT TO ALTERNATIVE CONTRACTING METHODS USING MULTIVARIATE ANALYSIS IN THE REGULATORY ENVIRONMENT

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For my dad,
for teaching me about building the world.
For my mom,
for teaching me about the importance of education.
For my husband,
for teaching me about unconditional love.
For my sister,
for teaching me to believe in myself.
For my children,
I will always support your dreams and
hope you experience the same joy in your accomplishments.

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I dedicate this work to my parents, Bob and Valerie; my husband, Brendan; my sister, Nicole; and my children, Kieran and future babies. Their unconditional love and encouragement make me a better person. I also want to acknowledge my parents-in-law, Kathleen and Kevin; my brothers-in-law, K.C., Todd, Brian, and Vic; my sisters-in-law, Mary, Crystal, Carolynn, and Mandy; and my nieces and nephews, Madeline, Thea, Christopher, Cale, Riley, Peter, Camden, Victoria, Evan, and Bridget. I feel a connection in some small way with each of them, and I am so very proud to have them in my life.

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SUMMARY

The selection of an appropriate procurement system contributes significantly to the outcome of a design and construction project (Chan, Lam, Scott, 2002; Love, 2002; Chan, Chan Scott, 2004). And while no one system is superior in all circumstances, there is probably a *best choice* for any specific project (Dell'Isola, 1997). Many owners base their project delivery method choice upon biased experience of in-house experts and/or advice from external consultants (Masterman and Gameson, 1994). Other owners use project delivery methods based on over-simplified practices that "take into account the characteristics of each job rather than adopt a method developed from detailed consideration of both the projects themselves and their effects on the ongoing business of the organization" (Griffith and Headley, 1997). Two of the earliest pioneers in this research, Skitmore and Marsden (1988), argue for the development and application of a more systematic approach to project delivery method selection. There is substantial research since then that suggests and even attempts to develop a systematic approach to project delivery method selection. However, existing literature rarely addresses public/government agencies, the regulatory environment, and legislative impediments are almost entirely neglected as suggested variables in project delivery method selection models.

This research addresses legislative impediments inherent to working in the government construction industry by answering the question: *Are there benefits of alternative project delivery methods, and are legislative impediments impacting any such benefits from being realized?* To answer these questions, the research begins with a literature review that defines the project delivery method process, and explains in detail

the types of project delivery methods and how they function. The research then provides a qualitative study that presents the perceived advantages and disadvantages of each method. Then, a second literature review provides an overview of previously published research in project delivery method selection, and examines federal and state legislative trends to establish the growing debate associated with alternative project delivery methods, focusing on the design-build method of project delivery. The literature review concludes that varying degrees of federal and state legislative limitations exist, and proceeds with the investigation of whether such regulatory impediments are impacting project delivery method selection for federal projects, suggesting that the removal of such impediments may allow the benefits of project delivery methods to be realized. A quantitative analysis is presented to test whether federal and state legislative limitations influence the realization of any benefits of alternative project delivery methods, and specifically design-build, for federal projects. Project characteristics from the U.S. General Services Administration Capital Construction Project database are tested. The database is analyzed with a statistical package, using a variety of quantitative techniques, to ascertain potential correlations among the variables, and specifically their relation to project delivery method selection. The research suggests that when an alternative project delivery method, specifically design-build, is chosen, there are benefits in time and cost savings, and the ability to use the alternative project delivery method is affected by the removal of the legislative impediment.

This research assists the public construction industry in choosing among project delivery methods and assessing the project characteristics and specifically the legislative impediments associated with a construction project. However, any construction industry decision-maker interested in public or private sector work may find this research helpful. This research moves the industry one step closer to understanding the implications of legislative limitations associated with alternative project delivery methods, and also provides further understanding of the benefits of alternative project delivery methods, and specifically design-build. This study seeks to advance discovery through its research methodology, and is unique because it can be a basis for future policy recommendations. While this research uses federal construction projects for quantitative investigation, this methodology can be generalized to other areas of construction contracting, especially at the state and local levels.

CHAPTER 1

INTRODUCTION

1.1 Overview

The selection of an appropriate procurement system contributes significantly to the outcome of a design and construction project (Chan, Lam, Scott, 2002; Love, 2002; Chan, Chan Scott, 2004). And while no one system is superior in all circumstances, there is probably a *best choice* for any specific project (Dell'Isola, 1997). Many owners base their project delivery method choice upon biased experience of in-house experts and/or advice from external consultants (Masterman and Gameson, 1994). Other owners use project delivery methods based on over-simplified practices that "take into account the characteristics of each job rather than adopt a method developed from detailed consideration of both the projects themselves and their effects on the ongoing business of the organization" (Griffith and Headley, 1997).

Researchers and practitioners are constantly seeking to determine which construction project delivery method best suits a project. This project delivery method selection process is part of the programming phase of a project, and typically is overshadowed by the need to determine sufficient program definition during the same phase. This problem is exacerbated in alternative project delivery methods in that the public owner does not have the design reviews that are common in traditional construction delivery methods. Public owners who are without experience in alternative project delivery methods or who are unsure about the appropriate application will opt for the traditional method of project delivery, design-bid-build, and face the risks associated with its low-bid process.

Two of the pioneers in this research, Skitmore and Marsden (1988), argue for the development and application of a more systematic approach to project delivery method selection. Since then, there is substantial research that suggests and even attempts to develop a systematic approach to project delivery method selection. However, existing literature rarely addresses public agencies and legislative impediments are almost entirely neglected. This research addresses legislative limitations inherent in the public construction industry by presenting an analysis that can be integrated into existing models and taken into consideration when choosing a project delivery method. The analysis uses a series of multivariate flowcarts, or models, that reflect how project delivery methods influence project characteristics, such as project duration and project cost. These flowcharts guide public owners in determining the advantages and disadvantages of alternative project delivery methods, such as design-build and construction manager at-risk. The analysis aids public owners and the construction industry by identifying, testing and analyzing the impact of legislative impediments in the project delivery method selection process. This research is not intended to create a new decision support system and add to the other 42 decision support systems that exist. Rather, this research uses multivariate flowcharts, or models, to analyze the impact of legislative impediments in the construction process, suggesting that benefits are realized when alternative project delivery methods, specifically design-build, are allowed to be selected.

This research addresses only legislative actions that are impediments to choosing a project delivery method. Other legislative actions exist that may impede the construction process, such as zoning, economic development, and environmental requirements. This research is limited to legislative impediments in selecting a project delivery method. For this research, a legislative impediment is defined to be any regulatory framework that limits the public owner's option to use an alternative project delivery method. This research is intended to complement existing decision support systems by presenting whether benefits exist to public owners when using alternative project delivery methods, and whether benefits exist to public owners when legislative impediments are lifted and alternative project delivery methods are allowed to be used.

1.2 Background

Kumaraswamy and Dissanayaka (2000) propose that procurement is "the action or process of acquiring or obtaining material, property or services at the operational level," that building procurement is the "amalgam of activities undertaken by a client to obtain a building," and that construction procurement is the "framework within which construction is brought about, acquired or obtained." In the past century, a high degree of specialization has evolved in the provision of various goods and services in the construction industry. This has led to a series of supply chains that include multiple layers of suppliers and builders (Kumaraswamy and Dissanayaka, 2000). These multiple layers have supported the development of various ways to structure construction procurement. The way procurement is structured, managed and organized is referred to in the construction industry as the *project delivery method*.

The construction industry has not established a standard definition of the project delivery method process, nor has it established accepted types and definitions of project delivery methods. Because of this, federal, state and local legislation and trade organizations have established their own definitions of the process and the types of project delivery methods. This has resulted in multiple interpretations of the project delivery method process.

In 2004, members from the American Institute of Architects (AIA) and The Associated General Contractors of America (AGC) trade organizations formed a task force to develop a basic understanding of the project delivery method process and definitions for the three primary project delivery methods: design-bid-build, construction manager at-risk, and design-build. Their goal was to "provide the industry with a set of definitions that others can use as a baseline…against which people can reconcile their own set of definitions" (AIA and AGC, 2004). Those definitions are used as a baseline for this research, and are supplemented by federal and state legislation and a literature review of published research. The AIA and AGC have not established a standard definition for the project delivery method process. Rather, they provide a discussion on "management" versus "delivery," associating the term "delivery" with project delivery method. Delivery is termed as the assignment of responsibility for providing design and construction services. Management is the coordination of the design and construction process. The AIA and AGC associate the assignment of responsibility as the fundamental difference between project delivery methods.

In the construction industry, there are three primary methods of project delivery. Construction industry professionals commonly refer to a "traditional" form of project delivery known as design-bid-build. There are two variations of this traditional form:

design-bid-build using separate-prime bidding method, and design-bid-build using single-prime bidding method for project delivery. These methods obligate public owners to award construction contracts based on the lowest, most responsible and responsive bidder. In the past decade, the choices of methods have expanded and are referred to as "alternative delivery methods." These are the construction manager at-risk and design-build project delivery methods. These alternative delivery methods obligate the public owner to award contracts based on a combination of qualifications and cost, or best value.

The use of project delivery methods can be traced back to the evolution of design and construction when ancient master builders provided a seamless service that included what is now referred to as design and construction, or design-build. In the past two centuries, in the dawn of the Industrial Revolution, the design and construction industry has become more specialized and segmented. In response to the growing segmentation of the construction industry, laws, beginning with the Miller Act of 1935, have been enacted to legally separate the duties of design and construction on federal projects in the United States.

This growing segmentation in the industry also prompted Congress to enact the Federal Property and Administrative Services Act of 1949, the first public contract laws mandating the separation of design and construction. This law requires the selection of builders on public contracts through open competition and based on the lowest responsible bid. The Brooks Architect-Engineer's Act, enacted in 1972, is believed to have solidified the separation of design and construction by requiring public owners to award architectural and engineering contracts based solely on qualifications. The theory behind the law is that, since federal projects are built by the lowest cost builder, the designs for the project should be developed by the highest qualified design firm. The enactment of these two laws is the basis for much debate and research in the public construction industry.

Over the past several decades, there has been growing dissention toward the design-bid-build project delivery method. Critics claim that choosing a builder based on the lowest price under the design-bid-build method supports unscrupulous behavior. This growing dissention has led to court cases to challenge the Brooks Act, which evolved to the passage of the National Defense Authorization Act of 1996, re-named the Clinger-Cohen Act. This Act allows all federal agencies to award one contract to an entity or team of entities to design and build the construction project. However, many federal agencies and state governments have yet to embrace design-build as a viable procurement system. Five years after the Clinger-Cohen Act was passed, almost half of all states did not allow design-build. And 10 years after its enactment, there are still five states that forbid design-build, and of those that allowed it, many are highly restrictive in its use.

1.3 Problem Statement

Selecting the most appropriate project delivery method for a project is an ongoing dilemma and has resulted in confusion among construction owners. Existing literature suggests that the type of delivery method used in a project has a direct effect on the outcome of the project. However, there has been no systematic study for the public construction industry on the possible outcomes of each of these methods. Rather, most decisions are based on presumed general advantages and disadvantages of each method. However, this problem is not specific to public owners: it reaches all providers in the public construction industry. Providers (designers, consultants, and builders) are attempting to understand how each of these methods are organized and managed to provide public owners with the highest and best possible value for their project. But, since there are multiple variations and interpretations of these methods, there is much confusion in the industry.

To address these problems, it is crucial to systematically investigate how the type of project delivery method affects the outcome of the project. Research methodologies are needed to provide this analysis, but such methodologies are still underdeveloped. Existing methodologies usually focus on specific aspects of the problem, do not provide a comprehensive analysis of the issues, and do not specifically address the distinct issues related to fully government-funded construction projects.

1.4 Research Objective and Scope

Much research and many tools exist to assist a public owner in choosing a construction project delivery method. This decision arises during the programming phase of a construction project. In a federal project, the programming phase identifies the technical construction requirements with a degree of detail that meets the program needs of the client agency. The deliverable of the programming phase is the concept of the project. Identifying the concept allows the project team to submit the concept to Congress for funding consideration, with the intent of obtaining congressional approval. This research proposes that other variables exist in a public construction project that can greatly impact the programming phase, and the choice of project delivery method. These variables are legislative impediments associated with a project.

The objective of this research is to investigate whether benefits exist when using an alternative project delivery method, and whether benefits are realized upon the removal of legislative impediments associated with project delivery method selection. This research addresses legal impediments inherent to working in the government construction industry by answering the question: *Are there benefits of alternative project delivery methods, and are legislative impediments impacting any such benefits from being realized? The hypothesis is that benefits exist to public owners when using an alternative project delivery method, specifically design-build, and such benefits are realized upon the removal of legislative impediments associated with project delivery method selection.* To answer these questions, the research begins with a literature review that defines the project delivery method process, and explains in detail the types of project delivery methods and how they function. A qualitative analysis is then presented that provides the perceived advantages and disadvantages of each method. A second literature review further examines federal and state legislative trends to establish current debate associated with alternative project delivery methods, focusing on the design-build method of project delivery. The research then provides an overview of previously published literature in project delivery method model development, and ends with a quantitative analysis to test whether federal and state legislative limitations influence the realization of any benefits of alternative project delivery methods, and specifically design-build, for federal projects. Project characteristics from the U.S. General Services Administration's Project Information Portal are tested. The database includes 20 years of agency-wide, over-prospectus projects, as defined in section 102-73.35 of the Federal Management Regulation (FMR). The Federal Management Regulation System prescribes policies concerning property management and related administrative activities. GSA issues the FMR to carry out the Administrator of General Services' functional responsibilities, as established by statutes, Executive orders, Presidential memoranda, Circulars and bulletins issued by the Office of Management and Budget (OMB), and other policy directives (FMR, 102-2.10). The database is analyzed with a statistical package using a variety of quantitative techniques to ascertain potential correlations among the variables, and, specifically, their relation to project delivery method selection. This research uses a series of quantitative models to test the hypothesis, and these models are intended to support the decision-making process for choosing a project delivery method. This research does not create a decision support system model, in which information is inputted in a model and the model then offers a "best choice" project delivery method to the user. Rather, this research provides analysis to be used in decision-making, and offers owners additional information that should be considered when using a decision support system model. Ultimately, this research takes into consideration the public owner's point-of-view and the identification of which variables allow them to proactively select an optimal project delivery method for their construction project.

1.5 Dissertation Outline

The research is divided into six chapters. Chapter 1 introduces the problem, provides objectives and the hypothesis, and presents a brief scope of the study. Chapter 2 offers a literature review of the various definitions and interpretations of the project delivery process, how they function, industry perceptions of advantages and disadvantages of each method through a qualitative study, and also presents the evolution and legislative trends of such methods. Chapter 3 reports on a second literature search of methodologies and variables from decision support systems in prior studies. Chapter 4 presents a methodology for this research, discusses the models (multivariate flowcharts) developed in this research, introduces and provides descriptive statistics of the data to test the hypothesis, and ends with testing the hypothesis using descriptive statistics and cross tabulations. Chapter 5 uses more advanced statistical techniques, correlation and multivariate regression, to test the hypothesis, and ends by reporting the findings. Chapter 6 presents conclusions, expected benefits for and the impact on the construction industry, and provides recommendations for future research.

1.6 Conclusions, Benefits and Expected Contributions

This research moves toward a clearer focus of the vast and confusing domain of project delivery method studies available for use by the public owner. By developing a unique methodology to test the hypothesis, this research will help the public owner organize and manage the procurement of a construction project. This research will aid public owners during the programming phase of a project when attempting to determine sufficient program definition. Determining sufficient program definition is a common problem in the construction industry; that problem is exacerbated in alternative contracting techniques in that the public owner does not have the design reviews that are common in traditional construction delivery methods. This research contributes to new knowledge in the study of project delivery method selection by embracing the multifactoral nature of the problem of its legislative limitations.

This research assists the public construction industry in choosing among project delivery methods and in assessing the project characteristics, and specifically the legislative limitations, associated with a construction project. This research adds new knowledge to growing discussions among policy-makers and advocates on how changes in federal, state and local legislation affect project delivery in public construction.

However, any construction industry decision-maker interested in public or private sector work may find this research helpful. This research moves the industry one step closer to understanding the impact of legislative limitations associated with the construction industry, and specifically the impediments associated with alternative project delivery methods and design-build. This study seeks to advance discovery through its research methodology. While this research is applicable to federal construction, this methodology can be generalized to other areas of construction contracting.

CHAPTER 2

DEFINITION OF PROJECT DELIVERY METHOD, QUALITATIVE RESEARCH, AND LEGISLATIVE TRENDS: A REVIEW OF THE LITERATURE

2.1 Purpose

The purpose of this chapter is to review existing literature to establish the point of departure for the research. It is divided into two sections. The first section of the chapter provides a basis for discussion by defining the project delivery method process, and explaining in detail the primary types of project delivery methods, how they function, and the perceived advantages and disadvantages of each method. The second section of this chapter reviews federal and state legislative trends to discuss a debate in the construction industry whether benefits using an alternative project delivery method, focusing on one particular method – design-build. The chapter concludes with a summary of the point of departure for this research.

2.2 Literature Search

The literature reviewed in this chapter is sought from multiple sources. First, peer-reviewed sources are collected through online databases using the GALILEO Interconnected Libraries for the State of Georgia, as presented in Table 2.1.

Table 2.1 Literature Review Sources

Architecture and Engineering	*Public Policy and Government Legislation*
Academic Search Premier	Code of Federal Regulations
ASCE Civil Engineering	Congressional Universe
Avery Index to Architectural Periodicals	Government Printing Office Catalog
Compendex	Public Affairs Information Service International
LexisNexus	Statistical Abstract of the United States
National Technical Information Services	On-line Postings of Federal Legislation
Web of Science	On-line Postings of State Legislation
Interlibrary Electronic Collections	
Online Search Engines	

Architecture and engineering databases form the basis for project delivery method research, including Academic Search Premier, ASCE Civil Engineering, Avery Index to Architectural Periodicals, Compendex, LexisNexus, National Technical Information Services (NTIS), and Web of Science. Public policy, government information and legislation research is attained from accessing online databases using the Code of Federal Regulations, Congressional Universe, Government Printing Office Catalog, Public Affairs Information Service (PAIS) International, and Statistical Abstract of the United States. Federal and State legislation is also sought from online postings of such legislation. Published theses and dissertations are another source for the literature review and are accessed through interlibrary electronic collections. Final collection of the literature review is attained through online search engines. Careful consideration of reliability is sought from all sources.

2.3 Types of Project Delivery Methods

The way procurement is structured, managed and organized is referred to in the construction industry as the *project delivery method*. The construction industry has not established a standard definition of the project delivery method process, nor has it established accepted definitions of project delivery methods. Because of this, federal, state and local legislation, and trade organizations have established their own definitions of the process and the types of project delivery methods. This has resulted in multiple variations and interpretations of the project delivery method process. The definitions provided herein are developed from the 2004 American Institute of Architects (AIA) and The Associated General Contractors of America (AGC) task force, which sought to create standardized definitions for the industry.

In the construction industry, there are three primary methods of project delivery. Construction industry professionals commonly refer to a “traditional” form of project delivery, known as design-bid-build. There are two variations of this traditional form: design-bid-build using separate-prime bidding method, and design-bid-build using single-prime bidding method for project delivery. These methods obligate public owners to award construction contracts based on the lowest, most responsible and responsive bidder, explained in detail below. In the past several decades, the choices of methods have expanded and are referred to as "alternative delivery methods." These are the construction manager at-risk and design-build project delivery methods. The following provides an overview of how these project delivery methods are organized and managed.

2.3.1 Design-bid-build (traditional)

This project delivery method has two commonly-accepted variations: design-bid-build using separate-prime bidding and design-bid-build using single-prime bidding. Both variations have four sequential phases: selection, design, bid, and construction. The selection phase entails hiring the designers, who are chosen based solely on qualifications. Once the designers are selected, design begins. It has three phases: (1) schematic design, during which the basic appearance and the plan are developed; (2) design development, during which the functional and aesthetic aspects of the project and the building systems that satisfy them are defined; and (3) construction documents, during which the details of assembly and construction technology are finalized. During design, the public owner creates the project requirements, also known as the project program. Also, the designers develop the design documents on the basis of those requirements. The type of bid specification packages that are created from the design documents is what distinguishes separate-prime and single-prime bidding.

2.3.2 Design-bid-build Using Separate- (or multiple-) Prime Bidding

In design-bid-build using separate-prime bidding, the designers create multiple bid packages for the following trades: heating, ventilating, and air conditioning; plumbing; electrical; and general construction (any work not included in the other three categories). Then, bidding begins on the construction project. Bids are received from prospective prime contractors and awarded to the lowest, most-responsible bidders. At the end of the bid phase, contracts are executed with each of the prime contractors. In the final phase, construction takes place. Under this method, it occurs after the design documents are complete, and the public owner contracts separately with the designers and prime contractors, as depicted in Figure 2.1.

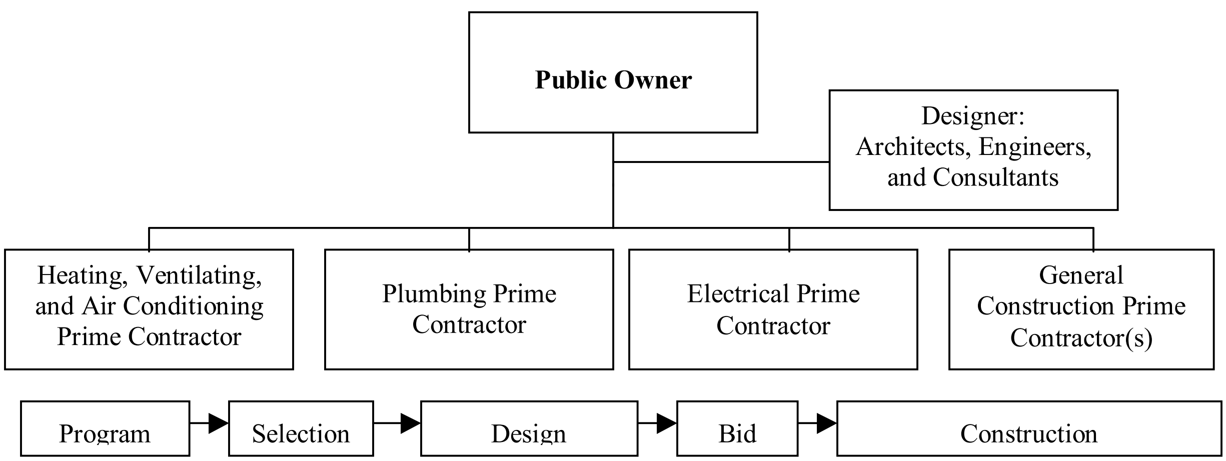


Figure 2.1: Design-Bid-Build using Separate-Prime Bidding Organizational Chart

2.3.3 Design-bid-build Using Single-prime Bidding

In design-bid-build using single-prime bidding, the designers create one bid package from the design documents, as opposed to multiple packages as in design-bid-build using separate-prime bidding. After one bid package is developed, construction bidding begins. Bids are received from general contractors and the project is awarded to the lowest, most-responsible bidder. At the end of the bid phase, one contract is executed. Construction is the project's final stage. It takes place after the design documents are complete. The public owner contracts separately with designers and the general contractor, and the general contractor contracts with subcontractors, as depicted in Figure 2.2.

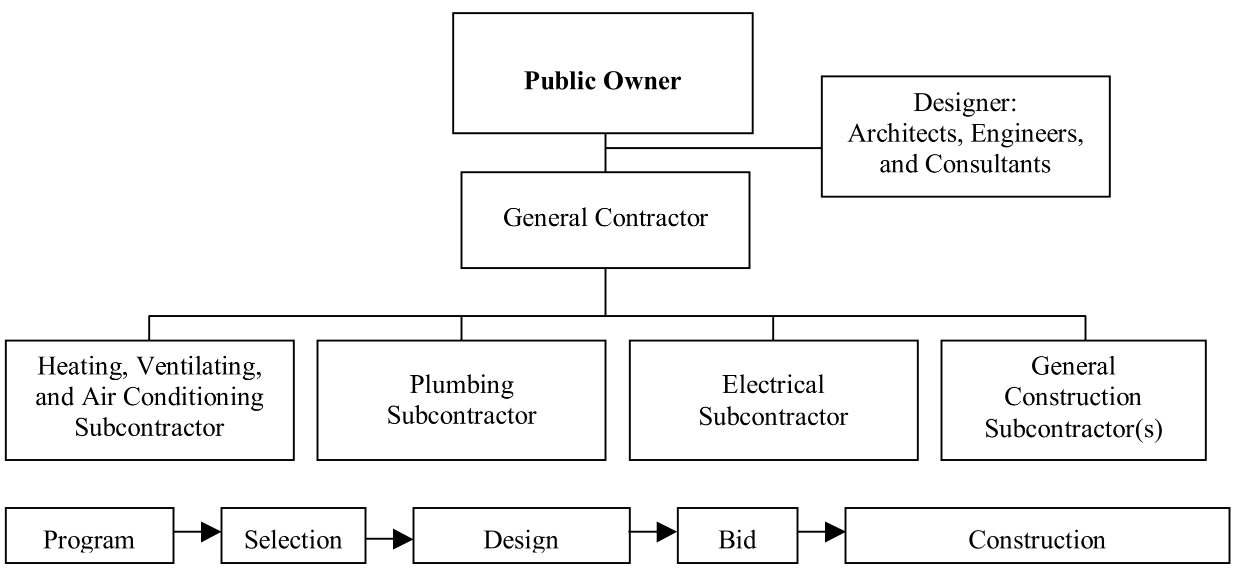


Figure 2.2: Design-Bid-Build using Single-Prime Bidding Organizational Chart

2.3.4 Construction Manager at-Risk

As with the design-bid-build method, there are four sequential phases of project delivery: selection (of a designer), design, bid-selection (of a construction manager), and construction. First, the public owner develops the project program and then requests proposals from prospective designers. In some cases, the public owner attempts to attract a company that has the ability to perform design and construction management services. If that happens, rather than requesting proposals for a second time for construction management services, a guaranteed maximum price for construction oversight is renegotiated with the designers later in the design process. As with other methods, the public owner awards the contract on the basis of qualifications. The designer then develops design documents. During this process, the public owner requests proposals from prospective construction managers. The construction manager is selected on the basis of qualifications and of cost. Several experts note that the selection process takes place when the schematic design phase of the design process is complete.

Once the construction manager is selected, the contract has two phases of execution. In the pre-construction phase, the construction manager works with the public owner and the designers for constructability reviews until the design documents are about 80 percent complete. The public owner determines the point in the design phase when the guaranteed maximum price is negotiated. Several experts indicate that the guaranteed maximum price is negotiated toward the end or at the end of the construction documents phase, or at the point in which the constructor is willing to accept the construction risk. Then, the construction contract is negotiated to include a guaranteed maximum price for the construction. The term ‘at-risk’ in the “construction manager at-risk” refers to the construction manager assuming a relatively high risk through the guaranteed maximum price (GMP), which requires the construction manager to ensure, for example, the performance and financial stability of subcontractors and vendors, fluctuations in material prices, schedule adherence, and possibly weather changes. This risk is the basis for the other risks. After the guaranteed maximum price has been set, the construction manager may begin construction, even though the design documents may not be complete. If construction begins early, the construction manager creates multiple bid packages from the incomplete design documents and opens bidding. Similar to the design-build-separate prime bidding method, for the construction manager at-risk, bid packages may be prepared for heating, ventilating, and air conditioning, plumbing, electrical, as well as other trades which may be broken out and separately bid, and general construction, which is work not included in the other categories. Contracts are awarded to the lowest, most responsible bidders, and construction takes place. Under this method, construction generally begins before the design documents are complete. The public owner contracts with the designers and construction manager, and the construction manager contracts with the subcontractors, as depicted in Figure 2.3.

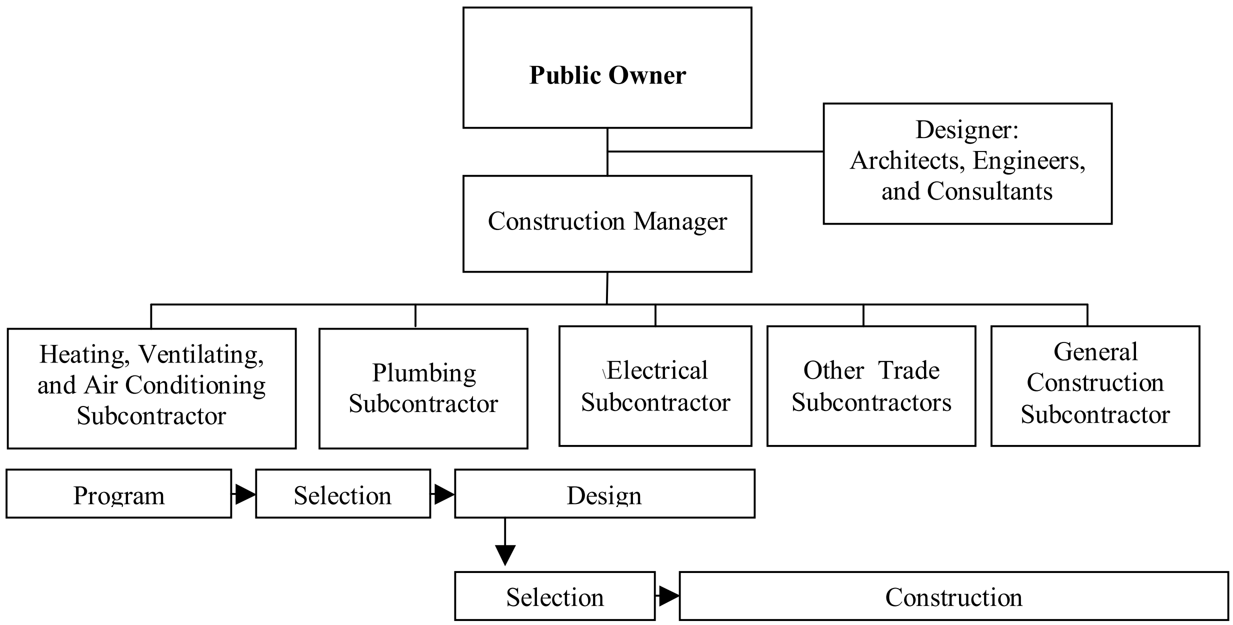


Figure 2.3: Construction Manager at-Risk Organizational Chart

2.3.5 Design-build

Unlike the design-bid-build and construction manager at-risk methods, this method only has three sequential phases: bid-selection, design, and construction. The public owner first prepares a detailed project program and then requests proposals to attract a design-builder. The design-builder is either a single company or a partnership of two or more companies. Several companies are selected on the basis of their qualifications. The design-builders then develop detailed proposals, which include design documents and a cost for construction. After developing the proposals, the public owner critiques each one. After which, each design-builder responds with design, adjusting the price accordingly. The public owner evaluates the revised proposals and makes the award based on lowest price. Like the construction-manager-at-risk method, the design-builder may begin construction after being hired. Under this method, construction typically begins before the design documents are complete. The public owner allows only one contract with a design-builder, in contrast to two or more contracts under other procurement methods, as depicted in Figure 2.4.

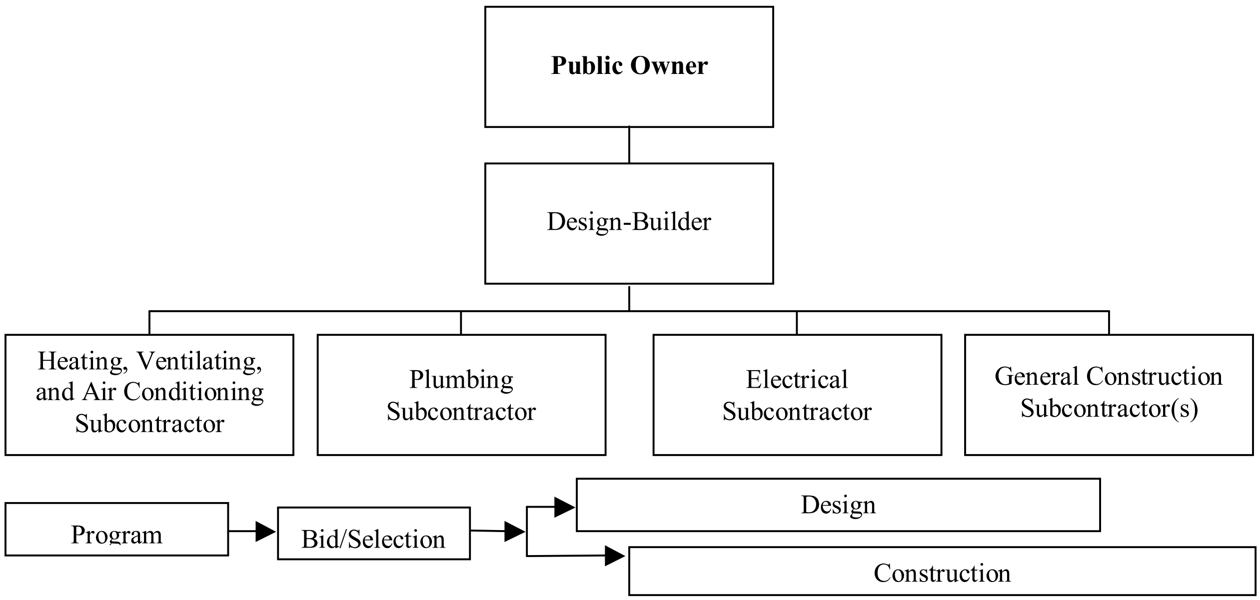


Figure 2.4: Design-Build Organizational Chart

2.4 Critical Analysis of Project Delivery Methods

The first section of this chapter provided a basis for discussion on the research by defining the project delivery method process, and explaining in detail the four primary types of project delivery methods and how they function. This section provides a critical analysis of the perceived advantages and disadvantages of each method. This analysis is relevant to establish the debate, passage and application that gave rise to controversy of the alternative project delivery methods, design-build and construction manager at-risk. A qualitative study is sought as a basis for this research to reveal such perceptions.

The qualitative study finds that opinions on the relative merits and risks of each method vary. To account for the differing opinions, input from experts representing all construction industry disciplines is sought. Advantages and disadvantages of each method are sought using four construction contracting industry goals as evaluation criteria: (1) controlling project costs; (2) meeting or accelerating the schedule; (3) ensuring a quality product; and (4) decreasing the administrative burden. To apply the findings of the literature review, a questionnaire is distributed to construction industry experts, as shown in Table 2.2.

Table 2.2: Questionnaire

Criteria	Explanation of Values	Project Delivery Methods: Design-Bid-Build Separate Prime	Design-Bid-Build Single Prime	Construction Manager at Risk	Design-Build
How effective is the method in providing the contractor an incentive to control project costs?	High = Costs are always met and usually reduced.				
	Medium = Costs are typically met and rarely reduced.				
	Low = Costs are rarely met and never reduced.				
How effective is the method in providing the contractor an incentive to meet or accelerate the project schedule?	High = The project schedule is always met and usually accelerated.				
	Medium = The project schedule is typically met and rarely accelerated.				
	Low = The project schedule is rarely met and never accelerated.				
How effective is the method in achieving the functional and aesthetic goals of the project?	High = Functional and aesthetic goals are always met.				
	Medium = Functional and aesthetic goals are usually met.				
	Low = Functional and aesthetic goals are rarely met.				
What level of owner management is required by the method to coordinate the design phase?	High = The public owner is highly involved in the preparation of the design package. The technical aspects of the package are highly scrutinized by the public owner.				
	Medium = The public owner is moderately involved in the preparation of the design package. The technical aspects of the package are carefully reviewed by the public owner.				
	Low = The public owner is less involved in the preparation of the design package. The designer holds primary responsibility for the review of the design package.				
What level of owner management is required by the method to coordinate the procurement phases?	High = The bid process is cumbersome. The owner prepares the bid package(s), reviews the response(s), negotiates (as necessary), and prepares the contract(s).				
	Medium = The bid process requires some effort. The owner may or may not work with a second party to coordinate the process.				
	Low = The bid process requires little effort. A second party typically coordinates the bid process.				
What level of owner management is required by the method to coordinate the construction phase?	High = The owner is highly involved in the construction phase. A full-time facilities representative manages the contract(s).				
	Medium = The owner is moderately involved in the construction phase. A part-time facilities representative manages the contract(s).				
	Low = The owner is less involved in the construction phase. A facilities manager allocates minimal weekly hours to contract oversight.				

Experts include academicians, registered architects, professional engineers, construction managers, general contractors, a legislator, local and state government officials from North Carolina, and a mechanical prime contractor. Local and state government officials from North Carolina are used as experts because this study is based on the change of state legislation in North Carolina. Historically, North Carolina's laws restricted public owners to only use the design-bid-build using separate-prime bidding project delivery method. (The laws of North Carolina do not apply to Army Corps of Engineers projects, federal buildings, or federal military bases in North Carolina). In 2001, the North Carolina General Assembly added two options for project delivery: design-bid-build using single-prime bidding and construction manager at-risk (N.C. GEN. STAT. art. 8, Public Contracts, § 143-128). The North Carolina statutes also include a special provision that allows the State Building Commission to approve alternative contracting techniques (N.C. GEN. STAT. art. 8, Public Contracts, § 143-135.26(9)). The most commonly approved method is design-build. The passage of these laws develops from growing dissention in the construction industry toward the design-bid-build project delivery method. Critics claim that choosing a builder based on the lowest price supports unscrupulous behavior. This growing dissention led to court cases to challenge the Brooks Act on the Federal level, which evolved to the passage of the National Defense Authorization Act of 1996, re-named the Clinger-Cohen Act. This Act allows all federal agencies to award one contract to an entity or team of entities to design and build the construction project, and allows the selection of a builder based on a combination of qualifications and cost. The passage of this Federal Act led to many discussions in North Carolina on the relative advantages and disadvantages of design-build and construction manager at-risk. Congressional debates were held concerning the passage of the Clinger-Cohen Act on the state level, and ultimately design-bid-build using single-prime bidding and construction manager at-risk were accepted in North Carolina in 2001. An expert from the Capital Program at The University of North Carolina at Chapel Hill discusses the legislative changes in North Carolina and the effect of such legislation:

> As UNC (The University of North Carolina at Chapel Hill) was about to embark upon a massive capital program in excess of $4.2 billion, it was clear that a greater number of construction delivery options were necessary for success. The North Carolina General Assembly's approval late in 2001 to add construction manager at risk and single-prime bidding to the long-used multi-prime bidding was a watershed event. (Kevin MacNaughton, Special Assistant for Capital Projects, 2003)

The qualitative study discusses the advantages and disadvantages of project delivery methods and uses snowball, or referral sampling, as a methodology: experts who were initially interested and available to participate referred additional experts (O'Sullivan and Rassell, 1999). Interviews are conducted separately with each expert to collect data on the performance aspects of each project delivery method. In total, 15 responses are incorporated into this study. Table 2.3 shows the general characteristics of these experts.

Table 2.3: Characteristics of Construction Industry Experts

Expertise	Designation	Company
Public Owner	Director Facilities Planning	State Government Agency
Registered Architect	Principal	Architecture Company
Public Owner, Certified Public Accountant	Director of Finance	County Government
General Contractor, Professional Engineer	Owner, Chairman of the Board	Construction Company
Elected Official, Registered Architect	State Senator	State Government Architecture Company
Public Owner, Construction Manager	Executive Vice President	Construction Management Company
General Contractor	Vice Chairman	Construction Company
Public Owner, Ph.D., Professional Engineer	Director of Facilities Planning Associate University Professor	Federal Government
Public Owner, Professional Engineer	Vice President of Facilities	State University System
Public Owner, Ph.D.	Vice President of Finance Assistant University Professor	State Government Agency
Registered Architect	Principal	Architecture Company
Construction Manager	Executive Associate	Architecture and Construction Management Company
Prime Contractor, Professional Engineer	Vice President	Mechanical Contractor
General Contractor, Professional Engineer	Vice Chairman	Construction Company
Public Owner, Professional Land Surveyor	Director of Facilities Planning	County Government

Although the number of construction industry experts is small, this qualitative study is still considered acceptable. Based on Hammersley and Atkinson's triangulation concept in 1983, at least three different sources are needed to validate a single phenomenon (Walker, 1997). Self-justification bias would question the validity of the data with only one expert's response. Because this study incorporates 15 experts' responses and the experience and backgrounds of such experts is diverse, the results in this qualitative study may be generalized to the greater construction industry.

2.4.1 Controlling Project Costs

Although many studies claim to determine the most cost-efficient or least-expensive project delivery method, as noted earlier, the task is impossible. So, for each method, the questionnaire asks if project costs are always met and usually reduced, typically met and rarely reduced, or rarely met and never reduced. The most efficient method is deemed to be the one cited by the highest percentage as always meeting and usually reducing project costs. Overwhelmingly, experts indicate that the construction manager at-risk method is the most efficient. For a graphic representation of the results, see Figure 2.5.

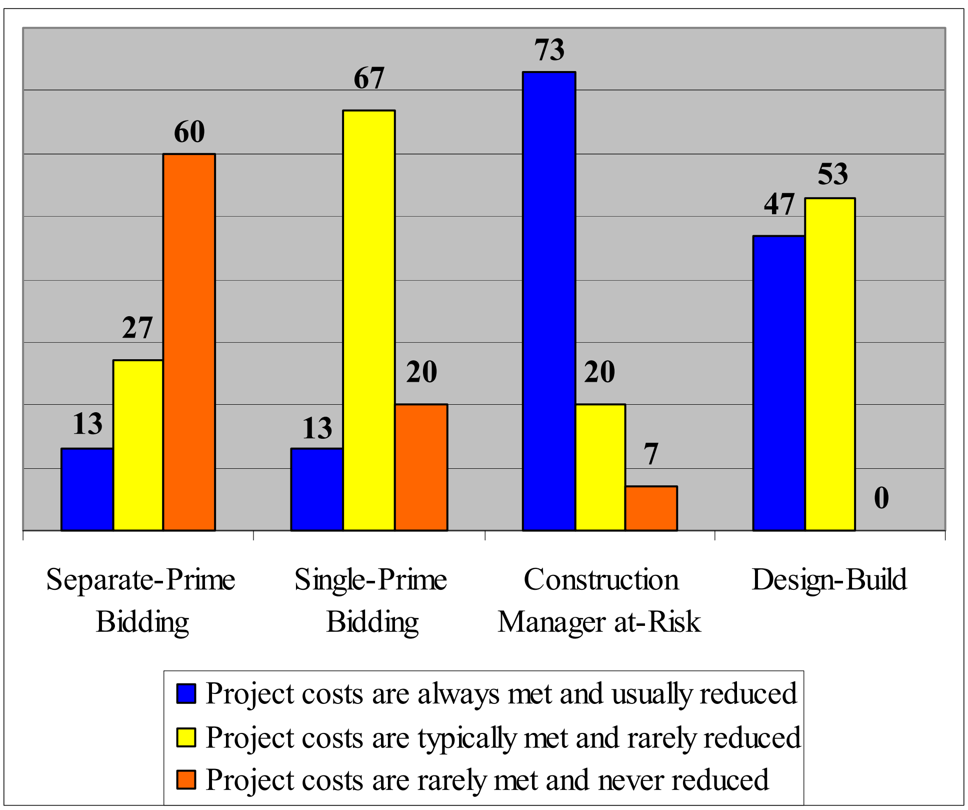


Figure 2.5: Controlling Project Costs

Seventy-three percent of experts respond that costs always are met and usually reduced because the construction manager assumes the financial risk associated with any profit or loss. If the budget is exceeded, the construction manager must work without charge to arrive at the guaranteed maximum price. Experts revealed that savings produced during the execution of the contract reverts back to the public owners. In some cases, the public owner and construction manager share the savings, also known as a shared savings program. In a shared savings program, when the direct project costs, including profit and overhead, are less than the guaranteed maximum price, the construction manager and public owner will share the difference on some stipulated percentage basis. Experts reveal that the shared savings program provides an additional incentive to the construction manager to control project costs. Experts also rank this method high because the construction manager is involved in all project phases, and there are more opportunities for increased value engineering and cost estimating. A government representative from Dare County, North Carolina, touts the benefits of construction manager at-risks:

> We have used construction manager at-risk with great success. We built our new Justice Center under this method, and we just awarded bids for several large water department projects under a construction manager at-risk contract. In both instances the bids cane in under projection. The Justice Center project came in on time and under budget – unheard of in government construction projects – and we saved over half a million dollars on the water bids. (Norma Mills, Attorney, 2003)

Even though this method ranks highest, experts state that public owners may have difficulty enforcing the contract. The guaranteed maximum price is based on incomplete design documents and is a defined price for an undefined product.

The design-build method is also efficient in controlling project costs, although not as efficient as the construction manager at-risk method. Forty-seven percent of experts respond that costs are always met and usually reduced. Additionally, 53 percent respond that costs typically are met. Experts rank the design-build method high because there are not as many change orders or as many claims stemming from errors and omissions in the design documents. The designers and the constructors (the general contractors or the prime contractors) are under one contract. And like the construction manager at-risk method, a project using the design-build approach benefits from increased value engineering and cost estimating during design. Nevertheless, public owners should be aware of the increased financial risks of using the design-build method. Because the fixed price in design-build is based on the design documents developed during the bid phase, changes in the project program may occur. Project program changes can be costly once construction is underway.

Although not as efficient as others, the two design-bid-build methods are also efficient in controlling project costs. Thirteen percent of experts report that costs always are met and usually reduced using either of the two design-bid-build methods. Also, 67 percent respond that costs are typically met using the single-prime bidding method, and 27 percent respond that they are typically met when using the separate-prime bidding method. With these methods, the public owner benefits from the designers' expertise and advice. The public owner also benefits from separating the designers and the contractor(s). The separation creates a system of checks and balances. Unlike the case with the other two methods, the public owner can make changes in the project program at a moderate cost during the design phase because construction has not begun.

Overall, however, the design-bid-build methods ranks low and the separate-prime bidding method ranks last with 60 percent of experts responding that costs are rarely met. One expert attributes the low rankings to the contract-selection process. Because the contract is awarded to the lowest, most-responsible bidder, contractors tend to underbid when they know that the project has problems. The problems will create change orders later. Also, because the chance for change orders increases in proportion to the number of contracts made on a project, public owners can potentially have four change orders from a design error using separate-prime bidding, as opposed to one with single-prime bidding. A representative from Appalachian State University in North Carolina offers an experience on design-bid-build using separate-prime bidding:

> By all accounts the multi-prime delivery system for this campus was a total disaster, and we have absolutely no intention of using this system for future construction projects. The majority of our future projects costing more than $15 million will be considered as candidates for construction manager at risk. The balance will in all likelihood be bid and awarded on the single-prime basis. (Clyde D. Robbins, Director of Design and Construction, 2003)

2.4.2 Meeting the Project Schedule

For each method, the questionnaire asks whether the project schedule is always met and usually accelerated, typically met but rarely accelerated, or rarely met and never accelerated. The term 'schedule' refers to a time table setting out the times for starting and completing each of the operations required for the construction of a building or other project. According to the experts, the design-build method is the most efficient in meeting or accelerating the project schedule. Sixty-four percent of experts respond that schedules are always met and usually accelerated using design-build, and 36 percent report that schedules are typically met. For a graphic representation of the results, reference Figure 2.6.

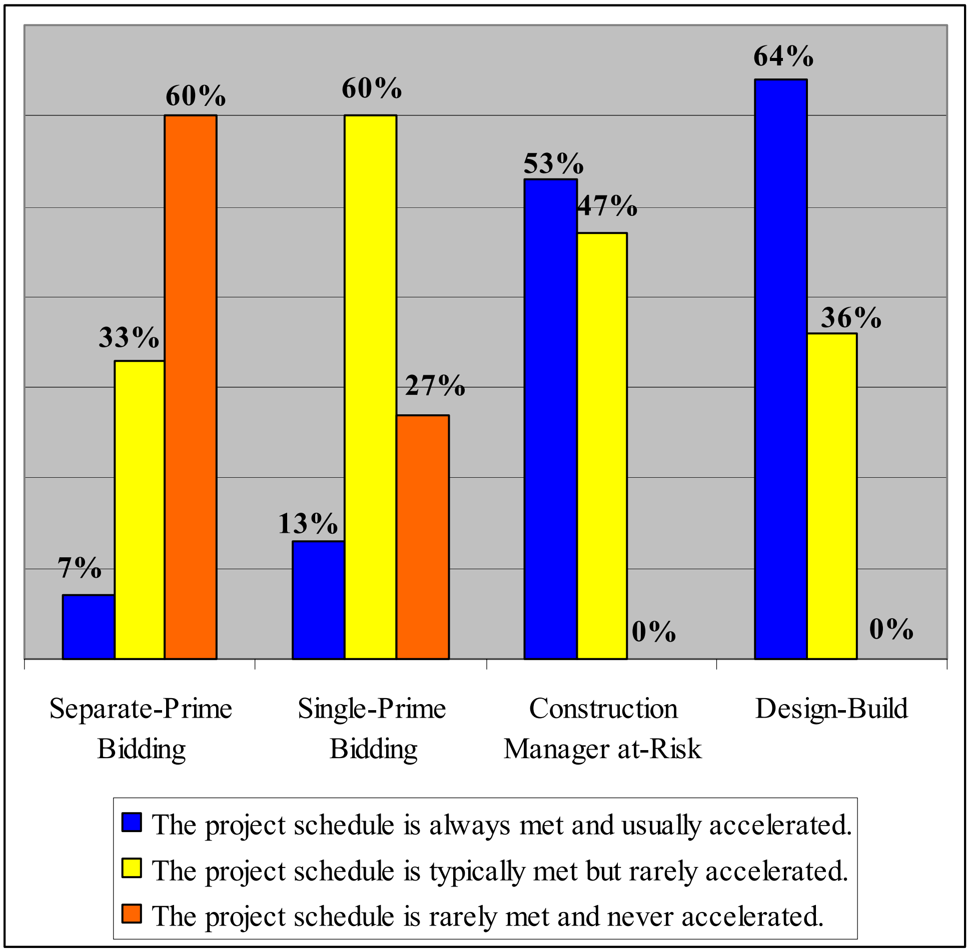


Figure 2.6: Meeting the Project Schedule

Experts respond favorably to design-build because phased construction can occur. Using this approach, the design-builder can avoid scheduling delays by identifying long lead times early. Even though the design-build method ranks highest in the study, one expert remarks that public owners with committees may encounter problems. In some cases, committees with multiple stakeholders may prolong decision-making. Phased construction relies on speedy decisions from the public owner. The construction manager at-risk method is also efficient in meeting or accelerating the schedule. Fiftythree percent of experts respond that the schedule is always met and usually accelerated, and 47 percent respond that the schedule is typically met. As with the design-build method, phased construction explains the high ranking. However, design-build reaps the benefits of phased construction earlier in the process than construction manager at-risk. Also, as with design-build, public owners must gain input from the stakeholders more quickly and earlier in the design process to reap the time savings of phased construction.

Both design-bid-build methods, design-bid-build using single-prime bidding and design-bid-build using separate-prime bidding, are also efficient in meeting and accelerating the schedule, although less so than the other methods. Sixty percent of experts respond that the schedule is typically met using the single-prime bidding method, and 33 percent of experts respond the same for the separate-prime bidding method. The main benefit to the public owner is the systematic checks and balances created by separating the designer and contractor(s). The designers scrutinize construction operations, while the constructors carefully review construction administration by the designers. Even though several experts favor these methods, they rank low overall. Twenty-seven percent of experts respond that the schedule is rarely met using single-prime bidding, and 60 percent respond the same for the separate-prime bidding. Experts suggest that public owners be aware that stakeholders take the initial decision deadlines less seriously because changes can be made later. A study expert from Dare County, North Carolina discusses schedule delays associated with the design-bid-build using single-prime project delivery method:

> Dare County found through experience that the single-prime process provided only a guaranteed minimum price for our new Justice Center and that the only incentive for maintaining a schedule was a punitive one in the form of liquidated damages. After much research and discussion and since it was before the passage of Senate Bill 914, the County obtained local legislation to allow alternative methods for the project. The County ultimately decided upon a design plus construction-manager-at-risk approach. We were able to obtain a guaranteed maximum price for the project, to include incentives for schedule improvements and for savings of the budgeted contingency, and to obtain a quality product knowing that both the architect and the contractor were on the same team and had the same boss. (David Clawson, CPA, 2003)

Another challenge with these methods is that checks and balances can create strained relationships and hinder coordination. This is especially important in the design-bid-build using separate-prime bidding method because the designer may work with four or more prime contractors.

2.4.3 Ensuring a Quality Project

The definition of what makes a quality project varies in the construction industry. Because of this, the questionnaire asks whether the functional and aesthetic goals of a project are met, rather than asking if the methods ensure a quality project. There is little distinction among the methods. Forty percent of experts respond that functional and aesthetic goals are always met under design-bid-build using single-prime bidding, construction manager at-risk, or design-build. Twenty-seven percent think that using separate-prime bidding is best. For a graphic representation of the results, see Figure 2.7. Overall, experts indicate that public owners have the greatest chance for a quality project using construction manager at-risk.

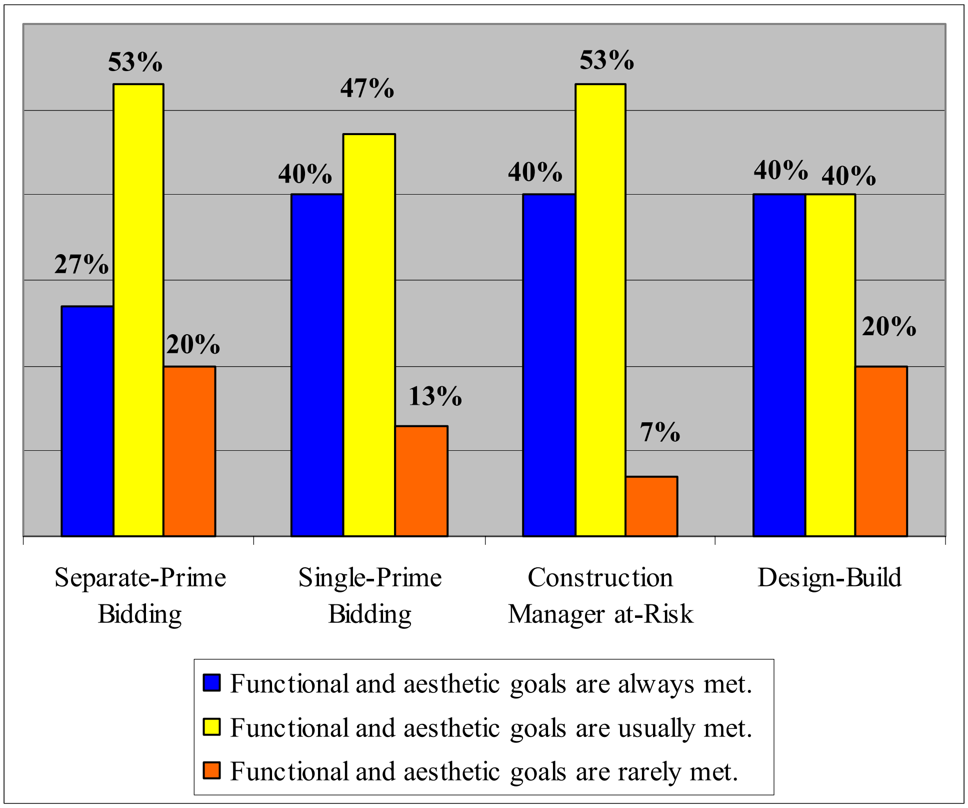


Figure 2.7: Ensuring a Quality Project

Under construction manager at-risk, public owners benefit from having input from construction personnel during design. This also is a characteristic of design-build. However, a conflict of interest can occur under design-build. In contrast, with construction manager at-risk, under design-build, the designer is not an independent advisor. When using design-build, public owners should be aware that the design-builder may be tempted to cut corners because it interprets design needs and may seek the lowest-cost alternative. Under the two design-bid-build methods, the designer is an independent advisor. That is, under these methods, the public owner holds separate contracts with the designer and the construction manager, so they are not contractually responsible to the prime contractors. Because of this and the expanded design phase, several experts indicate that a quality product is more common with using these methods. The designers are not under a deadline to produce high-quality design documents. All experts agree that having good design documents ensures a quality product.

When asked about the risks of these methods, experts again cite the contract-selection process. One explains that even well-qualified firms may be forced to shortchange the quality of supervisory staff, in order to submit a bid that is low enough to win. Public owners should be aware of this risk and the probability that shortchanging will multiply as more contractors become involved.

2.4.4 Reducing the Administrative Burden

Experts are asked whether the public owner is less involved, moderately involved, or highly involved in the design, bidding, and construction phases. Responses indicate that the design-build method called for the least involvement, thus providing the greatest reduction of administrative burden. It is followed by construction manager at-risk. Design-bid-build using single-prime bidding ranks a close third, and separate-prime bidding ranked last. For a graphic representation, see Figure 2.8.

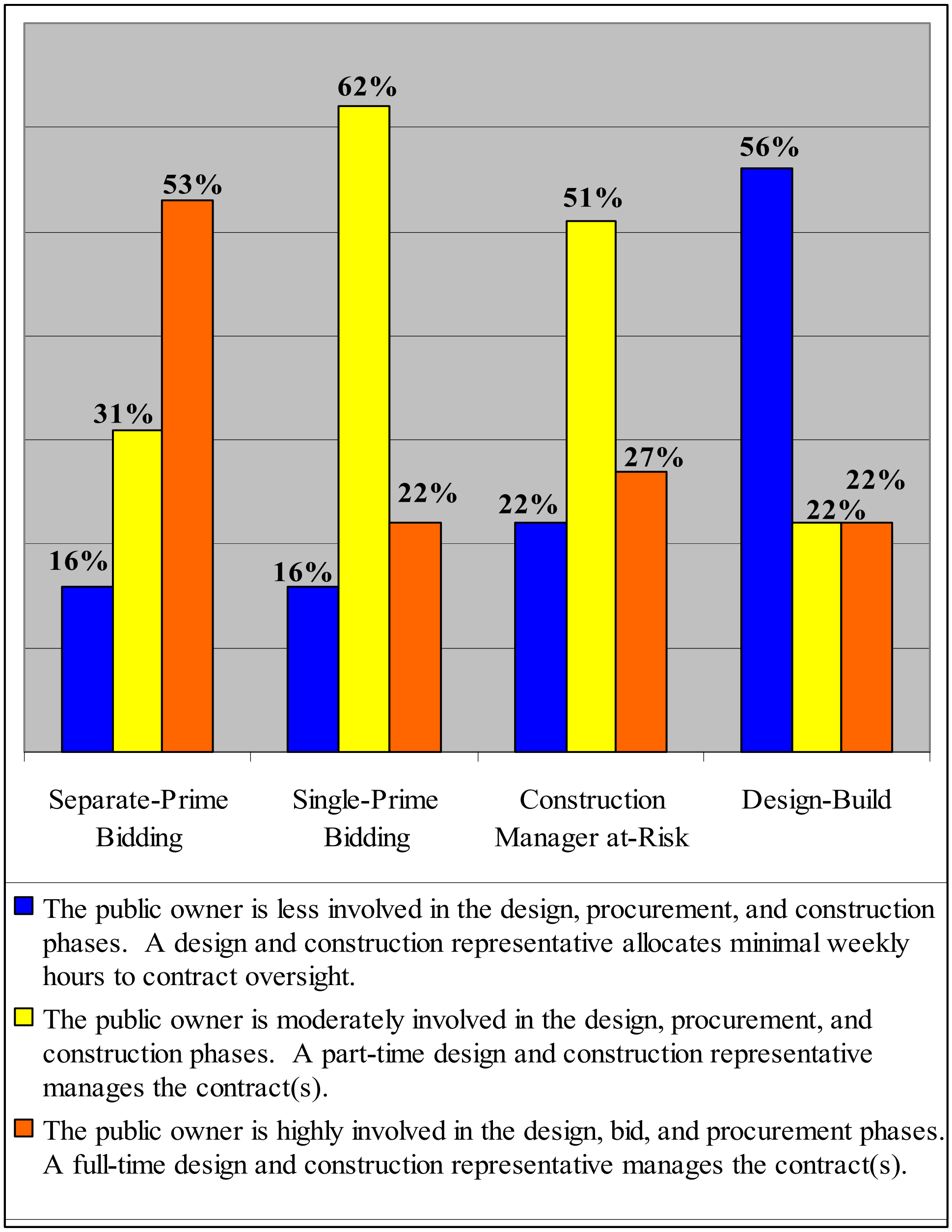


Figure 2.8: Reducing Administrative Burden

In general, the results show that administrative burden increases with the number of contracts. The design-build method benefits the public owner in reducing the administrative burden by holding only one contract. There is only one line of communication for the public owner. With construction manager at-risk and single-prime bidding, the public owner holds two contracts; with separate-prime bidding, the public owner usually holds five or more contracts. Each contract involves developing a bidding package, issuing it, receiving proposals, evaluating them, negotiating the contract, and overseeing its implementation. Even though the design-bid-build methods ranks low, experts state that they are easy to understand and public owners have worked with them for some time. Many experts express that there is confusion in the industry because the construction manager at-risk and design-build methods are relatively new and are used differently. For example, with the construction manager at-risk method, opinions differ about when proposals should be requested for the construction manager. Some public owners request proposals for the designers and the construction manager at the same time, while others request proposals for construction manager after schematic design, and yet others request proposals after design documents are 100 percent complete. Because these methods are relatively new, experts suggest that public owners consider the design-bid-build methods until more experience is shared in the public contracting industry. A study expert from The University of North Carolina at Chapel Hill adds this about design-bid-build using single-prime bidding, "Employing single-prime bidding on less complex projects has assured a single source of responsibility. Many institutions have found the prequalification of these hard bid contractors is worth the effort on most jobs" (Kevin MacNaughton, 2003). Regardless of the method used, owners' involvement depends upon how much time they dedicate to a project. Experts think that public owners should carefully judge their involvement and capacity level so they do not lose control over the project.

2.4.5 Critical Analysis Summary

Overall, the qualitative study in North Carolina reveals that experts think the design-build and the construction manager at-risk methods control project costs, reduce time, improve quality, and decrease administrative burden more than the design-bid-build methods. This study provides credible evidence within the industry that alternative delivery methods should be considered as options for a construction project. This research suggests that there are expected benefits from alternative delivery methods, and support the enactment of such legislation at all levels of government to ensure the availability of such methods.

2.5 Summary of Project Delivery Methods

The first section of this chapter provides an understanding of the project delivery process. An industry-developed standard definition of the project delivery process is presented, the prevailing four types of project delivery methods are described in detail, and, finally, a qualitative study as a critical analysis is provided. This first section also establishes that there is no industry-wide "accepted" definition of the project delivery method process and that there are wide variations in the delivery of such processes, which leads to confusion among industry professionals, both with the public owners managing the projects and the providers of such projects. Determining when or with which project these methods may best be used is the basis for this study. The first section also provides industry perceptions of each of the methods, and offers strong consideration concerning choosing alternative delivery methods, design-build and construction manager at-risk, for project delivery method selection. The second section of this chapter reviews legislative trends to establish the ongoing debate in the construction industry on whether benefits exist under alternative delivery methods with a focus on design-build.

2.6 Project Delivery Method Evolution

The use of project delivery methods can be traced back to the evolution of design and construction when ancient master builders or master masons provided a "seamless service that included what we now refer to as design and construction, or design-build" (Beard et al. 2001). That singular form of responsibility for design and construction can also be traced back to the Code of Hammurabi, the ruler of the first known metropolis, Babylon, in early 1700 B.C. The codes require all builders to "know the appropriate design for the required structure, and then must build it according to those traditionally accepted materials and forms" (Beard et al. 2001). These codes imply a seamless form of responsibility for the design and construction or building of a structure.

There are also references to singular forms of responsibility for design and construction into modern times. Sir Christopher Wren was appointed for the design and construction of Saint Paul's Cathedral; Wren's designs were accepted in 1675, and he then provided oversight of the construction until its completion in 1710 (Beard et al. 2001). Le Corbusier in the late 1800s and early 1900s also suggests a single form of design and construction responsibility:

> You employ stone, wood, and concrete, and with these materials you build houses and palaces: that is construction. Ingenuity is at work. But suddenly you touch my heart, you do me good. I am happy and I say: 'This is beautiful. That is Architecture. Art enters in. (Towards a New Architecture, 1923).

2.7 Analysis of Design-Build Legislation

The beginning of the second section of this chapter provides a brief history of the evolution of the design-build project delivery method, and presents design-build as the earliest alternative delivery method documented. The research suggests that, only in the dawn of the Industrial Revolution with the division of labor and segmentation of duties, did design-bid-build as a delivery method evolve. The final section of this chapter presents a review of federal and state legislative trends to establish the confusion in the industry of project delivery methods that use qualifications-based selection, referred to as alternative project delivery methods.

2.7.1 Legislative Trends: 1935-2001

In the past two centuries, in the dawn of the Industrial Revolution, the design and construction industry has become more specialized and segmented. Task specialization has evolved with mass production and the need for dividing the production process into individual tasks – or the division of labor. Historically, the Industrial Revolution supports the evolution of the division of labor theory that dividing labor into specific tasks and roles intends to increase productivity. The formation of professional societies has evolved to represent these new divisions of labor. In 1835, the Royal Institute of British Architects was formed; a year later, the American Institute of Architects was formed, but disbanded shortly thereafter. In 1852, the American Society of Civil Engineers and Architects developed, and, in 1869, it dropped "the Architects"; shortly after, the American Institute of Architects resurrected in 1857. The first architectural licensing laws were passed in the U.S. in 1897. The division of labor also facilitated the organization of trade unions to advance the interests of its working people. In 1886, the American Federal of Labor (AFL) was founded to organize its members according to a specific work function. Organizing into specific work functions segmented the construction industry: all carpenters belonged to the carpenters' union; the plasterers joined the plasterers' union; and the plumbers belonged to the plumbers' union. Each union had its own administration, policies and collective bargaining agreements. The primary goal of the union is to benefit its members through a collective unit, with that unit having a central function for job opportunities through its members. In 1935, the Congress of Industrial Organizations was formed to organize industrial workers into unions, such as automobile production and steel. In 1955, these two organizations merge into the AFL-CIO, the American Federal of Labor and Congress of Industrial Organizations.

2.7.2 Federal Legislative Trends

In response to the growing segmentation of the construction industry, laws are enacted. Legal separation of the duties of design and construction on federal projects in the United States began through the passage of a 1893 Congressional Act that authorized the Department of Treasury to "obtain plans, drawings and specifications for the erection of public buildings in the United States" through a fee competition, and then through the enactment of the Omnibus Public Buildings Act of 1926, which requires all capital project plans and specifications to be completed and approved before the construction can begin (Loulakis, 2003). A decade later, the Miller Act of 1935 requires a builder on a federal project in the U.S. of more than $100,000, to post a performance bond and a labor and material payment bond which guarantees builder performance and payment of such project. This need for capital is believed to prevent or discourage professional design and engineering firms from acting as builders (Beard et al. 2001). This growing segmentation in the industry prompted Congress to enact the Federal Property and Administrative Services Act of 1949, the first public contract law mandating the separation of design and construction by requiring the selection of builders on public contracts through open competition and based on the lowest responsible price. With this Act, the design-bid-build project delivery method evolved. The Brooks Architect-Engineer's Act, introduced in 1972 by U.S. Representative Jack Brooks of Texas, is believed to have solidified the separation of design and construction, and reinforce the design-bid-build project delivery method. This Act requires government agencies to award architectural and engineering contracts based solely on qualifications, rather than price, as previously required for the selection of builders in Federal Property and Administrative Services Act of 1949. These statutes state that it is "the policy of the Federal Government to . . . negotiate contracts for architectural and engineering services on the basis of demonstrated competence and qualification" with the government to "negotiate a contract with the highest qualified firm" for such services. This statute requires that firms are never chosen based on price or cost of the services, and that cost cannot be considered as an evaluation factor (40 U.S.C. §§ 541 - 544). The theory behind the law is that, since federal projects are built by the lowest cost builder, the designs for the project should be developed by the highest qualified design firm. The separation of design and construction also is intended to prevent abuses in the award of public projects. The Minnesota Supreme Court states the purpose of public bidding is to divest public officials of discretion to avoid even the appearance of “fraud, favoritism, and undue influence” (*Griswold v. Ramsey County*, 65 N.W.2d 647, 652, (Minn. 1954)).

The enactment of these two laws becomes the basis for much debate and research in the public construction industry. In the past two decades, there has been growing dissention toward the design-bid-build project delivery method. As discussed earlier in the chapter in the qualitative study, critics claim that choosing a builder based on their lowest price under the design-bid-build method supports unscrupulous behavior. Critics also suggest that builders will underbid a project that they know has design errors, and, once selected, the builder will offer solutions to such errors at inflated prices. In many cases, the final price of the construction project is higher than the highest bid during the procurement process. This growing dissention has supported the institution of lawsuits challenging the Brooks Act.

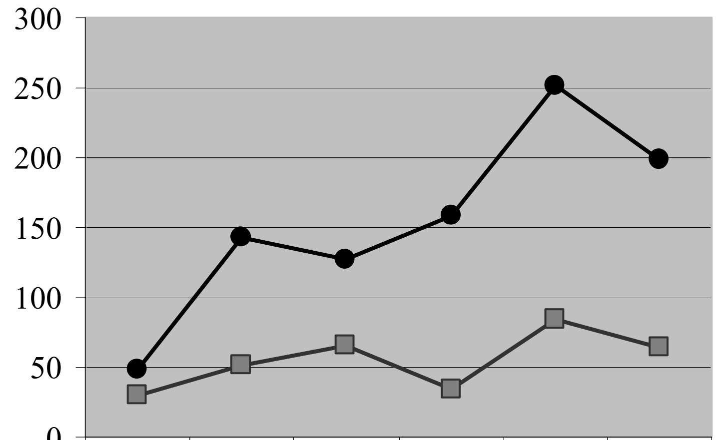
Even with the passage of these laws, design-build has been used in federal projects in the last half century. The earliest federal applications were used by the Naval Engineering Command for housing projects in 1940, the National Aeronautics and Space Administration (NASA) in 1962, and the Department of Housing and Urban Development in 1968 (Quatman, 2007). The use of design-build is thought to have expanded through the enactment of the Competition in Contracting Act (CICA) of 1984 which puts the sealed-bid method of contractor selection on par with competitive negotiation (Loulakis, 2003). There are problems with the CICA, however. The government used this process for defense contracts, rather than construction projects, and even marginal proposals are considered in the negotiation process as in the “competitive range,” to promote full-and-open competition.

Shortly after, the Military Construction Authorization Act of 1986 allows each branch of the military to use design-build for three pilot projects before October 1, 1990 (P.L. 99-167, December 3, 1985; P.L. 99-661, November 14, 1986). By the mid-1990s, a group of major trade and professional associations form the Design and Construction Procurement Coalition to "promote the adoption of legislation allowing federal agencies to have broader discretion to consider design-build" (Loulakis, 2003). One of the goals of the coalition is to develop a procedure to provide full-and-open competition and to limit the amount of construction industry investment in the design and construction solicitation process. The interests of the coalition expanded with the forming of the Design-Build Institute of America In 1993. The DBIA is a non-profit organization dedicated to expanding the use of design-build, and represent owners and design-build service providers who are interested in design-build but do not know how to successfully implement the process. The formation of the DBIA and the political workings of the Design and Construction procurement Coalition led to the passage of the Federal Acquisition Streamlining Act of 1994 and the National Defense Authorization Act of 1996 (Pub. L. No. 103-355, 108 Stat. 3243 and Pub. L. No. 104-106, § 4001, 110 Stat. 186, 642). These laws permit the Federal government to procure design-build services using the two-phase selection process as described in Chapter 2. The National Defense Authorization Act of 1996 that adopted the two-phase selection process is re-named the Clinger-Cohen Act. As mentioned earlier in the first section of the chapter, the two-phase selection process allows builders to be chosen based on a combination of price and qualifications, also referred to as design-price based selection (10 U.S.C. § 2305a and 41 U.S.C. § 253m), and the variables associated with qualifications can be tailored to suit the owner and the construction project. Under the 1996 Act, all federal agencies are permitted to use a qualifications-based selection method, such as design-build, if that method is "appropriate for the public project." The Federal Acquisition Regulations (FAR) is amended in 1997 to incorporate the two-phase selection process procurement procedures (48 C.F.R. §§ 36.102 - 36.104 and 36.300 - 36.303).

The advantageous impact of the Clinger-Cohen Act on public sector design-build is substantial (Loulakis, 2003). First, it created great interest in design-build in the construction industry, and for the first time it gives the Federal Government a way to eliminate marginal proposals. It also justified investment in time and money to builders interested in a solicitation. Builders learn early whether then are short-listed, and if so, then there are a limited number of competitors with which to compete against. This justified their investment in time and money to respond to a solicitation. The Clinger-Cohen Act generates a great interest among federal agencies and also becomes a catalyst for many state and local governments to adopt the two-phase selection process. The negative impact of the Clinger-Cohen Act is that it is thought to reduce competition for construction services by excluding smaller firms unable to lead the larger projects most amenable to the design-build approach. Design-build also is thought to provide an opportunity for favoritism to enter into the contract award process by including non-price factors in the basis for selection, and to undermine the inherent checks and balances between design and construction teams in the design-bid-build project delivery method, with the design team no longer independent of the construction contractor, and may increase project costs due to the elimination of the low bid contractor selection criteria. Assessing whether these impacts are valid is suggested as an area for future research.

2.7.3 State Legislative Trends

Following the lead of the federal government, state legislation has been enacted to enable the two-phase selection process for builders through the use of design-build as an alternative method of project delivery, even though many states have adopted the Miller Act for use at the state level (referred to as Little Miller Acts). Since 2001, 928 bills have been introduced in state legislatures concerning authorization of the use of design-build, as indicated in Figure 2.9.



	2001	2002	2003	2004	2005	2006
Introduced	49	143	127	159	251	199
Passed	30	52	66	35	84	64

Figure 2.9: Trends in Introduced Design-Build Legislation Since 2001

Thirty-six percent or 331 bills were enacted, at an increasing rate every year: 61 percent (49 proposed and 30 passed) in 2001; 36 percent (143 proposed and 52 passed) in 2002; 51 percent (127 proposed and 66 passed) in 2003; 22 percent (159 proposed and 35 passed) in 2004; 33 percent (251 proposed and 84 passed) in 2005; and, 32 percent (199 proposed and 64 passed) in 2006. This legislation is "owner-driven by government agencies not by industry associations. [Public owners] are looking for alternatives to low-bid, multiple contracts and are attracted by the cost- and time-savings that design-build can offer" (Quatman, 2007).

The number of states without design-build laws has been significantly reduced since 2001. At the end of the 2002 state legislative sessions, there are 26 states that allowed some form of the two-phase selection process. The states without design-build laws from that session are: Alaska, Alabama, District of Columbia, Delaware, Iowa, Indiana, Kansas, Massachusetts, Maryland, Michigan, Missouri, Mississippi, Montana, North Dakota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, and Wyoming (AIA, 2003). At the end of the 2005 state legislative sessions, there were seven states without design-build laws. Those are Alabama, Indiana, Iowa, Kansas, Michigan and Rhode Island. And at the end of the 2006 legislative sessions, there are 45 states that allowed some form of the two-phase selection process of builders using design-build for construction project delivery. The five states without design-build laws, forbidding the delivery method, are Alabama, Iowa, Michigan, Rhode Island and Wyoming. The 2006 legislative session enacted new design-build legislation in Kansas, a state without laws prior to 2006. In the 2007 session, legislation permitting design-build is introduced in Iowa, Michigan, and Rhode Island; Iowa legislation passed. Three states that remain without design-build legislation following the 2007 sessions are: Alabama (no legislation ever introduced), Michigan, and Rhode Island.

Even though state legislation permits design-build as a delivery method, in most cases, it is highly restrictive. Many states only allow design-build on a case-by-case basis or for special circumstances. In Louisiana, legislation passed in 2006 authorizes state and local entities to use design-build temporarily to rebuild in storm-ravaged parishes through 2008. In North Carolina, a State Construction Agency reviews and tracks the design-build project proposals, and then the project is taken to a State Building Commission for approval. Since the State Building Commission formed in 1998, fewer than 20 state-funded construction projects have been authorized to use design-build. In the 2007 legislative session, North Carolina enacted House Bill 443, which allows one of its counties to use design-build for construction of a justice center. In that state, each state-funded design-build project must be approved by the state legislature. Likewise, other states that authorize design-build on a case-by-case basis may only allow it for certain types of projects. Minnesota, New Hampshire and Louisiana only allow using design-build for transportation projects, and Rhode Island only allows design-build for water treatment facilities. Alabama, a state without design-build legislation, has case law that permits design-build under certain circumstances. In 1999, a design-build heating, ventilation and air conditioning (HVAC) contract is protested to the Alabama Supreme Court citing violation of the public competitive bidding law. The contract is determined to fall under a different state law where it was exempted as a "service contract" (*Anderson v. Fayette County Bd. of Educ.*, 738 So.2d 854 (Ala. 1999)). Similar case law may exist in other states, under which design-build contracts are authorized as "service contracts" and thus are not restricted by competitive bidding laws.

In some states, a one-step process is used to select a design-builder using solely qualifications-based selection, as legislated for architects and engineers under the Brooks Act. Arizona has legislation allowing "the use of the design-build method of construction and the use of qualifications-based selection of contractors with experience in stadium design or construction, by either direct selection or by public competition, to expedite the design and construction of any of its facilities or structures, or any facilities or structures leased to it or used by it pursuant to an intergovernmental agreement" (Ariz. Stat. 05.807.C.Title 34). Minnesota provides that an agency may solicit pricing information only after the agency has selected a contractor based on qualifications-based bidding. It provides that contractor selection procedures are within agency discretion, and may be adjusted to accommodate cost, scope, and schedule objectives. Minnesota also allows flexibility of selection procedures and criteria that may be used, which can include expertise, resources to perform the work, record of past performance, ownership status and employment practices regarding historically women, minorities, emerging small businesses or historically underutilized businesses, and availability. (Minn. H.F. 724, 2001). The theory is that capabilities of each firm are often more relevant to the success of the project than price. Most states, however, require the two-phase process, with some form of price or design competition as a second step in the procurement process.

2.7.4 Summary of Design-build Legislation

The second section of this chapter provides a history of the evolution of the project delivery method process, and provides an overview of federal and state legislative trends on design-build. This section supports earlier discussions on the confusion in the construction industry of the qualifications-based builder-selection process commonly applied with the design-build project delivery method. There is a steadily increasing trend of design-build bills being introduced in state legislatures which supports earlier claims of debate, passage and application giving rise to controversy in the industry on when and with which project these methods may best be used. These legislative trends support the basis for this study, suggesting that legislative limitations or legislative impediments exist to public owners in choosing a project delivery method for their construction project. The next chapter provides a literature review and analysis of previously published studies that sought to assist public owners in choosing a project delivery method for their design and construction project, and develops the hypothesis that benefits exist to public owners when using an alternative project delivery method, such as design-build, and that when legislative impediments are lifted allowing the use of design-build such benefits can be realized.

CHAPTER 3

PROJECT DELIVERY METHOD SELECTION MODELS: A REVIEW OF THE LITERATURE

3.1 Purpose

The previous chapter provides a basis for discussion of this research by defining the project delivery method process, and explaining in detail the types of project delivery methods and how they function. The previous chapter also provides a brief review of federal and state legislative trends to establish the debate, passage and application giving rise to controversy of project delivery methods that use qualifications-based selection for builders, focusing specifically on the design-build project delivery method. The purpose of this chapter is to provide an overview of previously published literature on project delivery method, with an emphasis on peer-reviewed decision support systems to assist public owners in selecting or choosing a project delivery method. This overview is divided into two sections.

This chapter begins by reviewing research methodologies applicable to construction management problems, similar to the problem this research addresses. Methodologies applied in prior studies on decision support systems are investigated. A brief overview of advantages and disadvantages of the existing decision support systems are presented in this discussion. In the next section of the chapter selection variables are extrapolated from those studies. The goal of this chapter is to indicate how prior studies have assisted public owners in project delivery method selection and how this research provides new knowledge and takes the construction industry one step closer to understanding the implications of choosing an alternative project delivery method, specifically design-build for a construction project.

3.2 Selection Models

The first section of this chapter provides an overview of previously published literature on project delivery methods, focusing specifically on peer-reviewed models and decision support systems to assist public owners in selecting or choosing a project delivery method. The literature review in Chapter 2 provides a basic background of the project delivery method process, describes the types of methods, discusses the perceived advantages and disadvantages of each method using a qualitative study, and reviews related federal and state legislative trends on the passage of projects delivery methods that use qualifications-based selection for builders. The literature review in Chapter 2 becomes the background study for this research. The literature review in this chapter requires its own type of methodological approach to background study. This methodological approach explores the evolution of project delivery method selection decision support system development and identifies state-of-the-art research, to provide a basis for developing new knowledge in the field of construction studies. Decision support systems that are published are analyzed to determine their contributions to this body of research and to determine how the topic of this research will impact the construction industry. While analyzing these published studies, this chapter also draws the selection variables presented in the literature. Each study provides selection factors to use in their decision support system and those selection factors are analyzed to test their impact with this research. The literature review in this chapter forms the point of departure for the research by confirming that existing decision support systems rarely use public/government agencies as the foundations for their research and that legislative impediments are almost entirely neglected as suggested variables in the decision support systems.

3.2.1 Sources

Extensive literature exists on the subject of construction contracting and project delivery methods. Even when narrowing the subject to specific types of methodologies, the volume of articles remains large. Generally, though, existing literature reviews the four existing common project delivery methods: design-bid-build using single-prime bidding; design-bid-build using separate-prime bidding; design-build; and construction manager at-risk. However, narrowing the subject to specific areas of application requires consideration of research on decision science, as the act of decision-making is a central function of science and of this research. There is no simple way to narrow the literature search in decision science in construction contracting. As such, this literature review narrows the focus to publications which seek to assist private or public owners in choosing or selecting a specific project delivery method for their construction project. The act of "making a choice" or deciding among project delivery method alternatives is the focus of the literature review, and forms the basis for studying the hypothesis of this research, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

The literature review in this chapter is sought from multiple sources. First, peer-reviewed sources are collected through online databases using the GALILEO

Interconnected Libraries for the State of Georgia. A key word search of "project delivery," "construction contracting," "delivery systems," "delivery methods," "procurement methods," "construction acquisition," "construction procurement," and "construction methods" is used in GALILEO, yielding a variety of abstracts relating to project delivery methods. This key word search allows for vast opportunities of research. Because the research through the key word search is broad, key words, such as "decision," "selection" and "choice," are used in conjunction to narrow the literature review focus.

The review of such sources reveals that most begin with defining the term "project delivery method" or "project delivery system," in order to form a basis for discussion on the research. As mentioned in the previous chapter, no industry-wide definition of this process exists so almost all sources develop their own definitions. Next, most sources discuss the sequencing of construction events or contractual relationships to distinguish between project delivery methods. Again, as mentioned earlier, the vast number of variations of these methods exists internationally. Since the volume of publications reaches around the world, the publications tend to present and describe how each of the methods in that research is organized and managed. And, finally, existing publications provide a decision support system to assist owners in the selection of a project delivery method using various methodologies to answer such questions.

3.2.2 Evolution of Selection Model Development

The design and construction industry becomes more specialized and fragmented in the first half of the twentieth century since the Industrial Revolution, as discussed in the previous chapter. Alongside this shift, the single point of procurement responsibility once provided by master builders in previous centuries evolves. The literature review reveals that the earliest discussions on project delivery method selection are published in the United Kingdom in the first half of the twentieth century.

Simon (1944), Emerson (1962) and Banwell (1964) call for different approaches to project delivery methods, from the traditional design-bid-build method. Emerson refers to the “integrated procurement routes as package deals and advocated their usage owing to the fusion of design and construction, whilst simultaneously acknowledging concerns over quality” (Kumaraswamy et al., 2000). These discussions in the United Kingdom and the use of design-build in the first half of the twentieth century by the Federal government, as mentioned in the second section of Chapter 2, lead to a series of studies blaming “short-sighted procurement strategies for stifling….the (design and construction) industry” (Kumaraswamy et al., 2000).

Interest in alternative project delivery systems expands in the 1970s and 1980s, beginning in London with a 1975 report from the National Economic Development Office (NEDO) which suggests the choice of project delivery method is critical to the success of the project. In the United States, a 1982 report by the Business Roundtable in New York states that the selection of an appropriate procurement technique can reduce total project costs by an average of five percent (Contractual, 1982). Trench (1991) considers five percent to be underestimated. The research community responds accordingly, as presented in Table 3.1.

Table 3.1 Procurement Selection Systems
[Based on Ambrose and Tucker 2000, adopted and expanded from Chan et al. 2001]

Author	Year	Methodology Description
Singh	1980	Weighted multi-attribute decision analysis.
Nahapiet and Nahapiet	1985	Weighted multi-attribute decision analysis.
National Economic Development Office (NEDO)	1985	Unweighted multi-attribute decision analysis as a procurement path decision chart.
Al-Sinan and Hancher	1988	Weighted multi-attribute decision analysis.
Skitmore and Mardsen	1988	Weighted multi-attribute decision analysis with NEDO as a basis with concordance and discriminant analysis.
Bennett and Grice	1990	System based on the NEDO and Skitmore and Marsden using a weighted multi-attribute decision analysis.
Franks	1990	Unweighted multi-attribute decision analysis, rating systems.
Singh	1990	Weighted multi-attribute decision analysis using NEDO.
Mohsini	1993	Knowledge-based expert system based risk and control.
Chan, Tam, Lam and So	1994	Weighted multi-attribute decision analysis.
Gorton	1994	Personal judgment in decision tree flowchart.
Liu	1994	Organizational behavior-based model with decision tree.
Masterman	1994	Decision support system based on weighting descriptors.
Skitmore, Martin and Love	1995	Weighted multi-attribute decision analysis/questionnaire.
Hibberd and Djebarni	1996	Expert knowledge by questionnaire/survey.
Eccles, O'Reilly and Stovin	1997	Probabilistic techniques.
Griffith and Headley	1997	Decision trees, procurement guidance manual and weighted multi-attribute decision analysis.
Spink	1997	Graphical guidelines from expert knowledge.
Ashworth	1998	Development of ELSIE, software system that acts as an intelligent advisor, Expert system
Dell'Isola, Licameli, and Arnold	1998	Unweighted multi-attribute decision analysis.
Gorton and Smith	1998	No methodology. Presented PDM variables.
Love, Skitmore, Martin and Earl	1998	Weighted multi-attribute decision analysis with Singh 1990 and Skitmore and Mardsen 1988 as basis.
Molenaar and Songer	1998	Data collected through case study analysis with weighted multi-attribute and linear regression modeling.
Miller and Evje	1999	Variable sorting system "CHOICE" using Excel.
Alhazmi and McCaffer	2000	Weighted multi-attribute decision analysis and analytic hierarchy process; multi-criteria/multi-screening.
Ambrose and Tucker	2000	Weighted multi-attribute decision analysis.
Kumaraswamy, Palaneeswaran and Humphreys	2000	Knowledge-based decision support system using expert system modeling.
Chan, Yung, Lam, Tam and Cheung	2001	Delphi technique to develop a weighted multi-attribute selection model.
Cheung, Lam, Leung and Wan	2001	Analytical hierarchy process to develop a weighted multi-attribute selection model.
Construction Industry Institute	2001	Weighted multi-attribute selection model using Excel.
Oyetunji	2001	Weighted multi-attribute selection model as a decision support tool using Excel spreadsheets.
Ribeiro	2001	Case-based framework.
Sidwell, Kennedy, Bennett, Chan	2001	Decision support system logic based on past decisions.
Tookey, Murray, Hardcastle and Langford	2001	Case study analysis based on Masterman [1994] selection model.
Chang and Ive	2002	Weighted multi-attribute selection model critique.
Khalil	2002	Analytical hierarchy process to develop a weighted multi-attribute selection model.
Luu, Ng, Chen, and Lam	2002	Fuzzy procurement selection criteria.
Almazroa	2004	Analytical hierarchy process to develop a weighted multi-attribute selection model.
Mahdi and Alreshaid	2005	Analytical hierarchy process for decision support system.
Mafakheri	2006	Analytical hierarchy process for decision support system.
Oyetunji and Anderson	2006	Multi-attribute rating technique with swing weights.
Ratnasabapathy and Rameezdeen	2006	Delphi surveying techniques to assess variables.

3.2.3 Selection Models: 1980 - 1989

Singh (1980), the National Economic Development Office (1985), Nahapiet and Nahapiet (1985), Nguyen (1985), Al-Sinan and Hancher (1988) and Skitmore and Mardsen (1988) are among the first to publish on selecting an "optimal" project delivery method. A 1985 model proposed by the National Economic Development Office (NEDO) is cited in multiple subsequent articles as the basis for further model development. NEDO develops a weighting/decision analysis rating system used commonly in value engineering sciences which uses a clients project priorities to assess the optimal delivery method. This rating system is a response to the NEDO report 10 years earlier. Singh (1980) and Skitmore and Mardsen [1988] also propose multi-attribute methodology techniques using weighted averages to project criteria; Skitmore and Mardsen then employ a discriminant analysis, which suggests statistical significance to their model. The model from Skitmore and Mardsen is based on the NEDO model. Al-Sinan and Hancher [1988] propose two models: a project delivery selection model (PDSM), and a project delivery decision model (PDDM), which are intended to assist developing countries in selecting a project delivery method also using a series of weighted averages.

In the earliest studies, Nahapiet and Nahapiet (1985) are the first to propose that other factors exist in addition to the project's technical characteristics that affect the choice of project delivery method. Their research suggests that there are unique characteristics of the client that affect the choice of delivery method, and also suggests that similar clients with similar project requirements may have comparable and consistent priorities. Their research also deems every project unique, and thus suggests that there is not a "one size fits all" project delivery method. This also suggests that project delivery method selection will require subjective assessment usually derived from experts' experiences.

The methods from Singh, NEDO, Nahapiet and Nahapiet, Al-Sinan and Hancher and Skitmore and Mardsen involve using expert observers or the client to weigh the importance of project criteria and its applicability to each project delivery method. A weighted evaluation method is suggested, which may then be supported by discriminant analysis and/or linear regression to indicate statistical significance of such findings. Discriminant analysis suggests examination of data collected under a set of criteria that are characteristics of which various procurement methods are expected to differ. Thus, procurement paths can be discriminated against for decision-making purposes.

3.2.4 Selection Models: 1990 - 1999

In the early 1990s, unweighted and weighted multi-criteria evaluation techniques as rating systems are present in the majority of published research. Multi-attribute decision analysis is a tool to measure objectivity in a subjective area of management. The multi-attribute technique is commonly associated as the foremost technique appropriate for examining criteria using weights and ratings in the most objective way (Love at al., 1998). Many of these studies employ surveying techniques in determining the importance of such variables.

Franks (1990) uses a rating system based on the ability of each procurement system to meet seven common satisfying criteria on a scale of one to five. Bennett and Grice (1990) develop a modeling system, based on the 1985 NEDO and the 1988

Skitmore and Marsden models, using a weighted multi-attribute decision analysis to establish strengths and weaknesses of such methods. Singh (1990) expands his 1980 research with a weighted multi-attribute decision analysis using the 1985 NEDO as a basis. Mohsini (1993) develops a computer program acting as a knowledge-based expert system, a "project acquisition strategy consultant" which establishes the project characteristics and bases the decision on the client's posture towards project control and risk.

Chan, et al. (1994) develop a weighted multi-attribute decision analysis as a rating system. This research is expanded and published in 2001. Gorton (1994) develops a decision tree flowchart based on project variables. Liu (1994) presents a cognitive perspective where the organizational behavior is modeled as an act-to-outcome process using a decision tree methodology. The act-to-product is the project definition and pre-design stage, and the product-to-outcome is the post-occupancy stage. Liu suggests that the decision-maker should "take into account the effect of these moderators using conjoint analysis (a technique used to model a decision-maker's judgment profile)."

Skitmore, at al. (1995) develop a weighted multi-attribute decision analysis based on results from a questionnaire. Hibberd and Djebarni (1996) survey 64 experts with a questionnaire on project delivery method criteria and satisfaction. Eccles, et al. (1997) employ probabilistic techniques for determining project delivery selection, using two selection variables of time and cost. Griffith and Headley (1997) develop a weighted multi-attribute decision analysis specific to small works projects. Konchar (1997) employ statistical techniques and linear regression in the analysis of multiple projects to determine the least cost and time in the evaluation of project delivery methods. Spink (1997) presents graphical guidelines as an aid to making a selection.

Ashworth (1998) develops an expert computer system as a decision analysis in method selection. Dell'Isola, et al. (1998) also present a decision tree analysis. Gorton and Smith (1998) provide guidance on advantages and disadvantages of each method. Love, et al. (1998) offer a questionnaire to base a multi-attribute weighted decision analysis. Molenaar and Songer (1998) employ statistical techniques using a questionnaire on satisfaction of design-build, which considers a variety of variables. Miller and Evje (1999) suggest that the choice of project delivery method should be determined based on the portfolio of projects, and offer a sorting system using Excel to aid in the decision. "CHOICE" links project financing with method selection. The software theory is that financing constraints dictate the choice of delivery method.

3.2.5 Selection Models: 2000 - 2006

In the 2000s, unweighted and weighted multi-criteria evaluation techniques as rating systems continue to be present in the majority of published research. Alhazmi and McCaffer (2000) provide a four-step process based on an analytic hierarchy process: (1) feasibility ranking; (2) evaluation by comparison; (3) weighted evaluation; and (4) expert source software. Ambrose and Tucker (2000) present an overview of existing models and then suggest a weighted multi-attribute decision analysis.

Kumaraswamy, et al. (2000) suggest a knowledge-based decision support system using expert system modeling. Chan, at al. (2001) employ the Delphi technique with a weighted multi-attribute selection model. The authors use four rounds of Delphi surveys with experts to determine a statistically significant consensus on the weighting of the utility factors for each procurement system.

Cheung, et al. (2001) provide a weighted multi-attribute selection model using an analytical hierarchy process to assess choices. Kumaraswamy and Dissanayaka (2001) conduct a study in Hong Kong using a sampling of building projects and professionals, which is structured into sample core modules for a knowledge-based decision support system. The Construction Industry Institute (2001) offers a decision support tool consisting of Excel spreadsheets, using compensation approach charts as a basis for selection. Oyetunji (2001) also provides a weighted multi-attribute selection model as a decision support tool using Excel spreadsheets.

Ribeiro (2001) presents a case-based framework for project delivery method selection. Case-based reasoning is a problem solving technique based on participant or expert experiences. Sidwell, Kennedy, Bennett, and Chan (2001) suggest a decision support system logic based on a continuous feedback system in the form of an Excel database, building on past actions as a best practice. Tookey, Murray, Hardcastle, and Langford (2001) present a case study analysis based on Masterman's (1994) method selection model. Their research attempts to substantiate Masterman's selection model using four case studies. Chang and Ive (2002) analyze the weighted multi-attribute selection model critique commonly used in project delivery method selection, and discuss potential pitfalls in its application. They suggest that linking coefficients on variables to method selection is flawed, and instead suggest developing expert systems to replace the coefficients, or a transaction-cost-based procurement route. This bases the choice of method selection in the context of the project rather than the owner's general preferences.

Khalil (2002) employs an analytical hierarchy process to solve unstructured problems in decision-making in method selection. Owners assign weights to the hierarchical project variables which are separated into three categories: owner needs, project characteristics, and owner preferences.

Luu, et al. (2002) offer fuzzy procurement selection criteria to project delivery method selection for projects in Australia. They suggest that selection of project criteria involve judgments and thus could be fuzzy or vague. The authors conduct surveys to verify variable importance in method selection, and normalize each variable. Almazroa (2004) employs a weighted multi-attribute selection model based on variables analyzed through questionnaires to construction industry professionals, and simultaneously conducts an analytical hierarchy process. Variables are segmented into three categories: project factors, owner objectives, and project parameters. Methods are compared to determine whether each method achieves the same result.

Mahdi and Alreshaid (2005) and Mafakheri (2006) both suggest an analytical hierarchy process for a decision support system, and also both present a case study to represent the method. Oyetunji and Anderson (2006) suggest the multi-attribute rating technique with swing weights as representatives of the Construction Industry Institute. The Oyetunji and Anderson research suggests that it is the only selection methodology that bases method selection based on quantitative metrics, using a simple multiattribute rating technique with swing weights (SMARTS). Most recently, Ratnasabapathy and Rameezdeen (2006) employ Delphi surveying techniques to assess variables.

3.2.6 Critical Analysis of Selection Models

The first section of this chapter provides an analysis of previously published research that seeks to assist public owners in choosing a project delivery method for their design and construction project. Methodologies used in previous research are investigated and the literature search reveals that extensive research exists on the subject of project delivery method selection, with earliest publications nearly three decades ago. The literature review also reveals that the volume of publications on the subject grows every year. An analysis of the literature suggests that the majority of research is based on a weighted multi-attribute decision analysis technique (MAUA); only in the past decade do alternate methodologies surface, such as the Delphi surveying, analytical hierarchy process, and, most recently, fuzzy logic. Other methodologies become more prevalent in the research because MAUA, while more commonplace, is often considered subjective. Skitmore and Mardsen (1988) suggest that "factor weights cannot be obtained easily by objective means and have to be elicited from practitioners in the field and it has been reported that practitioners have found difficulty in reaching a consensus on such matters." Skitmore and Mardsen also state that client priority ratings must be established using MAUA for each project. This can be further exacerbated for clients who may not have the necessary construction industry experience even to produce an adequate brief. MAUA methodology also does not consider evolving circumstances. MAUA represents a fixed place in time, and often cannot be repeatable.

The literature also reveals that there are difficulties with some or all of the models. Models are conditional and, therefore, are not widely applicable. Some models require advanced mathematical techniques which may not be user-friendly and can be time-consuming. Models do not consider the changing environment of the construction industry. They are not capable of continuous learning and do not build on existing or past modeling for future decisions. Many models are also applied to specific industries and rarely do models address public or government agencies. To continue the analysis of published research on the subject, this literature review extrapolates the selection variables or factors that each study considers in the next section, with specific emphasis on legislative limitations and the regulatory environment in support of testing the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

3.3 Selection Variables in Model Development

The first part of this chapter reviews published research that aids owners in selecting a project delivery method. While a review of such research is relevant, a critical analysis of the literature reveals that selection variables are the common component to the development of all models, and ultimately determined which method is chosen. It is important then to perform a literature search to extrapolate which variables are suggested. The employment of specific variables may predict or drastically manipulate the outcome of the selection model. Therefore, variables considered integral to project delivery method selection are extrapolated from the cited research and are described in the following sections.

3.3.1 Analysis of Selection Variables

In performing the literature search on the research presented earlier in this chapter, it is suggested that all models ignore important variables to method selection. Also, as suggested in this literature review, variables integral to project delivery method selection are numerous. The literature review reveals nearly 70 variables from the more than 40 sources. Managing these selection variables during program definition further exacerbates reaching a consensus with multiple stakeholders in project delivery method selection. These variables are extrapolated from the cited sources to provide further support for the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

In performing this literature review, variables that refer to the same underlying concept are grouped together. For example, *Speed* is identified as a factor in the majority of the cited sources and is interpreted differently. Some sources interpret *Speed* in commencement of design – how fast design can be completed - while others refer to *Speed* in context of the full project – how fast the design and construction can be completed. All interpretations are included in this one variable. Also, these variables are ranked by number of sources cited. *Speed* is the most cited variable in project delivery method selection, with 19 sources (nearly 50 percent) citing it as a major factor. The other top five factors are *Certainty*, *Flexibility*, *Quality* and *Risk*.

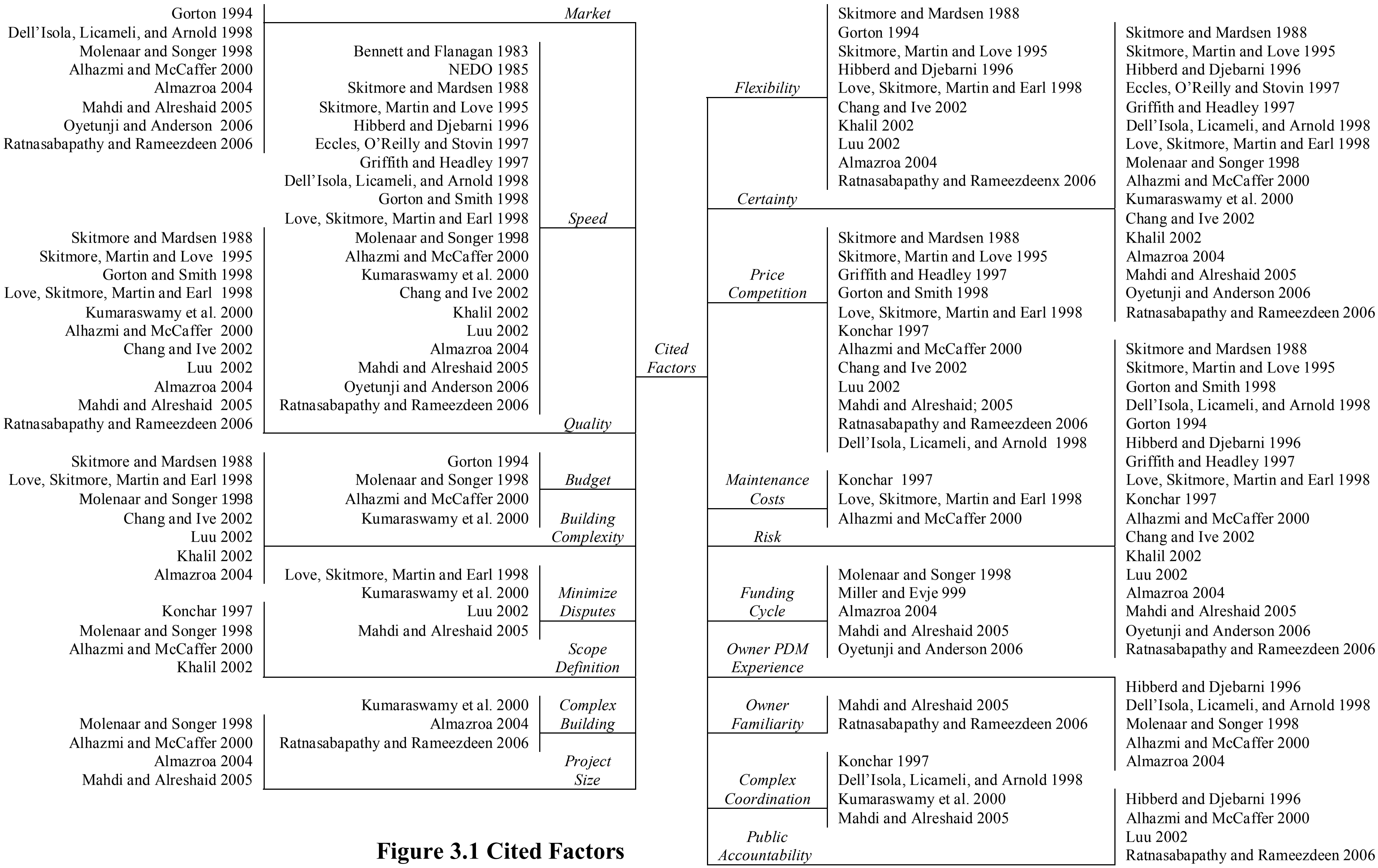


Figure 3.1 Cited Factors

Owner In-house Staff Experience. 2000 Alhazmi and McCaffer
Legal limitations of Procurement Choices. 1994 Gorton; 1998 Dell'Isola, Licameli, and Arnold
Owner's Business Goals. 1997 Griffith and Headley
Design of Specifications, Prescriptive- or Performance-based. 1998 Molenaar and Songer
Procurement allows additions to scope. 1998 Molenaar and Songer
Project has contingency allowance. 1998 Molenaar and Songer
Appropriate or non-appropriated funding. 1998 Molenaar and Songer
Interest in Emerging Design and Construction Processes. 1998 Molenaar and Songer; 2004 Almazroa
Repetitiveness of design elements. 1998 Molenaar and Songer
User's expectations. 1998 Molenaar and Songer; 2000 Alhazmi and McCaffer
Owner administrative burden. 1998 Molenaar and Songer; 2005 Mahdi and Alreshaid
Attitude toward changes and claims. 1998 Dell'Isola, Licameli, and Arnold
Need for early construction expertise. 1998 Dell'Isola, Licameli, and Arnold; 1994 Gorton
Attitude toward negotiation. 1998 Dell'Isola, Licameli, and Arnold
Labor relations policy. 1998 Dell'Isola, Licameli, and Arnold
Ability to bond work. 1998 Dell'Isola, Licameli, and Arnold; 2004 Almazroa
Complexity of contractual relationship. 1998 Dell'Isola, Licameli, and Arnold; 2005 Mahdi and Alreshaid
Type of facility. 1998 Dell'Isola, Licameli, and Arnold; 1997 Konchar
Client satisfaction. 2000 Kumaraswamy, Palaneeswaran, and Humphreys
Client confidence in construction team. 2000 Kumaraswamy, Palaneeswaran, and Humphreys
Team motivation. 2000 Kumaraswamy, Palaneeswaran, and Humphreys; 2000 Alhazmi and McCaffer
IT utilization/Data Management. 1997 Konchar ; 2000 Kumaraswamy, Palaneeswaran, and Humphreys
Client participation. 1997 Konchar
Constructability. 1997 Konchar; 2002 Khalil; 2004 Almazroa
Aesthetics. 1997 Konchar
Value engineering. 2002 Khalil; 2005 Mahdi and Alreshaid
Contract packaging. 2002 Khalil
Involvement after Award. 2002 Khalil
Political consideration. 2002 Luu; 2004 Almazroa
Safety. 2000 Alhazmi and McCaffer; 2004 Almazroa
Regulatory environment. 2004 Almazroa; 2006 Ratnasabapathy and Rameezdeen
Ensure confidentiality. 2004 Almazroa; 2006 Oyetunji and Anderson
Owner understanding of project scope. 2005 Mahdi and Alreshaid
Owner benefits from cost savings. 2005 Mahdi and Alreshaid
Desired contractual relationship. 2005 Mahdi and Alreshaid
Interest in contractor input. 2005 Mahdi and Alreshaid
Clarity of defined roles. 2005 Mahdi and Alreshaid
Conflict of interest. 2005 Mahdi and Alreshaid
Return on investment. 2006 Oyetunji and Anderson
Proprietary technology. 2006 Oyetunji and Anderson
Owner assumes minimal financial risk. 2006 Oyetunji and Anderson
Early procurement of long lead items. 2006 Oyetunji and Anderson
Socio-cultural suitability. 2006 Ratnasabapathy and Rameezdeen
Contractor punctuality. 1996 Hibberd and Djebarni
Dissatisfaction with previous procurement method. 1996 Hibberd and Djebarni
Continue existing working relationships. 1996 Hibberd and Djebarni
Existing building disruption. 2000 Alhazmi and McCaffer
Complex subcontracting arrangements. 2000 Kumaraswamy, Palaneeswaran, and Humphreys

Figure 3.1 Cited Factors

The research problem defined herein, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, is highlighted in this literature search. Only two publications suggest legislative limitations of procurement choices as a variable in project delivery method selection: Gorton (1994) and Dell'Isola, Licameli, and Arnold (1998). Further, only two others suggest the regulatory environment as a factor in method selection: Almazroa (2004) and Ratnasabapathy and Rameezdeen (2006). Thus, only four of all cited sources suggest legislative impediments as a factor in project delivery method selection, and all four of those sources does not go further in analyzing the impact of such variable.

Gorton (1994) examines the compatibility of various construction contracting methods with certain types of owners and projects, with one of the types of owners being government or public agencies. Gordon concludes that the traditional method of project delivery, design-bid-build, is most appropriate because of its competitive bidding process, and suggests that alternative methods may be appropriate in some cases. However, Gorton's work was written prior to the passage of the 1996 Clinger-Cohen Act, when design-build was authorized by the Federal government for use, and its conclusions may not be relevant today.

Dell'Isola, Licameli, and Arnold (1998) identify factors that relate to a particular project for a specific owner and suggest "legal limitations over owner's procurement choices." Legal limitations or their applicability to the regulatory environment are not explored further in this research.

Almazroa's (2004) dissertation research from the University of Pittsburg's School of Engineering, involves the development of a project delivery system decision framework. Almazroa explores the variables to assist a project owner in Saudi Arabia to determine what type of PDS to select for a building project, using three project delivery methods in the analysis: design-bid-build, design-build, and construction management at-risk. This research studies whether there are differences in cost, duration, quality, and safety using a qualitative questionnaire approach, similar to the qualitative study performed in this research and presented in Chapter 2. *Political consideration and government limitation* is suggested as a project parameter or key decision point in the qualitative survey, which is also included in the literature review of earlier studies. The research concludes that the design-bid-build method of project delivery is preferred by the study participants when considering politics and government limitations. However, this research does not explore government limitations of project delivery methods other than to include it as a parameter in the qualitative study and as a suggested variable when a public owner is deciding among delivery methods.

Ratnasabapathy and Rameezdeen (2006) develop a multiple decisive factor selection model using Sri Lanka as a case study, stating that, "the government, as the regulator and a major client, has neglected the development of alternative procurement methods (p. 4)." The *regulatory environment* is presented as a variable under external environment factors and is tested using a qualitative approach. This research is similar to Almazroa in that qualitative responses are solicited. The difference in this research is that the Delphi technique is used in developing a decision support system for Sri Lanka, rather than using an analytical hierarchy process, as in Almazroa. Also, this research, like the others, does not explore the regulatory environment other than to include it as a parameter in the qualitative study and as a suggested variable when a public owner is deciding among delivery methods.

The research presented herein is, therefore, timely in its application. Four recent studies have identified legislative limitations and the regulatory environment as factors to consider when choosing a project delivery method. However, there has been no research to date that has taken a quantitative approach to test whether legislative limitations affect project delivery method selection, or has taken any approach to identifying and analyzing the effect of legislative limitations specific to project delivery method selection on the construction industry.

3.4 Summary

This chapter begins with a review of previously published studies with hypotheses similar to the one in this research, determining whether benefits exist under various project delivery methods. Decision selection models are explored and methodologies applied to those studies are investigated. A chronological presentation of such studies is presented and suggested selection variables are extrapolated from those studies. It is determined that only four previous studies (of 42) identify legislative limitations and the regulatory environment as factors to consider when choosing a delivery method. Prior studies assist public owners in project delivery method selection; however, the models presented are not specific to legislative limitations of working in a regulatory environment. When legislative limitations and the regulatory environment are discussed in prior studies, none take a methodological approach to determine their effect on project delivery method selection. This research, thus, is timely in its application. As presented, there are still many states that do not allow alternative project delivery methods, such as design-build and construction manager at-risk. And as presented in the next two chapters, even with the passage of the Clinger-Cohen Act in 1996, the Federal government still does not embrace design-build as a viable method.

CHAPTER 4

QUANTITATIVE RESEARCH

4.1 Purpose

The previous chapter provides more-detailed basis for discussion on the research by presenting previously published literature on project delivery methods, specifically focusing on peer-reviewed decision support systems to assist public owners in selecting a project delivery method. It also investigates prior studies similar to the problem of this research, and extrapolates variables from those studies. An analysis of the previous chapter indicates that only four studies have addressed the regulatory environment and legislative limitations as predictors for project delivery method selection, the intent of this research, and of those studies all have only suggest those variables as possible parameters to use in decision support systems. None of those studies explore the impact of the regulatory environment and legislative limitations to the construction industry.

The goal of this chapter is to take a quantitative approach to determining whether benefits exist to a public owner when alternative project delivery methods, specifically design-build, are used for a construction project, and whether legislative limitations allowing the use of such alternative methods impede such benefits to be realized. The chapter begins by discussing the methodology technique chosen, and then presents data from the U.S General Services Administration (GSA) to measure outcomes based on a chosen project delivery method. The idea for this research originates from a design-build training session facilitated by the researcher for the U.S. General Services Administration, Region IV (GSA). GSA is using a selection model from the

Construction Industry Institute (CII, 2004), which continually yields the same project delivery method, design-build. So while its users have unique project-specific characteristics and variables applied to the CII model, it yields the same results, thus indicating a flaw with the CII model. The qualitative study as presented in Chapter 2 indicates that government agencies engaged in construction activities have regulatory requirements that may not be addressed in existing selection models, and Chapter 3 presents that four previous studies suggest the regulatory environment and legislative limitations as possible variables when using a decision support system. The research the presented in this chapter and in Chapter 5 takes a quantitative approach to investigate whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

4.2 Research Chronology

Real-world problems may often be too complex to be analyzed and, as such, studies are undertaken by the research community to be abstractions of such real-world problems. Research is investigated by taking a simplified version of the problem, and focusing on a certain point-of-view to analyze the problem. The purpose of this research is to identify the difference among project delivery methods and provide a basis for their performance, as shown in the methodology used in this research and graphically depicted in Figure 4.1. The methodology for this research begins with a qualitative study to determine industry perceptions of alternative project delivery methods, as presented in Chapter 2. This qualitative research indicates that state limitations bar or severely restrict the use of design-build, even though there are positive perceptions in the construction industry of design-build and construction manager at-risk. A literature review of Federal and State legislative trends is performed in Chapter 2 to analyze legislative limitations in using alternative delivery methods for government construction projects. Concurrently, a literature review is performed for previous delivery method selection research to identify studies that address legislative limitations in the selection model criteria, as presented in Chapter 3. Chapter 3 also analyzes legislative limitations and existing selection model research to provide a background study for testing the hypothesis. The qualitative study and the literature reviews prove valuable in supporting the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized. The next step in the research is to gather data from public owners to test such hypothesis, and to inquire into the problem of method selection and draw conclusions using a quantitative approach.

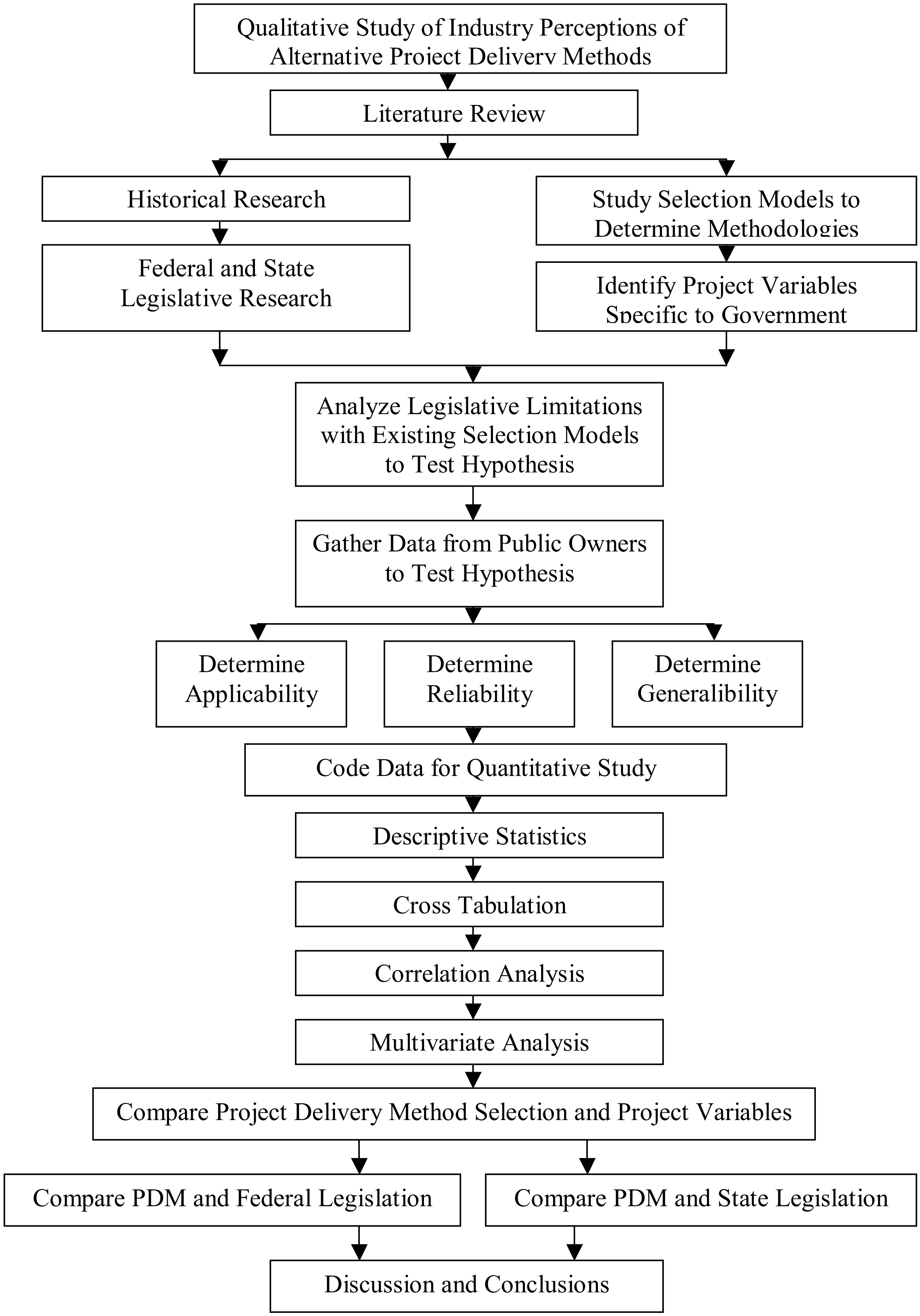


Figure 4.1 Research Methodology

Quantitative research addresses a problem by testing a hypothesis or theory composed of variables, which are analyzed with statistical procedures to determine whether the hypothesis or theory holds true (Crestwell, 1994). This research tests a set of interrelated variables that present a systematic view of the project delivery methods selection process by specifying legislative relationships among the variables to explain the selection process. This research takes a quantitative approach beginning with descriptive statistics of the dataset variables, and then analyzing them using cross tabulation, comparing the joint distribution of two variables. The common variable in all cross tabulation analyses is the project delivery method. The dataset is then researched more in depth to determine whether a correlation exists between the variables in the database and the project delivery method. This will indicate the strength and direction of a linear relationship between the project delivery method and the other project variables. A final quantitative test involves observation and analysis of more than one statistical variable at a time, known as multivariate analysis (Garson, n.d.), and results in the use of multivariate flowcharts or models to analyze the hypothesis. In design and analysis, this technique is used to perform studies across multiple dimensions while taking into account the effects of all variables on, in the case of this research, the project delivery method. Using this technique analyzes all concepts with respect to changing scenarios, as is more akin to the changing environment of the construction industry. Taking a quantitative approach to test such relationships is regarded within the research community as acceptable if such data for testing is reliable. This research uses a series of quantitative models to test the hypothesis, and these models are intended to support the decision making process of choosing a project delivery method. This research does not create a decision support system model, in which information is inputted in a model and then the model offers a "best choice" project delivery method to the user. Rather, this research provides analysis to be used in decision making, and offers owners additional information that should be considered when using any of the 42 decision support system models that exist in the construction industry. The next section discusses the dataset chosen to test the hypothesis and provides substantial support for reliability of the data.

4.3 SPSS and Data Coding

To test the hypothesis using a quantitative method of analysis, statistical software is procured. Several software programs are considered and SPSS is chosen because it has the capability of handling complex data manipulations and analyses, in addition to being user-friendly. For this reason, SPSS also is used by more than 250,000, public sector, academic and commercial customers worldwide (SPSS, 2008). Because this research focuses on the public sector and is being used for academic purposes, SPSS seems the logical choice. SPSS is used to assist the researcher in analyzing the hypothesis by generating tabulated reports, charts, and plots of distributions and trends, as well as descriptive statistics, cross tabulations, and correlation and multivariate analyses. Those tools are widely used throughout the construction industry and are applied in this research.

Once SPSS was procured, then decisions about coding are made. These decisions were made on the basis of what has been learned from previous studies and what will lead to the best functioning of testing the hypothesis in this research. Data is coded to meet the requirements of the SPSS software. In SPSS, each row in the database represents a different project. The columns in the database represent the variables that have been measured about each project. For each project, variables may include the name of the project, its location, the type of project, the estimated cost of the project, and the duration of the project. Each of these project characteristics is a variable and, until some particular analysis is undertaken, they are all variables in the analysis. For some variables, the researcher enters the number of the project characteristic, such as the year the project started. For other characteristics, the researcher has to invent a coding system. Such a system is, therefore, random. To represent the political party supporting the project, the researcher uses 0 for Republican and 1 for Democrat. What becomes important is to enter the numbers consistently to allow the statistical software to recognize that variable and perform the analyses. SPSS allows the researcher to enter "Republican" and "Democrat" (by changing the Type of variable from Numerical to a String), but the software is limited in the sorts of analyses that can be conducted. Also, as an example, for delivery methods, the researcher uses 0 for design-bid-build, 1 for design-build, 2 for construction manager at-risk/construction manager as-constructor, and 3 for design-build-bridging. These types of coding techniques are applied to all variables in the database. Specifics about the database, the projects contained within, and the variables or project characteristics are explained in detail in the next section.

4.4 Descriptive Statistics

The data used to test the research hypothesis, whether benefits exist to public owners when using alternative project delivery methods and whether benefits exist to public owners when legislative impediments are lifted, and alternative project delivery methods are allowed to be used, is provided from GSA's Project Information Portal (PIP). The PIP is a nationwide system for tracking the GSA Public Buildings Services (PBS) capital construction program. GSA is divided into 11 geographical regions, with its central administrative functions located in Washington DC, its National Capital Region. The National Capital Region developed the PIP as a web-enabled construction project fact sheet that is updated monthly by a designated project leader. The PIP allows reports to be generated based on the information contained in the database. These reports are provided to Congress and GSA executives to access information across regions. Because this dataset is a Congressional tool, the researcher deems the information contained to be reliable.

> Extensive report development has provided PBS executives with views across their regions and by customers that previously had been very difficult and time consuming to obtain. The PIP has helped PBS achieve its goal of keeping a "finger on the pulse" of a multi-billion capital construction program. PIP has achieved this by providing executive roll-ups of information, including a real-time dashboard of issues and actions for all projects in the portal. Updating projects by the project managers takes less than 30 minutes per month. Cultural and organization resistance to change is gradually being overcome by continuing to establish communication, trust and confidence between the project manager, the executive and the customer. Communication builds trust, and trust builds confidence that the system will provide reliable and up to date information. GSA can expect to save almost $2.4 million annually, or about $12 million over a 5-year horizon when the PIP will be fully functional through reduced reporting requirements by project managers. The unique qualities of PIP are its graphically pleasing, highly intuitive user interface and easy to understand and navigate information architecture. From a program level overview to a detailed list of projects for each PBS region, the information is easy to find and easy to update. The display of a project, from its design renderings, construction photos, or completed project views, makes the portal a destination for anyone within GSA who wants to know the progress, images, and detailed data about a project (Hagan, 2008).

The PIP tracks prospectus projects. A prospectus project is a capital construction or lease project above the prospectus level of funding. A capital construction project refers to construction projects on buildings that are owned by GSA. Lease projects are construction projects in buildings that are leased by GSA. Annual prospectus thresholds are designated by Congress and are referenced in Section 102-73.35 of the Federal Management Regulation (FMR).

Table 4.1 Prospectus Thresholds by Program Year in Millions of Dollars

Fiscal Year	Construction, Alteration and Lease Projects	Alterations in Leased Building
2009	2.66	1.330
2008	2.59	1.2950
2007	2.54	1.2700
2006	2.41	1.2050
2005	2.36	1.1800
2004	2.29	1.1450
2003	2.21	1.1066
2002	2.13	1.0651
2001	1.99	0.9971
2000	1.93	0.9660
1999	1.89	0.9432
1998	1.81	0.9053
1997	1.74	0.8393

Table 4.1 provides annual prospectus levels for projects tracked in the database. The data used in this research is taken at one point in time on November 30, 2007. At that time, the data consists of 496 prospectus projects, spanning 20 years, from 1988 to 2008, and representing $19,594,836,588 in total estimated projects costs and 180,836,593 gross square feet in space. Table 4.2 provides the number of projects by

fiscal year that span the 20 years in the database.

Table 4.2 Number of Projects by Program Year

Fiscal Year	Number of Projects (Frequency)	Percent
1988	2	.4
1989	1	.2
1990	1	.2
1991	5	1.0
1992	12	2.4
1993	8	1.6
1994	6	1.2
1995	17	3.4
1996	2	.4
1997	19	3.8
1998	0	0
1999	21	4.2
2000	21	4.2
2001	27	5.4
2002	42	8.5
2003	22	4.4
2004	28	5.6
2005	34	6.9
2006	16	3.2
2007	13	2.6
2008	5	1.0
Total	**404**	**81.5**
Missing	92	18.5

Missing signifies that 92 projects in the database do not provide the fiscal year. These are considered missing data in the analyses.

The database includes project characteristics (or variables) to assist Congress and GSA executives to track the progress of such projects. These variables are: (1) Region; (2) Project Type; (3) Program Area; (4) Project Delivery Method; (5) Political Party; (6) Gross Area; (7) Usable Space; (8) Congress Authorization; (9) Conference Appropriation; (10) Central Office Allowance; (11) Estimated Total Prospectus Cost; (12) Estimated Total Prospectus Cost Site; (13) Estimated Total Prospectus Cost Design; (14) Estimated Total Prospectus Cost Construction; (15) Congress Authorization Year; (16) Planning Phase Duration; (17) Design Phase Duration; and (18) Construction Phase Duration. Several of these variables were grouped to analyze the data in more detail: (19) Congress Authorization to Construction Finish Duration; (20) Planning Start to Construction Finish Duration; and (21) Design Start to Construction Finish Duration. To test the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, the researcher adds two new variables to the database: (22) Federal Legislation and (23) State Legislation.

This database is selected for this research and the variables contained within it are used as a basis for discovery because GSA's Project Information Portal (PIP) is the most comprehensive database that could be found. This database also is required through congressional mandate and so the data (variables) within it are required through such mandate. Other variables in the construction industry exist, and may be applicable to this research. Adding more variables and expanding the list of variables is suggested as an area of future research. Definitions of each of these variables and descriptive statistics within the PIP used for this research follow.

4.4.1. Region

The GSA region represents where the project is located. There are 11 geographical regions in GSA: New England, Northeast and Caribbean, Mid-Atlantic, Southeast, Great Lakes, Heartland, Greater Southwest, Rocky Mountain, Pacific Rim, Northwest/Arctic, and National Capital Region. There is a wide distribution of projects among regions, as presented in Table 4.3 and Figure 4.2, with a disproportionately high number of projects in the National Capital Region, 117 or 23.6 percent. This region represents Washington DC. Please note that starting with Table 4.3, the table provides four columns that represent the data: (1) *frequency* is the number of projects in the dataset for that category – in Table 4.2 it represents the number of projects in each region; (2) *percent* is the percent of projects in each region compared to all projects; (3) *valid percent* is a check to determine if the data is correct – this is generated by the statistical software; and (4) *cumulative percent* adds the number of projects for the previous categories. In regional distribution, there is an average of 37 projects in each region after excluding the National Capital Region. The National Capital Region is an outlier in the regional distribution analysis because almost 25 percent of all projects are appropriated to this region. The Southeast Sunbelt and the Great Lakes have the highest with 53 and 51 respectively, and the Mid-Atlanta and the Northwest/Artic have the least number of projects with 26 and 21 respectively.

Table 4.3 Regional Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
New England	38	7.7	7.7	7.7
Northeast & Caribbean	36	7.3	7.3	14.9
Mid-Atlantic	26	5.2	5.2	20.2
Southeast	53	10.7	10.7	30.8
Great Lakes	51	10.3	10.3	41.1
Heartland	27	5.4	5.4	46.6
Greater Southwest	39	7.9	7.9	54.4
Rocky Mountain	42	8.5	8.5	62.9
Pacific Rim	46	9.3	9.3	72.2
Northwest/Arctic	21	4.2	4.2	76.4
National Capital Region	117	23.6	23.6	100.0
Total	496	100.0	100.0	

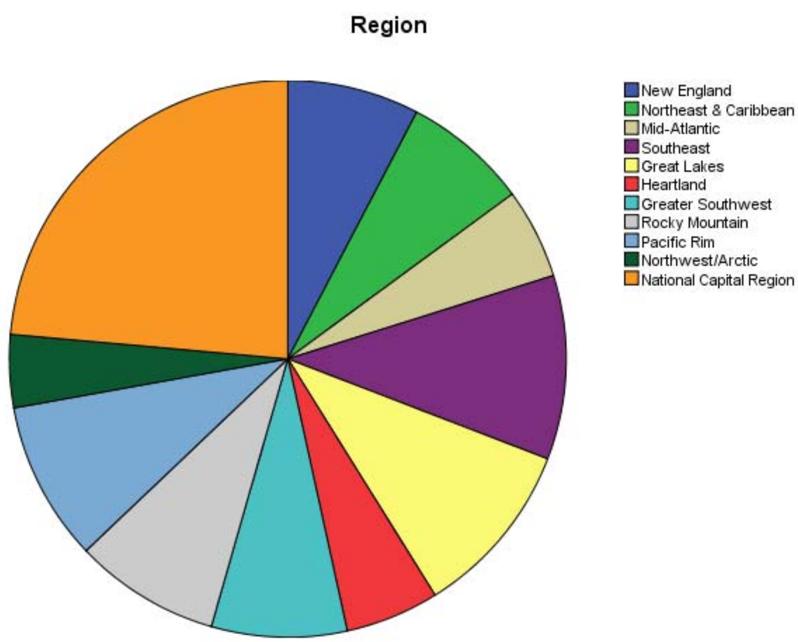


Figure 4.2 Regional Distribution

4.4.2. Project Type

The Project Type is the category of project to which the contract is awarded. There are three categories: Renovation and Alternation, New Construction and Lease-Construct. Forty-eight percent or 240 projects in the dataset are renovation and alternation, 40 percent or 202 projects are new construction, and 10 percent or 54 projects are lease-construct, as presented in Table 4.4 and Figure 4.3.

Table 4.4 Project Type Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Renovation & Alteration	240	48.4	48.4	48.4
New Construction	202	40.7	40.7	89.1
Lease-Construct	54	10.9	10.9	100.0
Total	496	100.0	100.0	

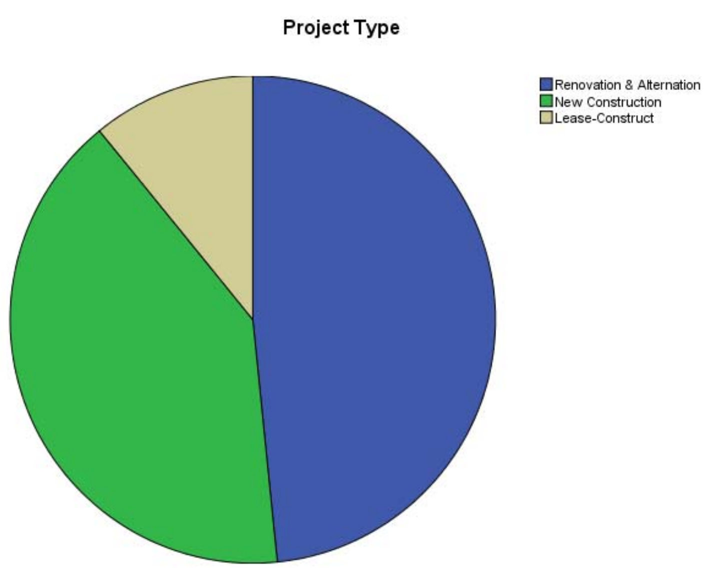


Figure 4.3 Project Type Distribution

4.4.3. Program Area

The Program Area is the particular program area of the project. There are three program areas: Federal Building, Border Station, and Courthouse. As presented in Table 4.5 and Figure 4.4, the majority are federal buildings, 64.7 percent and 321 projects. There are 80 courthouses representing 16.1 percent, and 95 border stations representing 19.2 percent.

Table 4.5 Program Area Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Courthouse	80	16.1	16.1	16.1
Federal Building	321	64.7	64.7	80.8
Border Station	95	19.2	19.2	100.0
Total	496	100.0	100.0	

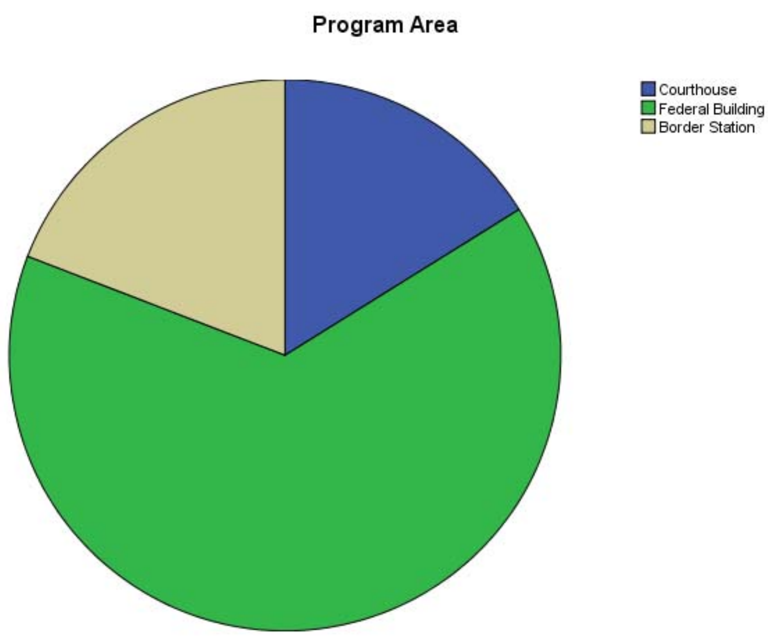


Figure 4.4 Program Area Distribution

4.4.4. Project Delivery Method

The Project Delivery Method is the way in which the procurement of certain facility construction contracts is handled. As mentioned in Chapter 2 of this research, multiple project delivery method variations exist in the construction industry. Chapter 2 provides definitions of 4 common project delivery methods: design-bid-build using single-prime bidding; design-bid-build using single-prime bidding, construction manager at-risk, and design-build. GSA applies several variations of these 4 primary project delivery methods. Establishing how these variations are used is critical to understand the results of the quantitative study.

First, GSA does not use the design-bid-build using separate-prime bidding method; however, GSA does use the design-bid-build using single-prime bidding and the design-build methods as explained in Chapter 2. GSA also has a variation of the design-build project delivery method, referred to as design-build-bridging. Instead of the public owner preparing a detailed project program as in design-build, in design-build-bridging, the public owner solicits a separate design entity, based on qualifications to complete the design through the design development phase. This design entity is referred to as a bridging architect. Once design is complete through the design development phase (approximately 35 percent), the public owner requests proposals to attract a design-builder to complete the design and perform construction. The balance of the design and construction phases is awarded to a single entity. Under this design-build variation, construction still typically begins before the design documents are complete, and the public owner hold two contracts, one with the design entity that completes the design through the design development phase, and a second contract with a design-builder who finishes the design and performs construction, as depicted in Figure 4.5.

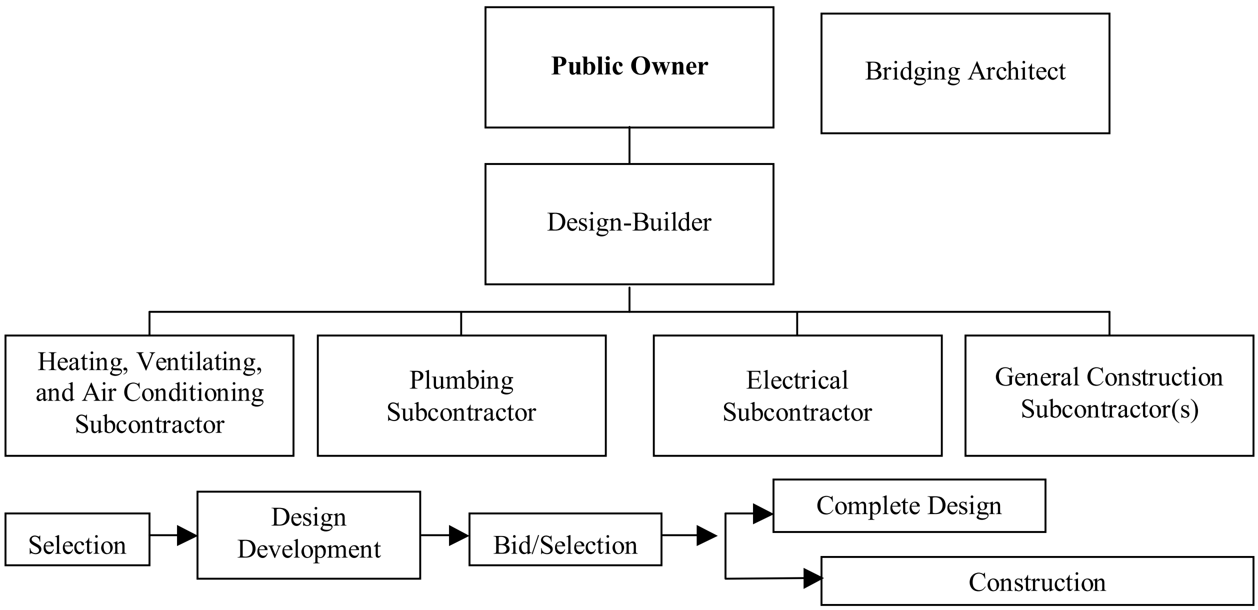


Figure 4.5: Design-Build-Bridging Organizational Chart

GSA also uses the construction manager at-risk method of project delivery; however, GSA also has a variation of this method and refers to that variation as construction manager as-constructor. GSA's construction manager as-constructor has the same four sequential phases of project delivery as in the construction manager at-risk project delivery method defined in Chapter 2: selection (of a designer), design, bid-selection (of a construction manager), and construction. First, GSA develops the project program and then requests proposals from prospective designers and then awards the contract on the basis of qualifications. The designer then develops design documents. During this process, GSA requests proposals from prospective construction managers and selects on the basis of qualifications and of cost. Once the construction manager is selected, the contract has two phases of execution. In the pre-construction phase, the construction manager works with GSA and the designers for constructability reviews until the design documents are usually complete. GSA has the option to determine how complete the design documents should be before construction negotiations begin. GSA has an option to negotiate the cost of construction based on a guaranteed maximum price, based on a fixed cost or based on a cost-plus-fee. Such fee structures are defined in Appendix A, and Figure 4.6 presents the construction manager as-constructor organization chart.

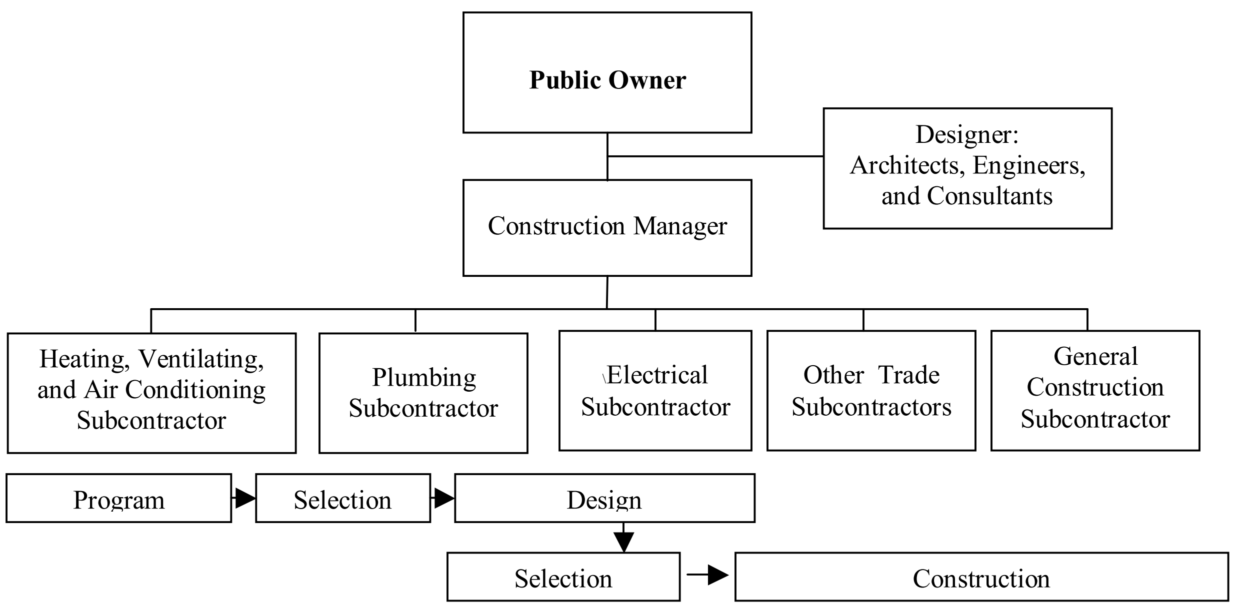


Figure 4.6: Construction Manager as-Constructor Organizational Chart

Within GSA's database, more than half of all projects are built using design-bid-build using single-prime bidding, or 252 projects, as presented in Table 4.6 and Figure 4.7. A cross tabulation of project delivery methods among other project characteristics is provided in Chapter 4.4 that will analyze the dataset further.

Table 4.6 Project Delivery Method Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Design-Bid-Build (Traditional)	252	50.8	50.8	50.8
Design-Build	100	20.2	20.2	71.0
Design-Build Bridging	69	13.9	13.9	84.9
Construction Manager as Constructor	75	15.1	15.1	100.0
Total	496	100.0	100.0	

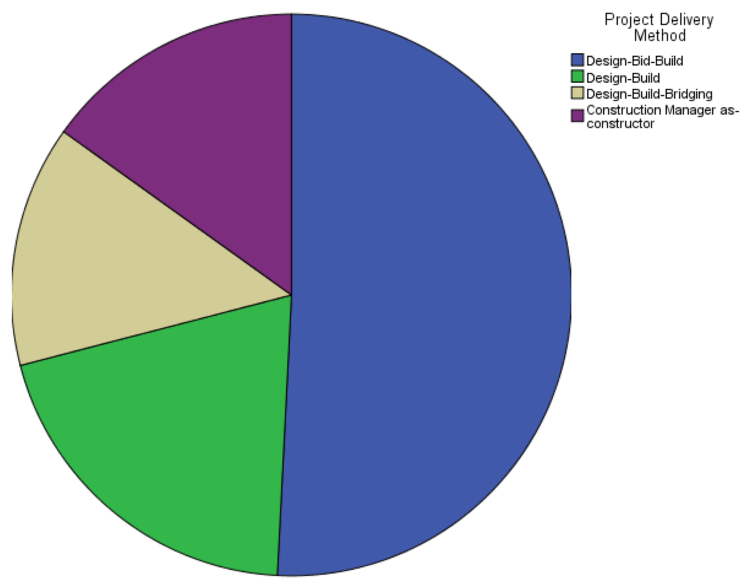


Figure 4.7 Project Delivery Method Distribution

4.4.5. Political Party

The Political Party represents the party affiliation of the incumbent member representing the Congressional district of project. There are two political parties presented in the database: Democrat and Republican. The majority of the projects in the database are supported by the Democratic Party, 73 percent, as presented in Table 4.7 and Figure 4.8. Fifteen percent are supported by a Republican Party member. Note that there are 55 projects, or 11.1 percent, in the database that do not identify political party representation. Those projects are noted on Table 4.7 as Missing Data.

Table 4.7 Political Party Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Republican	79	15.9	15.9	15.9
Democrat	362	73.0	73.0	88.9
Missing Data	55	11.1	11.1	100.0
Total	496	100.0	100.0	

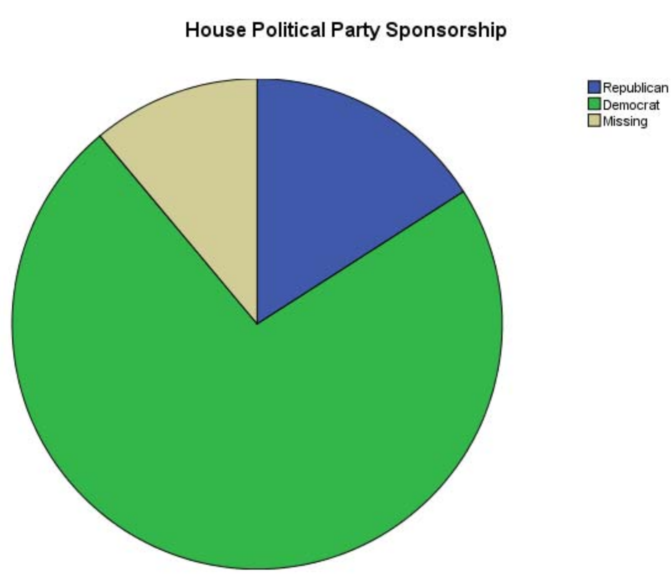


Figure 4.8 Political Party Distribution

4.4.6. Gross Area

The Gross Area represents the planned total gross area of building after completion. As presented in Table 4.7, the average gross area of projects in the dataset is 361,774 square feet.

4.4.7. Usable Space

The Usable Space represents the planned building area available for single-tenant occupancy and use after completion of the project. As presented in Table 4.7, the average usable are of space is 166,814 square feet or approximately 46 percent of the gross area.

4.4.8. Congress Authorization

Congress Authorization represents the total project funding Congress authorized. Understanding how funding is approved for a project is important to define Congress Authorization and the next two variables: Conference Appropriation and Central Office Allowance. A GSA region first sends a project in need of funding to GSA Central Office for consideration in the annual budget request. If Central Office approves of the request, that office submits the request to Congress for consideration. The request is considered by the House and supporters and opponents of the request debate. If passed by the House, the bill then moves to the Senate for consideration. When the House and Senate pass different versions of the same request (or different amounts of funding) a conference committee is appointed by the leaders of both chambers. The conference committee is given the task of resolving differences between the House and Senate versions. If the committee agrees, it goes back to both chambers for a final vote. If both chambers vote to support the request, then it goes to the White House for approval. At any step funding amounts can be changed. The PIP tracks the funding amounts starting with when and how much Congress authorized on the project.

4.4.9. Conference Appropriation

Conference Appropriation represents the total project funding Conference appropriated for the project.

4.4.10. Central Office Allowance

Central Office Allowance represents the total project funding allowed to date by GSA's central Office to the region executing the project.

4.4.11. Estimated Total Prospectus Cost (ETPC)

The Estimated Total Prospectus Cost is the estimated cost of all phases of the project. As presented in Table 4.7, the average ETPC is $39,242,285 in the dataset.

4.4.12. Estimated Total Prospectus Cost (ETPC) Site

The Estimated Total Prospectus Cost Site is the estimated cost of the site phase of the project. As presented in Table 4.7, the ETPC of the site phase is $7,338,421. Note that only 84 projects of 496 had ETPC site costs identified in the database.

4.4.13. Estimated Total Prospectus Cost (ETPC) Design

The Estimated Total Prospectus Cost Design is the estimated cost of the design phase of the project. As presented in Table 4.7 the ETPC of the design phase is $4,497,161. Note that only 286 projects of 496 had ETPC design costs identified. Projects that are firm-fixed price do not require a break-out of costs and, as such, design costs may not be included in the dataset for design-build and construction manager as constructor delivery methods.

4.4.14. Estimated Total Prospectus Cost (ETPC) Construction

The Estimated Total Prospectus Cost Construction is the estimated cost of the construction phase of the project. As presented in Table 4.7, the ETPC of the construction phase is $53,710,897 and only 304 of the 496 projects have ETPC construction costs identified. Projects that are firm-fixed price do not require a break-out of costs and, as such, construction costs may not be included in the dataset for design-build and construction manager as-constructor delivery methods.

4.4.15. Congress Authorization Year

The Congress Authorization Year is the Fiscal Year (in the form of a date) the project funding is authorized by Congress. It should be noted that the dataset provides the year when Congress authorized funding for the project, and then also provides start and finish dates for all phases of a prospectus project: planning phase, design phase, and construction phase. Other scheduling or duration variables are created by the researcher to analyze the data. These are created using variables in the database. For example, a new variable named *Planning Phase* is created which is equal to the days between *Planning Start* and *Planning Finish*. Also as an example, *Planning Start to Construction Finish* calculated the number of days between the Planning Start and Construction Finish. These new variables are represented below and are grouped to determine the number of days for each phase for each project, and they represent a new variable in the dataset.

4.4.16. Planning Phase Duration

The Planning Phase Duration is the date of the planning call submission, in which the project first appears in the 5-Year Plan (planning start), to the project's schedule date that is the authority start (planning finish).

4.4.17. Design Phase Duration

The Design Phase Duration is the date when conceptual design begins (design start) to the date when all design elements requiring government approval have final approval (design finish).

4.4.18. Construction Phase Duration

The Construction Phase Duration is the date when construction mobilization begins (construction start) to the date when all construction elements have been declared substantially complete (construction finish).

4.4.19. Congress Authorization to Construction Finish Duration

The Congress Authorization to Construction Finish Duration represents the

Fiscal Year (in the form of a date) project funding is authorized by Congress to the date when all construction elements have been declared substantially complete (construction finish).

4.4.20. Planning Start to Construction Finish Duration

The Planning Start to Construction Finish Duration represents the date of the planning call submission, in which the project first appears in the 5-year plan (planning start), to the date when all construction elements have been declared substantially complete (construction finish).

4.4.21. Design Start to Construction Finish Duration

The Design Start to Construction Finish Duration represents the date when conceptual design begins (design start) to the date when all construction elements have been declared substantially complete (construction finish).

Table 4.8 Descriptive Statistics of Dataset

Descriptive Statistics	N	Mean
Gross Area (SF)	496	361774.76
Usable Space (SF)	496	166814.60
Estimated Total Prospectus Cost ($)	496	39242285.08
ETPC Site ($)	84	7338421.52
ETPC Design ($)	286	4497161.23
ETPC Construction ($)	304	53710897.29
Planning Phase (Days)	496	962.26
Design Phase (Days)	496	840.57
Construction Phase (Days)	496	1025.05
Closeout Phase (Days)	496	1128.96
Planning Start to Construction Finish (Days)	496	1356.93
Congress Auth to Construction Finish (Days)	496	1236.40
Design Start to Construction Finish (Days)	495	2069.18

Table 4.8 shows the following: a mean of 962 days in the planning phase; a mean of 840 days in the design phase; and a mean of 1025 days for the construction phase for all projects in the dataset. There is a mean of 1356 days from the beginning of the planning phase to the end of construction, and 1236 days from when Congress authorizes funding for the project to the end of construction. Lastly, the data shows there is a mean of 2069 days from the beginning of design to the end of construction.

4.4.22. Federal Legislation

To test the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, the researcher adds Federal Legislation as a new variable to the database. Federal Legislation represents if the 1996 Clinger-Cohen Act is passed into law when Congress authorized funding for the project. The 1996 Clinger-Cohen Act allows qualifications-based selection of builders using the design-build and construction manager as-constructor forms of project delivery. This new variable provides information to explore the benefits of using alternative project delivery methods. Fifty-six projects in the database are approved by Congress before the Clinger-Cohen Act is enacted; these projects were approved by Congress before 1996. Three hundred and twenty-five projects in the database are approved after the Clinger-Cohen Act is enacted, or from fiscal year 1996 to 2008. And 115 projects in the database do not provide such information and those projects have missing data. These results in the database are depicted in Table 4.9.

Table 4.9 Descriptive Statistics of Federal Legislation

Clinger-Cohen Act of 1996	Number of Projects (Frequency)	Percent
Enacted before 1996	56	11.3
Enacted after 1996, and including 1996	325	65.5
Missing	115	23.2
Total	496	100.0

4.4.23. State Legislation

To test the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, the researcher adds State Legislation as a new variable to the dataset. State Legislation represents if design-build is allowed in the state when Congress authorized funding for the project. Allowing design-build suggests authorizing qualifications-based selection for builders. Table 4.10 provides the number of projects in the database that are located in each state, and Table 4.11 provides how many projects have design-build enacted and how many projects do not have design-build enacted in the state the project is located.

Table 4.10 Descriptive Statistics of Project Location by State

State	Number of Projects	Percent	State	Number of Projects	Percent
Alaska	2	.4	Mississippi	4	.8
Alabama	8	1.6	Montana	13	2.6
Arkansas	1	.2	North Carolina	7	1.4
Arizona	9	1.8	North Dakota	16	3.2
California	29	5.8	Nebraska	4	.8
Colorado	9	1.8	New Hampshire	4	.8
Connecticut	2	.4	New Jersey	3	.6
District of Columbia	76	15.3	New Mexico	5	1.0
Florida	14	2.8	Nevada	6	1.2
Georgia	10	2.0	New York	34	6.9
Hawaii	3	.6	Ohio	14	2.8
Iowa	5	1.0	Oklahoma	3	.6
Idaho	2	.4	Oregon	3	.6
Illinois	15	3.0	Pennsylvania	8	1.6
Indiana	5	1.0	Rhode Island	2	.4
Kansas	1	.2	South Carolina	3	.6
Kentucky	3	.6	Tennessee	5	1.0
Louisiana	5	1.0	Texas	25	5.0
Massachusettes	6	1.2	Utah	4	.8
Maryland	33	6.7	Virginia	19	3.8
Maine	10	2.0	Vermont	13	2.6
Michigan	8	1.6	Washington	14	2.8
Minnestoa	7	1.4	Wisconsin	2	.4
Montana	17	3.4	West Virginia	5	1.0

Table 4.11 Descriptive Statistics of State Legislation

If design-build is allowed in the state when Congress authorized funding for the project	Number of Projects (Frequency)	Percent
No	136	27.4
Yes	167	33.7
Missing	193	38.9
Total	496	100.0

Table 4.10 suggests that at least one project in the database is located in every

state in the United States, including the District of Columbia. The greatest number of projects, 76 or 15.3 percent, are located in the District in Columbia. This is because the federal government and GSA is based in Washington DC. New York ranks second and California ranks third with 34 and 29 projects respectively. Table 4.11 provides that 136 projects are located in states where design-build is not allowed when Congress authorized funding for the projects, and 167 projects are located in states where design-build is allowed when Congress authorized funding for the projects. The background study determined that no one has developed a history of when design-build is allowed in each state. Therefore, what is presented in the legislative trends in Chapter 2 is not comprehensive. Table 4.11 presents that there are 193 projects in the database that are located in states where that historical information is not available, and thus is considered as missing data in the analysis.

An analysis of the descriptive statistics presented in this section of Chapter 4 concludes that there are specific project variables in the database that may be considered outliers and are skewing the data. It is imperative then that other methods of analysis be performed on the data to test and explore the data in the hypothesis. The next section provides cross-tabulations of the data in this exploration.

4.5 Cross-Tabulation

Earlier in the chapter, tables are presented that contain frequency distributions for one variable at a time to partially describe the data. These are presented as descriptive statistics. Since the objective of the study is to test whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, the relationship between two variables must be examined at the same time to adequately test the hypothesis. For this purpose, it is appropriate to begin with constructing cross-tabulations. Cross-tabulations test the association among variables. This technique analyzes the relationships between independent and dependent variables, or between defined problems and factors contributing to those problems. This investigates cause-and-effect relationships, looking at the extent to which one variable (the cause) influences another variable (the effect) (Leedy and Ormrod, 2005). A variable that is studied in research as a possible cause of something else is the independent variable. A variable that is potentially influenced by the independent variable is the dependent variable, because it depends on the independent variable. In this research, the dependent variable is the project delivery method and the independent variables are the project characteristics, and specifically the variables to test the hypothesis, the legislative impediments. Cross-tabulations are performed using the dependent and independent variables to test the relationship of the associations.

As presented in the earlier section, there are 24 independent variables and one dependent variable (project delivery method) in the database, and all independent variables will be analyzed using cross-tabulations in this section. While cross-tabulations provide the relationship among two variables, it does not address the strength of the association. SPSS provides more sophisticated analytical techniques that will examine the strength of the relationship by modeling two or more independent variables. Those analytical methods are presented in the next chapter. However, it is appropriate in this section of Chapter 4 to extrapolate information from the project variables and explore their relationship with project delivery method selection before performing more detailed analyses.

4.5.1. Region

Cross-tabulation of project delivery method selection and regional distribution indicates that 10 of the 11 regions use the traditional design-bid-build method for project delivery more than any other method, as represented in Table 4.12 and Figure 4.9. All regions use the design-bid-build method more than any other method of project delivery, except for the Southeast Sunbelt region which uses construction manager as-constructor more than any other method. It uses the construction manager as constructor method more than any other method. The majority of the design-build projects are being performed in the National Capital Region, almost 36 percent. Two regions, New England and Northwest/Artic, have never used design-build for a prospectus project, and one region, Mid-Atlantic, has never used construction manager as constructor.

Table 4.12 Cross-Tabulation of Project Delivery Method and Region (Number of Projects)

	Region											
	New England	Northeast & Caribbean	Mid-Atlantic	Southeast	Great Lakes	Heartland	Greater Southwest	Rocky Mountain	Pacific Rim	Northwest/Arctic	National Capital Region	
Design-Bid-Build	23	19	20	16	23	13	27	9	29	8	65	252
Design-Build	0	4	5	10	8	10	7	5	8	0	43	100
Design-Build Bridging	14	9	1	4	2	0	1	22	6	6	4	69
Construction Manager as Constructor	1	4	0	23	18	4	4	6	3	7	5	75
Region Totals	38	36	26	53	51	27	39	42	46	21	117	496

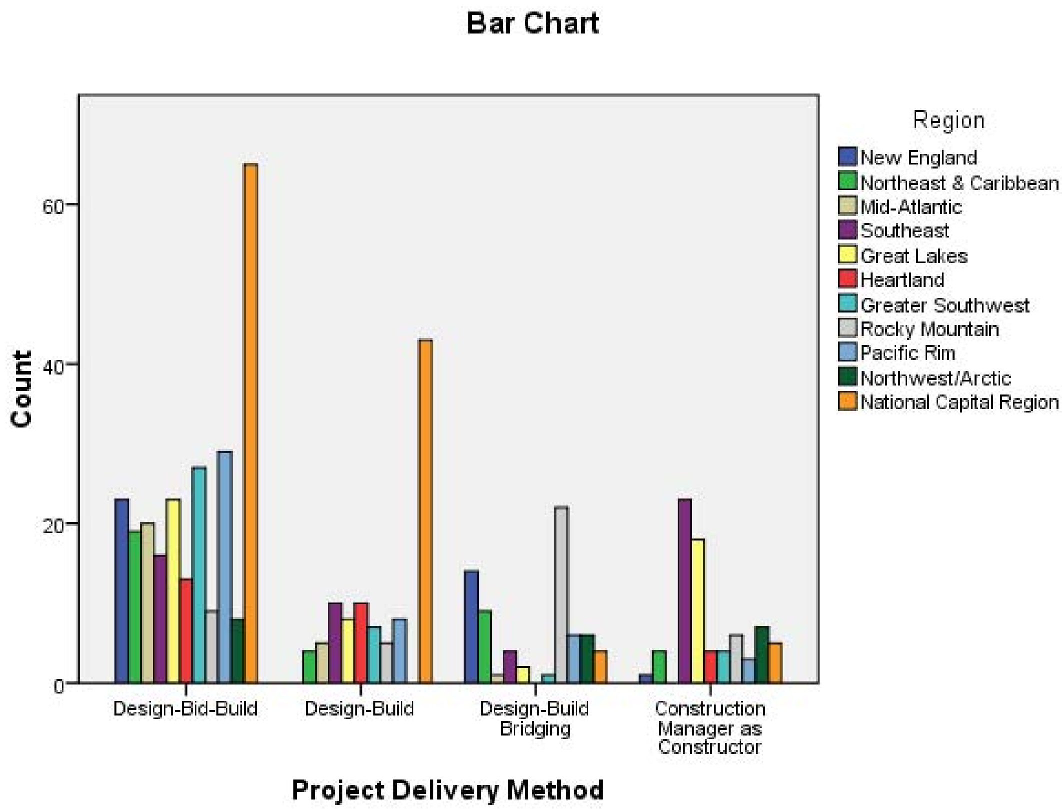


Figure 4.9 Cross-Tabulation of Project Delivery Method and Region

4.5.2. Project Type

Cross-tabulation of project delivery method selection and project type reveals that 90 percent of all lease-construction projects are using design-build, 84 percent of construction manager as constructor projects are new construction, and 63 percent of design-build-bridging projects are for renovation and alteration, as depicted in Table 4.13 and Figure 4.10. The majority of renovation and alteration projects and new construction projects use design-bid-build, 62.5 and 45 percents respectively.

Table 4.13 Cross-Tabulation of Project Delivery Method and Project Type (Number of Projects)

	Project Type			Total Number of Projects
	Renovation & Alteration	New Construction	Lease Construct	
Design-Bid-Build	152	96	4	252
Design-Build	39	12	49	100
Design-Build Bridging	10	58	1	69
Construction Manager as Constructor	39	36	0	75
Total	240	202	54	496

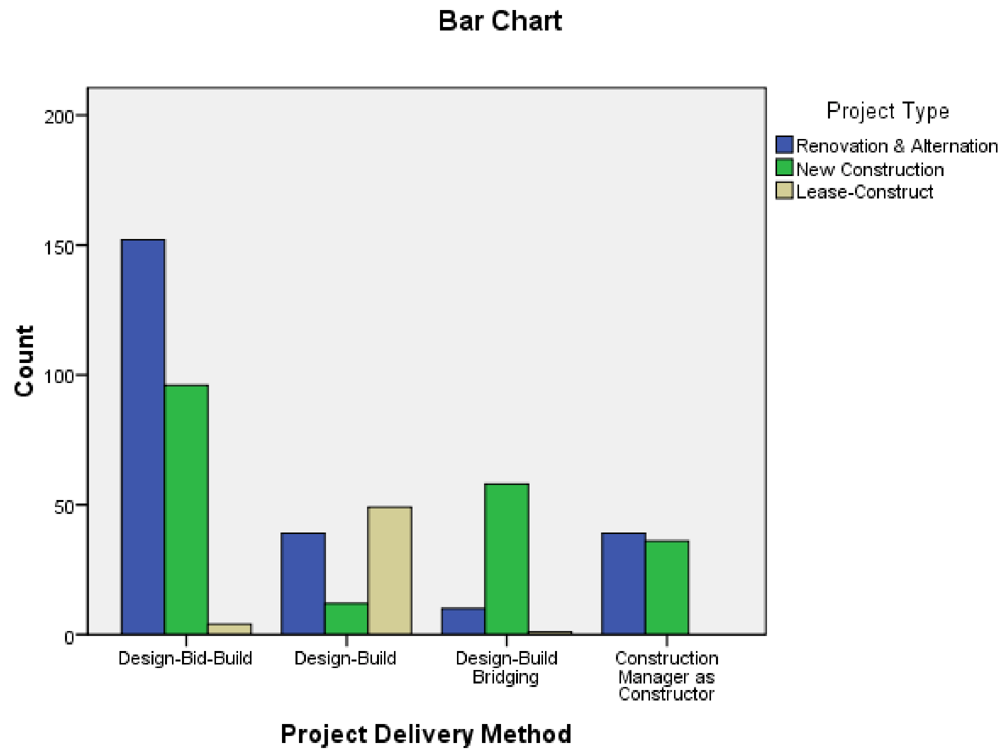


Figure 4.10 Cross-Tabulation of Project Delivery Method and Project Type

4.5.3. Program Area

Cross-tabulation of project delivery method and program area reveal that the majority of federal buildings and courthouses use design-bid-build, 56 and 53 percents respectively, as presented in Table 4.14 and Figure 4.11. The majority of border stations use the design-build-bridging method for project delivery and many federal buildings use alternative delivery methods. The greatest number of design-build and construction manager as constructor methods are being used in the construction of federal buildings.

Table 4.14 Cross-Tabulation of Project Delivery Method and Program Area (Number of Projects)

	Program Area			Total Number of Projects
	Courthouse	Federal Building	Border Station	
Design-Bid-Build	45	173	34	252
Design-Build	5	90	5	100
Design-Build Bridging	2	14	53	69
Construction Manager as Constructor	28	44	3	75
Total	80	321	95	496

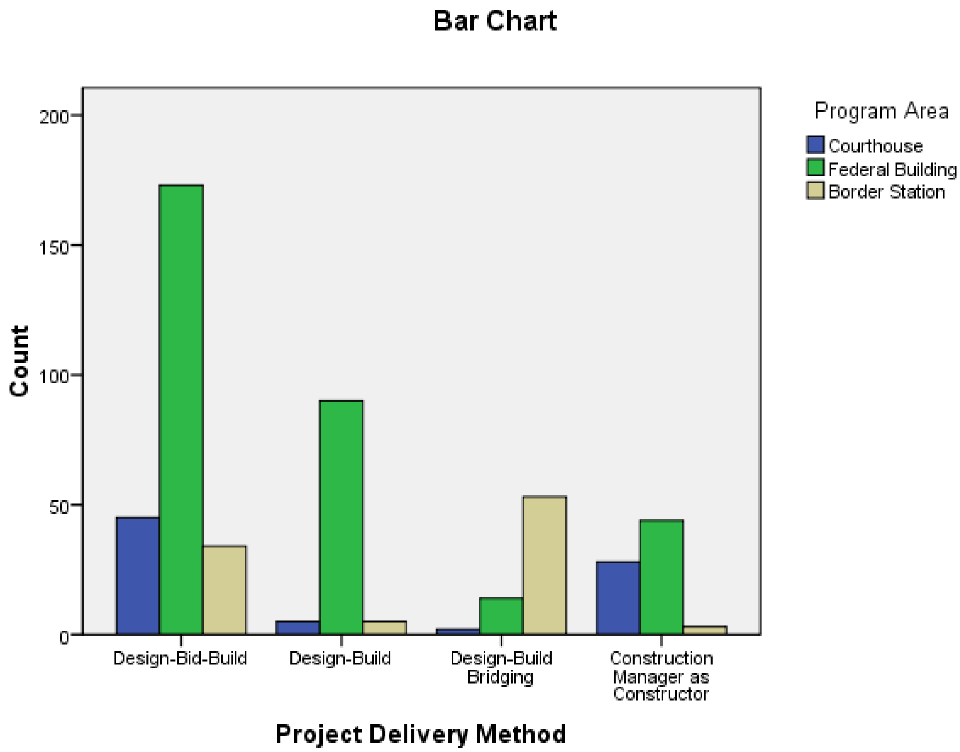


Figure 4.11 Cross-Tabulation of Project Delivery Method and Program Area

4.5.4. Project Delivery Method

The project delivery method is the dependent variable in this analysis.

4.5.5. Political Party

The vast majority, 82 percent of 362 projects, are sponsored by a member of the Democratic Party, as presented in Table 4.15 and Figure 4.12. And of those, more than half (57 percent) use the design-bid-build method for project delivery. Projects with Democratic sponsorship employ design-build second, followed closely by construction manager as constructor. The least number of projects sponsored by Democrats uses the design-build-bridging delivery method. Projects with Republican support generally chose design-bid-build, 41 percent, while design-build-bridging, construction manager as constructor and design-build rank second, third and last, respectively. The fewest number of projects sponsored by the Republican Party employ design-build as the chosen project delivery method.

Table 4.15 Cross-Tabulation of Project Delivery Method and Political Party (Number of Projects)

	Political Party Sponsorship			Total Number of Projects
	Republican	Democrat	Missing	
Design-Bid-Build	33	209	10	252
Design-Build	11	65	24	100
Design-Build-Bridging	19	30	20	69
Construction Manager as Constructor	16	58	1	75
Total	79	362	55	496

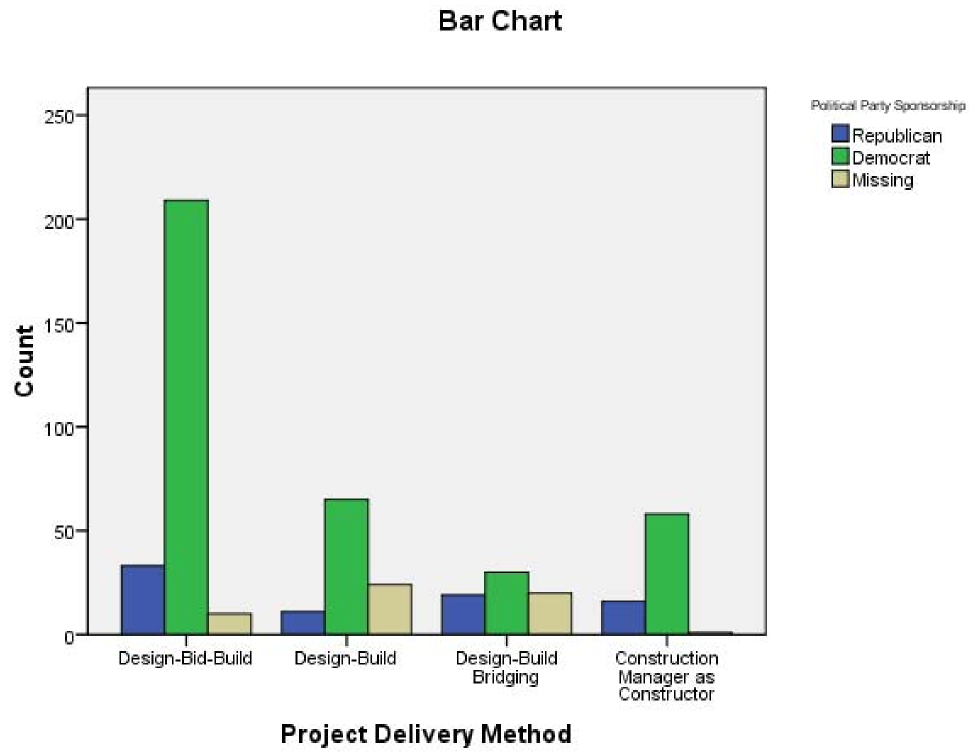


Figure 4.12 Cross-Tabulation of Project Delivery Method and Political Party

4.5.6. Gross Area

The average gross area of each of the four project delivery methods suggest that the largest projects or buildings in size are built using the construction manager as-constructor method, with an average of 449,364 gross square feet, as depicted in Figure 4.13. There is less than one percent difference in the average gross area for projects using design-build and construction manager as-constructor. Design-build projects average 447,482 gross square feet. Projects using design-bid-build rank third at 371,804 square feet, and the smallest projects in size use the design-build-bridging method of project delivery.

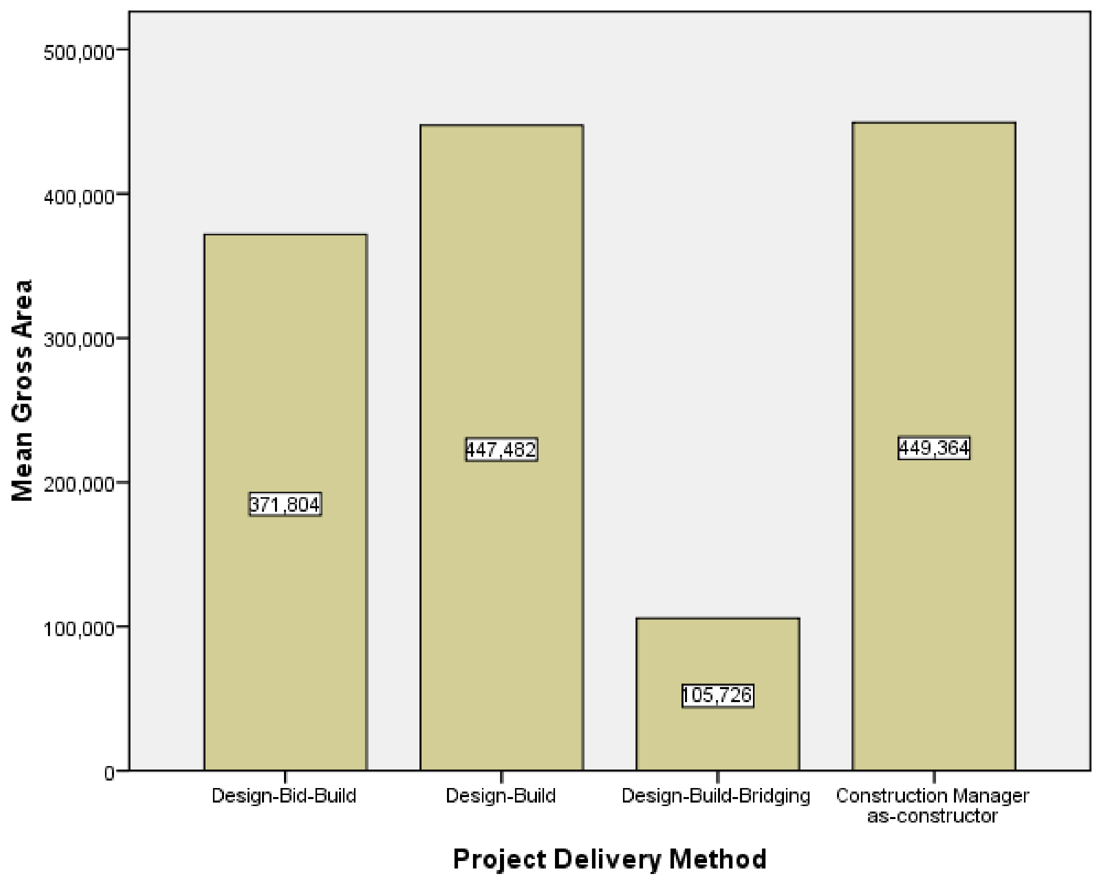


Figure 4.13 Cross-Tabulation of Project Delivery Method and Gross Area

4.5.7. Usable Space

Projects using the construction manager as-constructor method for project delivery have the greatest amount of usable space, with an average of 305,466 usable square feet, as depicted in Figure 4.14. The average gross-to-usable space is 68 percent. The design-build projects have the lowest amount of usable square feet in the average building, with 32 percent, or 145,258 square feet. While this percentage seems unusually low, it may be because many of the design-build projects in the dataset are for border stations which may not have high usable areas. The average design-bid-build project has a gross-to-usable space of 45 percent, or 170,492 square feet, and the average design-build-bridging project has 32 percent, or 33,914 square feet of usable space.

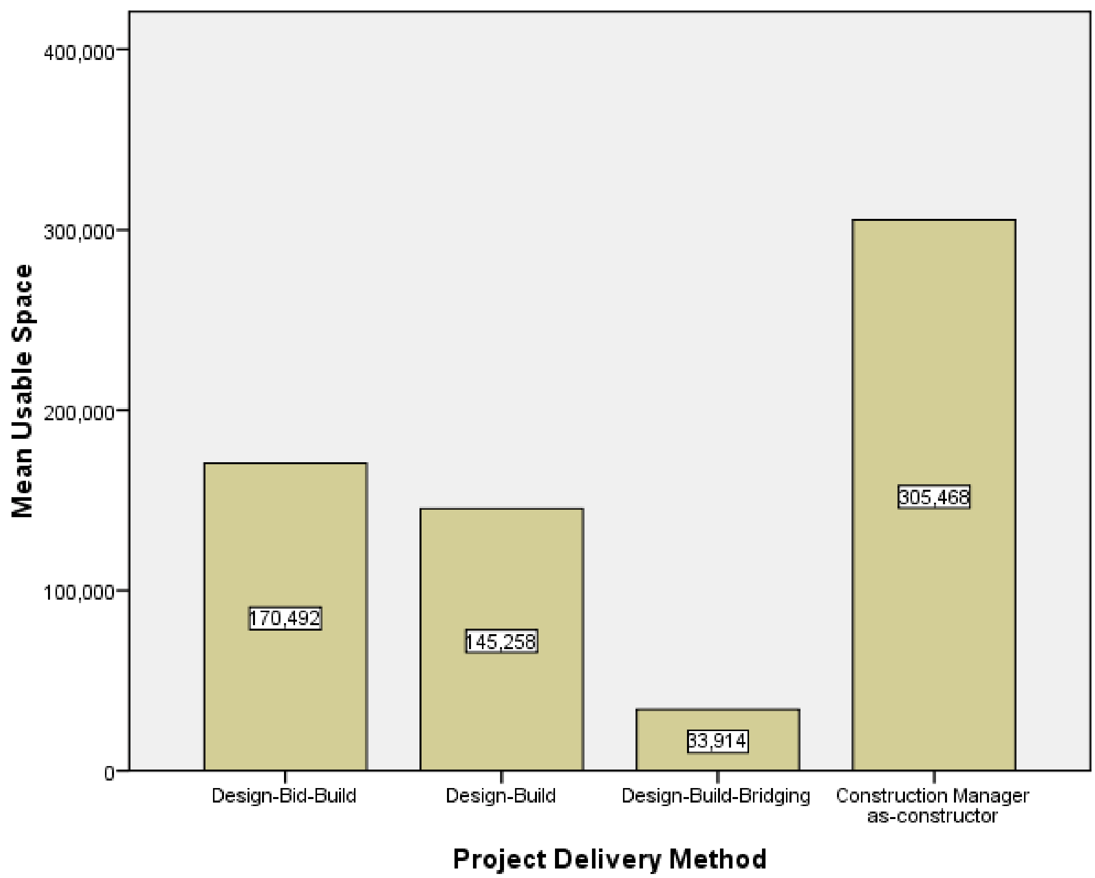


Figure 4.14 Cross-Tabulation of Project Delivery Method and Usable Space

4.5.8. Congress Authorization

A cross-tabulation chart comparing the average dollars authorized by Congress based on the project delivery method suggests that Congress is allocating more money to projects using construction manager as-construction methods than other project delivery methods, as depicted in Figure 4.15. Congress authorizes the following: an average of $39,200,886 for projects using construction manager as-constructor; an average of $29,988,756 for projects using design-bid-build; an average of $8,936,369 for projects using design-build; and an average $8,567,231 for projects using design-build-bridging.

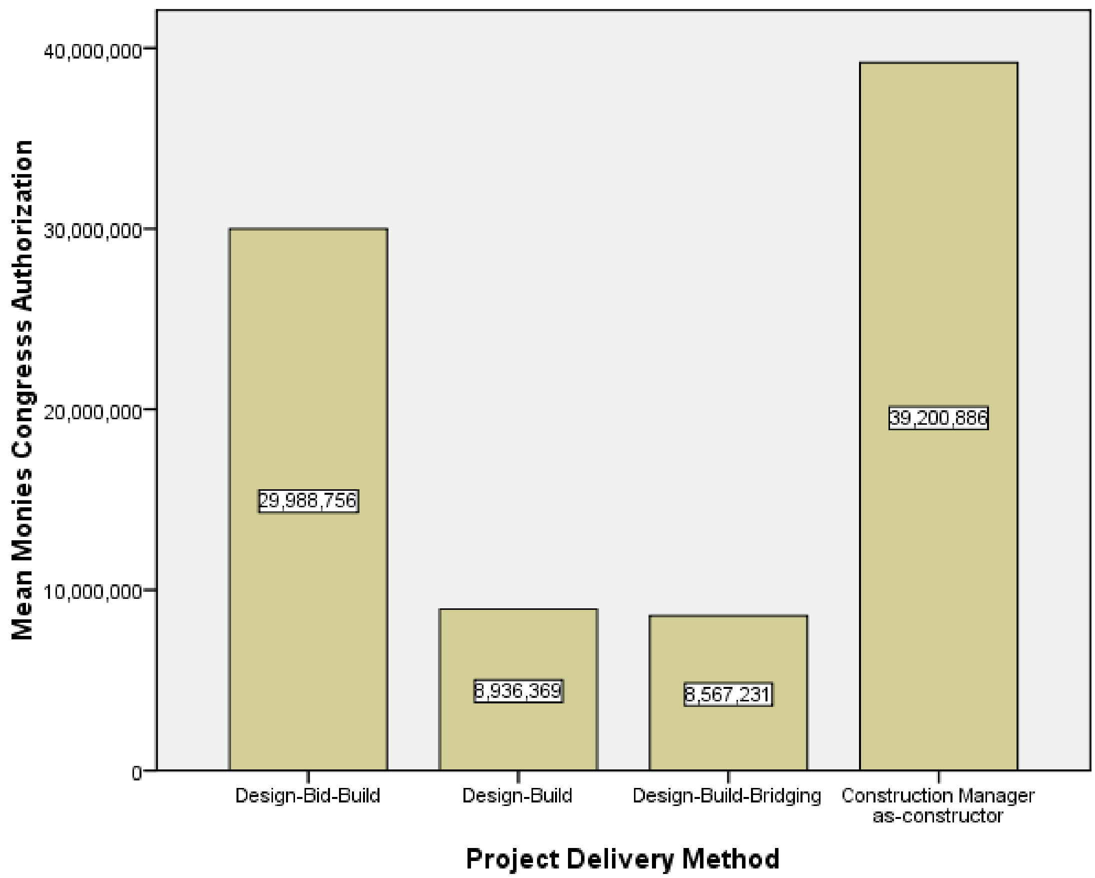


Figure 4.15 Cross-Tabulation of Project Delivery Method and Congress Authorization (Dollars)

4.5.9. Conference Appropriation

Once Congress approves funds for a project, the budget is forwarded to Conference Appropriations for consideration. Funds for the project can be increased or decreased depending on the outcome of the discussions. The data presented in this section provides the amount that is allocated under Conference Appropriations. In the next chapter, any differences in the amount authorized by Congress and approved through Conference Appropriations are explored. Figure 4.16 suggests that Conference Appropriations allocates slightly higher funds on average to all projects under every project delivery method. Comparing what is authorized by Congress and what is authorized through Conference appropriations, using construction manager as-constructor, projects average $40,980,085 after Conference appropriations, or a five percent increase from what is authorized by Congress. Design-bid-build has, on average, slightly higher amounts of funds from Conference appropriations, with $35,620,488, or a 16 percent increase. Projects using design-build have a 13 percent increase in funding between Congress authorization and Conference appropriations, with on average $10,270,436, and design-build-bridging projects have a six percent increase with $9,052,920 on average, between Congress authorization and Conference appropriations.

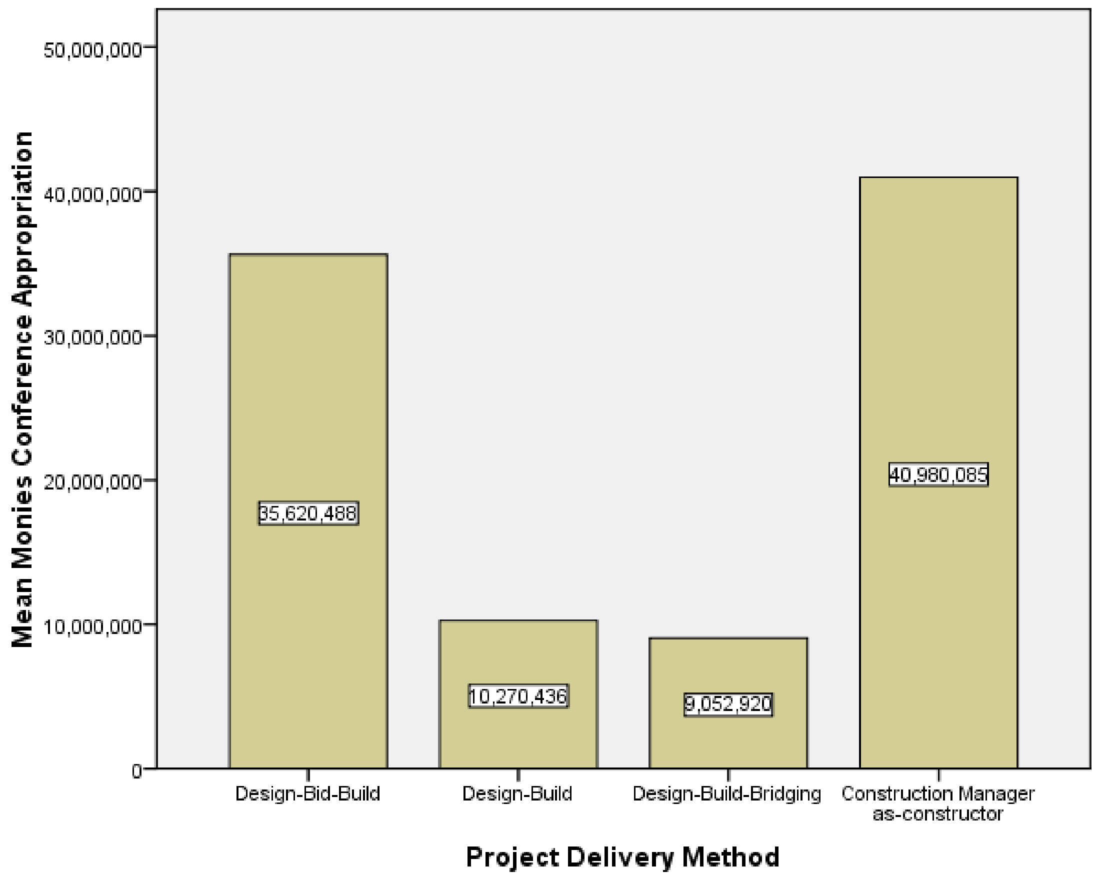


Figure 4.16 Cross-Tabulation of Project Delivery Method and Conference Appropriation (Dollars)

4.5.10. Central Office Allowance

After Conference appropriates funds, the project is advanced to General Services Administration's Central Office for further consideration. Cross-tabulations reveal that Central Office allows less funds overall, on average, to the GSA Region as is appropriated by Conference, as depicted in Figure 4.17. Congress authorizes and Conference appropriates more funds, on average, to projects using construction manager as-constructor. Central Office allows more funds, on average, for projects using the traditional design-bid-build process, or $32,740,537; however, these funds are, on average, nine percent less than what is appropriated to Central Office by Conference. There also is a significant decrease in the amount of funds on average that are provided to the region from central Office than what was appropriated by Conference under construction manager as-constructor methods. On average, $30,867,296 is allowed for projects using construction manager as-constructor, a 25 percent decrease from what Conference appropriates. An average of $30,867,296 is allowed for projects using construction manager as-constructor. Design-build projects realize a decrease of 18 percent to $8,424,746, on average, and design-build-bridging projects realize a decrease of 13 percent to $7,947,623, on average.

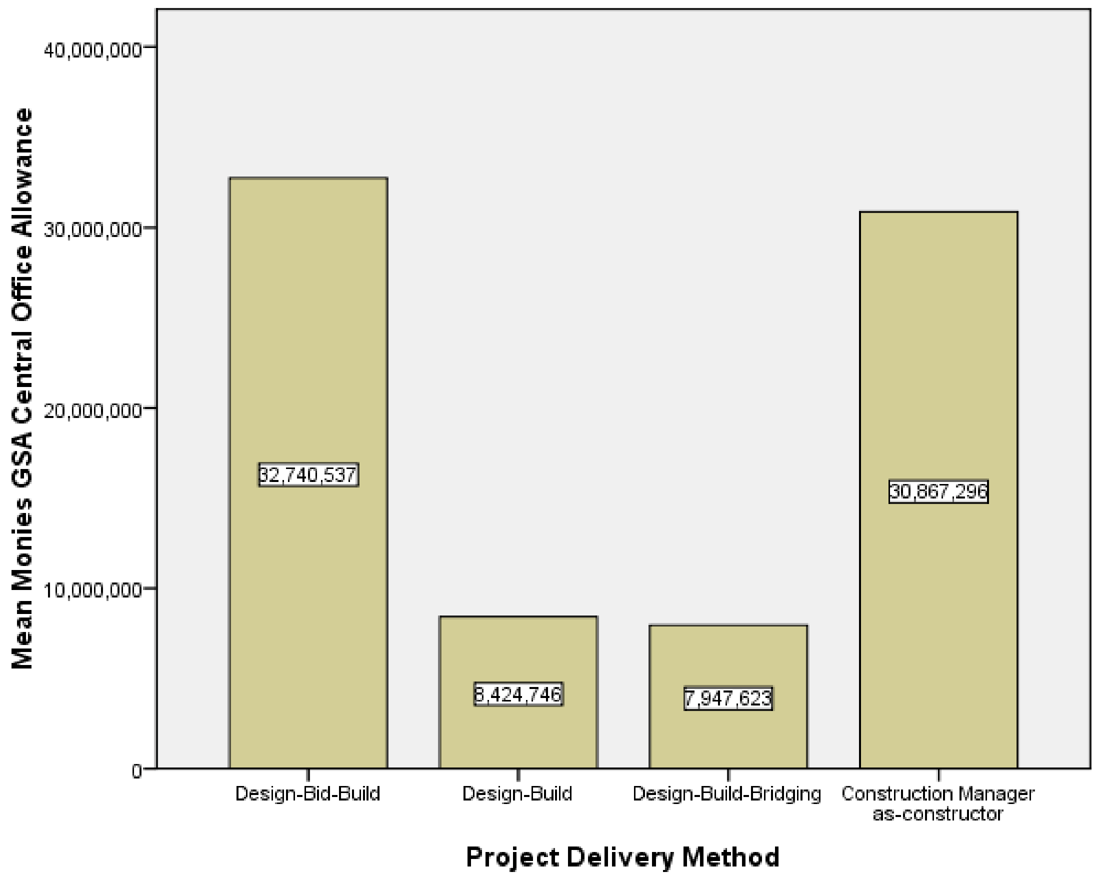


Figure 4.17 Cross-Tabulation of Project Delivery Method and Central Office Allowance (Dollars)

4.5.11. Estimated Total Prospectus Cost

The Estimated Total Prospectus Cost (ETPC) for the dataset reveals that projects using the design-bid-build delivery method, on average, are funded most heavily, with an average of $32,740,537 for all projects, as depicted in Figure 4.18. Project using construction manager as-constructor delivery method rank second in funding, with an average of $30,867,296. Design-build projects rank third with an average of $8,424,746 in funding, and design-build-bridging rank last with an average of $7,947,623 in funding.

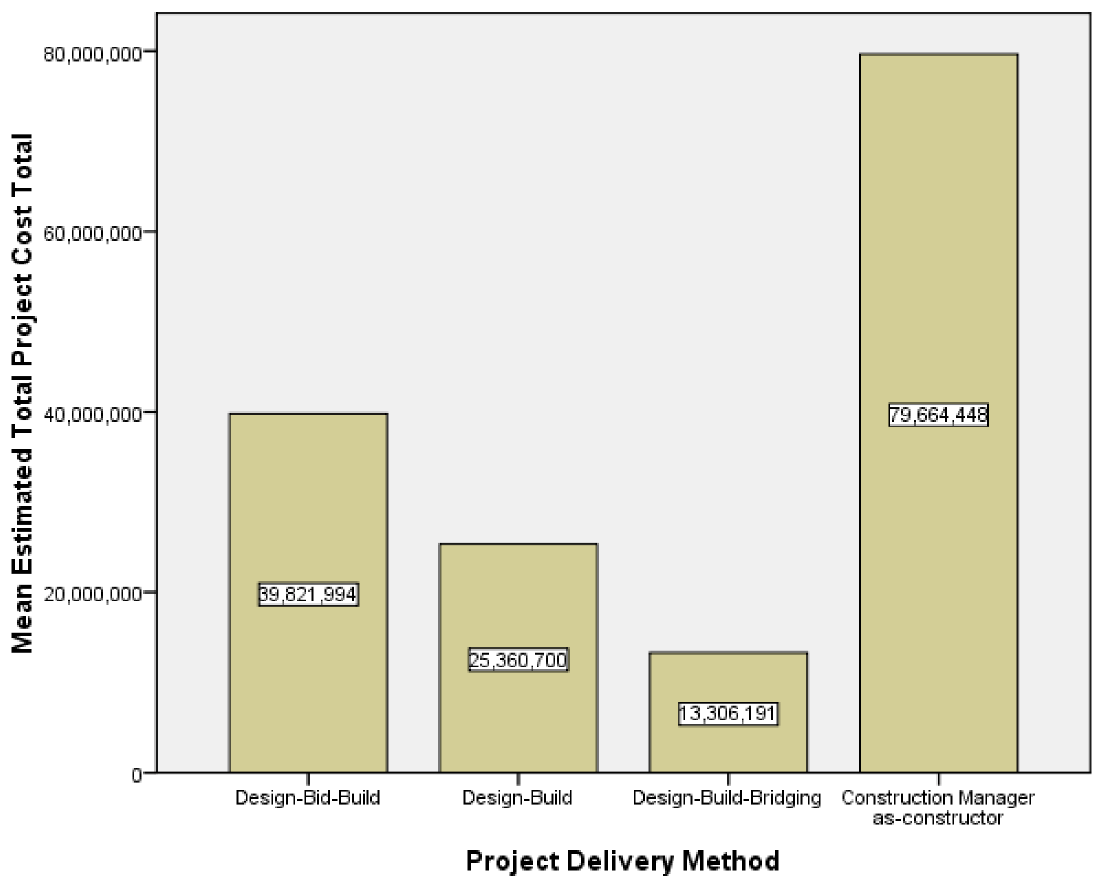


Figure 4.18 Cross-Tabulation of Project Delivery Method and Estimated Total Prospectus Cost (Dollars)

4.5.12. Estimated Total Prospectus Cost Site

The Estimated Total Prospectus Cost for site work suggests that more monies are projected for projects using design-build than all other project delivery methods, with $8,583,303, as presented in Figure 4.19. However, monies distributed for site work seem to be, on average, about the same for design-bid-build and construction manager as-constructor, higher for design-build and lower for design-build-bridging. Projects using construction manager as-constructor, on average, allocate $7,245,120 for site work, and projects using design-bid-build allocate an average of $7,239,317. Projects using design-build-bridging rank last with an average of $6,258,827 for site work.

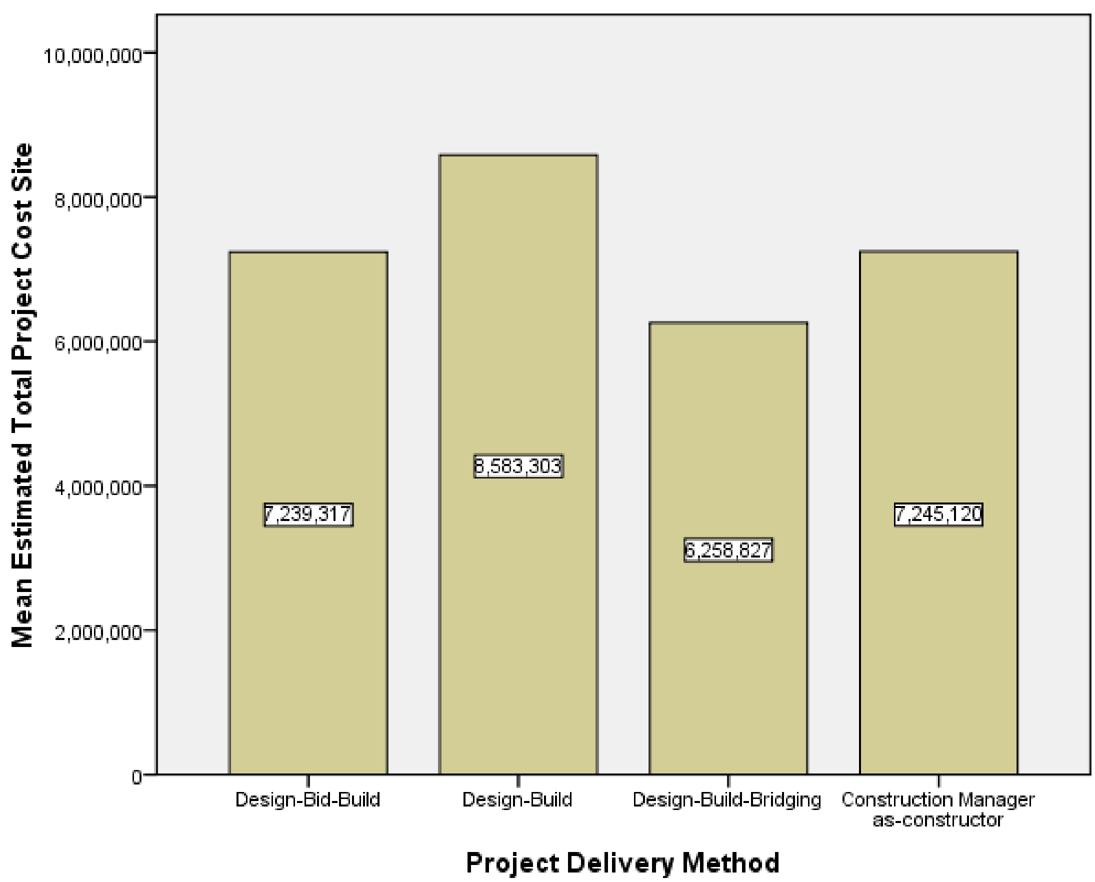


Figure 4.19 Cross-Tabulation of Project Delivery Method and Estimated Total Prospectus Cost Site (Dollars)

4.5.13. Estimated Total Prospectus Cost Design

An analysis of the Estimated Total Prospectus Cost for the design phase reveals that more funds, on average, are allocated for projects using the construction manager as-constructor delivery method, with projects receiving an average of $6,052,676, as presented in Figure 4.20. Significantly fewer funds are allocated to projects, on average, under other delivery methods. Projects using design-bid-build received an average of $4,435,802, while projects using design-build-bridging receive $3,551,847, and those using design-build receive $2,681,195. Design costs for projects using design-build are one-third of design costs for projects using construction manager as-constructor.

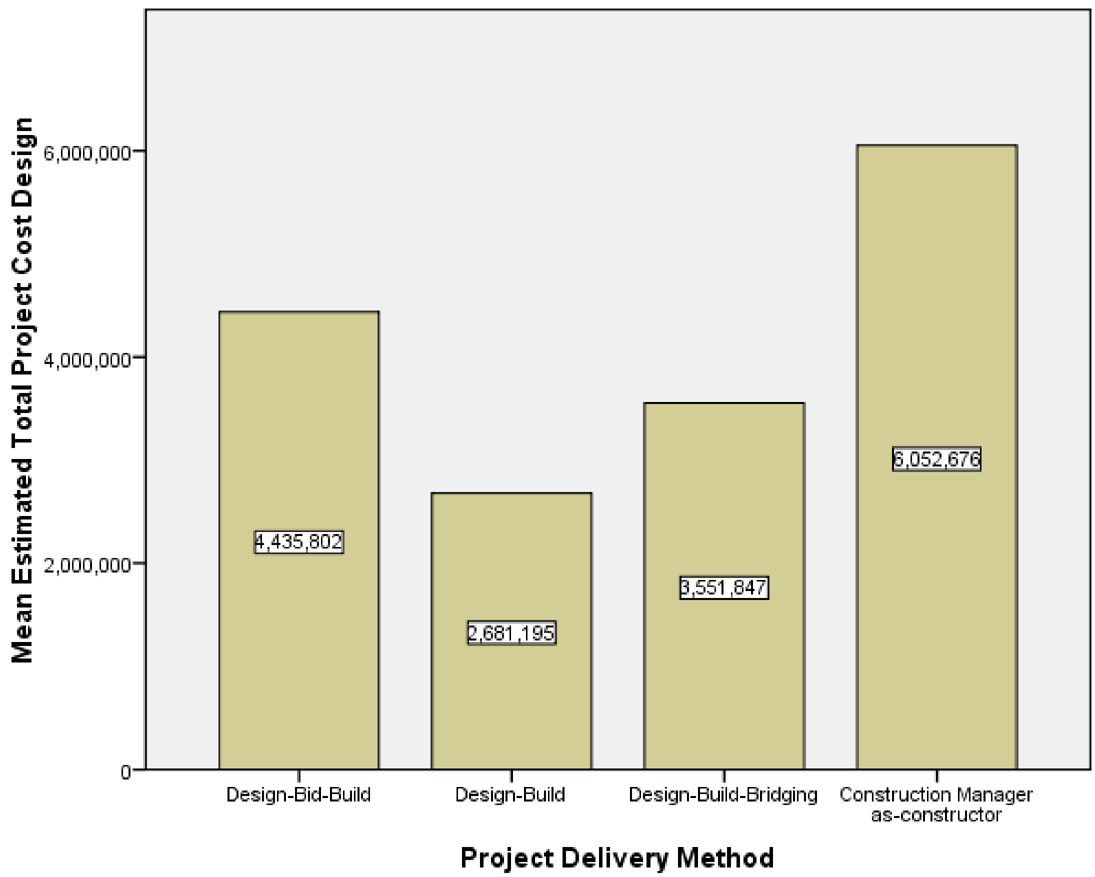


Figure 4.20 Cross-Tabulation of Project Delivery Method and Estimated Total Prospectus Cost Design (Dollars)

4.5.14. Estimated Total Prospectus Cost Construction

Much similar to the estimated total prospectus cost of construction, the estimated total prospectus cost for construction is significantly higher for projects using construction manager as-constructor, with an average of $80,747,864, as depicted in Figure 4.21. Projects using design-build-bridging are allocated an average of $52,838,345, while those using design-bid-build average $47,689,315, and those projects using design-build average $41,991,151.

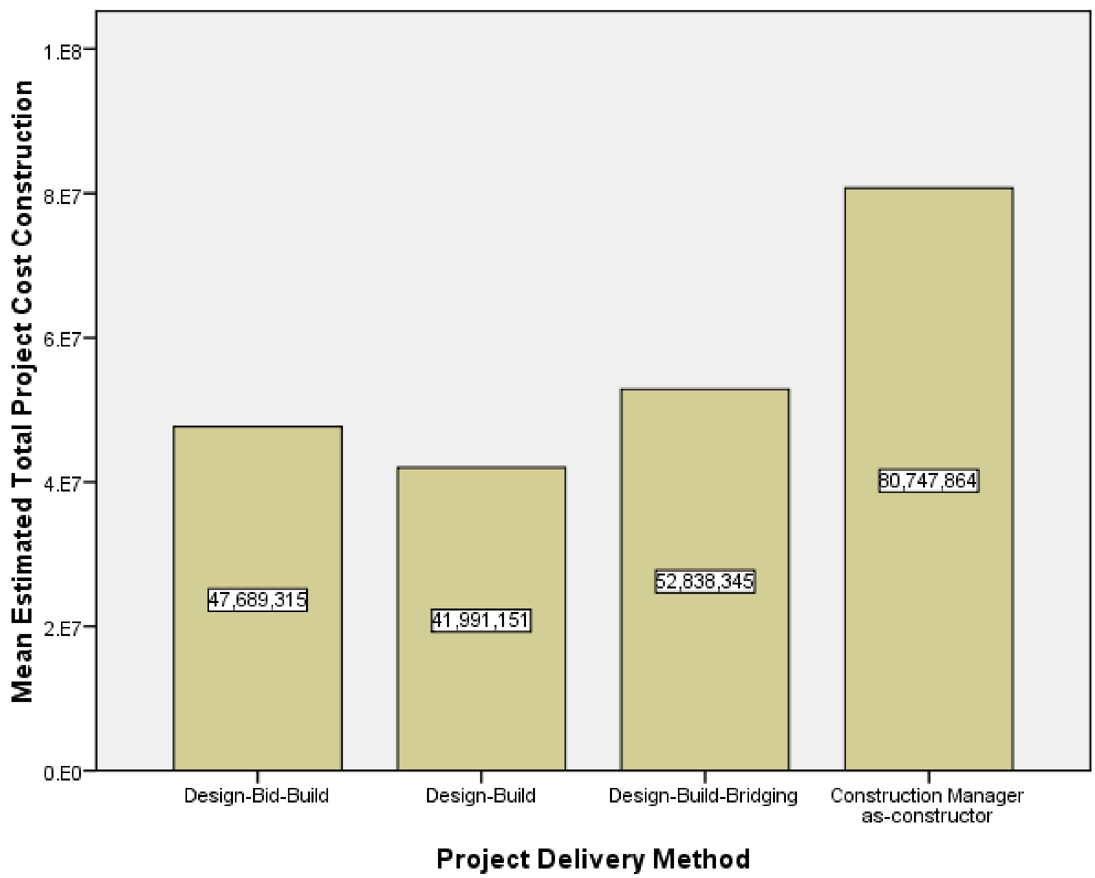


Figure 4.21 Cross-Tabulation of Project Delivery Method and Estimated Total Prospectus Cost Design (Dollars)

4.5.15. Congress Authorization Year

Constructing a cross-tabulation of fiscal year authorization (the fiscal year Congress authorized funding for the project) and project delivery method provides how many projects were approved under each method for each year since 1988, as depicted in Table 4.16 and Figure 4.22. Note that the number and column 999 in Table 4.16 represents projects in the database that do not provide the date funding is authorized by Congress; there are 102 of 496 projects in the dataset that do not note the year funding is authorized by Congress. Eighty percent of all projects in the database contain the year Congress authorized funding. Of those 394 projects, the only year Congress did not authorize funding on over-prospectus projects is 1998. The greatest number of projects authorized by Congress is in 2002 when 42 projects are authorized. The fewest projects are authorized between 1988 and 1991. This may only be attributable to the PIP software tracking the data; the software was in its development and implementation infancy in the early 1990s. The lowest number of projects authorized (5) is in 2008. There is a trend in the data that suggests that more projects in the 21st century are being approved using alternative delivery methods, such as design-build and construction manager as constructor, and less use a traditional design-bid-build method. This trend is apparent after 1996, when the Clinger-Cohen Act, which allows a best value selection of construction companies, is signed into law. The next chapter tests whether a statistically significant correlation exists between what method is selected and when it is selected. It should be noted that few of the design-build-bridging projects (20 percent) have data on fiscal year authorization.

Table 4.16 Cross-Tabulation of Congress Authorization Year and Project Delivery Method (Number of Projects)

	Congress Authority Fiscal Year																					Total
	999	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Design-Bid-Build (Traditional)	30	2	1	1	3	10	7	3	14	2	13	15	13	14	24	10	8	19	9	4	4	206
Design-Build	19	0	0	0	1	0	0	1	1	0	1	0	2	4	6	6	8	8	2	8	1	68
Design-Build Bridging	51	0	0	0	0	0	0	0	1	0	1	0	3	4	1	1	2	0	0	0	0	64
Construction Manager as Constructor	2	0	0	0	1	2	1	2	1	0	4	6	3	5	11	5	10	7	5	1	0	66
	102	2	1	1	5	12	8	6	17	2	19	21	21	27	42	22	28	34	16	13	5	404

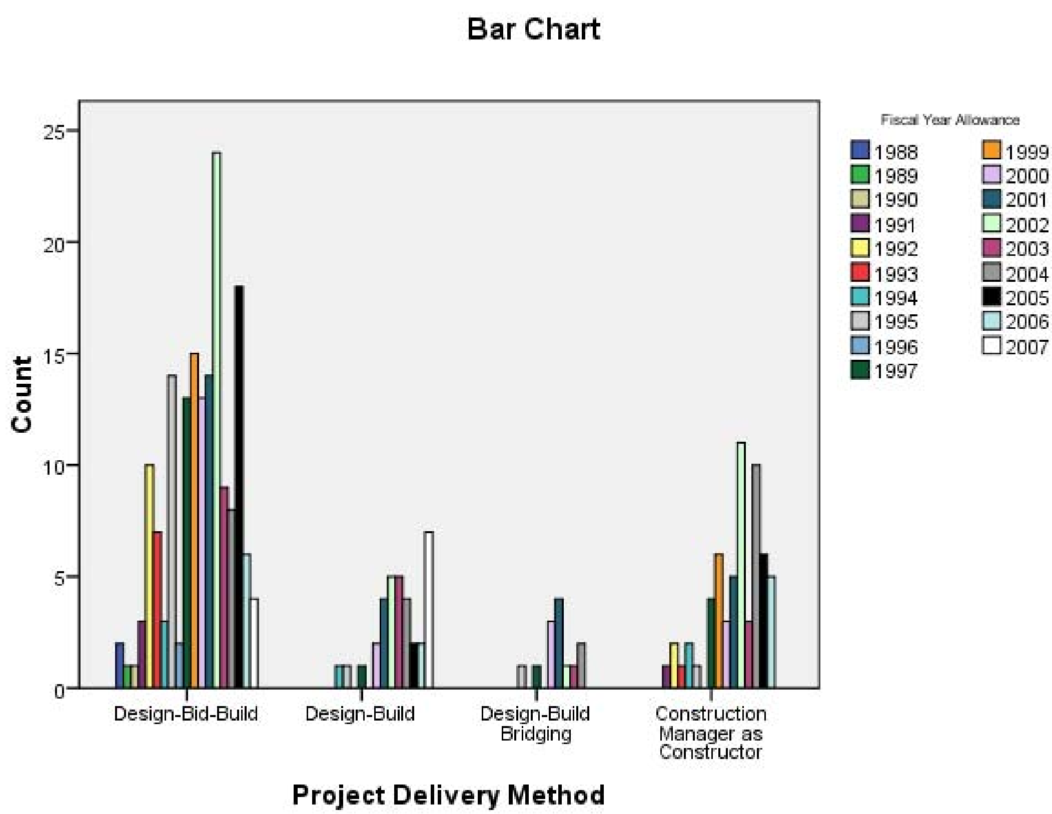


Figure 4.22 Cross-Tabulation of Congress Authorization Year and Project Delivery Method (Number of Projects)

4.5.16. Planning Phase Duration

The analysis reveals the average number of days in the planning phase varies only slightly between project delivery methods. As depicted in Figure 4.21, the average number of days in the planning phase for design-build-bridging is 996 and the average for design-bid-build is 970; the figure also shows an average of 950 days for construction manager as-constructor, and 928 days for design-build.

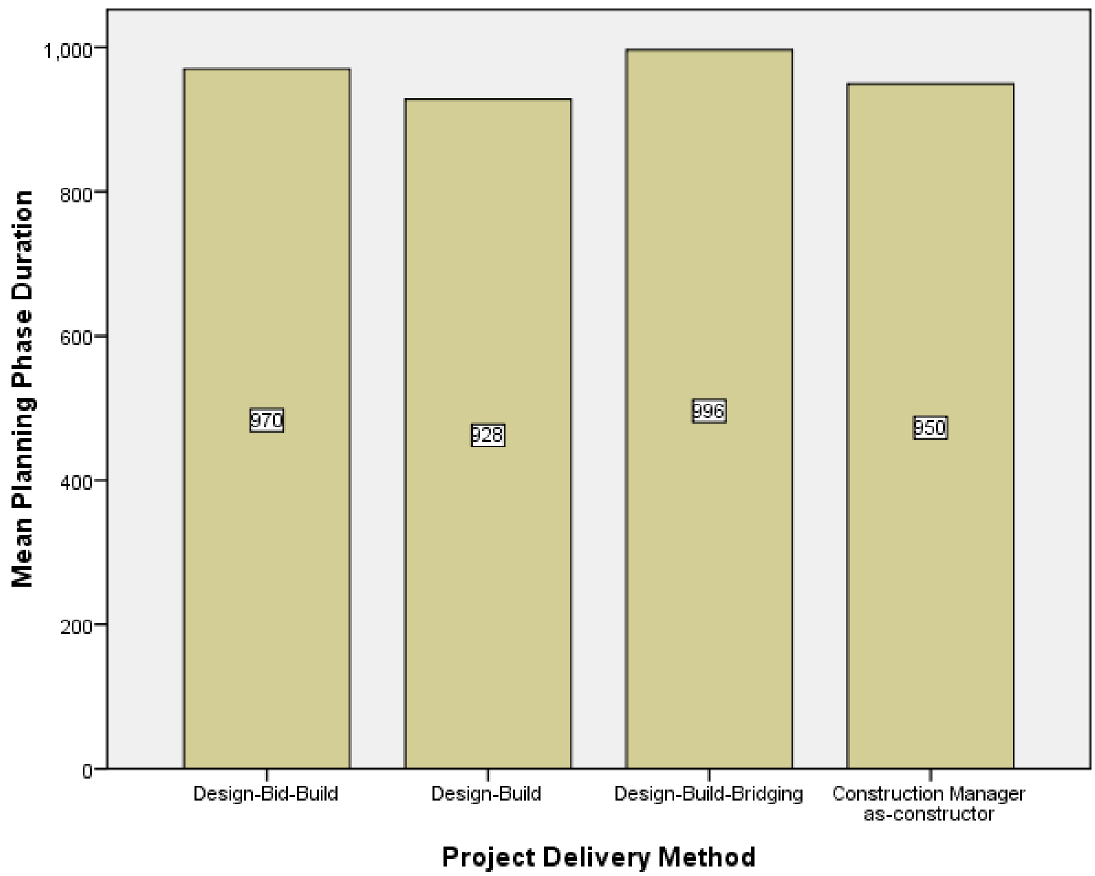


Figure 4.23 Cross-Tabulation of Planning Phase Duration and Project Delivery Method (Days)

4.5.17. Design Phase Duration

An analysis of the time to complete design varies significantly between project delivery methods, as presented in Figure 4.24. Projects using design-build have the shortest design period, with only an average of 604 days, whereas projects using design-bid-build average 840 days, those using design-build-bridging average 930 days, and those projects using construction manager as-constructor average 1,077 days. There is a great difference in the number of days (duration), on average, for these methods and the cross-tabulation analysis suggests that it may take twice as long to complete design using construction manager as-constructor than it does using the design-build delivery method.

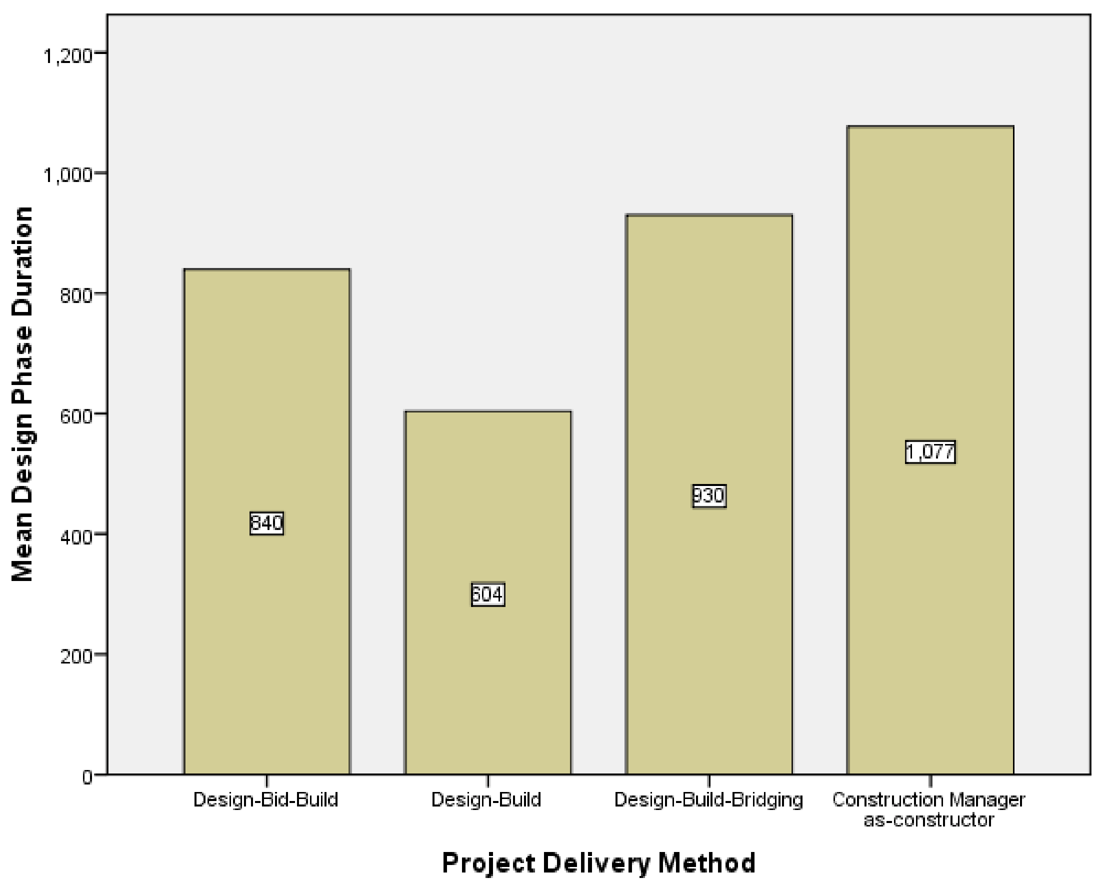


Figure 4.24 Cross-Tabulation of Design Phase Duration and Project Delivery Method (Days)

4.5.18. Construction Phase Duration

The construction phase using construction manager as-constructor and design-bid-build are almost the same. Projects using construction manager as-constructor extend 1,148 days, and projects using design-bid-build extend an average of 1,104 days, as depicted in Figure 4.25. Projects using design-build-bridging and design-build suggest time savings. Design-build-bridging projects average 966 days for construction and projects using design-build average 774 days. The analysis reveals that there is a significant discrepancy in the amount of time to administer the construction using construction manager as-constructor versus design-build, with a savings of 32 percent.

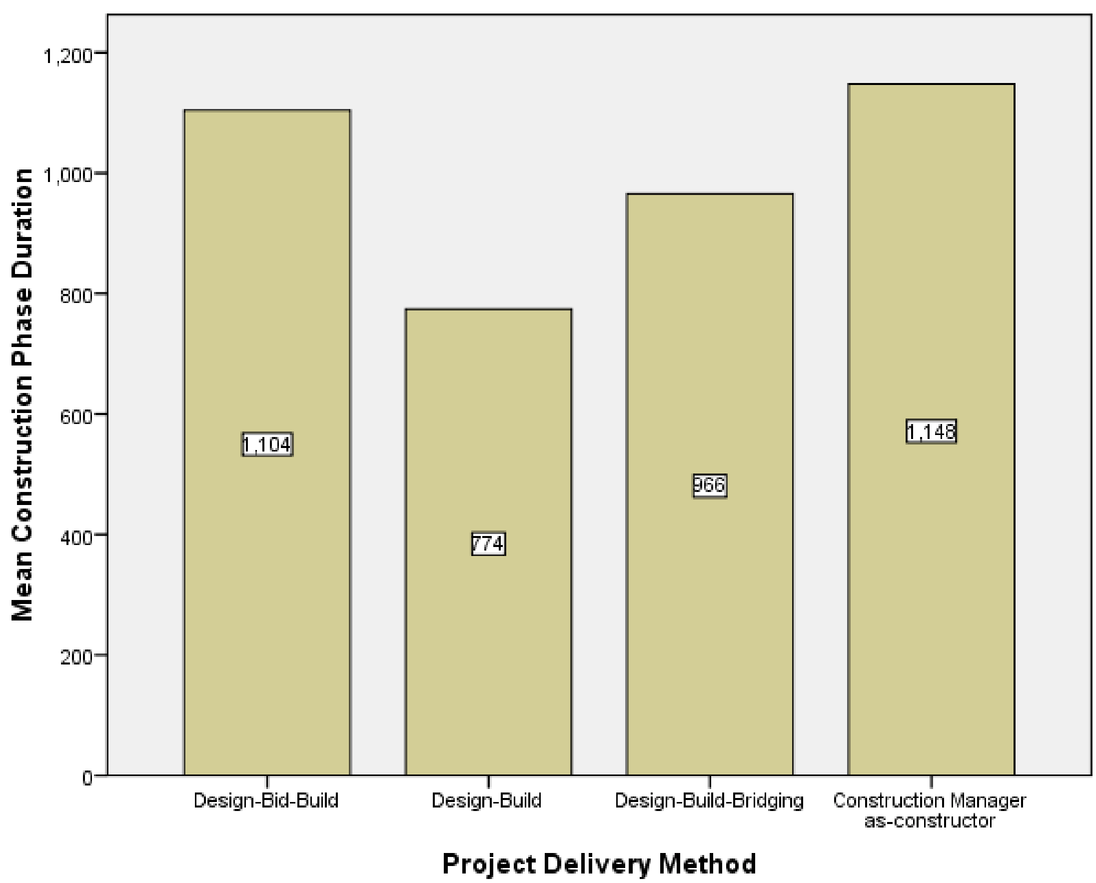


Figure 4.25 Cross-Tabulation of Construction Phase Duration and Project Delivery Method (Days)

4.5.19. Congress Authorization to Construction Finish Duration

Cross-tabulations analyzing the duration of the project when phases are grouped suggest that projects using construction manager as-constructor take longer from when Congress authorizes funds for the project and when construction ends, extending on average 1,518 days, as depicted in Figure 4.26. Projects using design-bid-build rank second averaging 1,231 days, and projects using design-build rank third averaging 1,189 days. The analysis also reveals that projects using design-build-bridging have the shortest duration, averaging 1,019 days. It should be noted that outliers may be present which skew the data. The next two variables group durational data differently.

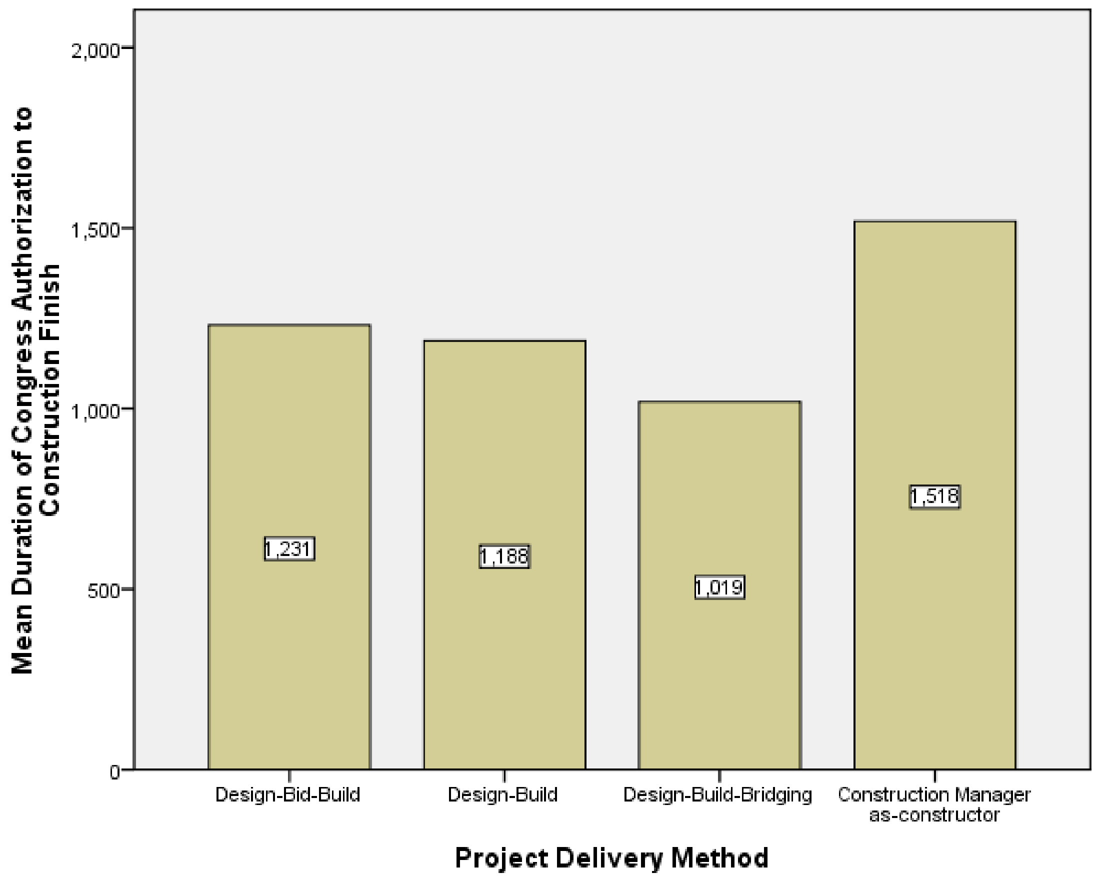


Figure 4.26 Cross-Tabulation of Duration of Congress Authorization and Construction Finish and Project Delivery Method (Days)

4.5.20. Planning Start to Construction Finish Duration

Cross-tabulation analysis indicating the duration between when the planning phase begins and when construction is complete suggests that projects using the construction manager as-constructor method have the longest duration, extending an average of 1,800 days, as presented in Figure 4.27. The analysis suggests that projects using design-build-bridging have the shortest duration with an average 1,054 days. Projects using design-bid-build rank second in longest durations with 1,359 days, and projects using design-build rank third with longest duration with 1,228 days.

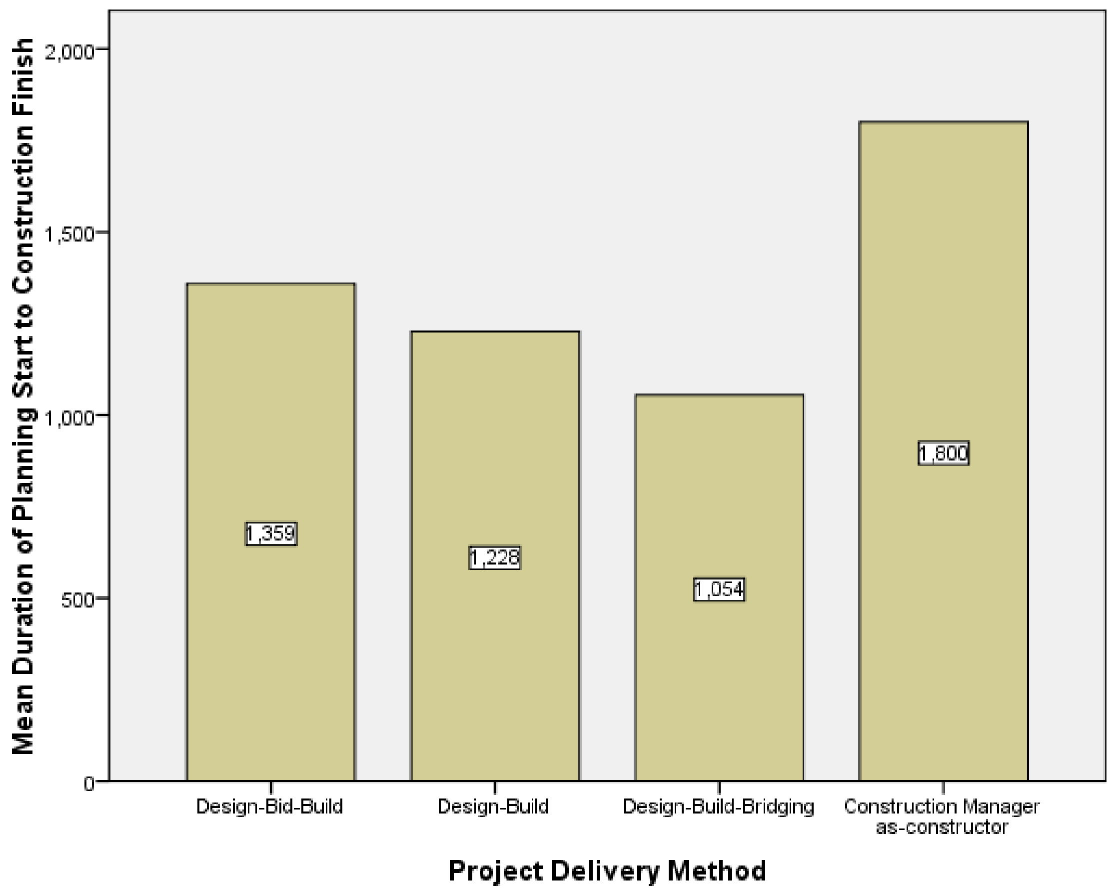


Figure 4.27 Cross-Tabulation of Duration of Planning Start and Construction Finish and Project Delivery Method (Days)

4.5.21. Design Start to Construction Finish Duration

The duration of time, on average, from when a design begins and when construction ends is telling. Similar to other cross-tabulations of time, projects using the construction manager as-constructor, on average, have the longest durations, with 2,661 days, as depicted in Figure 4.28. Cross-tabulations also suggest that projects using design-build-bridging have significantly lower durations, with an average of 1,099 days for design and construction phases. Projects using design-bid-build rank second in longest durations with an average of 2,246 days, and projects using design-build for project delivery average 1,850 days for design and construction activities.

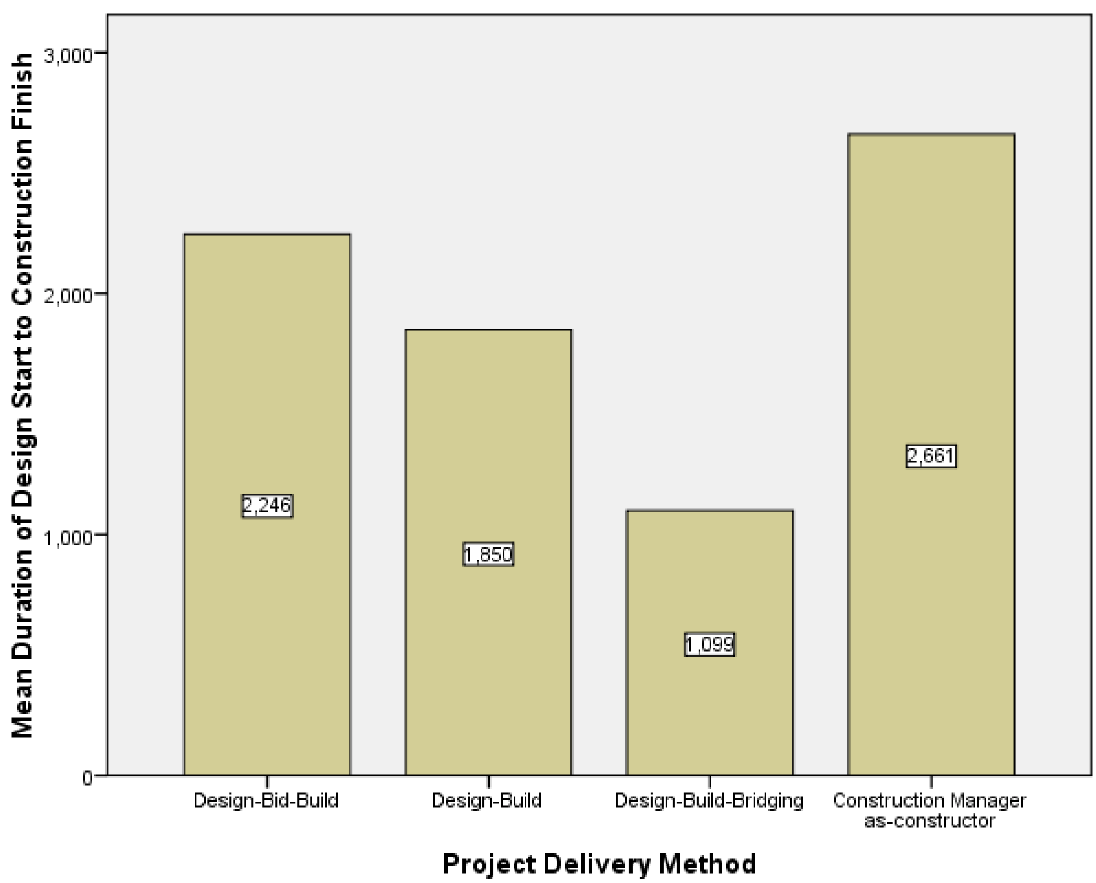


Figure 4.28 Cross-Tabulation of Duration of Design Start and Construction Finish and Project Delivery Method (Number of Projects)

4.5.22. Federal Legislation

This research tests whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized. Cross tabulation of the project delivery method and whether the 1996 Clinger-Cohen Act was passed when Congress authorized funding for the project is analyzed, as presented in Table 4.17 and Figure 4.29. This analysis reveals that design-bid-build is the project delivery method chosen more often project after the Clinger-Cohen Act is enacted: GSA public owners have lessened legislative restrictions on using an alternative delivery method and still choose design-bid-build. There are significant numbers of projects that choose design-build, design-build-bridging and construction manager as constructor once those legislative barriers are lifted. Only four projects choose design-build before 1996, and 73 choose design-build after 1996. There seems to be a trend using cross tabulation for the analysis. More detailed statistical analyses are explored in Chapter 5 to determine whether a statistically significant relationship exists among these variables.

Table 4.17 Cross-Tabulation of Project Delivery Method and Federal Legislation (Number of Projects)

	Federal Legislation			Total
	No	Yes	Missing	
Design-Bid-Build	44	173	35	252
Design-Build	4	73	23	100
Design-Build-Bridging	1	16	52	69
Construction Manager as Constructor	7	63	5	75
Total	56	325	115	496

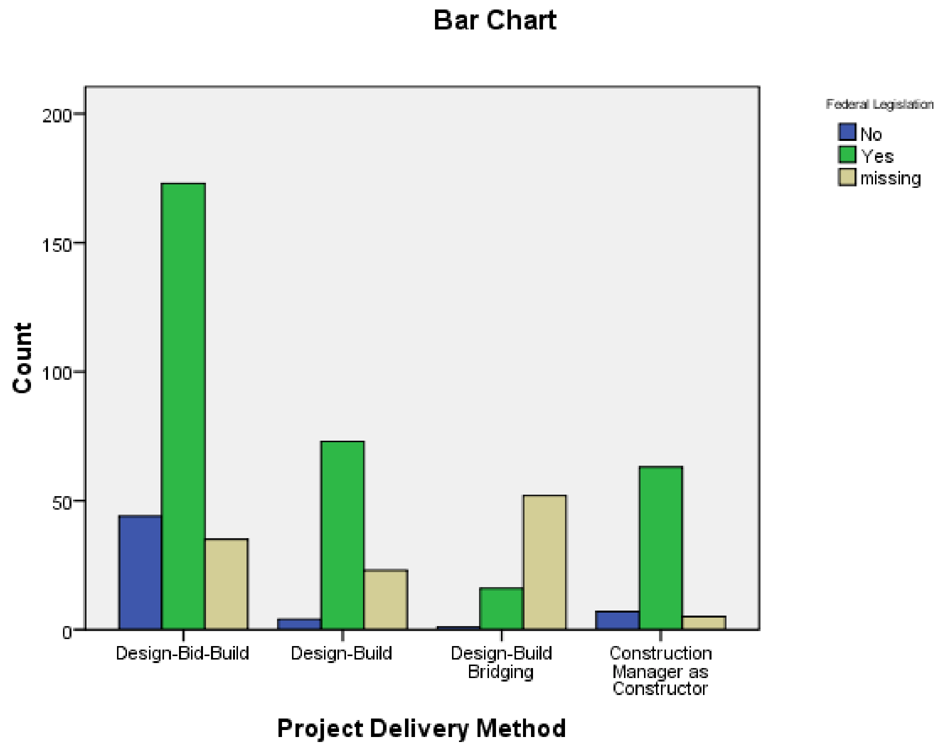


Figure 4.29 Cross-Tabulation of Project Delivery Method and Federal Legislation

4.5.23. State Legislation

Similar to *Federal Legislation*, cross-tabulation is explored to determine if there is trend in project delivery method selection and if design-build is authorized in the state when Congress authorized funding for the project. This tests whether benefits are realized when an alternative delivery method is chosen for a federal project when there are lessened legislative barriers at the state level. The results are presented in Table 4.18 and Figure 4.30. The analysis reveals that more federal projects choose an alternative delivery method if state legislation (in the state the project is located) allows the use of design-build. This is true in all delivery methods, except for design-build-bridging. The use of design-build for federal projects doubled in states that allow design-build. The use of design-bid-build stays almost stable and yet there is only a slight increase when there are lessened state legislative barriers. Using cross tabulation indicates a trend in the use of design-build with lessened state legislative barriers. More detailed statistical analyses are explored in Chapter 5 to determine whether a statistically significant relationship exists among these variables.

Table 4.18 Cross-Tabulation of Project Delivery Method and State Legislation (Number of Projects)

	State Legislation			Total
	No	Yes	Missing	
Design-Bid-Build	81	86	85	252
Design-Build	22	49	29	100
Design-Build-Bridging	8	4	57	69
Construction Manager as Constructor	25	28	22	75
Total	136	167	193	496

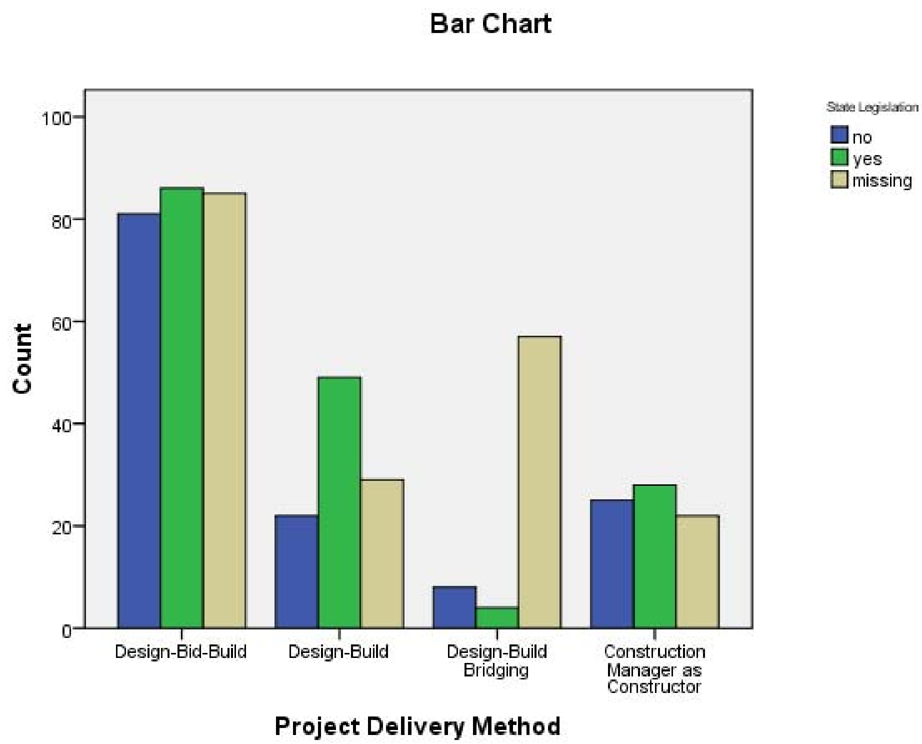


Figure 4.30 Cross-Tabulation of Project Delivery Method and State Legislation

4.6 Summary

The goal of this chapter is to present information using descriptive statistics and cross-tabulation analysis to present analysis that assists owners in project delivery method selection in the regulatory environment. The chapter begins by discussing the methodology technique chosen for this research and then presents data from the U.S General Services Administration (GSA) to measure the hypothesis. Project variables are presented and descriptive statistics of such variables are explored. The chapter ends using the cross-tabulation technique to ascertain whether a relationship exists among the variables in the database and project delivery method selection. The cross-tabulation analysis reveals that the largest projects in size use alternative delivery methods, such as design-build and construction manager as-constructor. Design costs are lower using design-build and design-build-bridging than other methods, and projects using construction manager as-constructor have the longest duration. This may be because one contract is awarded for design and construction and two or more contracts are awarded for the other three methods. The cross-tabulation analysis also reveals that there is an increase in the use of alternative delivery methods, especially design-build, once federal and state legislative barriers are lifted. Before Clinger-Cohen was passed in 1996, only 4 projects choose design-build; after this law is passed, 73 projects choose design-build. Design-build is selected twice as much after state legislative barriers are lifted. Cross-tabulations suggest a relationship among legislative impediments and project delivery method selection. However, while cross-tabulation as an analysis technique describes the relationship among two variables, it does not measure the strength of the relationship and does not describe whether a statistically significant relationship exists among the variables. To do this, the next chapter uses correlation to measure the association among the variables and then uses regression procedures to produce multiple correlations and determine whether a statistically significant relationship exists to test the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

CHAPTER 5

FINDINGS

5.1 Purpose

The previous chapter presents the research chronology of this study and describes how the quantitative analysis technique using SPSS tests the hypothesis. The previous chapter also presents data from the U.S. General Services Administration (GSA) to use in the quantitative analysis. The data set contains 496 over-prospectus projects with 24 project characteristics. The project characteristics are chosen as the variables in this study because this database and the information contained in it is congressionally-mandated. Descriptive statistics are drawn from an analysis of the project variables; then, the cross-tabulation technique is applied to ascertain whether a relationship exists among specific variables and the project delivery method selection. Using cross-tabulation, the previous chapter reveals that a relationship exists between project delivery method selection and legislative impediments. The goal of this chapter is to measure the association among the variables, and then to produce multiple correlations and determine whether a statistically significant relationship exists between the project delivery method and the project characteristics. The chapter begins using correlation analysis; a series of five predictive models are then developed to test the hypothesis under, before and after legislative impediments scenarios. The ultimate goal of this chapter is to extrapolate analysis from the relationships developed in the models to determine whether benefits exist after legislative impediments are lifted; regression techniques are used to assess any such impact.

5.2 Correlation Analysis

In Chapter 4, the descriptive statistics that are discussed relate to only a single variable. These are referred to as measures of central tendency and variability. Oftentimes, research seeks to determine if two or more variables are interrelated. For example, in Chapter 4, the research determines that relationships exist between the selection of an alternative project delivery method and whether federal legislation is enacted to allow alternative project delivery methods. Research also seeks to determine if a relationship exists between which project delivery method is selected and federal legislation, between the program type and the project type, and between the Estimated Total Prospectus Cost and the duration from the beginning of design through the end of construction. Relationships between two or more variables exist, and this research seeks to describe or indicate the strength of such relationships in the data.

The statistical process by which the nature of relationships among variables is investigated is referred to as a *correlation* (Leedy and Ormrod, 2005). One function of correlation studies the extent to which differences in one characteristic or variable are related to differences in one or more other characteristics or variables. A correlation exists if, when one variable increases (or decreases), another variable either increases or decreases in a predictable way. Correlation then is a bivariate measure of the association between two variables (Garson, n.d.). It measures the strength of the association. Correlation is most commonly reported in terms of its square (r^2), and is usually referred to as Pearson's r (Pearson product moment correlation); it is also referred to as a correlation coefficient (Leedy and Ormrod, 2005). It is a number between -1 and +1 and suggests two different ways the statistics can be analyzed: direction and strength. The direction of the relationship is indicated by its sign, or whether the number is positive or negative. A positive number indicates a positive correlation: as one variable increases, another variable also increases. A negative number indicates a negative relationship: as one variable increases, another variable decreases. The strength of the relationship is indicated by the size of the statistic. It varies from 0, indicating no relationship (random pairing of values), to 1, a perfect linear relationship (the more the x the more the y), or -1, a perfect negative linear relationship (the less the x the less the y). Correlation is the ratio of the observed covariance of two standardized variables divided by the highest possible covariance when their variables are arranged in the best possible match by order (Garson, n.d.). When the covariance is as high as the possible covariance, the correlation will have a value of 1, indicating perfectly matching order of two variables. Its square is interpreted as the percent of variance explained. For example, if the Pearson correlation is 0.55, then the independent variable explains 55 percent of the variance in the dependent variable. Using the hypothesis in this research, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, if the square is 0.55, then legislative impediments will explain 55 percent of the projects that use an alternative delivery method.

In addition to direction and strength, correlation also presents the likelihood that the direction and strength of the relationship being tested occurs by chance. The relationship is considered statistically significant, if it is unlikely to have occurred by chance. A statistically significant difference means that there is statistical evidence that there is a difference. It does not mean that the difference is significant in the common meaning of the word. The level of significance is usually referred to by the Greek symbol for alpha (α), and is commonly referred as the significance level. Research opinions vary about what standards must be met to ascertain whether a correlation occurs by chance. One common cutoff is a 1-in-20 probability: that any result will occur by chance only 5 percent (0.05) of the time, and other researchers use more rigorous 1-in-100 criterion: that any result will occur by chance only one percent (0.01) of the time (O'Sullivan and Rassell, 1999). A result based on .05 and .01 levels are deemed not to be due to chance, and are then commonly referred to as significantly significant predictors of the relationship being tested. The statistics presented in this section also test the relationship using two-tailed significance, which tests the chance the observed correlation is significantly different from zero correlation, in a positive or negative direction. A two-tailed test analyzes the absolute magnitude of the correlation. Garson (n.d.) explains that correlation is a common method of validating a measure to see if it correlates with some objective measures. This research tests whether certain project characteristics, and specifically legislative impediments, affect benefits being realized using alternative project delivery methods. Methods of establishing the reliability and validity measures rely heavily on correlation performed in this section.

5.2.1 Region

The Pearsonian correlation coefficient testing the dependent variable, the project delivery method, against the independent variable, the GSA region in which the project is located, suggests that there is a negative correlation, with -0.099, and a negative linear relationship, as depicted in Table 5.1. This relationship is considered statistically significant at the 0.05 level: there is a 2.7 percent chance that this relationship occurs by chance. However, since the Pearson coefficient is 0.099, this suggests that the region explains only 9.9 percent of the projects in the database; but because the database is large, with 496 projects, 44 projects are explained. An analysis of this coefficient suggests that regions choose one delivery method more than another for 44 projects in the database; the remaining 90 percent of projects have no established pattern in which project delivery method is selected in each region.

Table 5.1 Correlation of Project Delivery Method and Regional Distribution

		Project Delivery Method	Region
Project Delivery Method	Pearson Correlation	1	-.099*
	Sig. (2-tailed)		.027
	N	496	496
Region	Pearson Correlation	-.099*	1
	Sig. (2-tailed)	.027	
	N	496	496

* Correlation is significant at the 0.05 level (2-tailed).

5.2.2 Project Type

Project type, as the independent variable, is tested against the project delivery method, the dependent variable, using correlation, as presented in Table 5.2. Significant at the 0.01 level, there is a positive relationship between the project type and the project delivery method, with the Pearson coefficient of 0.131. The relationship between project type and project delivery method explains then only 13 percent of all projects in the database. An analysis suggests that this is highly significant, with less than one percent likelihood that this occurs by chance, between the type of project (renovation and alteration, new construction, or lease-construct) and the selection of project delivery method. A positive perfect linear relationship would have a value of 1. So while this has a positive relationship, it leans to a random pairing of values, or a value of zero. This means that there is a positive relationship between the project type and delivery method, but not a strong positive relationship. Referring back to the earlier cross-tabulation analysis of project type and project delivery method (Table 4.9), and applying the findings to correlation, results suggest that there is a greater likelihood that alternative project delivery methods are chosen for new construction and lease-construct than for renovation and alteration projects; this explains only 13 percent of cases, and there is a 0.004 percent likelihood that this relationship occurs by chance. Because the database is so large, however, with 496 projects, 64 projects using alternative project delivery methods are more likely to be new construction and lease-construct.

Table 5.2 Correlation of Project Delivery Method and Project Type

		Project Delivery Method	Project Type
Project Delivery Method	Pearson Correlation	1	.131**
	Sig. (2-tailed)		.004
	N	496	496
Project Type	Pearson Correlation	.131**	1
	Sig. (2-tailed)	.004	
	N	496	496

** Correlation is significant at the 0.01 level (2-tailed).

5.2.3 Program Area

Similar to Section 5.2.2, there is a positive correlation between the program area, as the independent variable, and the project delivery method, the dependent variable, with a 0.040 Pearson coefficient. This means that four percent of all projects in the database can be explained, as presented in Table 5.3. The greatest percentage of alternative project delivery methods are being applied to federal buildings and border stations. Although correlation suggests that there is a positive relationship, this analysis is not considered statistically significant (0.379, or 37 percent of the cases are explained by chance); therefore, there is a great likelihood that this relationship statistic occurs by chance.

Table 5.3 Correlation of Project Delivery Method and Program Area

		Project Delivery Method	Program Area
Project Delivery Method	Pearson Correlation	1	.040
	Sig. (2-tailed)		.379
	N	496	496
Program Area	Pearson Correlation	.040	1
	Sig. (2-tailed)	.379	
	N	496	496

5.2.4 Project Delivery Method

This project characteristic is the dependent variable in the analysis.

5.2.5 Political Party

Testing the dependent variable, the project delivery method, against the independent variable, the political party supporting the project, suggests a statistically significant positive relationship, with a Pearson correlation coefficient of 0.090, as depicted in Table 5.4. However, only 9 percent of all projects can explain the relationship between the project delivery method and the political party sponsoring the project. But because of the size of the database, this attributes to 44 projects. Referring back to Table 4.11, and applying those findings to correlation analysis, results suggest that there is a greater likelihood that alternative project delivery methods are being applied to projects with Democratic sponsorship. This holds true for approximately 44 projects and holds a 4.5 percent likelihood that this statistic occurs by chance.

Table 5.4 Correlation of Project Delivery Method and Political Party

		Project Delivery Method	Political Party Sponsorship
Project Delivery Method	Pearson Correlation	1	.090*
	Sig. (2-tailed)		.045
	N	496	496
Political Party Sponsorship	Pearson Correlation	.090*	1
	Sig. (2-tailed)	.045	
	N	496	496

* Correlation is significant at the 0.05 level (2-tailed).

5.2.6 Gross Area

The statistical relationship developed by analyzing project delivery method, as the dependent variable, and gross area, the independent variable, suggests a negative relationship, with -0.19, as presented in Table 5.5. This relationship, however, is only applicable to less than 2 percent of the projects in the database and is not statistically significant. There is a strong likelihood, a 67 percent likelihood that this coefficient occurs by chance. An analysis then suggests that there is a positive relationship in 1.9 percent of the projects in the database, but it is not statistically significant that the size of the building explains the selection of a project delivery method. Referring back to Figure 4.11, this statistic is surprising in that cross-tabulations suggest that the largest buildings, on average, use alternative project delivery methods.

Table 5.5 Correlation of Project Delivery Method and Gross Area

		Project Delivery Method	Gross Area
Project Delivery Method	Pearson Correlation	1	-.019
	Sig. (2-tailed)		.670
	N	496	496
Gross Area	Pearson Correlation	-.019	1
	Sig. (2-tailed)	.670	
	N	496	496

5.2.7 Usable Space

Six percent of all projects (or 29 projects) in the database are attributable to a positive relationship between the project delivery method, as the dependent variable, and usable space, the independent variable, with a Pearson coefficient of 0.064, as presented in Table 5.6. This suggests that 6.4 percent of all projects in the database have a high usable space and are using an alternative project delivery method. However, this is not a statistically significant finding (0.154), and, therefore, may have occurred by chance.

Table 5.6 Correlation of Project Delivery Method and Usable Space

		Project Delivery Method	Usable Space
Project Delivery Method	Pearson Correlation	1	.064
	Sig. (2-tailed)		.154
	N	496	496
Usable Space	Pearson Correlation	.064	1
	Sig. (2-tailed)	.154	
	N	496	496

5.2.8 Congress Authorization

This statistic measures the relationship between the dependent variable, project delivery method, and the difference in monies between what is authorized by Congress and the Estimated Total Prospectus Cost. As mentioned in Chapter 4, Congress first authorizes funds for a project, then Conference convenes to appropriate those funds, and, finally, GSA's Central Office allocates funds for the project. At each stage of the process, funds can be added or taken away. This statistic measures the likelihood that a greater percentage of funds is allocated to the project during this process. Correlation analysis suggests that there is a negative relationship between the project delivery method and the difference in what Congress authorized and the Estimated Total Prospectus Cost, with a Pearson correlation coefficient of -0.121, as depicted in Table 5.7. This means that fewer funds are going to projects that use alternative project delivery methods. However, even though highly statistically significant at the 0.01 level (0.007), this coefficient explains only 12 percent of all projects in the database; but because the database contains 496 projects, 60 projects can be attributed to this statistic. Sixty projects realize a lower percentage of funds authorized by Congress if using an alternative project delivery method, such as design-build and construction manager as-constructor.

Table 5.7 Correlation of Project Delivery Method and Congress Authorization minus Estimated Total Prospectus Cost

		Project Delivery Method	Congress Authorization minus Estimated Total Prospectus Cost
Project Delivery Method	Pearson Correlation	1	-.121**
	Sig. (2-tailed)		.007
	N	496	496
Congress Authorization minus Estimated Total Prospectus Cost	Pearson Correlation	-.121**	1
	Sig. (2-tailed)	.007	
	N	496	496

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.9 Conference Appropriation

This statistic measures the relationship between the dependent variable, project delivery method, and the difference in monies between what is appropriated by Conference and the Estimated Total Prospectus Cost. This measurement is the second phase of the funding approval process, as discussed in Section 5.2.8. As presented in Table 5.8, there is a negative relationship between the project delivery method and the difference in funds between what is appropriated by Conference and the Estimated Total Prospectus Cost. Alternative project delivery methods, such as design-build and construction manager as-constructor, receive a lower percentage of monies through the funding approval process than the traditional design-bid-build and design-build-bridging methods. This is highly significant, with less than one percent (0.008) likelihood that this is explained by chance. However, this statistic only explains 11.8 percent of the cases in the database; but since the database contains 496 projects, 58 projects suggest that those using alternative project delivery methods, such as design-build and construction manager as-constructor, receive a lower percentage of funding than what Conference has appropriated.

Table 5.8 Correlation of Project Delivery Method and Conference Appropriation minus Estimated Total Prospectus Cost

		Project Delivery Method	Conference Appropriation minus Estimated Total Prospectus Cost
Project Delivery Method	Pearson Correlation	1	-.118**
	Sig. (2-tailed)		.008
	N	496	496
Conference Appropriation minus Estimated Total Prospectus Cost	Pearson Correlation	-.118**	1
	Sig. (2-tailed)	.008	
	N	496	496

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.10 Central Office Allowance

The third phase of the funding approval process, this statistic measures the relationship between the dependent variable, project delivery method, and the difference in monies between what is allowed by Central Office and the Estimated Total Prospectus Cost. As presented in Table 5.9, and similar to the correlation analyses in sections 5.2.8 and 5.2.9, there is a negative relationship between the project delivery method and the difference in monies between what is allowed by Central Office and the Estimated Total Prospectus Cost, with a Pearson coefficient of -0.131. This is a highly statistically significant relationship, with less than one percent (0.004) of the variable attributable to chance. However, this statistic only explains 13 percent of all projects in the database. But since the database contains 496 projects, 64 of those projects suggest that those using alternative contracting methods are getting fewer funds from GSA's Central Office.

Table 5.9 Correlation of Project Delivery Method and Central Office Allowance minus Estimated Total Prospectus Cost

		Project Delivery Method	Central Office Allowance minus Estimated Total Prospectus Cost
Project Delivery Method	Pearson Correlation	1	-.131**
	Sig. (2-tailed)		.004
	N	496	496
Central Office Allowance minus Estimated Total Prospectus Cost	Pearson Correlation	-.131**	1
	Sig. (2-tailed)	.004	
	N	496	496

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.11 Estimated Total Prospectus Cost

Testing the dependent variable, the project delivery method, against the independent variable, the Estimated Total Prospectus Cost (ETPC), suggests a positive relationship, with a Pearson correlation coefficient of 0.082, as depicted in Table 5.10. Eight percent of all projects in the database, or 40 projects, suggest that alternative project delivery methods have higher Estimated Total Prospectus Costs. The analysis also indicates that this is not a statistically significant relationship (0.069), and thus almost 7 percent of the variance can be attributable to chance.

Table 5.10 Correlation of Project Delivery Method and Estimated Total Prospectus Cost

		Project Delivery Method	Estimated Total Prospectus Cost
Project Delivery Method	Pearson Correlation	1	.082
	Sig. (2-tailed)		.069
	N	496	496
Estimated Total Prospectus Cost	Pearson Correlation	.082	1
	Sig. (2-tailed)	.069	
	N	496	496

5.2.12 Estimated Total Prospectus Cost Site

Performing a correlation analysis to the dependent variable, the project delivery method, and the independent variable, the Estimated Total Prospectus Cost of the site work, suggests a negative relationship, with a coefficient of -0.004, as depicted in Table 5.11. This analysis suggests that alternative project delivery methods have less ETPC for site work than traditional design-bid-build and design-build-bridging methods. However, this coefficient is not highly statistically significant, with a two-tailed test predicting 0.972, or that there is a 97 percent likelihood that these results are by chance.

Table 5.11 Correlation of Project Delivery Method and Estimated Total Prospectus Cost Site

		Project Delivery Method	Estimated Total Prospectus Cost Site
Project Delivery Method	Pearson Correlation	1	-.004
	Sig. (2-tailed)		.972
	N	496	84
Estimated Total Prospectus Cost Site	Pearson Correlation	-.004	1
	Sig. (2-tailed)	.972	
	N	84	84

5.2.13 Estimated Total Prospectus Cost Design

Six percent of all projects in the database (29 projects) suggest that there is a positive relationship between the Estimated Total Prospectus Cost of design and the project delivery method, with a Pearson coefficient of 0.062, as presented in Table 5.12. This statistic suggests that alternative project delivery methods, specifically design-build, have lower ETPC for the design phase than design-bid-build and design-build-bridging. The analysis also presents a high likelihood that these results are received by chance, 0.296 or 29 percent, and thus cannot be considered statistically significant findings.

Table 5.12 Correlation of Project Delivery Method and Estimated Total Prospectus Cost Design

		Project Delivery Method	Estimated Total Project Cost Design
Project Delivery Method	Pearson Correlation	1	.062
	Sig. (2-tailed)		.296
	N	496	286
Estimated Total Project Cost Design	Pearson Correlation	.062	1
	Sig. (2-tailed)	.296	
	N	286	286

5.2.14 Estimated Total Prospectus Cost Construction

The dependent variable, project delivery method, is tested against an independent variable, Estimated Total Prospectus Cost of construction activities using correlation. Pearson correlation coefficient suggests a statistically significant relationship, at the 0.05 level (0.029) that a relationship exists, as presented in Table 5.13.

Table 5.13 Correlation of Project Delivery Method and Estimated Total Prospectus Cost Construction

		Project Delivery Method	Estimated Total Project Cost Construction
Project Delivery Method	Pearson Correlation	1	.125*
	Sig. (2-tailed)		.029
	N	496	304
Estimated Total Project Cost Construction	Pearson Correlation	.125*	1
	Sig. (2-tailed)	.029	
	N	304	304

*. Correlation is significant at the 0.05 level (2-tailed).

An analysis of this relationship shows that alternative project delivery methods, specifically design-build, have lower Estimated Total Project Costs for construction than design-bid-build and design-build-bridging. Twelve percent of the projects in the database, or 60 projects, can be attributable to this coefficient relationship.

5.2.15 Congress Authorization Year

The year Congress authorized funding for the project, as the independent variable, is tested against the project delivery method, the dependent variable in Table 5.14. Such correlation analysis suggests that there is a highly statistically significant relationship at the 0.01 level (0.006) between the year that Congress authorizes funding for the project and the likelihood that alternative project delivery methods are selected. This statistic shows that there is a greater likelihood of alternative project delivery method selection in the 2000s than in the 1990s. This statistic supports the hypothesis of this research; in the next section of this chapter, multivariate analyses will test legislative impediments, the year Congress authorized funding, and the project delivery method selection to ascertain potential relationships. This finding using correlation supports more-detailed studies of the hypothesis of whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

Table 5.14 Correlation of Project Delivery Method and Congress Authorization Year

		Project Delivery Method	Congress Authorization Year
Project Delivery Method	Pearson Correlation	1	-.135**
	Sig. (2-tailed)		.006
	N	496	404
Congress Authorization Year	Pearson Correlation	-.135**	1
	Sig. (2-tailed)	.006	
	N	404	404

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.16 Planning Phase Duration

The dependent variable, project delivery method, is analyzed using correlation to the independent variable, planning phase duration, to ascertain potential relationships. A negative relationship exists among these two variables, as depicted in Table 5.15. The correlation suggests that there is a longer planning phase using alternative project delivery methods, design-build and construction manager as-constructor, than design-bid-build and design-build-bridging methods, with a Pearson coefficient of -0.008. However, this relationship is not statistically significant, with an 86.4 percent (0.0864) likelihood that the relationship is by chance.

Table 5.15 Correlation of Project Delivery Method and Planning Phase Duration

		Project Delivery Method	Planning Phase Duration
Project Delivery Method	Pearson Correlation	1	-.008
	Sig. (2-tailed)		.864
	N	496	496
Planning Phase Duration	Pearson Correlation	-.008	1
	Sig. (2-tailed)	.864	
	N	496	496

5.2.17 Design Phase Duration

There is a strong significantly significant relationship between the dependent variable, the project delivery method, and the independent variable, the duration of the design phase, with a Pearson correlation of 0.119, as presented in Table 5.16. Significant at the 0.01 level (0.008), the Pearson coefficient suggests that 59 projects suggest that projects using design-build having a shorter design phase. Referring back to Figure 4.22 using cross-tabulation and applying statistics from correlation, design-build projects have the shortest design phases; this statistic is highly significant at the 0.01 level and attributable to 59 projects in the database.

Table 5.16 Correlation of Project Delivery Method and Design Phase Duration

		Project Delivery Method	Design Phase Duration
Project Delivery Method	Pearson Correlation	1	.119**
	Sig. (2-tailed)		.008
	N	496	496
Design Phase Duration	Pearson Correlation	.119**	1
	Sig. (2-tailed)	.008	
	N	496	496

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.18 Construction Phase Duration

A negative relationship exists between the project delivery method, the dependent variable, and the duration of the construction phase, the independent variable, with a Pearson coefficient of -0.016, as shown in Table 5.17. Less than 2 percent of all projects in the database can be attributable to this finding that construction activities take longer for design-build and construction manager as-constructor. Applying findings under cross tabulations, in Figure 4.23 to the correlation, a discrepancy in the data develops. Cross-tabulations indicate that projects using design-build have shorter construction phase durations than any other method. The data may be skewed by the finding that construction manager as-constructor projects actually take longer than any other delivery method or might be attributable to special attributes of individual projects within the 2 percent.

Table 5.17 Correlation of Project Delivery Method and Construction Phase Duration

		Project Delivery Method	Construction Phase Duration
Project Delivery Method	Pearson Correlation	1	-.016
	Sig. (2-tailed)		.721
	N	496	496
Construction Phase Duration	Pearson Correlation	-.016	1
	Sig. (2-tailed)	.721	
	N	496	496

5.2.19 Congress Authorization to Construction Finish Duration

Project delivery method selection, the dependent variable, is analyzed using correlation to the duration of time when the project is authorized by Congress when construction activities are complete. Pearson correlation suggests that there is a positive relationship among the variables, with a coefficient of 0.070, explaining 34 projects in the database, as presented in Table 5.18. This statistic suggests that design-build has a shorter duration from Congress authorization to construction finish. Referring back to Figure 4.24, and applying correlation, result indicate that this duration of time is longer in construction manager as-constructor and the other three methods (design-bid-build, design-build, and design-build-bridging) are, on average, similar in duration. This finding though is not statistically significant at 0.118, with an 11 percent likelihood that these results are by chance. More extensive studies on duration will be performed in the multivariate analyses.

Table 5.18 Correlation of Project Delivery Method and Congress Authorization to Construction Finish Duration

		Project Delivery Method	Congress Authorization to Construction Finish Duration
Project Delivery Method	Pearson Correlation	1	.070
	Sig. (2-tailed)		.118
	N	496	496
Congress Authorization to Construction Finish Duration	Pearson Correlation	.070	1
	Sig. (2-tailed)	.118	
	N	496	496

5.2.20 Planning Start to Construction Finish Duration

There is a positive relationship between project delivery methods, the dependent variable, and the duration of time between the beginning of the planning phase and the end of construction, with a Pearson coefficient of 0.086, as presented in Table 5.19. Referring back to Figure 4.25 and applying correlation, results indicate that construction manager as-constructor has a significantly longer duration than any other method. Design-build and design-build-bridging have the shortest durations between when planning starts and through the end of construction. This statistic will be analyzed further using multivariate analysis in the next section in that it is not considered to be statistically significant at the 0.05 level, but it does explain 5.6 percent of the variance due to chance.

Table 5.19 Correlation of Project Delivery Method and Planning Start to Construction Finish Duration

		Project Delivery Method	Planning Start to Construction Finish Duration
Project Delivery Method	Pearson Correlation	1	.086
	Sig. (2-tailed)		.056
	N	496	496
Planning Start to Construction Finish Duration	Pearson Correlation	.086	1
	Sig. (2-tailed)	.056	
	N	496	496

5.2.21 Design Start to Construction Finish Duration

This section measures the relationship between the duration of when the design starts and when the construction ends, the independent variable, and the project delivery method, the dependent variable. A Pearson coefficient of -0.010 suggests that a negative relationship is present between these variables, offering that design-build has a shorter duration, as presented in Table 5.20. Analyzing this statistic with Figure 4.26 suggests that there are skews in the data because the correlation offers an 83 percent (0.831) likelihood that this finding is by chance.

Table 5.20 Correlation of Project Delivery Method and Design Start to Construction Finish Duration

		Project Delivery Method	Design Start to Construction Finish Duration
Project Delivery Method	Pearson Correlation	1	-.010
	Sig. (2-tailed)		.831
	N	496	495
Design Start to Construction Finish Duration	Pearson Correlation	-.010	1
	Sig. (2-tailed)	.831	
	N	495	495

5.2.22 Federal Legislation

Testing whether a statistically significant relationship exists between federal legislation, specifically if the Clinger-Cohen Act is passed at the time Congress authorized funding for the project, the independent variable, and project delivery method, the dependent variable, specifically addresses the hypothesis. The hypothesis suggests that benefits exist when alternative project delivery methods are used and that legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized. The project delivery method is the dependent variable and the federal legislation variable is the independent variable, and the data is coded using a 0 to represent projects that are authorized by Congress without the Clinger-Cohen Act enacted, and a 1 to represent projects are authorized by Congress after the Clinger-Cohen Act is enacted. With a Pearson coefficient of 0.148 and statistically significant at the .01 level (.001), the analysis suggests that there is a positive relationship in the selection of an alternative project delivery method and the enactment of legislation allowing such selection, as presented in Table 5.21. Seventy-three projects in the database are explained by the relationship of this finding. This suggests that design-build is more likely chosen once federal legislation (Clinger-Cohen Act) allowing the selection of such methods is enacted. In the next section, this finding will be tested in more detail using multivariate analysis to provide further support for the hypothesis.

Table 5.21 Correlation of Project Delivery Method and Federal Legislation

		Project Delivery Method	Federal Legislation
Project Delivery Method	Pearson Correlation	1	.148**
	Sig. (2-tailed)		.001
	N	496	496
Federal Legislation	Pearson Correlation	.148**	1
	Sig. (2-tailed)	.001	
	N	496	496

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.23 State Legislation

The hypothesis also suggests that legislative impediments at the state level may be influencing realization of benefits of using design-build for federal projects. This statistic presented in Table 5.22 tests that hypothesis. The project delivery method is the dependent variable and the state legislation variable is the independent variable, and the data is coded using a 0 to represent projects that are authorized by Congress without design-build laws enacted in the states the projects are located, and a 1 to represent projects are authorized by Congress with design-build laws enacted in states the projects are located. Significant at the 0.05 level (0.017) and explaining 10 percent (0.107) of the projects in the database, 53 projects, design-build is more likely to be chosen for a federal project in a state that has enacted laws allowing design-build for state projects. This supports the hypothesis that state legislative impediments affect project delivery method selection for federal projects. In the next section, this finding will also be tested and scrutinized further using multivariate analysis to provide further support for the hypothesis.

Table 5.22 Correlation of Project Delivery Method and State Legislation

		Project Delivery Method	State Legislation
Project Delivery Method	Pearson Correlation	1	.107*
	Sig. (2-tailed)		.017
	N	496	496
State Legislation	Pearson Correlation	.107*	1
	Sig. (2-tailed)	.017	
	N	496	496

*. Correlation is significant at the 0.05 level (2-tailed).

5.3 Correlation Analysis Summary

This section on correlation suggests that positive and negative correlations exist among many of the variables in the dataset and project delivery method selection. There is strong support for the hypothesis, whether benefits exist when alternative project delivery methods are used and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, using correlation analysis. There are other findings in the database associated with time, cost and political support, in relation to the selection of a project delivery method, as presented in Table 5.23. Design-build projects have shorter design phases, are largely supported by the Democrat party, and have lower construction costs. Less projects funds, however, are being allocated to design-build projects by Congress, Conference and Central Office than other delivery methods. Even though these findings are considered statistically significant, Garson (n.d.) explains that there are several pitfalls in using correlation: (1) Correlation is symmetrical and does not provide evidence of which way the causation flows. If other variables also affect the dependent variable (project delivery method selection), then any covariance shared with the independent variable in a correlation may be falsely attributed to the independent variable. (2) Correlation may understate the relationship if two variables are correlated, of whether having perfectly linearity or perfectly negative linearity. (3) Correlation can also be a misleading average, if the variables depend on the value of the independent variable. This is known as homoscendasticity. (4) Garson also suggests that running many correlations "runs the risk that 5 percent of the coefficients may be found significant by chance alone (p. 12)."

Garson suggests that other measures of association be used to test the hypothesis, specifically regression.

Regression procedures produce multiple correlations (R), which is the correlation of multiple independent variables with a single dependent. The next section of this chapter examines the statistical strength of the relationship between the dependent variable (project delivery method selection) and multiple independent variables in the database, as a more-detailed and final test of the project characteristics in the database and, ultimately, the hypothesis.

Table 5.23 Summary of Correlation Analysis

Independent Variables Statistically Significant at the 0.01 Level	
Federal Legislation	0.148
Design Phase Duration	0.119
Conference Appropriation minus Estimated Total Prospectus Cost	-0.118
Congress Authorization minus Estimated Total Prospectus Cost	-0.121
Central Office Allowance minus Estimated Total Prospectus Cost	-0.131
Congress Authorization Year	-0.135
Independent Variables Statistically Significant at the 0.05 Level	
Estimated Total Prospectus Cost of Construction	0.125
State Legislation	0.107
Political Party	0.090

5.4 Multivariate Analysis Testing Project Characteristics

This section of the chapter tests and examines the relationships between the dependent variable (the project delivery method) and multiple independent (the project characteristics) variables using multiple regression analysis. Multiple regression or multivariate analysis shares all the same assumptions of correlation analysis: linearity of relationships; same level of relationship throughout the range of the independent variable; interval or non-interval data; and the absence of outliers (Garson, n.d.). Multivariate analysis, however, is different from correlation in that the statistics examine how effectively two or more (independent) variables allow the researcher to predict the value of another (dependent) variable. It allows the researcher to test whether more than one project characteristic explains the change of the relationship in the dependent variable, the project delivery method. This research utilizes linear multiple regression techniques to examine the data. Linear regression generates an equation in which a single or multiple independent variable(s) yield(s) a prediction for the dependent variable (Leedy and Ormrod, 2005). The multiple regression equation takes the form of $y = b_1x_1 + b_2x_2 + \ldots + b_nx_n + c$. The (b) are the regression coefficients or beta weights. They represent the amount the dependent variable (y) changes when the corresponding independent variable (x) changes one unit. The (c) is the constant, where the regression line intercepts the y-axis. The c represents the amount the dependent variable (y) will be when all the independent variables (x) are zero. Multiple regression then establishes that a set of independent variables explains a proportion of the variance in a dependent variable at some level. The significance level is also similar to correlation and is determined through a significance test of R^2, which can establish the relative predictive importance of the independent variables (Garson, n.d.).

To examine the data using multiple regression techniques, this research uses SPSS, the statistical software, to generate predictive models, and refers to examples from Garson (n.d.) to assist in explaining the results of the regression techniques. The first predictive model that is generated tests whether any project characteristics (as multiple independent variables) have a relationship to the selection of a project delivery method (as the dependent variable). In this model, all independent variables are entered in a single step and project delivery method is shown as the dependent variable. Table 5.24 and Table 5.25 provide general information about the first predictive model. It tells when the model is created (May 9, 2008, at 12:27:06 p.m.), how many projects are in the dataset (496), and how the model treats missing variables in the dataset. There are 496 projects in the dataset and all projects are included in this first predictive model. Also, the researcher defines missing values in the dataset using a label of 999. When SPSS generates the predictive model, all values of 999 are replaced with the variable mean. The variable means are presented in Chapter 4.

Table 5.24 Model 1 Notes

Output Created		09-May-2008 12:27:06
Comments		
	N of Rows in Working Data File	496
	Definition of Missing	User-defined missing values are treated as missing.
Missing Value Handling	Cases Used	For each variable used, missing values are replaced with the variable mean.
	REGRESSION /MISSING MEANSUB /STATISTICS COEFF OUTS CI R ANOVA COLLIN TOL CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT DMOrig /METHOD=ENTER Region ProjectTypeOriginal ProgramOriginal FederalLaws1996 StateLaws HousePoliticalParty GrossArea UsableSpace CongressAuthorityFY PlanningTime DesignTime ConstructionTime AuthoritythroughConstruction PlanningthroughConstruction DesignandConstTime ETPCSite ETPCDesign ETPCConstruction ETPCTotal MoniesETPCTminusCongAuth MoniesETPCTminusConfAppro MoniesETPCTminusCentOffAllow /PARTIALPLOT ALL /SCATTERPLOT=(*ZPRED ,*SDRESID) (DMOrig ,*ZPRED) /RESIDUALS HIST(ZRESID) NORM(ZRESID).	
Syntax		Processor Time
Resources	Elapsed Time	00:00:08.111
	Memory Required	21180 bytes
	Additional Memory Required for Residual Plots	19400 bytes

Table 5.25 lists all independent variables and the dependent variable.

Table 5.25 Model 1 Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	Monies Difference Central Office Allowance and ETPC Total, Planning Phase Duration, State Legislation, Duration of Design Start to Construction Finish, Program, Project Type, Region, Estimated Total Project Cost Site, Duration of Planning Start to Construction Finish, Usable Space, House Political Party Sponsorship, Design Phase Duration, Gross Area, Duration of Congress Authorization to Construction Finish, Federal Legislation, Estimated Total Project Cost Design, Construction Phase Duration, Monies Difference ETPC Total and Congress Authorization, Estimated Total Project Cost Construction, Congress Authority FY, Monies Difference ETPC Total and Conference Appropriation, Estimated Total Project Cost Total[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Project Delivery Method

The dependent variable is the project delivery method and the independent variables include the following: (1) Region; (2) Project Type; (3) Program Area; (4) Political Party; (5) Gross Area; (6) Usable Space; (7) Estimated Total Prospectus Cost minus Congress Authorization; (8) Estimated Total Prospectus Cost minus Conference Appropriation; (9) Estimated Total Prospectus Cost minus Central Office Allowance; (10) Estimated Total Prospectus Cost; (11) Estimated Total Prospectus Cost Site; (12) Estimated Total Prospectus Cost Design; (13) Estimated Total Prospectus Cost Construction; (14) Congress Authorization Year; (15) Planning Phase Duration; (16) Design Phase Duration; and (17) Construction Phase Duration; (18) Congress Authorization to Construction Finish Duration; (19) Planning Start to Construction Finish Duration; (20) Design Start to Construction Finish Duration; (21) Federal Legislation;

and (22) State Legislation. These variables are the same as those analyzed in the descriptive statistics and cross-tabulations in Chapter 4 and in the correlation analysis earlier in Chapter 5.

Table 5.26 is the "bottom line," or the summary. The R-squared is the percent of the dependent explained by the independent variables.

Table 5.26 Model 1 Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.327[a]	.107	.066	1.081	.107	2.581	22	473	.000

a. Predictors: (Constant), Monies Difference Central Office Allowance and ETPC Total, Planning Phase Duration, State Legislation, Duration of Design Start to Construction Finish, Program, Project Type, Region, Estimated Total Project Cost Site, Duration of Planning Start to Construction Finish, Usable Space, House Political Party Sponsorship, Design Phase Duration, Gross Area, Duration of Congress Authorization to Construction Finish, Federal Legislation, Estimated Total Project Cost Design, Construction Phase Duration, Monies Difference ETPC Total and Congress Authorization, Estimated Total Project Cost Construction, Congress Authority FY, Monies Difference ETPC Total and Conference Appropriation, Estimated Total Project Cost Total

b. Dependent Variable: Project Delivery Method

In the case of this model, the independents explain 10.7 percent of the variance. This suggests that the model is misspecified. Other variables, not suggested by the researcher, explain the bulk (89.3 percent) of the variance. Moreover, the independent variables may share common variance with these unmeasured variables and may affect each other. For example, those positively related may affect those negatively related. In fact, part or even all of the observed 10.7 percent might disappear if these unmeasured variables are entered first in the equation. The Adjusted R-Squared is a standard, arbitrary downward adjustment to account for the possibility that, with many independents, some of the variance may be due to chance. The more independents in the model suggest the more the adjustment penalty. Even though there are many independents in this model, the penalty is considered minor, with 0.066 or a 6.6 percent likelihood that these results are received by chance (the penalty.)

The ANOVA table, Table 5.27, tests the overall significance of the model and of the regression equation. For this model, the F value is below 0.05 (with 0.000), so the model is highly significant. The significance of the model suggests that there is a less than 1 percent likelihood that the predictions in this model are due to chance.

Table 5.27 Model 1 Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66.323	22	3.015	2.581	.000[a]
	Residual	552.481	473	1.168		
	Total	618.804	495			

a. Predictors: (Constant), Monies Difference Central Office Allowance and ETPC Total, Planning Phase Duration, State Legislation, Duration of Design Start to Construction Finish, Program, Project Type, Region, Estimated Total Project Cost Site, Duration of Planning Start to Construction Finish, Usable Space, House Political Party Sponsorship, Design Phase Duration, Gross Area, Duration of Congress Authorization to Construction Finish, Federal Legislation, Estimated Total Project Cost Design, Construction Phase Duration, Monies Difference ETPC Total and Congress Authorization, Estimated Total Project Cost Construction, Congress Authority FY, Monies Difference ETPC Total and Conference Appropriation, Estimated Total Project Cost Total

b. Dependent Variable: Project Delivery Method

Table 5.28 gives the b and beta coefficients and other coefficients of the model. The b coefficients and the constant are used to create the prediction (regression) equation.

Table 5.28 Model 1 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	1.071	.732		1.463	.144	-.367	2.510		
	Region	-.032	.015	-.096	-2.094	.037	-.062	-.002	.901	1.110
	Project Type	.193	.087	.116	2.232	.026	.023	.363	.695	1.440
	Program Area	-.015	.094	-.008	-.157	.875	-.199	.170	.759	1.318
	Federal Legislation	.000	.000	.150	1.393	.164	.000	.001	.162	6.156
	State Legislation	1.995E-5	.000	.009	.148	.882	.000	.000	.550	1.818
	Political Party	9.887E-5	.000	.028	.546	.585	.000	.000	.732	1.367
	Gross Area	3.900E-8	.000	.023	.431	.667	.000	.000	.651	1.535
	Usable Space	4.769E-7	.000	.129	2.108	.036	.000	.000	.507	1.974
	Congress Authorization Year	-9.064E-5	.000	-.032	-.274	.784	.000	.001	.140	7.165
	Planning Phase Duration	-5.279E-5	.000	-.017	-.355	.723	.000	.000	.792	1.263
	Design Phase Duration	.000	.000	.176	2.739	.006	.000	.001	.458	2.182
	Construction Phase Duration	.000	.000	-.188	-2.739	.006	.000	.000	.401	2.491
	Congress Authorization to Construction Finish Duration	1.013E-6	.000	.001	.012	.990	.000	.000	.639	1.566
	Planning Start to Construction Finish Duration	.000	.000	.128	2.352	.019	.000	.000	.636	1.571
	Design Start to Construction Finish Duration	-8.915E-6	.000	-.034	-.760	.448	.000	.000	.946	1.057
	Estimated Total Project Cost Site	-8.901E-9	.000	-.035	-.589	.556	.000	.000	.539	1.856
	Estimated Total Project Cost Design	-2.735E-9	.000	-.016	-.213	.831	.000	.000	.316	3.165
	Estimated Total Project Cost Construction	-2.921E-9	.000	-.198	-1.131	.259	.000	.000	.062	16.219
	Estimated Total Project Cost	1.752E-9	.000	.143	.799	.425	.000	.000	.059	17.011
	ETPC minus Congress Authorization	-2.837E-9	.000	-.146	-1.615	.107	.000	.000	.231	4.329
	ETPC minus Conference Appropriation	4.583E-9	.000	.267	1.718	.086	.000	.000	.078	12.848
	ETPC minus Central Office Allowance	-4.100E-9	.000	-.258	-1.756	.080	.000	.000	.088	11.404

a. Dependent Variable: Project Delivery Method

b. Shaded rows represent variables statistically significant at 0.05 level and below.

For this first predictive model, Project Delivery Method = -0.096*(Region) + 0.116*(Project Type) + -0.008 *(Program Area) + 0.028* (Political Party) + 0.023*(Gross Area) + 0.129*(Usable Space) + -0.146* (Estimated Total Prospectus Cost minus Congress Authorization) + 0.267*(Estimated Total Prospectus Cost minus Conference Appropriation) + -0.258*(Estimated Total Prospectus Cost minus Central Office Allowance) + 0.143*(Estimated Total Prospectus Cost) + -0.035*(Estimated Total Prospectus Cost Site) + -0.016*(Estimated Total Prospectus Cost Design) + -0.198*(Estimated Total Prospectus Cost Construction) + -0.032*(Congress Authorization Year) + -0.017*(Planning Phase Duration) + 0.176*(Design Phase Duration) + -0.188*(Construction Phase Duration) + 0.001*(Congress Authorization to Construction Finish Duration) + 0.128*(Planning Start to Construction Finish Duration) + -0.034*(Design Start to Construction Finish Duration) + 0.150*(Federal Legislation) + 0.009*(State Legislation) + 1.071. The beta coefficients are the standardized regression coefficients. Their relative absolute magnitudes reflect their relative importance in predicting the project delivery method. Betas are only compared within a model, not between. Betas are also highly influenced by misspecification of the model, and adding or subtracting variables in the equation will affect the size of the betas. Estimated Prospectus Cost minus Conference Appropriation is shown to be much more important than the other independent variables, with a beta of 0.267, and Estimated Prospectus Cost minus Central Office Allowance is shown to be the least important of the variables with a beta of -0.258.

The t-test measures the significance of each b coefficient. It is possible to have a regression model which is significant overall by the F test, but where a particular coefficient is not significant. In this model, at the 0.05 level: Region is significant at 0.037; Project Type is significant at 0.026; Usable Space is significant at 0.036; Design Phase Duration and Construction Phase Duration are both significant at 0.006; and Planning Start to Construction Finish Duration is significant at 0.019. This suggests that there are highly significant relationships between alternative project delivery methods and the region where it is located, suggesting that some regions choose alternative project delivery methods more than others, and may choose alternative delivery methods in the future. There is a relationship between alternative project delivery methods and the project type. Alternative project delivery methods are chosen for new construction and lease-construct more than renovation and alternation projects. Alternative project delivery methods have a greater amount of usable space, shorter design and construction durations, and shorter durations from when planning starts and construction finishes. Alternatively, many variables in the model are not highly significant: Program Area at 0.875; State Legislation at 0.882; Congress Authorization to Construction Finish Duration at 0.990; and Estimated Total Prospectus Cost of Design at 0.831. These statistics suggest that the program area (whether the project is a federal building, border station or courthouse) is not a predictor of using an alternative project delivery method, and whether design-build is allowed at the state level has no influence on alternative delivery method selection. The analysis also suggests that there are longer durations for alternative delivery methods between when Congress authorizes funds for the project and when construction is complete, and the cost of design is lower using alternative project delivery methods.

Future research may suggest that the model be re-run, dropping one variable at a time, starting with the least significant. The goal would be to create a model where all the independent variables are significant at the 0.05 level. The Confidence Interval on a b coefficient are the b's which can also be placed in the prediction equation to get the high and low estimates; though this is rarely done in existing research, it may be an area of future research. The Collinearity statistics suggest scrutiny when the independents are highly intercorrelated. The tolerance for a variable is 1 - R-squared for the regression of that variable on all other independents, ignoring the dependents. When tolerance is close to zero, there is a high multicollinearity of that variable with other independents and the b and beta coefficients will be unstable. VIF is the variance inflation factor, which is the reciprocal of tolerance. When the VIF is high, there is high multicollinearity and instability of the b and beta coefficients. This model suggests that several variables have high multicollinearity: Estimated Total Project Cost Construction; Estimated Total Project Cost; ETPC minus Conference Appropriation; and ETPC minus Central Office Allowance. Future research may consider dropping one or all of these variables from the model, or combining the variables to reduce multicollinearity in the model.

Table 5.29 contains summary data regarding residuals, meaning the difference between predicted and actual values.

Table 5.29 Model 1 Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.11	2.91	.93	.366	496
Std. Predicted Value	-2.840	5.407	.000	1.000	496
Standard Error of Predicted Value	.093	1.022	.206	.108	496
Adjusted Predicted Value	-.13	3.89	.94	.398	496
Residual	-1.902	2.592	.000	1.056	496
Std. Residual	-1.760	2.398	.000	.978	496
Stud. Residual	-2.422	2.439	-.001	1.006	496
Deleted Residual	-3.894	2.732	-.003	1.127	496
Stud. Deleted Residual	-2.435	2.452	.000	1.008	496
Mahal. Distance	2.639	441.739	21.956	37.614	496
Cook's Distance	.000	.309	.003	.016	496
Centered Leverage Value	.005	.892	.044	.076	496

a. Dependent Variable: Project Delivery Method

Std. residual, for example, is the standardized residual, or the raw residual divided by the standard deviation of residuals. Since the minimum standardized residual is -1.760, at least one prediction is almost two standard deviations below the mean residual. Studentized residuals are similar to standardized residuals and follow the t distribution. These are used in plots of standardized or studentized predicted values versus observed values. The deleted residual rows have to do with coefficients when the model is recomputed over and over, dropping one case from the analysis at a time. This is suggested as an area of future research. The bottom three rows are measures of the influence of the minimum, maximum, and mean case on the model. Cook's distance measures how much the b coefficients change when a case is dropped. In this model, it appears that there are problem cases since the maximum leverage is 0.892. This marks another area for future research because the maximum leverage should be 1 to avoid problems in the model.

To analyze the data in the model, further charts are developed. The zresid histogram in Figure 5.1 provides a visual way of assessing if the assumption of normally distributed residual error is met. In this model, there is a small skewness to the left. Skew refers to the amount of distribution is shifted to the left or right of the histogram. Negative skew means that more than 50 percent of the projects are toward the right of the histogram, and positive skew means the opposite. To determine how much skew is too much, in SPSS, if the Skewedness is more than two times as large as the Std. Error of Skewedness, the data may be unacceptably skewed (O'Sullivan and Rassel, 1999). The skew in Model 1 should not affect substantive conclusions.

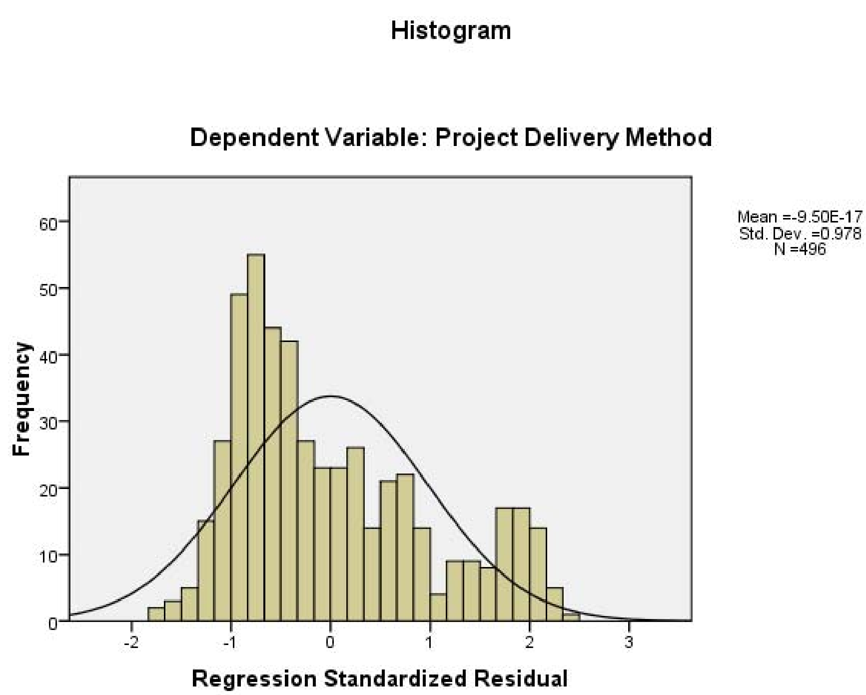


Figure 5.1 Model 1 Histogram

The normal probability plot (zresid normal p-p plot) in Figure 5.2 is another test of normally distributed residual error. Under perfect normality, the plot will be a 45-degree line. In this model, it is imperfect, but close enough for exploratory conclusions. Research strives for residuals to be randomly related to the value of the dependent. In this model, however, there is an upward-sloping trend.

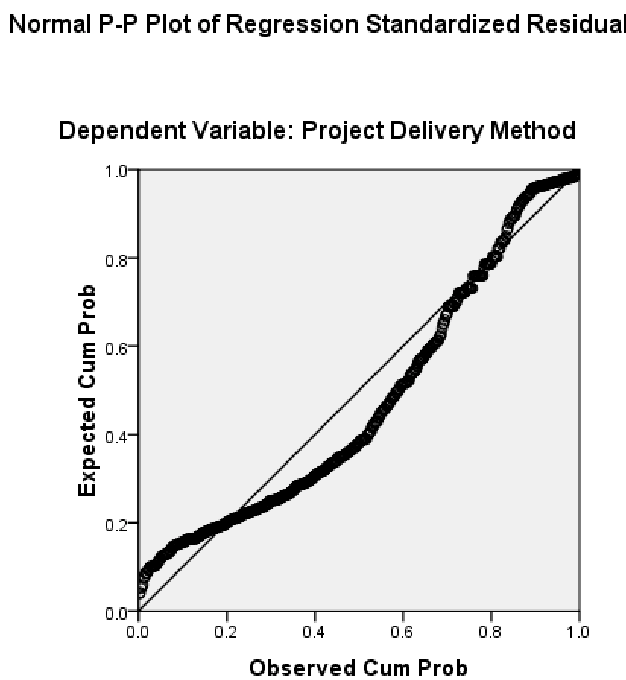


Figure 5.2 Model 1 Normal P-P Plot of Regression Standardized Residual

In the plot of standardized predicted values versus observed values, if 100 percent of the variance is explained in a linear relationship, the points in the scatter plot in Figure 5.3 will form a straight line. The lower the percent of variance explained, the more the points will form a cloud with no trend. The more the points are dispersed around the trend (in this model, a lot), the higher the standard error of estimate and the poorer the model. The plot in Figure 5.3 reflects that the model only explains a small percentage of the variance, also as observed in Table 5.25.

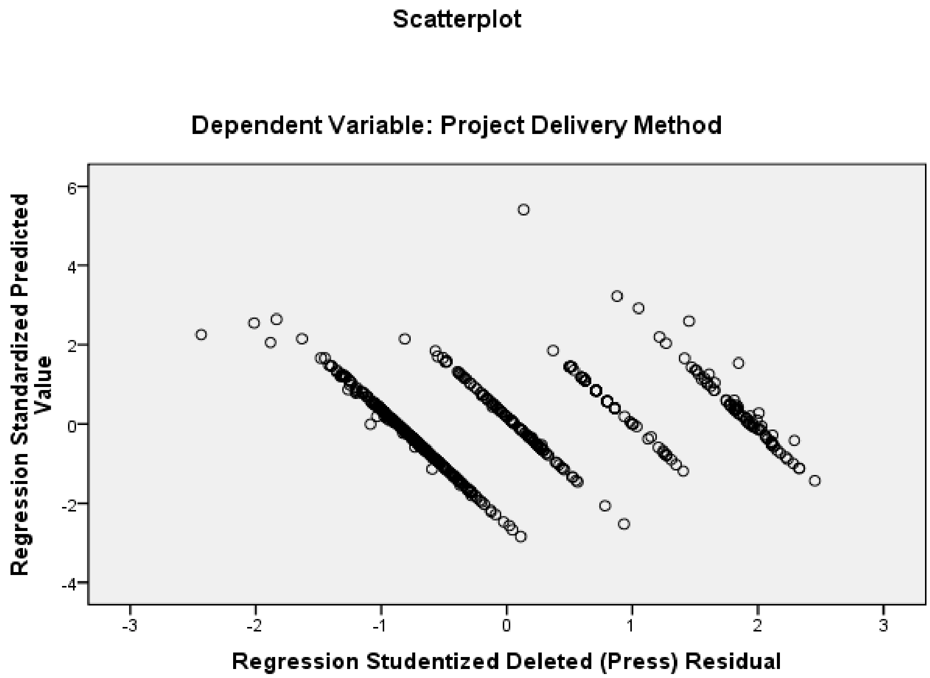


Figure 5.3 Model 1 Scatterplot of Model Variance

Partial regression plots simply show the plot of one independent variable on the dependent variable (project delivery method). Similar to the scatterplot in Figure 5.2 and 5.3, the points will form a straight line if the percent of the variance is 100 percent and will form a cloud the lower the percent of variance is explained. Figures 5.4 to 5.25 verify highly significant relationships between the Project Delivery Method (dependent) and independent variables Region, Project Type, Usable Space, Design Phase Duration, Construction Phase Duration and Planning Start to Construction Finish Duration, indicating high variances. Lower variances are shown for Program Area, State

Legislation, Congress Authorization to Construction Finish Duration, and Estimated Total Prospectus Cost of Design.

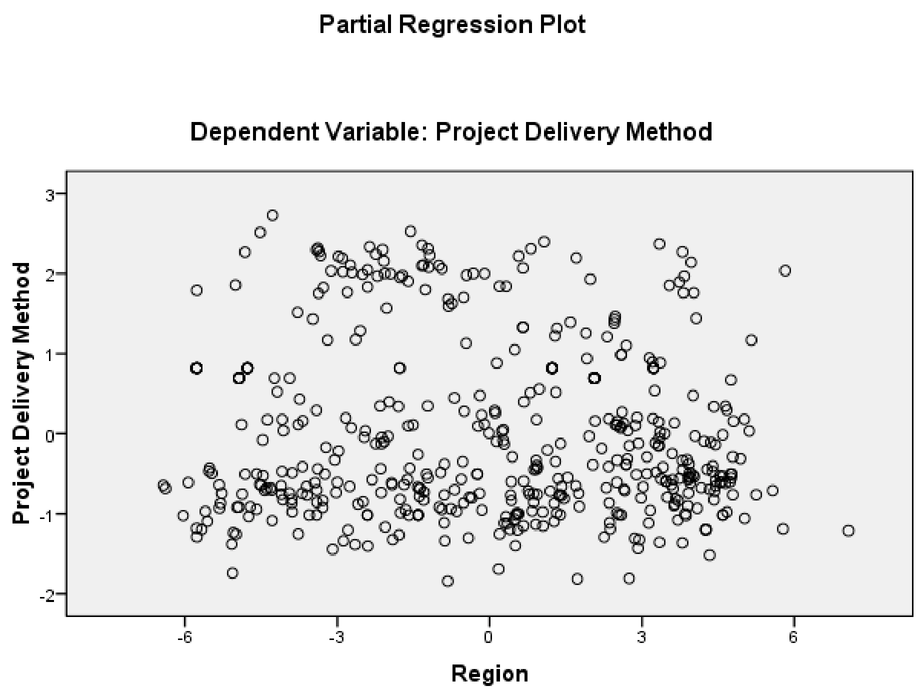


Figure 5.4 Model 1 Partial Scatterplot of Region as Independent

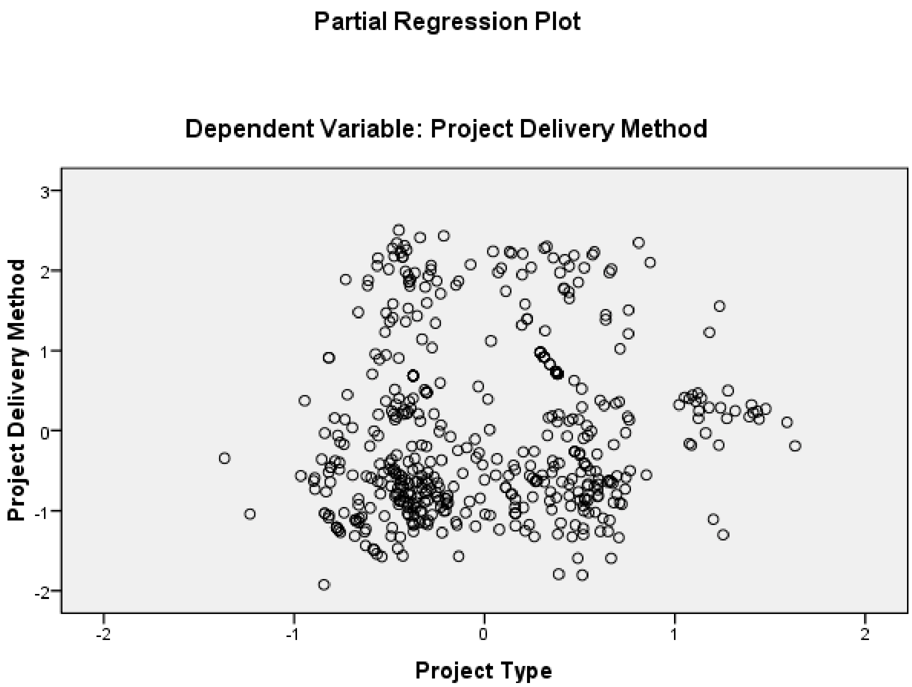


Figure 5.5 Model 1 Partial Scatterplot of Project Type as Independent

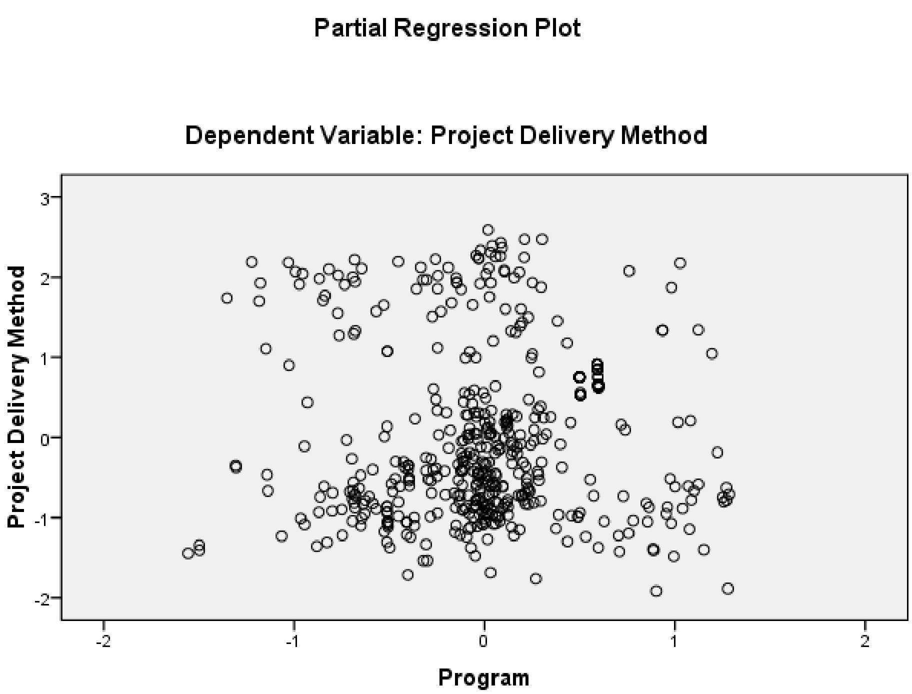


Figure 5.6 Model 1 Partial Scatterplot of Program Area as Independent

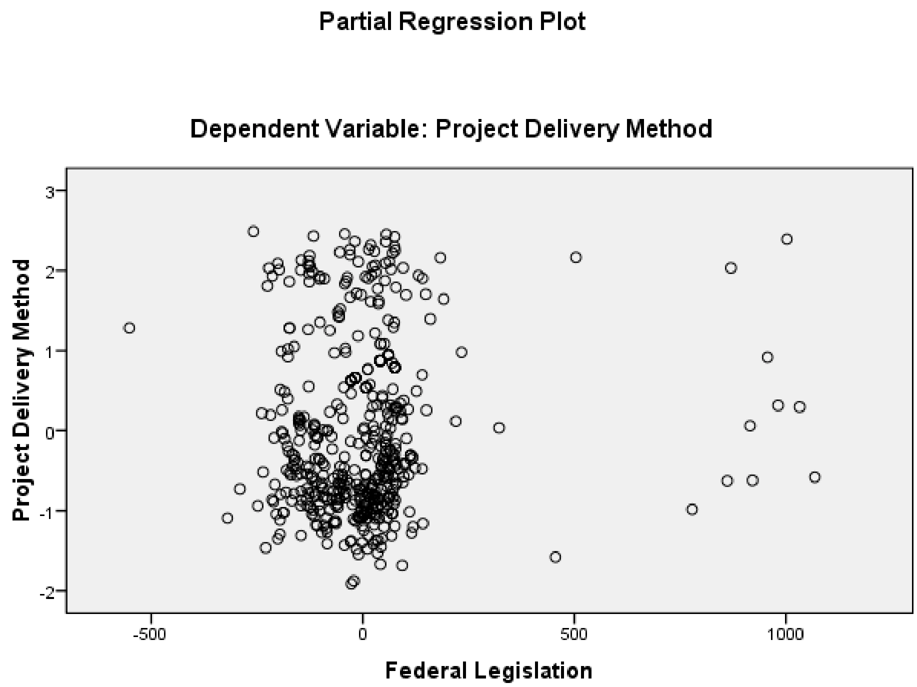


Figure 5.7 Model 1 Partial Scatterplot of Federal Legislation as Independent

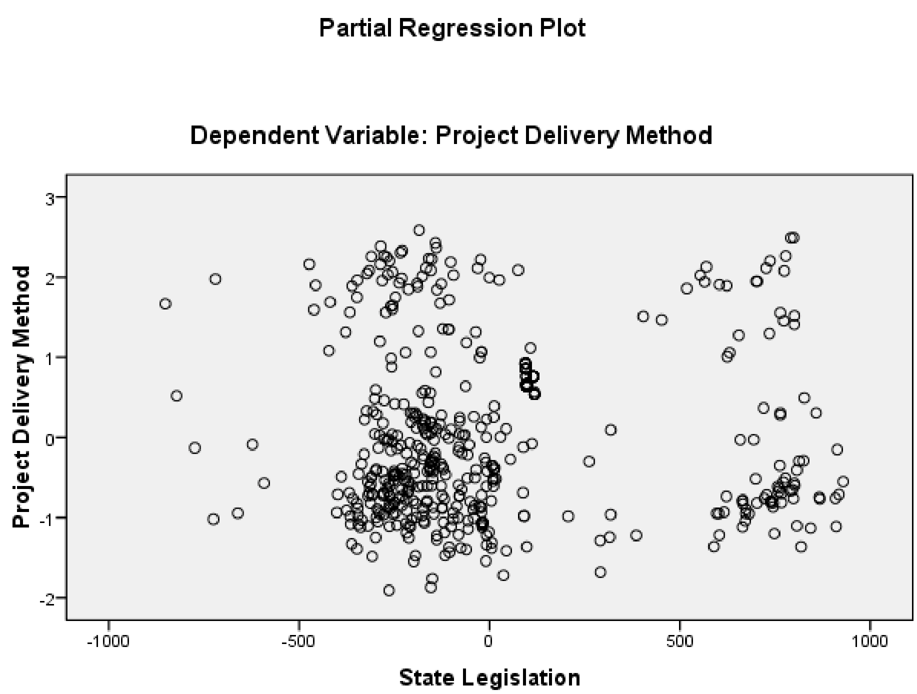


Figure 5.8 Model 1 Partial Scatterplot of State Legislation as Independent

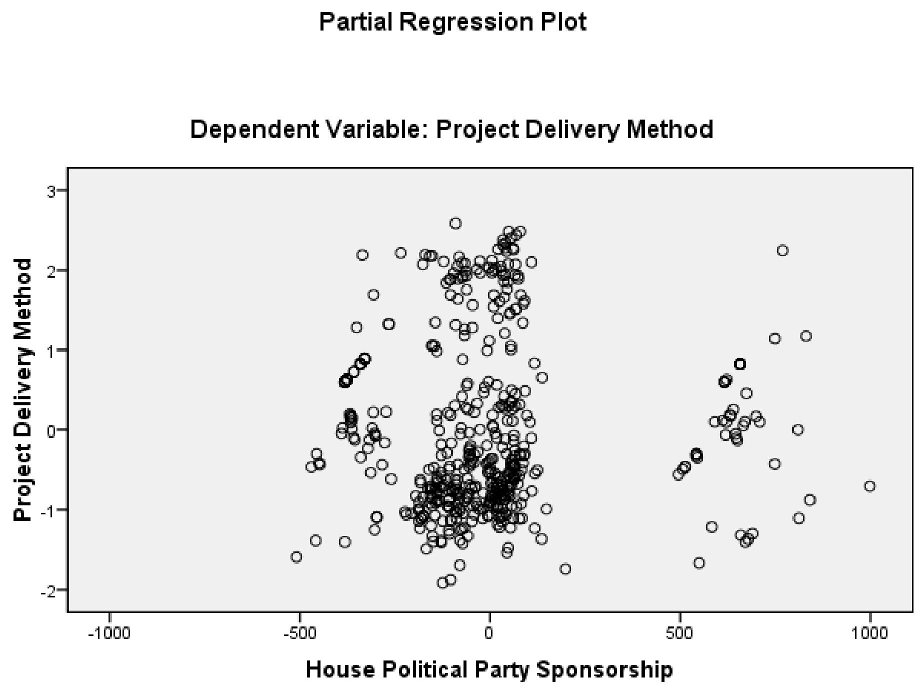


Figure 5.9 Model 1 Partial Scatterplot of Political Party as Independent

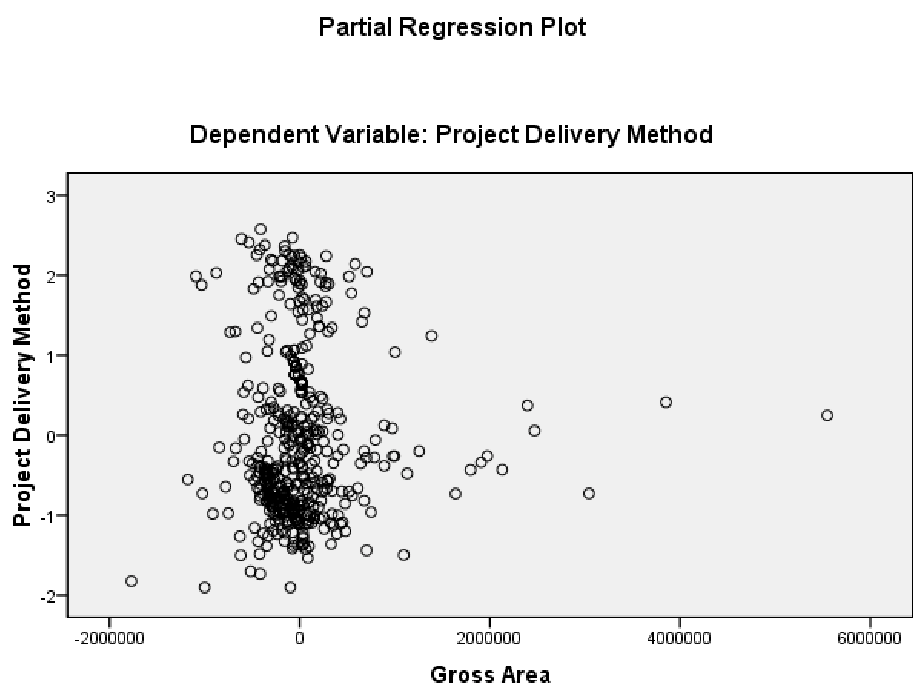


Figure 5.10 Model 1 Partial Scatterplot of Gross Area as Independent

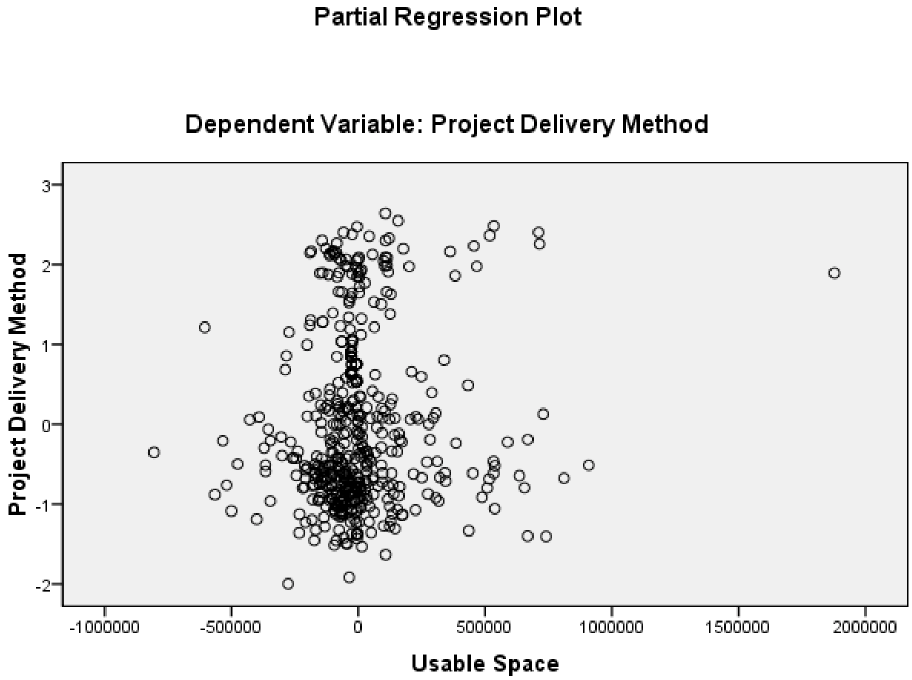


Figure 5.11 Model 1 Partial Scatterplot of Political Party as Independent

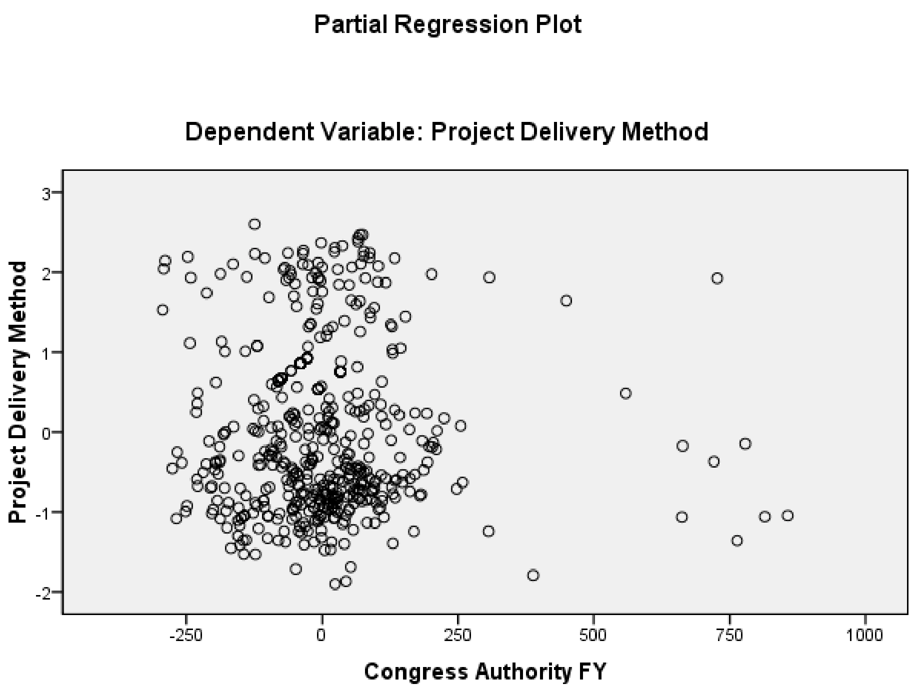


Figure 5.12 Model 1 Partial Scatterplot of Congress Authorization Year as Independent

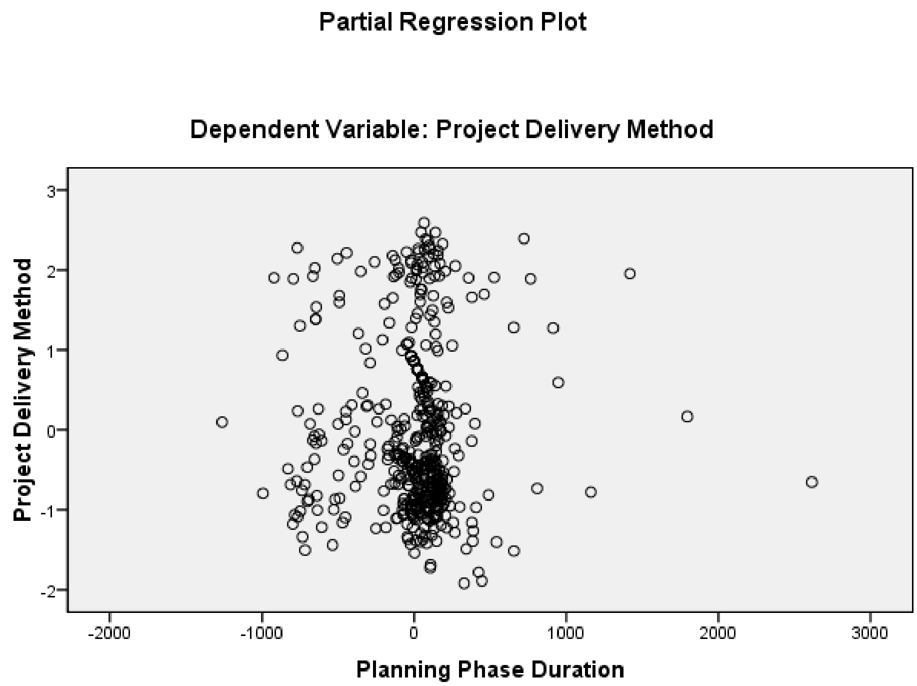


Figure 5.13 Model 1 Partial Scatterplot of Planning Phase Duration as Independent

Figure 5.14 Model 1 Partial Scatterplot of Design Phase Duration as Independent

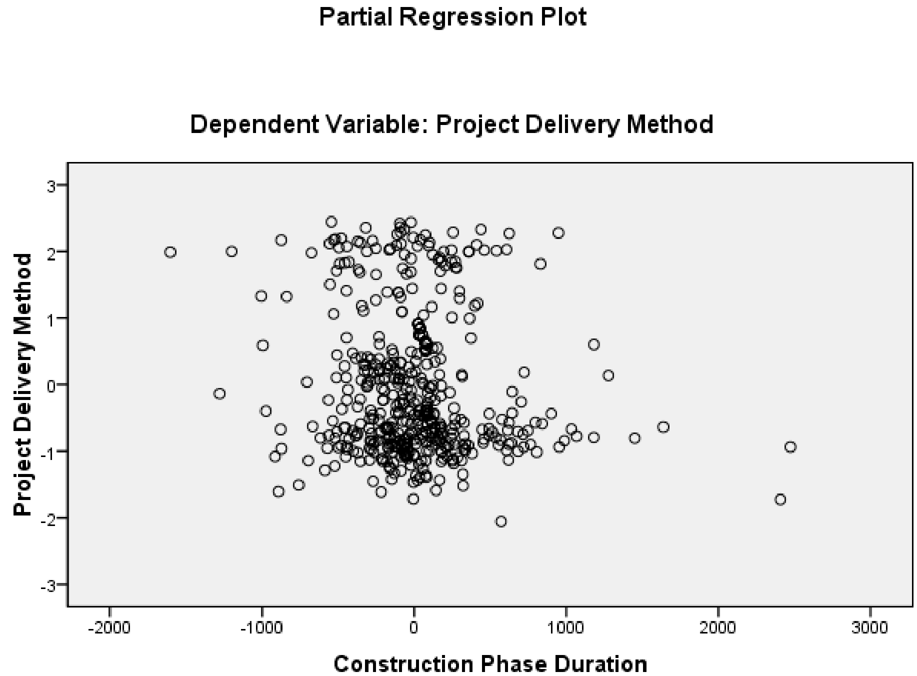


Figure 5.15 Model 1 Partial Scatterplot of Construction Phase Duration as Independent

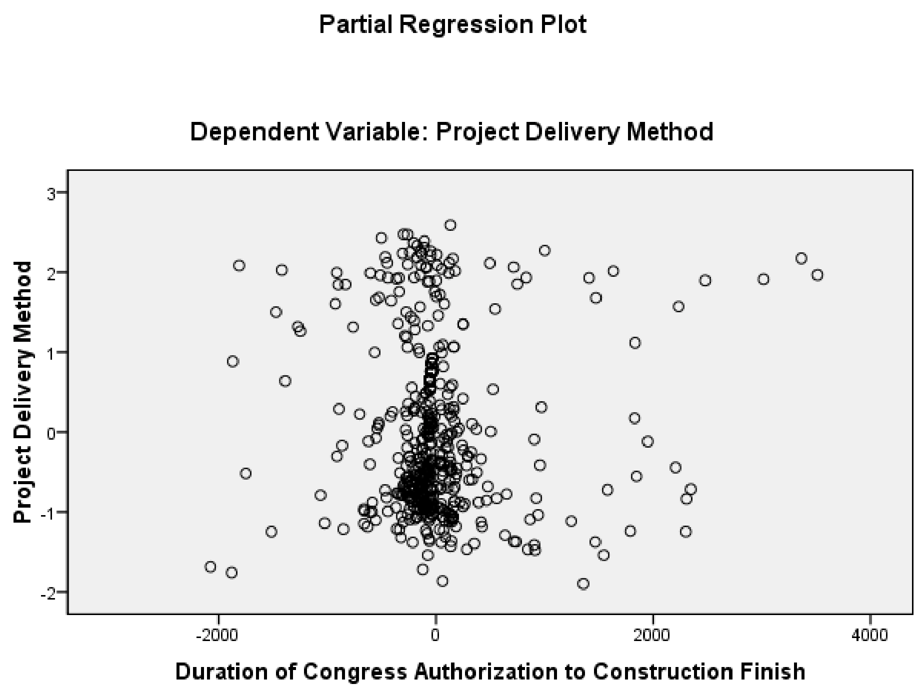


Figure 5.16 Model 1 Partial Scatterplot of Congress Authorization to Construction Finish Duration as Independent

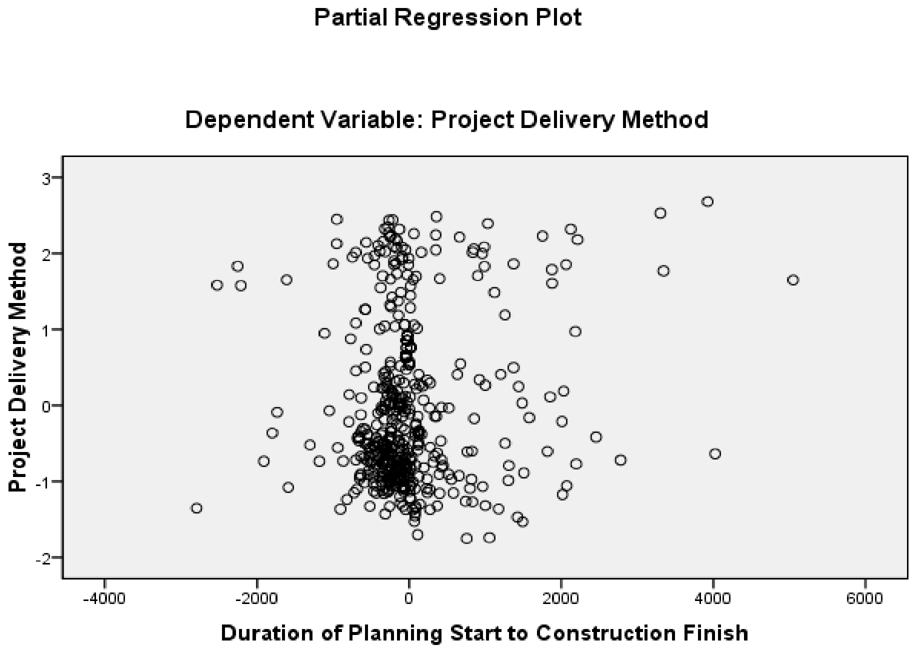


Figure 5.17 Model 1 Partial Scatterplot of Planning Phase to Construction Finish Duration as Independent

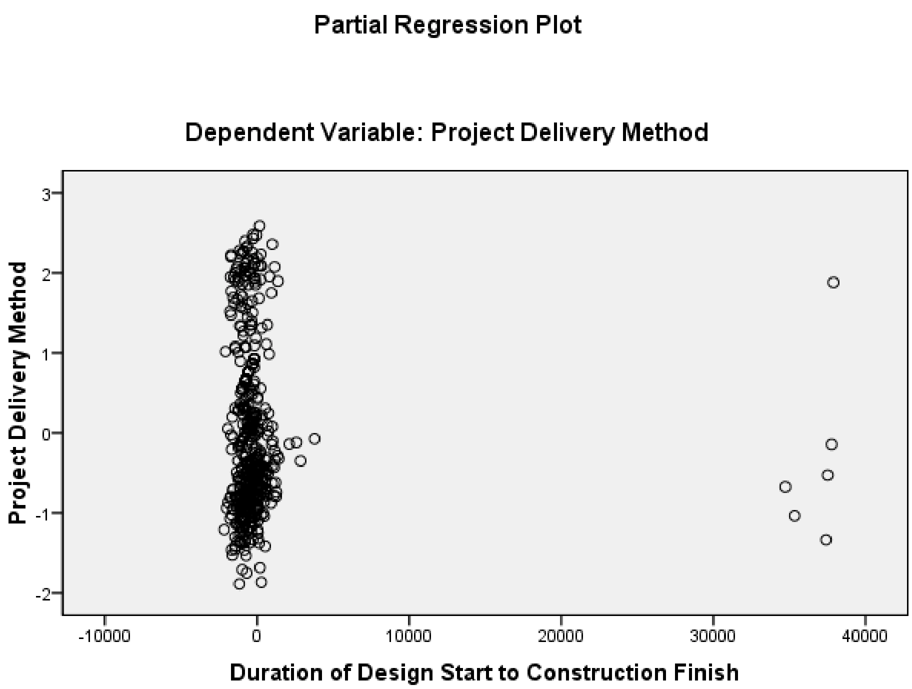


Figure 5.18 Model 1 Partial Scatterplot of Design Phase to Construction Phase Duration as Independent

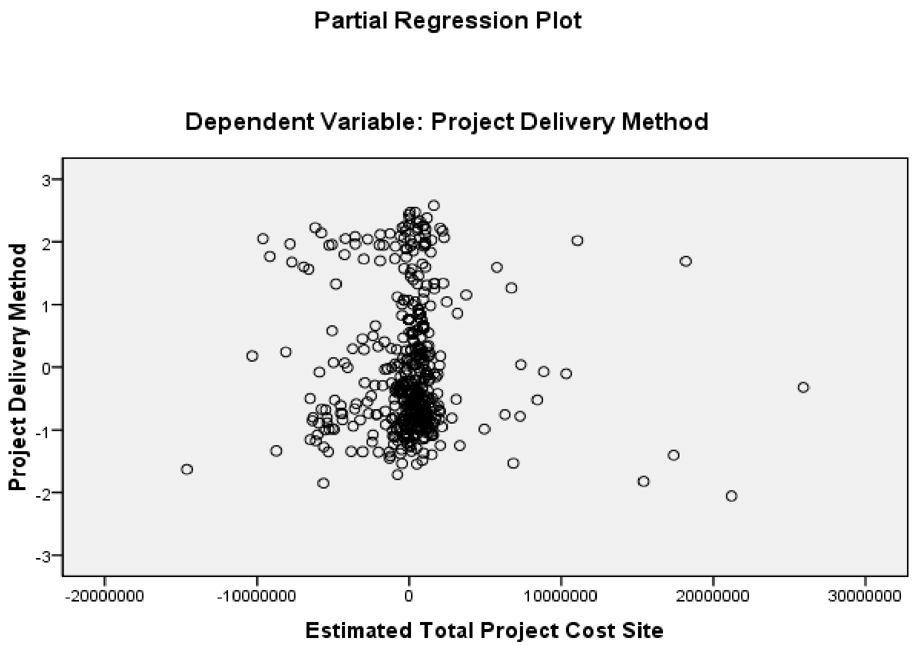


Figure 5.19 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost of Site as Independent

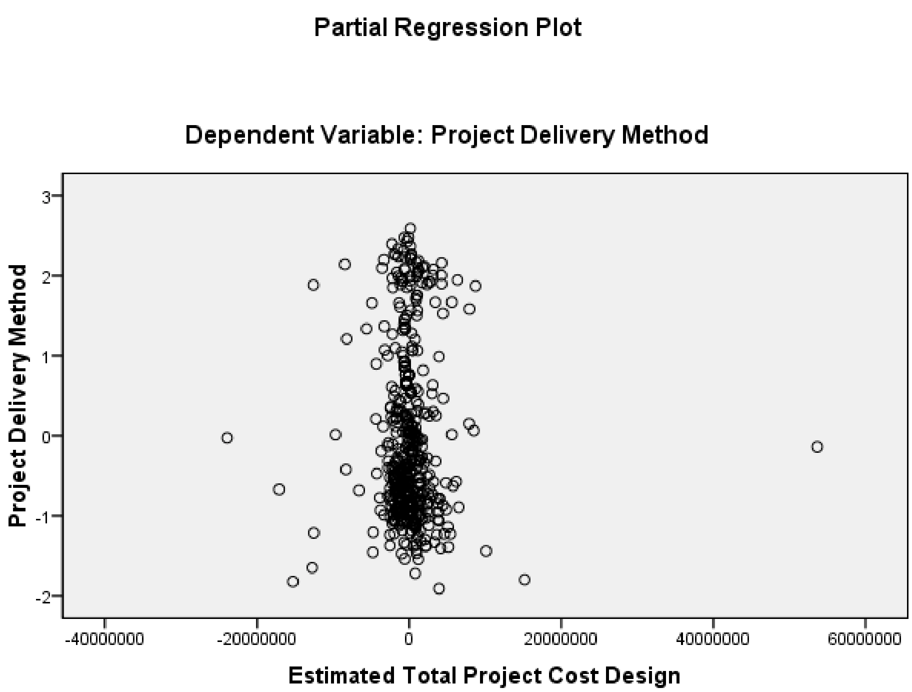


Figure 5.20 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost of Design as Independent

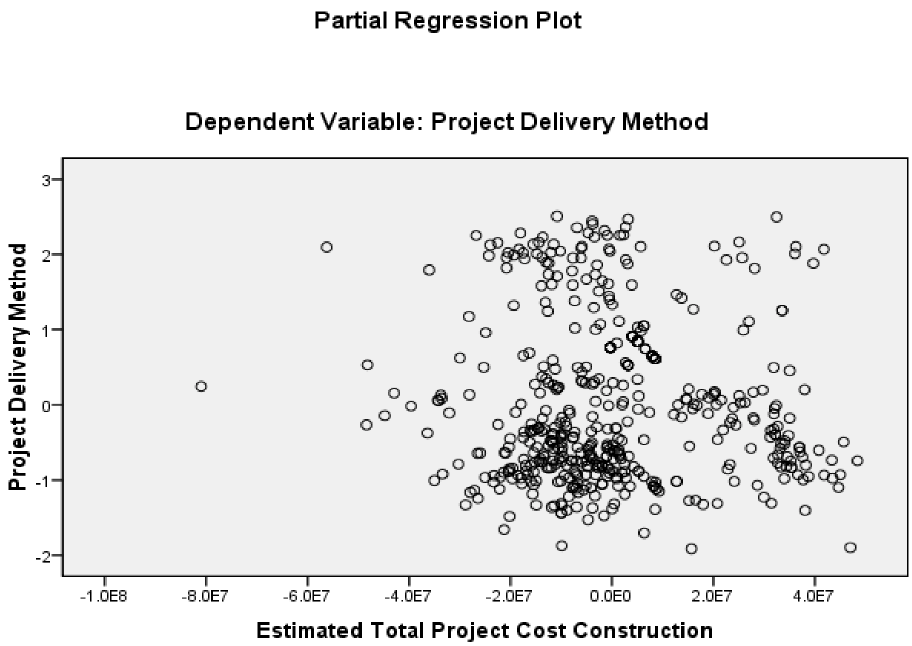


Figure 5.21 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost of Construction as Independent

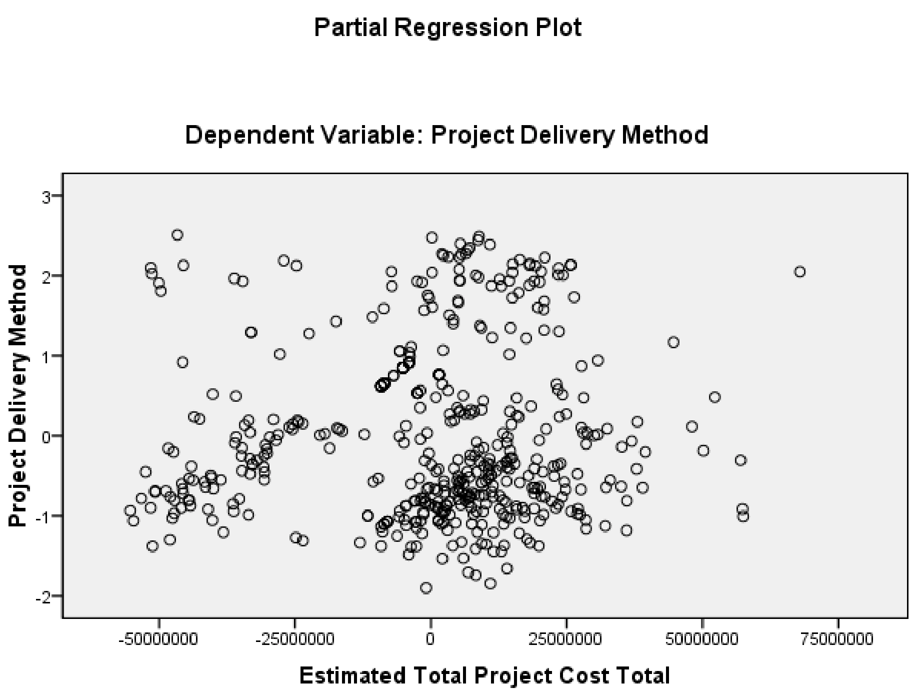


Figure 5.22 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost of as Independent

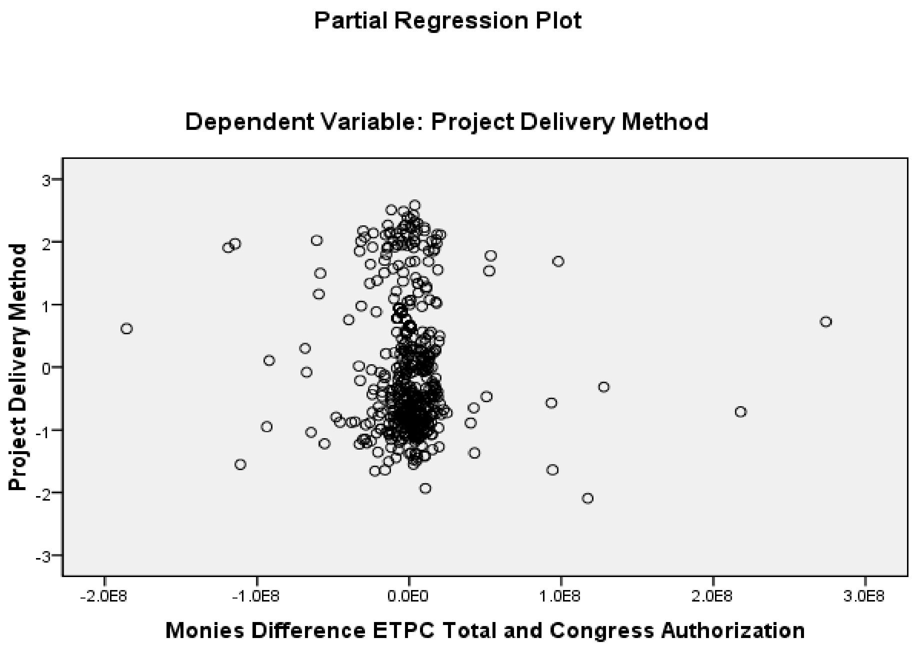


Figure 5.23 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost minus Congress Authorization as Independent

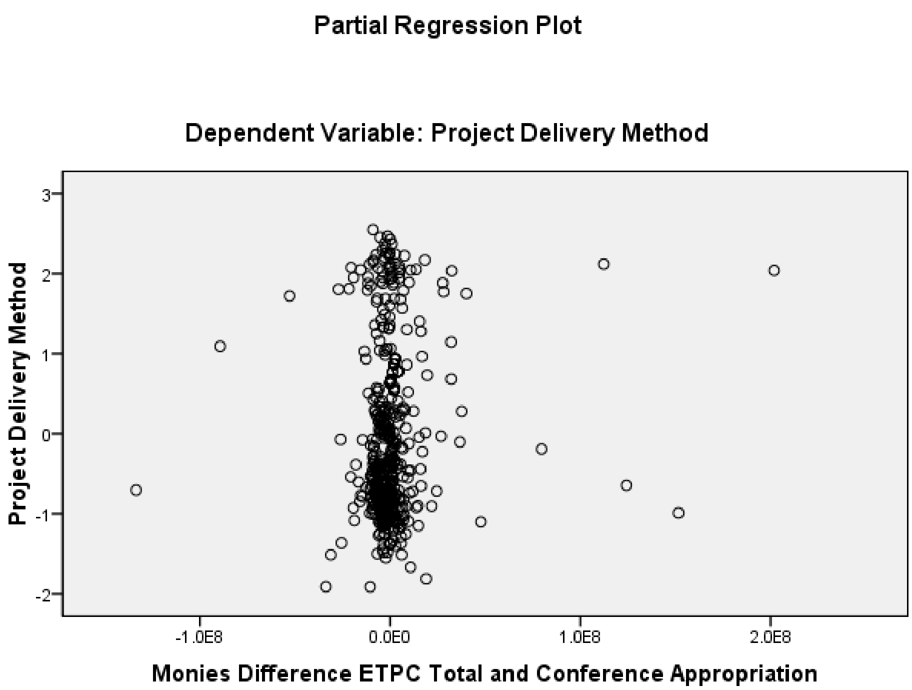


Figure 5.24 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost minus Conference Appropriation as Independent

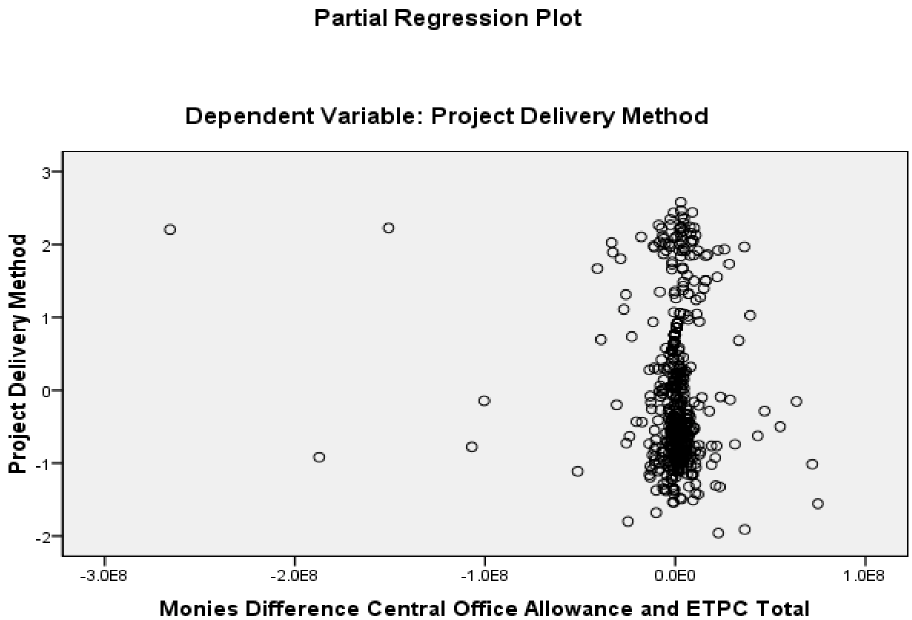


Figure 5.25 Model 1 Partial Scatterplot of Estimated Total Prospectus Cost minus Central Office Allowance as Independent

5.4.1. Summary of Multivariate Analysis Testing Project Characteristics

This section of the chapter tests and examines the relationships between the dependent variable (the project delivery method) and multiple independent (the project characteristics) variables using multiple regression analysis, referred to as Model 1. The analysis in Model 1 indicates statistically significant relationships between alternative project delivery method selection and the region where it is located, the project type (more new construction and lease-construct, and fewer renovation and alternation projects), the amount of usable space (more for alternative delivery methods), shorter design and construction durations, and shorter durations from when planning starts and construction finishes. Alternatively, the statistics in Model 1 suggest that the program area (whether the project is a federal building, border station or courthouse) is not a predictor of using an alternative project delivery method or whether design-build is allowed at the state level. The statistics also suggest that there are longer durations for alternative delivery methods between when Congress authorized funds for the project and when construction is complete, and the cost of design is lower using alternative project delivery methods. This model tests the first question of the hypothesis, whether benefits exist using alternative project delivery methods, and the results are statistically significant. The first predictive model analyzed the effect of the independent variables on the dependent variable, and two of the independent variables were related to legislative impediments at the federal and state levels. This next section specifically tests the second question of the hypothesis, and the main research intent, of whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized in a second predictive model.

5.5 Multivariate Analysis Testing Federal Legislative Impediments

A series of predictive models are developed in the final two sections of the chapter, sections 5.5 and 5.6, to test the second question of the hypothesis of whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized. Two models are developed to test the hypothesis under federal applications, and examine whether benefits exist after federal legislative impediments are eliminated. Statistically significant project characteristics or variables are drawn from the data in each of the predictive models and are explored in context to the hypothesis.

The federal legislative impediment tested is defined as whether the National Defense Authorization Act of 1996 (renamed the Clinger-Cohen Act) is enacted when the project delivery method is selected for a GSA prospectus project. As discussed in Chapter 3, the Clinger-Cohen Act adopted the two-phase selection process that allows builders to be chosen based on a combination of price and qualifications, also referred to as design-price based selection (10 U.S.C. § 2305a and 41 U.S.C. § 253m). This two-phase selection process is commonly associated with design-build. The variables associated with qualifications can be tailored to suit the owner and the construction project. Under the 1996 Act, all federal agencies are permitted to use a qualifications-based selection method, such as design-build, if that method is "appropriate for the public project." The Federal Acquisition Regulations (FAR) is amended in 1997 to incorporate the two-phase selection process procurement procedures for the design-build project delivery method (48 C.F.R. §§ 36.102 - 36.104 and 36.300 - 36.303).

The actual date when GSA selected a project delivery method for their prospectus project is not available in the data. Therefore, the model uses the date when Congress authorizes funding for the prospectus project. This date is used because when Congress authorizes funding for the prospectus project, Congress is also authorizing the specifics of the project, which includes its project delivery method. While federal agencies, such as GSA, have latitude in selecting a project delivery method, they also have latitude in changing the delivery method, although such a change is considered a cardinal change of the contract and is rarely done. This model suggests that federal agencies are highly restricted in choosing design-build, design-build-bridging and construction manager as-constructor as the project delivery method prior to the Clinger-Cohen Act of 1996. So any prospectus project being considered by Congress for funding before that date also has to submit a request for using an alternative project delivery method.

5.5.1 Before Clinger-Cohen Act of 1996

This section begins with testing whether legislative limitations allowing the use of alternative project delivery methods impede such benefits to be realized. Model 2 is developed to test whether benefits are realized with federal legislative impediments in place. Federal legislative impediments are defined as existing prior to the enactment of the Clinger-Cohen Act of 1996. To generate this second predictive model, the research refers to examples from Garson (n.d.) to explain the results of the regression techniques. The second predictive model tests whether project characteristics (as multiple independent variables) have a relationship to the selection of a project delivery method (as dependent variable) before the Clinger-Cohen Act of 1996 is enacted. This is the first of two models (Model 2 and 3) that are generated to test the hypothesis in federal applications, of whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized. As in the first predictive model (Model 1), which tests whether benefits exist when alternative project delivery methods are used, in Model 2, all independent variables are entered in a single step and project delivery method is shown as the dependent variable. Table 5.30 and Table 5.31 provide general information about the second predictive model. It shows when Model 2 is created (on May 9, 2008, at 4:15:20 p.m.), how many projects are in the dataset in the model (54), and how the model treats missing variables. Only 54 of those projects are approved by Congress before 1996 and, Model 2 tests their project characteristics in relation to alternative project delivery selection. Also, as in the first predictive model, the researcher defines missing values in the dataset of 54 projects using a label of 999.

Table 5.30 Model 2 Notes

Output Created		09-May-2008 16:15:20
Comments		
Input	Active Dataset	DataSet1
	N of Rows in Working Data File	54
	Definition of Missing	User-defined missing values are treated as missing.
Missing Value Handling	Cases Used	For each variable used, missing values are replaced with the variable mean.
Syntax	REGRESSION /MISSING MEANSUB /STATISTICS COEFF OUTS CI R ANOVA COLLIN TOL CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT DMOrig /METHOD=ENTER Region ProjectTypeOriginal ProgramOriginal FederalLaws1996 StateLaws HousePoliticalParty GrossArea UsableSpace CongressAuthorityFY PlanningTime DesignTime ConstructionTime AuthoritythroughConstruction PlanningthroughConstruction DesignandConstTime ETPCSite ETPCDesign ETPCConstruction ETPCTotal MoniesETPCTminusCongAuth MoniesETPCTminusConfAppro MoniesETPCTminusCentOffAllow /PARTIALPLOT ALL /SCATTERPLOT=(*ZPRED ,*SDRESID) (DMOrig ,*ZPRED) /RESIDUALS HIST(ZRESID) NORM(ZRESID).	
Resources	Processor Time	
	Elapsed Time	00:00:06.969
	Memory Required	21180 bytes
	Additional Memory Required for Residual Plots	19400 bytes

Table 5.31lists all independent variables and the dependent variable.

Table 5.31 Model 2 Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
2	Estimated Total Prospectus Cost minus Central Office Allowance, Political Party, Congress Authorization Year, Estimated Total Prospectus Cost Site, Planning Phase Duration, Design Start to Construction Finish Duration, Program Area, State Legislation, Design Phase Duration, Federal Legislation, Region, Planning Start to Construction Finish Duration, Congress Authorization to Construction Finish Duration, Construction Phase Duration, Project Type, Gross Area, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost Design, Usable Space, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Conference Appropriation[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Project Delivery Method

The dependent variable is the project delivery method and the independent variables include the following: (1) Region; (2) Project Type; (3) Program Area; (4) Political Party; (5) Gross Area; (6) Usable Space; (7) Estimated Total Prospectus Cost minus Congress Authorization; (8) Estimated Total Prospectus Cost minus Conference Appropriation; (9) Estimated Total Prospectus Cost minus Central Office Allowance; (10) Estimated Total Prospectus Cost; (11) Estimated Total Prospectus Cost Site; (12) Estimated Total Prospectus Cost Design; (13) Estimated Total Prospectus Cost Construction; (14) Congress Authorization Year; (15) Planning Phase Duration; (16) Design Phase Duration; and (17) Construction Phase Duration; (18) Congress Authorization to Construction Finish Duration; (19) Planning Start to Construction Finish Duration; (20) Design Start to Construction Finish Duration; (21) Federal Legislation;

and (22) State Legislation. These variables are analyzed in the descriptive statistics and cross-tabulations in Chapter 4 and in the correlation analysis earlier in Chapter 5.

Table 5.32 is the summary of Model 2. The R-squared is the percent of the dependent explained by the independents.

Table 5.32 Model 2 Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
2	.660[a]	.436	.035	1.023	.436	1.088	22	31	.407

a. Predictors: (Constant), Estimated Total Prospectus Cost minus Central Office Allowance, Political Party, Congress Authorization Year, Estimated Total Prospectus Cost Site, Planning Phase Duration, Design Start to Construction Finish Duration, Program Area, State Legislation, Design Phase Duration, Federal Legislation, Region, Planning Start to Construction Finish Duration, Congress Authorization to Construction Finish Duration, Construction Phase Duration, Project Type, Gross Area, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost Design, Usable Space, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Conference Appropriation

b. Dependent Variable: Project Delivery Method

In the case of this model, the independents explain 43.6 percent of the variance, which is much stronger than Model 1, which explains only 10.7 percent of the variance. Even with 43.6 percent variance, the model may have been slightly misspecified. Other variables, not suggested by the researcher, explain more than 50 percent (56.4 percent) of the variance. However, Model 2 suggests that the independent variables specified explain 43.6 percent of the variance, so this model is credible. As mentioned in Model 1, the Adjusted R-Squared is a standard, arbitrary downward adjustment to account for the possibility that, with many independent variables, some of the variance may be due to chance. The more independents in the model suggest the more the adjustment penalty. Even though there are many independents in this model, the penalty is considered overly minor, with 0.035 or a 3.5 percent likelihood that these results are received by chance (the penalty.)

The ANOVA table, Table 5.33, tests the overall significance of Model 2 and of the regression equation created for Model 2. For this model, the F value is not considered statistically significant (with 0.407); even though the R Square is significant, explaining 43.6 percent, the overall model is not considered statistically significant. The model suggests that there is a 40 percent likelihood that the predictions in this model are due to chance.

Table 5.33 Model 2 Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	25.049	22	1.139	1.088	.407[a]
	Residual	32.433	31	1.046		
	Total	57.481	53			

a. Predictors: (Constant), Estimated Total Prospectus Cost minus Central Office Allowance, Political Party, Congress Authorization Year, Estimated Total Prospectus Cost Site, Planning Phase Duration, Design Start to Construction Finish Duration, Program Area, State Legislation, Design Phase Duration, Federal Legislation, Region, Planning Start to Construction Finish Duration, Congress Authorization to Construction Finish Duration, Construction Phase Duration, Project Type, Gross Area, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost Design, Usable Space, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Conference Appropriation

b. Dependent Variable: Project Delivery Method

Table 5.34 gives the b and beta coefficients and other coefficients of the model. The b coefficients and the constant are used to create the prediction (regression) equation.

Table 5.34 Model 2 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
2	(Constant)	139.794	181.481		.770	.447	-230.339	509.926		
	Region	-.098	.073	-.298	-1.331	.193	-.247	.052	.362	2.761
	Project Type	.318	.603	.134	.528	.601	-.911	1.547	.284	3.522
	Program Area	-.311	.402	-.179	-.774	.445	-1.131	.509	.340	2.943
	Federal Legislation	.000	.001	-.060	-.246	.808	-.003	.002	.303	3.303
	State Legislation	-1.335E-5	.000	-.006	-.037	.970	.000	.001	.631	1.586
	Political Party	-.074	.377	-.031	-.196	.846	-.843	.695	.746	1.341
	Gross Area	1.020E-6	.000	.400	1.206	.237	.000	.000	.166	6.041
	Usable Space	-1.073E-6	.000	-.524	-.916	.367	.000	.000	.056	17.971
	Congress Authorization Year	-.069	.091	-.128	-.757	.454	-.254	.117	.638	1.566
	Planning Phase Duration	1.012E-6	.001	.000	.001	.999	-.002	.002	.208	4.815
	Design Phase Duration	-5.515E-5	.000	-.029	-.124	.902	.000	.001	.345	2.898
	Construction Phase Duration	.000	.000	-.474	-1.754	.089	-.002	.000	.250	4.006
	Congress Authorization to Construction Finish Duration	.000	.000	.200	.684	.499	.000	.001	.214	4.673
	Planning Start to Construction Finish Duration	.000	.000	-.261	-1.076	.290	.000	.000	.310	3.223
	Design Start to Construction Finish Duration	-2.079E-5	.000	-.101	-.630	.534	.000	.000	.712	1.405
	Estimated Total Prospectus Cost Site	-7.175E-8	.000	-.655	-1.541	.133	.000	.000	.101	9.910
	Estimated Total Prospectus Cost Design	3.160E-8	.000	.490	.921	.364	.000	.000	.064	15.514
	Estimated Total Prospectus Cost Construction	-4.674E-9	.000	-.623	-.999	.326	.000	.000	.047	21.413
	Estimated Total Prospectus Cost	6.219E-9	.000	.971	1.540	.134	.000	.000	.046	21.824
	Estimated Total Prospectus Cost minus Congress Authorization	1.694E-8	.000	.561	1.247	.222	.000	.000	.090	11.118
	Estimated Total Prospectus Cost minus Conference Appropriation	-1.705E-9	.000	-.126	-.200	.843	.000	.000	.046	21.897
	Estimated Total Prospectus Cost minus Central Office Allowance	-9.665E-9	.000	-.696	-.891	.380	.000	.000	.030	33.535

a. Dependent Variable: Project Delivery Method

For this second predictive model, Project Delivery Method (Selected before Clinger-Cohen Act) = -0.298*(Region) + 0.134*(Project Type) + -0.179 *(Program Area) + -0.031* (Political Party) + 0.400*(Gross Area) + -0.524*(Usable Space) + 0.561* (Estimated Total Prospectus Cost minus Congress Authorization) + -0.126*(Estimated Total Prospectus Cost minus Conference Appropriation) + -0.696*(Estimated Total Prospectus Cost minus Central Office Allowance) + 0.971*(Estimated Total Prospectus Cost) + -0.655*(Estimated Total Prospectus Cost Site) + 0.490*(Estimated Total Prospectus Cost Design) + -0.623*(Estimated Total Prospectus Cost Construction) + -0.128*(Congress Authorization Year) + 0.000*(Planning Phase Duration) + -0.029*(Design Phase Duration) + -0.474*(Construction Phase Duration) + 0.200*(Congress Authorization to Construction Finish Duration) + -0.261*(Planning Start to Construction Finish Duration) + -0.101*(Design Start to Construction Finish Duration) + -0.060*(Federal Legislation) + -0.006*(State Legislation) + 139.794. The beta coefficients are the standardized regression coefficients. Their relative absolute magnitudes reflect their relative importance in predicting the project delivery method. Betas are only compared within a model. Betas also are highly influenced by misspecification of the model; in this case, 56.4 percent of the model is not explained, and adding or subtracting variables in the equation will affect the size of the betas.

The t-test measures the significance of each b coefficient. It is possible to have a regression model which is significant overall by the F test, but where a particular coefficient is not significant. Conversely, it is possible to have a regression model which is not significant by the F test, as in the case of Model 2 at a level of 0.407, but which has a particular coefficient that is significant. Model 2 is not considered statistically significant and neither are any of the variables, at a level below 0.05. The construction phase duration is close to significant at the 0.10 level (0.089). This suggests that there are no significant relationships between alternative project delivery methods and project characteristics in projects authorized by Congress before the Clinger-Cohen Act of 1996. This makes sense because this model is developed to test whether alternative project delivery methods are selected in the face of legislative impediments. The legislative impediment is that the legislation authorizing alternative delivery methods is not available at the time Congress authorized funding for these 54 projects. Instead, many variables in the model are highly not significant: Federal Legislation at 0.808; State Legislation at 0.970; Political Party at 0.846; Planning Phase Duration at 0.999; Design Phase Duration at 0.902; and Estimated Total Prospectus Cost minus Conference Appropriation at 0.843. These statistics suggest these variables are not predictors of using an alternative project delivery method; rather, they are predictors of using design-bid-build. Projects that choose design-bid-build do not have state legislation allowing design-build (or qualifications-based selection for contractors), have longer planning and design phase durations, are not influenced by the political party representing the project, and have a lower percentage of funding passing through Conference appropriations. Because this model is considered not significant nor are any of its variables, future research may suggest that the model not be re-run. The Collinearity statistics suggest scrutiny when the independents are highly intercorrelated. The tolerance for a variable is 1 - R-squared for the regression of that variable on all other independents, ignoring the dependents. When tolerance is close to zero, there is a high multicollinearity of that variable with other independents and the b and beta coefficients will be unstable. Many of the variables in Model 2 are close to zero and so the betas may be unstable in the following: Estimated Total Prospectus Cost Site; Estimated Total Prospectus Cost Design; Estimated Total Prospectus Cost Construction; Estimated Total Prospectus Cost minus Congress Authorization; Estimated Total Prospectus Cost minus Conference Appropriation; and Estimated Total Prospectus Cost minus Central Office Allowance. VIF is the variance inflation factor, which is the reciprocal of tolerance. When the VIF is high there is high multicollinearity and instability of the b and beta coefficients. This model suggests that several variables have high multicollinearity: Usable Space; Estimated Total Prospectus Cost Site; Estimated Total Prospectus Cost Design; Estimated Total Prospectus Cost Construction; Estimated Total Prospectus Cost minus Congress Authorization; Estimated Total Prospectus Cost minus Conference Appropriation; and Estimated Total Prospectus Cost minus Central Office Allowance. Both factors suggest that this model not be re-run and only be used in its purpose to assess the affect of federal legislative impediments in federal applications.

Table 5.35 contains summary data regarding residuals: the difference between predicted and actual values.

Table 5.35 Model 2 Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.66	3.19	.48	.687	54
Std. Predicted Value	-1.667	3.944	.000	1.000	54
Standard Error of Predicted Value	.344	1.023	.635	.208	54
Adjusted Predicted Value	-103.93	113.68	.84	21.279	54
Residual	-1.540	2.331	.000	.782	54
Std. Residual	-1.505	2.279	.000	.765	54
Stud. Residual	-1.753	2.562	.023	.961	54
Deleted Residual	-113.677	104.934	-.363	21.382	54
Stud. Deleted Residual	-1.817	2.838	.037	.997	54
Mahal. Distance	5.015	52.018	21.593	15.190	54
Cook's Distance	.000	537.028	18.614	95.072	54
Centered Leverage Value	.095	.981	.407	.287	54

a. Dependent Variable: Project Delivery Method

As mentioned in Model 1, std. residual is the standardized residual: the raw residual divided by the standard deviation of residuals. Since the minimum standardized residual is -1.505, at least one prediction is between one and two standard deviations below the mean residual. Studentized residuals are used in plots of standardized or studentized predicted values versus observed values. The deleted residual rows have to do with coefficients when the model is recomputed over and over, dropping one case from the analysis at a time. This is not suggested for future research on this Model given its low statistically significant results. The bottom three rows are measures of the influence. Cook's distance appears that there are problem cases since the maximum leverage is 0.981. This further supports earlier findings of Model 2.

To analyze the data in the model, further charts are developed. The zresid histogram in Figure 5.26 provides a visual way of assessing if the assumption of normally distributed residual error is met. In Model 2, as described in Model 1, the small skewness to the left should not affect substantive conclusions. This reaffirms the previous conclusions in this model.

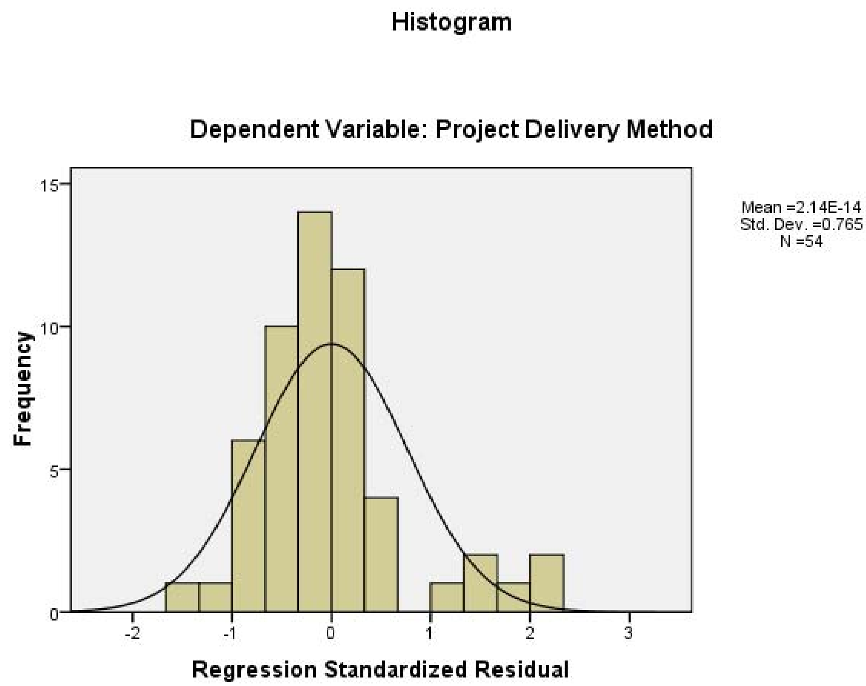


Figure 5.26 Model 2 Histogram

The normal probability plot (zresid normal p-p plot) in Figure 5.27 is another test of the normally distributed residual error. Under perfect normality, the plot will be a 45-degree line. In this model, it is significantly imperfect but is close enough for exploratory conclusions.

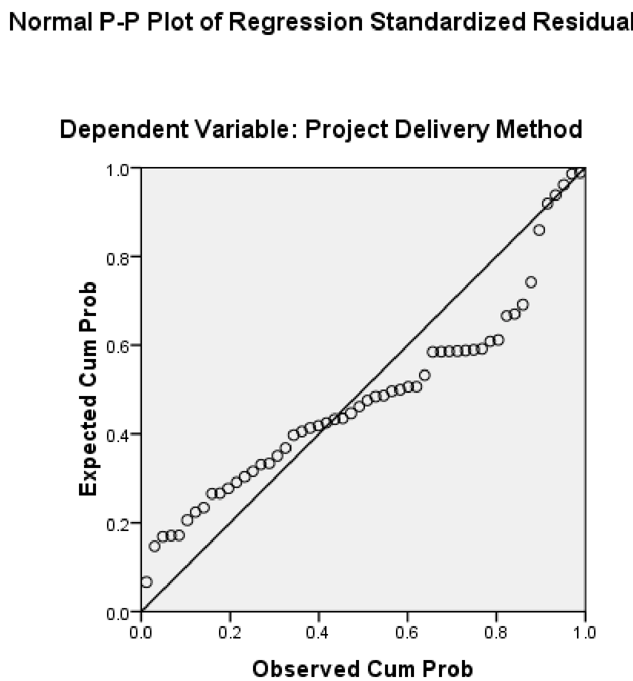


Figure 5.27 Model 2 Normal P-P Plot of Regression Standardized Residual

In the plot of standardized predicted values versus observed values, if 100 percent of the variance is explained in a linear relationship, the points in the scatter plot in Figure 5.28 will form a straight line. The lower the percent of variance explained, the more the points will form a cloud with no trend. The more the points are dispersed around the trend (in this model, a lot), the higher the standard error of estimate and the poorer the model. The plot in Figure 5.28 reflects Model 2's earlier findings that the model only explains a small percentage of the variance.

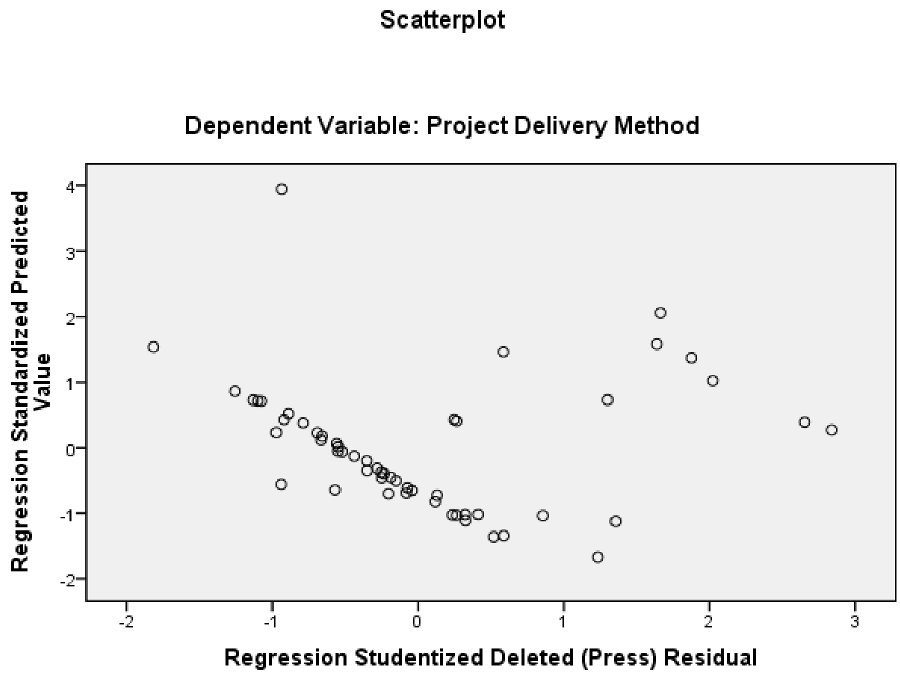


Figure 5.28 Model 2 Scatterplot of Model Variance

Partial regression plots show the plot of one independent on the dependent variable (project delivery method). Similar to the scatterplots in Model 1, the points will form a straight line if the percent of the variance is 100 percent and will form a cloud the lower the percent of variance is explained. Figures 5.29 to 5.50 verify low variances between the project delivery method (dependent) and the independents, as would be expected based on the earlier analyses of Model 2. The low variances are shown as cloud-like formations on all of the partial scatterplots.

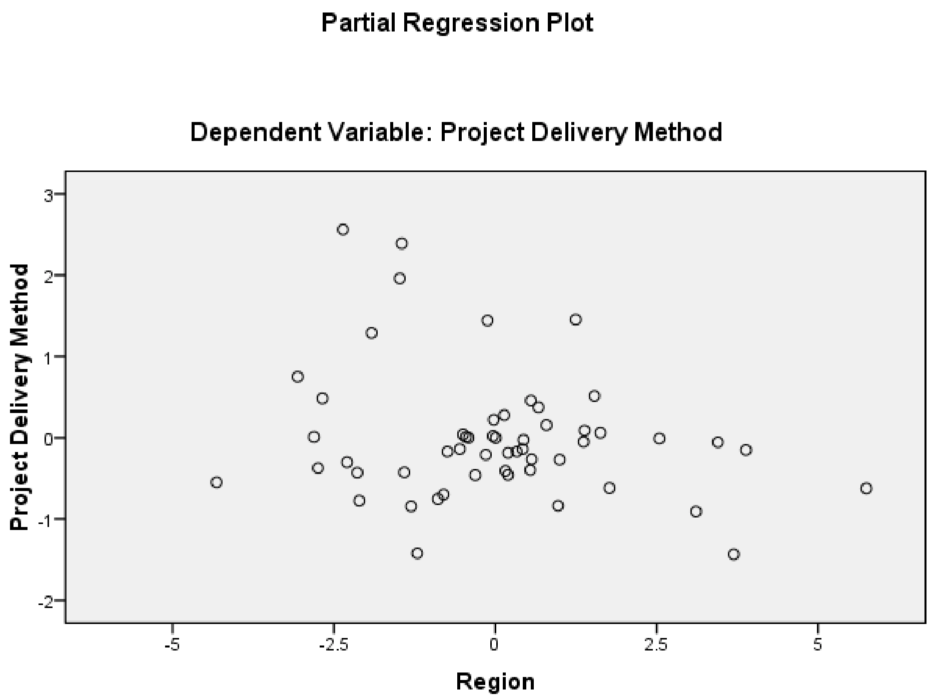


Figure 5.29 Model 2 Partial Scatterplot of Region as Independent

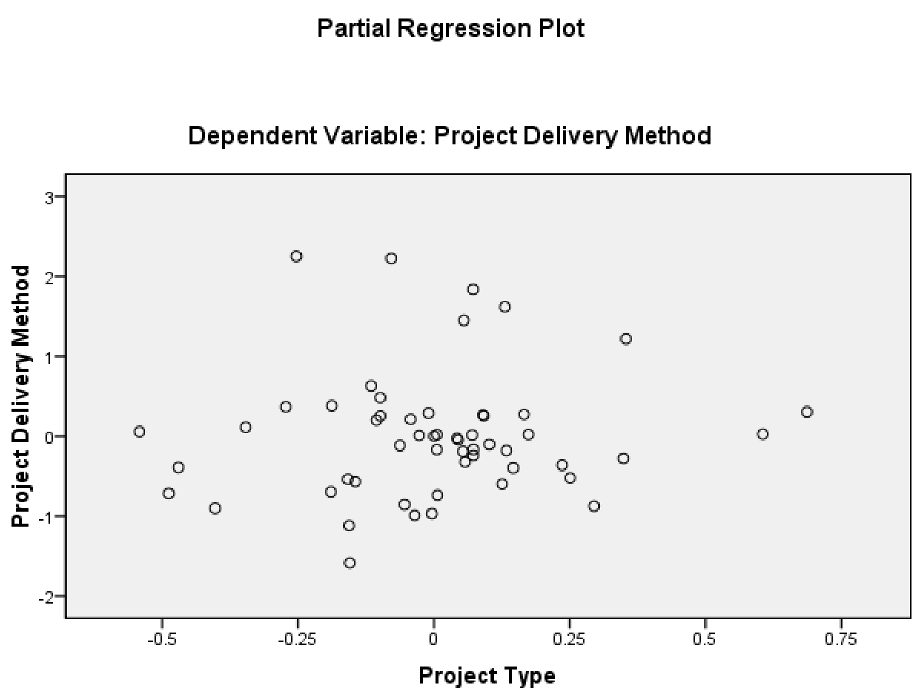


Figure 5.30 Model 2 Partial Scatterplot of Project Type as Independent

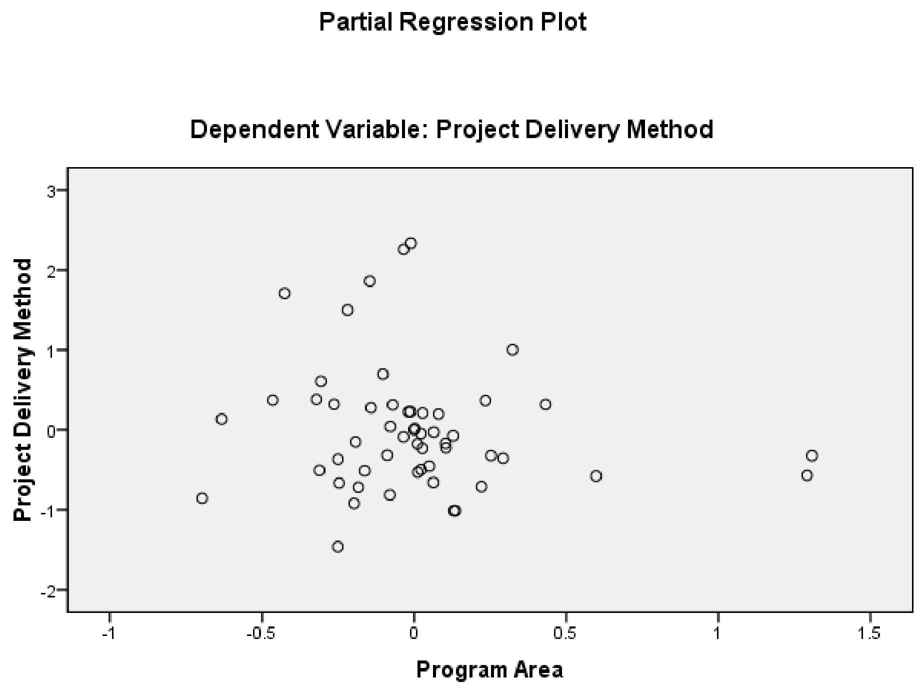


Figure 5.31 Model 2 Partial Scatterplot of Program Area as Independent

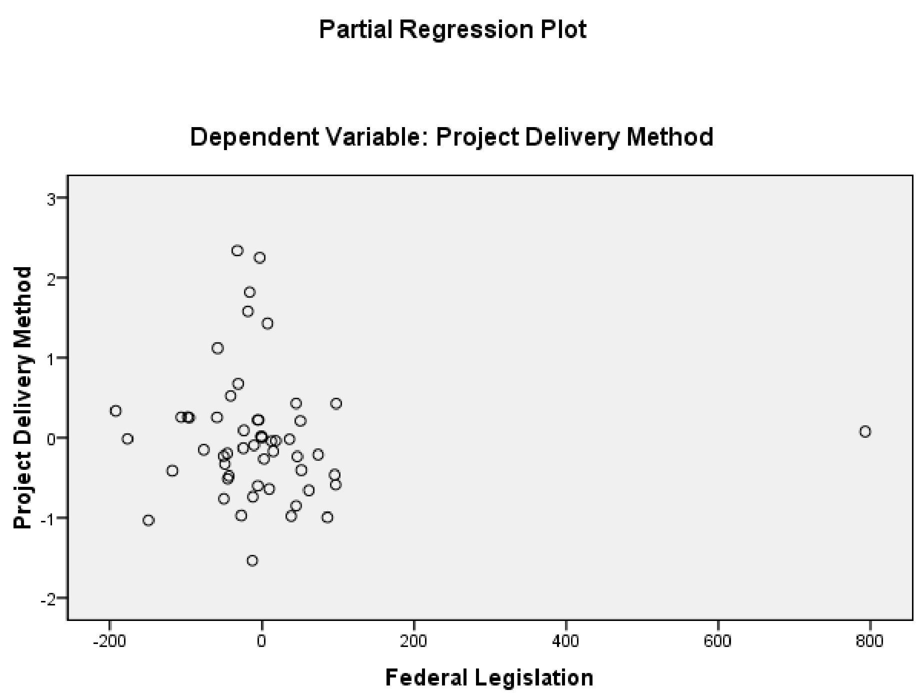


Figure 5.32 Model 2 Partial Scatterplot of Federal Legislation as Independent

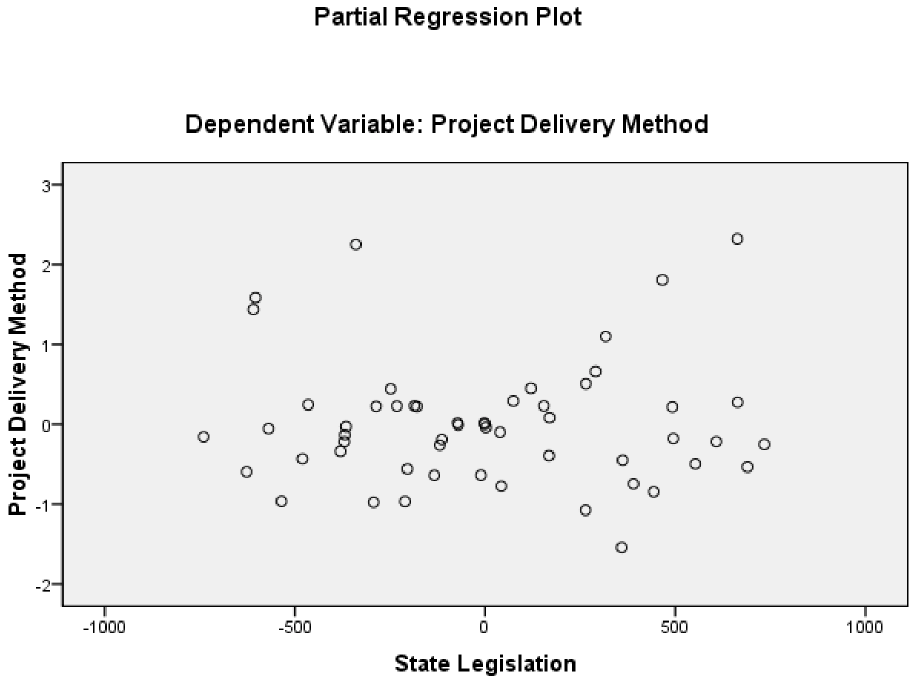


Figure 5.33 Model 2 Partial Scatterplot of State Legislation as Independent

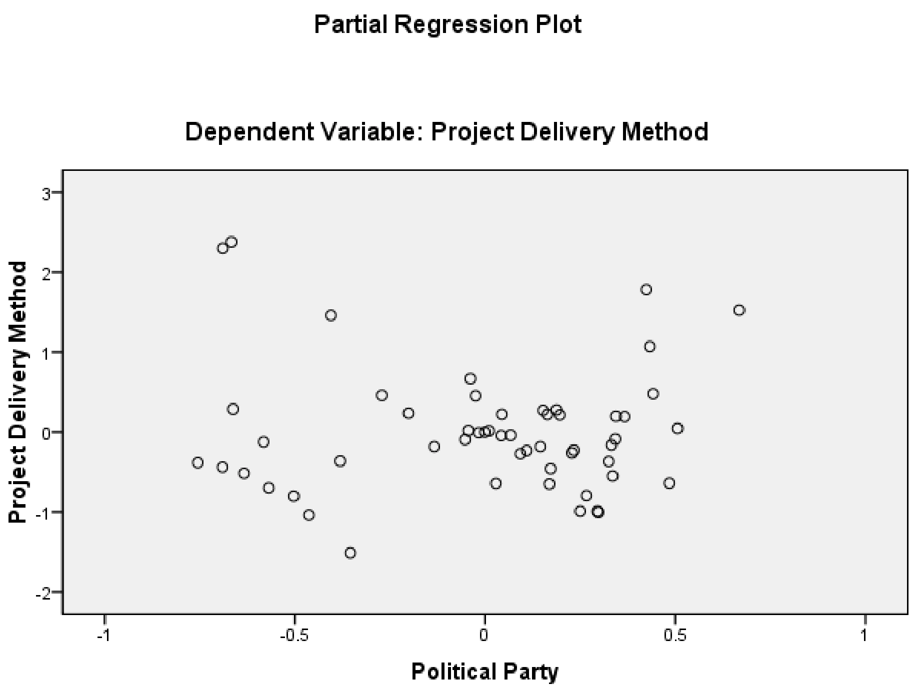


Figure 5.34 Model 2 Partial Scatterplot of Political Party as Independent

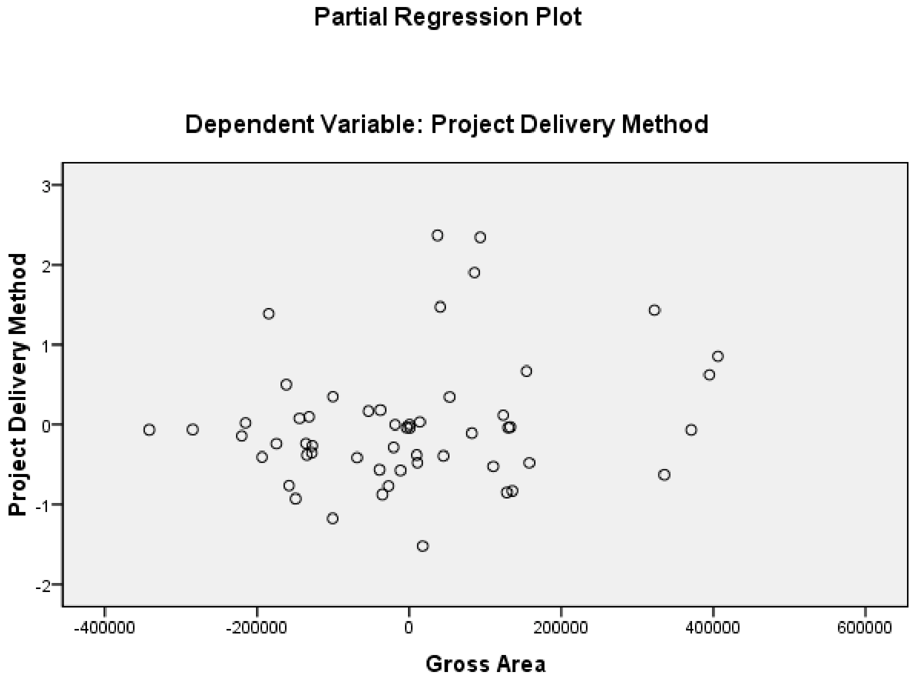


Figure 5.35 Model 2 Partial Scatterplot of Gross Area as Independent

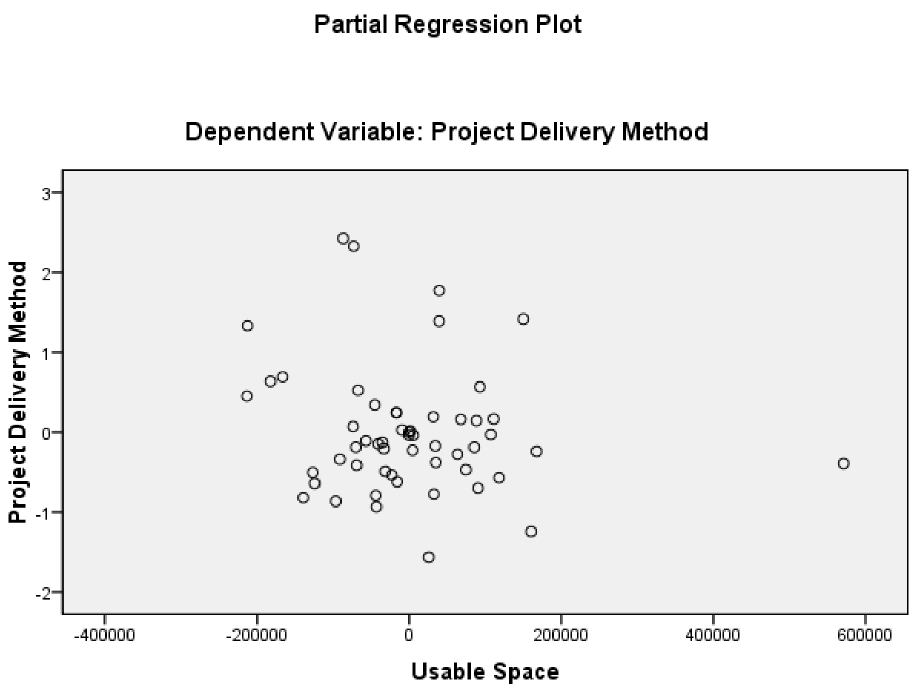


Figure 5.36 Model 2 Partial Scatterplot of Usable Space as Independent

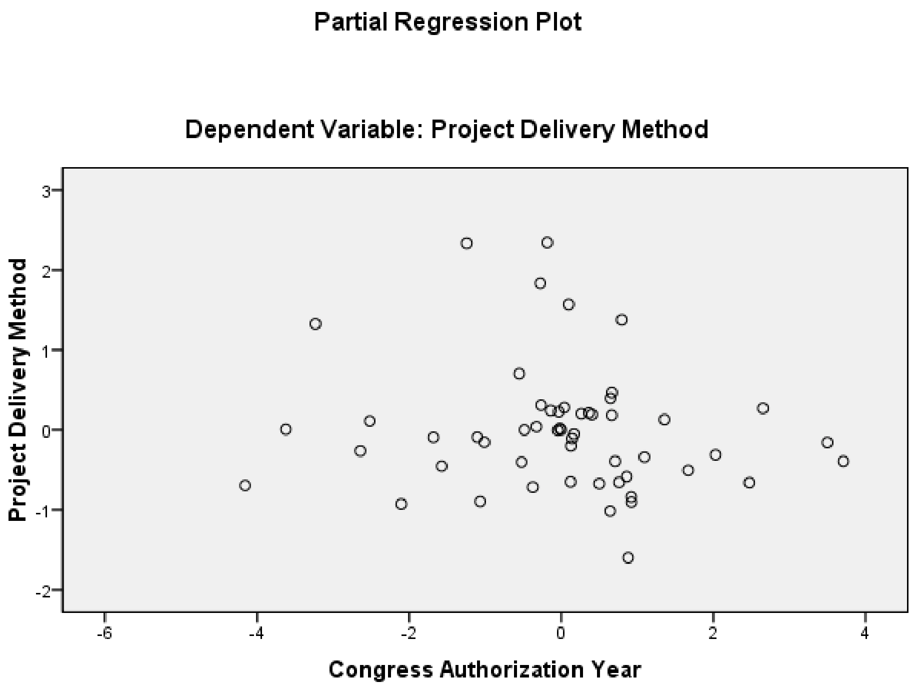


Figure 5.37 Model 2 Partial Scatterplot of Congress Authorization Year as Independent

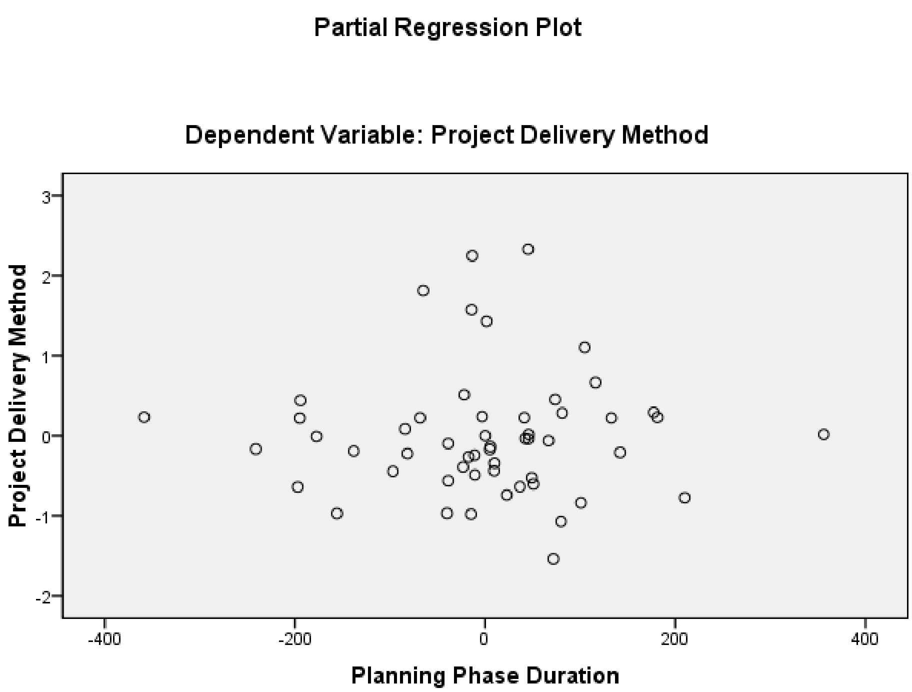


Figure 5.38 Model 2 Partial Scatterplot of Planning Phase Duration as Independent

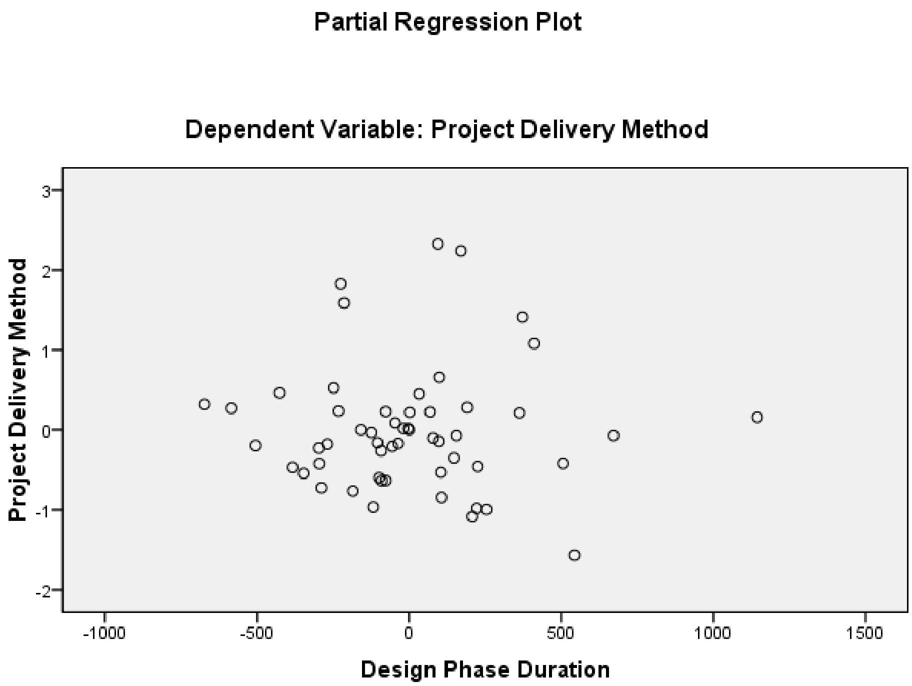


Figure 5.39 Model 2 Partial Scatterplot of Design Phase Duration as Independent

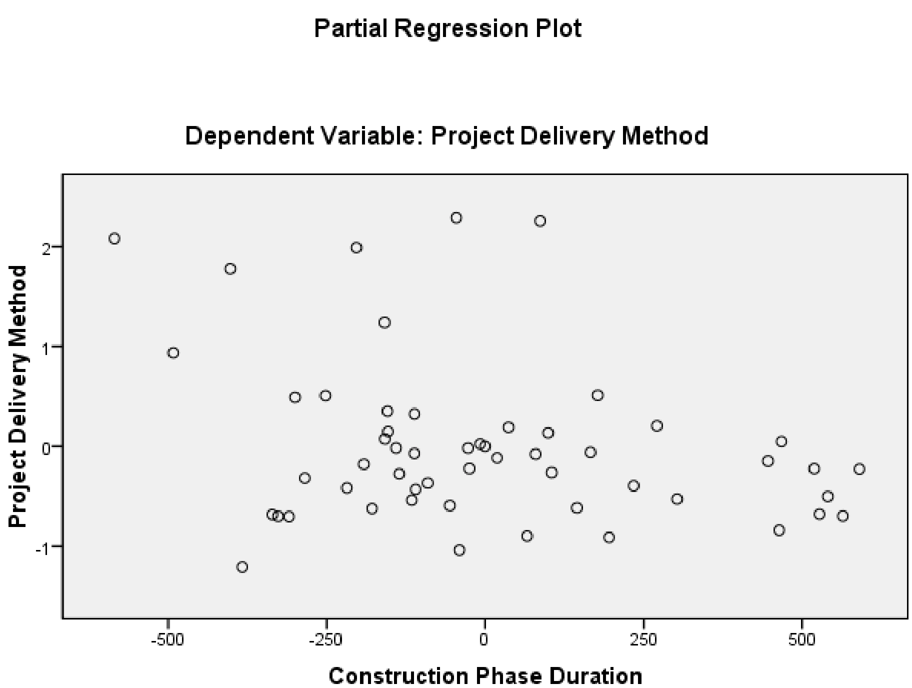


Figure 5.40 Model 2 Partial Scatterplot of Construction Phase Duration as Independent

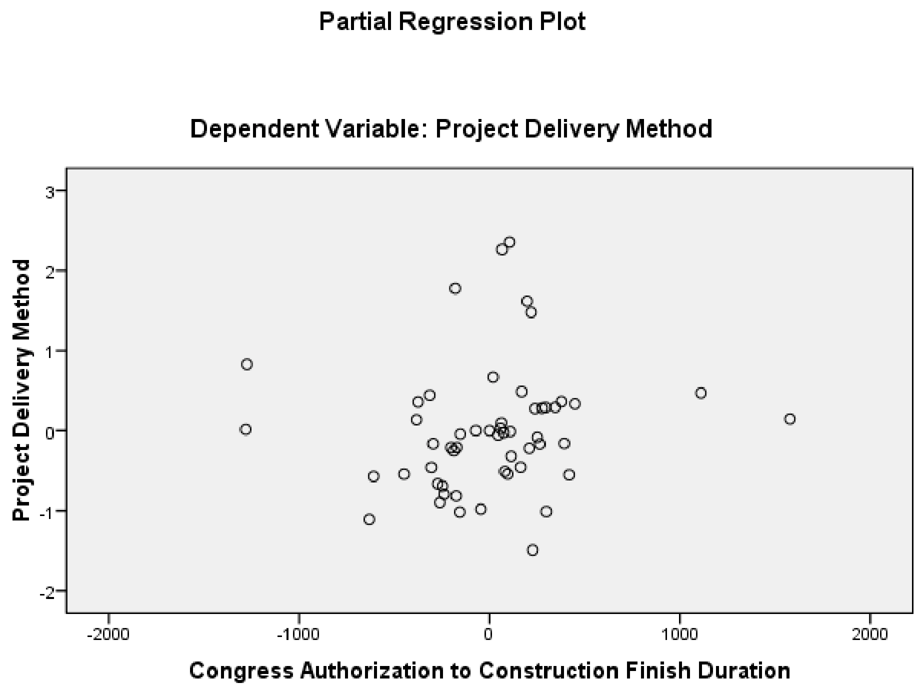


Figure 5.41 Model 2 Partial Scatterplot of Congress Authorization to Construction Finish Duration as Independent

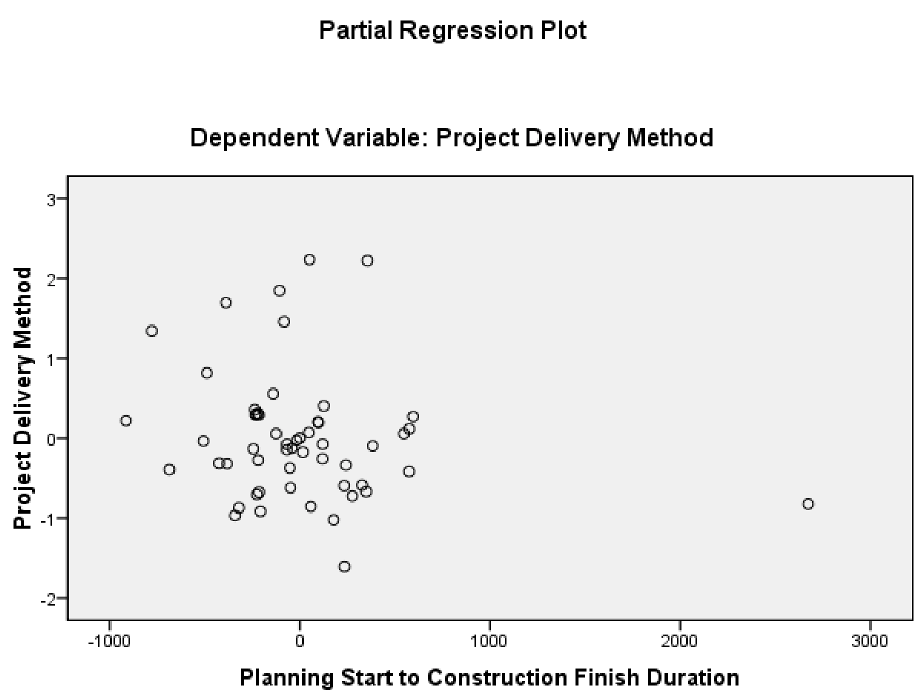


Figure 5.42 Model 2 Partial Scatterplot of Planning Start to Construction Finish Duration as Independent

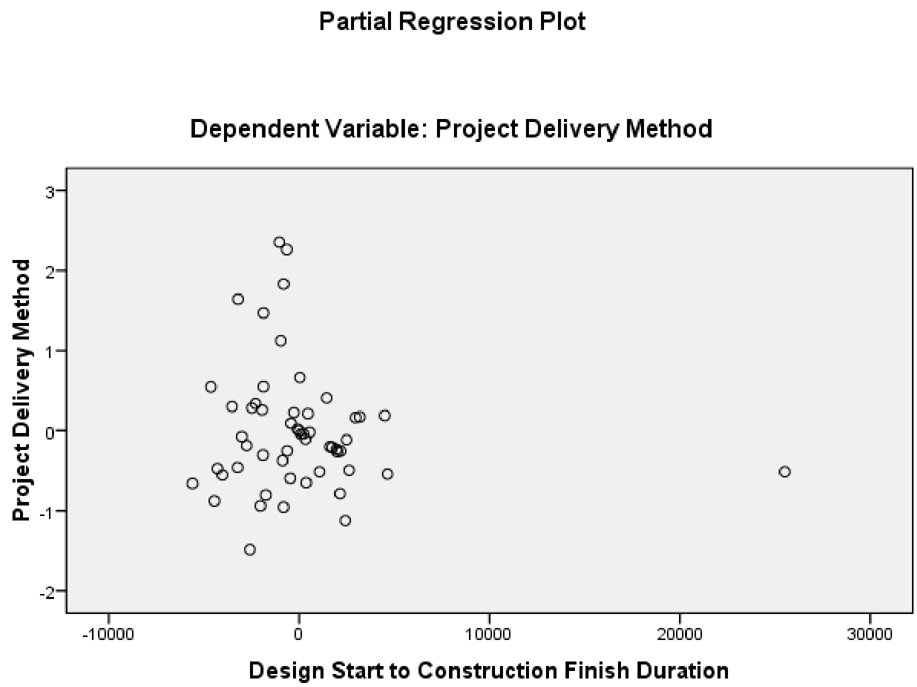


Figure 5.43 Model 2 Partial Scatterplot of Design Start to Construction Finish Duration as Independent

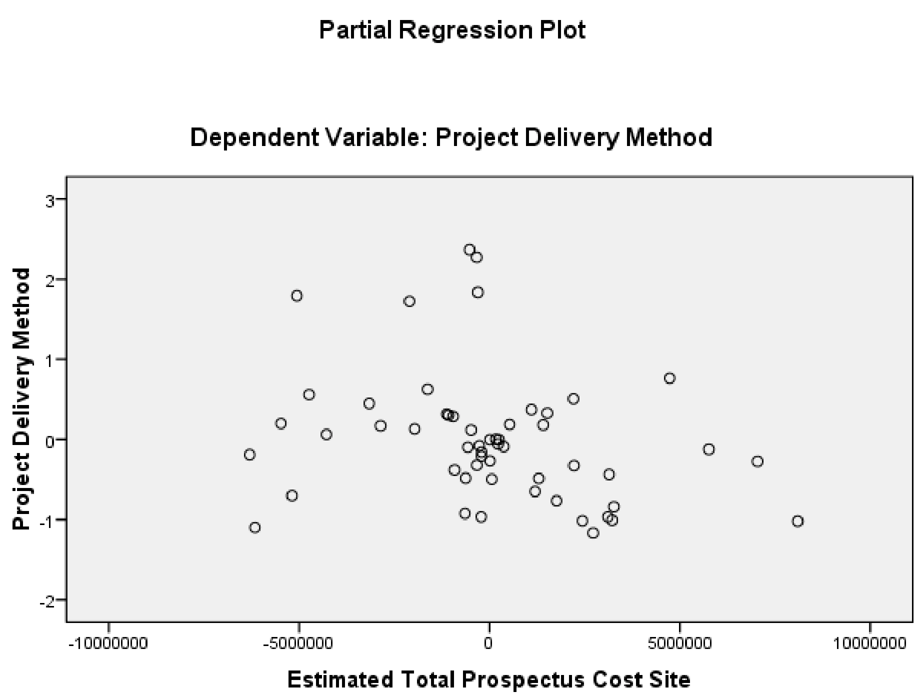


Figure 5.44 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost Site as Independent

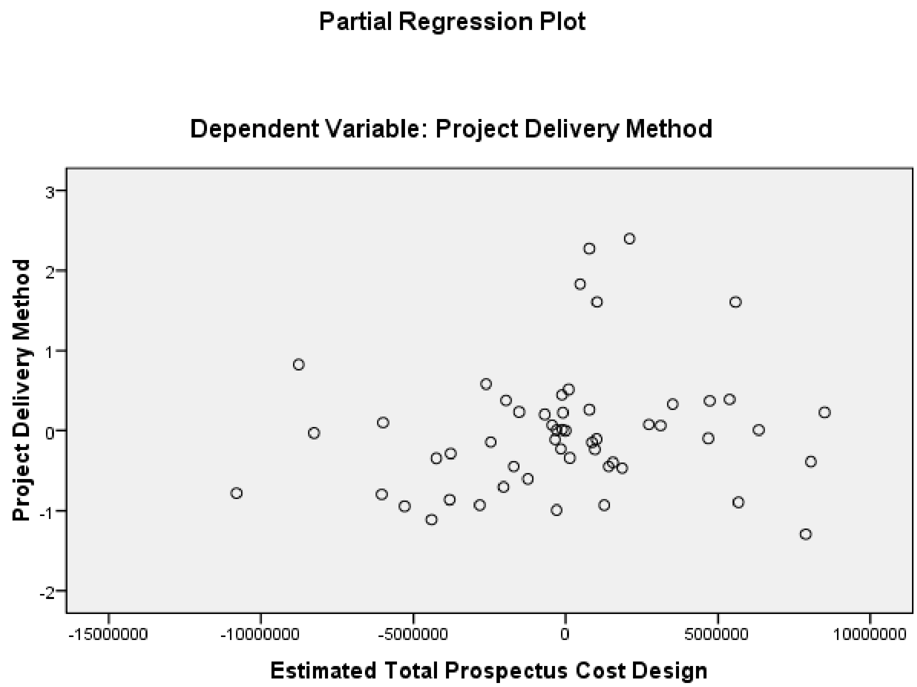


Figure 5.45 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost Design as Independent

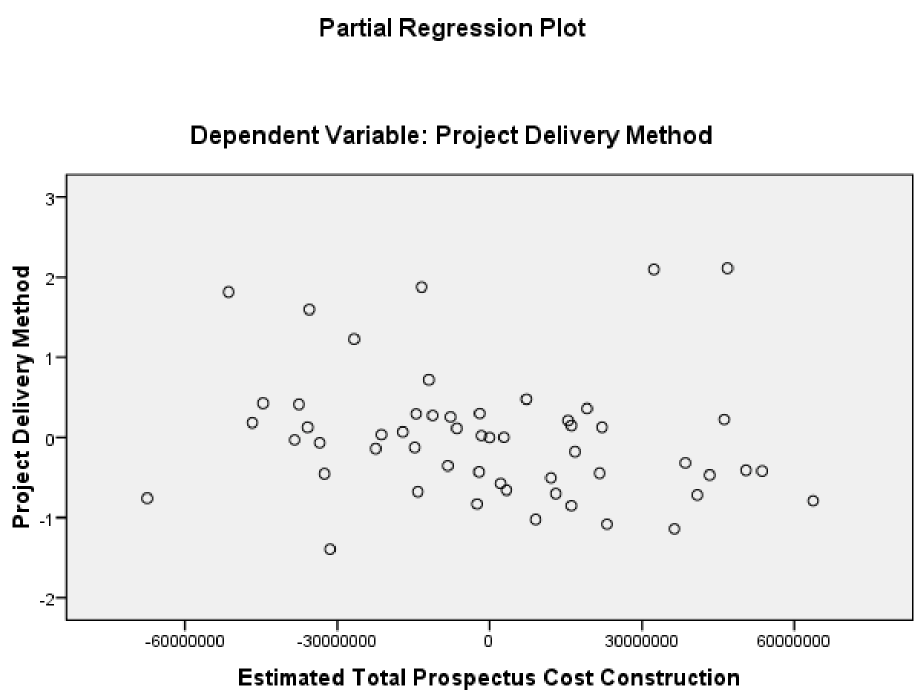


Figure 5.46 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost Construction as Independent

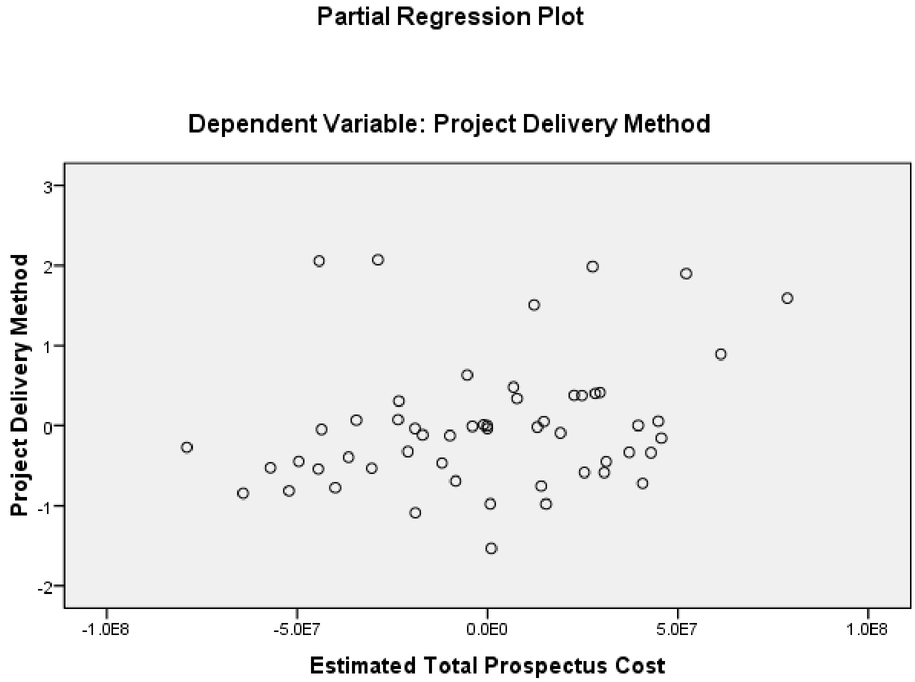


Figure 5.47 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost as Independent

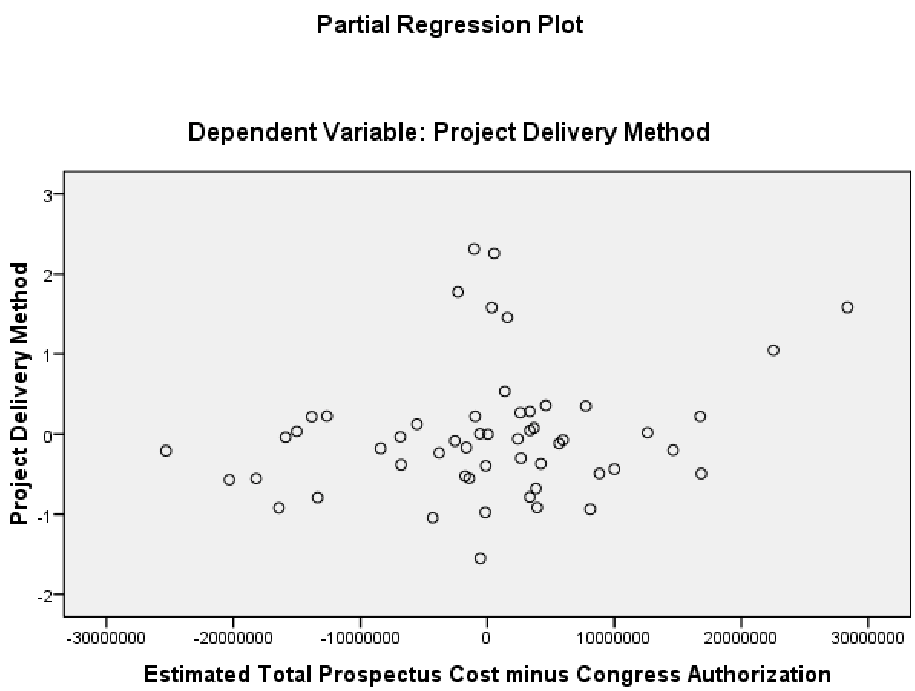


Figure 5.48 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost minus Congress Authorization as Independent

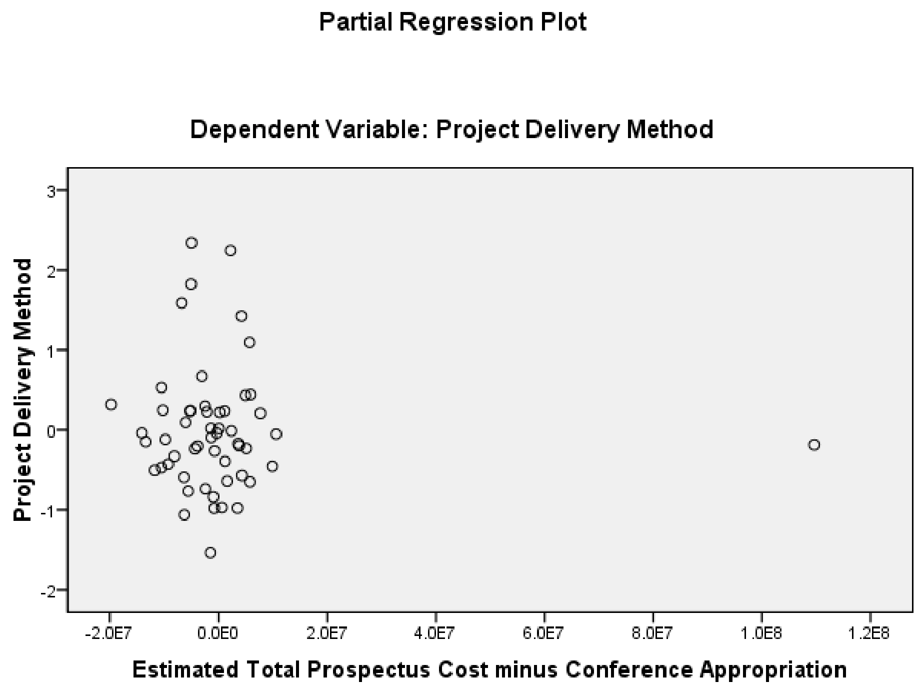


Figure 5.49 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost minus Conference Appropriation as Independent

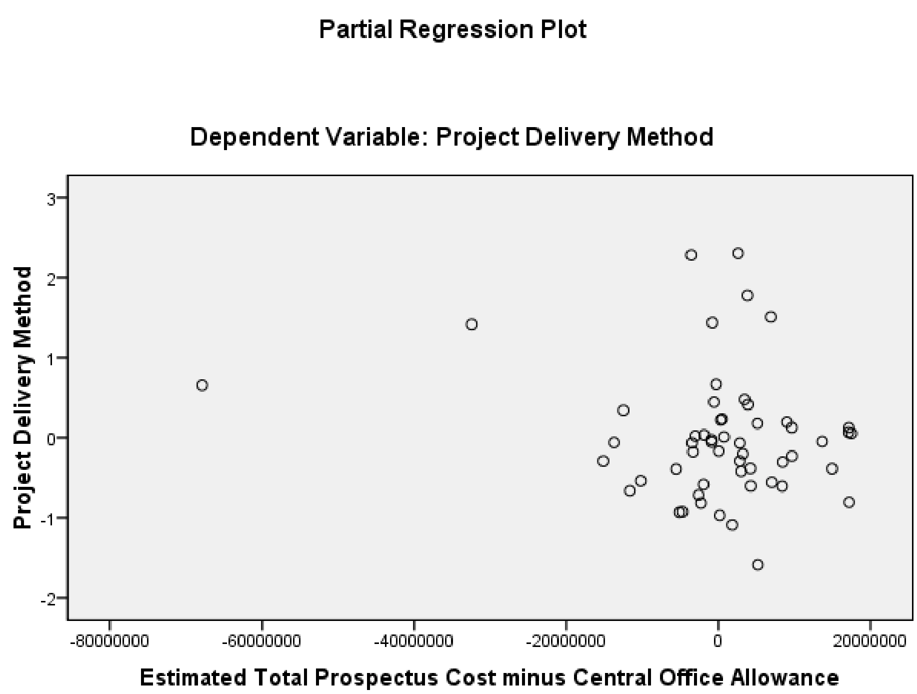


Figure 5.50 Model 2 Partial Scatterplot of Estimated Total Prospectus Cost minus Central Office Allowance as Independent

5.5.2 After Clinger-Cohen Act of 1996

The previous section, 5.5.1, develops and presents a second predictive model which tests and analyzes whether federal legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized. As presented, Model 2 is not considered statistically significant overall at the 0.05 level (at 0.407), and its betas are not statistically significant either and, therefore, its results can only be used for exploratory reasons. Since the hypothesis examines whether federal legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, a third predictive model is generated to examine the benefits of using an alternative project delivery method when federal legislative impediments are eliminated. Eliminating federal legislative impediments is defined as enacting the Clinger-Cohen Act of 1996, which allows qualifications-based selection of builders and provides a legislative process for selecting designers and builders under the design-build form of project delivery.

To generate this third predictive model, the research refers to examples from Garson (n.d.) to assist in explaining the results of the regression techniques. This third predictive model is the second of two models generated to test whether legislative impediments in federal applications impact project delivery method selection. Model 3 tests whether project characteristics (as multiple independent variables) have a relationship to the selection of a project delivery method (as the dependent variable) after the Clinger-Cohen Act of 1996 is enacted. As in the first and second predictive models (Model 1 and Model 2) which test project characteristics, in Model 3, all independent variables are entered in a single step and project delivery method is shown as the dependent variable. Table 5.36 and Table 5.37 provide general information about the third predictive model. It shows when Model 3 is created (on May 12, 2008, at 5:15:08 p.m.), how many projects are in the dataset in the model (248), and how the model treats missing variables in the dataset. The original dataset includes 496 projects, with 54 of those projects approved by Congress before the Clinger-Cohen Act of 1996 and with 248 of those projects approved by Congress after the Clinger-Cohen Act of 1996. The other 194 projects in the database do not provide the date Congress approved funding and, therefore, were eliminated form this particular analysis. Model 3 tests the characteristics of the 248 projects in relation to alternative project delivery selection. Also, all missing values within the variables in the database are replaced with the variable means.

Table 5.36 Model 3 Notes

Output Created		12-May-2008 17:15:08
Comments		
Input	Active Dataset	DataSet1
	N of Rows in Working Data File	248
	Definition of Missing	User-defined missing values are treated as missing.
Missing Value Handling	Cases Used	For each variable used, missing values are replaced with the variable mean.
Syntax	REGRESSION /MISSING MEANSUB /STATISTICS COEFF OUTS CI R ANOVA COLLIN TOL CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT DMOrig /METHOD=ENTER Region ProjectTypeOriginal ProgramOriginal FederalLaws1996 StateLaws HousePoliticalParty GrossArea UsableSpace CongressAuthorityFY PlanningTime DesignTime ConstructionTime AuthoritythroughConstruction PlanningthroughConstruction DesignandConstTime ETPCSite ETPCDesign ETPCConstruction ETPCTotal MoniesETPCTminusCongAuth MoniesETPCTminusConfAppro MoniesETPCTminusCentOffAllow /PARTIALPLOT ALL /SCATTERPLOT=(*ZPRED ,*SDRESID) (DMOrig ,*ZPRED) /RESIDUALS HIST(ZRESID) NORM(ZRESID).	
Resources	Processor Time	00:00:07.720
	Elapsed Time	00:00:07.720
	Memory Required	21180 bytes
	Additional Memory Required for Residual Plots	19400 bytes

Table 5.37 lists all independent variables and the dependent variable in Model 3.

Table 5.37 Model 3 Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
3	Estimated Total Prospectus Cost minus Central Office Allowance, Planning Phase Duration, State Legislation, Design Start to Construction Finish Duration, Federal Legislation, Project Type, Program Area, Region, Planning Start to Construction Finish Duration, Usable Space, Estimated Total Prospectus Cost Site, Design Phase Duration, Gross Area, Political Party, Congress Authority Year, Congress Authorization to Construction Finish Duration, Construction Phase Duration, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Conference Appropriation, Estimated Total Prospectus Cost Construction[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Project Delivery Method

The dependent variable is the project delivery method and the independent variables include the following: (1) Region; (2) Project Type; (3) Program Area; (4) Political Party; (5) Gross Area; (6) Usable Space; (7) Estimated Total Prospectus Cost minus Congress Authorization; (8) Estimated Total Prospectus Cost minus Conference Appropriation; (9) Estimated Total Prospectus Cost minus Central Office Allowance; (10) Estimated Total Prospectus Cost; (11) Estimated Total Prospectus Cost Site; (12) Estimated Total Prospectus Cost Design; (13) Estimated Total Prospectus Cost Construction; (14) Congress Authorization Year; (15) Planning Phase Duration; (16) Design Phase Duration; and (17) Construction Phase Duration; (18) Congress Authorization to Construction Finish Duration; (19) Planning Start to Construction Finish

Duration; (20) Design Start to Construction Finish Duration; (21) Federal Legislation; and (22) State Legislation. These variables are analyzed in the descriptive statistics and cross-tabulations in Chapter 4 and in the correlation analysis earlier in Chapter 5. Table 5.38 is the summary of Model 3. The R-squared is the percent of the dependent explained by the independents.

Table 5.38 Model 3 Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
3	.442[a]	.195	.116	1.155	.195	2.477	22	225	.000

a. Predictors: (Constant), Estimated Total Prospectus Cost minus Central Office Allowance, Planning Phase Duration, State Legislation, Design Start to Construction Finish Duration, Federal Legislation, Project Type, Program Area, Region, Planning Start to Construction Finish Duration, Usable Space, Estimated Total Prospectus Cost Site, Design Phase Duration, Gross Area, Political Party, Congress Authority Year, Congress Authorization to Construction Finish Duration, Construction Phase Duration, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Conference Appropriation, Estimated Total Prospectus Cost Construction

b. Dependent Variable: Project Delivery Method

In the case of this model, the independents explain 19.5 percent of the variance, R Square. Model 3 does not explain nearly as much of the variance as in Model 2; however, Model 3 holds its strength in its statistical significance, which is explained next. Explaining 19.5 percent of the variance suggests that Model 3 is misspecified. Other variables, not suggested by the researcher, explain more than 80 percent (80.5 percent) of the variance. The Adjusted R-Squared is a standard, arbitrary downward adjustment to account for the possibility that, with many independents, some of the variance may be due to chance. The more independents in the model suggest the more the adjustment penalty. Even though there are many independents in this model, the penalty is considered minor, with 0.116 or an 11.6 percent likelihood that these results are received by chance (the penalty.)

Table 5.39, the ANOVA table, tests the overall significance of Model 3 and of the regression equation created for Model 3. For this model, the F value is considered highly statistically significant at the 0.01 level (with 0.000); even though the R Square is not significant, explaining 19.5 percent, the overall model the model is credible. Model 3 then suggests that there is less than a one percent likelihood that the predictions in this model are due to chance, and thus using social sciences accepted standards, this model is highly credible.

Table 5.39 Model 3 Anova

Model		Sum of Squares	Df	Mean Square	F	Sig.
3	Regression	72.698	22	3.304	2.477	.000[a]
	Residual	300.104	225	1.334		
	Total	372.802	247			

a. Predictors: (Constant), Estimated Total Prospectus Cost minus Central Office Allowance, Planning Phase Duration, State Legislation, Design Start to Construction Finish Duration, Federal Legislation, Project Type, Program Area, Region, Planning Start to Construction Finish Duration, Usable Space, Estimated Total Prospectus Cost Site, Design Phase Duration, Gross Area, Political Party, Congress Authority Year, Congress Authorization to Construction Finish Duration, Construction Phase Duration, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Conference Appropriation, Estimated Total Prospectus Cost Construction

b. Dependent Variable: Project Delivery Method

Table 5.40 provides the b and beta coefficients and other coefficients of the model. The b coefficients and the constant are used to create the prediction (regression) equation.

Table 5.40 Model 3 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
3	(Constant)	-81.495	67.979		-1.199	.232	-215.452	52.462		
	Region	.007	.024	.018	.284	.777	-.040	.053	.875	1.143
	Project Type	.078	.158	.037	.491	.624	-.234	.390	.623	1.605
	Program Area	-.624	.159	-.254	-3.913	.000	-.938	-.310	.849	1.178
	Federal Legislation	.000	.000	.068	1.030	.304	.000	.001	.819	1.221
	State Legislation	-2.455E-5	.000	-.009	-.132	.895	.000	.000	.793	1.260
	Political Party	.000	.001	.033	.446	.656	.000	.001	.642	1.557
	Gross Area	-8.498E-8	.000	-.056	-.756	.450	.000	.000	.654	1.530
	Usable Space	6.649E-7	.000	.146	1.868	.063	.000	.000	.582	1.717
	Congress Authority Year	.041	.034	.094	1.220	.224	-.025	.108	.602	1.662
	Planning Phase Duration	2.564E-5	.000	.010	.129	.897	.000	.000	.640	1.562
	Design Phase Duration	.000	.000	.239	2.669	.008	.000	.001	.447	2.236
	Construction Phase Duration	.000	.000	-.324	-3.238	.001	.000	.000	.358	2.794
	Congress Authorization to Construction Finish Duration	.000	.000	-.074	-.945	.345	.000	.000	.580	1.724
	Planning Start to Construction Finish Duration	.000	.000	.227	2.899	.004	.000	.000	.581	1.721
	Design Start to Construction Finish Duration	-1.659E-5	.000	-.058	-.913	.362	.000	.000	.890	1.124
	Estimated Total Prospectus Cost Site	-1.582E-8	.000	-.054	-.752	.453	.000	.000	.687	1.455
	Estimated Total Prospectus Cost Design	2.443E-8	.000	.108	.474	.636	.000	.000	.069	14.564
	Estimated Total Prospectus Cost Construction	-5.704E-9	.000	-.381	-1.000	.318	.000	.000	.025	40.605
	Estimated Total Prospectus Cost	6.992E-9	.000	.546	1.550	.123	.000	.000	.029	34.700
	Estimated Total Prospectus Cost minus Congress Authorization	-2.232E-9	.000	-.143	-.996	.320	.000	.000	.174	5.751
	Estimated Total Prospectus Cost minus Conference Appropriation	4.331E-9	.000	.296	1.328	.186	.000	.000	.072	13.936
	Estimated Total Prospectus Cost minus Central Office Allowance	-8.040E-12	.000	.000	-.003	.998	.000	.000	.066	15.191

a. Dependent Variable: Project Delivery Method
b. Shaded rows represent statistically significant variables.

For this third predictive model, Project Delivery Method (Selected after Clinger-Cohen Act) = 0.018*(Region) + 0.037*(Project Type) + -0.254 *(Program Area) + -0.033* (Political Party) + -0.056*(Gross Area) + 0.146*(Usable Space) + -0.143* (Estimated Total Prospectus Cost minus Congress Authorization) + 0.296*(Estimated Total Prospectus Cost minus Conference Appropriation) + 0.000*(Estimated Total Prospectus Cost minus Central Office Allowance) + 0.546*(Estimated Total Prospectus Cost) + -0.054*(Estimated Total Prospectus Cost Site) + 0.108*(Estimated Total Prospectus Cost Design) + -0.381*(Estimated Total Prospectus Cost Construction) + 0.094*(Congress Authorization Year) + 0.010*(Planning Phase Duration) + 0.239*(Design Phase Duration) + -0.324*(Construction Phase Duration) + -0.074*(Congress Authorization to Construction Finish Duration) + 0.227*(Planning Start to Construction Finish Duration) + -0.058*(Design Start to Construction Finish Duration) + 0.068*(Federal Legislation) + -0.009*(State Legislation) + -81.495. The beta coefficients are the standardized regression coefficients and their relative absolute magnitudes reflect their relative importance in predicting the project delivery method. Betas are highly influenced by misspecification of the model; in this case, 80.5 percent of the model is not explained, and adding or subtracting variables in the equation will affect the size of the betas.

Model 3 is considered highly statistically significant (with a less than one percent likelihood that the results of the model are due to chance, or 0.000) and many of the variables are also considered of high significance, at a level of 0.05. Program Area is significant at the 0.000 level, which suggests that alternative project delivery methods, specifically design-build, are more often used in federal buildings and border stations. Alternative project delivery methods also have a greater use of Usable Space, with a significance level of 0.063. While this is not at or below the 0.05 level, this research draws its results from the data for exploratory reasons. Considered highly significant, the duration of time to complete design and construction is dramatically shortened using design-build. The Design Phase Duration is significant at the 0.008 level and Construction Phase Duration is significant at the 0.001 level. This suggests that there is less than a one percent chance that these variables in the model result by chance. Also significant is the duration from when the planning phase begins and when construction ends, with a significance of 0.004, or less than one percent chance that the model suggests that design-build has this shortened duration. Conversely, there are several variables in the model that are not highly significant: Region at 0.777; State Legislation at 0.895; Planning Phase Duration at 0.897; and Estimated Total Prospectus Cost minus Central Office Allowance at 0.998. These results suggest that there is no Region with a pattern of selecting a particular project delivery method, that there is no relationship between when design-build is allowed at the state level and if design-build is chosen at the federal level, that design-build requires a longer planning phase than other methods, and that Central Office withholds a greater percentage of funds authorized by Congress for projects using alternative delivery methods. This may suggest that GSA's Central Office assumes that the use of alternative project delivery methods should save money. These last statistics suggest these variables are not predictors of using an alternative project delivery method; rather, they are predictors of using design-bid-build. Projects that choose design-bid-build do not have state legislation allowing design-build (or qualifications-based selection for contractors), have shorter planning phase durations, and have a greater percentage of funding passing through GSA's Central Office. Because this model is considered highly significant, future research may suggest that the model be re-run, eliminating variables with the least significance to ultimately obtain a model with overall high significance and with all its variables of high significance. The tolerance for a variable is 1 - R-squared for the regression of that variable on all other independents, ignoring the dependents. When tolerance is close to zero, there is a high multicollinearity of that variable with other independents and the b and beta coefficients will be unstable. Many of the variables in Model 3 are not close to zero and so the betas do not suggest instability. Also, Model 3 suggests that only a few variables have high multicollinearity due to their variance inflation factor (VIF): Estimated Total Prospectus Cost Construction, and Estimated Total Prospectus Cost. Both factors suggest that this model be re-run in future research.

Table 5.41 contains summary data regarding residuals, or the difference between predicted and actual values.

Table 5.41 Model 3 Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.37	3.10	.97	.543	248
Std. Predicted Value	-2.480	3.929	.000	1.000	248
Standard Error of Predicted Value	.144	.971	.320	.147	248
Adjusted Predicted Value	-.57	3.32	.96	.568	248
Residual	-2.232	2.879	.000	1.102	248
Std. Residual	-1.932	2.493	.000	.954	248
Stud. Residual	-2.311	2.559	.002	.998	248
Deleted Residual	-3.319	3.033	.007	1.217	248
Stud. Deleted Residual	-2.333	2.591	.003	1.001	248
Mahal. Distance	2.861	173.726	21.911	25.466	248
Cook's Distance	.000	.139	.005	.015	248
Centered Leverage Value	.012	.703	.089	.103	248

a. Dependent Variable: Project Delivery Method

The minimum standardized residual is -1.932 and at least one prediction is between one and two standard deviations below the mean residual. The deleted residual rows have to do with coefficients when the model is recomputed over and over, dropping one case from the analysis at a time. This is an area suggested for future research on this Model, given its high statistically significant results. The bottom three rows are measures of the influence and Cook's distance appears that there may be problem cases since the maximum leverage is 0.703. In future research, if Model 3 is re-run, then Cook's distance should be lessened in theory and, thus, the results of this model may have more applicability in testing the hypothesis.

To analyze the data in the model in more detail, charts are developed. The zresid histogram in Figure 5.51 provides a visual way of assessing if the assumption of normally distributed residual error is met. In Model 3, the small skewness to the left should not affect substantive conclusions. This reaffirms the previous conclusions in this model.

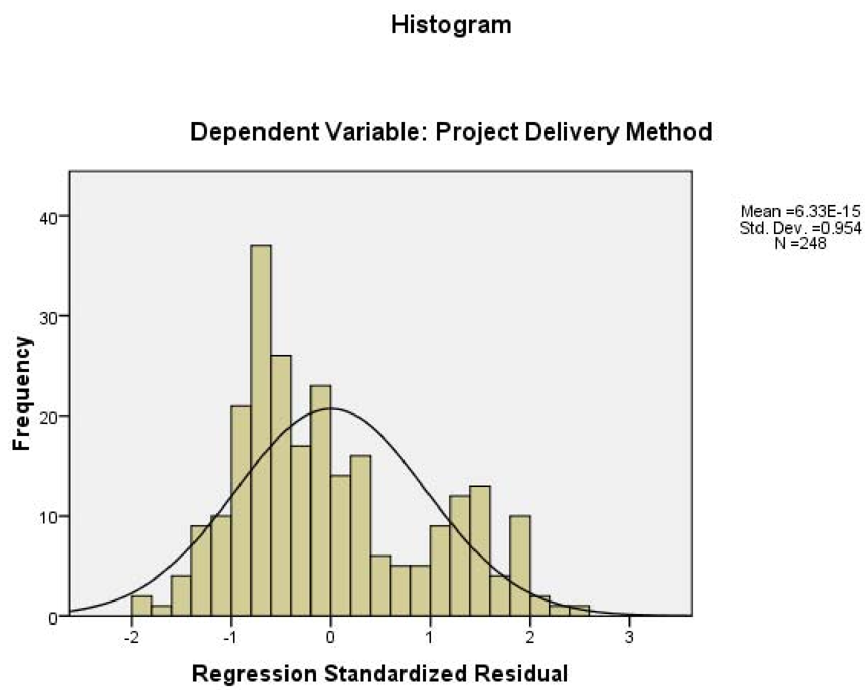


Figure 5.51 Model 3 Histogram

The normal probability plot (zresid normal p-p plot) in Figure 5.52 is yet another test of normally distributed residual error. Under perfect normality, the plot will be a 45-degree line. In Model 3, it is imperfect, but better than Model 2 and still valid for exploratory conclusions.

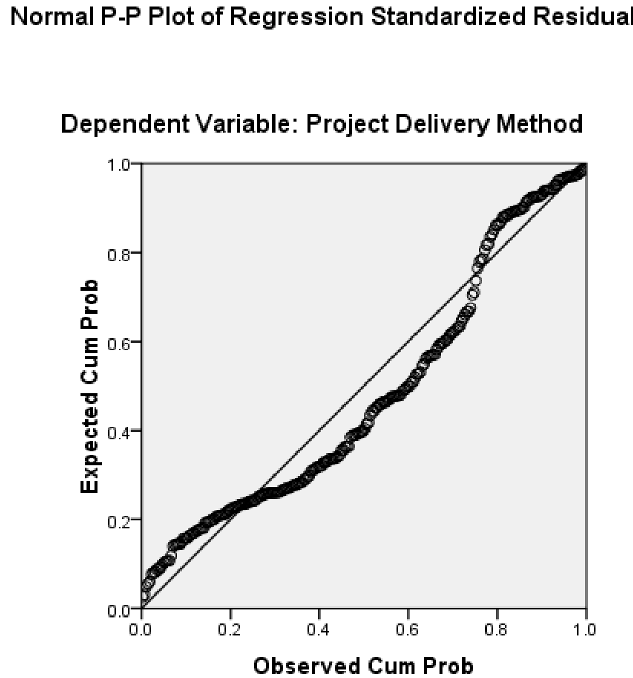


Figure 5.52 Model 3 Normal P-P Plot of Regression Standardized Residual

In the plot of standardized predicted values versus observed values, if 100 percent of the variance is explained in a linear relationship, the points in the scatter plot in Figure 5.53 will form a straight line. The lower the percent of variance explained, the more the points will form a cloud with no trend. The more the points are dispersed around the trend, the higher the standard error of estimate and the poorer the model. The plot in Figure 5.53 reflects that the model only explains a small percentage of the variance, or 19.5 percent, as discussed earlier.

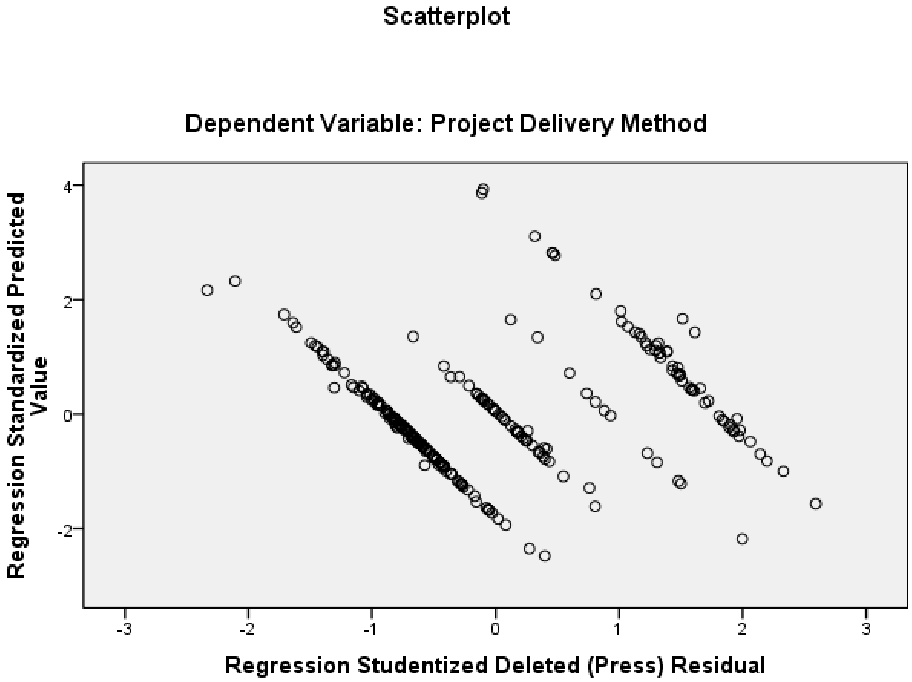


Figure 5.53 Model 3 Scatterplot of Model Variance

As mentioned in earlier models, partial regression plots show the plot of one independent on the dependent variable (project delivery method). The points will form a straight line if the percent of the variance is 100 percent, and will form a cloud the lower the percent of variance is explained. Figures 5.54 to 5.75 verify high variances between the project delivery method (dependent) and several of the independents. The low variances are shown as cloud-like formations on all of the partial scatterplots.

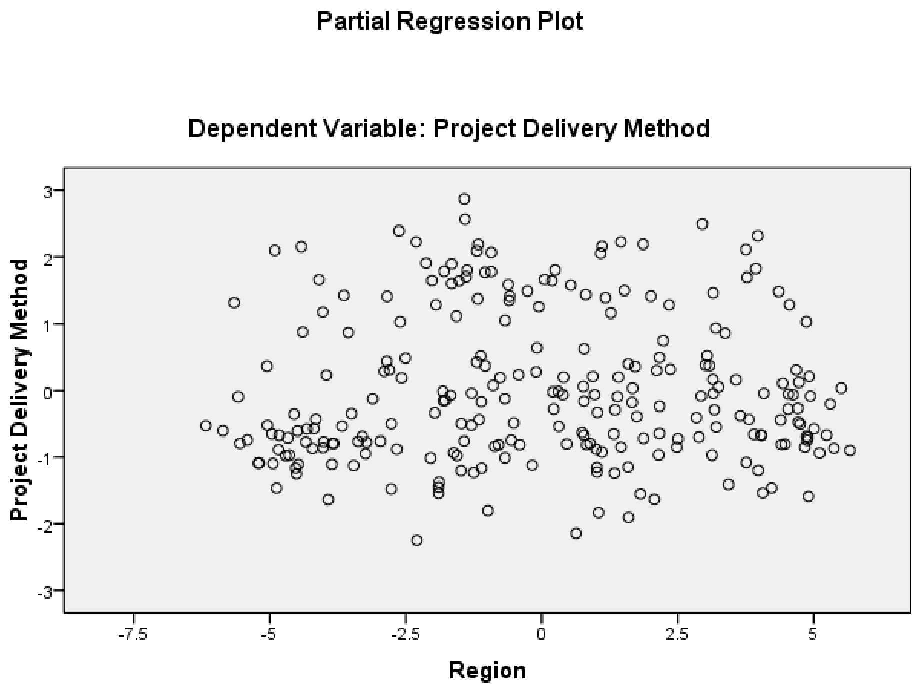


Figure 5.54 Model 3 Partial Scatterplot of Region as Independent

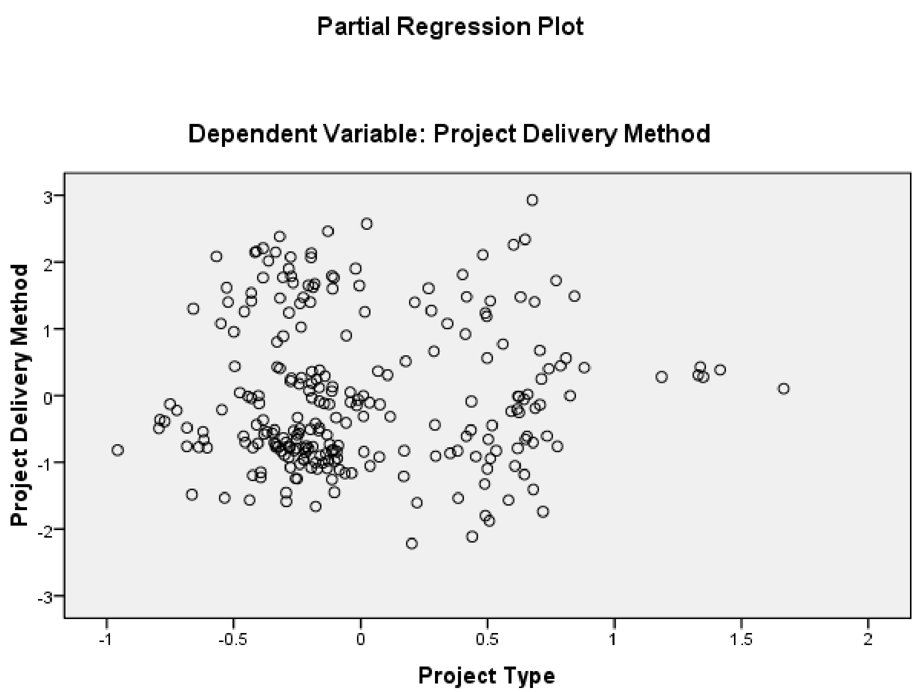


Figure 5.55 Model 3 Partial Scatterplot of Project Type as Independent

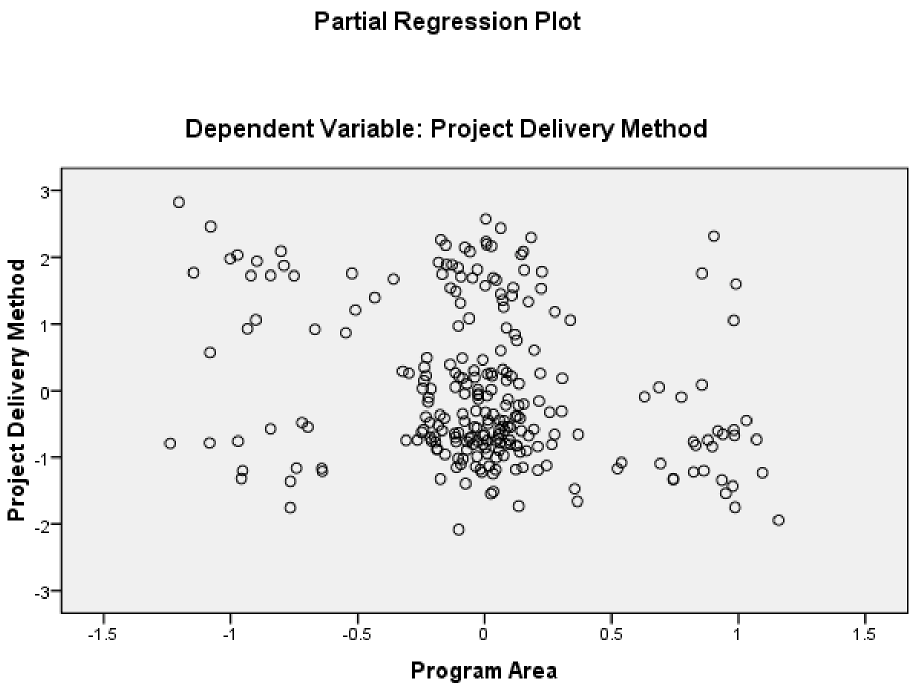


Figure 5.56 Model 3 Partial Scatterplot of Program Area as Independent

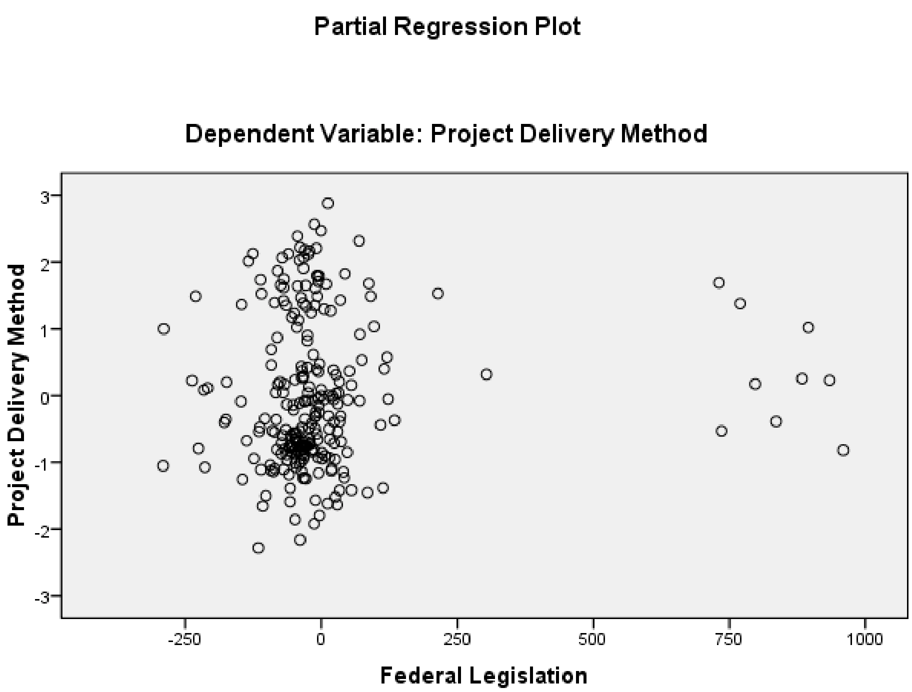


Figure 5.57 Model 3 Partial Scatterplot of Federal Legislation as Independent

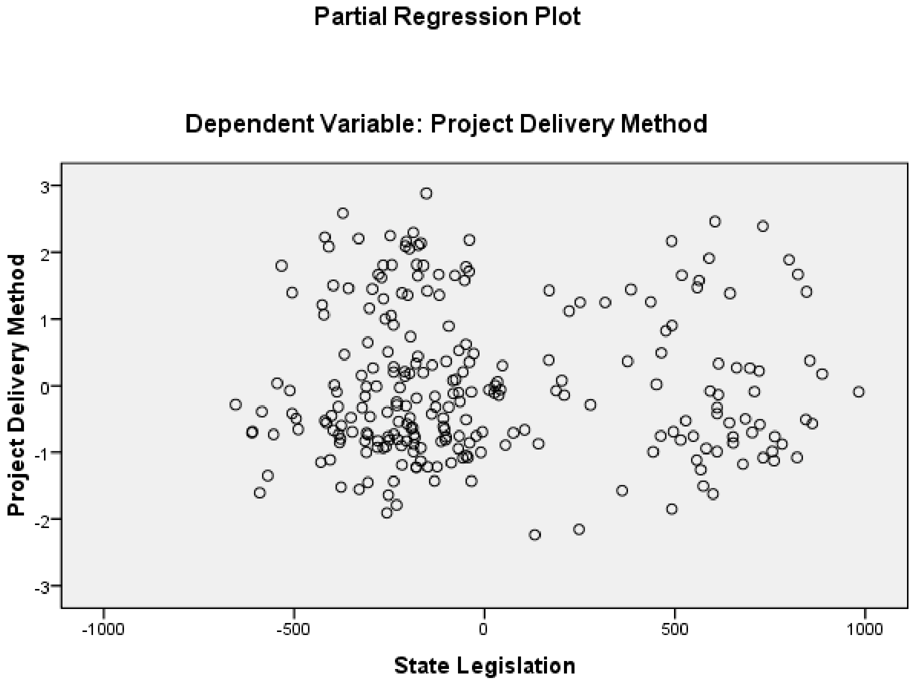


Figure 5.58 Model 3 Partial Scatterplot of State Legislation as Independent

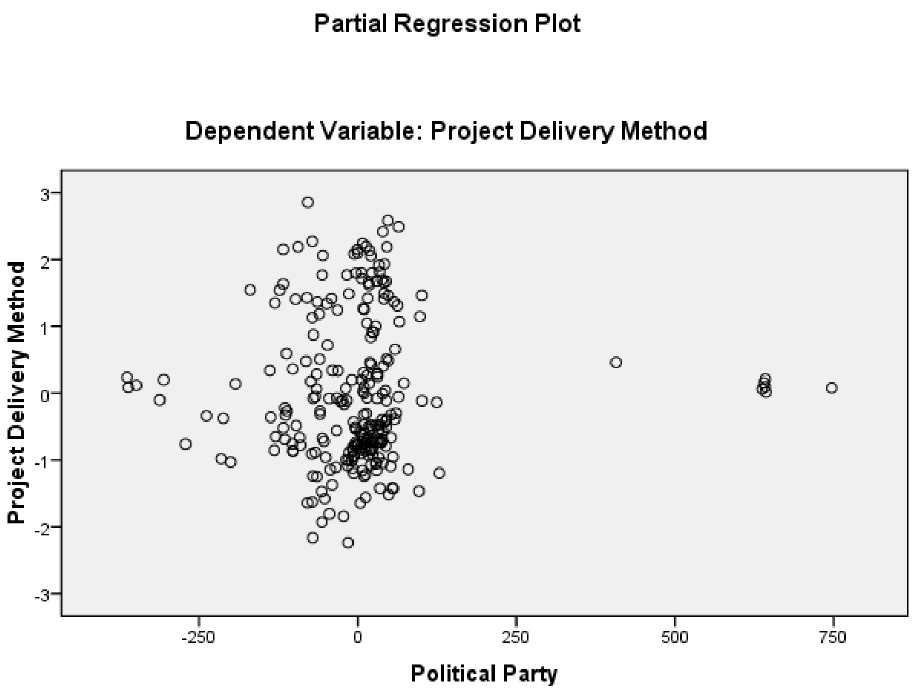


Figure 5.59 Model 3 Partial Scatterplot of Polical Party as Independent

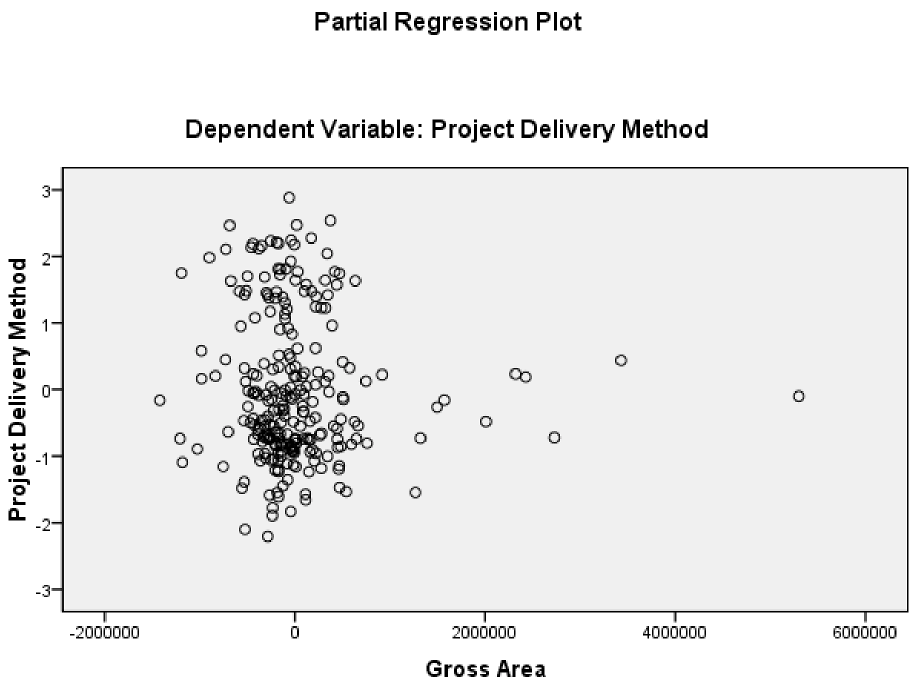


Figure 5.60 Model 3 Partial Scatterplot of Gross Area as Independent

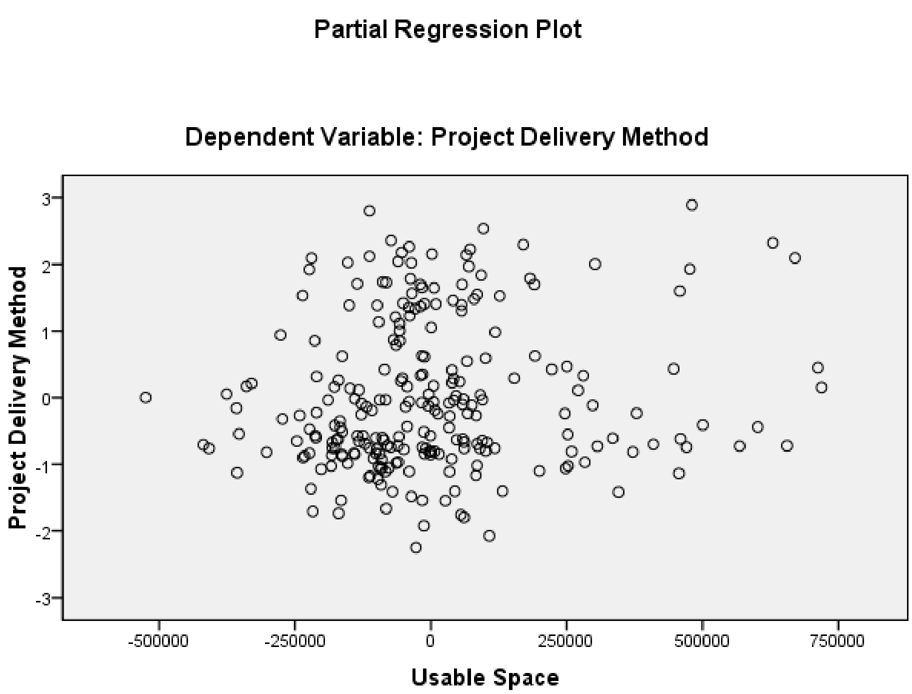


Figure 5.61 Model 3 Partial Scatterplot of Usable Space as Independent

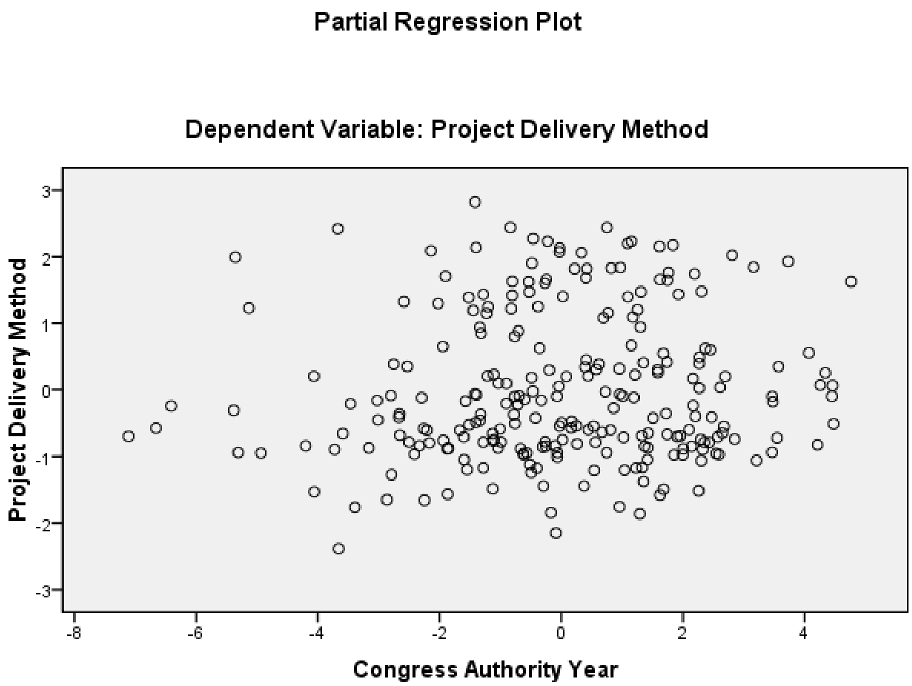


Figure 5.62 Model 3 Partial Scatterplot of Congress Authorization Year as Independent

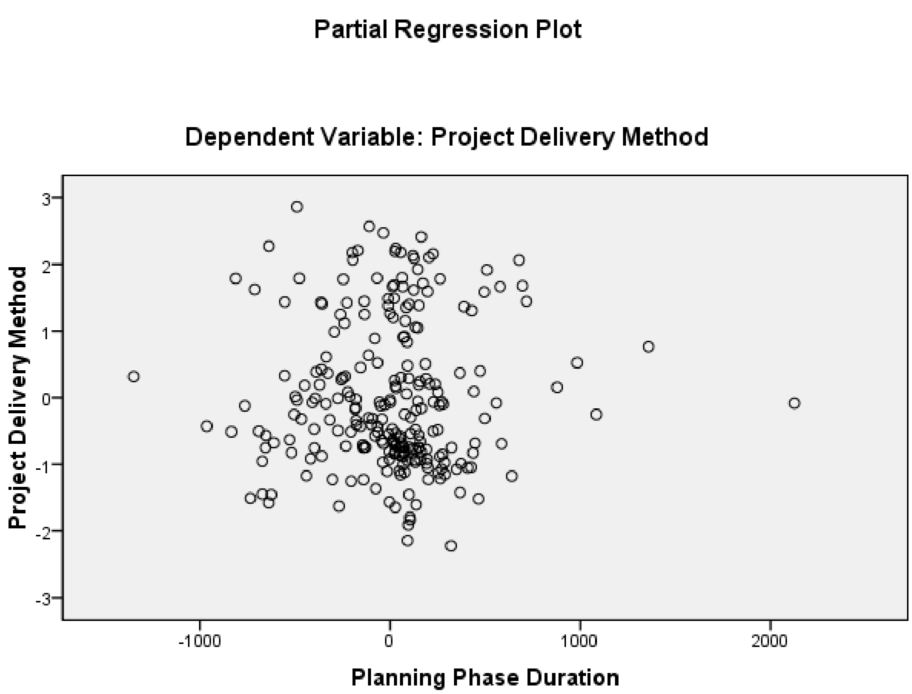


Figure 5.63 Model 3 Partial Scatterplot of Planning Phase Duration as Independent

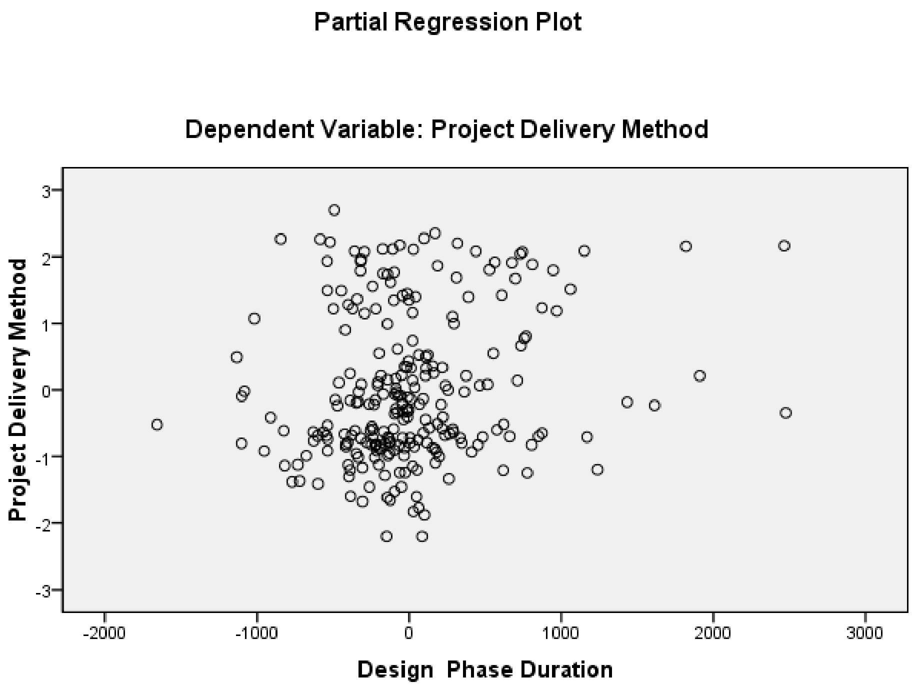


Figure 5.64 Model 3 Partial Scatterplot of Design Phase Duration as Independent

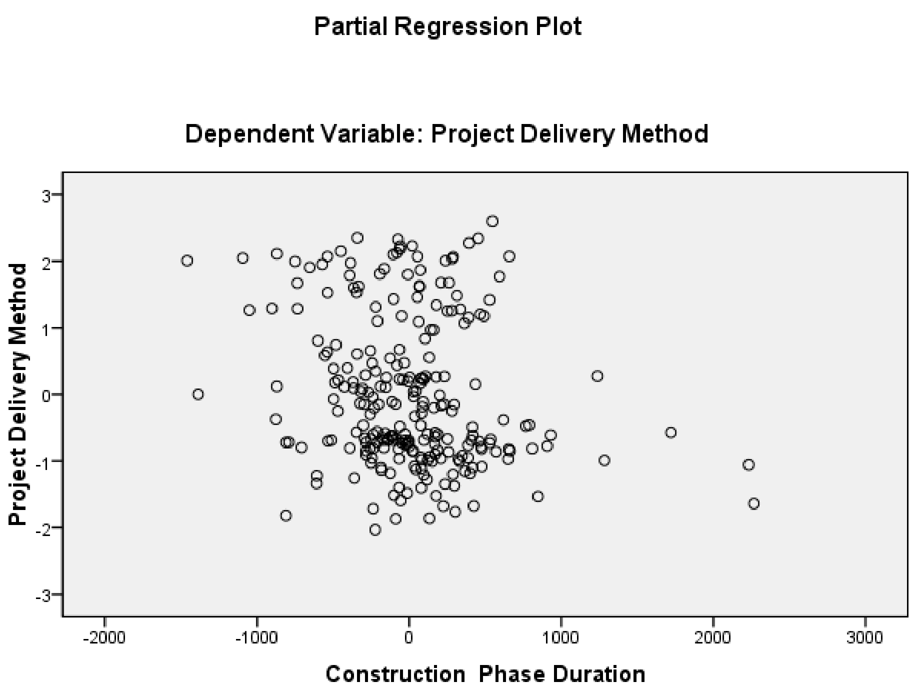


Figure 5.65 Model 3 Partial Scatterplot of Construction Phase Duration as Independent

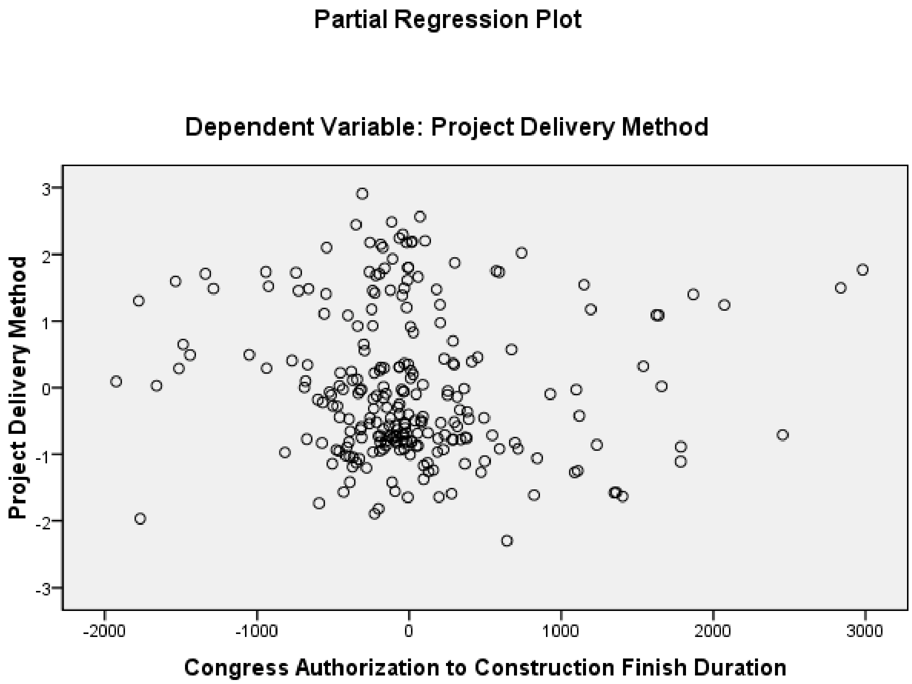


Figure 5.66 Model 3 Partial Scatterplot of Congress Authorization to Construction Finish Duration as Independent

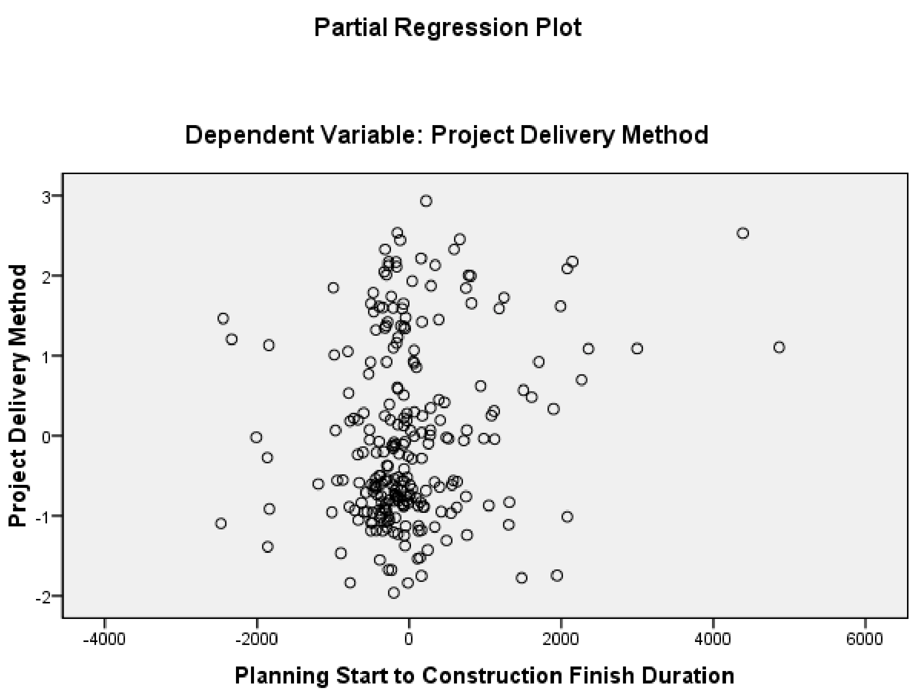


Figure 5.67 Model 3 Partial Scatterplot of Planning Start to Construction Finish Duration as Independent

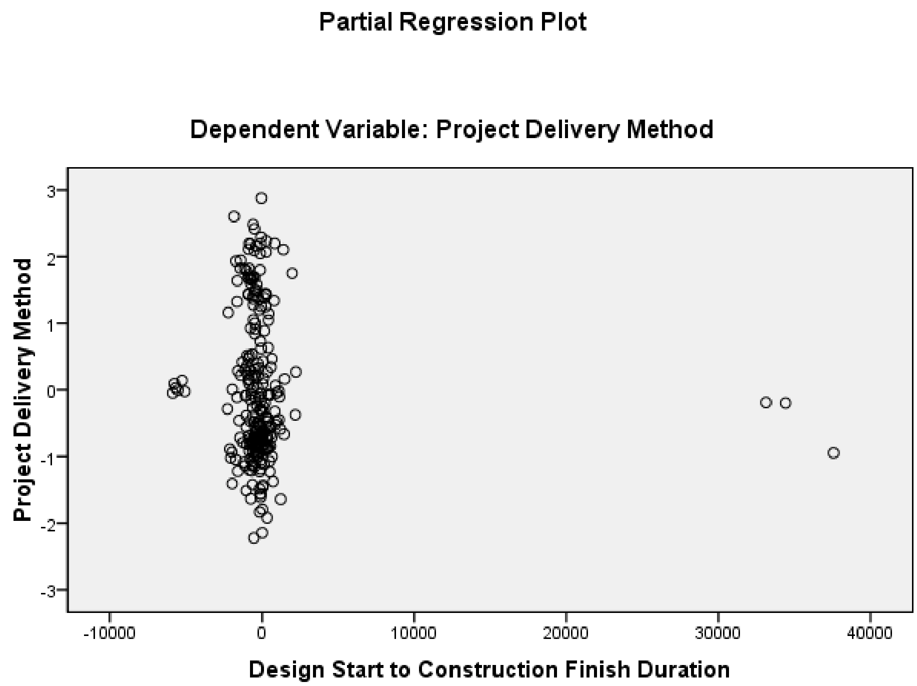


Figure 5.68 Model 3 Partial Scatterplot of Design Start to Construction Finish Duration as Independent

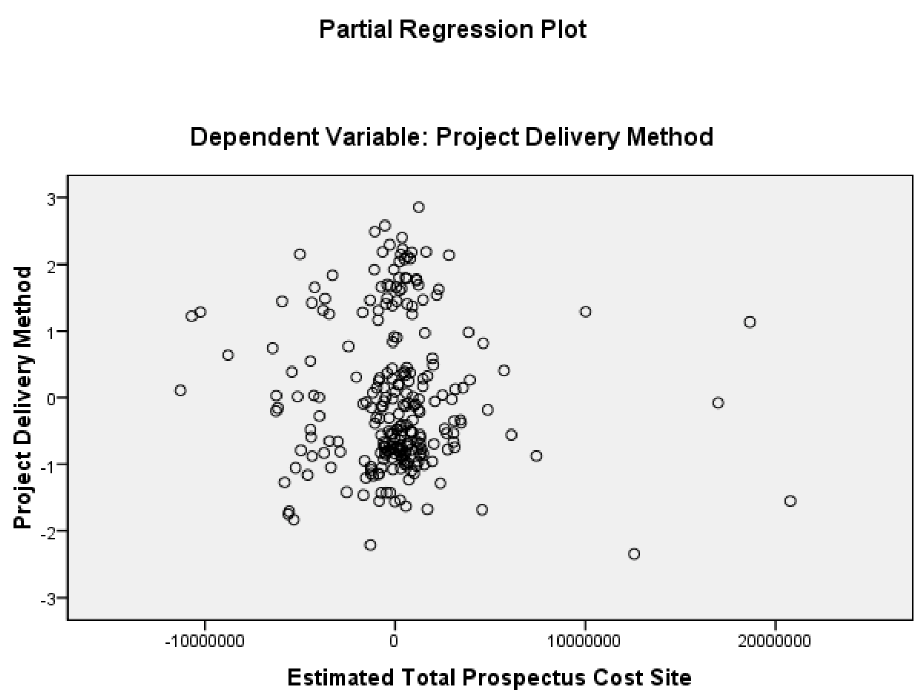


Figure 5.69 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost Site as Independent

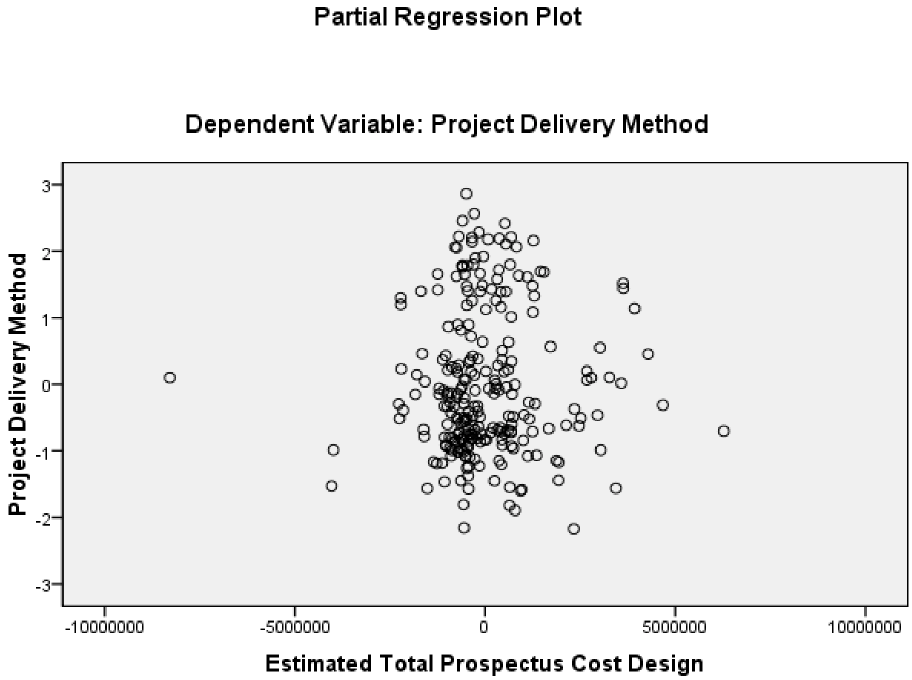


Figure 5.70 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost Design as Independent

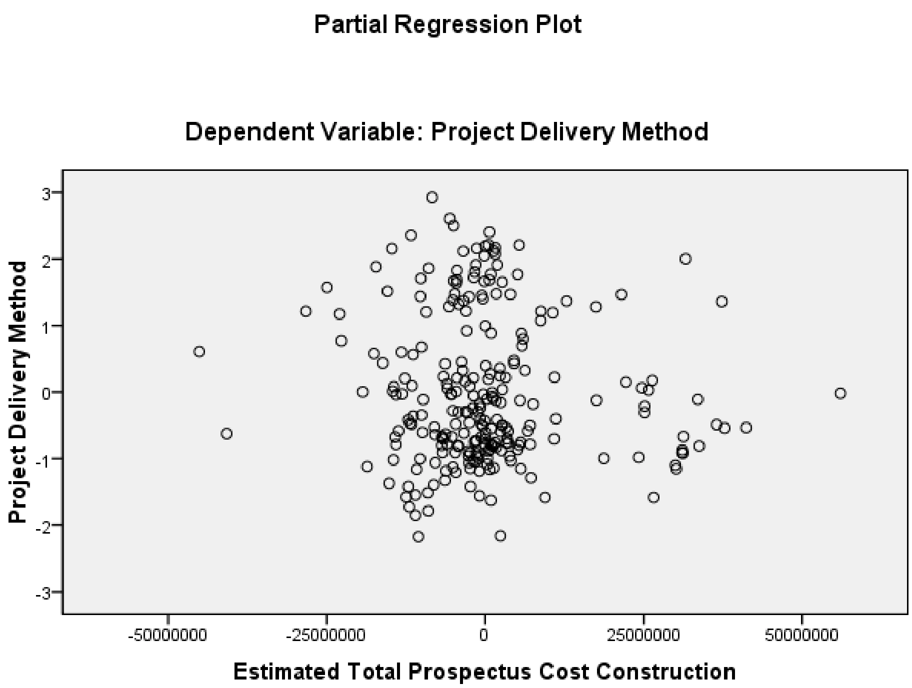


Figure 5.71 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost Construction as Independent

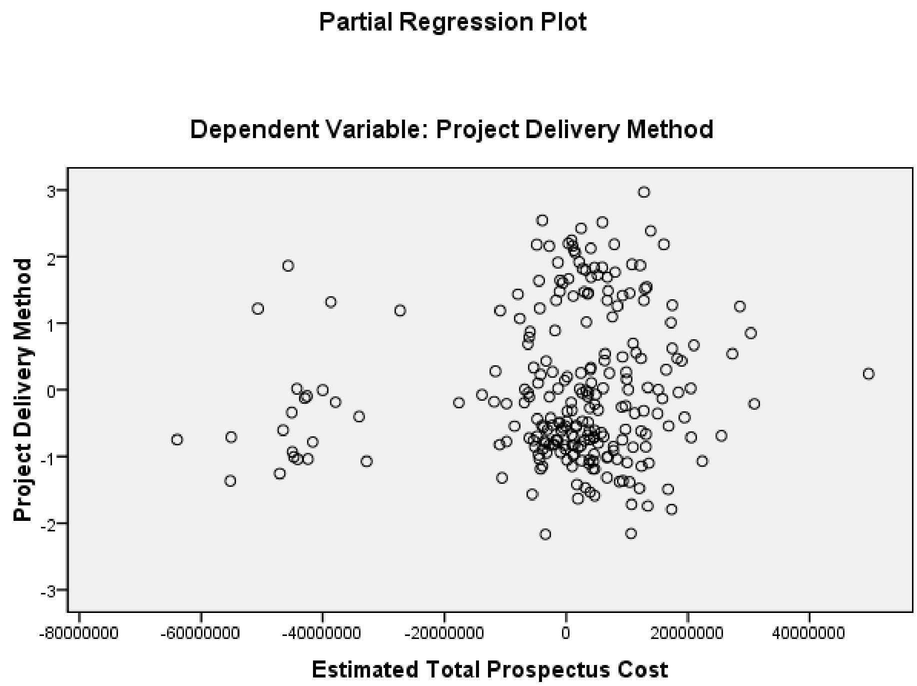


Figure 5.72 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost as Independent

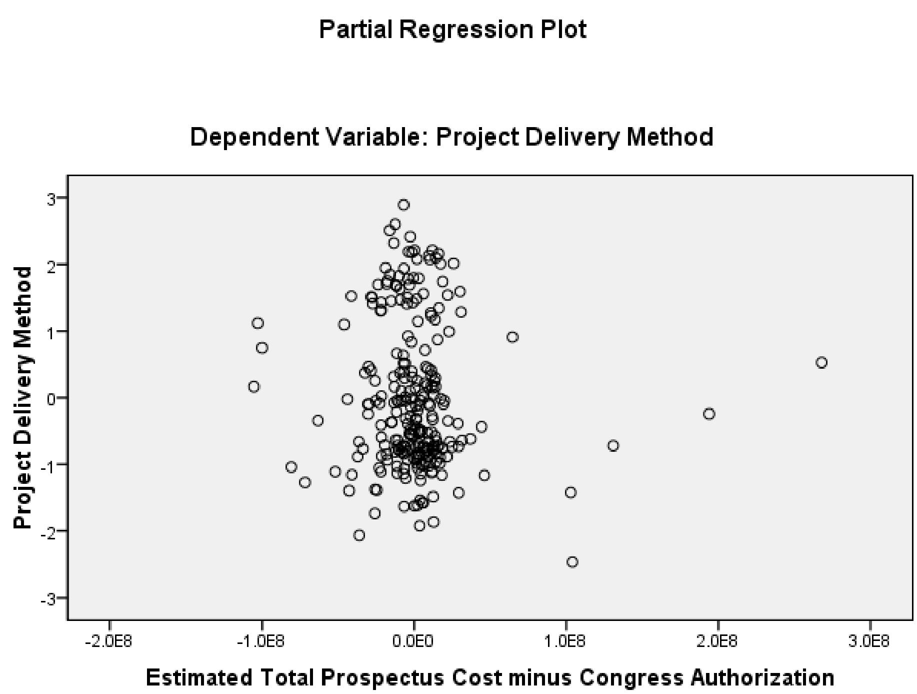


Figure 5.73 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost minus Congress Authorization as Independent

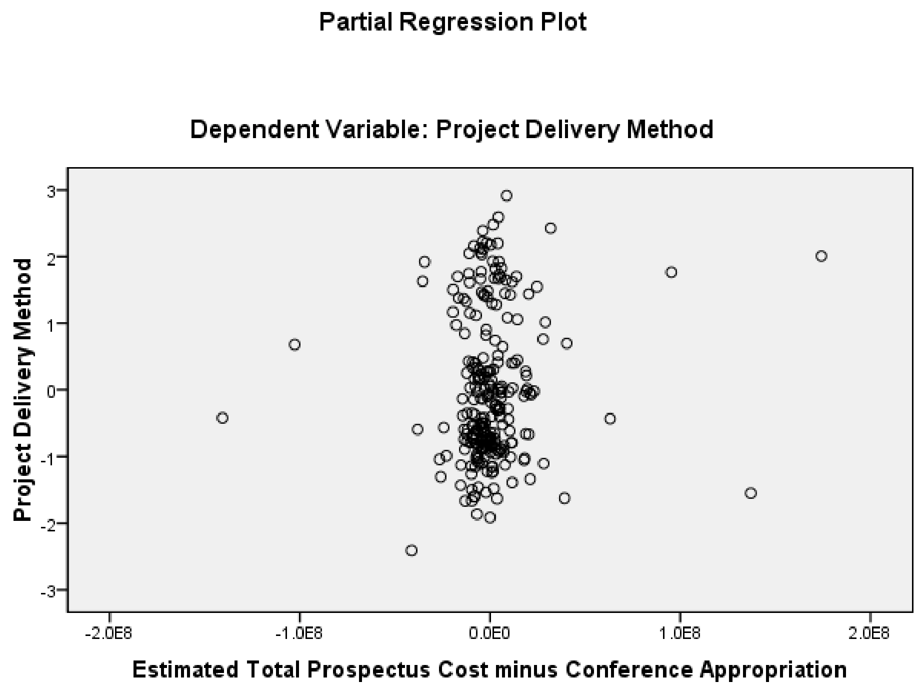


Figure 5.74 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost minus Conference Appropriation as Independent

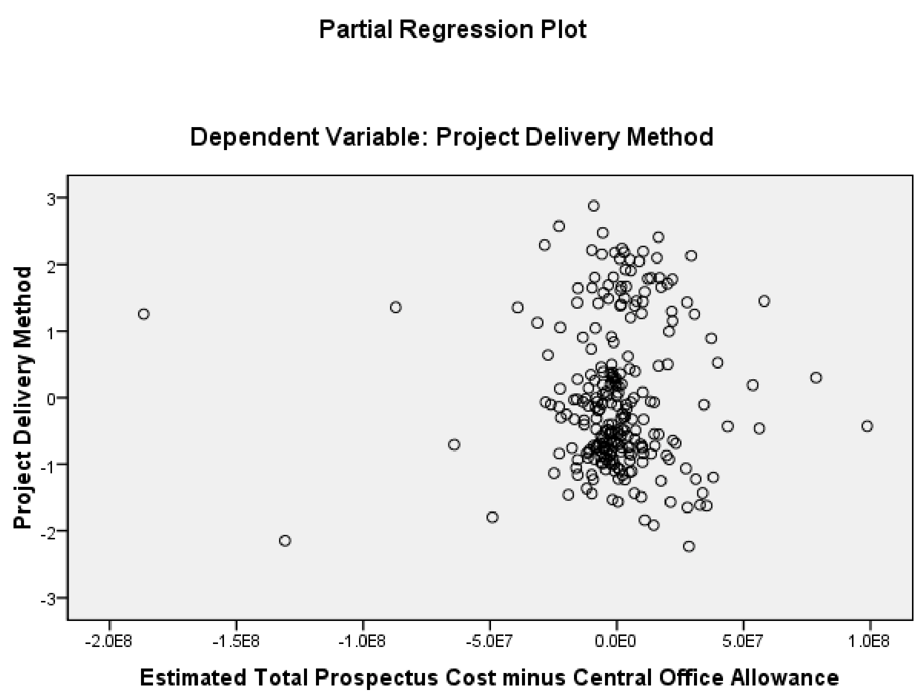


Figure 5.75 Model 3 Partial Scatterplot of Estimated Total Prospectus Cost minus Central Office Allowance as Independent

5.5.3 Summary of Multivariate Analysis Testing Federal Legislative Impediments

This section of the chapter tests the hypothesis, whether federal legislative limitations allowing the use of alternative project delivery methods impede benefits to be realized, and examines the relationships between the dependent variable (project delivery method) and multiple independent variables (the project characteristics) using regression techniques. A series of two predictive models are developed in this section to test the impact of alternative delivery methods after federal legislative impediments are eliminated, specifically after the Clinger-Cohen Act of 1996. Model 2, the first predictive model in this section, tests the impact of project delivery method selection before the Clinger-Cohen Act of 1996, and Model 3 tests the impact of alternative project delivery methods after the Clinger-Cohen Act of 1996. The goal of these two models is to assess the benefits of using an alternative project delivery method, specifically design-build, for a construction project.

In Model 2, the independents explain 43.6 percent (R Square) of the variance; however, the model is not considered statistically significant with an F value of 0.407, suggesting a 40 percent likelihood that the predictions in this model are due to chance. None of the variables are considered significant, at a level below 0.05, which suggests that there are no significant relationships between alternative project delivery methods and project characteristics before the Clinger-Cohen Act of 1996. This makes sense because this model is developed to test whether alternative project delivery methods are selected in the face of legislative impediments. Instead, many variables in Model 2 are not highly significant, including: Federal Legislation; State Legislation; Political Party; Planning Phase Duration; Design Phase Duration; and Estimated Total Prospectus Cost minus Conference Appropriation. These statistics suggest these variables are not predictors of using an alternative project delivery method; rather, they are predictors of using design-bid-build. Projects that are chosen design-bid-build do not have state legislation allowing design-build at the state level (or qualifications-based selection for contractors), have longer planning and design phase durations, and have a lower percentage of funding passing through Conference appropriations.

The results of the second predictive model of this section, Model 3, are almost the opposite of Model 2. Model 3's F value is considered highly statistically significant at the 0.01 level (with 0.000), and its R Square is not significant, explaining only 19.5 percent of the overall model. Model 3 suggests that there is less than a one percent likelihood that the predictions in this model are due to chance; however, more than 80 percent of the model is explained by reasons other than by the independents in the model. Even though the R Square is low, the model is credible in assessing the significance of the b coefficients in the model. Many of the variables in Model 3 are considered of high significance, at a level of 0.05, and suggest the benefits of using an alternative delivery method, and specifically design-build, for their construction project. Alternative project delivery methods are more often used in federal buildings and border stations, have a greater use of Usable Space, and the duration of time to complete design and construction is dramatically shortened using design-build. The most significant findings are that design-build benefits a project by reducing the duration of the design and construction phases. Earlier qualitative research presented in Chapter 2 suggests that overlapping design and construction, which is typical in a design-build project, creates shorter design and construction durations. Model 3 corroborates the qualitative findings presented in Chapter 2 with these quantitative findings in Chapter 5.

Also significant is that public owners benefit from shortened durations from when the planning phase begins to when construction ends. Conversely, using design-build does not benefit public owners in the planning phase duration and in the percentage of funding between the Estimated Total Prospectus Cost and the amount of funds received from GSA's Central Office. Model 3 suggests that GSA's Central Office is withholding a greater percentage of funding for projects using alternative delivery methods. This may suggest that GSA's Central Office expects design-build or construction manager as-constructor to save money.

These two predictive models prove the second question in the hypothesis. Federal legislative impediments affect the benefits that exist when alternative project delivery methods are allowed to be used. Legislative impediments affect the project outcome of a design and construction project. The last section of this chapter tests the impact of project delivery method selection under state legislative impediments.

5.6 Multivariate Analysis Testing State Legislative Impediments

The last section of this chapter concludes with testing whether state legislative impediments affect the benefits that exist when alternative project delivery methods are allowed to be used for a federal project. While state governments do not have jurisdiction for fully federally-funded projects, political conditions at the state level may exist and may influence the selection of a project delivery method. Similar to the last section of the chapter, two models are developed to test the impact. Models 2 and 3 in the last sections of the chapter test the impact of project delivery methods before and after the enactment of the Clinger-Cohen Act of 1996. The Clinger-Cohen Act is considered a legislative impediment. Similarly, Models 4 and 5 in these next two sections test the impact of project delivery methods for federal projects before and after state legislative impediments are eliminated or reduced in the state in which the project is located. Statistically significant project characteristics or variables are drawn from the data in each of these two predictive models, Model 4 and Model 5, and are explored in its context to the hypothesis.

Defining state legislative impediments is multifaceted. In the context of federal legislative impediments, state legislative impediments suggest that legislation exists at the state level that fully restricts qualifications-based selection for builders. This does not suggest that the absence of such legislation which acknowledges qualifications-based selection for builders allows its use. Rather, as explained in Chapter 2, there are levels of restrictions that state public agencies must follow in the use of alternative project delivery methods that allow builder selection based on best value. Following the lead of the federal government, many state governments enable the two-phase selection process for builders through the use of the design-build as an alternative method of project delivery; but, in most cases, it is highly restrictive. Many states only allow design-build on a case-by-case basis or for special circumstances. As explained earlier in Chapter 2, in Louisiana, for example, legislation passed in 2006 authorizes state and local entities to use design-build temporarily to rebuild in storm-ravaged parishes through 2008. In North Carolina, a State Construction Agency reviews and tracks the design-build project proposals, and then the project is taken to a State Building Commission for approval. Likewise, other states that authorize design-build on a case-by-case basis may only allow it for certain types of projects, such as transportation projects or for water treatment facilities.

In the context of the development of Model 4 and Model 5, this research defines a state legislative impediment as lack of authorization of design-build at the time Congress authorizes funding for the GSA federal project. Model 4 examines the impact of state legislative impediments before design-build legislation is authorized in the state the project is being built. Model 5 examines the impact of state legislative impediments after any, even highly-restrictive, design-build legislation is authorized in the state the project is being built.

5.6.1 Before Design-Build Legislation

This section begins with testing and analyzing whether state legislative impediments affect the benefits that exist when alternative project delivery methods are allowed to be used for a fully federally-funded construction project. The theory is that other bodies of government exist that may have heightened restrictions, and legislative impediments in those bodies of government may affect the outcome of a design and construction project. The model developed for this section, Model 4, tests whether project characteristics (as multiple independent variables) have a relationship to the selection of a project delivery method (as the dependent variable) for a federal project with state legislative impediments in place. To generate this second predictive model, the researcher refers again to examples from Garson (n.d.) to assist in explaining the results of the regression techniques. This is the first of two models (Model 4 and Model 5) that are generated to test the hypothesis in relation to lower bodies of government, in this case, the state level. As in the other predictive models, Table 5.42 and Table 5.43 provide general information about the second predictive model. It shows when Model 4 is created (on May 9, 2008, at 4:22:01 p.m.), how many projects are in the dataset in model (136), and how the model treats missing variables in the dataset.

Table 5.42 Model 4 Notes

Output Created		09-May-2008 16:22:01
Comments		
Input	Active Dataset	DataSet1
	N of Rows in Working Data File	136
	Definition of Missing	User-defined missing values are treated as missing.
Missing Value Handling	Cases Used	For each variable used, missing values are replaced with the variable mean.
Syntax	REGRESSION /MISSING MEANSUB /STATISTICS COEFF OUTS CI R ANOVA COLLIN TOL CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT DMOrig /METHOD=ENTER Region ProjectTypeOriginal ProgramOriginal FederalLaws1996 StateLaws HousePoliticalParty GrossArea UsableSpace CongressAuthorityFY PlanningTime DesignTime ConstructionTime AuthoritythroughConstruction PlanningthroughConstruction DesignandConstTime ETPCSite ETPCDesign ETPCConstruction ETPCTotal MoniesETPCTminusCongAuth MoniesETPCTminusConfAppro MoniesETPCTminusCentOffAllow /PARTIALPLOT ALL /SCATTERPLOT=(*ZPRED ,*SDRESID) (DMOrig ,*ZPRED) /RESIDUALS HIST(ZRESID) NORM(ZRESID).	
Resources	Processor Time	
	Elapsed Time	00:00:07.030
	Memory Required	21180 bytes
	Additional Memory Required for Residual Plots	19400 bytes

The original dataset includes 496 projects, with 136 of those projects located in states restricting design-build for project delivery at the time Congress authorized funding for the project. Missing values in the dataset use a label of 999, and all such values are replaced with the variable means. Table 5.43 lists all independent variables and the dependent variable.

Table 5.43 Model 4 Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
4	Estimated Total Prospectus Cost minus Central Office Allowance, Project Type, Planning Phase Duration, Estimated Total Prospectus Cost Site, Congress Authorization to Construction Finish Phase Duration, Design Start to Construction Finish Duration, Political Party, Program Area, Estimated Total Prospectus Cost, Planning Start to Construction Finish Duration, Region, Congress Authority Year, Design Phase Duration, Federal Legislation, Gross Area, Estimated Total Prospectus Cost minus Congress Authorization, Usable Space, Construction Start to Construction Finish, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost minus Conference Appropriation[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Project Delivery Method

The dependent variable is the project delivery method and the independent variables include the following: (1) Region; (2) Project Type; (3) Program Area; (4) Political Party; (5) Gross Area; (6) Usable Space; (7) Estimated Total Prospectus Cost minus Congress Authorization; (8) Estimated Total Prospectus Cost minus Conference Appropriation; (9) Estimated Total Prospectus Cost minus Central Office Allowance; (10) Estimated Total Prospectus Cost; (11) Estimated Total Prospectus Cost Site; (12) Estimated Total Prospectus Cost Design; (13) Estimated Total Prospectus Cost

Construction; (14) Congress Authorization Year; (15) Planning Phase Duration; (16) Design Phase Duration; (17) Construction Phase Duration; (18) Congress Authorization to Construction Finish Duration; (19) Planning Start to Construction Finish Duration; (20) Design Start to Construction Finish Duration; and (21) Federal Legislation. These variables have been analyzed in the descriptive statistics and cross-tabulations in Chapter 4, and in the correlation analysis earlier in Chapter 5. Table 5.44 is the summary of Model 4. The R-squared is the percent of the dependent explained by the independents.

Table 5.44 Model 4 Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
4	.589[a]	.347	.227	1.029	.347	2.890	21	114	.000

a. Predictors: (Constant), Estimated Total Prospectus Cost minus Central Office Allowance, Project Type, Planning Phase Duration, Estimated Total Prospectus Cost Site, Congress Authorization to Construction Finish Phase Duration, Design Start to Construction Finish Duration, Political Party, Program Area, Estimated Total Prospectus Cost, Planning Start to Construction Finish Duration, Region, Congress Authority Year, Design Phase Duration, Federal Legislation, Gross Area, Estimated Total Prospectus Cost minus Congress Authorization, Usable Space, Construction Start to Construction Finish, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost minus Conference Appropriation

b. Dependent Variable: Project Delivery Method

In the case of this model, the independents explain 34.7 percent of the variance, R Square, and Model 4 holds its strength in its statistical significance, which is explained next. Explaining 34.7 percent of the variance suggests that Model 4 is somewhat misspecified. Other variables, not suggested by the researcher, explain more than 60 percent (65.3 percent) of the variance. The Adjusted R-Squared is a standard, arbitrary downward adjustment to account for the possibility that, with many independents, some of the variance may be due to chance. The more independents in the model suggest the more the adjustment penalty. Even though there are many independents in this model, the penalty is considered minor, with 0.227 or a 22.7 percent likelihood that these results are received by chance (the penalty.)

Table 5.45, the ANOVA table, tests the overall significance of Model 4 and of the regression equation created for Model 4. For this model, the F value is considered highly statistically significant at the 0.01 level (with 0.000); even though the R Square is relatively not significant, explaining 34.7 percent of the overall model, the model is credible. Model 4 then suggests that there is less than a one percent likelihood that the predictions in this model are due to chance.

Table 5.45 Model 4 Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
4	Regression	64.315	21	3.063	2.890	.000[a]
	Residual	120.795	114	1.060		
	Total	185.110	135			

a. Predictors: (Constant), Estimated Total Prospectus Cost minus Central Office Allowance, Project Type, Planning Phase Duration, Estimated Total Prospectus Cost Site, Congress Authorization to Construction Finish Phase Duration, Design Start to Construction Finish Duration, Political Party, Program Area, Estimated Total Prospectus Cost, Planning Start to Construction Finish Duration, Region, Congress Authority Year, Design Phase Duration, Federal Legislation, Gross Area, Estimated Total Prospectus Cost minus Congress Authorization, Usable Space, Construction Start to Construction Finish, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost minus Conference Appropriation

b. Dependent Variable: Project Delivery Method

Table 5.46 provides the b and beta coefficients and other coefficients of the model. The b coefficients and the constant are used to create the prediction (regression) equation.

Table 5.46 Model 4 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
4	(Constant)	-199.844	67.758		-2.949	.004	-334.073	-65.615		
	Region	-.023	.030	-.069	-.749	.455	-.082	.037	.680	1.472
	Project Type	.209	.169	.116	1.240	.217	-.125	.544	.651	1.537
	Program Area	-.410	.197	-.190	-2.078	.040	-.801	-.019	.687	1.455
	Federal Legislation	.000	.001	.046	.427	.670	-.002	.003	.499	2.004
	Political Party	.000	.001	.045	.542	.589	-.001	.002	.825	1.212
	Gross Area	2.169E-7	.000	.148	1.034	.303	.000	.000	.279	3.582
	Usable Space	1.757E-7	.000	.055	.373	.710	.000	.000	.262	3.811
	Congress Authority Year	.101	.034	.311	2.969	.004	.034	.168	.520	1.923
	Planning Phase Duration	.000	.000	-.184	-1.428	.156	-.001	.000	.344	2.906
	Design Phase Duration	8.692E-5	.000	.060	.459	.647	.000	.000	.336	2.972
	Construction Phase Duration	.000	.000	-.191	-1.308	.193	.000	.000	.270	3.710
	Congress Authorization to Construction Finish Duration	.000	.000	.051	.584	.560	.000	.000	.749	1.335
	Planning Start to Construction Finish Duration	.000	.000	.244	2.863	.005	.000	.000	.789	1.267
	Design Start to Construction Finish Duration	-1.215E-5	.000	-.035	-.424	.672	.000	.000	.845	1.183
	Estimated Total Prospectus Cost Site	-2.548E-8	.000	-.130	-.692	.490	.000	.000	.162	6.188
	Estimated Total Prospectus Cost Design	1.884E-8	.000	.172	.742	.459	.000	.000	.107	9.366
	Estimated Total Prospectus Cost Construction	-1.836E-9	.000	-.142	-.390	.697	.000	.000	.043	23.217
	Estimated Total Prospectus Cost	6.926E-10	.000	.062	.166	.869	.000	.000	.041	24.339
	Estimated Total Prospectus Cost minus Congress Authorization	-9.274E-9	.000	-.314	-2.549	.012	.000	.000	.378	2.644
	Estimated Total Prospectus Cost minus Conference Appropriation	3.974E-9	.000	.175	.476	.635	.000	.000	.042	23.618
	Estimated Total Prospectus Cost minus Central Office Allowance	1.351E-9	.000	.062	.177	.860	.000	.000	.046	21.706

a. Dependent Variable: Project Delivery Method
b. Shaded rows indicate statistically significant variables at the 0.05 level and below.

For this fourth predictive model, Project Delivery Method (selected before state design-build legislation) = -0.069*(Region) + 0.116*(Project Type) + 0.197 *(Program Area) + 0.045* (Political Party) + 0.148*(Gross Area) + 0.055*(Usable Space) + -0.314* (Estimated Total Prospectus Cost minus Congress Authorization) + 0.175*(Estimated Total Prospectus Cost minus Conference Appropriation) + 0.062*(Estimated Total Prospectus Cost minus Central Office Allowance) + 0.062*(Estimated Total Prospectus Cost) + -0.130*(Estimated Total Prospectus Cost Site) + 0.172*(Estimated Total Prospectus Cost Design) + -0.142*(Estimated Total Prospectus Cost Construction) + 0.311*(Congress Authorization Year) + -0.184*(Planning Phase Duration) + 0.060*(Design Phase Duration) + -0.191*(Construction Phase Duration) + 0.051*(Congress Authorization to Construction Finish Duration) + 0.244*(Planning Start to Construction Finish Duration) + -0.035*(Design Start to Construction Finish Duration) + 0.046*(Federal Legislation) + -199.844. The beta coefficients are the standardized regression coefficients and their relative absolute magnitudes reflect their relative importance in predicting the project delivery method. Betas are highly influenced by misspecification of the model; in this case, 65.3 percent of the model is not explained, and so adding or subtracting variables in the equation will affect the size of the betas.

The t-test examines the significance of each b coefficient. It is possible to have a regression model which is significant overall by the F test, and several of the coefficients also are significant. Model 4 is considered highly statistically significant (with a less than one percent likelihood that the results of the model are due to chance, or 0.000), but only three of the variables are also considered of high significance, at a level of 0.05. Program Area is significant at the 0.05 (0.040) level and suggests that projects using alternative project delivery methods, specifically design-build, are more often used in federal buildings and border stations. There also seems to be a relationship with the year Congress authorizes funding for the projects in this dataset, and the duration of time from the beginning of planning to the end of construction. These results are similar to findings in Model 3. Conversely, there are several variables in the model that are not highly significant: Estimated Total Prospectus Cost at 0.869, and Estimated Total Prospectus Cost minus Central Office Allowance at 0.860. Because this model is considered highly significant, future research may suggest that the model be re-run, eliminating variables with the least significance to ultimately obtain a model with overall high significance and with all its variables of high significance. The tolerance for a variable is 1 - R-squared for the regression of that variable on all other independents, ignoring the dependents. When tolerance is close to zero, there is a high multicollinearity of that variable with other independents and the b and beta coefficients will be unstable. Many of the variables in Model 4 are not close to zero and so the betas do not suggest instability. Also, Model 4 suggests that only a few variables have high multicollinearity due to their variance inflation factor (VIF): Estimated Total Prospectus Cost Construction; Estimated Total Prospectus Cost; Estimated Total Prospectus Cost minus Central Office Allowance; and Estimated Total Prospectus Cost minus Conference Appropriation. These factors suggest that this model be re-run for future research. Table 5.47 contains summary data regarding residuals, or the difference between predicted and actual values.

Table 5.47 Model 4 Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.75	3.64	.83	.690	136
Std. Predicted Value	-2.291	4.075	.000	1.000	136
Standard Error of Predicted Value	.162	1.017	.371	.184	136
Adjusted Predicted Value	-5.51	3.97	.78	.923	136
Residual	-2.175	2.687	.000	.946	136
Std. Residual	-2.113	2.610	.000	.919	136
Stud. Residual	-2.315	2.722	.007	.990	136
Deleted Residual	-2.612	5.511	.046	1.207	136
Stud. Deleted Residual	-2.361	2.803	.011	.998	136
Mahal. Distance	2.337	130.694	20.846	26.084	136
Cook's Distance	.000	1.271	.018	.109	136
Centered Leverage Value	.017	.968	.154	.193	136

a. Dependent Variable: Project Delivery Method

The minimum standardized residual is -2.113 and at least one prediction is between two and three standard deviations below the mean residual. The deleted residual rows have to do with coefficients when the model is recomputed over and over, dropping one case from the analysis at a time. This is an area suggested for future research on this Model given its high statistically significant results. The bottom three rows are measures of the influence and Cook's distance appears that there may be problem cases since the maximum leverage is 0.968. In future research, if Model 4 is re-run, then Cook's distance should be, in theory, lessened and thus the results of this model may have more applicability in testing the hypothesis. To analyze the data in the model in more detail, charts are developed. The zresid histogram in Figure 5.76 provides a visual way of assessing if the assumption of normally distributed residual error is met. In Model 4, the small skewness to the left should not affect substantive conclusions. This reaffirms the previous conclusions in this model.

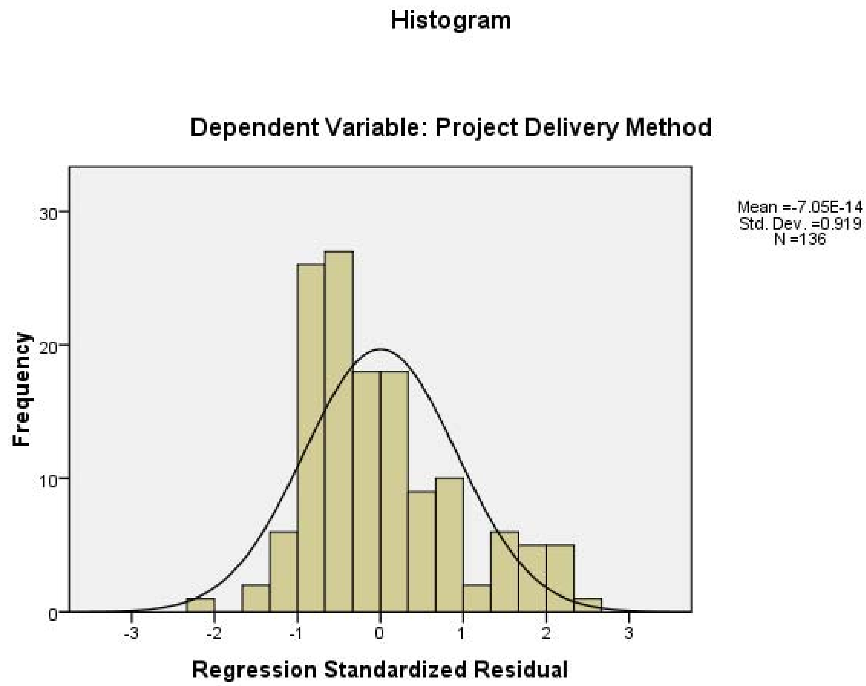


Figure 5.76 Model 4 Histogram

The normal probability plot (zresid normal p-p plot) in Figure 5.77, under perfect normality, will be a 45-degree line. In Model 4, the skewness is imperfect as in Models 1-3 and is still valid for exploratory reasons.

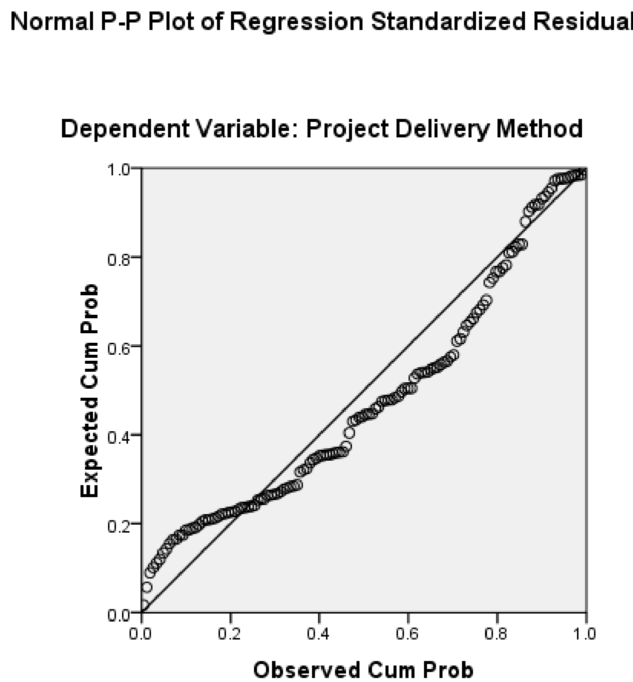


Figure 5.77 Model 4 Normal P-P Plot of Regression Standardized Residual

In the plot of standardized predicted values versus observed values, if 100 percent of the variance is explained in a linear relationship, the points in the scatterplot in Figure 5.78 will form a straight line. The lower the percent of variance is explained, the more the points will form a cloud with no trend. The more the points are dispersed around the trend, the higher the standard error of estimate and the poorer the model. The plot in Figure 5.78 reflects that the model explains a small percentage of the variance, 34.7 percent, as discussed earlier.

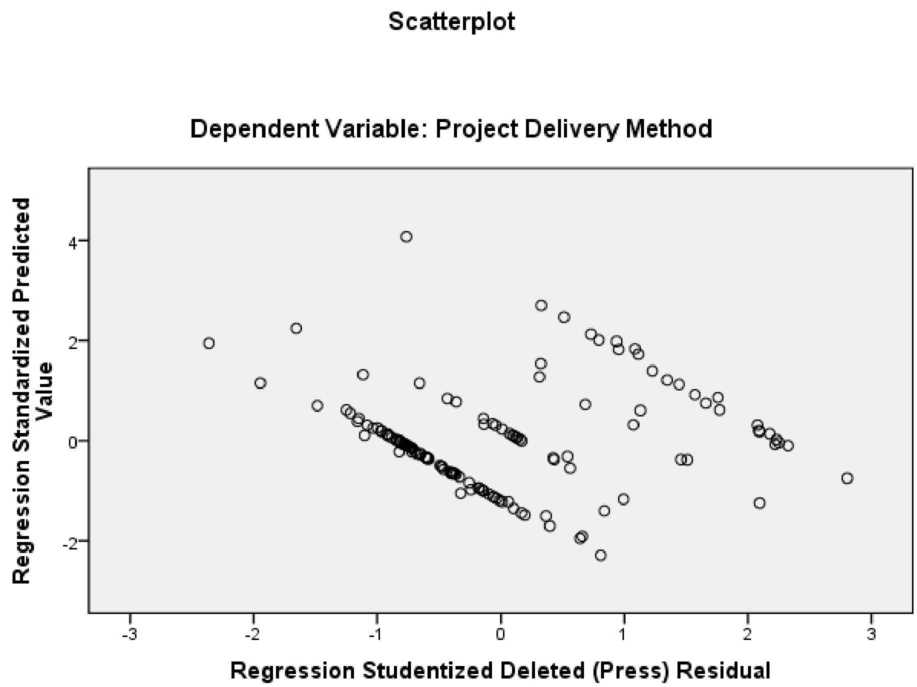


Figure 5.78 Model 4 Scatterplot of Model Variance

Also, as mentioned in earlier models, partial regression plots show the plot of one independent on the dependent variable (project delivery method). The points will form a straight line if the percent of the variance is 100 percent, and will form a cloud the lower the percent of variance is explained. Figures 5.79 to 5.99 verify high variances between the Project Delivery Method (dependent) and several of the independents. The low variances are shown as cloud-like formations on all of the partial scatterplots.

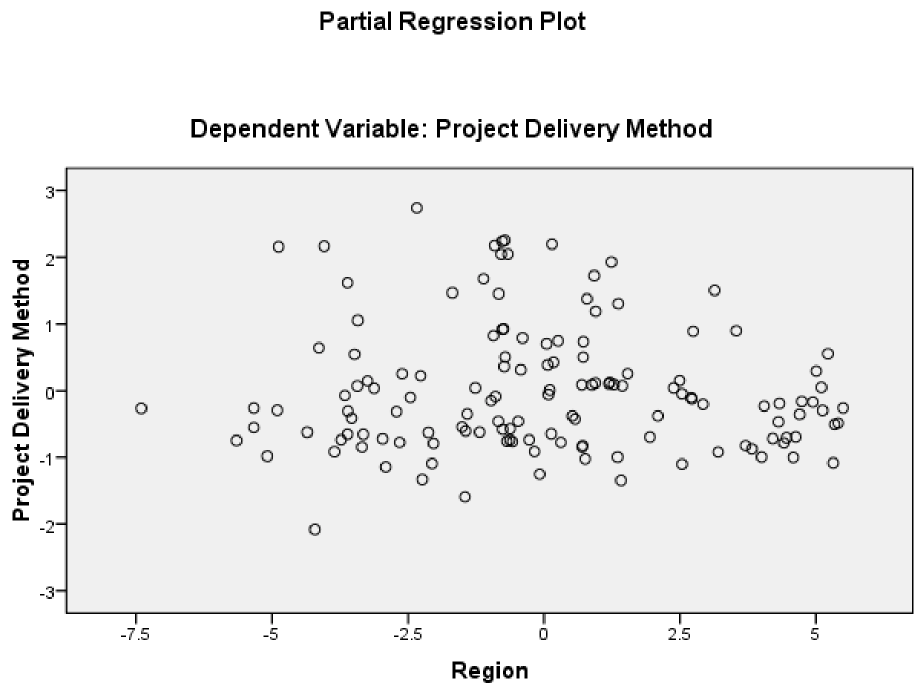


Figure 5.79 Model 4 Partial Scatterplot of Region as Independent

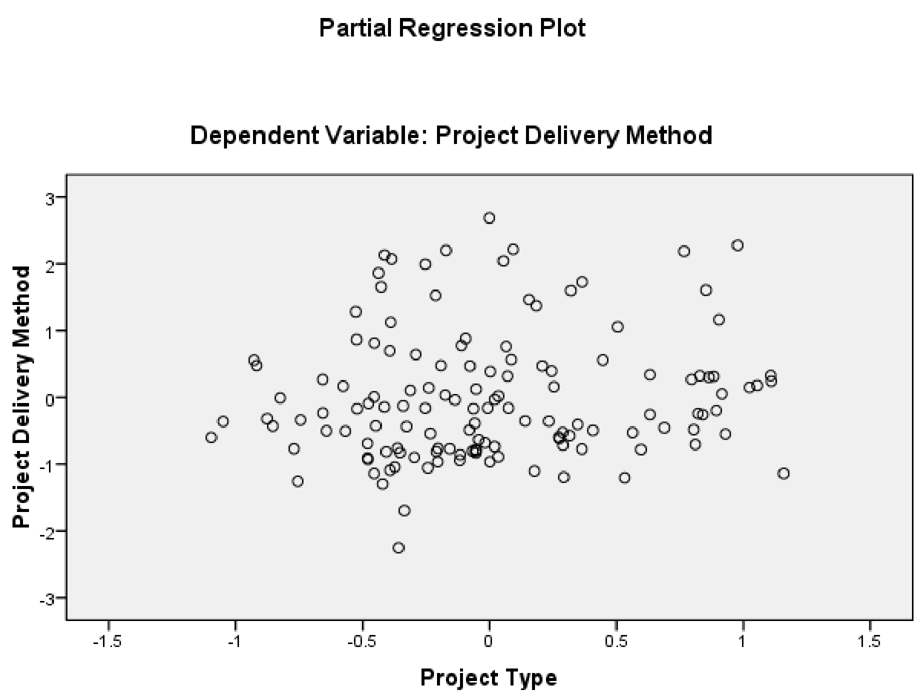


Figure 5.80 Model 4 Partial Scatterplot of Project Type as Independent

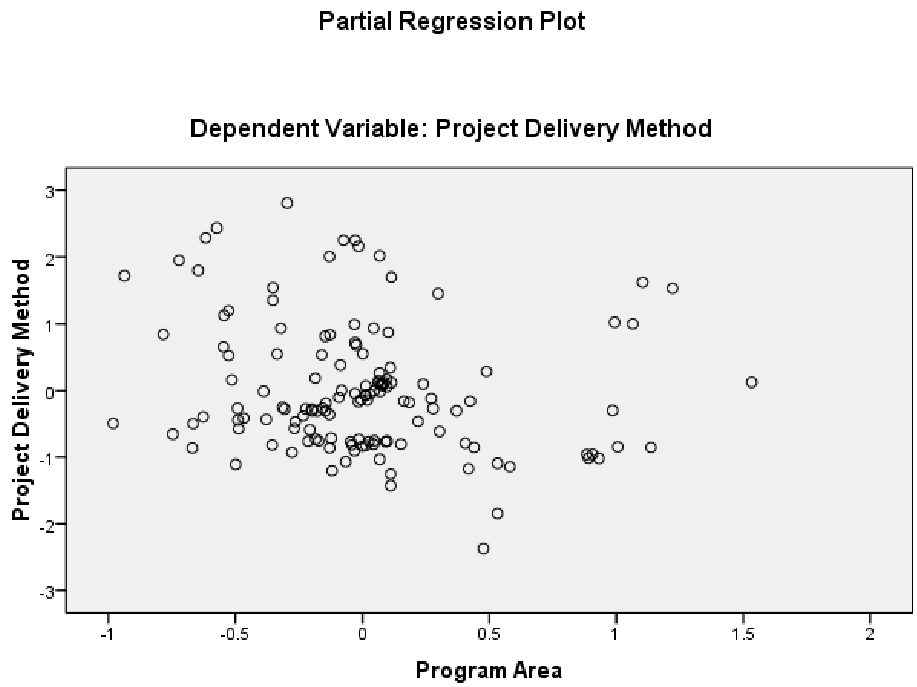


Figure 5.81 Model 4 Partial Scatterplot of Program Area as Independent

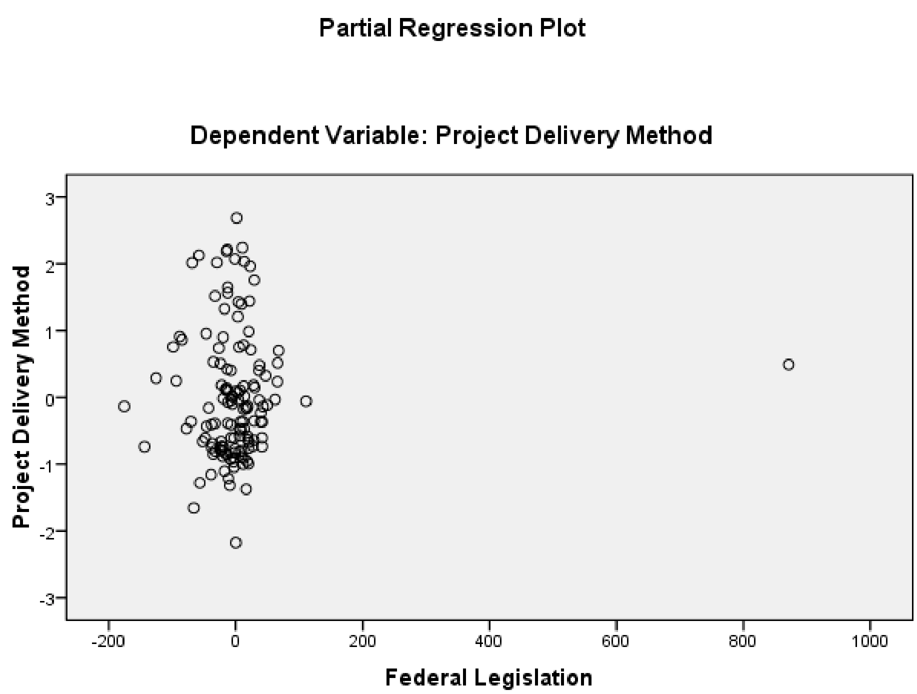


Figure 5.82 Model 4 Partial Scatterplot of Federal Legislation as Independent

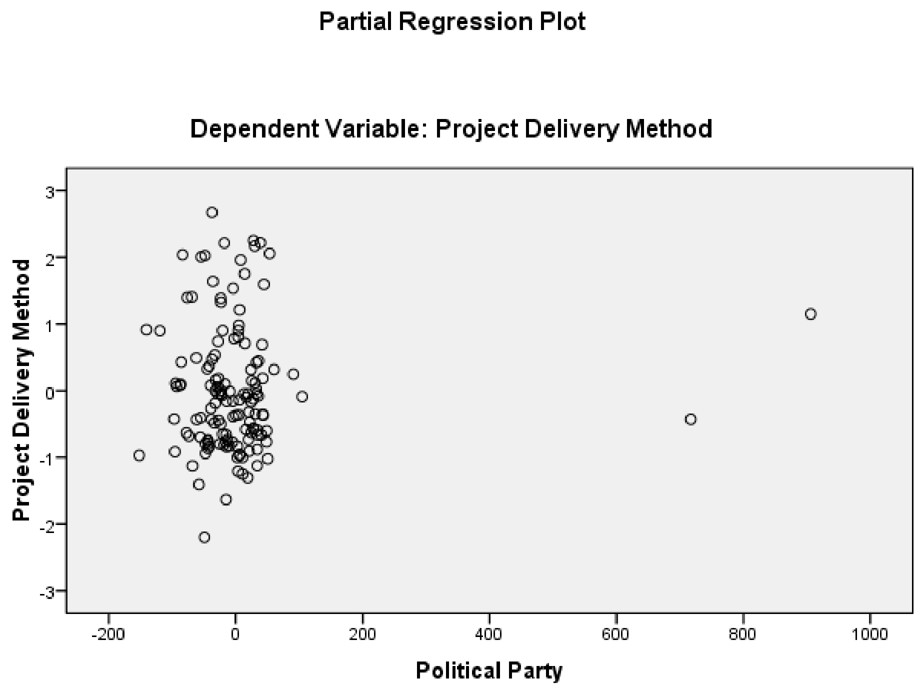


Figure 5.83 Model 4 Partial Scatterplot of Political Party as Independent

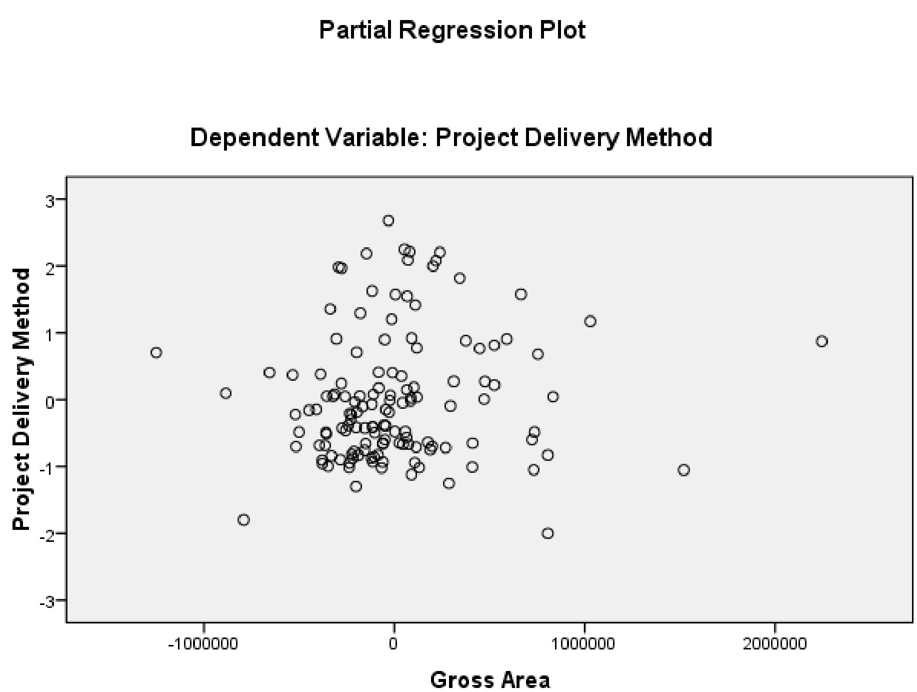


Figure 5.84 Model 4 Partial Scatterplot of Gross Area as Independent

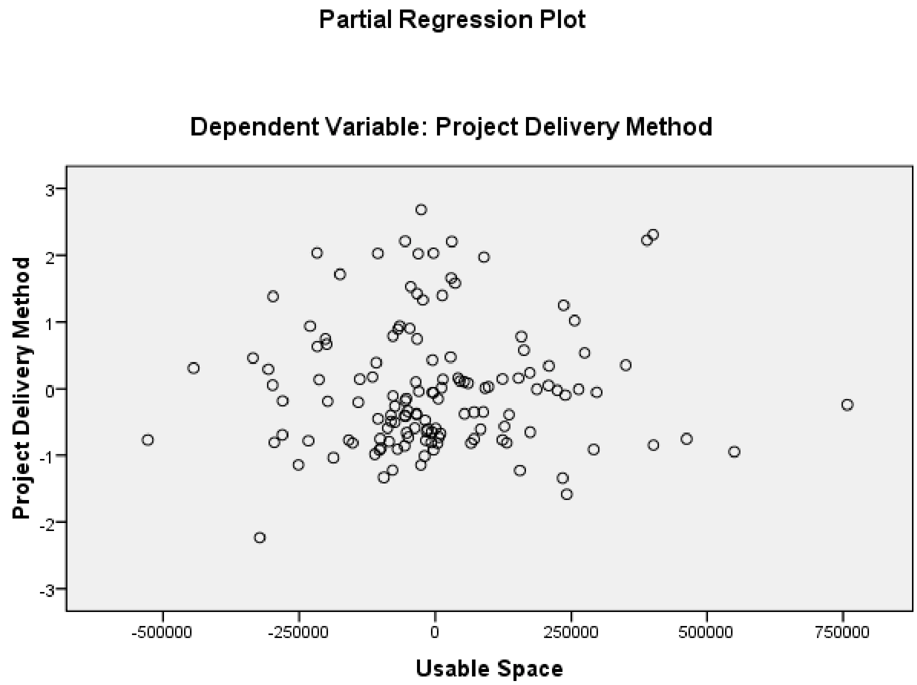


Figure 5.85 Model 4 Partial Scatterplot of Usable Space as Independent

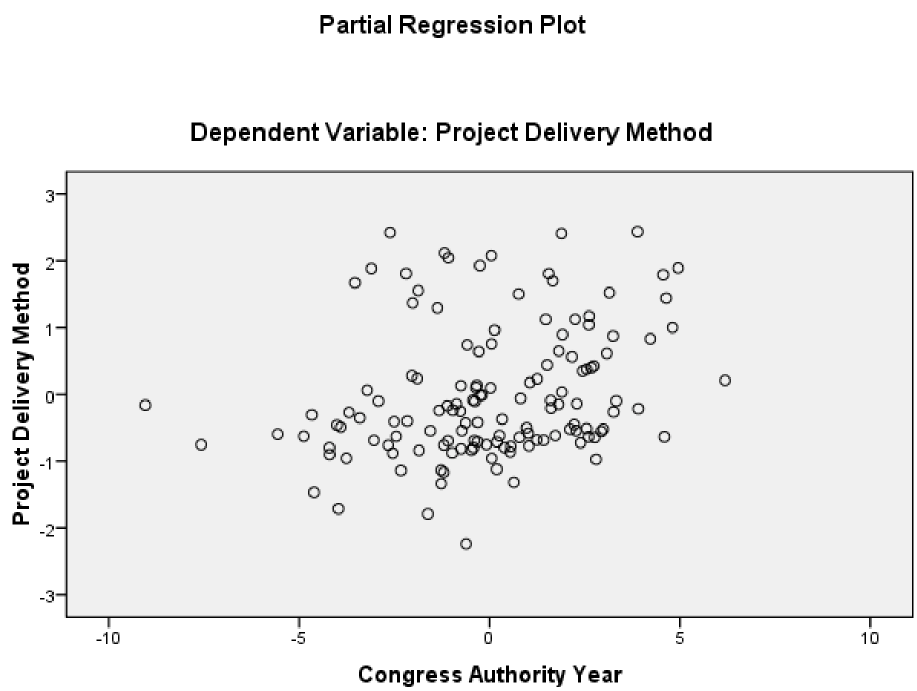


Figure 5.86 Model 4 Partial Scatterplot of Congress Authorization Year as Independent

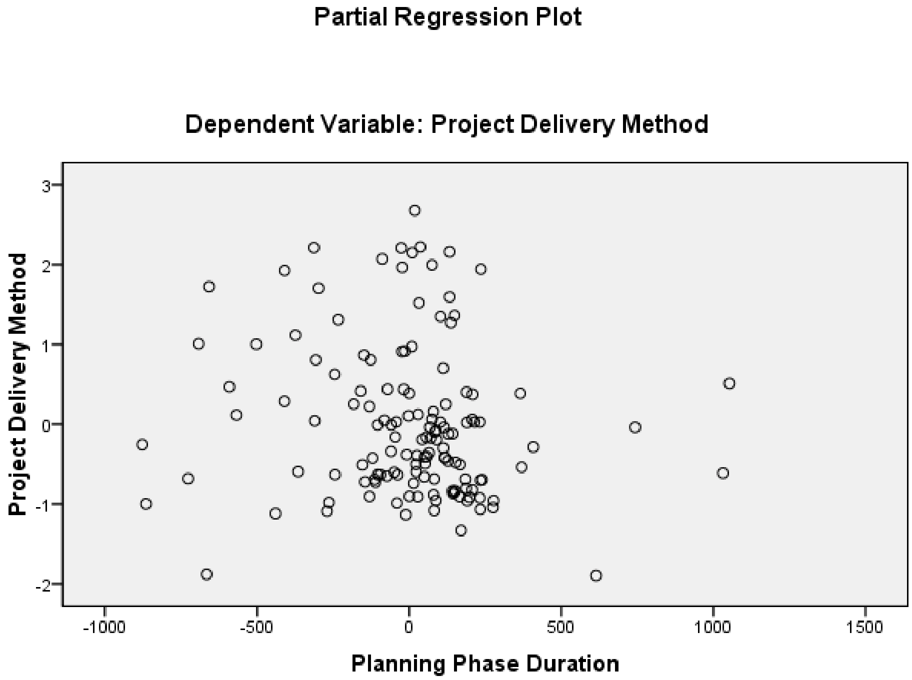


Figure 5.87 Model 4 Partial Scatterplot of Planning Phase Duration as Independent

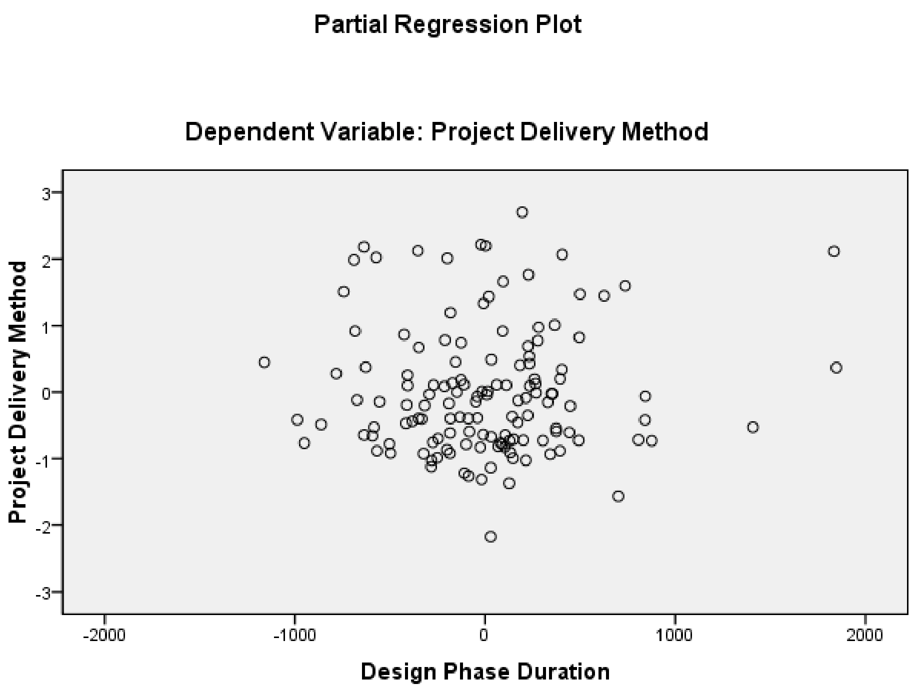


Figure 5.88 Model 4 Partial Scatterplot of Design Phase Duration as Independent

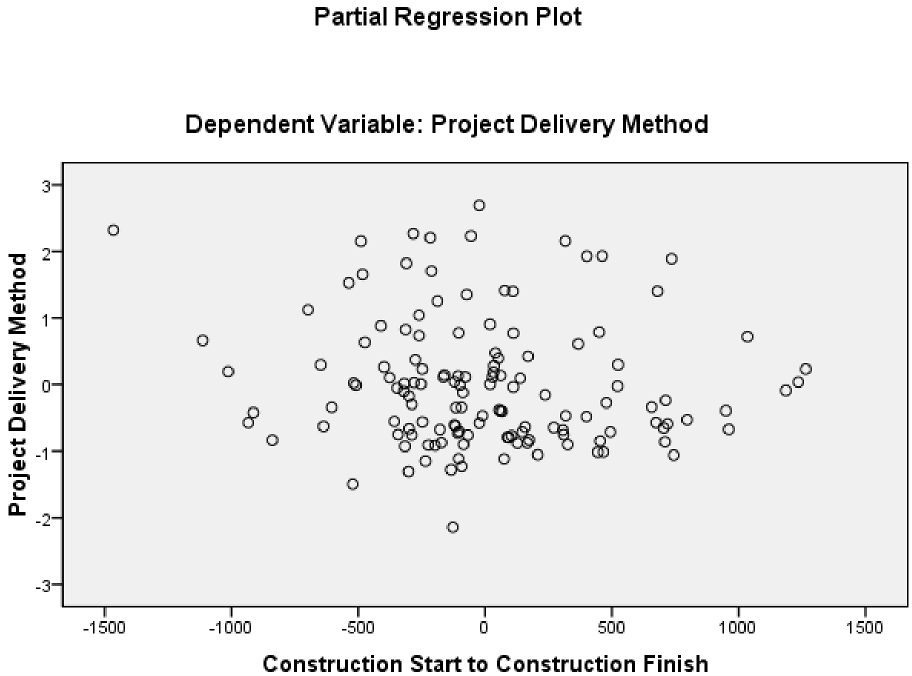


Figure 5.89 Model 4 Partial Scatterplot of Construction Phase Duration as Independent

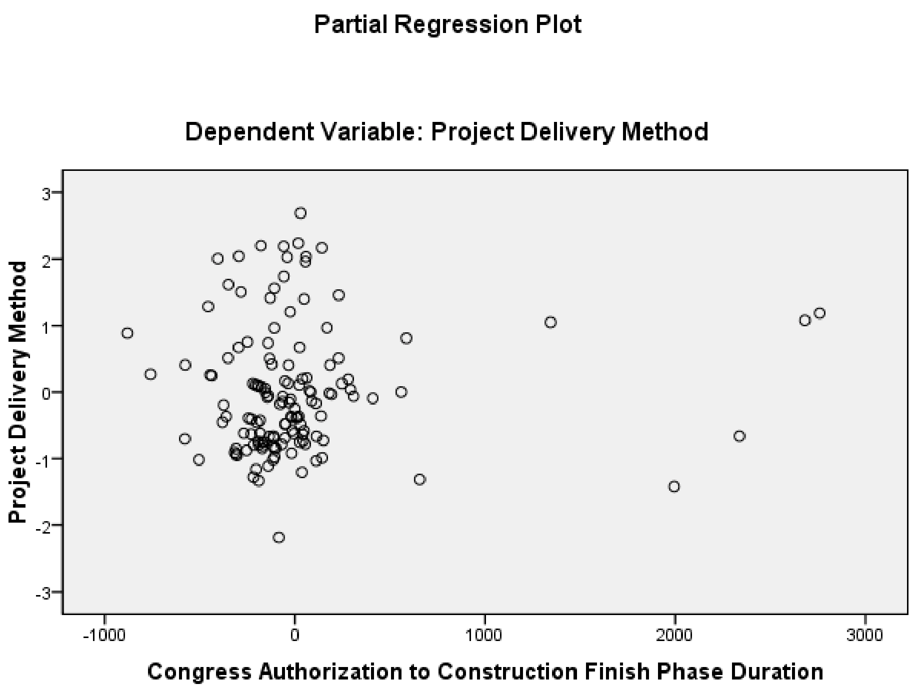


Figure 5.90 Model 4 Partial Scatterplot of Congress Authorization to Construction Finish Duration as Independent

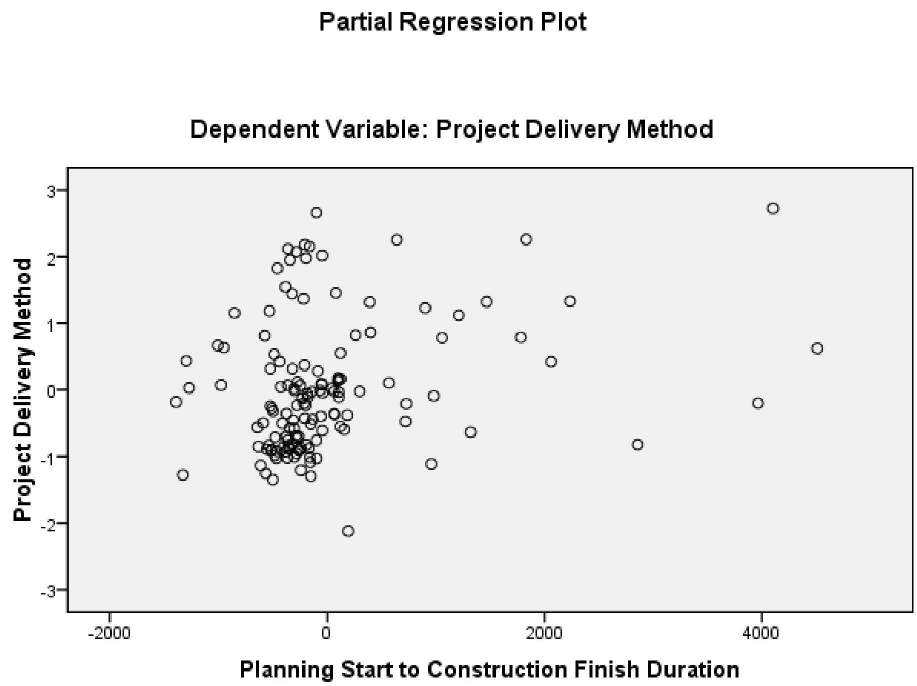


Figure 5.91 Model 4 Partial Scatterplot of Planning Start to Construction Finish Duration as Independent

Figure 5.92 Model 4 Partial Scatterplot of Design Start to Construction Finish Duration as Independent

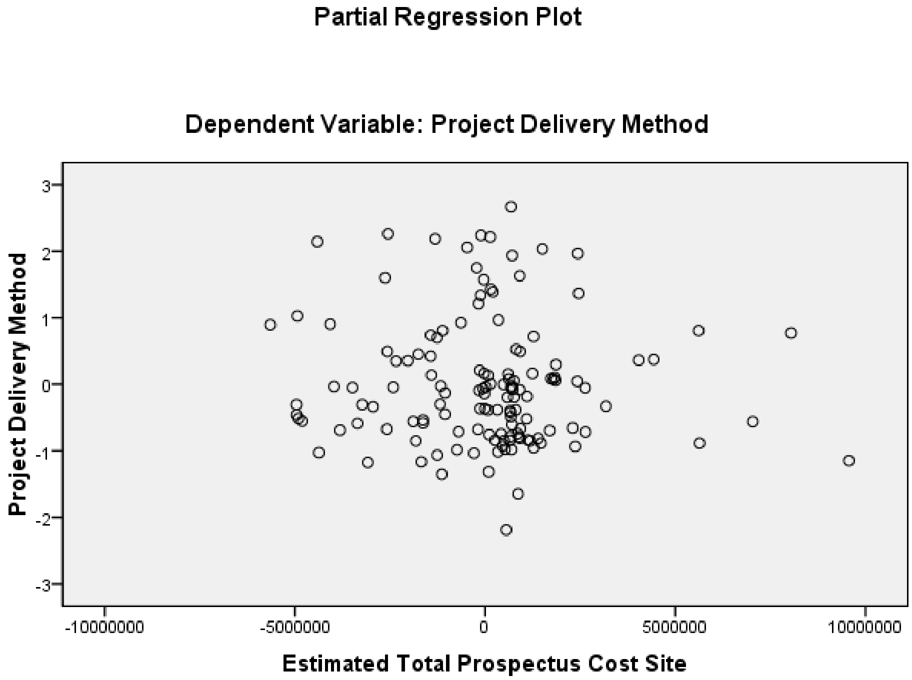


Figure 5.93 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost Site as Independent

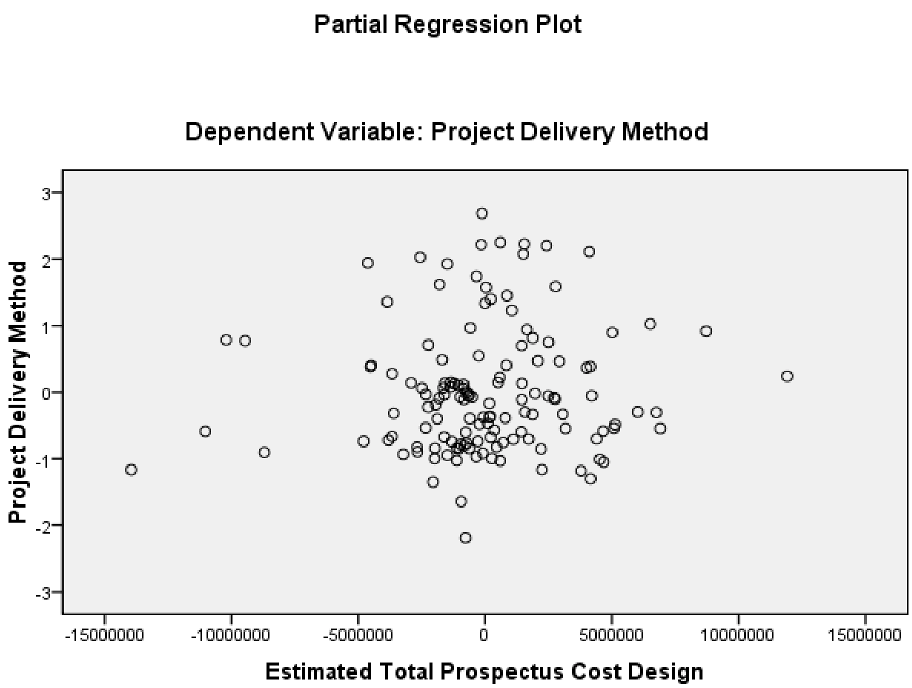


Figure 5.94 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost Design as Independent

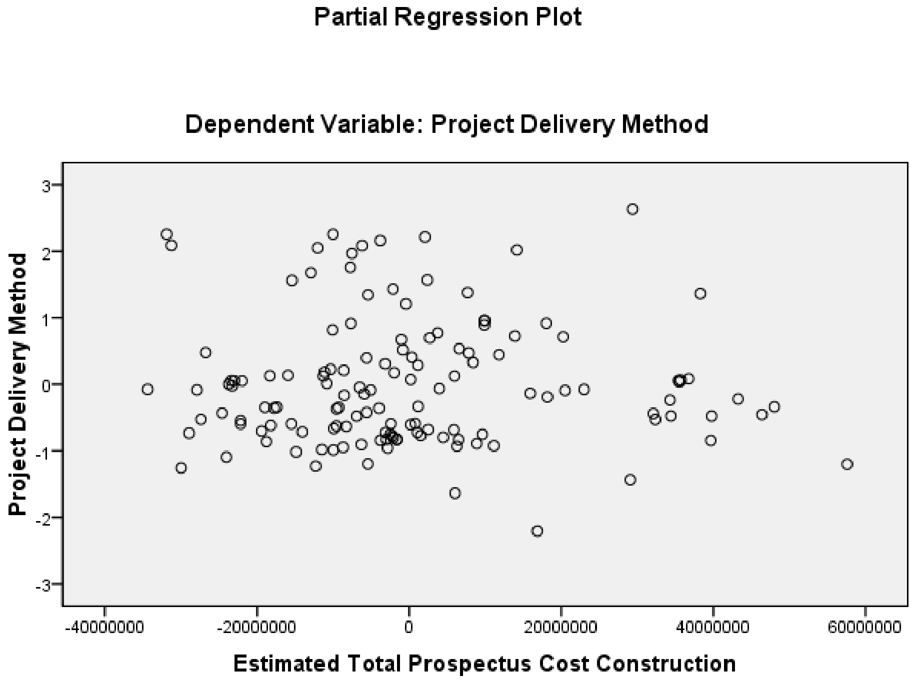


Figure 5.95 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost Construction as Independent

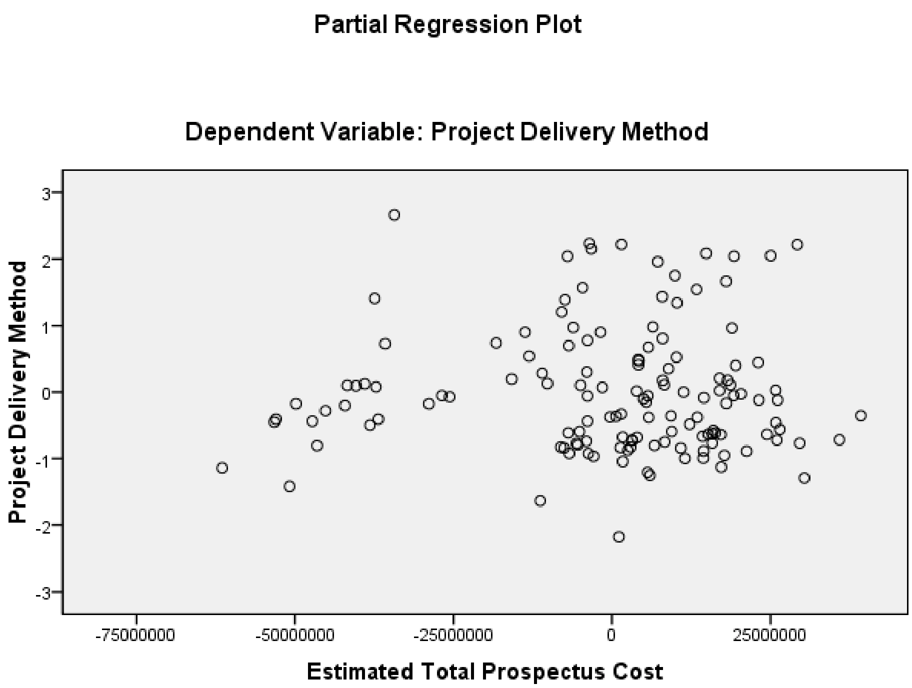


Figure 5.96 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost as Independent

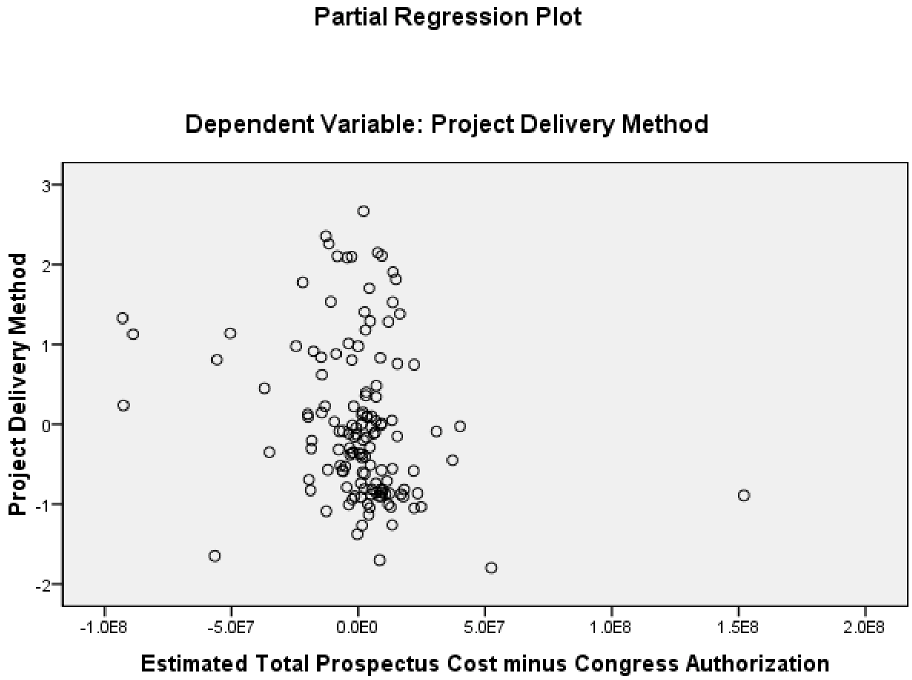


Figure 5.97 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost minus Congress Authorization as Independent

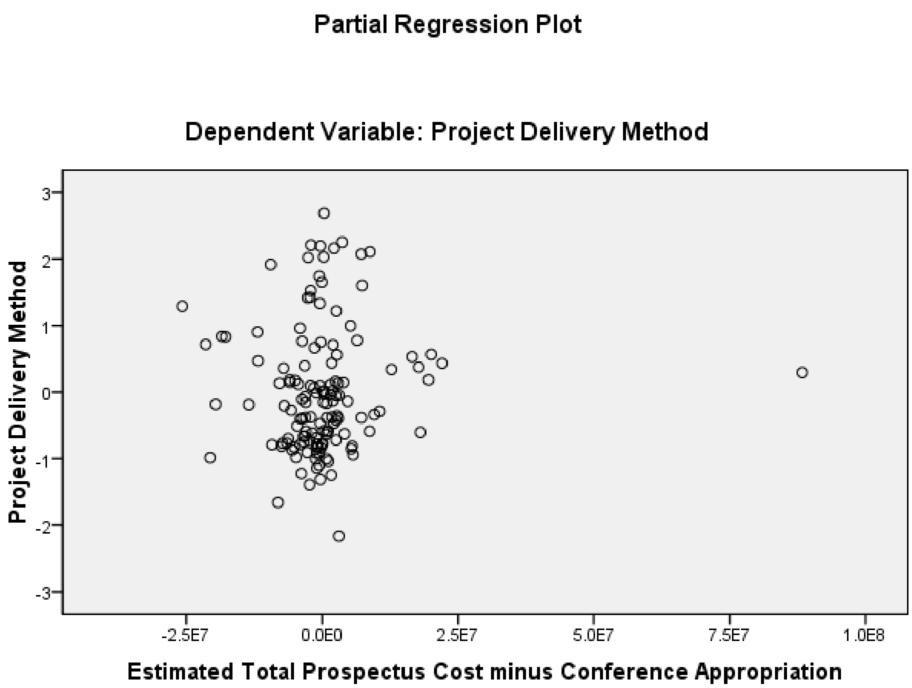


Figure 5.98 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost minus Conference Appropriation as Independent

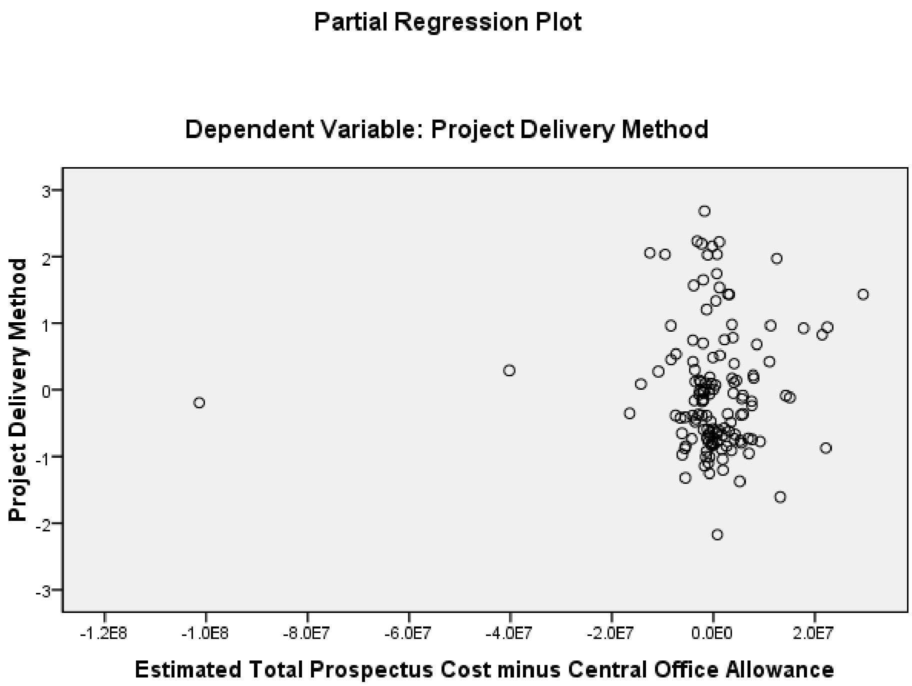


Figure 5.99 Model 4 Partial Scatterplot of Estimated Total Prospectus Cost minus Central Office Allowance as Independent

5.6.2 After Design-Build Legislation

The last section, 5.6.1, develops and presents a fourth predictive model testing and analyzing the impact of state legislative impediments in place. As presented, Model 4 is considered statistically significant at the 0.01 level (at 0.000), and several of its betas are statistically significant. Since the hypothesis examines whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized, a fifth and final predictive model is generated to examine the benefits of using an alternative project delivery method when state legislative impediments are eliminated. Eliminating state legislative impediments is defined as allowing qualifications-based selection of builders and also provides a legislative process for selecting designers and builders under the design-build form of project delivery.

To generate this fifth predictive model, the research refers to examples from Garson (n.d.) to assist in explaining the results of the regression techniques. This fifth predictive model is the second of two models generated to test whether legislative impediments impact project delivery method selection in the presence of state legislative impediments. This model is tested under the theory that political considerations from other bodies of government may affect project delivery method selection. Model 5 tests whether project characteristics (as multiple independent variables) have a relationship to the selection of a project delivery method (as the dependent variable) after design-build is allowed on a state level. All independent variables are entered in a single step and project delivery method is shown as the dependent variable. Table 5.48 and Table 5.49 provide general information about the fifth predictive model. It shows when Model 5 is created (on May 9, 2008, at 4:32:57 p.m.), how many projects are in the dataset in model

(167), and how the model treats missing variables in the dataset. The original dataset includes 496 projects, with 167 of those projects with funding authorized by Congress after design-build legislation is allowed in the states the projects are located. Model 4 includes 136 projects with funding authorized by Congress before design-build legislation is allowed in the states the projects are located, and the remaining 303 projects in the database did not have information about when design-build is authorized in the state which it is located. Therefore, 303 projects in the database are not analyzed in Models 4 and 5. Model 5 tests the characteristics of the 167 projects in relation to alternative project delivery selection. Also, all missing values of 999, as in the other four predictive models, are replaced with the variable means.

Table 5.48 Model 5 Notes

Output Created		09-May-2008 16:32:57
Input	Active Dataset	DataSet1
	N of Rows in Working Data File	167
	Definition of Missing	User-defined missing values are treated as missing.
Missing Value Handling	Cases Used	For each variable used, missing values are replaced with the variable mean.
Syntax	REGRESSION /MISSING MEANSUB /STATISTICS COEFF OUTS CI COLLIN TOL CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT DMOrig /METHOD=ENTER ProjectTypeOriginal Region ProgramOriginal HousePoliticalParty GrossArea UsableSpace CongressAuthorityFY PlanningTime DesignTime ConstructionTime AuthoritythroughConstruction PlanningthroughConstruction DesignandConstTime ETPCSite ETPCDesign ETPCConstruction ETPCTotal MoniesETPCTminusCongAuth MoniesETPCTminusConfAppro MoniesETPCTminusCentOffAllow /PARTIALPLOT ALL /SCATTERPLOT=(*ZPRED ,*SDRESID) (DMOrig ,*ZPRED) /RESIDUALS HIST(ZRESID) NORM(ZRESID).	
Resources	Processor Time	
	Elapsed Time	00:00:06.730
	Memory Required	18188 bytes
	Additional Memory Required for Residual Plots	16784 bytes

Table 5.49 lists the dependent and independent variables in Model 5.

Table 5.49 Model 5 Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
5	Estimated Total Prospectus Cost minus Central Office Allowance, Design Start to Construction Finish Duration, Project Type, Region, Program Area, Planning Phase Duration, Gross Area, Estimated Total Prospectus Cost Site, Usable Space, Planning Start to Construction Finish Duration, Design Phase Duration, Congress Authority Year, Political Party, Construction Phase Duration, Congress Authorization to Construction Finish Duration, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Congress Authorization, Estimated Total Prospectus Cost minus Conference Appropriation[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Project Delivery Method

The dependent variable in Table 5.49 is the project delivery method and the independent variables include the following: (1) Region; (2) Project Type; (3) Program Area; (4) Political Party; (5) Gross Area; (6) Usable Space; (7) Estimated Total Prospectus Cost minus Congress Authorization; (8) Estimated Total Prospectus Cost minus Conference Appropriation; (9) Estimated Total Prospectus Cost minus Central Office Allowance; (10) Estimated Total Prospectus Cost; (11) Estimated Total Prospectus Cost Site; (12) Estimated Total Prospectus Cost Design; (13) Estimated Total Prospectus Cost Construction; (14) Congress Authorization Year; (15) Planning Phase Duration; (16) Design Phase Duration; (17) Construction Phase Duration; (18) Congress Authorization to Construction Finish Duration; (19) Planning Start to Construction Finish Duration; and (20) Design Start to Construction Finish Duration. These variables are analyzed in the descriptive statistics and cross-tabulations in Chapter 4, and in the correlation analysis earlier in Chapter 5. Table 5.50 is the summary of Model 5. The R-squared is the percent of the dependent variable explained by the independents.

Table 5.50 Model 5 Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
5	.439[a]	.193	.082	1.046	.193	1.743	20	146	.033

a. Predictors: (Constant), Construction Phase Duration, Program Area, Design Start to Construction Finish Duration, Estimated Total Prospectus Cost Site, Region, Congress Authority year, House Political Party Sponsorship, Gross Area, Estimated Total Prospectus Cost minus Congress Authorization, Planning Phase Duration, Usable Space, Planning Start to Construction Finish Duration, Design Phase Duration, Project Type, Congress Authorization to Construction Finish Duration, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Central Office Allowance, Estimated Total Prospectus Cost minus Conference Appropriation

b. Dependent Variable: Project Delivery Method

In Model 5, the independents explain 19.3 percent of the variance, R Square and Model 5 holds its strength in its statistical significance, explained in the next table. Explaining 19.3 percent of the variance suggests that Model 5 is misspecified. Other variables, not suggested by the researcher, explain more than 80 percent (80.7 percent) of the variance. The Adjusted R-Squared is a standard, arbitrary downward adjustment to account for the possibility that, with many independents, some of the variance may be due to chance. The more independents in the model suggest the more the adjustment penalty. Even though there are many independents in this model, the penalty is considered minor, with 0.082 or an 8.2 percent likelihood that these results are received by chance (the penalty.)

The ANOVA table, Table 5.51, tests the overall significance of Model 5 and creates the regression equation for Model 5. For this model, the F value is considered statistically significant at the 0.05 level (with 0.033); even though the R Square is not relatively significant, explaining 19.3 percent the overall model, the model is credible. Model 5 then suggests that there is a 3.3 percent likelihood that the predictions in this model are due to chance.

Table 5.51 Model 5 Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
5	Regression	38.162	20	1.908	1.743	.033[a]
	Residual	159.790	146	1.094		
	Total	197.952	166			

a. Predictors: (Constant), Construction Phase Duration, Program Area, Design Start to Construction Finish Duration, Estimated Total Prospectus Cost Site, Region, Congress Authority year, House Political Party Sponsorship, Gross Area, Estimated Total Prospectus Cost minus Congress Authorization, Planning Phase Duration, Usable Space, Planning Start to Construction Finish Duration, Design Phase Duration, Project Type, Congress Authorization to Construction Finish Duration, Estimated Total Prospectus Cost Construction, Estimated Total Prospectus Cost Design, Estimated Total Prospectus Cost, Estimated Total Prospectus Cost minus Central Office Allowance, Estimated Total Prospectus Cost minus Conference Appropriation

b. Dependent Variable: Project Delivery Method

Table 5.52 provides the b and beta coefficients and other coefficients of the model. The b coefficients and the constant are used to create the prediction (regression) equation.

Table 5.52 Model 5 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
5	(Constant)	14.761	138.070		.107	.915	-258.113	287.635		
	Project Type	.099	.152	.067	.652	.515	-.201	.399	.519	1.926
	Region	-.018	.026	-.055	-.681	.497	-.070	.034	.848	1.180
	Program Area	-.602	.203	-.249	-2.959	.004	-1.004	-.200	.778	1.285
	Political Party	4.848E-6	.000	.001	.014	.989	.000	.001	.565	1.770
	Gross Area	-1.392E-7	.000	-.097	-1.142	.255	.000	.000	.771	1.297
	Usable Space	6.450E-7	.000	.191	2.003	.047	.000	.000	.611	1.637
	Congress Authorization Year	-.007	.069	-.011	-.098	.922	-.143	.129	.478	2.090
	Planning Phase Duration	-2.912E-5	.000	-.011	-.123	.902	.000	.000	.682	1.467
	Design Phase Duration	.000	.000	.155	1.523	.130	.000	.001	.532	1.879
	Construction Phase Duration	.000	.000	-.071	-.652	.515	.000	.000	.471	2.123
	Congress Authorization to Construction Finish Duration	-4.689E-5	.000	-.038	-.295	.768	.000	.000	.340	2.938
	Planning Start to Construction Finish Duration	7.236E-5	.000	.074	.600	.549	.000	.000	.364	2.750
	Design Start to Construction Finish Duration	-9.757E-6	.000	-.039	-.489	.625	.000	.000	.872	1.147
	Estimated Total Prospectus Cost Site	-2.351E-8	.000	-.058	-.711	.478	.000	.000	.828	1.208
	Estimated Total Prospectus Cost Design	1.094E-7	.000	.556	2.004	.047	.000	.000	.072	13.940
	Estimated Total Prospectus Cost Construction	-2.351E-9	.000	-.185	-.495	.622	.000	.000	.040	25.301
	Estimated Total Prospectus Cost	5.897E-10	.000	.055	.149	.882	.000	.000	.041	24.326
	Estimated Total Prospectus Cost minus Congress Authorization	1.589E-9	.000	.129	.226	.821	.000	.000	.017	59.233
	Estimated Total Prospectus Cost minus Conference Appropriation	6.047E-9	.000	.491	.721	.472	.000	.000	.012	83.898
	Estimated Total Prospectus Cost minus Central Office Allowance	-3.684E-9	.000	-.309	-.545	.586	.000	.000	.017	57.943

a. Dependent Variable: Project Delivery Method
b. Shaded rows represent statistically significant variables at the 0.05 level and below.

For this fifth predictive model, the Project Delivery Method (selected after state design-build legislation) = -0.055*(Region) + 0.067*(Project Type) + -0.249 *(Program Area) + 0.001* (Political Party) + -0.097*(Gross Area) + 0.191*(Usable Space) + 0.129* (Estimated Total Prospectus Cost minus Congress Authorization) + 0.491*(Estimated Total Prospectus Cost minus Conference Appropriation) + -0.309*(Estimated Total Prospectus Total Cost minus Central Office Allowance) + 0.055*(Estimated Total Prospectus Cost) + -0.058*(Estimated Total Prospectus Cost Site) + 0.556*(Estimated Total Prospectus Cost Design) + -0.185*(Estimated Total Prospectus Cost Construction) + -0.011*(Congress Authorization Year) + -0.011*(Planning Phase Duration) + 0.155*(Design Phase Duration) + -0.071*(Construction Phase Duration) + -0.038*(Congress Authorization to Construction Finish Duration) + 0.074*(Planning Start to Construction Finish Duration) + -0.039*(Design Start to Construction Finish Duration) + -14.761. The beta coefficients are the standardized regression coefficients and their relative absolute magnitudes reflect their relative importance in predicting the project delivery method. Betas are highly influenced by misspecification of the model; in this case, 80.7 percent of the model is not explained, and so adding or subtracting variables in the equation will affect the size of the betas.

The t-test examines the significance of each b coefficient. It is possible to have a regression model which is significant overall by the F test, and several of the coefficients are also significant. Model 5 is considered highly statistically significant (with a 3 percent likelihood that the results of the model are due to chance, or 0.033). And similar to the Model 4, only three of the variables are also considered of high significance, at a level of 0.05. Program Area is significant at the 0.05 (0.040) level, which suggests that projects using alternative project delivery methods, specifically design-build, are more often used in federal buildings and border stations. There also seems to be a relationship between Usable Space and alternative project delivery methods, with a significance of 0.047. This suggests that design-build uses a greater amount of usable space than projects using other methods of project delivery. And as reported in other models, the Estimated Total Prospectus Cost Design is significant at the 0.047 level, which suggests that design costs are significantly lower using design-build. Findings from the qualitative study presented in Chapter 2 offer that, because design and construction are awarded to one entity, the design costs should be less. Conversely, there are several variables in the model that are not highly significant: Political Party at 0.989; Congress Authorization Year at 0.922; Planning Phase Duration at 0.902; and Estimated Total Prospectus Cost at 0.882. These results suggest that there is no relationship between the political party supporting the project and the selection of a project delivery method, that projects using design-build have a longer planning phase, and that the total estimated cost of the project is lower using design-build. Because this model is considered highly significant, future research may suggest that the model be re-run, eliminating variables with the least significance to achieve a model with overall high significance and with all its variables of high significance. Only six of the variables in Model 5 have tolerances close to zero, and so the betas for those variables may suggest instability. It should be noted that all the variables with tolerances close to zero are associated with estimated costs. Model 5 also suggests that only a few variables have high multicollinearity due to their variance inflation factor (VIF), and those variables are associated with estimated costs. Both the tolerance levels and the VIF suggest that this model be re-run for future research, and those variables associated with estimated costs be scrutinized. Table 5.53 contains summary data regarding residuals, the difference between predicted and actual values.

Table 5.53 Model 5 Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.01	2.82	.84	.479	167
Std. Predicted Value	-1.731	4.129	.000	1.000	167
Standard Error of Predicted Value	.153	1.005	.339	.152	167
Adjusted Predicted Value	.02	5.19	.87	.606	167
Residual	-2.237	2.470	.000	.981	167
Std. Residual	-2.138	2.361	.000	.938	167
Stud. Residual	-2.496	2.482	-.006	1.012	167
Deleted Residual	-4.186	2.788	-.022	1.208	167
Stud. Deleted Residual	-2.542	2.528	-.003	1.020	167
Mahal. Distance	2.570	152.194	19.880	24.346	167
Cook's Distance	.000	.704	.015	.061	167
Centered Leverage Value	.015	.917	.120	.147	167

a. Dependent Variable: Project Delivery Method

The minimum standardized residual for Model 5 is -2.237 and at least one prediction is between two and three standard deviations below the mean residual. The deleted residual rows have to do with coefficients when the model is recomputed over and over, dropping one case from the analysis at a time. This is an area suggested for future research on this Model given its high statistically significant results. The bottom three rows are measures of the influence and Cook's distance appears that there may be problem cases since the maximum leverage is 0.704. In future research, if Model 5 is re-run, then Cook's distance should be lessened and closer to zero; thus, the results of this model may have more applicability in testing the hypothesis. To analyze the data in the model in more detail, charts are developed. The zresid histogram in Figure 5.100 provides a visual way of assessing if the assumption of normally distributed residual error is met. In Model 5, the slight skewness to the left should not affect substantive conclusions. This reaffirms the previous conclusions in this model.

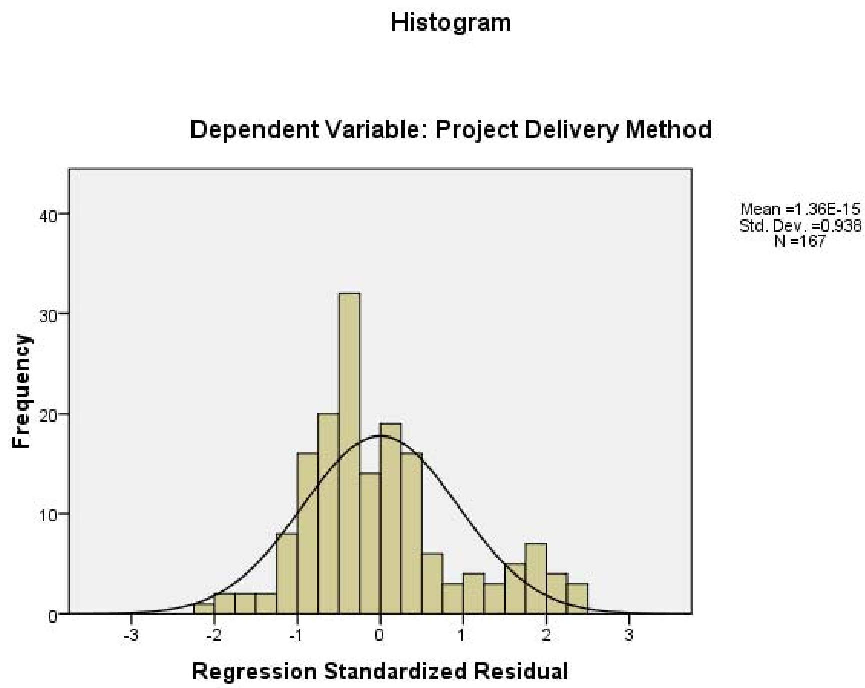


Figure 5.100 Model 5 Histogram

The normal probability plot (zresid normal p-p plot) in Figure 5.101, under perfect normality, will be a 45-degree line. In Model 5, as in the mother models in this research, it is imperfect, but still close enough for exploratory conclusions.

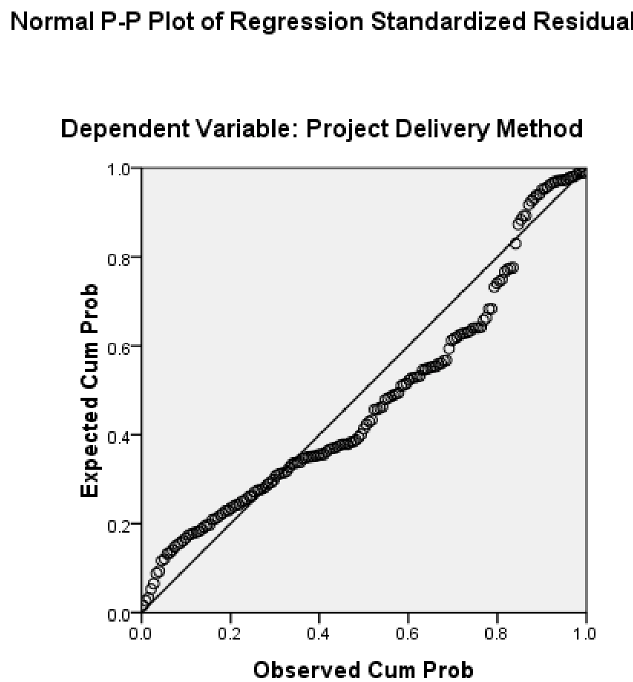


Figure 5.101 Model 5 Normal P-P Plot of Regression Standardized Residual

In the plot of standardized predicted values versus observed values, if 100 percent of the variance is explained in a linear relationship, the points in the scatterplot in Figure 5.102 will form a straight line. The lower the percent of variance explained, the more the points will form a cloud with no trend. The more the points are dispersed around the trend, the higher the standard error of estimate and the poorer the model. The plot in Figure 5.102 reflects the facts that the model explains a small percentage of the variance, or 19.3 percent, as discussed earlier.

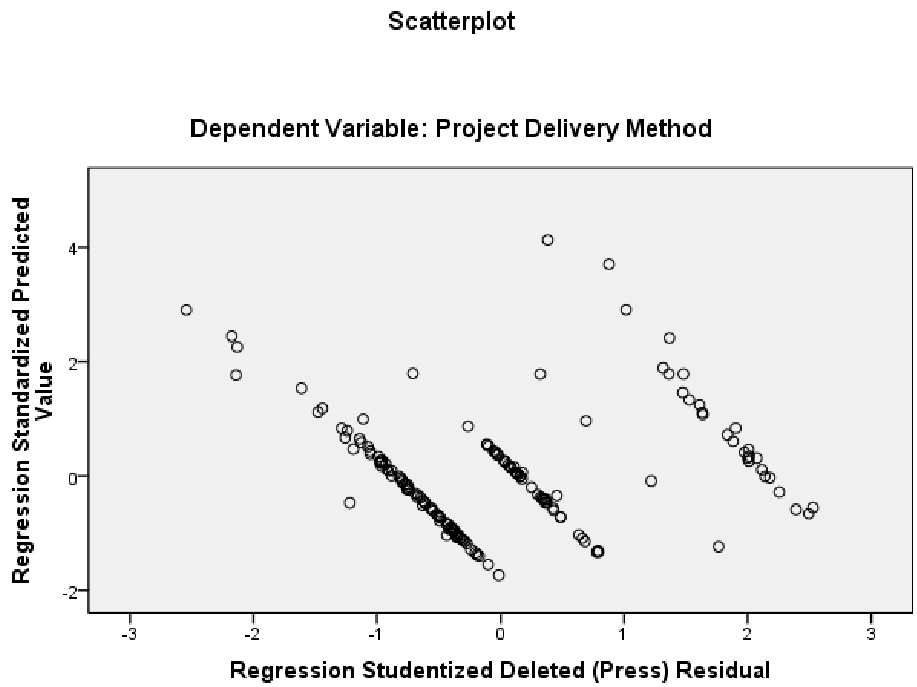


Figure 5.102 Model 5 Scatterplot of Model Variance

Also, as mentioned in earlier models, partial regression plots show the plot of one independent on the dependent variable (project delivery method). The points will form a straight line if the percent of the variance is 100 percent, and will form a cloud the lower the percent of variance is explained. Figures 5.103 to 5.121 verify high variances between the project delivery method (dependent) and several of the independents. The low variances are shown as cloud-like formations on all of the partial scatterplots.

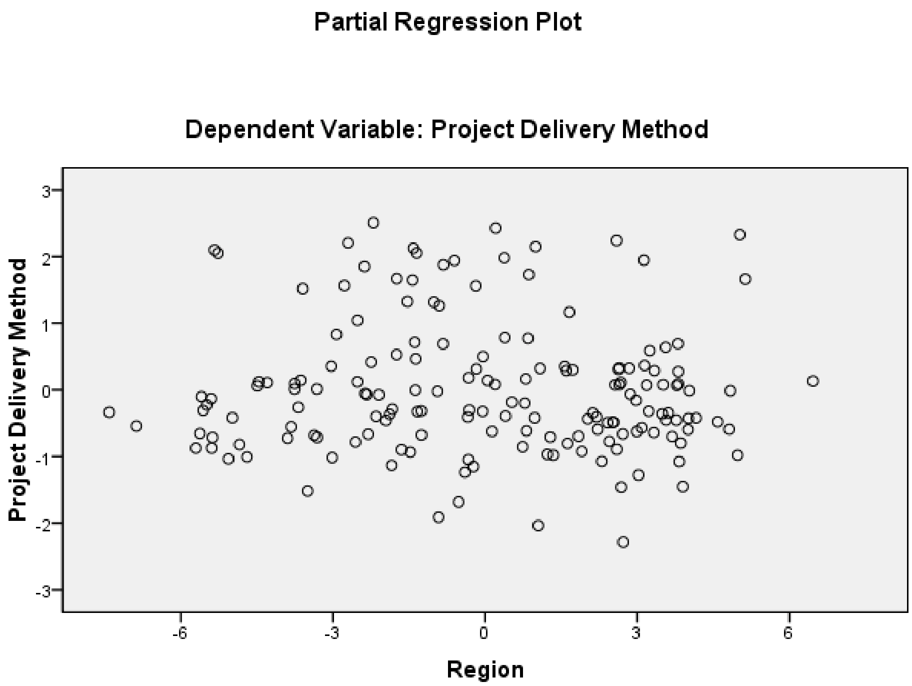


Figure 5.103 Model 5 Partial Scatterplot of Region as Independent

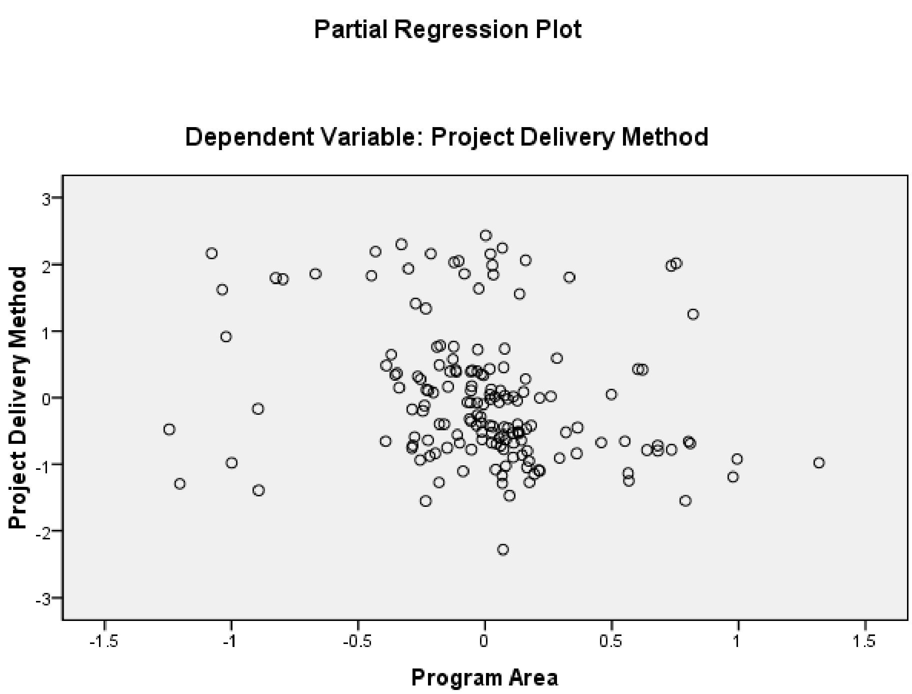


Figure 5.104 Model 5 Partial Scatterplot of Program Area as Independent

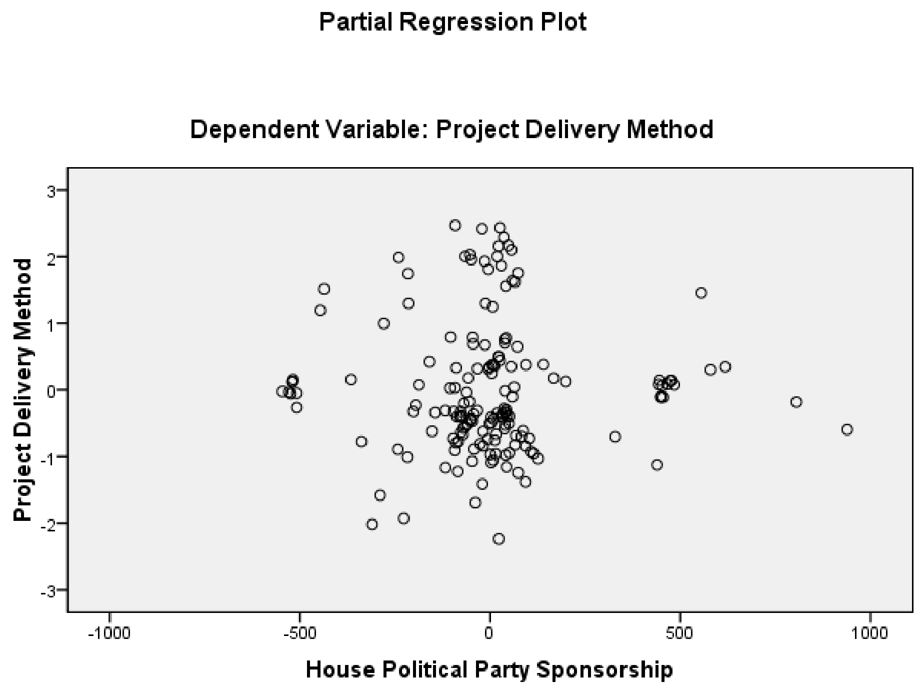


Figure 5.105 Model 5 Partial Scatterplot of Political Party as Independent

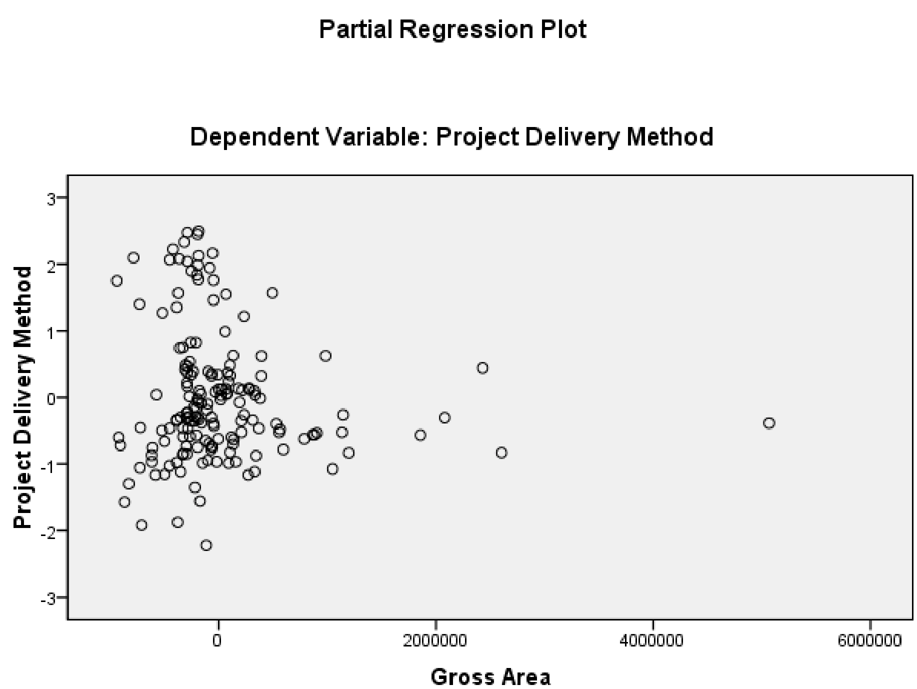


Figure 5.106 Model 5 Partial Scatterplot of Gross Area as Independent

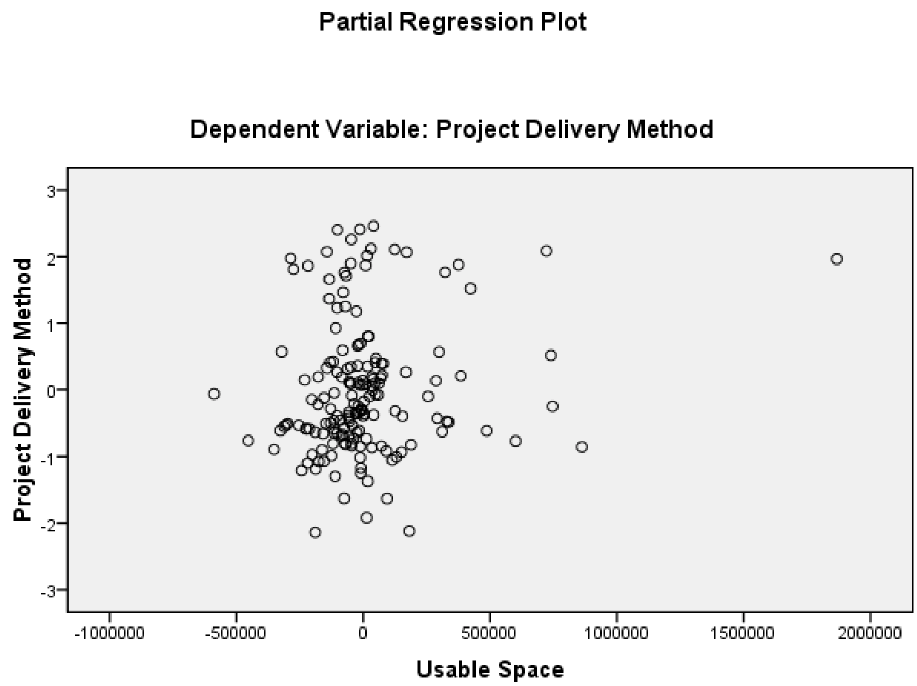


Figure 5.107 Model 5 Partial Scatterplot of Usable Space as Independent

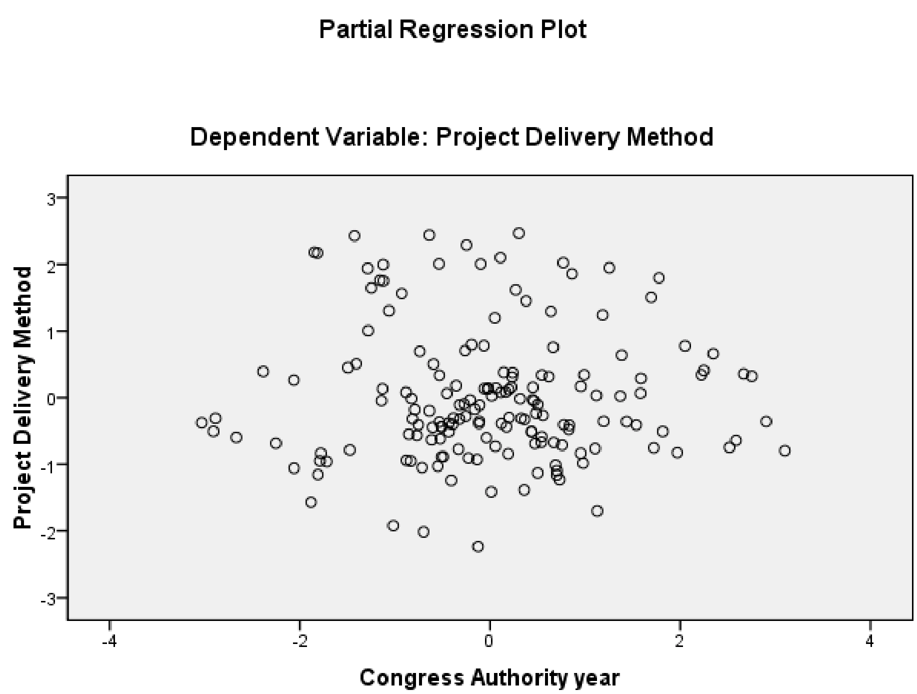


Figure 5.108 Model 5 Partial Scatterplot of Congress Authorization Year as Independent

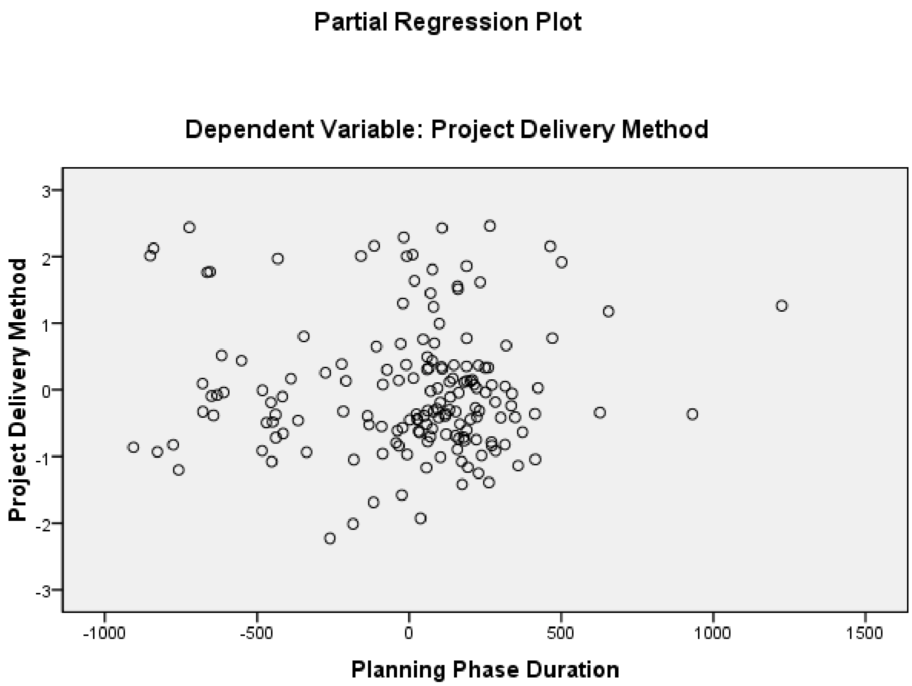


Figure 5.109 Model 5 Partial Scatterplot of Planning Phase Duration as Independent

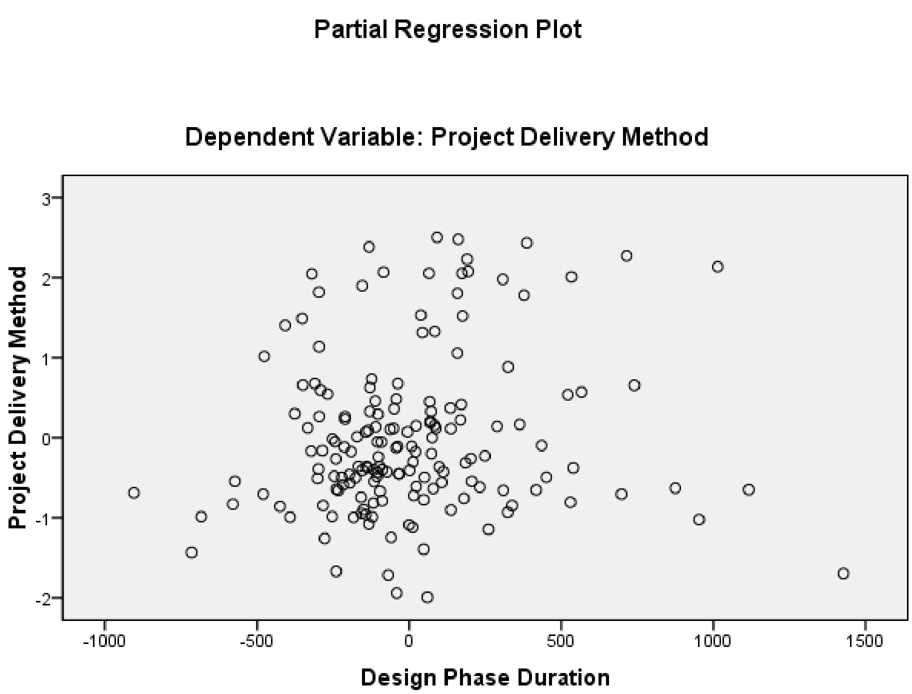


Figure 5.110 Model 5 Partial Scatterplot of Design Phase Duration as Independent

Figure 5.111 Model 5 Partial Scatterplot of Construction Phase Duration as Independent

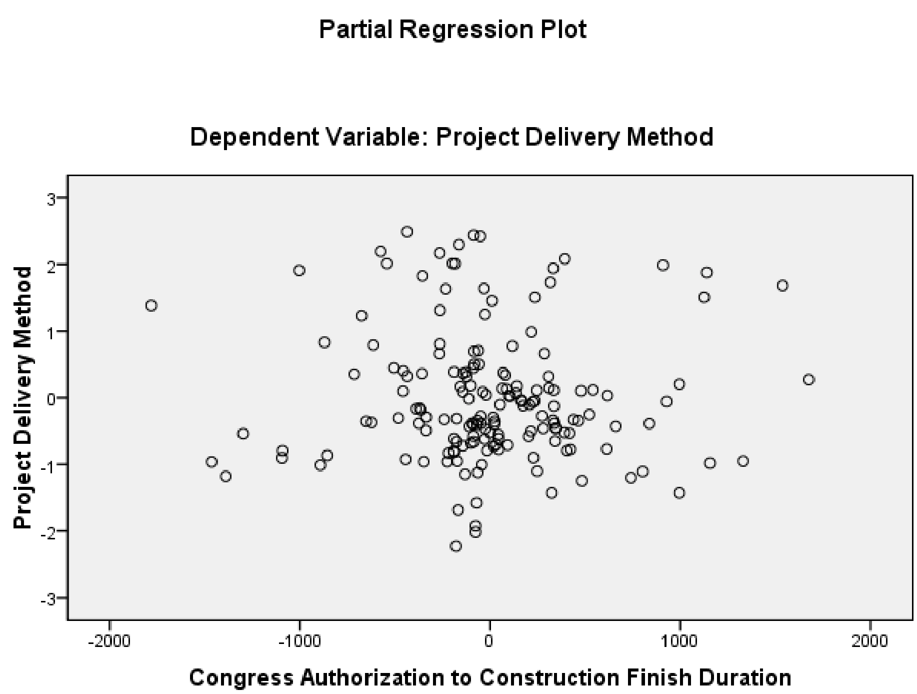


Figure 5.112 Model 5 Partial Scatterplot of Congress Authorization to Construction Finish Duration as Independent

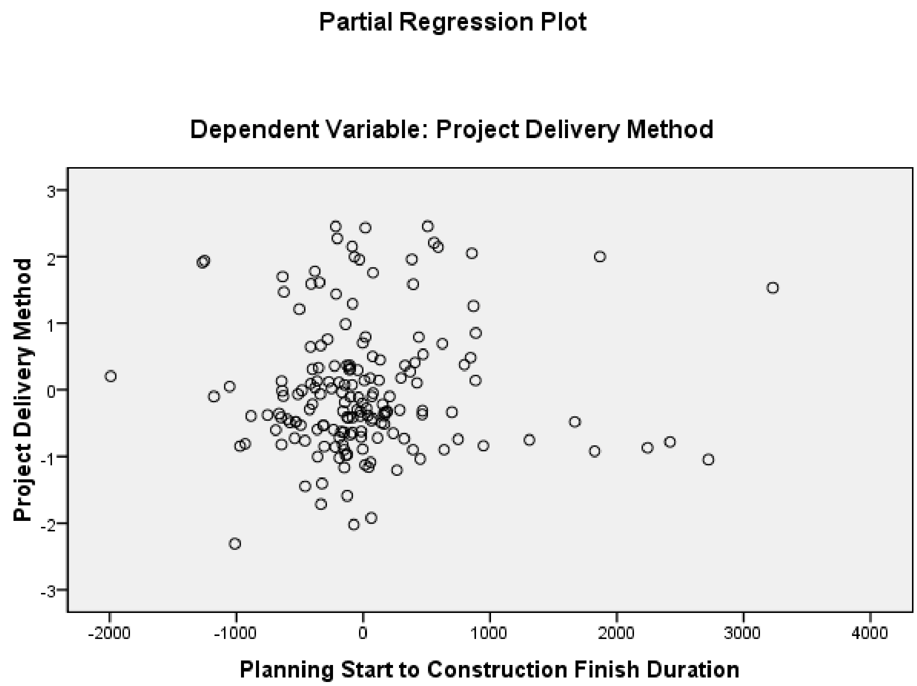


Figure 5.113 Model 5 Partial Scatterplot of Planning Start to Construction Finish Duration as Independent

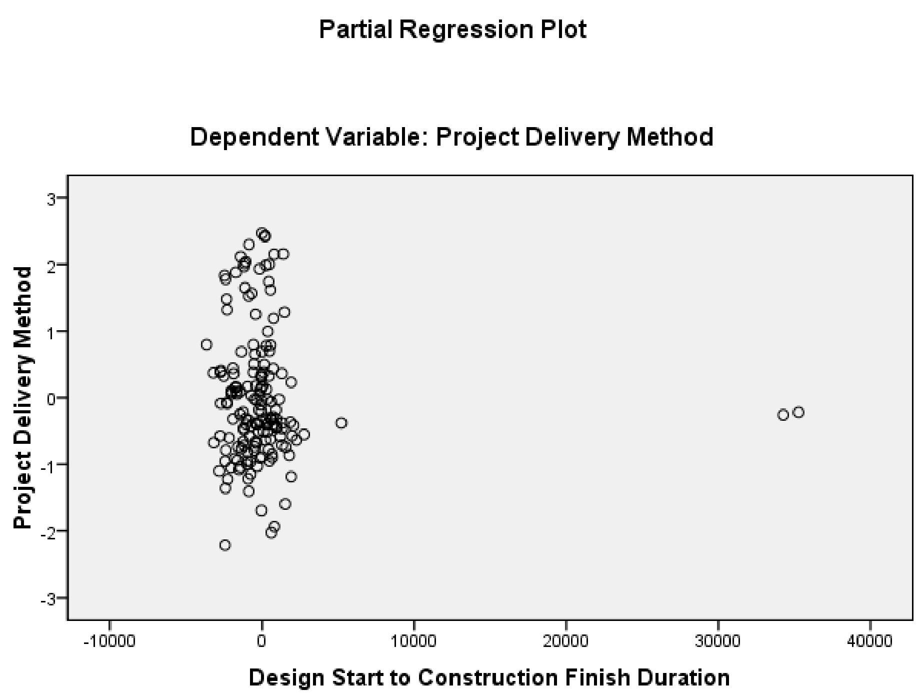


Figure 5.114 Model 5 Partial Scatterplot of Design Start to Construction Finish Duration as Independent

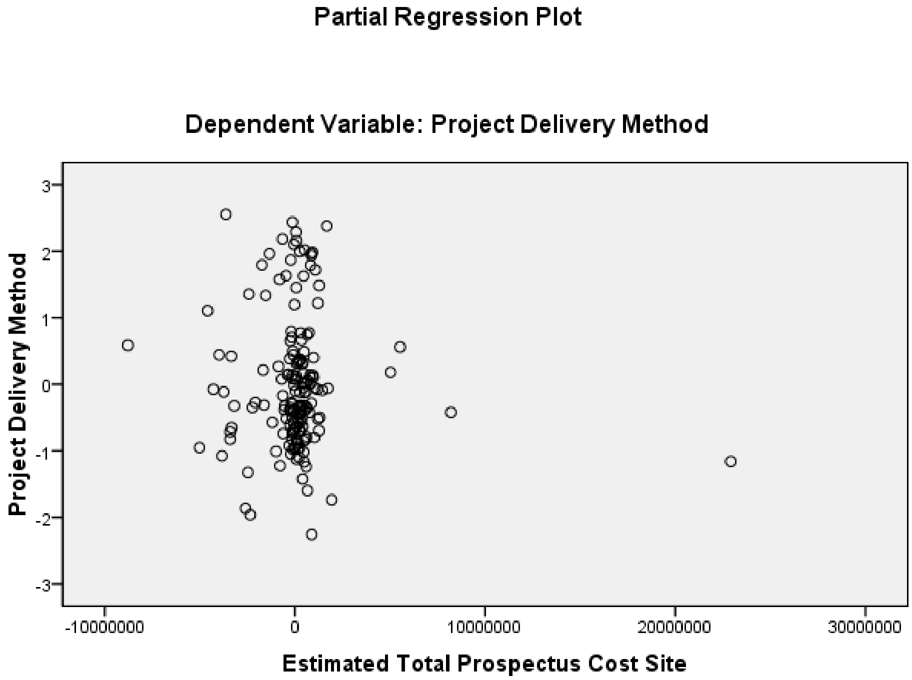


Figure 5.115 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost Site as Independent

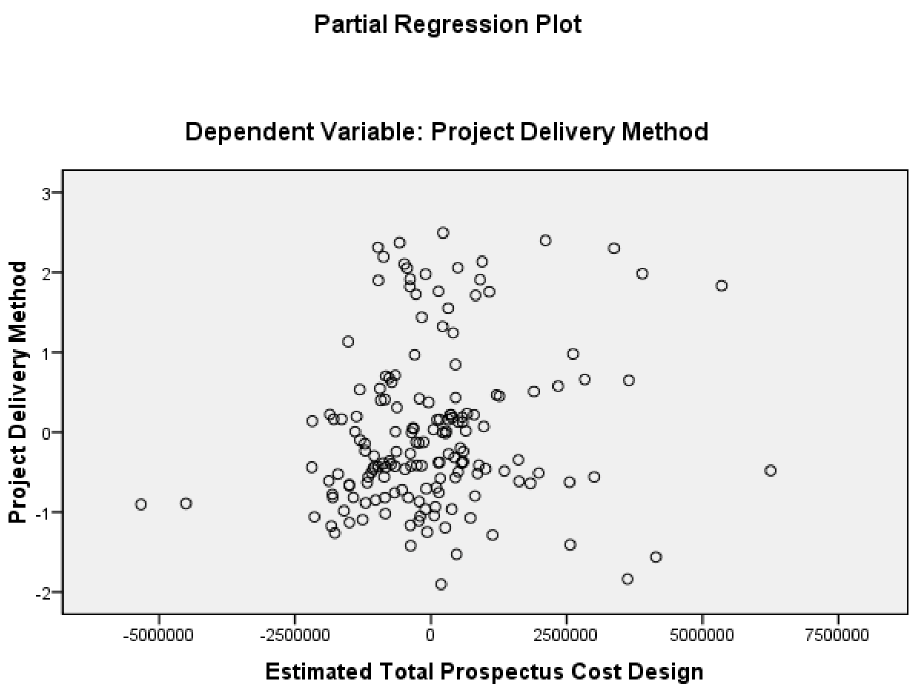


Figure 5.116 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost Design as Independent

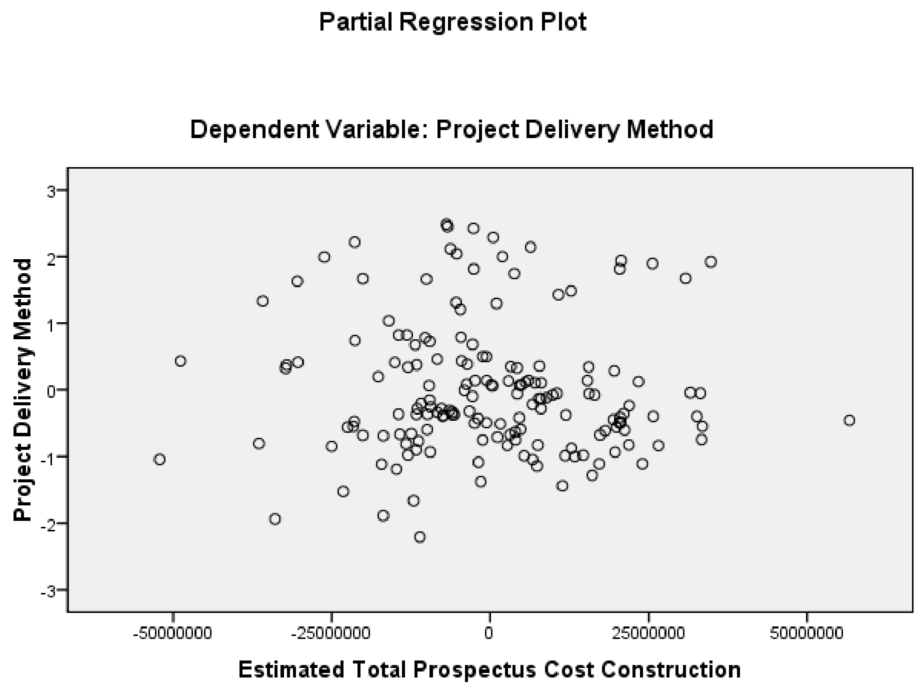


Figure 5.117 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost Construction as Independent

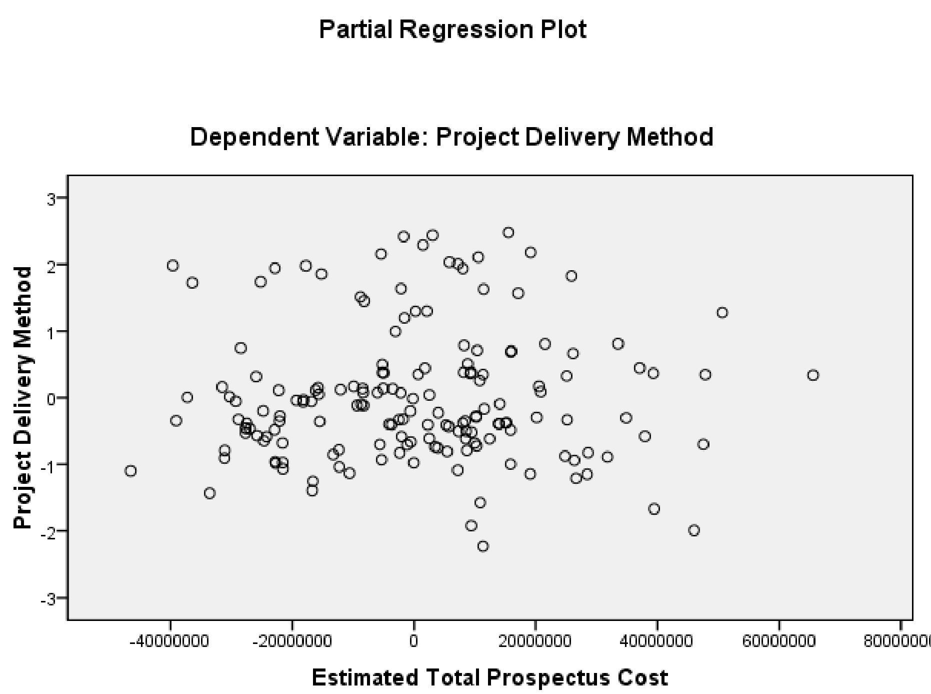


Figure 5.118 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost as Independent

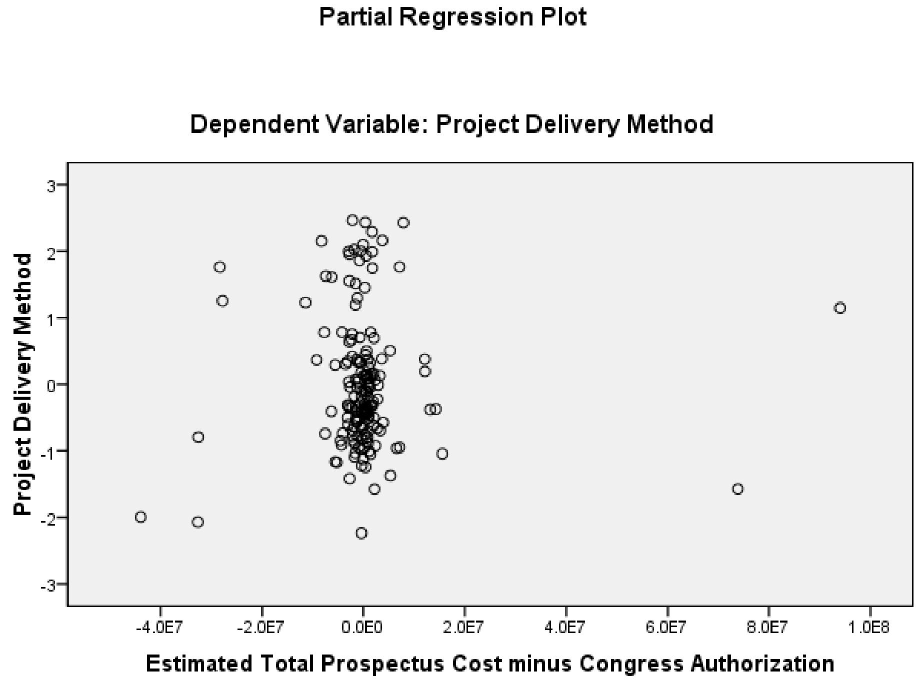


Figure 5.119 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost minus Congress Authorization as Independent

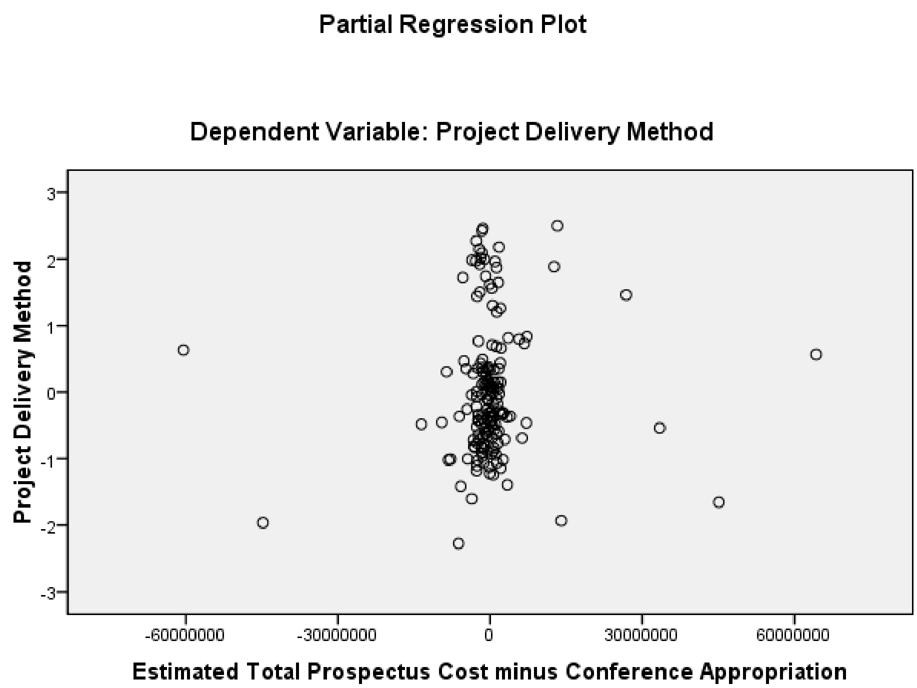


Figure 5.120 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost minus Conference Appropriation as Independent

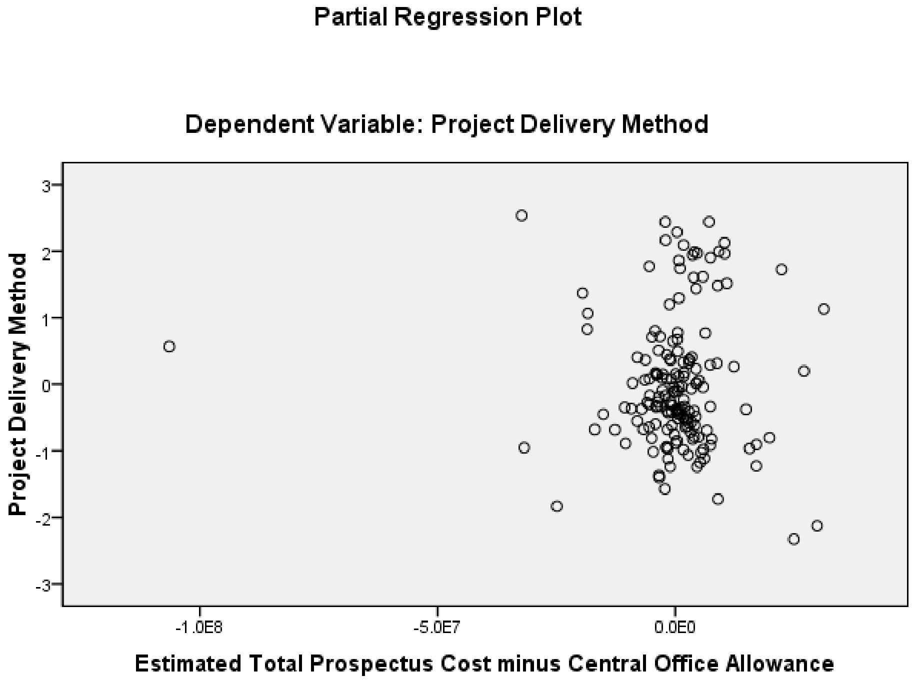


Figure 5.121 Model 5 Partial Scatterplot of Estimated Total Prospectus Cost minus Central Office Allowance as Independent

5.6.3 Summary of Multivariate Analysis Testing State Legislative Impediments

This section of the chapter concludes the research which tests whether state legislative impediments affect the benefits that exist when alternative project delivery methods are allowed to be used. As mentioned earlier, while state governments do not have jurisdiction for fully federally-funded projects, political conditions at the state level may exist and may influence the outcome of a design and construction project. Similar to the previous section of the chapter, two models are developed to test the impact after state legislative impediments are eliminated or reduced. In the context of the development of Model 4 and Model 5, this research defines a state legislative impediment as lack of authorization of design-build at the time Congress authorizes funding for the GSA federal project. Model 4 examines the impact before design-build legislation is authorized in the state the project is being built. Model 5 examines the impact after any, even highly-restrictive, design-build legislation is authorized in the state the project is being built. The goal of these two models is to assess the benefits of using alternative project delivery methods, specifically design-build, for a construction project under the premise that the removal of state legislative impediments have a positive effect.

In Model 4, in the first predictive model in this section, the independents explain 34.7 percent of the variance (R Square), and the model also is considered highly statistically significant (with a less than 1 percent likelihood that the results of the model are due to chance, or 0.000). Model 4 suggests a benefit of design-build (and alternative delivery methods using qualifications-based selection for builders) in the duration of time from the beginning of planning to the end of construction. Design-build reaps the benefits of shortened durations. The model also indicates that the estimated total prospectus cost is lower using design-build.

In Model 5, the F value is considered statistically significant at the 0.05 level (with 0.033); even though the R Square is relatively not significant, explaining 19.3 percent of the overall model, the model is credible. Model 5 suggests that there is a 3.3 percent likelihood that the predictions in this model are due to chance. The model also offers that projects using design-build have a greater amount of usable space than projects using other methods of project delivery, and that design costs and estimated total prospectus costs are significantly lower using design-build. Conversely, projects using design-build have a longer planning phase. This finding substantiates the qualitative study in Chapter 2 that design-build and construction manager at-risk or as-constructor require greater programming efforts, and thus longer planning phases.

These two predictive models, which assess the impact of state legislative impediments on project delivery method selection for a federal project, support the hypothesis. Even state legislative impediments affect project delivery method selection in the type of benefits available to public owners when using an alternative project delivery method, specifically design-build, for a construction project. The analysis in this section suggests then that public owners should consider legislative impediments and get relief from them from other bodies of government when choosing a delivery method for their construction project.

5.7 Summary

The beginning of this chapter suggests that statistically significant correlations exist among many project characteristics in the database and project delivery method selection. However, Leedy and Ormrod (2005) remind that correlation does not necessarily indicate causation: “Finding a correlation in a data set is equivalent to discovering a signpost. That signpost points to the fact that two things are related, and it reveals the nature of the relationship (positive or negative, weak or strong).” The results from the correlation analysis lead to using multivariate analysis techniques later in the chapter. Using multivariate analysis testing the hypothesis, whether benefits exist when using an alternative project delivery method and whether legislative impediments affect any such benefits to be realized when alternative project delivery methods are allowed to be used, the statistics suggest that there are benefits to a construction project when federal and state legislative impediments are lifted or reduced. When federal legislative impediments are lifted, public owners reap the benefits by shortened durations of time to complete design and to complete construction. Earlier qualitative research presented in Chapter 2 suggests that overlapping design and construction, which is typical in design-build, creates shortened design and construction schedules. Quantitative research is presented in this chapter to support such qualitative findings. Also significant is that public owners benefit from shortened durations from when planning begins to when construction ends. The qualitative research suggests though that planning takes longer using design-build; however, the overall process of planning, design and construction is shortened. When state legislative impediments are reduced or lifted, projects with more square feet tend to use design-build more often when design-build is allowed. Design costs and estimated total prospectus costs are significantly lower when using design-build and other methods using qualifications-based builder selection. These findings substantiate the hypothesis of this research: that benefits exist when alternative project delivery methods are used and legislative limitations allowing the use of alternative project delivery methods impede any such benefits to be realized.

CHAPTER 6

SUMMARY, CONTRIBUTIONS, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 Purpose

This chapter summarizes the steps taken in this study, and suggests conclusions and contributions of this research. At the end, areas of inquiry to follow-up on the findings of this research are recommended.

6.2 Summary

Selecting the most-appropriate delivery method for a project is an ongoing dilemma and has resulted in confusion among many construction owners. Previous research suggests that the type of delivery method impacts the outcome of the construction project, in terms of lower costs, shortened schedules, and better quality. The choice then is especially important to public owners charged with fiscal responsibility of public funds. This challenge reaches all providers in the public construction industry who are attempting to understand how each of these methods are organized and managed to provide public owners with the highest and best possible value for their project. This research provides methodologies to offer a comprehensive analysis of the impact of legislative impediments on project delivery method selection and the outcome of public construction projects. Methodologies for performing such analyses in construction research are still underdeveloped. Existing methodologies usually focus on specific aspects of the problem and, therefore, do not provide a comprehensive analysis of the issues, and specifically the distinct issues related to fully government-funded projects. This research provides such an analysis. It is divided into six chapters.

Chapter 1 introduces the problem definition, objectives, scope of the study, and offers a brief problem solution discussion.

Chapter 2 presents a literature review explaining the various definitions and interpretations of the project delivery process, how they function, industry perceptions of advantages and disadvantages of each method, and the evolution and legislative trends of such methods. The first section of the chapter provides an industry-developed standard definition of the project delivery process, discusses the four types of project delivery methods, and then provides a qualitative study of the perceptions of each method. This first section establishes that there is no industry-wide "accepted" definition of the project delivery method process and that wide variations exist in the delivery of such processes. This leads to confusion among industry professionals. The first section also offers consideration concerning choosing alternative delivery methods, such as design-build and construction manager at-risk, for project delivery method selection from the qualitative study. The qualitative study suggests that design-build and construction manager at-risk delivery methods save money, have shorter project durations, and reduced administrative burden, without sacrificing the quality of the project. The second section of Chapter 2 reviews legislative trends to establish the controversial nature of the alternative delivery methods, with a focus on design-build. A history of the project delivery method process is provided, as is an overview of federal and state legislative trends on design-build. The results of this background study suggest that federal legislation that separates the design and construction industry has been in place since the mid-1800s; however, the separation was eliminated in 1996 with the Clinger-Cohen Act, which provides a two-phase, qualifications-based selection process for builders and authorizes the use of design-build. The background study also suggests that many states are enacting similar design-build legislation, but many states are still highly restrictive in its application. The legislative trends discussed in this chapter support the basis for this study and the hypothesis, that legislative impediments affect the outcome of a design and construction project.

Chapter 3 provides a literature search of methodologies and draws variables from selection models in previously published studies with hypotheses similar to the one in this research. A chronological presentation of such studies is presented and suggested selection variables are extrapolated. As shown in this search, only four previous studies identify legislative limitations and the regulatory environment as factors to consider when choosing a delivery method. However, the four models are not specific to limitations of working in a regulatory environment. When legislative limitations and the regulatory environment are discussed in prior studies, none take a qualitative and quantitative approach to determine their effect on the outcome of a project. The literature review in this chapter suggests the timeliness and uniqueness of this research.

Chapter 4 presents a methodology for this research which defines the model, introduces and provides descriptive statistics of the data to test the hypothesis, and ends with testing the hypothesis using cross-tabulation. The methodology for this research begins with a qualitative study to determine industry perceptions of alternative project delivery methods. A literature review of Federal and State legislative trends is then conducted, in order to draw legislative limitations in using alternative delivery methods for government construction projects. Concurrently, a literature review of previous delivery method selection models is performed, in order to identify studies that address legislative limitations in the selection model criteria. The literature reviews prove valuable in supporting the hypothesis. Data from the U.S General Services Administration (GSA) is then selected to quantitatively measure the hypothesis. Project variables are presented and descriptive statistics of such variables are explored. Chapter 4 ends using the cross-tabulation technique to ascertain whether a relationship exists among the variables in the database and project delivery method selection. The cross-tabulation analysis reveals that the largest projects in size use alternative delivery methods, such as design-build and construction manager as-constructor. Design costs are lower using design-build and design-build-bridging than other methods, and projects using construction manager as-constructor have the longest duration. This may be because one contract is awarded for design-build, and two or more contracts are awarded for design-build-bridging, construction manager as-constructor, and design-bid-build. The cross-tabulation analysis also reveals that there is an increase in the use of alternative delivery methods, especially design-build, once federal and state legislative barriers are lifted. Before Clinger-Cohen is passed in 1996, only four projects choose design-build; after this law is passed, 73 projects choose design-build. Design-build is selected twice as often after state legislative barriers are lifted. Cross-tabulations suggest a relationship among legislative impediments and the outcome of a project.

Chapter 5 measures the strength of the relationship between legislative impediments and the outcome of a project. Correlation is used to measure the association among the variables, and then regression procedures are used to produce multiple correlations and to determine whether a statistically significant relationship exists.

Results in this chapter suggest that statistically significant correlations exist among many project characteristics in the database and project delivery methods. Then, using multivariate analysis techniques, the statistics suggest that there are benefits to a construction project when legislative impediments are lifted or reduced. When federal legislative impediments are lifted, public owners reap the benefits by greater usable space, and shortened durations of time to complete design and construction. Also of significance is that public owners benefit from shortened durations in the process from when the planning phase begins to when construction ends. The qualitative research suggests that though planning takes longer using design-build, the overall process of planning, design and construction is shortened, and this finding is verified in the quantitative research. When state legislative impediments are reduced or lifted, public owners benefit in the greater amount of usable space than projects using other methods of project delivery, thus proving the hypothesis for state legislative impediments as well. The quantitative study also finds that design costs and estimated total prospectus costs are significantly lower when using design-build and other methods using qualifications-based selection for builders, such as construction manager as-constructor.

Chapter 6 presents conclusions of the research, the expected benefits for and the impact on the construction industry, and finally provides recommendations for future research.

6.3 Conclusions

The philosophy of science suggests that there is no other way of representing "meaning" except in terms of relations between some qualities or quantities; either way involves relationships among variables (Hill and Lewicki, 2007). The developed methodology, which combines qualitative and quantitative analyses, is applied to the specific problem in this research to investigate whether benefits exist when alternative project delivery methods are used, and whether legislative limitations allowing the use of alternative project delivery methods impede any such benefits from being realized. The results of the qualitative study in Chapter 2 and the quantitative study in Chapter 5 provide sufficient evidence for proof of the research hypothesis: there is strong evidence that the type of delivery method affects the outcome and overall performance of a construction project, and that legislative impediments affect project delivery method selection and the outcome and overall performance of a construction project.

The qualitative study in Chapter 2 finds that projects using design-build and construction manager at-risk have lower costs, shorter schedules, and result in less administrative burden to the owner, without impacting the quality of the project. These qualitative findings are based on surveying 15 experts in the construction industry. These members represent all groups within the construction industry, including academicians, registered architects, professional engineers, construction managers, general contractors, a legislator, local and state government officials, and a mechanical prime contractor. Each of these experts has a financial stake in one of the four primary project delivery methods, and even though they represent differing views in the construction industry, their opinions as presented in the qualitative study are highly similar.

The patterns of opinions in the qualitative study warranted more in-depth exploration of this issue of project delivery method selection. And, as such, this research sought to test these qualitative findings using quantitative techniques. A combination of descriptive statistics, cross-tabulations, correlation and multivariate analyses are employed as quantitative techniques to test the hypothesis. Descriptive statistics relate to a single variable and offer analysis, such as the data consisting of 496 prospectus projects, spanning 20 years, from 1988 to 2008, and representing $19,594,836,588 in total estimated projects costs and 180,836,593 gross square feet in space. Oftentimes, however, research seeks to determine if two or more variables are interrelated. For example, this research tests whether benefits exist when alternative project delivery methods are used. To test these relationships, cross-tabulations are applied.

The cross-tabulation analysis in this research reveals that the largest projects in size use design-build and construction manager as-constructor. Design costs are lower using design-build and design-build-bridging than other methods, and projects using construction manager as-constructor have the longest duration. This may be because one contract is awarded for design and construction, and two or more contracts are awarded for the other three methods. The cross-tabulation analysis also reveals that there is an increase in the use of design-build once federal and state legislative barriers are lifted. Before Clinger-Cohen is passed in 1996, only four projects choose design-build; after this law is passed, 73 projects choose design-build. Design-build is selected twice as often after state legislative barriers are lifted. Cross-tabulations also suggest a relationship among legislative impediments and project delivery method selection. However, while cross-tabulation as an analysis technique describes the relationship among two variables, it does not measure the strength of the relationship and does not describe whether a statistically significant relationship exists among the variables. To do this, this research uses correlation to measure the association among the variables, and then uses regression procedures to produce multiple correlations and determine whether a statistically significant relationship exists to test the hypothesis.

Using correlation, this research suggests that positive and negative correlations exist among many of the variables in the dataset and project delivery method selection. There is strong support for the hypothesis using correlation analysis, and correlation also suggests that design-build projects have shorter design phases, are largely supported by the Democratic party, and have lower construction costs. Further, less project funds are being allocated to design-build projects by Congress, Conference, and Central Office than other delivery methods. These findings are significant; however, other more sophisticated methods of analysis exist that are applied to this research. These are multivariate regression techniques.

Regression examines the correlation of multiple independent variables with a single dependent, and also examines the statistical strength of the relationship between the dependent variable (project delivery method selection) and multiple independent variables in the database. A series of five multivariate flowcharts, or models, are used to test the hypothesis of this research.

The first predictive model tests whether any project characteristics have a relationship to the selection of a project delivery method. The analysis in Model 1 indicates statistically significant relationships between alternative project delivery method selection and the region where it is located, the project type (more new construction and lease-construct, and fewer renovation and alternation projects), the amount of usable space (more for alternative delivery methods), shorter design and construction durations, and shorter durations from when planning starts and construction finishes. The statistics also suggest that there are longer durations for alternative delivery methods between when Congress authorized funds for the project and when construction is complete, and the cost of design is lower using alternative project delivery methods. Model 1 tests the first question of the hypothesis, whether benefits exist to using alternative project delivery methods, and the results are statistically significant.

The second and third predictive models test the second question of the hypothesis, whether legislative limitations allowing the use of alternative project delivery methods impede the benefits found in Model 1 from being realized. These models examine the relationships between the dependent variable (project delivery method) and multiple independent variables (the project characteristics) to test the impact of alternative delivery methods after federal legislative impediments are eliminated, specifically after the Clinger-Cohen Act of 1996. Model 2 tests the impact of project delivery method selection before the Clinger-Cohen Act of 1996, and Model 3 tests the impact of alternative project delivery methods after the Clinger-Cohen Act of 1996. Model 2 is not considered statistically significant with a 40 percent likelihood that the predictions in this model are due to chance. None of the variables are considered significant, at a level below 0.05, which suggests that there are no significant relationships between alternative project delivery methods and project characteristics before the Clinger-Cohen Act of 1996. This makes sense because this model is developed to test whether alternative project delivery methods are selected in the face of legislative impediments. The results of Model 3 are almost the opposite of Model 2. Model 3 is considered highly statistically significant and many of the variables are also considered of high significance. Design-build is more often used in federal buildings and border stations, has a greater use of usable space, and the duration of time to complete design and construction is dramatically shortened. The most significant findings are that design-build benefits a project by reducing the duration of the design and construction phases. Earlier qualitative research presented in Chapter 2 suggests that overlapping design and construction, which is typical in a design-build project, creates shorter design and construction durations. Model 3 corroborates the qualitative findings presented in Chapter 2 with these quantitative findings in Chapter 5. Also significant in Model 3 is that public owners benefit from shortened durations from when the planning phase begins to when construction ends. Conversely, using design-build does not benefit public owners in the planning phase duration and in the percentage of funding between the Estimated Total Prospectus Cost and the amount of funds received from GSA's Central Office. Model 3 suggests that GSA's Central Office is withholding a greater percentage of funding for projects using alternative delivery methods. However, this may suggest that GSA's Central Office expects design-build or construction manager as-constructor to save money. The findings in Model 2 and Model 3 prove the second question in the hypothesis that federal legislative impediments affect the benefits that exist when alternative project delivery methods are allowed to be used. The last two models in this research that use multivariate regression techniques test the impact of project delivery method selection under state legislative impediments.

Model 4 examines the impact before design-build legislation is authorized in the state the project is being built. Model 5 examines the impact after any, even highly-restrictive, design-build legislation is authorized in the state the project is being built. The goal of these two models is to assess the benefits of using design-build for a construction project under the premise that the removal of state legislative impediments has a positive effect. Model 4 is considered highly statistically significant, suggesting that design-build reaps the benefits of shortened durations. Model 5 is also considered statistically significant and offers that projects using design-build have a greater amount of usable space than projects using other methods of project delivery, and that design costs and estimated total prospectus costs are significantly lower using design-build. Conversely, projects using design-build have a longer planning phase. This finding substantiates the qualitative study in Chapter 2 that design-build requires greater programming efforts, and thus longer planning phases. These two predictive models also support the hypothesis. Even state legislative impediments affect project delivery method selection in the type of benefits available to public owners when using design-build for a construction project. These analyses suggest that public owners should consider legislative impediments when choosing a project delivery method and get relief from them from legislative impediments associated with other bodies of government when choosing a delivery method for their construction project.

Lastly, this research draws conclusions with regard to the relationship between project delivery method and cost, which is one of the most commonly sought-out questions in the construction industry. This study draws guidance from the General Accountability Office to interpret the term ‘estimated costs’:

> In the absence of definitive legislative expression otherwise, the term *estimated cost* of a project may be said to comprehend the reasonable cost of a project erected in accordance with the plans and specifications, and that the inclusion of cost elements generally not covered by the plans and specifications such as furniture and equipment installed for the occupancy and use of the project would appear to be questionable. B-146312-O.M.-November 28, 1961

This research presents qualitative and quantitative analyses which suggest that design-build as a form of project delivery has lower estimated costs. Industry perceives that design-build as an alternative delivery method has lower costs, even with its two-phase qualifications- and cost-based selection criteria. Quantitative data from the U.S. General Services Administration supports those perceptions with statistically significant findings that the Estimated Total Prospectus Cost is lower for projects using design-build. However, it should be noted the conclusions derived from this study must be viewed within the context of the study's scope. The quantitative study focuses on federal buildings and the qualitative study focuses on state buildings, which do not account for the vast majority of public buildings. At the same time, findings of this research can provide some insight for other publically-funded buildings. However, their applicability to such projects requires further investigation into the complexity of legislative restrictions with regard to jurisdictional overlapping of governments and funding sources.

6.4 Contributions and Globalization of Research

Choosing an appropriate procurement method for construction projects continues to be one of the most-important topics for construction research. Yet, methodologies for investigating such topics are greatly underdeveloped. This research advances discovery through its methodology. Most studies focus on qualitative methodologies because the data available for quantitative studies is rarely accessible. This research begins with understanding perceptions of procurement methods using a qualitative study, and then takes advantage of Federal Congressional mandates to gather quantitative data. Combining qualitative and quantitative methodologies provides a comprehensive analysis to assess the impact of legislative impediments on project delivery method selection. The quantitative analysis is performed to provide a basis for better analyzing the experts' responses in the qualitative study and providing a more-thorough analysis of the issues. As a result, the proposed methodology proves to be a valuable approach in analyzing the effect of legislative impediments on the outcome of a construction project, and is recommended for future research in the construction industry.

This research moves toward a clearer focus of the vast and confusing domain of project delivery method studies. By offering additional insight into the benefits of alternative project delivery methods and the impact of legislative impediments on the outcome of a project, this research helps the public owner organize and manage the procurement of a construction project. This research aids public owners during the programming phase of a project when attempting to determine sufficient program definition. Determining sufficient program definition is a common problem in the construction industry; that problem is exacerbated when using alternative contracting techniques because the public owner does not have the design reviews that are common in traditional construction delivery methods. The results of this research should be considered when determining project delivery method selection. This research also assists public owners without experience in alternative contracting methods, or who are unsure about the appropriate application. This research contributes to new knowledge in the study of project delivery method selection by embracing the multifactoral nature of the problem by analyzing legislative limitations inherent to public owners.

This research is unique because it can be a basis for future policy recommendations. In this study, state legislative limitations affect the outcome of fully federally-funded construction projects. Fully federally-funded construction projects may also be impacted by other municipalities at the regional or local level. Understanding the implications of such legislative limitations across government jurisdictions supports the removal or reduction of such restrictions. This cross jurisdiction suggests that legislative limitations affect all areas of the construction industry. This research provides additional understanding of the effect of legislative restrictions, which may assist public management professionals in the development of policies and procedures to address such political risks.

This research does not create a new model and add to the existing 42 models discussed in this research and available to public owners in determining a project delivery method. Rather, this research analyzes the implications of legislative impediments by using five models and the most comprehensive database available to suggest benefits of design-build and the impact of legislative impediments on project outcome. The results in this study will aid public owners when deciding which variables are important to be used in their chosen project delivery method decision support system.

This research can be used by all providers (architects, engineering, builders, suppliers, etc.) in the public construction industry who are attempting to understand how each of these methods are organized and managed, in order to provide public owners with the highest and best possible value for their project. This research can also be generalized to parallel funding processes and internal policy limitations in corporate applications. Because the confusion of project delivery method selection reaches far beyond the borders of the United States, this research has international applications. Many international countries are struggling with the same dilemmas and are searching for more information to aid them in selecting the best project delivery method. Internationally, many project delivery method variations exist and the construction industry is grappling with understanding all the nuances of these methods, and their impact on project outcomes.

6.5 Recommendations for Future Research

This research proposes a unique methodology in analyzing the impact of legislative limitations on project delivery method selection. This methodology performs a systematic analysis of how organizing and managing the acquisition process impacts a construction project. The findings in this study bring multiple issues into attention, which suggest further investigation and opportunity to expand and generalize this research.

One of the major recommended follow-ups to this study is to investigate legislative limitations in other forms of government, such as examining state government data, to explore whether the removal of legislative impediments affect the outcome of a construction project. This research does not study whether city, regional or local municipalities have more-stringent legislative impediments for project delivery method selection. If such limitations exist, such impediments may be affecting construction projects that are fully-funded through other forms of governments. Such studies also will help further develop, test and, ultimately, improve the unique methodology of using public policy as a basis for future research.

Design-build is also thought to provide an opportunity for favoritism to enter into the contract award process by including non-price factors in the basis for selection. It is also thought to undermine the inherent checks and balances between design and construction teams in the design-bid-build project delivery method, with the design team no longer independent of the construction contractor, and may increase project costs due to the elimination of the low bid contractor selection criteria. Assessing whether these impacts are valid is suggested as another area for future research.

In a related area, future research may consider the development of a decision support system to model qualifications-based selection factors to reduce and drastically eliminate the perception of favoritism in procurement process for design-build. This would help the construction industry determine the best way to manage the qualifications-based builder-selection process commonly applied with the design-build project delivery method.

There are few qualitative studies that assess the impact of the Clinger-Cohen Act of 1996 from the perspective of the construction industry. Perceived advantages of the Clinger-Cohen Act are that it provides a way for public owners to eliminate marginal proposals, and also justified a builder's investment in time and money to respond to a solicitation early on in the process by eliminating the large number of competitors. Perceived disadvantages suggest that the Clinger-Cohen Act is thought to reduce competition for construction services by excluding smaller firms unable to lead the larger projects most amenable to the design-build approach, and provides an opportunity for favoritism to enter into the contract award process by including non-price factors in the basis for selection. Assessing whether these impacts are valid is suggested as another area for future research.

In the quantitative analyses, all five multivariate regression models suggest that there is a high likelihood that the predictions of the models occurred by chance, and that other variables are influencing the project delivery method selection. Future research suggests then that other variables be sought out to explain a greater percentage of the results. This would create a better design of the models and decrease the likelihood of results being received by chance. Similarly, more advanced multivariate techniques should be considered in further analysis of the data, and variables without statistical significance should be removed from the models to ultimately achieve highly statistically significant models with highly statistically significant variables.

Likewise, the database from the U.S. General Services Administration in this research does not study whether mixing a wide variety of project types, sizes and budgets might skew the data in ways that are not controlled for. An example is the projects in the Washington D.C. area, the National Capital Region and Region 11. Almost 25 percent of projects in the database are located in this area, and the effect of laws and regulations may be politically, culturally, and possibly technically unique. An area of future research is to delve into the unique characteristics of the 11 GSA regions to determine if political, cultural and technical patterns exist in the data based on location.

Another research opportunity is to apply the hypothesis and methodology in this study to corporate settings. The majority of previous research concentrates on project delivery method selection in the private construction industry; however, political risks (as impediments) may exist that impact project delivery method selection and the outcome of a construction project in the private sector. Such data from large private owners can be used to evaluate other aspects of organizing and managing the construction procurement process, in order to develop a source of best practices, and to further validate the findings of this study.

The challenge in any research study is finding data applicable and available for exploration. Researchers are constantly searching for data and, in that attempt, interpreting such needs for specific data (or databases) to construction industry leaders is difficult. Oftentimes, data is available, and because the researcher did not interpret such needs well, the data is overlooked. The data in this research is congressionally mandated and available to the public; however, the data was only found while the researcher was managing construction projects for the U.S. General Services Administration. This research then might not have been accessible if the researcher were not an employee, even though it is technically supposed to be public. The implications of this for other researchers, or for study of the public domain, is that data may be available and that interpreting such needs accurately to construction industry leaders is of fundamental importance. In commentary published June 9, 2008 in *Federal Computer Week*, Steve Kelman, professor of public management at Harvard University's Kennedy School of Government and former administrator of the Office of Federal Procurement Policy, expresses his concern that "government does not collect sufficient data on procurement performance results. Given the importance of contracting, our failure to gather performance information is a scandal." Kelman acknowledges that it often is difficult to collect reliable performance and trend data on the procurement system. Kelman offers that the private sector generally finds that improved performance "more than offsets the costs of collection." Researchers in the fields of public policy research and construction research should perform research to make such determinations. Certainly, this difficulty in the public domain may be exacerbated with collecting data from the private sector because such data may be perceived as proprietary, for example, collecting and disseminating research using data associated with profit. The amount of systematic research on project delivery method selection is still very limited, and this is part of a larger systemic issue of other missing or limited data on construction industry practices.

And finally, this research and previous studies indicate that benefits exist to public owners in using alternative project delivery methods. Yet, as this research explains, these methods have not been overwhelmingly adopted by the public construction industry. As an example fewer than 20 percent of all projects at GSA since the Clinger-Cohen Act of 1996 was enacted, allowing design-build, use design-build. An area of future research is to study why design-build has not been equally adopted with other methods of project delivery. The reasons for not using design-build are unknown and could be a good area for future research. Several hypotheses of reasons are suggested such as the government's hesitancy to spend taxpayers dollars attempting new methods, the lack of availability of design-build firms or entities interested in partnering in design-build ventures for government construction projects, the political influence of the general contractor industry to support the design-bid-build using single-prime bidding, and the political influence of union representation to support the design-bid-build using separate-prime bidding method.

The findings in this dissertation add to the overall body of construction industry research and begin to suggest many other fields of exploration related to the procurement of construction projects. This study intends to provide a basis for future investigations on the advantages of alternative project delivery methods, as well as understanding opportunities for removal of impediments restricting the use of such methods.

"Consult not your fears, but your hopes and your dreams. Think not about your frustrations, but about your unfulfilled potential. Concern yourself not with what you tried and failed in, but with what it is still possible for you to do." Pope John Paul XXIII

Valerie Rose Riecke Smith, Summer of 2008

APPENDIX A
GLOSSARY OF CONSTRUCTION TERMS

Bid package: A group of documents issued to contractors who are bidding on a construction project. The documents include information on the bidding process and the design documents (see below); also called "bidding documents" or "invitation to bid (ITB) package."

Change order: A revision in the contract documents after the execution of the contract. A change order is an order to change the work to be performed under a contract. It is usually given by the public owner to a general or prime contractor (see column 3) or by a general or prime contractor to a subcontractor.

Cost estimating: Calculation of the approximate direct and indirect costs of the project.

Design documents: The construction documents and the project specifications. The construction documents are drawings that describe the construction requirements. The project specifications are detailed written instructions, which explain each phase of work to be done.

Designer: Architects; landscape architects; civil, structural, mechanical, plumbing, and electrical engineers; technical consultants; and specifications writers.

Guaranteed maximum price: An amount stipulated in a construction contract as the maximum sum payable by the public owner to the construction manager for the work specified.

Long lead time: The extended period required to manufacture certain materials. Long lead times may create scheduling delays if the items involved are needed before they are manufactured.

Phased construction: Overlapping of design and construction, also called "fast tracking." The construction schedule is compressed by overlapping some activities that otherwise would be performed sequentially. Phased construction increases project delivery speed because construction can start before the design documents are complete. An example is to start site work and construction of the foundation before the interior is completely designed.

Prime contractor: A company responsible for all facets of construction or renovation of a building, in its particular trade: (a) heating, ventilating, and air conditioning; (b) plumbing; (c) electrical work; or (d) general construction (any work not included in the other three categories). The prime contractor has a direct contractual relationship with the owner.

Project costs: The direct and indirect costs associated with the execution of a project.

Project program, project requirements: A general project description, including project objectives, functional uses, occupancy requirements, and budget and time considerations and limitations.

Proposal: The document submitted by a bidder to a public owner for design and/or construction of a project; also called "bid."

Underbid: To submit a bid that is less than the cost to perform the work.

Value engineering: The process of analyzing the direct cost versus the value of alternative materials, equipment, and systems.

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