A TRANSACTION COST FRAMEWORK FOR EVALUATING CONSTRUCTION PROJECT ORGANIZATIONS

by

Theodore D. Lynch

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ABSTRACT

A project delivery system is a set of contracts and commitments that defines the organizational relationships and responsibilities of the different entities involved in designing and constructing a facility. This research presents a Project Delivery Cost Impact Framework that identifies and describes the specific cost impacts of project delivery systems so that comparisons may be made between the available systems. This framework was developed through the application of organization theory, primarily transaction cost economics, to construction project organizations.

Several levels of analysis within a construction project organization are identified. They are the individual, group, firm, inter-firm, and project levels. Each of these levels may be organized in several ways with associated organization and transaction costs. This thesis focuses on the project level and takes the owner's perspective.

At the project level, several organization/transaction costs are identified. The costs of the activities involved in putting the design and construction contracts in place for a project were grouped and termed Project Procurement costs. Since contracts are not self-enforcing, Contract Administration costs relate to monitoring and administering the contracts once they are in place. The costs associated with the flow of information, particularly between design and construction organizations, and the inefficiencies that may arise in these exchanges are considered Information Communication costs. Finally, the work of the different organizations must be planned, coordinated, and controlled. The costs of these activities and possible conflicts or misunderstandings that may occur are considered the Firm Interaction costs. Detailed path models (based on transaction cost economics) demonstrate the impact of project delivery systems on the four organization/transaction costs as well as production costs.

The path model demonstrating the relationship between the project delivery system and project procurement cost is evaluated with expert interviews and case studies of United States Postal Service projects. Most of the variables and relationships in the model are supported by the data, but several modifications are suggested.
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CHAPTER ONE

INTRODUCTION

Recently, an owner was planning to build an arena to stage various events, primarily basketball. The owner had a fixed budget for the project as well as a target date for opening the arena. They wanted it completed for the beginning of a basketball season so that they could earn revenue soon after the facility would be opened. This owner built a number of facilities each year and had an experienced staff. However, this project was larger and more unique than most every other project they had completed.

The owner had many choices for procuring the facility but decided to use a traditional delivery system for the project with separate contracts for design and construction. They had always used the traditional approach even though they had encountered problems in the past such as claims, disputes, missed budgets, missed deadlines, and poor quality. They had contemplated experimenting with other types of delivery systems but did not know how they would affect the outcome of the project in terms of cost, time, and quality. They were also unsure if other delivery systems would help avoid the problems they encountered on projects where the traditional delivery system was used. They had no criteria to evaluate and select a different delivery system, and despite its shortcomings, they felt comfortable with the process of the traditional system.

The owner chose an architect, and together, they developed a design for the arena. The owner enjoyed the experience working with the architect since the architect kept them involved and included them in many of the design decisions. Once the design was completed, both the architect and owner were pleased with its appearance. The architect had been estimating the project as it was designed and believed that it would also be within the budget set by the owner.

The owner then prequalified a group of construction teams to bid the design, and the teams, subsequently, developed and submitted their bids. When the owner opened the bids, they found that the lowest bid was 25% above their budget. They attempted to negotiate with some of the contractors but could not lower the prices sufficiently.
One of the bidding contractors had been involved with many design-build projects and was a strong advocate of its use. They approached the owner and suggested that the owner start over and use a design-build competition. They convinced the owner that they had nothing to lose since they could set the budget and target completion date in the request for proposal. In the face of cancellation of the project, the owner decided to try this approach even though they had no experience with design-build.

The owner developed the request for proposal based on the program established for the original design. They prequalified design-build teams and required that they develop proposals to meet a set of functional requirements, a fixed budget, and a target completion date. Each team submitted a proposal that complied with the owner’s requirements.

The owner reviewed the proposals and chose one that appeared to provide the best value. They were nervous about entering into a contract based on an incomplete design but felt that if the completed facility met their functional requirements, they would be satisfied.

Eventually, the project was completed on time, and the owner was pleased with the outcome. However, the owner still had many questions regarding the use of alternative project delivery systems. They were unsure if they received the best possible value for the project, which delivery system better suited their needs, how the delivery system would affect their own organization, and what delivery system they would use for future projects. They needed an objective means or criteria for selecting the most appropriate delivery system for a project based on their organization, experience, project requirements, and type of facility.

1.1. Problem Statement

For the purpose of this study, this researcher defines a project delivery system as a set of contracts and commitments that defines the organizational relationships and responsibilities of the different entities involved in designing and building a facility. The owner is typically responsible for choosing the project delivery system at the outset of a project.

Several basic project delivery systems are identified by the American Society of Civil Engineers [ASCE 88]. The traditional system is characterized by sequential execution of
design and construction with each performed by a separate contractor. Owner construction has been typically used by large sophisticated owners who develop their own in-house staff for design and construction. Construction management (CM) is a system where a specific firm, the construction manager, is hired to coordinate the efforts of the owner, design consultants, and constructors. Multiple primes is a system in which the owner contracts with several prime contractors for the design and construction of separate building systems. Design-build is a project delivery system in which design and construction services are acquired via a single contract. The development of alternative project delivery systems, such as construction management in the 70's and design-build in the 90's, appears to be a result of deficiencies in existing delivery systems.

Recent literature [McManamy 94] shows that since the mid 1980's, design-build has been used increasingly as an acceptable alternative for construction in private sector markets. According to ENR's annual survey of the Top 400 Contractors, design-build awards last year accounted for $71 billion, or nearly one-third of the group's entire 1993 new contract volume. Just six years ago, the design-build total was under $25 billion [McManamy 94].

Design-build has joined construction management, multiple primes, and owner construction as yet another acceptable alternative to the traditional design-bid-build project delivery approach. Many owners are faced with design-build use but don't know how to compare this to the other alternatives.

According to the ASCE Policy Statement on Design-Build [ASCE ], the pressures causing owners, designers, and contractors to utilize alternative project delivery systems include:

- Demand for better quality and continuous improvement in project delivery and in the final product;
- Demand for more innovative and cost-effective products and services;
- Desire to avoid legal entanglements of adversarial relationships;
- Desire for better handling of risk on projects;
- Desire to have fewer delays and faster project delivery schedules;
• Need to adapt to changing business culture and increased foreign competition; and

While it may be true that owners are feeling these pressures, it has been difficult to
determine the extent to which alternative project delivery systems can relieve them. The use
of alternative project delivery systems has caused much controversy and discussion in the
industry. Professional organizations now exist to promote the interests of specific project
delivery approaches. Additionally, conferences have been dedicated to the discussion of
the merits of alternative project delivery systems. Arguments continue to be heard for each
of the different project delivery systems. However, today’s evidence regarding the best
method for organizing construction projects provides mostly anecdotal and general
information for answers.

The problem is clear. There is no objective means for comparing alternative project
delivery systems for construction. There is a need to identify and understand the specific
impacts of project delivery systems on total project costs. The development of
measurements of these cost impacts should help move us from anecdotal and general
analysis towards a science of project organization in which a systematic comparison of
project delivery systems can be performed.

The success of a construction project is critically affected by the firms involved on the
project, the way they are organized, and the contracts that define their relationships
[Sanvido 92]. An understanding of the relationships between project delivery and total
project costs should lead to more objective and informed project organization decisions.

1.2. Objectives

The objectives of this study are to:

1. Develop a framework for identifying the impacts of a project organization, at
different organizational levels, on the costs of a project.

The framework establishes a long term research agenda that will eventually allow for
objective comparisons between competing project delivery systems. The framework first
identifies different levels in a project organization and explains how costs are generated at
these different levels. The levels include the individual, group, firm, inter-firm, and
project. Second, concentrating at the project level of the organization, specific categories of
cost impacts are identified. The cost of each category is dependent on the project delivery system being used. Organization theory is used as a basis for developing the framework.

2. Develop models to demonstrate the relationships between the project delivery system being used and the project level costs.

The project level of the framework identifies specific variables and the relationships between these variables to show how the project delivery system impacts the costs of the project. The variables originate primarily from transaction cost economics, an economic theory of organization [Williamson 75]. Path models (described in section 1.3) help show the relationships between variables.

3. Evaluate selected parts of the framework by studying similar type projects.

Many of the relationships defined in the framework are from applying transaction cost economics to construction projects. Therefore, it is important to explore these relationships through observation of real projects. The impact of the project delivery system on procurement costs, one of the primary relationships from the framework, was selected for detailed measurement and testing. Experts were interviewed using questionnaires generated to explore the variables of interest. Also, case studies of similar types of projects were performed to provide further support of the models. The evaluation of the rest of the framework is recommended for future research.

1.3. RESEARCH METHODOLOGY

This section first defines what a framework is. The framework presented in this thesis is comprised of several different types of models. The modeling techniques used are then described. The methods used to evaluate the models are discussed next, followed by a list of steps taken to perform the research.

A framework is an explanation of the key factors, or variables, and the presumed relationships among them. A framework may be either graphic or narrative in form. They can be rudimentary or elaborate, theory-driven or commonsensical, descriptive or causal.
[Miles and Huberman 84]. To help convey the ideas of the framework, three modeling techniques\(^1\) are used.

**IDEF1X** [1985] is an information modeling method that allows for the representation of entities and relationships between various entities. The modeling method also allows for hierarchical breakdowns of entities and the definition of attributes for each entity.

**IDEF\(_0\)** [Integrated 1981] models show both processes and the information and resources which are inputs, outputs, mechanisms and controls of each process. This modeling method also allows for the hierarchical decomposition of processes.

Path models are used to represent the relationship between three types of variables: (1) independent variables, (2) dependent variables, and (3) test variables [Rosenberg 68]. The relationship between independent variables and dependent variables cannot properly be understood without considering other variables associated with them; these are called test variables. The type of test variables that are identified here are intervening variables. An intervening variable is a consequence of the independent variable and a determinant of the dependent variable [Rosenberg 68]. Figure 1.1 shows a generic path model. The independent variable can positively or negatively impact the intervening variable. The intervening variable will then impact the dependent variable either positively or negatively.

![Figure 1.1: Generic path model.](image)

Case studies and interviews were used to evaluate the selected parts of the framework. These methods are most appropriate where the events are contemporary, no large body of

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\(^1\)Modeling allows the researcher to show "a simplified picture of a part of the real world" [Lave and March 75, p. 3]. It provides a representation of the field being studied while limiting the domain so that the field is understandable. It provides focus to the phenomenon of concern to the researcher.
evidence exists, there is little control over the events, and the research is exploratory in that it addresses the questions, "how?" or, "why?" [Yin 89]. The framework and models presented in this thesis are exploratory. Also, there is not a large body of evidence due to the recent acceptance of several of the project delivery systems. Finally, experimentation with delivery systems by this researcher would be nearly impossible. Therefore, case studies and interviews appear to be the best choice for research methods.

To achieve the objectives, the following steps were taken.

1. **Review relevant literature.**

   Critical success factors, project delivery systems, contracts, and organization theory literature, particularly transaction cost economics, provide an understanding of the current state of industry and help determine the key aspects of project delivery.

2. **Develop a framework to identify and demonstrate how costs are generated at different levels of the project organization.**

   IDEF1X is used to model the five levels of analysis in the project organization (individual, group, firm, inter-firm, and project) and the costs generated at each level. These costs are dependent on how they are organized. The framework is further developed for the project level of the organization. The IBPM [Sanvido 90], an IDEF0 model of the processes required to provide a facility, and the critical success factors are analyzed, and five different cost categories that are impacted by the project delivery system are identified.

3. **Develop path models demonstrating the specific cost impacts of different project delivery system choices.**

   Once the five primary cost categories impacted by the project delivery system are identified, the actual relationships between these cost categories and the project delivery system being used are defined. Transaction cost economics identifies the dimensions of a transaction and relates the cost of these dimensions to the level of integration of the firms involved in the transaction. It provides a theoretical foundation for explaining the relationships between project delivery and project costs. Path models help illustrate these relationships. In these models, the project delivery system, represented by level of contract integration, is the independent variable and the five cost categories identified in the process
model are the dependent variables. Intervening variables that help provide a theoretical explanation of the relationships between the independent and dependent variables are also present.

4. **Evaluate the framework through interviews and case studies of similar type projects.**

Throughout the explanation of the framework, examples from previous projects are provided as evidence for many of the relationships. These examples are from literature and work experience of this researcher. Anticipating the difficulties that would arise in attempting to measure all the variables and relationships in the framework, this researcher chose to concentrate on measuring and testing one of the models, the impact of the project delivery system on procurement costs. This model was chosen since the variables and relationships can be readily measured and tested.

Case studies of United States Postal Service (USPS) facilities were used to evaluate the relationships in the model. Also, key personnel on these projects were interviewed to verify whether expert opinion would support the relationships developed in the thesis. USPS projects were chosen for a number of reasons. Project complexity and owner type could be held relatively constant. Also, a large number of Postal Service projects are constructed each year which provided an adequate set of data. Finally, Postal Service projects were exclusively delivered with a traditional design-bid-build delivery system up until several years ago. Over the past few years, design-build has become a preferred delivery system. Therefore, a number of projects using the two delivery systems were available for comparison.

1.4. **Reader’s guide**

Chapter 2 presents a summary of the project delivery related literature and organization theory, particularly transaction cost economics. Chapter 3 provides an overview of the framework that identifies the different levels of analysis of the project organization and the types of costs generated at these levels. Five project organization levels and five cost categories at the project level of the organization are identified. In chapter 4, the relationship between the project level organization and one of the five cost categories, project procurement, is decomposed and explained. Specific variables are identified and path models show the relationships between them. Similarly to chapter 4, four other
models demonstrating the relationship between the level of contract integration and the
other project level costs are presented and described in chapters 5 through 8. Readers
interested in the models and the application of organization theory should read chapters 5
through 8 before continuing on with chapter 9. In chapter 9, the first model, the
relationship between the level of contract integration and project procurement cost, is
evaluated through case studies and interviews. The results are presented and discussed,
with possible modifications to the model identified. Readers more interested in the
measuring and testing of the models should skip to chapter 9 once finished with chapter 4.
Finally, in chapter 10, the research is discussed, critiqued, and concluded. Also, several
areas for future research are identified.
CHAPTER TWO

LITERATURE REVIEW

This chapter reviews several bodies of literature that were important in the development of this thesis. Project delivery related literature documents the lack of formal methodologies for selecting delivery systems. Next, relevant organization theory is examined. Finally, one area of organization theory, transaction cost economics, is explored as a primary foundation for this research and is explained in detail.

2.1. PROJECT DELIVERY LITERATURE REVIEW

The key literature related to project delivery includes critical success factors, project delivery systems, and contracts. These bodies of literature are relevant to understanding the current state of the construction industry and determining the key aspects of project delivery.

2.1.1. Critical success factors

Critical success factors are "those few things that must go well to ensure success for a manager or organization, and therefore, they represent those managerial or enterprise areas that must be given special and continual attention to bring about high performance" [Boynton and Zmund 84]. Approximately twenty studies were reviewed and summarized.

A total of fourteen different factors were identified from the studies. Most of the factors related to project organization, project team behavior, communication of information, and contracts. These are integral parts of project delivery and demonstrate its importance for achieving a successful outcome of a project. It appears that integrated design and construction approaches may provide an atmosphere where these factors may be more easily achieved. However, since integrated approaches are still only used on a small percentage of today's projects, the success factors may not provide a complete picture; there must be some tradeoffs (e.g., production costs) to achieving these factors.
2.1.2. Project delivery systems

Several project delivery systems including traditional, owner construction, construction management, multiple primes, and design-build were defined in chapter one. The American Institute of Architects [AIA 87] identified two essential questions that must be answered for project delivery. (1) Are design and construction single or separate responsibilities, and (2) are they sequential or overlapped? The answer to the second question is heavily influenced by the outcome of the first decision. Therefore, one of the primary distinguishing features of project delivery systems is the level of contract integration for services. Contracts were found to actually be integrated along two dimensions. The first dimension is process. Design and construction processes can be contracted for separately or under a single integrated contract. The second dimension is building systems. The processes of design and construction can be divided or integrated and then contracted out for a number of building systems.

Few tools exist to help the owner make the project delivery selection, and, as a result, different delivery systems are being used with varying degrees of success. Several authors have examined factors affecting the choice of a project delivery system [AIA 76, AIA 87, Barrie 84, Barrie and Paulson 92, Building Futures Council 94, Bynum 83, Fazio 88, Hinze 93, Ndekguri and Turner 94, Lynch 95], but typically, these discussions focus on the advantages and disadvantages of each system. Several key criteria used for comparison include: quality, cost, timeliness, responsibility, and general appropriateness of the approaches.

These advantages and disadvantages have evolved into decision support tools to help owners choose the “right” delivery system to match the needs and characteristics of a particular project [Vesay 91, Mohsini 93, Tatum and Fawcett 86, Al-Sinan and Hancher 88, Kirschenman 86]. These methods are based on opinions and small sample case studies of project successes and mishaps.

2.1.3. Contracts

A contract is a legally binding agreement between two or more parties to exchange something of value [Sweet 88]. According to Sweet, the principle function of enforcing a contract is to encourage economic exchanges that lead to economic efficiency and greater
productivity. They are a key element of project delivery since they define the relationships and desired behavior of the firms involved on a project. Contract literature was reviewed to determine the key elements of a contract and to find how contracts are affected by the different project delivery systems.

Three broad classifications of contracts exist: classical, relational, and neoclassical [Macneil 74]. Classical contracting is where buyers and sellers meet for an instant to exchange standardized goods at equilibrium prices. Relational contracting refers to situations in which long term relations are established between companies so that they are mutually dependent on each other. The reference point for contracting is the entire relationship as it has developed through time. Neoclassical contracts describe long-term agreements under conditions of uncertainty for which complete presentation of actions for all outcomes is costly. Third party assistance may be used in resolving disputes and evaluating performance. The problems with neoclassical contracts are that not all future contingencies for which adaptations are required can be anticipated at the outset; the appropriate adaptations will not be evident for many contingencies until the circumstances materialize; and since changes are often ambiguous, contracting may well give rise to disputes [Macneil 74]. In construction, the owner is typically responsible for the cost impacts (change orders) resulting from incomplete complex contracts.²

The AIA documents for traditional contracting define three different parties: the owner, architect, and contractor. In this arrangement, the architect provides third party assistance and acts as an agent of the owner. An agent is one who performs work on behalf of another, called the principle, and in doing so, the acts of the agent are binding. An agency relationship is one based on trust and loyalty. On the other hand, the contractor and owner relationship is a commercial arms-length one where each party looks out for their own best interest [Sweet 88].

A design-build contract represents the most radical departure from the traditional agreements since the design-build delivery system changes the roles of the parties involved and the basic character of the exchange. The design-build contract refers to only two

²For this research, the term “contract” refers to the written agreement between two parties as well as other documents, such as drawings and specifications, that describe the scope of their exchange.
parties: the owner and design-builder. There is now a single source of responsibility for both the design and construction of the facility, and the owner has no contractual commitment to any third party. Also, the owner is no longer contracting for design and construction services. The owner is now contracting for the purchase of a product. The design-build team is responsible for the complete design and construction of a facility to meet the performance requirements specified by the owner [DBIA 94]. The owner can now hold the design professional and/or constructor liable for any defects or omissions in the design and construction of a facility.

2.1.4. Summary of project delivery related literature

The following is a summary of some of the key points realized through the project delivery related literature review:

- Many of the critical success factors are directly related to project delivery. Factors include project organization, project team behavior, communication of information, and contracts. Integrated approaches appear to provide a better environment for achieving these factors, however, cost trade-offs must exist in achieving these factors.

- There are several available project delivery systems and the research typically lists advantages and disadvantages of each system developed from opinions and cases.

- The primary distinguishable feature of project delivery is the level of contract integration. Integration occurs along two dimensions: process and building systems.

- All complex contracts are incomplete since they cannot anticipate at the outset all future contingencies for which adaptations are required. Complex contracts are costly to write and monitor.

- Traditional project delivery is neoclassical contracting where the architect provides third party assistance and acts as an agent to the owner. An agency relationship is one based on trust and loyalty. The contractor and owner relationship is a commercial arms-length one where each party looks out for their own best interests.
• An owner in a traditional project delivery system is contracting for services and is
typically responsible for compensating for cost impacts due to incomplete
information in the contracts. An owner in an integrated approach is contracting for
a product to meet a set of functional requirements and can therefore hold design-
builder liable for defects or omissions.

Although the project delivery related literature was informative, nowhere did it provide
a framework or a systematic means for evaluating and choosing a project organization for
construction. The outcomes described in the lists of advantages and disadvantages and
success factors do not help provide an understanding of the underlying principles causing
them. Therefore, organization theory was examined next to seek out a theoretical
foundation for understanding the impacts of different project delivery systems.

2.2. Organization theory

In this section, definitions for organizations and organization theory are first presented.
Several theories are then reviewed.

2.2.1. What is an organization?

Organizations are social entities that are goal-directed, deliberately structured activity
systems with an identifiable boundary [Aldrich 79]. This definition may need more
explanation. Organizations are composed of people and groups of people who interact with
each other to perform essential functions. They exist for a purpose, and their members
work towards this mission. An activity system means that an organization performs work
activities. The organization is deliberately subdivided to perform these activities and to
achieve efficiencies in the work processes. This deliberate structure is used to coordinate
and direct the separate groups and departments. The boundary identifies which elements
are inside and which are outside the organization. Membership is distinct, and the
members normally have some commitment to contribute to the organization in return for
money, prestige, or other gain [Daft 92].
2.2.2. What is organization theory?

Organization theory is a way to view and analyze organizations more accurately and deeply than one otherwise could. The way to see and think about organizations is based upon patterns and regularities in organizational design and behavior. Organization scholars search for these regularities, define them, measure them, and make them available to the rest of us [Daft 92].

Organization theory focuses on the organizational level of analysis but with concern for groups and the environment. To explain the organization, one should look not only at its characteristics but also at the characteristics of the environment and of the departments and groups that make up the organization. Organization theory is distinct from organizational behavior. Organizational behavior is the micro approach to organizations because it focuses on the individuals within organizations as the relevant units of analysis. Organizational behavior examines concepts such as motivation, leadership style, and personality, and is concerned with cognitive and emotional differences among people within organizations. Organization theory is a macro examination of organizations because it analyzes the whole organization as a unit. It is concerned with people aggregated into departments and organizations, and with the differences in structure and behavior of the organization level of analysis. Organization theory is the sociology of organizations, while organizational behavior is the psychology of organizations [Daft 92].

2.2.3. Organization theory

Numerous theories of organization have evolved. The different theories in many ways overlap but typically take on different perspectives or different units of analysis. This section briefly describes some of the history and different schools of thought on organization theory. This in no way represents a complete summary of organization theory. Many theories have not been addressed, and each one presented has many texts devoted to them. The summary presented here is to recognize some of the theories that have contributed to this researcher’s understanding of organizations.
2.2.3.1. Classic management perspective

The modern era of management theory began early in this century with the classical management perspective, which included both scientific management and administrative principles approaches. Scientific management, pioneered by Frederick Taylor [1911], claimed decisions about organization and job design should be based on precise, scientific procedures after careful study of individual situations. Administrative principles focused more on the total organization and grew from the insights of practitioners. Henry Fayol proposed fourteen principles of management such as each subordinate receives orders from only one superior and similar activities in an organization should be grouped together under one manager [Daft 92].

The principles from classical management theory have worked and are still working, for they address themselves to very real problems of management, problems more pressing for managers than those discussed by social science [Perrow 86]. Project management and the various project management techniques such as linear responsibility charts and network analysis are modern extensions of classical management theory.

2.2.3.2. Project management

There is little literature on construction management that is not about project management. In the view of Cleveland and King [1968], the main purpose of project management is to provide a “unifying agent” across the various functions of the organization in the face of uncertainty and complexity. However, project management discusses relationships within organizations and not among organizations, as is found on construction projects. Project management addresses the question of how to organize to meet contractual commitments. This is a different question from that of how do these firms organize themselves to meet a client’s requirements, and it also does not include the issue of transactions between firms. While the short-term goal of the firms in a project organization may be the successful completion of the project, their longer term goals of survival and growth as firms may be divergent [Winch 89].
2.2.3.3. Human relations perspective

In addition to classical management theory, other academic approaches emerged. The Hawthorne studies [Whitehead 38] showed that positive treatment of employees increased motivation and productivity and laid the groundwork for subsequent work on morale, leadership, motivation, productivity and human resource management. The human relations theorists sought to restore individuals with their needs and drives, to a central place in organization theory, a place denied them by classical management theory. Many of these theories should be considered with organizational behavior literature since many of them focus on the individual.

2.2.3.4. Bureaucracy

The work of sociologists on bureaucracy, beginning with Weber, appeared in the 1950s and 1960s and helped establish the notions of bureaucracy [Daft 92]. Weber believed that bureaucracy would assist organizations. He proposed a set of organizational characteristics that would ensure efficient functioning in both government and business settings. The six characteristics include rules and procedures, specialization and division of labor, hierarchy of authority, technically qualified personnel, separate position from position holder, and written communication and records [Weber 47].

2.2.3.5. Decision making

Later, organizations came to be characterized as rational, problem-solving, decision-making systems. March and Simon [1958] were concerned with the organization as a problem of social psychology and spoke to organizational rather than to individual decision making. Several important terms and theories emerged from this work including satisficing behavior and bounded rationality. Satisficing is the practice of selecting an acceptable goal or alternative solution rather than the maximum or optimum solution possible [Simon 56]. Simon used this concept in decision-making to describe how a person making a decision may look for alternatives and then select one from experience that will provide a reasonable result. Bounded rationality emphasizes the limitations of the individual’s rationality [Simon 56]. Often the factors involved in a decision may be too numerous and complex for the decision maker to understand completely. The decision-maker will attempt to make rational decisions based on this limited knowledge. Bounded rationality will be described in greater
detail later in the chapter. Many subsequent theories were developed to describe the
decision-making process. These theories are useful in analyzing a decision, such as the
decision for construction firms whether to pursue a project or not [Messner 94], but have
less utility when trying to analyze the construction project organization as a whole.

A great many problems occur when all organizations are treated as similar, which was
the case with both the administrative principles and bureaucratic approaches that tried to
design all organizations alike. Contingency means that one thing depends upon other
things, or that an organization’s characteristics depend upon the total situation. What
works in one setting may not work in another setting. There is no one best way. Two
important viewpoints include the role of technology and that of environment on
organizational choices.

2.2.3.6. Technology

The potential importance of technology as a factor in organizational structure was
discovered during the 1960s [Porrow 86]. Research was undertaken to understand more
precisely the relationship of technology to other characteristics of organizations.

Woodward [1965] researched manufacturing technology and found clear relationships
between technology and structure. She developed a scale of technical complexity with
three basic technology groups: small-batch production, large-batch production, and
continuous process production. The management systems for small-batch production and
continuous process production were more free flowing and adaptive, with fewer
procedures and less standardization. Large-batch production, or mass production, was
more mechanistic with standardized jobs and formalized procedures. Woodward stated,
"Different technologies impose different kinds of demands on individuals and
organizations, and those demands had to be met through an appropriate structure"
[Woodward 65]. Construction may be positioned in the small-batch production technology
since most all facilities and the environment in which they are built are unique for each
project. There has been some movement towards mass production and subsequent
standardization in the construction industry, especially in the manufactured housing
segment.
Other researchers noted that service technologies differ from manufacturing technologies. Service technologies are characterized by intangible outcomes and direct client involvement in the production process. Service firms do not have the fixed, machine-based technologies that appear in manufacturing organizations; hence, organization design often differs [Daft 92]. Construction does not appear to fall neatly into either service or manufacturing technologies. It has characteristics of both a service and manufacturing technology.

Perrow [1967] established a framework for classifying a department's technology. Understanding the variety and analyzability of a technology tells one about the management style, structure, and process that should characterize that department. Routine technologies are characterized by mechanistic structure, and nonroutine technologies by organic structure. This theory may have application to construction due to the large variation in types of facilities constructed. Very simple, generic types of facilities such as warehouses may require different types of organization structure than a highly specialized, complex facility such as nuclear power plant.

Another important idea is the interdependence among departments [Thompson 67]. The extent to which departments depend on each other for materials, information, or other resources determines the amount of coordination required between them. As interdependence increases, demands on the organization for coordination increase. Organization design must allow for the correct amount of communication and coordination to handle interdependence across departments. Three types of interdependence were identified: pooled, sequential, and reciprocal. For pooled interdependence, low communication is needed between departments and they can be coordinated through standardization, rules, and procedures. Sequential requires more communication and can be coordinated through plans, schedules, and feedback. Finally, reciprocal requires a high amount of communication and coordination. Techniques for coordination include mutual adjustment, cross-departmental meetings, and teamwork [Thompson 67]. This theory is useful for demonstrating the types of coordination that may be needed between construction firms involved in a project. However, the relations between firms, often with differing goals, are dictated by contracts. Therefore, this theory and the methods of coordination cannot be directly applied without taking into consideration the characteristics of the construction project organization.
Galbraith [1974] followed Thompson's work and put his ideas into a larger framework of information processing. His basic proposition was that the greater the uncertainty of the task, the greater the amount of information that has to be processed between decision makers during the execution of the task. Several strategies were presented for increasing the information processing capabilities of the firm including the establishment of rules, hierarchical referral, goal setting, reduction of the need to process information, and increase the capacity to process information. To reduce the need to process information, a firm may create slack resources or create self-contained tasks. To increase the capacity to process information, a firm may invest in vertical information systems or create lateral relations [Galbraith 74]. Each of these strategies has increasing costs associated with them so the choice of a strategy is an important decision.

Hammer and Champy use some of these same ideas in their work on reengineering [1993]. They concentrate on redesigning processes and suggest the creation of self-contained tasks. Also, they stress the importance of the use of new information technologies as a means for integrating and coordinating tasks.

2.2.3.7. Environment

The next group of theories takes the environment as the central focus. The change and complexity in environmental domains has major implications for organization design and action. Many organizational decisions, activities, and outcomes can be traced to stimuli in the external environment. Organizational environments differ in terms of uncertainty and resource dependence. Organizational uncertainty may be the result of stable-unstable and simple-complex dimensions of the environment [Duncan 72]. Resource dependence is the result of scarcity of the material and financial resources needed by the organization. Organizations try to survive and achieve efficiencies in a world characterized by uncertainty and scarcity [Aldrich 79].

An important concept is that of buffering and boundary spanning [Thompson 67]. Organizations are open systems that are involved with many external elements. Specific departments and functions are created to deal with uncertainties. The organization can be conceptualized as a technical core with departments that buffer environmental uncertainty. Boundary-spanning roles provide information about the environment [Thompson 67]. This plays an important role when discussing the organization of construction projects
since the project organization is actually a temporary organization of firms. Each of the firms involved in the project will try to buffer themselves from the environment and other firms. To effectively integrate and coordinate the construction process, these buffers may need to be reduced. One important option to consider is the movement of these processes from separate firms into a single firm.

A second important theory recognizes that varying levels of differentiation and integration that may take place among departments in response to environmental uncertainty [Lawrence and Lorsch 69]. When the external environment is complex and rapidly changing, organizational departments become highly specialized to handle the uncertainty in their external sector. One outcome of high differentiation is that coordination, or integration, between departments becomes difficult. Therefore, as differentiation increases so does the need for integration. Lawrence and Lorsch [1969] concluded that organizations perform better when the levels of differentiation and integration match the level of uncertainty in the environment. Winch [1989] points out that this theory was used to analyze the responses of organizations to environmental uncertainty but argues that this is one of the few uncertainties that construction firms do not face to any great extent. He states that the changes in the economic environment, the construction market, and construction technology do not change very rapidly. He suggests that the uncertainties that construction firms face is within the construction process that causes most of the problems. Secondly, the main element of differentiation in the construction project is between firms, not within them [Winch 89].

One last theory related to environment is resource dependence [Ulrich and Barney 84]. The environment is the source of scarce and valued resources essential to organizational survival. Resource dependence means that organizations depend on the environment but strive to acquire control over resources in order to minimize their dependence. Organizations are vulnerable if vital resources are controlled by other organizations, so they try to be as independent as possible. However, when costs and risks are high, companies also team up to reduce resource dependence and the possibility of bankruptcy [Ulrich and Barney 84]. This theory makes an attempt to explain the relationships between firms and why they may join together. However, it does not address the role of contracts on the relationship between firms and does not treat the joining of firms as an issue of efficiency.
2.2.4. Conclusion of organization theory

Most of the theories described in the previous section were developed for the examination of relationships within organizations. However, integration in construction projects means the integration of firms, not departments or functions. These theories do not address the relationships between firms and the impact of contracting on the relationship. This is not to say that these theories do not have a use in construction. Rather, a theory for construction project organizations must also take into account the nature of construction with temporary organizations of firms with divergent goals. Transaction cost economics may well be able to help explain the construction project organization since it incorporates some of the organization theory previously presented with the impact of contractual relationships between firms.

2.3. Transaction cost economics

Transaction cost economics borrows from organization theory, including the work of Simon [1958] and Thompson [1967], as well as contract theory [Macneil 74], and economics. This theory appeared to have the best potential for providing an understanding of construction project organizations since it attempts to explain where the boundaries of an organization should be. It also takes into account the nature of the construction project organization with its inter-firm relationships dictated by contracts. Oliver Williamson [1975] developed this theory and remains one of its main proponents.

The main premise of transaction cost economics is that, in addition to the costs of production, there are also costs of transactions between parties. When transaction costs are high, it is argued that it is cheaper to transact within a firm rather than between firms. The key is to assess the efficiency properties of alternative contracting modes. A market and a firm are two alternatives for completing a set of transactions. A market transaction is one that involves an exchange between firms, and a firm transaction is one that occurs within a single hierarchy. The choice between the alternatives depends on the relative efficiency of each mode. Trade-offs between production and transaction costs must be weighed.

Williamson [1975] identified a set of environmental factors which when combined with a set of human factors explains the circumstances under which transactions may become costly. Faced with such difficulties, the firms may then decide to bypass the market and
move the transactions within a single firm, governed by administrative processes. He argued that if transaction costs are negligible, the organization of economic activity would be irrelevant since any advantages one mode of organization would appear to have over another will simply be eliminated by costless contracting. However, this is not the case [Williamson 75].

2.3.1. Terminology

There are four primary terms repeated throughout Williamson's work: uncertainty and complexity, small-numbers bargaining, bounded rationality, and opportunism. The pairing of uncertainty with bounded rationality and small numbers with opportunism are especially important.

Bounded rationality was defined by Herbert Simon as, "The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behavior in the real world." Bounded rationality refers to human behavior that is "intendedly rational, but only limitedly so" [Simon 61]. There are both physical limits and language limits. Physical limits include limits on the powers of individuals to receive, store, retrieve, and process information without error. Language limits are the inability of individuals to articulate their knowledge or feelings by the use of words, numbers, or graphics in ways which permit them to be understood by others.

The limits of rationality are reached under conditions of uncertainty and/or complexity. Complexity may be referred to as the number of possible outcomes of a situation, while uncertainty is the degree to which all the possible outcomes can be considered or identified. In the absence of either of these conditions, the appropriate set of contingent actions can be fully specified at the outset in the contracts. Long-term contracts, however, are impeded by bounded rationality considerations since the extent to which uncertain future events can be expressly taken into account is limited. Given opportunism, contracts that cannot anticipate all possible outcomes may pose interest conflicts between the parties. Organization theories related to technology [Woodward 65, Perrow 67, Thompson 67, and Galbraith 74] and environment [Aldrich 79, Thompson 67, Lawrence and Lorsch 69, and Ulrich and Barney 84] are useful in identifying sources of uncertainty and complexity.
Opportunism refers to a lack of candor or honesty in transactions or "self-interest seeking with guile" [Williamson 75]. It involves making false or self-disbelieved statements in the expectation that individual advantage will be gained. If opportunism did not exist, long-term, complex contracts would not be necessary. Work could be performed by contractors in an adaptive, sequential manner, and owners could reimburse them for their effort. Since contractors and owners may be prone to opportunistic behavior, an effort must be made to anticipate all contingencies or outcomes and spell out terms in the contracts much more fully than would otherwise be necessary [Williamson 75].

Also, since contractors may act opportunistically on a detailed agreement (e.g., substitute cheaper materials than those specified), the agreement needs to be monitored. Therefore, integrating processes within a firm may occur because it permits economies to be realized in both initial contracting and monitoring respects.

Small numbers bargaining describes a weak competitive environment where there are few contractors for an owner to choose from. Opportunistic inclinations pose little risk as long as there is strong competition among contractors. With the absence of small numbers competition, rivalry among large numbers of bidders will minimize opportunistic inclinations. It is in the interest of each party to seek terms most favorable to him, which encourages opportunistic representations and haggling. Small numbers situations may also arise once a contract is signed between the owner and contractor and is subject to opportunistic behavior on changes to the contract [Williamson 75].

Williamson characterizes a transaction by the amount of uncertainty and complexity, the level of competition, the transaction investment specificity, and the frequency of transacting. Uncertainty, complexity, and competition have been described.

Transaction investment specificity represent the degree to which assets used in a transaction can not be used in other exchanges, e.g., Hensel Phelps Construction Company developed customized formwork for the Tabor Center project in Denver, CO that could not be reused on other projects. Items that are unspecialized are less costly to owners and contractors since owners can easily turn to alternative sources, and contractors can use the assets from project to project without difficulty. Transaction investments can be in the form of specialized physical capital, human-capital, and interface investments between parties involved in the transaction. For project delivery, the key transaction investment is
in the form of interface investments. Parties and individuals who have worked together, or have experience as a team, have made an investment in developing their relationships; efficient means of communication may evolve and be employed by the parties so that complex events can be handled in an informal way [Williamson 75]. When firms new to each other are working together on a project, time will need to be spent developing a working relationship and understanding the capabilities of the other firms and personnel involved. This has important consequences for construction issues such as constructability, development and communication of information, and troubleshooting of problems.

The frequency of transacting refers to the number of potential future exchanges that may occur between two parties. Frequency of transacting may be considered one time, occasional, or recurrent. The frequency of transaction affects the degree to which opportunism plays a role. If the frequency of a transaction is high, there will be a greater interest by the parties in sustaining the relationship. Therefore, the temptation to act opportunistically should be limited.

A related concept to those presented thus far is information impactedness. It exists when true underlying circumstances relevant to the transaction are known to one or more parties but cannot be costlessly discerned by or displayed for others. The reason why outsiders are not on a parity with insiders is usually because outsiders lack firm-specific, task-specific, or transaction-specific experience. Such experience is a valuable resource and can be used in strategic ways by those who have acquired it. Information impactedness arises mainly because of uncertainty and opportunism, though bounded rationality is involved as well.

Information impactedness can occur before and during contract execution. If information is asymmetrically distributed between the parties to an exchange, then the exchange is subject to hazards. It is asymmetry coupled with the high costs of achieving information parity and the proclivity of parties to behave opportunistically that poses the problem. Information impactedness will not impair a market exchange if the parties are not opportunistic, an unbounded rationality condition exists, or a large-numbers competition condition exists. If all of these conditions do not exist, shifting the transaction from the market to a hierarchy should eliminate opportunism. Information impactedness arises in construction. The inexperienced owner will often hire agents to help achieve information
parity and limit opportunistic behavior. The relationship between general contractors and specialty subcontractors is also subject to information impacted situations.

The key terms of transaction cost economics have been explained. Next, the impact these terms have on the organization of work is presented.

2.3.2. Impact of transaction cost economics on organizations

When applying transaction cost economics to construction organizations, the main criteria for choosing a delivery system should be cost economizing. Economizing has two components: economizing on production expense and economizing on transaction costs. One of the problems of economizing includes the choice between a special-purpose and a general-purpose item or service. A general-purpose item affords all of the advantages of market procurement, but possibly at the sacrifice of valued design or performance characteristics. A special-purpose item has the opposite features: valued differences are realized but market procurement may pose hazards [Williamson 75]. An example in construction terms may be an owner having to choose between a generic type facility and an architecturally unique facility.

If transaction costs are negligible, buying rather than making will normally be the most cost-effective means of procurement. Not only can static scale economies be more fully exhausted by buying rather than making, but the supplier who aggregates uncorrelated demands can realize collective pooling benefits [Williamson 75]. This is a key consideration for construction firms contemplating the development of additional in-house capabilities.

Organizing tasks within a firm holds several advantages to a market when opportunism and small-numbers exist. First, parties to an internal exchange are less able to obtain subgroup gains at the expense of the overall organization by opportunistic representations. Second, internal organization can be more effectively audited. Finally, when differences do arise, internal organizations have an advantage over market in dispute settling respects [Williamson 75].

When an exchange has a high amount of uncertainty and complexity, organizing within a single firm holds several advantages over a market. First, firms can deal with uncertainty and complexity in an adaptive, sequential fashion without incurring the same types of
opportunities or hazards that market contracting would pose. Rather than specifying the entire decision tree in advance, and deriving the corresponding contingent prices, events are permitted to unfold and attention is restricted to only the actual rather than all possible outcomes. Second, efficient means of communication and methods of working together may evolve and be employed so that complex events can be handled in an informal way. This may, however, also evolve with firms that frequently work together. Third, it is more likely that individuals within a firm will have similar goals. Therefore, a firm may help to reduce divergent expectations [Williamson 75].

For some transactions, a shift from one structure to another may permit a simultaneous reduction in both the expense of writing a complex contract and the expense of executing it effectively in an adaptive, sequential way. The shift of a transaction or related set of transactions from market to hierarchy is not all gain, however. Flexibility may be sacrificed in the process and other bureaucratic disabilities may arise as well. Also, there may be a trade off in production costs [Williamson 75].

Transferring a transaction out of the market into the firm still leaves open the matter of how these transactions are going to be organized internally [Williamson 75]. Two propositions are relevant:

1. just as market structure matters in assessing the performance properties of market organization, so does internal structure matter in assessing alternative internal modes; and

2. transaction costs are central to performance assessments of both kinds. By holding the degree of vertical integration constant, the choice between alternative internal modes for organizing successive stages of production turns mainly on transaction cost rather than technological considerations.

2.3.3. Analysis through transaction cost economics

Williamson [1987] notes that in most previous studies, the firm is characterized as a production function. In this view of the firm, economizing takes the form of efficient choice of factor proportions. Issues relating to the organization of work and the subsequent transaction costs rarely surface under the production function approach. A comparative institutional assessment of the properties of alternative modes thus replaces the
conventional calculation of cost minimization. By holding technology constant, one can examine whether transaction cost savings are realized by organizing one way rather than another. This can be done by examining the design and construction of similar types facility procured with different delivery systems.

Williamson [1987] suggests that the question of optimal work organization is poorly posed when stated in terms of a hierarchy's existence or its absence. Attention should be shifted to whether reliance on the hierarchy is excessive (generates adverse side effects) and whether appointments to hierarchical positions are made in a way that both promotes efficiency and commands general respect. A well-working system is one that matches work modes with job attributes and worker preferences in a discriminating way.

Williamson [1987] notes that different modes of organization must be compared, and he provides a methodology to facilitate this assessment. This thesis attempts to make use of this methodology. The basic steps are as follows:

1. focus on a specific production process (e.g., design and construction) and identify the relevant transaction cost dimensions for assessing performance,

2. expressly describe alternative organizational modes, across which the degree of hierarchy varies (e.g., traditional and design-build delivery methods), for accomplishing the task,

3. perform a comparative evaluation of each mode with respect to a common set of performance and transaction cost attributes.

2.3.4. Previous applications to construction

Torger Reve and Raymond E. Levitt [1984] made the point that transaction cost analysis provides a viable theoretical perspective for the study of organization and governance in construction. However, they go on to concentrate on the traditional project organization of trilateral governance of a client, engineering consultant, and contractors instead of using it to compare alternative modes of project delivery. Most of the paper reviews what the traditional mode of organization is and what types of relationships currently exist on projects. The authors use the theory to identify possible ways to reduce transaction costs within the traditional arrangements. The discussion in this paper is strictly
theoretical with no empirical evidence. The paper identifies and discusses the implications of a professional relationship between the client and the consultant and a clan-type relationship between the consultant and the contractors within the context of large construction projects.

The relationship between the client and engineering consultant in construction does not always meet all professional standards, and the relationship between the engineering consultant and the various contractors is not always characterized by cooperation and trust. The alternative is commonly to use costly surveillance and control systems which should be considered a second-best alternative to truly professional and clan-type relationships [Reve and Levitt 84].

Grahm Winch [1989] makes a better attempt at applying the transaction cost theory. He suggests that, in spite of their considerable usefulness of previous organization theory, they contain no framework for analyzing the inevitable differences in interest between the different firms that are members of the project organization. He goes on to show how the transaction cost approach allows for these differences to be analyzed.

He identifies some of the sources of uncertainty and complexity. He argues that the market is not complex since for the most part, the range of potential clients and the range of potential competitors is well known. He also believes that technological change offers little uncertainty since the rate of technological change in the construction industry is relatively slow. The main sources of uncertainty in construction are identified as task uncertainty, natural uncertainty, organizational uncertainty, and contracting uncertainty. Construction is identified as small batch production. Each project requires new design work, and new production problems to be solved, but by the time these are solved the project has ended and not all expertise gained is transferable. Natural uncertainty includes the environment with its unpredictable weather. Organizational uncertainty is identified as a function of project size. The tensions within the temporary organizations are enhanced with increasing numbers of organizations. If a firm has not worked with the other firms, they do not know how well the relationship will work. The first three sources of uncertainty above are caused by the site-specific nature of production in construction. Winch notes that good management might be able to reduce them. For contracting uncertainty, Winch notes that estimating is not an exact science. The assessment of the project during estimating presents a great amount of uncertainty, especially since the uncertainty is often the burden of the
contractor once the contract has been signed. Errors in estimating are also likely to involve
the omission of costs rather than the addition. Secondly, each contract represents a high
proportion of total turnover for most firms, small changes in the bidding success rate can
lead to large changes in levels of turnover.

Intra-organizationally each firm is structured on the basis of pooled interdependence.
Inter-organizationally, the firms within each project organization are structured on the basis
of sequential interdependence through a series of market transactions. In terms of process,
the firms are bound together by the flows of information and materials in between. These
flows are largely financed by the client through interim payments, and largely controlled by
the firms who allocate productive resources to the project.

Winch believes that this high level of market governance of transactions has led to the
sum of transaction and production costs being greater than if similar transactions were
carried out under hierarchical governance. While there is a lot of data available on
production costs, very little is known about the scope and magnitude of transaction costs.

Based on transaction cost economics, Winch argues that the rational response to the
project uncertainty, project complexity, and post-contract bilateral monopoly situation
identified above would be to move these processes in to a single firm. This would
economize on bounded rationality due to uncertainty and complexity. In particular, the
designer/main contractor, and main contractor/specialist subcontractor transaction interfaces
could be beneficially governed by hierarchy rather than the market. Hierarchy would ease
the transfer of expertise from one project to another; greatly enhance feedback when
technical problems are encountered; reduce response times when natural uncertainties are
met; and greatly reduce organizational uncertainty as an established project organization
could be transferred from one project to another. As far as complexity is concerned,
feedback as the detail of the construction project task unfurls would greatly ease the
adjustments that would need to be made to the elements overlooked.

Hierarchy would also economize on the directly quantifiable element of market
transaction costs. These include preparing contract documents; multiplicated estimating
effort by subcontractors; external arbitration in disputes; and increased contract
management effort by owners, designers, construction managers, and contractors as each
party tries to limit opportunistic behavior by the others. Thus, hierarchy could significantly reduce management overheads.

Why then has there been little or no shift towards hierarchy? Two possible explanations are explored: existence of powerful market forces pulling the opposite direction and the existence of institutional barriers to market forces.

The major force pushing the industry towards the market governance of transactions may be the response to contracting uncertainty. The high level of uncertainty has lead to an emphasis upon flexibility rather than efficiency. The emphasis upon flexibility encourages firms to reduce commitment to fixed capital and therefore limits technological change, and commitment to human capital and therefore reduces the investment in training.

Construction firms are encouraged to subcontract and subcontract again to reduce the problems of contracting uncertainty and to gain maximum flexibility. Market governance is not chosen in order to gain competitive reductions in production costs, but to minimize fixed assets. Strategies which improve the performance of construction firms in terms of profit maximization are incompatible with the effective management of the project and strategies to improve the provision of the built environment. Project activity is seen mainly as a source of cash flow. Many companies aim to be a cash rich rather than an asset rich business, preferably the client’s cash.

Additionally, institutional pressures of bureaucratic inertia and professional autonomy exist. To retain their relative economic and social power, professions must exclude others from their sphere of expertise. At the same time they must maintain their professional ethic in the exercise of their monopolized expertise.

2.3.5. Summary of transaction cost economics

Most of the work on transaction cost economics has been done by Oliver E. Williamson, who also originated the theory. The theory is relatively new as a method of studying organizations and has come under some criticism of other organizational researchers who support other theories. Transaction cost economics seems particularly applicable to construction projects due to the number of separate firms often involved and the related transaction costs incurred. The rise in the use of design-build seems to be best explained by a transaction cost analysis. However, there is still debate on the proper
project delivery method. The existing modes of organization need to be compared. A framework for analyzing and measuring the relative efficiency of different project organization structures, in terms of their production and transaction costs, could be valuable to the industry.

2.4. Summary

Project delivery related literature including project success factors, advantages and disadvantages of project delivery systems, and contracts were first reviewed. These provided useful information but no theoretical basis for comparing delivery systems. Organization theory was explored next with many of these theories providing valuable tools for evaluating and analyzing construction project organizations. However, most of these theories address intra-firm concerns rather than inter-firm. Finally, transaction cost economics, an economic theory of organizations, was identified as potentially the most useful theory for construction since it takes into account the inter-firm nature of the industry. This theory and previous attempts at applying it to construction were discussed. The remainder of this thesis attempts to apply this in demonstrating the impacts of project delivery on project costs.
CHAPTER THREE

THE PROJECT ORGANIZATION COST IMPACT FRAMEWORK

This chapter provides a description of the Project Organization Cost Impact Framework that is the basis of this thesis. The framework identifies the different levels at which organization-related decisions can be made and demonstrates the impacts of these organizational choices on several categories of project level costs. The framework is developed to different levels of detail in chapters four and five and provides a basis for a long term research agenda.

The first step in understanding the impact of project organizations on costs, is identifying the different levels within the project organization at which costs are generated. The balance of the chapter identifies the cost categories that are impacted.

3.1. LEVELS OF ANALYSIS OF THE PROJECT ORGANIZATION

For this study of building project organizations, the five levels of analysis explained below are the individual, group, firm, inter-firm, and project.

3.1.1. Individual level

The lowest level of analysis of a project organization at which costs are generated is the individual. At the “individual” level, a single person may perform all the tasks needed to provide a product or service. All the work that the single individual performs would be considered direct work. Direct work activities are those performed by individuals which contribute to a final contracted product. For example, if a brick wall needs to be built, an individual may perform all the bricklaying functions to construct that wall.

3.1.2. Group level

The next highest level of analysis is the group level. If a task requires multiple skills, a higher production rate, or if it is impossible for one individual to complete it safely, then
several individuals may need to be involved. These individuals together may be considered a “group.” Two examples of groups are a department in an engineering office and a crew on a construction site.

When individuals perform in a group, they spend time on direct work activities. They must also interact with each other to organize, coordinate, and distribute the work, and to communicate information. Several mechanisms are available to assist with these activities including routines, rules, standards, plans, schedules, mutual adjustment, and feedback [Thompson 67]. There are different costs associated with each mechanism, and the choice between them depends on the work type of their organization. These costs will be considered “group level organization/transaction costs.” To minimize these costs, many groups are organized around similar tasks, e.g., iron workers, or around similar products, e.g., a structural steel bolt up crew. Figure 3.1 illustrates how individuals are joined together to form a group using an IDEFIX [1985] format.

![Diagram](image)

Figure 3.1: Group Level Organizations

3.1.3. Firm level

As the work to be done becomes more involved and more complex, groups may be joined together to form a “firm.” A firm provides employment to individuals and allows
groups to share overhead. A firm also typically performs other activities such as finding work, recruiting a work force, and paying individuals performing work.

A firm must interact with the environment to survive; it both consumes resources and exports resources or services to the environment. It must continuously change and adapt to the environment. The firm has to find and obtain needed resources, interpret and act on environmental changes, dispose of outputs, and control and coordinate internal activities in the face of environmental complexity and uncertainty. Organizations tend to buffer their production subsystem from these uncertainties and complexities of the environment by creating functions to interact with the external world [Thompson 67]. Boundary spanning subsystems play this role by handling input and output transactions with the environment and reducing their uncertainty and complexity. For example, a purchasing department acts as a boundary spanning department on the input side of a firm [Katz and Kahn 78].

The costs generated from these additional activities that arise when moving from a group to a firm such as buffering the production systems, coordinating the work, distributing the work, and communicating information between the groups in a firm may be considered "firm level organization/transaction costs."

There are basically three generic structures for organizing the production functions in a firm which are graphically represented in Figure 3.2 [Daft 92]. The "firm level organization/transaction costs" are dependent on the structure that is chosen.

The first is a functional structure. In a functional structure, activities are grouped together by common function from the bottom to the top of the organization. All engineers are located in the engineering department, and the vice-president of engineering is responsible for all engineering activities. A functional structure enjoys some efficiencies over other structure options such as economies of scale within departments, ability to develop in-depth skills, and the ability of the organization to accomplish functional goals. However, inefficiencies may arise such as slow response time to environmental changes, slow decision making due to hierarchy overload, poor horizontal coordination among departments, and a restricted view of organizational goals [Duncan 79]. These types of inefficiencies are considered organization/transaction costs for this type of organization structure.
In a product structure, groups can be organized according to individual products, services, product groups, major projects or programs, divisions, businesses, or profit centers. The distinctive feature of a product structure is that grouping is based on organizational outputs. A product structure enjoys some efficiencies over the functional structure from an ability to quickly adjust in an unstable environment and more clearly identify responsibility for the product, to more easily coordinate across functions. Also, a product structure provides the ability to adapt to differences in products, regions, and clients, and centralizes decision making. However, inefficiencies may arise such as inability to exhaust complete economies of scale in functional departments, difficulty in coordinating across product lines, elimination of in-depth competence and technical specialization, and lack of integration and standardization across product lines [Duncan 79]. These are organization/transaction costs associated with this organization structure.

As a practical matter, many structures in the real world do not exist in the pure form of functional or product. An organization’s structure may be multi-focused in that both product and function, or product and geography, must be emphasized at the same time. This type of structure, called a hybrid structure, is the third generic structure [Daft 92]. The matrix organization, an example of a hybrid structure, uses both product and functional
structures simultaneously. The product managers and functional managers have authority within the organization, and employees report to both of them.

3.1.4. Inter-firm level

A single firm may not have all the capabilities to provide an owner with a certain unit of work. Firms may then join together in a number of ways to provide an owner with all the capabilities required to provide a certain unit of work. These firms together are considered an "inter-firm" organization. The inter-firm organization may have one lead firm that subcontracts or joint ventures with other companies to obtain additional capabilities. When more than one firm joins together, there are costs associated with coordinating the functions, distributing the work, communicating information between the firms, and contracting functions. Contracting functions include putting agreements in place and monitoring the contracts. All these costs may be considered "inter-firm level organization/transaction costs." Figure 3.3 represents how firms may be joined together to form an inter-firm organization.

Figure 3.3: Inter-firm Level Organizations
3.1.5. Project level

An owner may choose to divide the work required to provide a facility and contract with several inter-firm organizations. This level will be considered the “project” level. For example, in a traditional project delivery approach, the owner typically contracts with a design entity to develop the design. The owner then takes the design and contracts with a construction entity to build the facility. The owner must spend effort coordinating the work and transactions between the organizations and between the organizations and themselves. There will also be costs for contracting for the services, monitoring the contracts, and communicating information between the inter-firm organizations. These costs may be considered “project level organization/transaction costs.”

The project’s contracts may be organized along two dimensions, and Figure 3.4 shows several possible organization scenarios. The first dimension by which project contracts may be organized is process. Design and construction processes can be contracted for separately or under a single integrated contract. The second dimension is building systems. The processes of design and construction can be subdivided or integrated and then

![Figure 3.4: Project Level Organizations](image-url)
contracted by building system. The manner in which the contracts are organized is commonly referred to as the project delivery system. However, instead of specifying a particular project delivery system in this study, they will be classified on a scale of level of contract integration. As the owner reduces the number of contracts they enter into, the level of contract integration increases. The inter-firm organizations that are contracted directly with the owner are considered prime contractors.

The next section focuses the study on the project level of the project organization. Two basic cost categories are considered at this level: production costs and project level organization/transaction costs. Four subcategories of project level organization/transaction costs are then identified.

3.2. TOTAL PROJECT COSTS

The previous sections described the different levels of the project organization at which costs are generated. The total project cost will include not only the cost of the direct work but also the group level organization/transaction costs plus the firm level organization/transaction costs plus the inter-firm level organization/transaction costs plus the project level organization/transaction costs.

The price that an inter-firm organization charges for a job includes all of their organization/transaction costs at the group level, firm level, inter-firm level, and project level. The owner also incurs their own project level organization/transaction costs. The manner in which the owner contracts for a service will impact their own project level organization/transaction costs as well as the organization/transaction costs of the inter-firm. Therefore, from an owner’s perspective, the project cost will equal the contract prices from each inter-firm organization plus their own costs.

This study adopts an owner’s perspective and considers two basic cost categories (see Figure 3.5). First, the owner and each inter-firm organization contracted with the owner will incur project level organization/transaction costs. Second, production costs are incurred by each of the inter-firm organizations contracted with the owner. Production costs are all the costs that are not project level organization/transaction costs and include the direct work cost at the individual level plus all the organization/transaction costs at the
inter-firm, firm, and group levels. The contract price for an inter-firm organization equals the sum of their production costs and their project level organization/transaction costs.

![Diagram of Total Project Costs](image)

Figure 3.5: Categories of Total Project Costs

Figure 3.6 shows a decomposition of the production costs. In the next section, the project level organization/transaction costs will be further decomposed. This study will focus on classifying and measuring the relationships between the production and organization/transaction cost categories and the type of project organization being used.

### 3.2.1. Project level organization/transaction costs

A project delivery process model (Figure 3.7) was developed to facilitate the decomposition of the project level organization/transaction costs. This project delivery process model was based on a simplified version of the Integrated Building Process Model [Sanvido 90] that focuses on the “contract for services” process. Process and information flows related to this process were included in the model.
Three main processes relevant to the owner are identified in the model: contract for services, design facility, and construct facility. Also, four subcategories of project level organization/transaction costs are identified. The owner contracts for services which results in a project organization consisting of design and construction organizations contracted to design and construct the facility. The cost of the process, contract for services, is the first subcategory of project level organization/transaction costs. The term project procurement will be used in this thesis to represent the cost of "contract for services." The contracts with the organizations must then be administered by the owner over the life of the project. Contract administration is the second subcategory of project level organization/transaction costs and is represented by triangles on the figure. The facility design is performed by the design organization and is a constraint on the construction process. The construction organization may also provide feedback (e.g., optimization or constructability information) to the design organization as they develop the design. The cost of inefficiencies that arise in the exchanges between the design and construction organizations are considered information communication (represented by an
Figure 3.7: Project Level Costs Identified on the Project Delivery Process Model
oval on the figure). The behavior of the firms may also affect the cost of the project. A diamond was added to the figure to describe the firm interactions, the fourth and final subcategory of project level organization/transaction costs. The selection of these four categories of project level organization/transaction costs is also identified as the critical project success factors which include team, contracts, information communication, and experience [Sanvido 92]. More detailed descriptions of these categories will follow.

3.2.2. Project level cost categories

In this section, the categories of project level costs identified by the project delivery process model will be defined. Figure 3.8 summarizes the decomposition of project level organization/transaction costs.

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Figure 3.8: Project Level Organization/Transaction Costs
Project procurement is the process by which an owner puts together a project team to design and construct a facility. The owner must go through this process for each separate contract signed. Design and construction organizations compete for these contracts based on selection criteria such as qualifications, proposals, and bids. The owner must select a project delivery system, coordinate the contracts, write the contracts, develop the functional requirements for the facility, evaluate the firms, select the firms, and negotiate the agreements. Contractors develop proposals and bids and negotiate agreements. As the degree of contract integration increases, there will be fewer contracts to write, coordinate, and negotiate. However, more detailed information and requirements for the facility should be developed to ensure that the owner ends up with the desired facility. The contractors may also have to develop more detailed proposals.

Contract administration describes the manner in which the owner and contractors monitor and enforce the terms of the contracts. The owner may make changes to the contract which must be defined and negotiated. Disputes may arise during the life of the contract and must be settled. As the level of contract integration increases, the effort to administer them may decrease because of the changes in complexity of the agreement and the actual number of contracts. Typically, the basis for the agreement moves from a product specification, where the details of the design are developed before construction contracts are signed, to a functional specification in which the design and construction inter-firms are responsible to provide an end product that will meet the requirements of the owner. The owner will need to be less involved with the process and more concerned with the final product. Also, when a single contract for design and construction are used, the responsibility for the project is assigned to one firm. Since the basis for the agreement is a functional specification and there is a single source responsibility, the owner is no longer subject to changes in the contract due to mistakes and the effort required to verify and negotiate them. Finally, the single source responsibility should reduce the number of disputes that arise.

Information communication represents inefficiencies in the way the design entity communicates the design to the construction entity and the construction entity communicates their knowledge to the design entity. When information is communicated across contractual boundaries, it is often more detailed, formal, and in large batches. Also, when information is communicated across contractual boundaries, the possibility of firms not knowing each other’s capabilities increases. This may lead to the development of
information communication inefficiencies such as overdevelopment of information, overdesign of capacities for building systems, poor constructability, mistakes, and missing information. This may also lead to greater project duration since the work of design and construction can have less overlap.

*Firm interactions* describes how cooperatively the design and construction organizations work together on a project. Typically, firms each have their own goals for a project (including profit) as a primary objective. Often, the goals of a firm, particularly profit, may not be compatible because they may be competing for the same resources or may be dependent on each other for the completion of work.

*Production* describes the processes that are internal to an inter-firm organization under contract with the owner. In a traditional project delivery system, one example of production would be the processes performed by the architect under contract with the owner. Individuals perform the direct work of designing the facility. Individuals may be grouped into departments who design different building systems. The departments collectively make up the firm. The architect may also subcontract the design for some building systems. The architect’s firm and their subcontractors collectively make up the design inter-firm organization under contract with the owner. Their total efforts are considered production. The costs of their effort for a project include the direct work, the managing of the direct work, a portion of the overhead carried by the firm, and finally the profit they add to the total costs and overhead.

### 3.3. Summary

This study attempts to understand the impacts of the owner’s choice of project delivery system on the total costs of a project. The total costs of the project to the owner include the costs for project procurement, contract administration, information communication, firm interactions (project level organization/transaction costs), and the production costs for designing and constructing the facility. Figure 3.9 summarizes the relationships that are of importance to this study. Each of the relationships shown will be further defined in Chapter 4.
As the relationships between these variables at the project level are further explored, keep in mind that other levels, such as individual, firm, and inter-firm levels may be studied in the future. Many of the same principles and theories that will be used to explain the relationships of variables at the project level also apply at the inter-firm, firm, and group levels. This study represents the beginning of a long term research agenda. The major effort of this research has been to develop this framework and to develop relationships at the project level. Eventually, all levels of the project organization may be studied.
CHAPTER FOUR

RELATIONSHIP BETWEEN LEVEL OF CONTRACT INTEGRATION AND PROJECT PROCUREMENT

This chapter introduces the models that describe the impacts of the level of contract integration (project delivery systems) on project level costs. Five models have been developed with each providing a detailed breakdown of one of the relationships between the level of contract integration and the five categories of project level costs: project procurement, contract administration, information communication, firm interactions, and production. These models were developed by applying organizational theories, particularly transaction cost economics [Williamson 75], to construction projects.

This chapter describes the first model, impact of level of contract integration on project procurement (see Figure 4.1), and the other models are described in subsequent chapters. In the beginning of each chapter, an overall view of the model to be described (see Figure 4.2) is followed by definitions of all the terms in the model. The relationships between each of the variables in the model are then explained using the corresponding theories. An example from a construction project then clarifies a single relationship to the reader where appropriate.

Figure 4.1: Context of the Model to be Described Within the Overall Framework
Figure 4.2: The Impact of Level of Contract Integration on Project Procurement
The models in chapters four through eight should be read from the left to the right. The level of contract integration is the first term on each of the models. Arrows connect the terms that are related and the symbol on the arrow (a plus or a minus) defines what type of relationship it is. With a positive relationship, if the first variable increases or decreases, the second variable will behave in a similar manner. With a negative relationship, if the first variable changes, the second variable will change in the opposite direction.

It must be kept in mind while reading the following sections that these relationships are from an owner's perspective. Contractors and architect/engineer's (a/e's) are portrayed in unflattering ways in many instances. However, it is emphasized that not all contractors and a/e's necessarily behave in the fashions described. Also, owners' behaviors are not always ideal and often, they act in opportunistic ways when given the chance. Again, the relationships are from the owner's viewpoint and represent possibilities that an owner should consider when choosing a project delivery system.

4.1. Definitions of Key Terms Related to Project Procurement Impacts

The following are definitions for the terms used in Figure 4.2. Included with each of the definitions is the unit of measurement and a possible method of measuring each term.

The *Level of contract integration* is the degree to which the processes of design and construction for building systems are combined. This is represented by the contracts between the owner and the contractors for each segment of the work. A segregated situation (low integration) is represented by multiple specialty designers and multiple specialty construction contractors contracting with an owner. A highly integrated situation is represented by a single contract between an owner and one entity, such as a design-builder, for the entire design and construction of the facility. The level of contract integration can be documented on a matrix of building systems (e.g., structural, architectural, mechanical, electrical) versus building processes (manage, design, construct, and operate).
4.1.1. Intervening variables

The \textit{Number of contracts} is the quantity of contracts the owner has with other firms to provide design and/or construction services for a facility/facility systems.

The term \textit{Contractual reliance on functional requirements} refers to the degree to which functional or performance requirements for a facility are used as a basis for a contract rather than a completed design or product specification. A high degree of reliance on functional or performance requirements would be represented by a situation where little design has been completed and the overall requirements of the facility are functionally specified. The degree of reliance on functional or performance requirements will decrease as more building design details are developed for the building systems. A low degree of reliance on functional or performance requirements would be a situation where the detailed design is complete and all products are specified.

The \textit{Frequency of purchase}, an intervening variable not related to level of contract integration, represents how often an owner requires new facilities to be built. The frequency of purchase ranges from a one-time purchaser, through occasional, to recurrent. A value of frequency of purchase may be found for a project by using a ratio of the value of that project to the total volume of new construction that owner is concurrently building or the project to the total number of projects in a specified period of time.

\textit{Competition} represents the number of firms or inter-firm organizations with which the owner has the option of contracting to perform a specified piece of work. Competition represents the number of firms or inter-firm organizations competing to win a contract, and is measured by counting the number of submitted proposals or bids for a particular project.

4.1.2. Cost impact variables

\textit{Coordinating contracts} is the number of hours or costs the owner and their agents spend developing scopes of work and schedules for each contract. Activities include developing separate bid packages that will neither exclude nor overlap scopes of work, scheduling those packages for award, and scheduling contractors to begin work.

The term \textit{Developing pre-contract information/requirements} represents the number of decisions or amount of information that the owner must provide prior to executing any
contracts for design and construction. The information requirements include the development of functional and/or product specifications. The functional requirements are typically defined first followed by specified products or design to meet the functional requirements. The information requirements of the owner also include setting a budget limit, determining proposal requirements, developing selection criteria, and setting deadlines.

*Writing the agreement* is the number of hours or costs that the owner and their consultants incur while writing the contractual agreement between themselves and their contractors. The agreement is a document specifically designed to formalize the construction contract. It condenses the contract elements, states the work to be done and the price to be paid for it, and provides suitable spaces for the signatures of the parties ([Clough 81]). The time taken to write contracts should be related to the complexity of the agreement. Contracts with more clauses should take more time to write. However, with the use of standard contracts, this may not be true. Therefore to compare projects, the complexity of the agreement should be measured as well as the time to develop the agreement. Relative measurements for time that can be used include a ratio of the time to write the agreement compared to the project duration and a ratio of the number of hours to write the agreement to the total contract value. The complexity of the agreement can be measured by the number of clauses that a contract has for future contingencies or outcomes that may result during the life of the contract. Values may range from none to high.

*Developing proposals/bids* is the number of hours or costs incurred by each prospective contractor to develop a proposal or bid to the owner. To measure and compare projects, a ratio of the time to develop the proposals/bids to the total project time and a ratio of the number of hours to develop the proposals/bids to the total contract value may be used for all prospective contractors. The effort includes items such as assembling and coordinating the project inter-firm organization, pre-qualifying the inter-firm organization, performing system designs (architectural, structural, mechanical, etc.) as specified in the functional requirements, estimating the costs, and developing the actual written proposal to be presented to the client.

*Reviewing/selecting proposals* is the number of hours or costs the owner and their consultants incur to review submitted proposals/bids. They usually verify that the submitted proposals meet the specified requirements and then select the best solution from
those that meet the requirements. To measure and compare projects, a ratio of the time to review and select the proposals/bids to the total project duration and to the total contract value may be used.

_Negotiating the agreement_ is measured by the number of hours or costs the owner, their consultants, and contractors incur to negotiate and execute the final agreements for design and construction. To measure and compare projects, a ratio of the time to negotiate and execute the agreement to the total project duration and to the total contract value may be used.

4.2. **DESCRIPTION OF PROJECT PROCUREMENT IMPACTS**

In the following sections, each relationship from Figure 4.2 is isolated and given an equation number. An explanation for the relationship is provided followed by an example. The examples are shown in italics.

**4.2.1. Number of contracts**

\[ \text{Level of contract integration} \rightarrow \text{Number of contracts} \quad (1) \]

As the owner integrates contracts, the number of contracts the owner holds with contractors will decrease. This relationship will affect the coordination effort the owner must put forth. This is described in section 4.2.4.

*For example, when an owner moves from a traditional project delivery approach where separate contracts are used for design and construction services to a design-build approach where a single contract is used for design and construction, the owner is integrating contracts. They are moving from a two contracts to one contract.*

**4.2.2. Contractual reliance on functional requirements**

\[ \text{Level of contract integration} \rightarrow \text{Contractual reliance on functional requirements} \quad (2) \]
If an owner plans on contracting separately for design and construction services, they can develop the functional requirements for the facility and then hire and work with an architect over time to develop a design to meet those functional requirements. The owner has flexibility in changing the functional requirements based on how the design progresses. Once the design is completed, the owner can bid the design and contract for the construction of the facility. The construction contractor is contracted to provide services to build the facility as it appears in the design. The owner is warranting that the design will work.

If the owner instead decides to integrate the design and construction contracts, they are now hiring both the design and construction services up front. This contract is often primarily based on specified functional requirements and possibly some design. In this situation, the owner is relying more on functional requirements. This is opposite of the previous situation where a product specification or a design is developed prior to executing construction contracts [DBIA 94]. By relying more on functional requirements for the facility, the owner may be more uncertain of what the final facility will physically look like. However, the owner should be more certain of how the facility will perform.

For example, an owner may go to a design-builder for the design and construction of a clean room facility. If there is no design completed prior to hiring a design-builder, the owner may specify the facility in performance terms. The owner can request that they have a facility that provides 20,000 square feet of class I clean room to support certain manufacturing functions. The design-builder can then design and construct a facility that has 20,000 square feet of clean room space. The owner can take the finished facility and compare the performance of the facility to the specified functional requirements to verify that the design-builder has met the terms of the contract. On the other hand, if an owner uses the traditional approach, they can still use the functional specification to hire an architect/engineer (A/E) to design the facility. The owner may then have more input such as how the facility may be laid out and what materials will be used. The developed design is now a product specification which can be used to hire a general contractor.

4.2.3. Competition
As the level of contract integration increases, it is expected that the pool of competitors for a given market will be less. The increase in contract integration will require firms to have more skills. The resources required to develop these skills may limit the number of firms. Many firms may not have the resources to develop a wide range of skills required to compete on projects with integrated contracts. However, if the market for integrated firms grows, it is expected that firms will eventually comply to meet these needs and competition will eventually increase.

When the United States Post Office moved from using a traditional project delivery approach with separate design and construction contracts to a design-build delivery method, there was a dramatic drop in the number of competing inter-firm organizations for projects. There were not many firms who were qualified to perform both the design and construction functions for a project.

4.2.4. Coordinating contracts

\[ \text{Number of contracts} \rightarrow \text{Coordinating contracts} \] (4)

As the number of contracts decreases, the owner’s effort in coordinating contracts should also decrease. The owner will need to spend less time determining where each contractor’s scope of work starts and ends, and eliminating scope gaps or overlapping of work. Also, the owner has lower effort at scheduling contracts for execution. The contractor can hire or perform services as they are required for the project.

If separate contracts are used for the construction of the electrical and mechanical systems for a facility, their scope of work must be carefully delineated. For example, the panel boards for the mechanical equipment, such as chillers, are sometimes supplied and installed by the mechanical contractor and sometimes by the electrical contractor. However, on occasion, the mechanical contractor may supply the panel boards, but the electrical contractor will install them. The contracts for the mechanical and electrical work must be coordinated so that only one of them will be performing the function. If the mechanical and electrical work is performed under a single contract, the contract does not have to specify which party will perform the work. It must only specify the work to be done or the functional requirements of the facility.
4.2.5. Developing pre-contract information/requirements

Contractual reliance on functional requirements $\rightarrow$ Developing pre-contract information/requirements

(5)

If the owner is contractually relying on a set of functional requirements, they must be more careful to describe in detail the desired performance of the final facility prior to executing the contracts. This must be done so that first, a proposal and price can be developed by the contractors and secondly, to assure the owner that the facility will perform at a certain level and prevent opportunistic action by contractors attempting to cut corners. The owner will have less involvement with the development of the design and will lose some flexibility in making changes to their requirements. Therefore, the owner must use more effort developing their functional requirements for the facility prior to contract execution.

Continuing the example from section 4.2.2, say the owner did only specify that they wanted 20,000 square feet of class one clean room space to a design-builder, but later realized that they would use mini-environments in a long and narrow configuration to support the manufacturing process. This could have a great cost impact to a design-builder, especially if they have already started excavation for the foundations or if they planned for a ballroom type clean room. In the traditional approach, the owner can add to their requirements as the design develops without too great a cost impact.

4.2.6. Writing the agreement

Contractual reliance on functional requirements $\rightarrow$ Writing the agreement

(6)

Attempts are made in construction contracts to overcome the possibility of incomplete contracts so that opportunistic behaviors by the contractors, where changes do arise, can be avoided. These attempts often come in the form of contract clauses that will address all outcomes that may arise during the life of the contract. This type of contract is referred to as a contingent claims contract [Williamson 75]. When an owner relies more on a set of functional requirements for a facility rather than a specified design, the owner should be less concerned with how the process unfolds and what different situations arise. The
owner should now be more concerned with what the final product will be. The contracts should therefore become less complex when they rely on a set of functional requirements. Since this agreement is less complex, there should be less effort in writing the agreement.

Change orders are common examples of situations that are subject to opportunism by contractors. When an owner integrates contracts, they may base the contract on a set of functional requirements. It is the inter-firm organization's responsibility to meet these requirements and changes due to errors and omissions are no longer the responsibility of the owner. The owner, therefore, no longer must develop contractual mechanisms to deal with errors or omissions in the design that are found during construction or even determine if the changes truly exist.

In a traditional project delivery arrangement, the contract has developed over time to include many clauses that attempt to anticipate and prescribe what should be done if the process goes differently than planned. The AIA Document A201 General Conditions of the Contract for Construction [AIA 87] is nineteen pages long. The clauses, in addition to those defining the parties and their responsibilities, contemplate progress and completion, delays and extensions of time, payments withheld, failure of payment, emergencies, arbitration, change orders, concealed conditions, claims for additional cost, uncovering of work, correction of work, acceptance of defective or non-conforming work, and termination of the contract among many others.

An example of how some clauses may not be needed when moving from the traditional approach to the design-build approach is the design development clauses. In the typical contract for design services in a traditional approach, it is specified that three different phases of design packages be developed (schematic, design development, and working drawings) and approved by the owner. When using the design-build approach, the owner should no longer be concerned with how much design is completed and how it is packaged. It is the responsibility of the design-builder to provide a facility that meets the functional requirements established by the owner. How they get to the finished product is their responsibility.
4.2.7. Developing proposals/ bids

Contractual reliance on functional requirements \[\rightarrow\] Developing proposals/ bids

(7)

When a proposal is developed based on a performance specification, the effort to develop the proposal should be greater. Typically, the owner will want to see at least a schematic design to verify that the facility design will meet their functional requirements. Also, the cost for the project is often included in the proposal. When a design is used for the basis of a proposal/ bid, the effort by the contractor should be less. Since the design is completed, the major activity is developing a cost estimate for the work.

For example, in a recent design-build competition for the $200 million Hawaii Convention Center, five inter-firm organizations spent hundreds of thousands of dollars each developing proposals. The request for proposal (RFP) required that each of the inter-firm organizations develop the design through the schematic phase. The cost to estimate and bid a set of completed documents for a similar facility would cost significantly less.

Competition \[\rightarrow\] Developing proposals/ bids

(8)

If there is a low number of competitors developing proposals or bids for a project, those contractors who are developing the proposals or bids may put less effort in to developing them. They may feel that there effort will be enough to win the contract with the given amount of competition. If there are a number of competitors for a given project, contractors proposing or bidding may believe they will need to put in extra effort to be better than the competition and win the contract. Also, with more competitors, the sum of all contractors’ efforts to develop proposals/ bids increases. Conversely, an owner may act opportunistically by allowing a large bid list.

For example, if an owner decides that they would like to build a clean room facility in a remote area with no local contractors and would like to have a firm that will perform all the design and construction in-house, they may find it difficult to find firms to perform that work. If a design-builder was available to do the work and knew that the owner had no
other options, it is likely that the design-builder will need to spend less effort pursuing the work. The owner may be forced to use them.

4.2.8. Reviewing/ selecting proposals/ bids

\[ \text{Competition} \xrightarrow{+} \text{Reviewing/ selecting proposals/bids} \] (9)

As the number of competitors on a project increases, there will be more proposals or bids for the owner to review. The more proposals or bids the owner has to review, the more effort will be required to select the winner.

For example, on similar projects with similar type requests for proposals (rfp), the owner who accepts fifteen proposals will exert more effort reviewing and selecting than an owner who accepts only five proposals.

\[ \text{Developing proposals/bids} \xrightarrow{+} \text{Reviewing/ selecting proposals/bids} \] (10)

When more detailed proposals are developed, the owner in turn will need to expend more effort to review the proposals and select the winning one. This evaluation and selection process must be done to, first, see if the proposals meet the requirements of the request for proposal (rfp), and second, to pick which proposal is the best solution. Also, the design-build approach sometimes uses a two-step approach which involves, first, the development of a technical proposal followed by a price. In a traditional approach, typically there is only one step that involves price alone.

Continuing the example of the convention center in section 4.2.7, the owner for the competition put together a ten member panel to select the winning proposal. The proposals, models, and verbal descriptions were very detailed and for each member of the panel to review and compare the different proposals took close to a month to complete. In contrast, different bids for a completed design can be more easily compared and selected.
4.2.9. Negotiating the agreement

If there is little or no competition to limit opportunism by contractors, it may become difficult for an owner to negotiate and put in place an agreement under fair terms. This increased effort to negotiate the agreement will increase costs.

Using a similar example to the one used in section 4.2.7, if an owner decides that they would like to build a clean room facility in a remote area with no local contractors, and would like to have a firm that will perform all the design and construction in-house, they may find it difficult to find firms to perform that work. If a firm was available, that firm could be in a monopoly situation with the owner and could demand a higher profit. The owner would more than likely attempt to negotiate with this design-builder to try and lower that profit level. However, if there are no other design-builders to choose from, it is likely that the owner will have a difficult time negotiating and receiving a lower price.

4.2.10. Frequency of purchase

Increased frequency of purchase by the owner should help attenuate opportunistic behavior since such behavior may jeopardize the contractor's chances of receiving future work from that owner. Frequency of purchase reduces opportunistic behavior in a similar
manner as competition will. When an owner will be purchasing more facilities in the future, the contractors working on the current project are, in effect, competing for future work by the manner in which they perform or behave. If the owner will be building more facilities in the future, the contractors may be more inclined to help the owner and not be strictly acting in a self-seeking manner. Therefore, the owner may not need to develop detailed clauses to anticipate all future contingencies but may rely on their frequency of purchase to limit opportunistic behavior.

Also, if the owner will be purchasing more facilities in the future, the contractors developing proposals/ bids may put more effort in to make a positive impression on the owner. This may position them favorably for future work.

Additionally, when an owner will be purchasing more facilities in the future, they may not have to be as careful when verifying whether the proposal/ bid meets the established requirements. The firms proposing or bidding should be less inclined to cut corners or leave things out if they know that doing so will affect their chances at receiving future work. Also, the more often an owner purchases facilities, the better they should become at reviewing proposals and bids.

Similarly, the owner may be able to use the threat of the contractor's behavior affecting the chance of them receiving future work again during negotiation of the agreement. This should decrease their effort to negotiate the agreement. The contractor should more likely to be reasonable in a negotiation.

A large design-build contractor is developing two proposals to two different owners for the design and construction of office buildings. This is the first time that the contractor is proposing to each of the owners. The first owner will likely be only purchasing this one office and does not appear to have any future building needs after this facility. The second owner, on the other hand, has a large building program planned over the next ten years. Given these two scenarios, it is likely that the contractor will spend more time on the proposal to the owner who will be building more facilities in the future. In effect, each time the contractor proposes to this owner, they are also competing for future projects by the quality of the work they do.
4.3. SUMMARY

This chapter described the relationship between the level of contract integration and the cost of project procurement. It was demonstrated that organization theory, particularly transaction cost economics, could be used to define the variables and develop the relationships between them.

In chapter nine, the detailed path model presented in this chapter is evaluated. Expert opinions were solicited to gain support for the relationships presented in the models. Also, the variables in the model were measured and rated for project cases. A description of the methods used, the selection of projects, the development of questionnaires, and the data collection and analysis techniques are presented.

Once the contracts are in place, they must be administered. The owner is responsible for enforcing the terms of the contracts they hold with contractors. In the next chapter, the cost impacts of the level of contract integration on the effort to administer the contracts is described.
CHAPTER FIVE

RELATIONSHIP BETWEEN LEVEL OF CONTRACT INTEGRATION AND CONTRACT ADMINISTRATION

This chapter describes the relationship between the level of contract integration and contract administration, the second of five relationships defined in the framework in chapter three (see Figure 5.1). Figure 5.2 provides an overall view of the model. Definitions of new terms are presented next. A detailed description of the model with supporting examples follows.

![Diagram showing relationships between Contract Integration, Project Procurement, Contract Administration, Information Communication, Firm Interactions, and Production.]

Figure 5.1: Context of the Model to be Described Within the Overall Framework

5.1. DEFINITIONS OF KEY TERMS RELATED TO CONTRACT ADMINISTRATION IMPACTS

The following are definitions for the terms used in Figure 5.2. Only terms that were not defined on the previous model are presented. The definitions also include the unit of measurement as well as a possible method of measurement of each term.
Figure 5.2: The Impact of Level of Contract Integration on Contract Administration
5.1.1. Intervening variables

A Small number situation is a low or non-competitive trading relationship, or monopoly. In the context of the model in Figure 5.2, small number situations often arise after the contract is awarded. Once the contract is awarded, the owner cannot turn to another contractor to perform changes in the work without incurring considerable costs. The contractor can therefore act opportunistically and price changes at a premium. This term is similar to competition defined in chapter four. However, competition, for the purpose of this study, describes the number of firms competing for the award of a contract. When few contractors are competing for the award of a contract, this would also be considered a small number situation.

5.1.2. Cost impact variables

Monitoring contracts represents the number of hours or costs the owner and their consultants expend to verify that each contractor is following the terms of their contract. To measure and compare projects, ratios of the time spent monitoring the contracts to the total number of contracts, time spent monitoring contracts to the total project time, and time spent monitoring contracts to the total contract value of the project may be used.

Inspecting/testing of completed facility is measured by the number of hours or costs the owner and their agents incur to compare the performance of the completed facility to the prescribed contractual requirements. To measure and compare projects, ratios of the time spent inspecting/testing to the total project time and time spent inspecting/testing to the total contract value of the project may be used.

Changing the contract refers to the number of hours used or costs incurred by the owner, their agents, and contractors to identify, write, price, negotiate, and approve changes in the work. The contractors must make sure they are fairly compensated for work that is different from, or additional to, the original contract. The owner must ensure that the proposed changes are legitimate and necessary and then approve, negotiate and settle on a fair price for the work with the contractor. The time spent by the owner and their consultants as well as the time spent by the contractors can be measured. Comparisons between projects can be made using the ratios of the total time spent to the total number of changes, the total time spent to the total project duration, and the total time spent to the total
contract value of the project. Also, the number of changes that are made to the contract (includes design documents) that result from mistakes, missing information, or even misrepresentations by contractors can be measured. Comparisons between projects may then be done by using ratios of number of changes to the contract to the number of contracts and the number of changes to the contract to the total contract value of the project.

*Interpreting contracts* is the number of hours or costs the owner and their agents incur while applying the terms of the agreement to ambiguous situations that may arise during the life of the contract. To measure and compare projects, a ratio of the time spent interpreting the contracts to the total project time and a ratio of the time spent interpreting the contracts to the total contract value may be used.

*Resolving disputes* is the number of hours or costs the owner, their consultants, and contractors incur resolving disagreements between the owner and contractors regarding contract changes or interpretation. Resolution methods range from negotiation to litigation. The effort to resolve disputes can be measured in hours and compared to other projects with the ratios of number of disputes to the number of contracts, the time spent settling the disputes to the total project duration, and the time spent settling the disputes to the total contract value of the project.

5.2. DESCRIPTION OF CONTRACT ADMINISTRATION IMPACTS

In the following sections, each relationship from Figure 5.2 is isolated and given an equation number. An explanation for the relationship is provided followed by an example. As in the previous section, examples are in italics.

Two of the relationships shown on Figure 5.2 are the same as those from Figure 4.2. These relationships include equation numbers (2) and (6). They are not described here again.

5.2.1. Small number situations

![Diagram: Level of contract integration leading to Small number situations]
When an owner integrates contracts, they will be subjecting themselves to fewer small number situations after the contracts are signed. Change orders are situations where small number situations arise. As the level of contract integration increases, the responsibility for the project is consolidated in fewer inter-firm organizations, and the contract for the facility is often based on functional requirements. Changes due to errors and omissions are the contractor’s responsibility and the owner is no longer subject to opportunism related to changes.

5.2.2. Monitoring contracts

\[
\text{Writing the agreement} \quad \xrightarrow{+} \quad \text{Monitoring contracts} \quad (17)
\]

Equations (2) and (6) demonstrated that as the level of contract integration increases, the complexity of the agreement will decrease. The owner has moved toward the purchase of a product where the contractor is responsible for providing a fully-functioning facility. Since the agreement is less complex and the owner will be less concerned with the process the contractors use, the owner will need to spend less effort monitoring contracts.

Consider again the example from section 4.2.6 regarding the use of the design development clauses. If the contract for design services in a traditional approach specifies that three different phases of design packages be developed (schematic, design development, and working drawings), the owner must verify each of these design packages to see that they are complete. When using the design-build approach, that clause should not be necessary since the owner should not be concerned with how much design is completed and how it is packaged. It is the responsibility of the design-builder to provide a facility that meets the functional requirements established by the owner. Therefore, the effort to monitor the detailed clauses in a traditional approach should be greater than those in a design-build approach.

5.2.3. Inspecting/ testing of the completed facility

\[
\text{Contractual reliance on functional requirements} \quad \xrightarrow{+} \quad \text{Inspecting/ testing of completed facility} \quad (18)
\]
Again, with an integrated approach, the contract relies on a set of functional requirements. Since the performance specification/functional requirements for the completed facility will need to be more detailed than with a product specification or design, it will take more effort by the owner to perform the final inspection/testing of the facility to ensure the requirements are met. In a traditional arrangement, the contractors must build according to the design. The owner can monitor the work as it progresses to ensure the product specification/design is being followed, but ultimately, the responsibility for the performance of the facility is not the contractors’.

For example, if a functional specification is used and states that the contractor is to provide 20,000 square feet of clean room space, the owner and the contractors will have a stake in the outcome of the testing. The design-builder will be responsible for making any changes necessary to bring the facility up to the proper performance level. In a traditional approach, the design was developed in a manner that should provide the desired performance. If the construction contractor is monitored and builds the facility according to the design, the facility should perform as originally desired. The contractor should not be responsible for rework needed to bring the facility up to the desired level of performance if the design was faulty.

5.2.4. Changing the contract

Contractual reliance on functional requirements → Changing the contract

When the owner uses contracts that rely on a set of functional requirements for a facility, they typically hire a single inter-firm organization to deliver the product to match those specified requirements. Any efforts required to reach the desired goal are the responsibility of the inter-firm organization, and changes to design details are no longer the responsibility of the owner. Therefore, there will be no changes in the contract due to errors and omissions by the inter-firm organization responsible for providing the facility. On the other hand, with a traditional approach, the contractor is hired to build the specified design. The owner is warranting that the design can be built and that it meets their needs. If field conditions are different from what the design has specified, changes will need to be made, and the owner is responsible for the costs to make the changes. There will be effort
put forth by both the contractors and the owner in identifying, verifying, pricing, and negotiating changes.

If a concrete contractor follows the mix design specified by the design professional and the concrete is then found to be not strong enough, the contractor may have to replace the concrete. The owner would typically be responsible for redesigning the mix and for the rework costs of the contractor. With a functional specification describing the concrete strength, the contractor would typically have to replace the work at their own expense.

Small number situations → Changing the contract

In addition, since the owner is no longer responsible for changes, they are no longer subject to small numbers situations in which contractors may act opportunistically. The opportunistic behavior that may be avoided includes the fabrication of questionable changes to the contract and the development of inflated estimates to perform legitimate changes to the contract.

For example, if the owner is responsible for the changes in the concrete work from the previous example, they typically must use the same contractor who is on site. It is not typically economically feasible to bid out the change work. This puts the contractor and owner in a monopolistic trading situation, and the price the owner will pay may reflect this.

5.2.5. Interpreting contracts

Writing the agreement → Interpreting contracts

Since the complexity of the agreement will be less in a more integrated project delivery approach, there will be less need for interpreting clauses and applying them to ambiguous situations. Instead of attempting to take into account all possible outcomes of the process in the contract, the final product is of more concern. The effort in interpreting contracts should therefore be less for the owner and contractors during the project.

Continuing the example from sections 4.2.6 and 5.2.2 of the design development clause in a traditional owner and architect agreement, the owner will review each of the
design packages: schematic, design development, and working drawings. Since there are no standards for how much information should be in each set of drawing packages, the owner may make their own interpretation as to the completeness of each of the design packages. It is possible that the owner would then request more design to be performed. In a design-build delivery system, the contracts should not contain this clause.

5.2.6. Resolving disputes

Changing the contract \[\rightarrow\] Resolving disputes (22)

Interpreting contracts \[\rightarrow\] Resolving disputes (23)

Disputes may arise when the owner and the contractors have differences in opinions on interpretations of the contracts, of what actions should be taken in situations not covered by the contract, the existence of changes to the contract, and the corresponding prices for the changes. Many mechanisms, e.g. arbitration, have been developed to resolve such disputes. The parties involved in a dispute may negotiate and settle before the dispute escalates. Other disputes may escalate beyond these methods and go to litigation. As a dispute escalates, so do the costs to settle them.

Continuing the example from section 5.2.4, if the concrete contractor believes they followed the mix design specified by the design professional and the design professional insists that the mix design should provide the proper strength of concrete, a dispute may arise if the concrete is then found to be not strong enough, and the concrete has to be replaced. The owner and the contractors will need to spend time and money resolving the dispute.

5.2.7. Frequency of purchase

Frequency of purchase \[\rightarrow\] Monitoring contracts (24)
Increased frequency of purchase by the owner should help attenuate opportunistic behavior since such behavior may jeopardize the contractor's chances of receiving future work from that owner [Williamson 75]. If the owner will be building more facilities in the future, the contractors may be more inclined to please the owner and not act in a strictly self-seeking manner. Therefore, the owner may be able to use the threat of the contractor's behavior affecting the chance of them receiving future work. Opportunistic behavior, such as substituting cheaper materials in place of those specified, may be attenuated by an increase in frequency of purchase. This may allow the owner to reduce their effort at monitoring the contracts. This may be thought of as moving from quality control to quality assurance functions. Contractors may also be less inclined to fabricate changes or overprice changes that do arise. Finally, the owner can expect to see less claims and thus need to spend less effort at resolving disputes.

If an owner is a large pharmaceutical firm who will be building many facilities in the future possibly with the same contractor, opportunistic behavior such as the fabrication or exaggeration of changes to the contract and inflation of prices for changes should be less of a concern. The owner can prevent the contractors who behave this way from working on future projects. It is also less likely that the contractor will vigorously oppose or dispute the interpretations and decisions made by the owner.

5.3. Summary

This chapter described how the level of contract integration impacts the cost for the owner to administer the contracts with the inter-firm organizations. In general, it appears that the cost to administer contracts decreases as more integrated project delivery systems are used. The inter-firm organizations under contract with the owner must often communicate information with each other, as well as with the owner. Inefficiencies that lead to additional costs will often arise and are dependent upon how the inter-firm
organizations are contracted for and organized. The next chapter describes some of the information communication costs that are impacted by the project organization.
CHAPTER SIX

RELATIONSHIP BETWEEN LEVEL OF CONTRACT INTEGRATION AND INFORMATION COMMUNICATION

This chapter describes the relationship between the level of contract integration and information communication, the third relationship from the framework described in chapter three (see figure 6.1). In Figure 6.2, a model of the decomposition of this relationship is presented. Definitions of terms not already used in the previous two models are then provided. A detailed description of the model with supporting examples follows.

![Diagram of Contract Integration Model]

Figure 6.1: Context of the Model to be Described Within the Overall Framework

6.1. DEFINITIONS OF KEY TERMS RELATED TO INFORMATION COMMUNICATION IMPACTS

The following are definitions for the terms used in Figure 6.2. Only terms that were not defined on the previous two models are presented. The definitions also include the unit of measurement as well as a possible method of measurement of each term.
Figure 6.2: The Impact of Level of Contract Integration on Information Communication
6.1.1. Intervening variables

The *a/e’s knowledge of contractor’s processes/capabilities* reflects the architect/engineer’s level of knowledge of a contractor’s processes, capabilities, and/or means and methods. The architect/engineer’s knowledge may range from no knowledge at any level of building system or process to full knowledge of all. Knowledge may be gained through common experience on previous similar projects or by early involvement of the contractor in the design process. If the a/e and contractor have no experience working together and the contractor was not involved with the design, it can be assumed that they have no knowledge of that contractor’s processes/capabilities. Otherwise, a qualitative evaluation could be made by questioning both the a/e and the constructor.

The *Contractor’s knowledge of a/e’s design* represents the level of confidence the contractor has that the design is representative of the conditions that will arise during construction, and that the design will be constructable. The level of knowledge may range from high to low and is often reflected in the contractor’s contingency. A qualitative measurement can be found by questioning the contractor about their knowledge of the designer’s capabilities and their confidence in the design. A quantitative value represented by the ratio of the contingency to the contract value may also be used.

*Inter-firm experience* is the resulting knowledge that firms gain about each other from working together on projects. Familiarity and trust between firms may permit communication efficiency. Firms who have not worked together may need time to understand each other’s capabilities and to develop methods of communication. Also, if firms have worked together on previous projects, they may understand their roles better. Inter-firm organization experience may range from a high level of experience to a low level of inter-firm organization experience. The number of previous projects on which the firms have worked together can be used as a measurement.

*Continuity of information flow* refers to the number of individuals/companies required to communicate an item of information from the sender to the intended receiver. Each extra individual/company that information must flow through adds time to the total duration of the information flow. Also, when information must flow across contractual boundaries, it often is sent in large batches. A high continuity of information flow occurs when information flows continually from the sender directly to the intended receiver. The
continuity of information flow can be measured by counting the number of contractual boundaries information must flow through from the sender to the intended receiver of information, and also, the time information takes to travel from sender to receiver.

*Adaptive decision-making* describes the degree to which decisions can be made or actions taken when the need or the situation arises. This may be seen as an antonym of planning for all outcomes. When planning for all possible outcomes, actions or designs may be developed for different possible situations that may arise. With adaptive decision-making, only those outcomes that arise are acted on. A high degree of adaptive decision-making would be a situation where the design and construction of a facility follow closely together.

### 6.1.2. Cost impact variables

*Constructability* is the optimum use of construction knowledge and experience in planning, engineering, procurement, and field operations to achieve overall project objectives [CII 86]. The optimum solution may vary from organization to organization since their processes, techniques, and qualifications will be different for each. Constructability may be qualitatively measured by obtaining evaluations from both a/e's and constructors. Values may range on a relative scale of high constructability (easier to construct) to low constructability. It may be easier to recognize levels of constructability by comparing the labor productivity or total cost per square foot to construct alternative designs of building systems for similar type facilities.

*Overdesign of systems* refers to the unnecessary addition of “safety factors” to the design of a system to ensure that the system will produce at a certain level of performance or because of opportunistic behavior by the design professional. Overdesign of systems can be measured on a single project by soliciting expert opinion. The level of overdesign of systems may be measured by comparing the capacities of systems on similar type facilities, e.g., pounds per square foot for the structural frame. The level of overdesign may range on a scale from low to high.

*Economic contingencies* refer to the addition of extra costs to a bid or proposal by a contractor to allow for uncertainties or different possible contemplated outcomes of a project. Contingencies often are kept as a single separate line item in a bid or proposal or
are distributed among line items for different categories of work. Contingencies may be measured and compared by finding the ratio of contingencies to total contract value. They may then be placed on a relative scale from high to low where no contingencies would represent a low value.

*Unnecessary information* refers to the development of a design beyond the point which would be necessary to communicate the intent of the design. This may depend on the level of communication possible between the contractors and designers. The development of unnecessary information is often done to ensure that all details are specifically noted and are not the subject of later claims by contractors or to aid in communication between unfamiliar parties or individuals. The level of unnecessary information may be documented by studying individual building systems, and questioning the individuals responsible for constructing them. They could be asked which details were not needed to perform their work. Any details not required by them could be considered unnecessary information. Therefore, a low amount of unnecessary information represents just enough design information for the tradesman to construct the artifact.

*Wasted time* refers to the time lost by not overlapping or phasing design and construction. Time is wasted when the design must be completed for competitive construction bidding. Also, when information flows across contractual boundaries, it often does so in large batches. The elimination of separate design and construction contracts may allow for design information to flow earlier and more often. A low amount of time is wasted when the construction of building systems and components start before the design for those systems is completed. To measure and compare projects, the total time saved on a project can be measured as the amount of overlap in design and construction. Also, the percent difference in duration can be calculated for similar type facilities or the ratios of square feet of building completed per month can be compared for similar type facilities.

*Wrong information/mistakes* refers to designs or design solutions that are found during construction to be inappropriate or wrong. This may arise when designers make certain erroneous assumptions about construction conditions to develop working drawings. This contrasts to a situation in which designers and constructors use adaptive decision-making and develop solutions based on the conditions that arise. To measure and compare projects, the ratio of the dollar amount of change orders from mistakes to the total contract value may be used.
6.2. DESCRIPTION OF INFORMATION COMMUNICATION IMPACTS

In the following sections, each relationship from Figure 6.2 is isolated and given an equation number. An explanation for the relationship is provided, often followed by an example. As in the previous sections, examples are in italics.

One of the relationships shown on Figure 6.2 is the same as one from Figure 5.2. This relationship is described in equation number (16). It is not described here again.

6.2.1. Inter-firm experience

\[ \text{Level of contract integration} \rightarrow \text{Team experience} \]

(27)

As the level of contract integration increases, it is assumed that the inter-firm organizations performing the work have either worked together before or are within the same company. This previous experience working together represents an increase in inter-firm organization experience.

6.2.2. Continuity of information flow

\[ \text{Level of contract integration} \rightarrow \text{Continuity of information flow} \]

(28)

As the level of contract integration decreases, information must flow across more contractual boundaries before it reaches its intended receiver. Also, when information flows across contractual boundaries, it often does so in large batches. By eliminating contractual boundaries, information can flow more directly and freely to those who need it, in small batches. Therefore, increasing levels of contract integration represent a higher continuity of information flow.

For example, a low continuity of information flow is illustrated when an electrical design consultant develops a design. The completed design may then be passed to the architect for review and incorporation with the rest of the building design. Once the design for all the other building systems are complete, the full design for the building may then
pass to the owner. The owner may then bid the design to a general contractor. The general contractor may subsequently subcontract with an electrical contractor to construct the electrical system. The electrical design flowed through four different firms before it finally was received by the intended user, the electrical subcontractor.

6.2.3. Adaptive decision making

As the level of contract integration increases, contractual boundaries that often do not allow for adaptive decision-making, are eliminated. Increasing levels of contract integration economizes on bounded rationality by allowing the inter-firm organization to use adaptive decision-making. Instead of attempting to determine and plan for all contingencies and outcomes, only those situations that arise are dealt with.

If separate contracts are used for design and construction, the design is typically completed and used as a basis for bidding the construction work. The design professional must first develop all the design details before any construction starts. The design professional will have to make certain assumptions about actual field conditions. If the designer and constructor were under the same contract, the design and construction could be overlapped and the design professional could develop details based on how construction unfolds. This represents an adaptive decision-making situation.

6.2.4. The A/E’s knowledge of contractor’s processes/ capabilities

As inter-firm organizations work together and gain experience, they also gather knowledge of each other’s means and methods. The a/e who has worked with a particular construction contractor will better understand their capabilities based on the previous projects on which they worked together.
For example, an ale who has worked with a particular general contractor may know that the general contractor does a large volume of self-performed concrete work and owns flying forms. They may look for opportunities to use this in their design.

6.2.5. Contractor's knowledge of A/E's design

\[ \text{Team experience} \quad \rightarrow \quad \text{Contractor's knowledge of A/E's design} \quad (31) \]

Again, as inter-firm organizations work together and gain experience, they also learn about each other's means and methods. The contractor who has worked with a particular a/e will better understand their design strengths and possible weaknesses based on the previous projects on which they worked together.

For example, a contractor who has worked with a particular a/e on previous projects may know that the a/e often overdesigns the ductwork. The contractor may know that the sizes may be reduced thus saving on material costs. Contractors who have not performed work in the past with this designer may not immediately recognize this and base their bid on the provided design.

6.2.6. Constructability

\[ \text{A/E's knowledge of contractor's processes/capabilities} \quad \rightarrow \quad \text{Constructability} \quad (32) \]

Highly constructable designs may arise when construction means and methods of the contractor or pool of eligible contractors are considered in the design phase of a project. Each construction inter-firm organization uses their own methods and has their own expertise. In a traditional approach, the design professional typically does not know who the constructor will be until after the design is completed. As the contracts are integrated, solutions that make the best combination of design and construction methods can be chosen. Constructability, therefore, may be the result of the a/e having knowledge of the construction contractor's processes and capabilities.
Consider the example from section 6.2.4 which describes how an a/e who has worked with a particular general contractor may know that the general contractor does a large volume of self-performed concrete work and owns flying forms. If the a/e knows that general contractor will be on their project before design starts, then the a/e would try to design the frame to use the flying forms which are very economical. This design would have a high degree of constructability for the general contractor.

6.2.7. Overdesign of systems

\[ \text{A/E's knowledge of contractor's processes/capabilities} \rightarrow \text{Overdesign of systems} \]  \hspace{1cm} (33)

When the design professional working on a project does not know the contractor who will be building the facility, this may introduce inefficiencies into the design. The design professional may want to assure that the building systems will work once they are constructed. If they do not know who will be building them, they may design the building systems for the least skilled contractors and include larger safety factors to compensate and ensure a certain level of performance. As the a/e's knowledge of the contractor's processes and capabilities increases, it should reduce their uncertainty of performance. It is then less likely that the design professional will have to overdesign the building systems.

A mechanical designer may be developing a design to be awarded to the contractor with the lowest price. The designer may believe that the low bidder will install poor quality ductwork which has a higher degree of leakage than specified. Therefore, when sizing the ductwork, the designer may use one size larger duct than what should be required to ensure that the proper quantity of air reaches each room. This larger ductwork results in greater material costs as well as higher installation costs. It may also impact other trades that will be sharing limited ceiling space.

\[ \text{Small number situations} \rightarrow \text{Overdesign of systems} \]  \hspace{1cm} (34)

With the traditional project delivery system, once the design is contracted for, the owner is involved in a small numbers situation with the design professional where the owner cannot economically hire another design professional to take the place of the current
one. The owner and the design professional are involved in a bilateral monopoly, and therefore, this relationship may be subject to opportunistic behavior by the design professional. The design professional may act opportunistically by overdesigning the building’s systems. By overdesigning the systems, they may actually be increasing their fees by increasing the construction costs, especially if the fees are based on a percentage of the construction costs. They have no incentive to reduce costs and design efficient systems. Another possible opportunistic behavior is considered in the following example.

A mechanical designer's fee may be quite small. To compensate for this low fee, they may save labor hours by making generous assumptions about the cooling load for the facility rather than performing detailed calculations to determine the load and appropriate design to meet those cooling requirements. This overdesign in systems may result in larger capacity equipment such as chillers, air handlers, cooling towers, more labor to install these pieces of equipment, and also, increased energy costs over the life of the facility.

6.2.8. Economic contingencies

Contractor's knowledge of A/E's design \[\rightarrow\] Economic contingencies  

(35)

Equation (31) described how a contractor will gain knowledge of an a/e's designs and design capabilities through experience working with them. A contractor's knowledge of the a/e may provide them with more confidence in the abilities of the a/e. This confidence may allow them to reduce their contingencies for a project. If on the previous project working with this a/e, there were few mistakes or problems with the design, the contractor can have similar expectations for the next project. Also, with this experience and knowledge of the a/e, the contractor may know what individual on the design inter-firm organization will best answer any questions that may arise during construction.

For example, an electrical contractor may reduce their contingencies if they have worked together in the past with the electrical designer. They may know that on past projects, the electrical designer was easily accessible to answer any questions. With that in mind, the electrical contractor knows that they will get the information they need, when they need it and may be able to reduce their contingencies.
In a traditional approach, the design professional may need to make assumptions regarding field conditions and base the design on those assumptions. The contractor bidding the work for the project is basing their price on a completed design. They may also have uncertainties regarding the ability to construct the design and may therefore include contingencies. When the design and construction inter-firm organization are under the same contract, they may use adaptive decision-making. By using adaptive decision-making, the design professional can develop the design to match the actual field conditions that arise during construction. The construction inter-firm organization will then not have to include contingencies for all possible outcomes of the construction process. Instead of basing the estimate on possible false assumptions made by the designer, they can now price the work for designs that are based on actual field conditions.

In a design-build clean room project, the mechanical designer may not attempt to design the exact location for exhaust ducts for the tools to be used in the clean room until required for fabrication. They know that the placement of tools is not certain and the owner often make changes up until the last minute. Also, it is easier to design the placement of the exhaust ducts once the clean room space is finished. Therefore, the constructor will not be estimating the price of installing the exhaust ducts until the location for placement is certain. The contractor will not need to include contingencies to take into account possible differences from design to construction.

6.2.9. Standardization of facility/ systems

When the owner chooses to hire a number of specialty designers and constructors to design and construct a unique facility, costs due to this specialization may arise. Each specialist may design novel systems. The combination of these systems may result in a highly specialized or unique facility. The more unique a project is, the more expensive it is expected to be. Standardization strives to reduce costs through repetitions of common
work elements. Transaction cost economics shows that decreased costs result from the use of similar equipment and materials from project to project (lowers the specificity of physical-capital investments), the use of skills developed on previous projects (lowers the specificity of human-capital investments), and also the use of relationships developed on previous projects between designers and constructors (lowers the specificity of interface investments). Although standardization that comes from inter-firm organization experience may reduce the costs of the project, it also typically means the owner must make the choice between a special-purpose and a general-purpose product. A general-purpose product may come at the sacrifice of valued design or performance characteristics that can be found on a highly specialized facility.

*For example, if a design inter-firm organization is put together to build a prison and it is made up of several different design firms that have not worked together in the past, it is likely that the design will be unique from any previous projects. Each firm will use their own standard details and their own ideas/concepts. Each time a new inter-firm organization is put together, a unique design will be developed. If the same design inter-firm organization is used from one prison project to another prison project, the design for those prisons might become standardized. At least standardized details will evolve. Also, from project to project, those details that did not work well can be adjusted on the following project. When a new design is used for each project, it is difficult to incorporate lessons learned on future designs. It is assumed that the more times a design is repeated, the less effort will be required.*

**6.2.10. Unnecessary information**

\[
\text{Team experience} \quad \longrightarrow \quad \text{Unnecessary information}\quad (38)
\]

Individuals and firms who have worked together have will have a more experienced inter-firm organization (lower interface investment specificity). From working together, they may develop efficient methods for information communication such as using fewer details to communicate design intent. In some cases, standards developed from previous projects can be used. In other cases, they can refer to previous similar situations and make decisions based on that instead of having to consult with each other again. When the
design and construction inter-firm organizations do need to consult, they have an established relationship which should facilitate communication. Therefore, the overall effect is less development of unnecessary information. Firms and individuals who have not worked together before must be careful to provide sufficiently detailed information to ensure their intent is clear.

A mechanical design-build company has developed design standards for sheetmetal and piping for the company. Material types are standardized by pipe size and sheetmetal seams are standardized for different required pressures, sizes, and gages of sheetmetal. The designers do not have to identify material types for piping and seam types for ductwork on all the drawings.

\[
\text{Small number situations} + \text{Unnecessary information} \quad (39)
\]

As stated under the model for procurement, when separate design and construction contracts are used, the agreement must be more detailed to take into account future outcomes and limit opportunistic behavior resulting from the small numbers situation. The same is true for the design information. It may have to be very detailed and explicit to prevent claims of additional work by the construction inter-firm organization. This additional information may not be needed to construct the facility but adds cost to the development of the design. As contracts are integrated, design information can be developed to the extent that it is sufficient to communicate intent.

On a design-build project for a government agency, the architect and designers came on site on a number of occasions and verbally provided solutions to problems that were presented by the construction inter-firm organization. If the design and construction inter-firm organizations were separate entities on a lump sum project, it is likely that the architect and designers would have to develop a design solution, write it up, submit it to the contractors for pricing, and then approve the quoted price before it would be done.

\[
\text{Adaptive decision-making} \rightarrow \text{Unnecessary information} \quad (40)
\]
When the design and construction contracts are integrated, the design and construction inter-firm organizations can develop the design in close coordination with the construction of the facility. Design details can be developed to address actual conditions instead of making incorrect assumptions before construction, that may result in mistakes. Instead of developing the whole design to address possible field conditions, only those conditions that arise are addressed and designed for, thus limiting the amount of unnecessary information.

For example, the designers at a mechanical design-build company often do not try to determine the best locations for ductwork and draw them on the construction drawings. They will often just identify the quantity of air that a room requires and where the diffuser should be located. Once the construction inter-firm organization arrives at this part of the work, they can detail the ductwork based on the field conditions.

6.2.11. Wasted time

\[ \text{Continuity of information flow } \rightarrow \text{Wasted time} \] (41)

In equation (28) in section 6.2.2., it was noted that as the level of contract integration increases, the continuity of information flow will improve. By eliminating contractual boundaries, less time will be wasted since information can flow more directly to those who need it and the information can flow more freely, in small batches. The more people required to communicate the same information, the longer the time. Also, each party will handle the information in a different amount of time depending on their workload.

Consider the example used in section 6.2.2. regarding the flow of information from the electrical design consultant to the electrical contractor. Each party the information passed through increased the transmittal time. The design consultant gave the design to the architect. The architect then incorporated it with the design of the rest of the building before passing it on to the owner for bidding. The winning general contractor eventually provided the design to the electrical contractor. If the contracts were more integrated, the electrical designer could develop the information and pass it on to the constructor as the design proceeds. This is a higher continuity of information and wastes less time.
Unnecessary information \[ \rightarrow \] Wasted time (42)

From section 6.2.10, it was shown that unnecessary information may be developed for several reasons: to bid the construction and prevent opportunistic behavior, to compensate for low inter-firm organization experience, and to overcome the inability to use adaptive decision-making. The cost of developing this information results in extra hours of design time. The time taken to develop this information also delays the construction of the facility and increases the total duration of the project. This results in additional interest on construction loans and opportunity costs due to lost income from the new facility.

For example, a mechanical designer will use time to determine duct locations and detail them on the drawings when they really may only need to identify the quantity of air needed in a room and the location of the diffuser. The construction inter-firm organization can get the relevant information quicker and more easily and start construction earlier.

6.2.12. Wrong information/ mistakes

Continuity of information flow \[ \rightarrow \] Wrong information/ mistakes (43)

Again, as the level of contract integration decreases, the continuity of information flow will increase. This increases the likelihood that information either will not get to the intended receivers or mistakes may arise in the transfer and translation of the information. Fewer mistakes should occur as the level of contract integration increases because information can flow more directly to those who need it.

Unnecessary information \[ \rightarrow \] Wrong information/ mistakes (44)

As discussed in section 6.2.10, unnecessary information is developed for a number of reasons: to bid the construction and prevent opportunistic behavior, to ensure proper communication between inter-firm organization members with little experience working together, and to compensate for the inter-firm organizations inability to use adaptive decision-making. The more detailed information is developed, the greater the likelihood
that mistakes will occur. This is especially true when design decisions must be made early and adaptive decision-making cannot be used. In an integrated approach, decisions can be made as necessary and solutions developed based on as found conditions, thus limiting mistakes resulting from wrong assumptions made earlier than necessary.

Consider a mechanical designer detailing ductwork. If the designer attempts to determine all the placement for the ductwork before construction starts, it is likely that some choices will be incorrect. The mechanical designer may assume a depth for recessed luminaires used in a space. When the product is selected, it may require a larger ceiling space resulting in a change in the ductwork path. If adaptive decision-making could have been used, the ductwork would have been detailed by the constructor when it was required, thus eliminating the design mistake.

6.3. Summary

In this chapter, it was shown that inefficiencies in communicating information may arise as the level of contract integration decreases. To this point in the thesis, the impact of the level of contract integration on the cost categories of project procurement, contract administration, and information communication have been identified and explained. Two relationships from the framework presented in chapter three remain to be described. In the next chapter, the relationship between level of contract integration and firm interactions and the resulting costs are explored.
CHAPTER SEVEN

RELATIONSHIP BETWEEN LEVEL OF CONTRACT INTEGRATION AND FIRM INTERACTIONS

The delivery system in use on a project will affect how the firms in the project interact with each other. This chapter describes the relationship between the level of contract integration and firm interactions. As shown in Figure 7.1, this is the fourth relationship from the Project Delivery Cost Impact Framework presented in chapter three. Figure 7.2 provides an overall view of the model of the decomposition of this relationship. Definitions of terms not already used in the previous three models are provided next. A detailed description of the model with supporting examples follows.

Figure 7.1: Context of the Model to be Described Within the Overall Framework

7.1. DEFINITIONS OF KEY TERMS RELATED TO FIRM INTERACTIONS IMPACTS

The following are definitions for the terms used in Figure 7.2. Only terms that were not defined on the previous three models are presented. The definitions also include the units and a possible method of measuring each term.
Figure 7.2: The Impact of Level of Contract Integration on Firm Interactions
7.1.1. Intervening variables

*Congruency of goals* represents the degree to which the goals of individual firms correspond with the goals of other firms or of the whole project. Sub-goal pursuit is a situation where firms are more concerned with their own responsibilities and goals and act in a manner to benefit themselves at the expense of the overall project and/or other firms. Congruency of goals may range from high to low and is often a function of the number of firms involved and how they are contractually related.

7.1.2. Cost impact variables

*Troubleshooting ability* refers to the ability of the design and construction inter-firm organizations to develop solutions for unanticipated events or problems that may arise during a project. The ability to troubleshoot problems was found to be critical to the success of a project (success factor studies). The result of poor troubleshooting may be time delays or budget overruns. A qualitative evaluation of troubleshooting ability may be obtained from individuals involved in a project and may range from high ability to low.

*Task/event responsibility* represents the degree to which responsibilities for activities or products are assigned to the various contractors. Scope gaps may occur between the design and construction inter-firm organizations. Responsibilities for mistakes are often disputed between the design and construction inter-firm organizations. Task/event responsibility ranges from high uncertainty to low uncertainty and is heavily dependent on the degree of contract integration.

*Dependency conflicts* refer to possible conflicts that may arise because firms are dependent on each other to do their work or must share resources. Dependencies exist on all construction projects within and between the design and construction inter-firm organizations and may be a function of the complexity of the project and the organization. Conflicts will not necessarily arise because of dependencies. The firm interactions in the dependent situations will determine whether conflicts occur. Conflicts often arise because each firm will seek terms favorable to themselves which often conflicts with the desires of other firms.
7.2. Description of Firm Interactions Impacts

Each relationship from Figure 7.2 is isolated and given an equation number. An explanation for each relationship is provided and is often followed by an example.

7.2.1. Congruency of goals

\[
\begin{align*}
\text{Level of contract integration} & \quad \quad + \quad \quad \rightarrow \quad \text{Congruency of goals}\\
\text{Team experience} & \quad \quad + \quad \quad \rightarrow \quad \text{Congruency of goals}
\end{align*}
\]

(45)

As the level of contract integration increases, there will be fewer inter-firm organizations under contract with the owner. Each inter-firm organization may have separate goals. Integrating the contracts reduces the number of possible conflicting goals that arise when many different entities are involved with a project.

As discussed in section 6.2.1, as the level of contract integration increases, the interface investment specificity should decrease. It is likely that the firms involved in an integrated project delivery system have worked together before. Due to their experience working with each other, the uncertainty of how each will behave and the assumption of responsibility for different tasks should be lower. Therefore, it is expected that inter-firm organization members with experience will be better able to manage conflicting goals. The inter-firm organization can use past experience and precedence to troubleshoot problems as they occur, assign responsibilities for tasks, and work out dependency conflicts.

For example, if the drywall contractor and mechanical contractor have worked together in the past, they may have developed a working relationship that allowed the mechanical contractor to install their ductwork first. Knowing that going into the project, the drywall contractor could price their work accordingly.
7.2.2. Troubleshooting ability

Often, a project does not unfold as planned and unexpected problems arise. When these problems arise, it is critical to the success of the project that it be handled efficiently (success factor studies). As the level of contract integration decreases, the responsibility for handling problems as they arise becomes more difficult to determine. Often times, handling such problems may come at the expense of the goals of the firm. To effectively troubleshoot these problems, each member of the inter-firm organization must be able to act quickly and be willing to sacrifice some of their own goals to meet the overall goals of the project. With an integrated approach, the question of responsibility is removed and the goals of the project are unified with those of the inter-firm organization.

Consider the case where the formwork for concrete walls was thought to be ready for pouring. The water stop had not been placed in the formwork where the wall met the slab. The concrete subcontractor and the waterproofer both claimed that it was not their work. The inter-firm organization had to wait for the owner's representative to determine responsibility and a plan of action since it would now be difficult to place the water stop in the forms. If they were on the same inter-firm organization, the decisions could have been made by the inter-firm organization and the water stop could have been put in without delay.

7.2.3. Dependency conflicts

Firms involved in a small numbers situation will often seek terms that will benefit them most. This may result in them acting opportunistically and making a false claim as to the importance of them having priority in the sequencing of the work and work space. A false claim such as this may result in dependency conflicts. Other contractors will also likely want priority in the schedule.
Continuing the example from section 7.2.1, both the drywall contractor and mechanical contractor are in a small numbers trading relationship with the owner. The drywall contractor may behave opportunistically and claim that they did not anticipate having to install drywall with ductwork in place and may submit a change order even though the drywall contractor could have anticipated this. Their small number situation with the owner provided an opportunity for them to claim that there was a dependency conflict.

\[ \text{Congruency of goals} \rightarrow \text{Dependency conflicts} \quad (49) \]

As the level of contract integration decreases, more contracted firms will be involved with a project. Each firm involved in a project has their own goals typically including profit which may not be congruent with the overall goals for the project. The maximization of profit for each firm may be done at the expense of other firms. This may become a problem when firms are dependent on each other or on the same resources.

For example, it may be more profitable for a drywall contractor to hang their drywall before the mechanical contractor installs their ductwork. It will be typically be more difficult for the mechanical contractor to install their ductwork after the drywall has been hung, thus their profit goals have been affected by the goals of the drywall contractor. By contractually unifying these contractors, the sequence can be chosen that will provide the best overall profit for the combined trades. As the level of contract integration increases, the goals for the project should become more unified. As activities are moved within a single organization, the sequence of firms moves from sequential and reciprocal interdependencies between firms to a situation of pooled interdependence (all within a single firm). The integrated inter-firm organization makes decisions on sequencing that will provide an overall benefit to the project.

7.2.4. Task/ event responsibility

\[ \text{Small number situations} \rightarrow \text{Task/ event responsibility} \quad (50) \]

Contractors in a small numbers situation may act opportunistically, which may result in false claims as to what their scope of work or responsibilities are. With an integrated
approach, there is a single source of responsibility that limits opportunistic behavior; the inter-firm organization cannot look to any other firms to take responsibility or blame for scope gaps or mistakes.

\[
\text{Congruency of goals} \rightarrow \text{Task/ event responsibility} \quad (51)
\]

As stated above, as the level of contract integration decreases, more firms with their own goals are involved with a project. The goals of a single firm involved in a project may conflict with the overall goals for the project. As the level of contract integration decreases, the scope of work for the project must be carefully detailed and distributed among the contracted parties. The responsibility for some activities may not be clear from the contracts. For those items that are questionable, the profit goals of a company may make it desirable to shift responsibility to other firms. With an integrated project delivery system, the contracted inter-firm organization provides a single source of responsibility for the project. The owner has less need to worry about gaps in the scope of work.

Consider the earlier example from section 4.1.2.4 regarding a mechanical and electrical contractor and the supply and installation of panelboards for equipment. If it is not specified who should supply and install the panelboards, neither the electrical nor the mechanical contractor will want to take responsibility for the work since it would decrease their profit. They may spend time and energy trying to assign responsibility for the work to each other. If, however, they are on the same inter-firm organization, the work could be done without wasting time and energy determining who should perform the work. That way, the profit for the inter-firm organization will maximized.

7.2.5. Disputes

\[
\text{Dependency conflicts} \rightarrow \text{Disputes} \quad (52)
\]

\[
\text{Task/ event responsibility} \rightarrow \text{Disputes} \quad (53)
\]
When dependency conflict and questions of scope/responsibility arise, the likelihood increases that the parties involved will dispute. For each solution to dependency and responsibility issues, one firm is likely to receive a more favorable solution than the other. Disputes may arise, and they could be settled through negotiation or eventually, litigation.

7.2.6. Frequency of purchase

\[ \text{Frequency of purchase} \quad + \quad \text{Congruency of goals} \]  \hspace{1cm} (54)

As described on earlier models, the frequency of purchase by the owner can have a significant impact on the behavior of contractors. If an owner will be purchasing more design and construction services in the future, the owner and the contractors have an interest in behaving in a manner that will not jeopardize their relationship. This should help reduce opportunistic behavior and limit sub-goal pursuit by individual companies.

7.3. Summary

This chapter described the relationship between the level of contract integration and firm interactions. By integrating contracts, it appears that less conflicts will occur between firms, thus providing savings in costs to the owner.

In the models described in this and the three previous chapters, the subcategories of project level organization/transaction costs were discussed. The other primary category of costs is production. Again, production includes the costs of direct work by individuals plus the organization/transaction costs from the inter-firm, firm, and group levels of each of the organizations contracted with the owner. The impact of the level of contract integration on production costs will be addressed in the next chapter.
CHAPTER EIGHT

RELATIONSHIP BETWEEN LEVEL OF CONTRACT INTEGRATION AND PRODUCTION

The first four models, described in chapters four through seven, showed how the level of contract integration impacts the project level organization/transaction costs. This chapter details the relationship between the level of contract integration and the other major cost category, production. This is the final relationship from the overall framework presented in chapter three (see Figure 8.1). Again, for this study, production costs include the cost of direct work at the individual level, the group level organization/transaction costs, the firm level organization/transaction costs, and the inter-firm level organization/transaction costs. Figure 8.2 is a model of the decomposition of the relationship between the level of contract integration and production. Terms in Figure 8.2 that have not already been described in previous chapters are presented, followed by a detailed description of the model with supporting examples.

![Diagram](image)

Figure 8.1: Context of the Model to be Described Within the Overall Framework
Figure 8.2: The Impact of Level of Contract Integration on Production
8.1. Definitions of Key Terms Related to Production Impacts

The following are definitions for the terms used in Figure 8.1. Only terms that were not defined on the previous four models are presented. The definitions also include the unit of measurement as well as a possible method of measurement of each term.

8.1.1. Intervening variables

*Internal competition/profit seeking* is the degree to which a inter-firm organization or department within a firm performing a function must be cost competitive with an outside source or contractor. A function within a firm can be identified as a profit center by designation or if it can be documented that a firm considers competitive outside contractors or vendors with those provided in-house.

*Specialization* describes the number of core capabilities or skills to which a company devotes resources and develops within their organization. The more processes or functions that an organization performs, the less specialized they are. Specialization can range from highly specialized where a firm performs one process for one building system to low specialization where a firm performs a number of processes for a number of building systems.

*Utilization of production capacities* is the extent to which a firm or a department within a firm can completely use all of their production capacity or capabilities. Economies of scale are exhausted when a firm has full utilization of their capacities. Utilization of production capacities can be documented as the percentage of production capacity used or the ratio of the amount of productive time (total time minus idle time) to the total time available for a department.

8.1.2. Cost impact variables

*Profit* is money added by a contractor to their costs for a project that represents the financial return a contractor will receive for providing their services. Profit is often expressed in terms of return on investment or a percentage of costs.

*Productivity* of direct work represents the level of production that is achieved with a given amount of resources, for an individual or firm. It is often expressed in terms of a
measurable physical work unit per period of time (e.g., work hours per cubic yard of concrete).

*Contributory work* includes activities that support but are not directly involved in the actual production processes. These may include field activities such as handling materials, cleanup, and reading design drawings. Also included with this are management functions such as planning, acquiring resources, establishing budgets, scheduling, and pricing change orders.

*Overhead* refers to the costs for an organization to be in business (or general business expenses) such as office rent, heat, lights, office supplies, furniture, telephone, advertising, travel, and the salaries of executives and office employees. The cost of unused production capabilities is also included with this.

*Non-contributory work* refers to idle time, rework, and all other activities that are neither direct work nor contributory work.

### 8.2. DESCRIPTION OF PRODUCTION IMPACTS

In the following sections, each relationship from Figure 8.1 is isolated and given an equation number. An explanation for the relationship is provided followed by an example. As in the previous section, examples are in italics.

Two of the relationships shown on Figure 8.1 are the same as ones from previous figures. The relationships that are repeats correspond to equation numbers (3) and (29). They are not described here again.

#### 8.2.1. Internal competition/ profit seeking

\[ \text{Level of contract integration} \rightarrow \text{Internal competition/ profit seeking} \]  

(55)

As the level of contract integration increases, many functions that previously would be contracted for are now internalized within a firm. Internalizing a function within a firm
may take away the competitive nature of that inter-firm organization since they do not have to compete externally for work.

*For example, the sheetmetal shop that is internal to a mechanical contractor may not be as efficient as an outside contractor who must compete to provide sheetmetal to contractors. Therefore, when a function is moved from the marketplace into the hierarchy of a company, they are now in a less competitive environment. The firm often exclusively uses the internal function rather than contracting outside the firm since the internal shop often provides the service and flexibility that an outside contractor may not be able to provide. However, since there is now little competitive drive for survival, the department within a firm may have less incentive to improve their productivity.*

### 8.2.2. Specialization

As the level of contract integration increases, firms or inter-firm organizations will need to have more skills or capabilities to compete for the contract. By increasing their number of skills, a firm decreases their specialization.

*For example, when a design firm that traditionally performed just structural engineering work develops in-house design capabilities for mechanical and electrical systems, they have become less specialized.*

### 8.2.3. Utilization of production capacities

As a firm increases its capabilities by internalizing many functions, it may become more difficult to use the full capacities of each of their in-house skills. Some of the skills that are developed in-house may not be needed for every project. If a firm specializes in a single skill, it is more likely they will use the full economies of scale since they can compete for a
number of projects. When the personnel in a firm are idle, their time is charged to the corporate overhead.

The department within the full service firm specializing in the design of steel trusses will likely only be needed for some of the firm’s projects. They may have a difficult time using their full production capabilities on concrete framed projects and thus the firm’s utilization of production capacity will decrease.

8.2.4. Profit

\[ \text{Competition} \xrightarrow{} \text{Profit} \quad (58) \]

As the level of contract integration increases, the number of firms that perform the work may decrease because firms with more capabilities will be needed. Since there are less competitors, higher profits should be expected.

For example, when the US Postal Service first started using the design-build delivery method, there were few firms that could compete for the contracts, and the profit margins for the companies were quite high. As they continued to use design-build, more firms developed the skills to perform this work. As more firms competed for these contracts, the profits for these firms also decreased.

8.2.5. Productivity of direct work

\[ \text{Competition} \xrightarrow{} \text{Productivity of direct work} \quad (59) \]

External competition is similar to internal competition. If there is little competition for contracts, it is expected that firms will not have to work at becoming more efficient. As the level of contract integration increases, there will be less firms available that will be able to perform all the necessary processes. Therefore, firms providing a wide range of services and who are competing for contracts calling for a wide range of services will typically have less competition. With less competition, there may be less incentive to improve productivity.
For example, a large design-build firm working in a certain area has found their niche in the marketplace. They have found that certain clients prefer the design-build method to procure their buildings. They also know that they are the only design-builders in the area. The firm has enjoyed high profit margins on past projects and therefore have little incentive to bring about changes in the company that may increase their productivity.

\[ \text{Internal competition/profit seeking} \quad \rightarrow \quad \text{Productivity of direct work} \quad (60) \]

As the level of contract integration increases, many functions that previously would be contracted for are now internalized within a firm. Internalizing a function within a firm may take away the competitive nature of that inter-firm organization since they do not have to compete for work.

For example, the sheetmetal shop that is internal to a mechanical contractor may not be as efficient as an outside contractor who must compete to provide sheetmetal to contractors. Therefore, when a function is moved from the marketplace into the hierarchy of a company, they are now in a less competitive environment. The firm often exclusively uses the internal function rather than contracting outside the firm since the internal shop often provides the service and flexibility that an outside contractor may not be able to provide. However, since there is now little competitive drive for survival, the department within a firm may have less incentive to improve their productivity.

\[ \text{Specialization} \quad \rightarrow \quad \text{Productivity of direct work} \quad (61) \]

As the level of contract integration increases, firms must be able to perform more processes for more building systems. When firms add additional capabilities to their firm they are decreasing their level of specialization. With decreased specialization, it is expected that the efficiency of production will decrease. A company performing one function or process will probably be more efficient than a company that does that process along with many others. A company that can concentrate its efforts and resources on improving a single process should become more efficient. Therefore, as the level of contract integration increases, less specialized firm will be needed. These firms may not be as productive as a specialized firm.
It is expected that a design firm specializing in steel trusses may be more efficient at performing designs than a structural design department within a full service architecture/engineering firm. The firm specializing in that system can concentrate their firm's resources on providing this highly specialized design service. The department within a full service firm has to compete with all the other building systems design groups for the company's resources. Also, this department will likely not have as much experience since these systems are not needed on all facilities.

### 8.2.6 Contributory work

```
Specialization → Contributory work
```

(62)

With increased capabilities, the hierarchy and the management needed to coordinate and plan the activities of the organization will increase. This represents increases in the level of contributory work.

*If a construction firm develops design capabilities in-house and thus becomes less specialized, they may have to add other management roles to coordinate between the design and construction departments. One function that may need to be performed is to provide feedback from the construction inter-firm organization to the design inter-firm organization as to the effectiveness of the design for a particular project.*

### 8.2.7 Overhead

```
Utilization of production capacities → Overhead
```

(63)

As a firm increases its capabilities by internalizing many functions, it may become more difficult to use up the full capacities of each of their in-house skills. Some of the skills that are developed in-house may not be needed for every project. If a firm specializes in a single skill, it is more likely they will use the full economies of scale since they can compete for a number of projects. When the personnel in a firm are idle, their time is charged to the corporate overhead.
For example, the steel truss design department within the full service design firm will not be needed for every project since that system is specialized and few projects will require them. The time that this department is not performing design work for a particular project will be charged to the overhead of the firm.

8.2.8. Non-contributory work

Adaptive decision-making $\rightarrow$ Non-contributory work

From previous models it was shown that more adaptive decision-making can be used with increased contract integration. As the level of contract integration increases, firms are contracting more for a completed facility through the use of specified functional requirements. Their contracts do not attempt to contemplate how the work will be performed. The firms can develop solutions as the need arises. Assumptions and decisions based on these assumptions should be reduced and therefore, rework resulting from mistakes should be reduced. Non-contributory work such as rework should decrease due to the ability to use adaptive decision-making.

Consider the example from section 6.2.8. regarding the designer specifying the location for exhaust ducts for tools in a clean room. If they attempt to do this, even though they know that the placement of tools is not certain, and the owner often make changes up until the last minute, it is likely they will have to rework the design. This rework in design represents non-contributory work. If they wait to specify the placement of the exhaust ducts until after the clean room space is finished, the design will not have to be reworked.

8.3. Summary

This chapter described the last relationship (the impact of the level of contract integration on production costs) from the Project Delivery Cost Impact Framework presented in chapter three. This model demonstrated how production inefficiencies may arise as contracts are integrated. The four previous models described the impact of the level of contract integration on the project level organization/transaction costs. By studying the overall framework and models, it can be seen that there are trade-offs between project level organization/transaction costs and production efficiency. Integrated project delivery
systems, such as design-build, may economize on project level organization/transaction costs, but these savings may be offset by increased production costs.

In the next chapter, the first model from the Project Delivery Cost Impact Framework, the one from chapter four relating to the costs of project procurement, is evaluated with interviews and case studies. Similar type facilities are examined and as a result, modifications to the model are suggested.
CHAPTER NINE

MODEL EVALUATION

This chapter describes the evaluation of the Project Organization Cost Impact Framework through interviews and case studies. Since the research presented here is exploratory and based on organizational theories, an evaluation based on experts' opinion and case studies provides support for the thesis and verifies that the variables and relationships in the research are relevant.

The first part of the chapter identifies the parts of the framework which were measured and tested and the project types and firms chosen for measuring and testing. The second part describes the questionnaires for the interviews and case studies. Next, summaries of the data are followed by an analysis and discussion of the results. Finally, modifications to the model are identified.

The goal of this chapter was to test and evaluate one part of the framework, the relationship between level of contract integration and project procurement described in chapter four (Figure 4.1). Many of its variables are readily measurable. The methodology may be used with the appropriate modifications for testing the models described in chapters five through eight.

9.1. SCOPE OF MEASURING AND TESTING

This section identifies the parts of the framework that were tested. This is followed by a description of the project types and firms on which the model was tested.

9.1.1. Selection of parts of the framework to test

The following relationships, taken from Figure 4.1, represent those that were measured and tested. The relationship number (to the right of the relationship) is used for reference in tables later in this chapter.
Level of contract integration —> Number of contracts  
(1)

Level of contract integration —> Contractual reliance on functional requirements  
(2)

Level of contract integration —> Competition  
(3)

Number of contracts —> Coordinating contracts  
(4)

Contractual reliance on functional requirements —> Developing pre-contract information/requirements  
(5)

Contractual reliance on functional requirements —> Writing the agreement  
(6)

Contractual reliance on functional requirements —> Developing proposals/bids  
(7)

Competition —> Developing proposals/bids  
(8)

Competition —> Reviewing/Selecting proposals/bids  
(9)

Developing proposals/bids —> Reviewing/Selecting proposals/bids  
(10)

Competition —> Negotiating the agreement  
(11)
9.1.2. Selection of projects to measure and test models

Testing the models developed in this thesis focused on mail sorting facilities built by the United States Postal Service (USPS) for the following reasons:

1. the USPS builds similar facilities thus, complexity and owner type were relatively constant, and the impacts of the level of contract integration on project level costs were better isolated;

2. a large number of USPS projects are constructed each year which provided an adequate set of data; and

3. USPS projects were exclusively delivered with a traditional design-bid-build delivery method (low contract integration) up until several years ago. Over the past few years, design-build (high contract integration) has become a preferred delivery method. Therefore, a number of projects using the two delivery methods were available for comparison.

Two contractors were selected to participate in the study. The first contractor was a large general contractor that had provided services to the USPS on a number of traditional and design-build projects (acting as a joint venture partner with a design firm). The second contractor was a design-builder (both design and construction capabilities within their firm) that had performed multiple projects for the USPS.
The USPS has two major facilities offices, one in Philadelphia, PA and the other in Memphis, TN. The Memphis office is responsible for all the design, construction and real estate activities for mail processing facilities in the southeast and west of the Mississippi River. The Philadelphia office is responsible for the northeast. The USPS capital budget for the next four years is between $3 and $4 billion. Their average annual workload includes new construction of over four hundred facilities.

A typical project for the USPS is called a primary or secondary mail processing facility. The main purpose of one of these facilities is to process incoming and outgoing mail. The actual facilities are light industrial construction. Areas for sorting and distributing mail make up the majority of these facilities, but they also include administrative offices. These facilities house much equipment including optical code readers, bar code sorters, flat sorters, and tray mail conveyor systems. These facilities operate continuously.

Up until the late 1980's, the USPS exclusively used the traditional project delivery approach with separate design and construction contracts. At that point the USPS started experimenting with the design-build delivery method. They expected that with their large program of construction and the repetitive nature of the facilities that design-build might provide efficiencies. The expected efficiencies included standardization, reduction in project time, less in-house resources, greater accountability with one contract, possibly less costs, and finally, maximization of contractor and designer input [Ferrari 95].

The USPS senses that this move toward the use of design-build has been fruitful and now use this form of delivery method on almost all their projects. They have seen reductions in their own staff and reduced delivery times for projects, but are not certain how economical overall the switch has been. They have not been able to verify and quantify any cost savings [Ferrari 95].

The USPS uses a two step, best value approach for design-build. They first pre-qualify firms. The USPS then develops a concept design which they consider to be approximately ten percent design completion. Next, in the Memphis office of the USPS, a request for design-build guaranteed maximum price (GMP) proposals is generated and provided to the prequalified teams. Teams develop a technical solution and a GMP. The USPS awards the contract to the proposal providing the best value based on a combined evaluation of the technical proposal and price. In the Philadelphia office, the process is
done somewhat differently. The teams proposing are basically competing on fees. In both offices, the USPS encourages the use of alternate methods and shares with the contractors any savings that come as a result of their proposed alternatives [Ferrari 95].

9.2. Data Collection

Two types of data were solicited from the USPS and the contractors participating in this research. First, interviews with key project individuals provided expert opinion on the model's relationships. Secondly, case study data further supported the models. This section presents the methods for developing the questions for the interviews and case studies and summarizes the researched case study projects.

9.2.1. Interview questionnaire development

A questionnaire of non-leading questions guided the interviews (the questionnaire for USPS representatives is in Appendix A, and for contractors is in Appendix B). A non-leading question allows a respondent to provide an explanation of an answer. In their dialogue, they may also discuss issues and variables other than those identified for the study. The participants were not shown the relationships before or during the interviews to avoid bias. Each relationship to be measured and tested had multiple questions related to it.

As an example of how the questionnaire was developed, Figure 9.1 shows the part of the questionnaire used to solicit expert opinions on relationships (1) and (4). Question 1.a. determines whether there is a relationship between the number of contracts and the amount of coordination necessary. To gain support for relationship number (4) from this question, the respondent would need to point out that the activities are dependent on the number of contracts or the project delivery system used. Question 1.b. was developed as another check for relationship number (4). Through examples, the respondent may make the distinction between the coordination activities needed for different delivery systems. If the respondent provides an example for one delivery system, the interviewer could follow up by asking how that would differ for another project delivery system. For the relationship to be supported again, the respondent would have to explain in the examples that more effort or activity is required for project delivery systems with lower levels of contract integration. Question 1.c. is another check on relationship (4). This question provides a direct query to the relationship. If the respondent has already discussed this in the answer
to the first two questions, then asking this question may be redundant. Finally, question 1.d. asks the obvious question regarding how the number of contracts changes as the level of contract integration changes. Since this relationship and corresponding question are evident, there is no need for further questions regarding relationship (1).

\[ \text{Level of contract integration} \rightarrow \text{Number of contracts} \quad (1) \]

\[ \text{Number of contracts} \rightarrow \text{Coordinating contracts} \quad (4) \]

1. Coordinating contracts
   a. What activities must you go through when coordinating contracts?
   b. What would you consider a high and low effort at coordinating contracts?
   c. How does the delivery system being used affect the level of coordination you must provide?
   d. How does the delivery system affect the number of contracts?

Figure 9.1: Example Questions for Expert Interviews

9.2.2. Case study questionnaire development

For the case study questionnaires, two types of data were desired for each individual variable in the model being tested. The first type of data was an actual measurement or cost for the variable. For example, for the variable “number of contracts,” the number would be identified such as two for the traditional project delivery or one for design-build. Figure 9.2 is an excerpt from the case study questionnaire. These questions were generated to determine the cost and effort by the contractors to develop proposals or bids. The first three questions ask for specific numerical data such as the cost to develop the proposal, the work hours, and the duration. The second type of data was a subjective evaluation of the
variable "developing proposals/bids" by the project participant. For the variable "developing proposals/bids," the contractors were asked to rate the effort required to develop them on a scale from one (lowest) to five (highest). The ratings data was another comparison of the variables for the two delivery methods.

<table>
<thead>
<tr>
<th>Developing proposals/ bids</th>
</tr>
</thead>
<tbody>
<tr>
<td>What was the cost to develop the proposal or bid?</td>
</tr>
<tr>
<td>How many work hours?</td>
</tr>
<tr>
<td>How many months?</td>
</tr>
<tr>
<td>How would you characterize the effort?</td>
</tr>
<tr>
<td>(1 - low, 5 - high)</td>
</tr>
</tbody>
</table>

Figure 9.2: Excerpt from Case Study Questionnaire

9.3. SUMMARY RESULTS OF DATA COLLECTION

The following sections summarize the data collection. Interview data is presented first followed by the case studies.

9.3.1. Interviews

A total of six expert interviews were performed; four representatives from the USPS and one representative from each of the two contractors involved with the study. Each of the individuals from the two contractors were responsible for all the USPS work for their firms.

The interview data for each respondent was evaluated and reduced to a numerical rating for each relationship in the model. Table 9.1 presents the results. A relationship was rated a 1 when a respondent disagree with it or believed that the relationship was actually the opposite of that presented in the model. A 2 was given when the respondent disagreed but identified exceptions or situations where the relationship could apply. When a respondent stated that there was no relationship between the variables or that the relationship was not relevant, a rating of 3 was given. A 4 was given to relationships that the respondent agreed with but could identify exceptions or situations where it would not apply. Finally, those relationships that the respondents fully agreed with were rated a 5.
<table>
<thead>
<tr>
<th>Interviewee Relationship</th>
<th>1 USPS</th>
<th>2 USPS</th>
<th>3 USPS</th>
<th>4 DB</th>
<th>5 GC</th>
<th>6 USPS</th>
</tr>
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<tr>
<td>(1)</td>
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</tr>
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<td>4</td>
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</tr>
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<td>2</td>
<td>3</td>
<td>2</td>
</tr>
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<td>5</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

1 = disagree
2 = disagree, but not always/necessarily true
3 = no relationship
4 = agree, but not always/necessarily true
5 = agree

USPS = United States Postal Service representative
DB = design-build firm representative
GC = general contractor representative

For example, three of the participants answering the questions regarding relationship (4) made a distinction in the amount of contract coordination effort for the owner when moving from a traditional approach to the design-build approach. One respondent described how when the USPS first started using the design-build approach, they took the two contracts for design and construction and placed them together. They found that by putting the two contracts together, they no longer had to designate which of the clauses applied to the architect and which clauses applied to the general contractor. All references could now be made to the “design-builder.” This respondent was given a rating of 5, signifying that he agreed with the relationship. Another respondent did not believe that there was a difference in effort to coordinate contracts when moving from a traditional to a design-build. However, when questioned further regarding other delivery methods, he believed that there was a significant amount of effort to coordinate contracts in a multiple prime scenario. Therefore, this response was given a rating of 4, signifying that he agreed with exceptions. He agreed that as contracts are reduced going from multiple-prime to
traditional, there is a reduction in coordination effort but not any difference moving from a traditional delivery system to design-build.

9.3.2. Case studies

The goals of the case studies included determining if the variables were correct, verifying if they could be measured, and explaining the circumstances around the relationships. Data was collected from nineteen projects, six traditional and thirteen design-build. The people evaluating the case studies rated each variable and provided actual cost and duration measurements where appropriate for each project. Examples of case study data are provided in Table 9.2. The example projects in the table are those provided by the USPS. The tables containing all the case studies are extensive and would be disruptive to the flow of the chapter if presented here. Therefore, they have been placed in Appendix C.

A discussion of the results from the interview data in Table 9.1, the case study data in Table 9.2, and the case study data in Appendix C follows next.

9.4. Data analysis and discussion

The following is an analysis and discussion of the collected data. Most of the respondents were using the USPS projects as reference points for the questions asked in the interviews. This is an important point since the type of owner and type of project impact the relationships.

In this analysis and discussion, each of the relationships is first presented. The results of the expert opinion and case studies are then provided for each relationship. Finally, the results of both the expert opinion and case study data are discussed.

9.4.1. Number of contracts

\[
\text{Level of contract integration} \quad \rightarrow \quad \text{Number of contracts} \quad \quad \quad (1)
\]

All respondents agreed with this straightforward relationship, and all the case studies also supported it. From the owner’s perspective, when moving from a traditional project
<table>
<thead>
<tr>
<th>Variables</th>
<th>Projects</th>
<th>USPS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trad-1</td>
<td>Trad-2</td>
</tr>
<tr>
<td><strong>Facility Information</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility types</td>
<td>GMF</td>
<td>GMF</td>
</tr>
<tr>
<td>Size (thousand of square feet)</td>
<td>80.1</td>
<td>212.0</td>
</tr>
<tr>
<td>Cost in Millions (design and construction)</td>
<td>$7.2</td>
<td>$16.6</td>
</tr>
<tr>
<td>Cost/square foot</td>
<td>$89.6</td>
<td>$78.3</td>
</tr>
<tr>
<td>Project duration (months)</td>
<td>29.8</td>
<td>38.3</td>
</tr>
<tr>
<td>Square foot (thousands)/month</td>
<td>2.7</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Level of contract integration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 = multiple prime, 3 = traditional, 5 = design-build</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Number of contracts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of contracts between USPS and contractors</td>
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<td>2</td>
</tr>
<tr>
<td><strong>Contractual reliance on funct. requirements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design % before construction contract?</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>1 = product, 3 = product/functional, 5 = functional</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Competition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of competing teams</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Rating: 1 = no competition, 5 = highly competitive</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Coordinating contracts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost to coordinate contracts ($thousands)</td>
<td>$35.9</td>
<td>$83.0</td>
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<td>3</td>
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<tr>
<td><strong>Developing pre-contract info./ requirements</strong></td>
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<tr>
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<tr>
<td><strong>Writing the agreement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost to write the agreement ($thousands)</td>
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<td>$83.0</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td>6</td>
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<td>3</td>
</tr>
<tr>
<td>Rating of effort to write: 1 = lowest, 5 = highest</td>
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<td>2</td>
</tr>
<tr>
<td><strong>Developing proposals/ bids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per contractor ($thousand)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Total effort of all contractors ($thousand)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td>7</td>
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<tr>
<td>Rating of effort: 1 = low, 5 = high</td>
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<tr>
<td><strong>Reviewing/ selecting proposals/ bids</strong></td>
<td></td>
<td></td>
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<tr>
<td>Cost to review/ select ($thousands)</td>
<td>$0.0</td>
<td>$0.0</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rating of effort: 1 = low, 5 = high</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Negotiating the agreement</strong></td>
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<td></td>
</tr>
<tr>
<td>Cost to negotiate ($thousands)</td>
<td>$0.0</td>
<td>$0.0</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rating of effort required: 1 = low, 5 = high</td>
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<td>1</td>
</tr>
<tr>
<td><strong>Frequency of purchase</strong></td>
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<td></td>
</tr>
<tr>
<td>Rating: 1 = once, 3 = occasional, 5 = recurrent</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

USPS = case study projects provided by the United States Postal Service
Trad = projects delivered with the traditional delivery system
DB = projects delivered with the design-build delivery system
delivery system to design-build, the number of contracts decreased from two to one. This relationship should remain as it is on the model.

9.4.2. Contractual reliance on functional requirements

The interview responses for this relationship included four 4’s and two 5’s. The case study data showed that the traditional projects relied on an “all product” specification, and the design-build specifications relied on a mix of functional and product specification. The traditional case study projects all had 100% design completion listed while all the design-build projects had between 10% and 30%, which also supports this relationship. Although some respondents did not agree with the terms being used, they said that when design was not completed, there was some use of performance or functional specification. Several respondents also noted that by not developing design to the working drawings stage, the design-build team can use their own creativity to meet the requirements for the facility.

The amount of design completed before contracts are entered into can be highly variable and is not necessarily a function of the level of contract integration. Design-build provides an opportunity to use contracts relying on functional requirements or detailed design. The traditional approach requires the design to be developed and used as a basis for the construction agreement. Therefore, this relationship should remain as it is on the model.

9.4.3. Competition

Every respondent had similar answers to questions regarding this relationship. All responses were 4’s indicating agreement with the relationship. The values from the case studies appear to be very similar. The extremes went from only one competitor on one of the design-build projects to ten on another design-build project. The traditional projects had mostly five and six competitors per project.
The general consensus to the reason was that when the USPS first started using the design-build approach, the competition greatly decreased because there were not many firms with the right qualifications to perform the work. However, with the increased demand for firms capable of performing design-build work for the USPS, more firms developed those skills. There are now many capable and qualified firms to perform this type of work. A new relationship can therefore be added to the model (see section 9.5). As the frequency of purchase by an owner increases, so will the competition. Firms will develop the skills necessary to meet the demands of owners. This relationship should remain on the model if discussing an initial move to a more integrated approach. If deciding between two delivery systems with mature markets, this relationship should be removed from the model.

9.4.4. Coordinating contracts

\[
\text{Number of contracts} \quad \rightarrow \quad \text{Coordinating contracts}
\] (4)

The interview responses for this relationship were three 4's and three 5's indicating that half the respondents agreed with the relationships and the other half agreed with exceptions. The case study data ratings did not appear to differ too much between the design-build and traditional approaches. The costs to coordinate contracts, provided by the USPS, however, did appear to be greater for the traditional projects.

Those respondents that agreed with the relationship mentioned that there was coordination of contracts between the a/e (architect/engineer) and general contractor on traditional projects that did not exist on design-build projects as explained in section 9.3.1. Again, the others stated that there was little change in effort to coordinate contracts for the owner when moving from a traditional approach to design-build. There was recognition among them, however, that if the owner used a multiple prime type delivery system, there definitely would be a greater amount of coordination of contracts. The case study data appears to support the relationship but there was only a slight decrease in the effort rating when moving from the traditional approach to design-build. Therefore, this relationship should remain as it is on the model.
9.4.5. Developing pre-contract information/requirements

Contractual reliance on functional requirements $\rightarrow$ Developing pre-contract information/requirements

The interview responses for this relationship varied. Three respondents gave 5’s, one gave a 4, one a 3, and one a 2. The case study data appears to support the relationship. If the data supplied from the USPS is examined (since they are developing the pre-contract information), their average ratings show that the design-build delivery method takes more effort. Their costs also were considerable higher for the design-build delivery system.

The respondent who disagreed with the relationship discussed how the USPS, in a design-build GMP situation, is permitted to audit the design-builder at any time and up to three years after the project is completed. This provided the USPS respondent with increased confidence in their request for proposal (rfp) and therefore, they did not need to be more careful developing the functional requirements than if they were working with an a/e developing the design. If something needed to be changed in the design-build approach, and they believed they were being overcharged, they could perform an audit of the actual cost for that change or for the whole project.

Also, it was mentioned that the USPS has a standard design criteria which they do not have to change or modify for each project. Therefore, regardless of any project, there is very little change in the effort to develop the rfp from project to project except for the initial design.

Those that agreed with the relationship stated that the design performed by the USPS for a design-build project definitely has caused their cost or effort to rise for design-build. This is often their largest expense for contracting for services. However, the individual who felt there was no relationship stated that this cost is a part of design costs and therefore, the bids from design-builders should reflect this. Based on the definition used in this thesis though, this relationship should remain as it is on the model.
9.4.6. Writing the agreement

The interview responses for this relationship also varied. Two respondents agreed, three agreed with exceptions, and one disagreed with exceptions. The case study data from the contractors showed that they did not believe there was a difference in the effort needed to write the agreements when moving from one delivery system to another. The case study data from the USPS showed that their costs to write the traditional agreements were greater than their costs to write the design-build agreements. However, the USPS representatives rated the effort to be higher for the design-build agreements.

Two issues must be addressed regarding this relationship: the effort to develop the contracts and the complexity of the agreement. These should actually be two different categories. The effort to develop the contracts for design-build may have been higher than a traditional approach because the USPS had standard contracts for the traditional project delivery approach. For design-build, they assembled the design and construction contracts from the traditional approach. Over the course of projects, they have realized that the contracts should change, and they could eliminate some clauses. Therefore, the agreements have become less complex, but the effort to get there may have been greater than if they had used their standard traditional projects.

One respondent disagreed that the contracts have become less complex since the USPS started using the design-build approach. He did note that some clauses could be eliminated, but since there is more negotiation with the design-build approach, the contracts must reference any items that are negotiated. This ends up causing the agreement to be more complex.

Overall, it appears that the USPS has not taken full advantage of the opportunities to eliminate clauses in the agreements for design-build. With an agreement relying on functional requirements to describe the facility, the USPS must relinquish their desire to direct contractors how to perform. One example discussed by an interviewee brings this type of behavior to light. The contractor on this design-build project designed the slab so that steel reinforcing was not required. The USPS representative on this project would not
accept a slab without reinforcing even though the functional requirements did not specify this. The contractor showed the calculations to the USPS indicating that the steel was not needed, but the USPS representative still insisted on having it in the slab. If the USPS is to achieve better costs, they need to let the contractor use their own creativity to develop solutions to meet the functional requirements. This may include eliminating clauses that inhibit the design-build team.

To summarize the findings regarding this relationship, it appears that this relationship holds true if the total effort to develop contracts is considered. Standard contracts may have taken years to develop and refine but can often be easily applied to a project. Even though the contracts for design-build should be less complex compared with those used on traditional projects, it probably takes more effort to write these agreements since they have not had as many years to develop.

9.4.7. Developing proposals/ bids

Contractual reliance on functional requirements → Developing proposals/ bids

All of the respondents except one believed that there was no relationship between these variables. One person agreed. The case study data from the contractors showed that the average ratings did not vary greatly. However, the costs for developing the proposals/ bids appeared to be greater for the traditional projects.

For design-build, the effort to develop proposals can be highly variable since it is dependent on what information is asked for in the rfp. This is primary reason that most respondents believed that there was no relationship between the variables. However, it was pointed out by the respondent agreeing with the relationship that it is typical to find that the most expensive proposals are those in which a significant design effort must be made by the team based on a set of functional requirements. At the same time, as on many USPS projects, a design-build team could be chosen on a cost plus project based on the fee alone, which takes minimal effort. The cost and effort to estimate and bid traditional projects are less variable than the cost and effort to develop proposals for design-build projects.
For USPS projects, the cost to develop a design-build proposal is much less than a
detailed estimate and bid for a similar type project delivered with a traditional approach.
One possible reason mentioned was that it is less labor intensive to perform a conceptual
estimate than a detailed one. Many used the USPS as a basis to respond to the questions
regarding this relationship, and therefore, did not agree that the relationship existed.
Therefore, for this type of project, the relationship should probably be removed from the
model. However, this relationship may hold true for other types of projects and will,
therefore, remain on the model in Figure 4.1.

\[ \text{Competition} \rightarrow \text{Developing proposals/bids} \] (8)

Three of the respondents believed that there was no relationship between these variables
and two disagree with exceptions. The case study data supports this relationship if the total
effort of all the contractors is used. However, for individual contractors, their efforts did
not significantly vary when the level of competition changed.

Most of the respondents felt that when competition is too high, the effort of an
individual firm may actually decrease or, more likely, firms will drop out of the
competition. Therefore, once a firm decides to compete, they will typically put in a good or
similar effort.

One respondent noted that if an extreme case is used, this relationship would have a
better chance of existing. For example, if only one team is competing for a proposal, it is
likely they will spend less effort since they know they will win. Once a second team is
added, the individual effort should greatly increase.

When the total combined efforts of all the contractors is considered, the relationship
makes much more sense. As the number of competitors increases, there are more firms
expending resources. Therefore, when looking at an individual firm's effort, the
relationship may not always hold true, but when looking at the sum of all contractor's
efforts, the relationship is supported. Therefore, this relationship should remain on the
model.

One of the most often mentioned factors affecting the cost or effort to develop
proposals was the number of times the contractor had proposed to that particular owner.
The USPS has a large set of standard design criteria that many contractors felt was difficult to understand for a single project. Therefore, frequency of purchase of the owner and the experience level between the contractors and the owner plays an important role in impacting the effort to develop proposals or bids. These relationships did not appear on the original model and should be added (see section 9.5).

9.4.8. Reviewing/ selecting proposals/ bids

\[ \text{Competition} \rightarrow \text{Reviewing/ selecting proposals/bids} \] (9)

Four of the respondents agreed with the relationship while two agreed with exceptions. The case study data for this relationship is difficult to analyze since the competition did not vary greatly between the traditional and design-build delivery systems. It should be noted that the USPS claimed that there was no cost to them to review bids for the traditional delivery system projects.

This relationship was obviously true, agreed on, and should remain as it is on the model. It was pointed out by the USPS that the number of competing firms was the major factor affecting the time to review and select proposals. However, several noted that if the competition is good and the proposals are of high quality, reviewing individual proposals becomes easier because there is a greater confidence that the firms are qualified to perform the work.

\[ \text{Developing proposals/bids} \rightarrow \text{Reviewing/ selecting proposals/bids} \] (10)

Four of the respondents agreed with the relationship while two agreed with exceptions. If the case study projects for the design-build projects are examined, the relationship appears to be supported. When the proposals took more effort to develop, the USPS spent more effort reviewing them. Therefore, this relationship should remain as it is on the model. Comparisons between the two delivery systems based on the case studies are difficult since the USPS incurs very little cost reviewing bids for the traditional projects.
Those individuals who agreed with exceptions believed that although the detail of the proposal is a factor in how difficult it is to review, other factors may be more important such as expertise of the evaluators, workload of the evaluators, the number of proposers, and most of all, whether or not they prequalified the firms. If they did not pre-qualify, the USPS would have to be much more careful when choosing the winning proposal.

One respondent remarked that it sometimes is more difficult to evaluate proposals when very little information is asked for in the rfp. If there is little information to evaluate, the decision becomes much more subjective. This subjectivity was seen as an added difficulty for this particular respondent.

9.4.9. Negotiating the agreement

The answers regarding this relationship showed a variety of opinions. Two respondents agreed with exceptions, two felt that there was no relationship, and two disagreed with exceptions. The case study data does not provide any evidence, positive or negative, on this relationship since the competition did not vary greatly for the design-build and traditional projects.

Those who disagreed with the relationship stated that if the USPS has competitors that continue to have similarly qualified and priced proposals, they will request clarifications and “best and final offers.” So, competition allows the USPS to continue the negotiation process, and thus the cost of the negotiation process increases. On the other hand, as long as there is competition with other capable and ready contractors to perform the work, the owner can easily turn to any of them without a large negotiation effort. When an owner is in a situation where only one or two contractors are capable, those contractors hold more power in the negotiation process. Therefore, although the cost and time involved with negotiation may increase, the actual effort put in by the USPS is less difficult. It is understandable that respondents may take different viewpoints on this relationship.
Therefore, the existence of this relationship does not appear to be strongly supported by the data and should be removed from the model.

It was noted by the respondents that there is typically a difference in negotiation when going from the traditional approach to design-build. In the traditional approach, the contract is based on a product specification and therefore, there is typically less room for negotiation. The contractors have bid on a completed set of documents. With design-build there is still flexibility in the design and thus more negotiation may be needed to make the final design and price decisions. This relationship was not specified in the original model and should be added (see section 9.5).

9.4.10. Frequency of purchase

Frequency of purchase → Writing the agreement

Five of the respondents agreed with exceptions with the relationship. One respondent felt there was no relationship between the variables. It is interesting to note that for the final four relationships relating to frequency of purchase’s impact on costs, individual responses for each relationship were consistent. One individual felt that for all the relationships, frequency of purchase has no relationship with other variables.

The case study data for all the relationships involving the frequency of purchase were irrelevant since the USPS was the only owner studied. They had the same frequency of purchase, regardless of delivery system.

The one respondent, an owner, who felt that there was no relationship between the two variables, stated that they would put equal effort in regardless of how many facilities they would be purchasing. Others felt that this relationship was true but for another reason beside that of limiting opportunistic behavior. They felt that they could take a long term approach with the development of the contracts. They could start conservatively and include everything in the design-build contract that was in the separate design and construction contracts from the traditional approach. They could then slowly eliminate those clauses that were unnecessary. Therefore, the more often they bought facilities, the less the effort to write the agreements. This was also supported in that the effort to write
the contracts for the traditional approach was less even though they were typically considered less complex than the design-build. To determine the cost to develop the traditional agreements, one would have to look at the entire life of the development of those agreements. It undoubtedly took much effort for the standard agreements to reach their final form.

Relationship (12) should remain as it is on the model.

\[
\text{Frequency of purchase} \quad \uparrow \quad \text{Developing proposals/ bids} \quad (13)
\]

Two of the respondents agreed with the relationship, three agreed with exceptions, and the other respondent believed there was no relationship between the two variables.

It was noted by several respondents that this relationship depended on how many times the design-builder or contractor had proposed or bid in the past to a particular owner. A firm proposing to an owner who will be purchasing more facilities in the future will put more effort into their first proposal. However, the more a firm proposes to the same owner, the easier it becomes to assemble the proposal. This relationship will remain on the model, but the above condition should be considered.

The respondent stating that no relationship existed believed that firms would use equal effort developing proposals, regardless of the owner. He felt that if a firm is going to spend the resources to put together a proposal, they will put in a full effort.

\[
\text{Frequency of purchase} \quad \downarrow \quad \text{Reviewing/ selecting proposals/ bids} \quad (14)
\]

Two of the respondents agreed with the relationship, two agreed with exceptions, and two believed there was no relationship between the two variables.

It became obvious from the interviews that the USPS has used frequency of purchase to insure that the design-build teams provide a facility to meet their requirements. They have been able to develop a large set of standard design criteria for all projects. They re-use them for all projects even if very little applies to a particular project. One contractor noted that they used this set of standard design criteria to allow late changes, if based on
these criteria. Therefore, this standard design criteria, which has been developed due to their frequency of purchase, may allow them to be less careful reviewing and selecting a proposal. This relationship may not always be true but will remain on the model since it should be considered by the decision-maker.

Frequency of purchase \( \rightarrow \) Negotiating the agreement \hspace{1cm} (15)

Three of the respondents agreed with the relationship, one agreed with exceptions, and the other two felt there was no relationship between the variables.

Again, most respondents felt that the USPS uses the fact that they will be purchasing more facilities in the future as a negotiation tool. One respondent remarked at how the representative for the USPS on one of their projects often made comments on how they should perform their work if they want repeat business. The respondents who said that no relationship exists said so because the USPS does very little negotiation, regardless of delivery system. Therefore, it would be difficult for them to use the fact they will be purchasing facilities in the future as a negotiation advantage. This relationship will remain as it is on the model.

9.5. Modifications of the Model/Relationships

It appears from the limited measurements of the model that some of the relationships may not be relevant, such as (7) and (11) or may actually be the opposite of that presented, such as relationship (8). It also became apparent that several new relationships needed to be added to the model. These were discussed in the previous section and the following is a summary list of those relationships that need to be added.

Contractual reliance on functional requirements \( \rightarrow \) Negotiating the agreement \hspace{1cm} (65)

There is typically a difference in negotiation when going from the traditional approach to design-build. In the traditional approach, the contract is based on a product specification which typically allows less room for negotiation. The contractors have bid on a completed
set of documents. With design-build there is still flexibility in the design and thus more negotiation may be needed to make the final design and price decisions.

\[\text{Frequency of purchase} \quad \rightarrow \quad \text{Developing proposals/bids} \quad (66)\]

\[\text{Team experience} \quad \rightarrow \quad \text{Developing proposals/bids} \quad (67)\]

The more often a contractor develops proposals/bids for a particular owner, the more efficient they will typically become. The USPS has a large set of standard design criteria for their projects that many contractors felt would be difficult to get a handle on for a single project. Therefore, frequency of purchase of the owner and the experience level between the contractors and the owner plays an important role in impacting the effort to develop proposals or bids. The term "team experience" is based on the definition presented in chapter six.

\[\text{Frequency of purchase} \quad \rightarrow \quad \text{Competition} \quad (68)\]

When an owner first starts using a particular project delivery approach, the competition may initially decrease because there may not be many firms with the right qualifications to perform the work. However, with an increased demand for firms capable of performing work under a particular project delivery approach, more firms will develop those skills. Therefore, as the frequency of purchase by an owner increases, the competition will also eventually increase.

Modifying these relationships as described results in the revised overall model shown in Figure 9.3. This model presents the relationships for USPS projects. Testing of the models presented in chapters five through eight is needed to provide similar revisions. The new model for the USPS may not be generalizable to all projects.
Figure 9.3: The Impact of Level of Contract Integration on Project Procurement for USPS projects
9.6. **Summary**

In this chapter, the model of the cost impacts of level of contract integration on project procurement was evaluated with interviews and case studies of USPS projects. Based on these interviews and case studies, several modifications to the model were suggested. However, it was noted that the new model may not be valid for all project types. In the next chapter, the research presented in this thesis is discussed, critiqued, and concluded. This discussion also includes directions for future research.
CHAPTER TEN

SUMMARY AND CONCLUSIONS

This chapter summarizes and concludes this thesis. First, the contributions of the research are identified and described. Second, the limitations of the research are presented including commentaries on the framework and models, the research methods, and the organization theories, particularly transaction cost economics. Third, areas for future research are identified, and several are described. Finally, overall conclusions of the research are presented.

10.1. CONTRIBUTIONS OF THE RESEARCH

Several contributions were made related to the understanding of project organizations in construction. The following represent a summary of the major contributions of this research.

1. A framework was developed for identifying different construction organizational choices and the impacts of them on the costs of a project.

Organization choices occur at several different levels of a project organization. The levels include the individual, group, firm, inter-firm, and project. The individual performs direct work. However, when individuals, groups, and firms are organized, they generate costs to organize, coordinate, communicate, and transact with each other. There are different types of costs associated with each organization option at each level.

2. Models were developed that demonstrate the cost impacts of different project delivery systems at the project level.

Concentrating on the project level of a construction project organization, costs were categorized as either transaction costs or production costs. Transaction costs were decomposed into several categories of costs including procurement, contract administration, information communication, and team behavior. By identifying the cost impacts of different delivery systems, they may be more objectively compared.
3. *Organization theories were applied to construction to develop the framework and models.*

Previous work on project delivery systems often provided information on advantages, disadvantages, and success factors. This information is useful but was insufficient in providing an understanding of underlying principles and reasons for those outcomes. Organization theory was examined to see if appropriate theories existed that could help provide understanding of the impacts of different construction project organization options. Many organization theories were useful for explaining how work should be organized. However, most organization theories take a single perspective, such as the role of technology or environment, and concentrate on how work should be organized within the firm. Construction, however, mainly deals with relationships between firms where contracts dictate the relationships. Transaction cost economics was chosen as an organization theory that appeared to have the most potential in providing an understanding of construction organization. It helped explain how inter-firm relationships dictated by contracts impact an organization while also incorporating other parts of organization theory. The framework and models applied transaction cost economics and selected parts of other organization theories to construction organizations.

4. *Transaction costs for construction were identified and classified.*

As mentioned above, transaction cost economics was used as a basis for the framework and models developed. To develop the framework and models, transaction costs for construction needed to be identified. Several categories including procurement, contract administration, information communication, and team behavior were identified and may eventually be measured and compared for different delivery systems. Previous authors have noted the difficulty in identifying and measuring transaction costs [Williamson 75, Reve and Levitt 84, Winch 89].

5. *A method was developed for evaluating the variables in the models.*

The model of the impact of level of contract integration on procurement costs was evaluated through interviews and case studies. This provided an example method for measuring transaction costs. One type of facility was chosen for study. US Postal Service projects were delivered with both the traditional project delivery system and the design-build delivery system. The research in this thesis is an early stage development of
understanding transaction costs in construction. The main contribution was the application of the theory and identification of variables and their relationships. Although the measuring and testing did not significantly add to the theories and models, it did demonstrate that the variables may be measured.

10.2. LIMITATIONS OF THE RESEARCH

The research performed was theoretical and exploratory in nature. By its definition, there were several limitations to the research. These include the framework and models developed, the research methods used, and the theories that formed the basis of the research.

10.2.1. Limitations of the framework and models

1. *The framework and models take the viewpoint of the owner.*

From reading the thesis it may be gathered that all contractors and designers are dishonest and prone to opportunistic behavior. While this is probably not the case, it should also be recognized that owners can act as opportunistically as contractors. The models developed in this research do not take this into account.

2. *Some concepts from transaction cost economics may have lost meaning in translation to variables in the models.*

Some terms from transaction cost economics were found to be difficult to express in construction terms. Therefore, some of the theory may not have translated clearly into the models. Path models provide a means for showing relationships between variables, but the explanations of the relationships are more valuable since they provide more descriptions of how the theories applied. The models therefore have a difficult time standing alone.

3. *The framework and models are difficult to practically apply in their current form.*

No practical applications were developed from the thesis since much of the research is descriptive. Also, the path models are not readily applicable to a problem or decision. Therefore, applications may need to be developed from the research.
4. The framework and models only consider the design and construction processes.

The planning, management, and operation processes have not been included with the model. Eventually these should be included to provide a more complete picture of the construction project organization.

5. The framework and models don’t take into account other possible external variables.

The effects of contract payment methods such as lump sum, unit price, and cost plus have not been addressed. These payment strategies may be used effectively to reduce the impacts of opportunism and uncertainties. Also, there may be other possible factors that reduce uncertainty and opportunism that the models don’t address such as the experience of the owner and varying the complexity of the facility.

6. There is a great amount of variation in the way the design-build method can be implemented.

It was sometimes difficult to generalize about this delivery method in the models due to the wide variation. The primary variation is the amount of design completed and the subsequent reliance on functional requirements in the contracts.

7. The framework and models don’t take into account the possible combinations of delivery systems.

For example, specialty design-builders may be used for some building systems on a project, while the rest of the building may be delivered with a traditional approach. The models consider one generic type of delivery system against another.

8. The models do not consider legal issues and their impacts on project delivery choices.

There are legal concerns related to each delivery system, especially design-build. This model assumed that each delivery system is a viable option for an owner and ignored the legal implications of each delivery system.
10.2.2. Limitations on measuring and testing

The evaluation of the models involved limited measuring and testing of one of the models — the impact of level of contract integration on procurement. Although the methods selected, interviews and case studies, were appropriate for this type of exploratory research, this researcher believes that they provided little new insight. There were several limitations to the measuring and testing that prevented it from being more valuable.

1. Only one of the models was evaluated.

When using the models developed in the thesis, they should all be considered for a particular organization decision. There are always trade-offs in costs between the different transaction costs and production costs. If only one part of the model is considered, it provides an incomplete picture. The evaluation of the single model, however, did provide a method for possibly measuring and testing the rest of the models.

2. Only one type of facility was evaluated using the models.

The selection of one type of facility (US Postal Service projects) allowed the researcher to isolate the relationship between level of contract integration and procurement costs. However, different types of facilities will produce different levels of uncertainty and complexity.

3. Only two delivery systems were compared during the evaluation of the models.

Although a variety of project delivery options exist today, only the traditional and design-build approaches were compared. Other delivery systems such as owner construction, multiple prime, and construction management should also be considered.

4. The results of the model evaluation may not be generalizable to all situations.

Because the evaluation was done for one type of facility, one type of owner, and two delivery systems, the results may not be generalizable to all projects. The models would first have to be tested with these variables varying.
5. *Cost data collected on transaction costs may not be accurate.*

When actually trying to collect data for projects, it was difficult since most companies do not keep accurate data on transaction costs. Production costs would be more readily available.

### 10.2.3. Limitations of transaction cost economics

Transaction cost economics is useful in explaining the relationships between firms and the role of contracting. Unlike other schools of thought on organizations, it also has the potential to incorporate other organization theories. Many organization theories choose a perspective and discount other possibilities. This theory is more inclusive in that other theories fit nicely with it. However, there were some limitations to the theory when trying to apply it to construction.

1. *For construction, transaction cost economics takes a different perspective than that originally developed for manufacturing.*

Originally, transaction cost economics was developed for manufacturing to help explain the development of large integrated companies. The "make or buy" decision was the primary focus. For construction, the decision is how an owner wants to organize a project most efficiently. Firms may make the decisions whether to integrate additional capabilities within a single firm, but owners are the ones typically driving the way firms decide to organize. With the increased interest of owners in using a single source for delivery for projects, more firms are developing this capability.

2. *Transaction cost economics focuses mainly on the costs of writing and enforcing complex contracts.*

This is a large cost for construction but some of the other transaction costs less emphasized by Williamson may be more important for construction. The costs for writing contracts in construction is often minimum due to the standardization of contracts. The transaction costs identified but not emphasized by Williamson include the team's experience working together and its impacts on issues such as constructability, information communication, and team behavior. Also, buffers were discussed by Williamson but in the terms of inventory. The equivalent for construction may be the time buffers between the
design and construction phases of a project. This may very well be the greatest transaction cost for some types of facilities.

3. *Transaction cost economics assumes that transaction costs are reduced when they are moved within a single firm.*

Although this makes sense, it may not actually be the case. Individuals working within a firm may just as likely be prone to opportunism. Therefore, it is important to compare the total costs of delivery systems.

4. *Transaction cost economics stresses that efficiency should be the deciding factor for organizing.*

In construction though, the owner may have other priorities such as aesthetic concerns, level of involvement in the process, and flexibility of the process. These may be more important to an owner than total project costs.

10.3. **Future Research**

One of the primary goals of this research was to establish new directions for future research. The framework and models developed in this thesis open up many possibilities for exploration. The next section describes the necessary further development of the framework and models. Possible research applications resulting from this thesis are then detailed.

10.3.1. **Further development of the framework and models**

The following two items represent the next steps in the development of the framework and models developed in this thesis.

1. *Continue the development, measuring and testing of the models developed in this thesis.*

The models presented in this thesis are in the early stage of development. It is envisioned that the relationships in the models will eventually become equations. One will be able to enter the project characteristics and circumstances into the models and be
provided an accurate determination of which delivery system will be the most efficient for the project. To get to that point, the limitations of the models (described earlier) must be addressed. The models need to be further tested and refined on other types of projects and other delivery systems. Also, the inclusion of other processes; such as managing, planning, and operation [Sanvido 90]; should also be considered. The first testing of the other models would be similar to what was performed for this thesis. Its purpose would be to verify that the variables and the relationships between them are correct. Subsequent measuring and testing would then allow for the formation of equations. This measuring and testing may be completed with surveys to increase the volume and validity of the data.

2. Develop other levels of the framework.

One of the main purposes of this research was to develop a framework from which other researchers could follow. In addition to the further development of the models presented in this thesis, future researchers may want to study the other levels of the project organization. Figure 10.1 illustrates that each level of the project organization and their impacts on costs could be examined.

![Diagram](image)

Figure 10.1: Future Research on Framework

At each level, there are many different options for organizing, and each will have different cost consequences. Within a particular delivery system, comparisons between the
relative efficiencies of different means of organizing the firms may be made such as comparing joint-venture design-build with design-build performed by a general contractor subcontracting the design work. Also, different means of organizing departments within a firm could be compared in efficiency terms. A matrix organization versus a functional organization is one example. At the group level, comparisons could be made between groups composed of similarly skilled individuals versus groups of multi-skilled individuals. Finally, an example at the individuals level might be to compare the economic trade-offs between using manual labor versus machinery. At the levels of a project organization other than the project level, other organization theories, such as those related to environment and technology, may need to be more heavily relied upon to understand the associated cost impacts of organization decisions.

10.3.1. Related research applications

The following are suggested research topics related to the theories presented and developed in this thesis.

1. **Analyze the "make or buy" decision for construction firms.**

   A specific topic that appears to have value would be to develop a method, based on the theories presented here, to analyze whether a construction firm should self-perform work or subcontract elements of the work. There is much variation in the industry by the amount of work self-performed by contractors. However, there must be some type of trade-off in transaction and production terms that could be evaluated.

2. **Examine the impact of organizations on innovation.**

   Many types of innovation could possibly be developed and implemented more easily in other organizational forms than that of the traditional delivery system. For example, it was noted in this thesis that standardization may come as a direct result of integrating design and construction teams into a single firm. A study of the role of project organizations on innovation may be a valuable step to take prior to attempting to innovate within the boundaries of the traditional project delivery system.
3. **Understand the role of environmental uncertainty on transaction costs.**

This thesis assumes a project is delivered domestically. Performing work in other countries introduces many new uncertainties and complexities. A study relating how a firm reduces these uncertainties and weighs the costs of transacting with self-performing work could be performed.

### 10.4. Concluding Remarks

At the outset of this thesis, it was stated that there was no current objective means of comparing project delivery systems. Although this thesis may not also provide this means, it does make progress in that direction. Previous work on project delivery systems provided useful information, but did not provide a theoretical or underlying principle for project outcomes. It is hoped that the research developed here will lead to a science of construction project organization.

Organization theories were reviewed and transaction cost economics was chosen as the theory that best explains the difference in efficiency between project delivery systems. It introduces the concept of transaction costs and how they can be minimized by integrating within a single firm. There are typically trade-offs between transaction and production costs. Most previous work in construction concentrated on the costs of production possibly because they are easier to quantify. However, large changes in overall efficiency may be possibly obtained through changes in organization and the arrangement of transactions.

This researcher believes that it is important to look outside traditional construction literature and current construction practices to other fields of study especially organization theory. Much of today's construction research looks at what the current state of industry is, identifies the best practices, and disseminates these to others. Researchers should take more of a lead and provide insight and education to industry. A better balance of best current practices with insightful theories would benefit the construction industry.
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APPENDIX A

INTERVIEW QUESTIONNAIRE FOR USPS
1. Coordinating contracts
   a. What activities must you go through when coordinating contracts?

   b. What would you consider a high and low effort at coordinating contracts?

   c. How does the delivery system being used affect the level of coordination you must do?

   d. How does the delivery system affect the number of contracts?

2. Performance specification vs. Product specification/ design development
   a. How does the type of delivery system affect the basis of the contract (performance vs. design)?

   b. How much design should be completed before contracts are signed for both design-build and traditional?

   c. What aspects of a contractor's means and methods is it important for you to have knowledge of?

   d. Why do you feel it is important?

   e. What steps can you take to compensate for the difference in knowledge between yourselves and contractors?

   f. With what delivery systems does the level of knowledge become less of a concern to you, as the owner?

Figure A.1: Interview Questionnaire for USPS
g. How do you feel the use of a performance specification affects the level of knowledge you must have?

h. How do you feel the delivery system affects the likelihood of you receiving a facility to match your needs?

i. What steps can you take to better ensure the performance of the final facility under both the traditional and design-build delivery?

3. Developing pre-contract information/ requirements

   a. How does the delivery system being used affect the amount of information or decisions you need to make before contracts are signed?

   b. Why does the delivery system affect the amount of information that needs to be developed?

   c. What would you consider to be a high and low amount of information to develop?

   d. With design-build, what decisions would you rather postpone?

   e. To what degree do you believe the USPS rfp is sufficient to attain the final product you desire?

   f. What aspects of the rfp do you feel could be more or less detailed?

4. Writing the agreement

   a. What do you consider to be a high and low complexity for an agreement?

Figure A.1 (continued): Interview Questionnaire for USPS
b. How does the use of a performance specification affect the complexity or detail of an agreement?

c. How does the complexity of the agreement change going from traditional to design-build?

d. Why does it change?

e. What items should be added or deleted when moving from a traditional to a design-build agreement?

f. How can you be sure if the agreement will sufficiently cover all possible outcomes that may arise on the project?

5. Developing proposals/ bids
   a. What do you consider to be a high and low effort at developing a proposal?

   b. What are the major activities involved with developing a proposal?

   c. How do you feel the effort required to develop a proposal changes the more times a proposal is developed for a particular owner?

   d. How does the detail of the rfp affect the detail of the proposal?

6. Competition
   a. What do you consider to be a high and low level of competition?
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>b. How do you feel the number of competitors affects contractor's behavior or effort at getting the contract?</td>
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</tr>
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<td>c. How do you feel the number of competitors affects your own behavior or effort in contracting for services?</td>
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<tr>
<td>d. How has the level of competition changed for USPS when they went from the traditional approach to design-build?</td>
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</tr>
<tr>
<td>7. Reviewing/selecting proposals</td>
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<td>a. What do you consider a high or low effort to review and select proposals?</td>
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<td>b. What do you consider a long or short amount of time to review and select a proposal?</td>
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<td>c. What impact does the complexity of the proposal have on your effort required to review them?</td>
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<td>d. How does the level of competition affect the effort you must spend on reviewing/selecting a proposal?</td>
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<td>8. Negotiating the agreement</td>
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<td>a. What do you consider a high and low effort to negotiate an agreement?</td>
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<tr>
<td>b. What items are typically negotiated for once the proposal has been selected?</td>
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<td>c. How does the level of competition affect the amount of negotiation performed?</td>
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Figure A.1 (continued): Interview Questionnaire for USPS
9. **Frequency of purchase**

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<td>a. Do you consider the USPS to be a high or low frequency purchaser of facilities?</td>
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<td>b. How do you think the frequency of purchase affects the contractor's effort at developing proposals, negotiating agreements?</td>
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<td>c. How does your frequency of purchase affect your behavior or effort?</td>
</tr>
<tr>
<td>d. Can you give an example where your actions would be different if you were not going to be purchasing more facilities in the future?</td>
</tr>
<tr>
<td>e. Does a contractor's performance on any one USPS project affect their chances of receiving future work from the USPS?</td>
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</table>

Figure A.1 (continued): Interview Questionnaire for USPS
APPENDIX B

INTERVIEW QUESTIONNAIRE FOR CONTRACTORS
1. Coordinating contracts  
   a. What activities must an owner go through in coordinating contracts?
   
   b. What would you consider a high and low effort at coordinating contracts?
   
   c. How does the delivery system being used affect the level of coordination an owner must do?
   
   d. How does the delivery system affect the number of contracts?

2. Performance specification vs. Product specification/design development  
   a. How does the type of delivery system affect the basis of the contract (performance vs. design)?
   
   b. How much design should be completed before contracts are signed for both design-build and traditional?
   
   c. What aspects of your means and methods is it important for an owner to have knowledge of?
   
   d. Why do you feel it is important?
   
   e. What steps can an owner take to compensate for the difference in knowledge between themselves and contractors?
   
   f. With what delivery systems does the level of knowledge become less of a concern to the owner?

Figure B.1: Interview Questionnaire for Contractors
g. How does the use of a performance specification affect the level of knowledge an owner must have?

h. How does the delivery system affect the likelihood of an owner receiving a facility to match their needs?

i. What steps can an owner take to better ensure the performance of the final facility under both the traditional and design-build delivery?

3. Developing pre-contract information/requirements
   a. How does the delivery system being used affect the amount of information or decisions to be made by the owner?
   b. Why does the delivery system affect the amount of information that needs to be developed?
   c. What would you consider to be a high and low amount of information for an owner to develop?
   d. With design-build, what decisions do you believe the owner would rather postpone?
   e. To what degree do you believe the USPS RFP is sufficient for the owner to attain the final product they desire?
   f. What aspects of the RFP could be more or less detailed?

4. Writing the agreement
   a. What do you consider to be a high and low complexity for an agreement?

Figure B.1 (continued): Interview Questionnaire for Contractors
<table>
<thead>
<tr>
<th><strong>b.</strong> How does the use of a performance specification affect the complexity or detail of an agreement?</th>
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<tr>
<td><strong>c.</strong> How does the complexity of the agreement change going from traditional to design-build?</td>
</tr>
<tr>
<td><strong>d.</strong> Why does it change?</td>
</tr>
<tr>
<td><strong>e.</strong> What items should be added or deleted when moving from a traditional to a design-build agreement?</td>
</tr>
<tr>
<td><strong>f.</strong> How can the owner be sure if the agreement will sufficiently cover all possible outcomes that may arise on the project?</td>
</tr>
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**5. Developing proposals/ bids**

<table>
<thead>
<tr>
<th><strong>a.</strong> What do you consider to be a high and low effort at developing a proposal?</th>
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<tr>
<td><strong>b.</strong> What are the major activities involved with developing a proposal?</td>
</tr>
<tr>
<td><strong>c.</strong> How does the effort required to develop a proposal change the more times a proposal is developed for a particular client?</td>
</tr>
<tr>
<td><strong>d.</strong> How does the detail of the rfp affect the detail of the proposal?</td>
</tr>
</tbody>
</table>

**6. Competition**

| **a.** What do you consider to be a high and low level of competition? |

---

Figure B.1 (continued): Interview Questionnaire for Contractors
b. How does the number of competitors affect your behavior or effort at getting the contract?

c. Can you give an example of how the number of competitors affected the amount of effort you put forth developing a proposal?

d. How has the level of competition changed for USPS when they went from the traditional approach to design-build?

7. Reviewing/selecting proposals
   a. What do you consider a high or low effort to review proposals by the owner?

   b. What do you consider a long or short amount of time to review and select a proposal?

   c. What impact does the complexity of the proposal have on the effort required to review them?

   d. How does the level of competition affect the effort the owner must spend on reviewing/selecting a proposal?

8. Negotiating the agreement
   a. What do you consider a high and low effort to negotiate an agreement?

   b. What items are typically negotiated for once the proposal has been selected?

   c. How does the level of competition affect the amount of negotiation performed?
9. Frequency of purchase
   a. What do you consider to be a high and low frequency of purchase?

   b. How does the frequency of purchase by the owner affect your effort at: developing proposals, negotiating agreements?

   c. How do you feel it affects the behavior or effort of the owner?

   d. Can you give an example where your actions would be different if the possibility of receiving future work was at stake?

   e. Does your performance on any one USPS project affect your chances of receiving future work from them?

Figure B.1 (continued): Interview Questionnaire for Contractors
APPENDIX C

CASE STUDY DATA
## Table C.1: Case Study Data

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<th>Variables</th>
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<td>Design % before construction contract?</td>
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VITA

Theodore D. Lynch graduated from The Pennsylvania State University in 1992 with a Bachelor of Architectural Engineering. Prior to attending graduate school, Ted held several jobs. As a carpenter's assistant, he worked on the renovation of an historic landmark residence in Honesdale, PA into offices for Highlights for Children, a children's magazine publisher. As an architectural draftsman for Swendsen Associates, Inc., located in Honesdale, PA, Ted developed design drawings for several building projects in northeast Pennsylvania including a residential development, a nursing home, a hospital, a physician’s office, and a head and neck injury clinic. As a surveyor for the same company, he assisted in the layout of a new residential subdivision. He also performed field measurements for planned renovation projects. Ted also labored for Baker Concrete Construction, Inc. on a $60 million research office building for Merck & Co., Inc. at West Point, PA.

During his graduate work, Ted worked closely with Southland Industries, a mechanical design-build contractor with headquarters in Long Beach, CA. One summer, he worked as an estimator in their home office. He spent another summer in their Honolulu office performing a variety of functions. He estimated and developed proposals for several potential projects, developed pricing for a design-build hotel renovation project, and helped with the close-out of a design-build arena for the University of Hawaii. While under employment with Southland Industries, he has also been involved with several special projects for the firm including the redevelopment of their operations manual and the organization and development of a historical construction cost database.

While at Penn State, Ted was a teaching assistant for several courses. He developed curriculum, lectured, advised, and created and graded homework and tests for two undergraduate construction methods courses. He also lectured, graded assignments, and advised students in undergraduate Construction Management thesis courses. He has also participated in the development of the Partnership for Achieving Construction Excellence (PACE), and planned and managed the 1994 PACE Research Seminar and PACE Roundtable.