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COMPETITION AND PRICE ANALYSIS OF INDEFINITE DELIVERY INDEFINITE QUANTITY CONTRACTS FOR CONSTRUCTION

by

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B.S., Clemson University, 1999

M.S., Clemson University, 2011

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

Of the requirement for the degree of

Doctor of Philosophy

Department of Civil, Environment, and Architectural Engineering

2017

This thesis entitled:

Competition and Price Analysis of Indefinite Delivery Indefinite Quantity Contracts for Construction

written by Matthew Scott Stanford
has been approved for the Department of Civil, Environmental, and Architectural Engineering

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Dr. Keith Molenaar, Committee Chair

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Dr. Matthew Hallowell

Date: ______________

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

IRB Protocol # 16-0265

Abstract

Stanford, Matthew Scott (Ph.D., Civil Engineering, Department of Civil, Environmental, and Architectural Engineering)

Title: Competition and Price Analysis of Indefinite Delivery Indefinite Quantity Contracts for Construction

Thesis directed by Professor Keith R. Molenaar

Indefinite delivery-indefinite quantity (IDIQ) construction contracts use an overarching master contract between an owner and contractor for multiple projects over a specified time period. The practice is widespread in the U.S. federal government but its efficacy has been the subject of relatively few studies. This dissertation offers a state-of-practice review of IDIQ construction contracting as well as an empirical analysis of the competition and cost implications of using IDIQ contracts. Content analysis of 90 federal requests for proposal reveals IDIQ contracting use for a wide range of facility types and construction services. Findings suggest that IDIQ contracts reflect the inherent paradoxical organizational tensions in public sector procurements. On one hand, IDIQ contracts reflect a desire for flexibility, simplified procurement processes, and finding the most qualified contractors. On the other hand, public owners must put control mechanisms in place to obtain a fair price, protect the public interest, and comply with regulations. Statistical analysis of 935 U.S. Department of Defense construction projects shows that IDIQ contracting corresponds with lower levels of competition as measured by the number of bids, even when controlling for factors like delivery method and market conditions. A subsequent analysis of 316 U.S. Air Force construction projects shows IDIQ contracting is associated with approximately five percent higher costs, driven by higher bid prices as compared to engineering estimates. However, multiple award IDIQ contracts also appear to be effective at maintaining a minimal level of competition needed to protect the public's interest. Interviews with practitioners reveal that IDIQ contracting may yield reduced transaction costs, better schedule performance, and other benefits that offset the cost premium. For design-build projects in particular, IDIQ contracts may serve as a streamlined alternative to two-step source selection. The findings of this dissertation contribute to bodies of knowledge on IDIQ contracts and framework agreements, neoclassical economic theory and paradox theory as applied to the construction industry, and construction project delivery methods research. It is the largest empirical study of IDIQ construction projects to date. The findings also have practical implications for public owners with large asset portfolios and for contractors interested in pursuing IDIQ contracts.

DISCLAIMER CLAUSE: The views expressed in this dissertation are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.

Acknowledgements

I am especially grateful to my advisor and mentor Professor Keith Molenaar for agreeing to work with me on this dissertation. Keith has shown incredible patience and a willingness to help me navigate the PhD process in a timely manner. Keith, I could not have asked for a better advisor.

I also want to thank the members of my committee for reviewing my work and providing feedback at critical junctures. Professors James Diekmann, Paul Goodrum, Doug Gransberg, and Matthew Hallowell made for a great team with different perspectives on how to most effectively accomplish my research objectives. Professor Rajagopalan Balaji of CU Boulder also provided advice on the statistical analysis.

Thanks to Brigadier General Greg Seely, USAF (ret) for offering me this once-in-a-lifetime opportunity to pursue a PhD on active duty, which has refocused my career and opened many new doors. My thanks also to the other members of the Department of Civil and Environmental Engineering at the U.S. Air Force Academy, including Lieutenant Colonel Pat Suermann, Dr. Jim Pocock, Colonel John Christ, and others for providing valuable advice and support before and during the PhD process.

I am grateful for my Master's advisor, Dr. Leidy Klotz, who reintroduced me to research a few years ago and showed me that research can be fun and rewarding. Leidy, thanks also for recommending Keith Molenaar and CU Boulder.

Several members from Air Force Civil Engineer Center were instrumental in helping me tackle this dissertation. This dissertation would have been much tougher and far less relevant without the help of several key people. Ben Kindt, Shannon Buckley, and Tim Sullivan all provided ideas and critical feedback to help shape and refine my study. Ben went out his way to get me contacts, access, travel funding, and an appropriate audience to present my findings. Scott Ward and Jim Winslow, as well as Keith Herndon from the Air Staff, helped me access the majority of the data I used in this dissertation. Tony Dipiero from NAVFAC likewise provided insight on the cost performance metrics.

I am indebted to the 40-plus respondents to questionnaires and interviews that helped support this study. They remain anonymous, but provided invaluable expertise and a deeper level of understanding than databases and spreadsheets could ever offer.

My research group was also worth its weight in gold by providing timely and critical feedback on my ideas, presentations, and papers. Thanks especially to Doug Alleman, Arthur Antoine, Evan Dicks, Eric Antillon, Wesam Bietelmal, Harrison Mesa, and Kelly Sheeran.

Most importantly, words can't express the appreciation to my family. This includes my parents who instilled a desire for learning and education, my children who keep me grounded and humble, and most especially my wife. Chrissy stands beside me in my every endeavor and this one was no exception.

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CHAPTER I: INTRODUCTION

Problem

The adversarial and fragmented nature of the construction industry is well documented along with the associated negative implications for project performance, productivity, innovation and industry reputation (e.g. Dubois and Gadde 2002; Egan 1998; Howard et al. 1989; Latham 1994). Such inefficiencies in public sector construction, which in the US totaled over $270 Billion in 2014 (U.S. Census Bureau News 2014), can also mean poor stewardship of tax dollars and erosion of the public's trust in government.

In response to such problems, construction research of the last two decades has repeatedly investigated the influence of project delivery strategies and project team relationships as ways to improve project performance and overcome the obstacles of fragmentation and conflict fueled by self-interested parties (e.g. Anvuur and Kumaraswamy 2007; Chan et al. 2004; Cheng et al. 2000). Trends such as partnering, alternative delivery or contract methods, early contractor involvement, and integrated project delivery can all be seen as approaches to improve team dynamics and bolster project performance. Scholars and practitioners have examined these trends and others at length.

However, little research has examined the role of long-term, multi-project contract structures on project performance. One such contract structure common in the federal sector and growing at the state and local levels is the indefinite delivery-indefinite quantity (IDIQ) contract. This contracting method has been employed for public sector construction services since at least the early 1980s, and has spread throughout federal, state, and municipal construction programs over the past three decades. IDIQ contracts allow a government procurement agency to establish an initial master, or "umbrella," contract for an unspecified amount of construction services. Under this agreement, individual projects are then executed by task orders to be awarded as requirements outlined in the master agreement materialize into projects over the duration of the contract, usually from one to five years.

While IDIQ contracts are widely accepted as being more efficient for government contracting personnel resulting in decreased procurement times and transaction costs, these claims are based primarily on practitioner opinion. Other practitioners and legal scholars have offered critiques of multi-project agreements related to limiting competition and increasing prices, but not in a construction contracting context. Furthermore, there has been little discussion of how IDIQ contracting fits in a theoretical framework of procurement decisions. This has resulted in a gap in knowledge about the proper application of this tool and the associated implications for long term contract structures and project success.

Purpose

This dissertation attempts to address these gaps. The purposes of this research effort were:

- systematically examine and document the state of practice of IDIQ contracting, and;
- empirically evaluate the competition and cost implications of IDIQ contracting.

Background

Introduction of Key Terms

IDIQ contracting for the procurement of goods and services originated with the federal government and can be traced to the creation of the General Services Administration in 1949 (Comptroller General of the United States 1979). Systematic use of

IDIQ contracts for construction purposes has been in place since at least the early 1980s (Moore and Stout 1988). Today the procedures for federal agency use of IDIQ contracts are well codified in federal law and policy. Because public sector and industry terminology of IDIQ contracts can vary from agency-to-agency, this dissertation adopts the following definitions to define the major aspects and types of IDIQ contracting for construction. The definitions are derived from the Federal Acquisition Regulation (U.S. GSA 2015) except where indicated. Figure 1 shows the relationship of the key terms schematically.

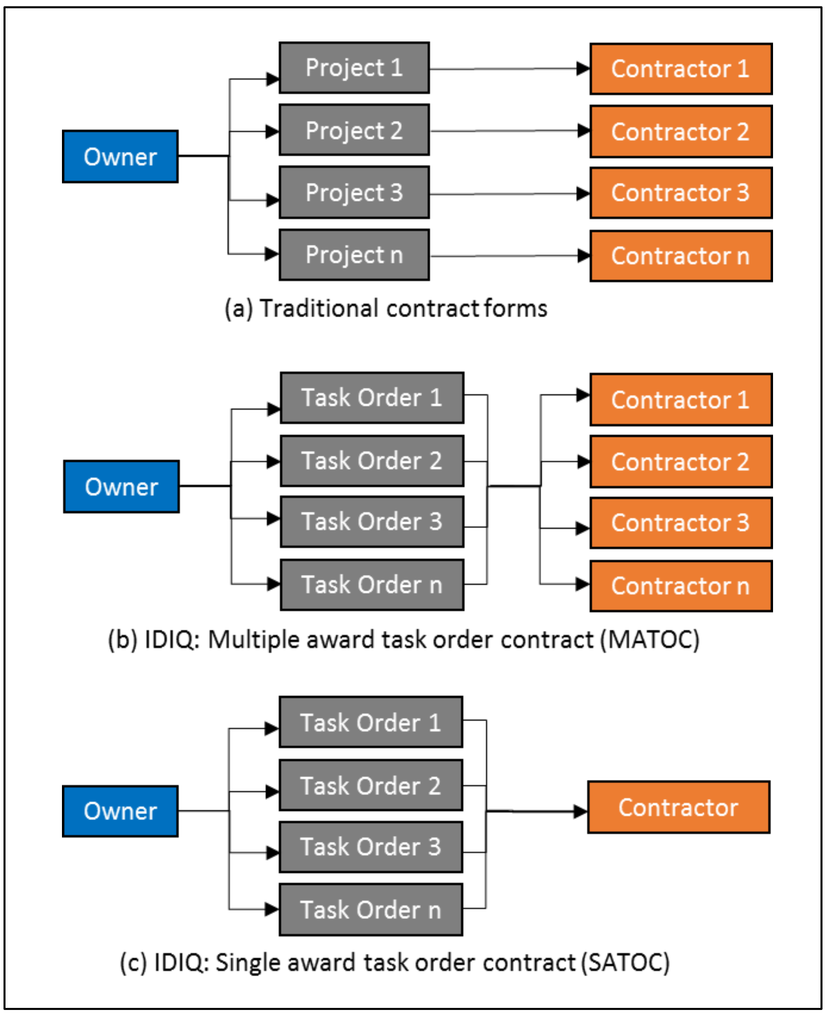

Fig. 1-1. Comparison of Traditional and IDIQ Contract Forms (adapted from Rueda 2013)

- ***Stand-alone contract*—**a traditional contract, used for a specified scope of work in a specified time period; adopted for use in this paper to contrast with multi-project agreements.
- ***Indefinite delivery-indefinite quantity (IDIQ) contract*—**a type of contract "used to acquire supplies and/or services when the exact times and/or exact quantities of future deliveries are not known at the time of contract award." IDIQ contracts typically have established minimum and maximum amounts of work.
- ***Framework agreement*—**European Union equivalent to an IDIQ contract; however these agreements may or may not be binding in nature (European Commission 2005).
- ***Task order*—**the agreement for a specific project or scope of work, issued under the master contract. Master contracts usually contain numerous task orders. For framework agreements, the equivalent term is "call off."
- **Single award task order contract (SATOC)—**IDIQ contract in which the owner will choose only one contractor to perform the service(s). Task order price is usually determined by direct negotiation between the owner and contractor.
- ***Multiple award task order contract (MATOC)*—**IDIQ contract in which the owner will choose *multiple* contractors to provide the service(s). As requirements materialize, pre-selected contractors compete for individual task orders.
- ***Job order contract (JOC)*—**an IDIQ construction contract that utilizes a unit-price guide, such as RSMeans (2015), and contractor coefficient for determining project price. The contractor coefficient, which is submitted as part of the master contract proposal, provides a way for the contractor to include their overhead and profit.

JOC agreements can be either single award or multiple award in nature (Army Contracting Agency 2003; Center for Job Order Contracting Excellence 2014).

Use of IDIQ Contracts for Construction Services

There is no definitive information on the number or total value of IDIQ contracts in use in the U.S., but a review of literature suggests that their use at multiple levels of government as well as in the private-sector, and for nearly every type of construction sector (vertical, horizontal, etc.). The best estimates are available at the federal level. One writer estimated that IDIQ contracts comprised 28% of all federal spending—not just the construction sector—a number that doubled between 1990 and 2011 (Brodsky 2011). Another study put the estimate of all indefinite delivery contracts (including IDIQ) at around 49% of federal spending in 2014 (NCMA 2015). From the large Department of Defense (DoD) database used in this study, IDIQ contracts comprised 42% of projects and 40% of spending from 2009-2015. Therefore, this investigation into IDIQ contracts or framework agreements should generalize to a large and growing sector of the construction market.

Sources show use of IDIQ contracts at the federal, state, and municipal levels (Center for Job Order Contracting Excellence 2014; Department of the Air Force 2014; Gianakis and McCue 2012; Henry and Brothers 2001; Rueda-Benavides and Gransberg 2014; The Gordian Group 2014a). Similar contract forms are also in use in the private sector. In 2014 the American Institute of Architects developed a new contract template for IDIQ-type agreements (AIA 2014) in response to market research suggesting a demand for this type of agreement (J. Balance, AIA, personal correspondence, 2015). A similar procurement tool, framework agreements, is also used in Europe (Constructing Excellence 2005), highlighting that this type of agreement is not limited to the US.

Literature further reveals examples that public owners have employed IDIQ contracts for a range of construction services, including: vertical construction (Center for Job Order Contracting Excellence 2014; The Gordian Group 2014b), interior renovations (Henry and Brothers 2001), horizontal construction and highway maintenance (Rueda-Benavides and Gransberg 2014), and water/wastewater infrastructure (Williamson and Burton 2014). Owners have also established standby IDIQ contracts for both domestic emergency repair programs (Gransberg and Loulakis 2012; Jeffrey and Menches 2008) and multi-billion dollar international defense programs with construction components (Air Force Civil Engineer Center 2014; Department of the Army 2012; NAVFAC 2015).

Benefits and Limitations of IDIQ Contracting

As with any contract tool or project strategy, IDIQ contracts have advantages and disadvantages. Much of this dissertation serves as an approach to evaluate these advantages and disadvantages in more depth.

The major perceived advantages and disadvantages of IDIQ contracts are shown in Tables 1 and 2, respectively. While a few of these findings are based on empirical analysis of project data (marked with an asterisk), many are based on the perceptions captured in owner surveys, case studies, or analysis of select lawsuits. From the owner's perspective, the benefits listed in Table 1 can make IDIQ an attractive option. Yet the critiques summarized in Table 2 make the benefits seem less certain. These tables provide a brief introduction to the previous work related to IDIQ contracts, and many of these benefits and concerns are revisited in the following chapters in more depth.

Table 1-1. Perceived Benefits of IDIQ Contracting

Perceived Benefit of IDIQ Contracting	Source(s):
Reduced procurement time	(Gransberg et al. 2015) (Moore and Stout 1988)* (Gianakis and McCue 2012)
Reduced transaction costs or administrative burden	(Lam and Gale 2014a)* (Constructing Excellence 2005) (Moore and Stout 1988)*
Improved flexibility with unknown requirements	(Gransberg et al. 2015) (Gianakis and McCue 2012)
Improved partnering/ relationship between owner and contractor	(Constructing Excellence 2005)
Higher success rate in winning contracts	(Back and Sanders 1996)
Improved small and disadvantaged business (SDB) participation	(Gianakis and McCue 2012)
Improved preconstruction costs	(Gransberg et al. 2015) (Williamson and Burton 2014)
Improved schedule performance (construction phase only)	(Lam and Gale 2014a)* (Henry and Brothers 2001)*
Improved construction quality	(Lam and Gale 2014a)* (Gianakis and McCue 2012)

* denotes conclusions based on empirical study of project data

Table 1-2. Concerns about IDIQ Contracts

Concern	Source(s):
Overly broad statements of work subject to abuse by government owner	(Kipa et al. 2008) (Wong 2006)
Difficulty in bidding by contractors	(Benjamin 2001) (GAO 1997)
Unique payment provisions (e.g. JOC unit pricing)	(Farris 2002)
Reduced competition (and potentially increased costs)	(Yukins 2007)
Exclusion of small businesses due to contract "bundling"	(Benjamin 2001) (Thornton 2001)

Theoretical Frameworks

This dissertation offers four theoretical frameworks for investigating IDIQ contracting: paradox theory, neoclassical economics, transaction cost economics, and "co-opetition." These frameworks helped shape the research presented in the following chapters as well as designs for future research.

Paradox Theory: Understanding Paradoxical Organizational Tensions in Contracts

Paradoxical tensions have been used in organizational studies to "describe conflicting demands, opposing perspectives, or seemingly illogical findings" (Lewis 2000). Paradoxes emerge from elements that are related but seemingly contradictory due to underlying tensions in the system. In the case of organizational tensions, Lewis' seminal work (2000) characterizes the underlying tension as one between control and flexibility. Various management theories tend to emphasize either control or flexibility, but paradox theory explains the presence of both simultaneously (Smith et al. 2010).

Both Koppenjan et al. (2011) and Szentes and Eriksson (2015) used paradoxical tensions as part of a framework to examine organizations involved in construction megaprojects. They conclude that control and flexibility must be balanced and managed simultaneously at multiple interfaces by project managers to ensure project success.

Reviewing IDIQ and framework agreement literature in this light reveals several paradoxical tensions in the contract structure and terms. For example, Yukins (2007) highlights that owners can face tension between wanting to lessen their administrative burden in the contracting process versus maintaining competition and fair price. Likewise, Benjamin (2001) calls attention to the tension between owners gaining flexibility through broad statements of work and contractors facing more uncertainty in the bidding process. Public sector procurements also reflect tension between selecting the most qualified contractor and the one with the lowest price, an additional challenge for IDIQ contracts since the scope of work is not defined at the time of contract award.

This dissertation adds to this body of literature by identifying and classifying the tensions present in IDIQ contracting, most notably in Chapter 2.

Neoclassical Economic Theory: Understanding Competition and Price

Neoclassical microeconomic theory provides a useful lens for analyzing the construction industry in general (Runeson and Raftery 1998; Skitmore et al. 2006), and IDIQ contracts, more specifically. Neoclassical economic theory provides a basis for the concepts of supply and demand, markets, competition, and rational choice. Buyers purchase goods or services with the goal of maximizing utility; producers sell goods (services) to maximize profits. Under the condition of perfect competition, markets determine the price at which the good or service can be offered.

As noted previously, IDIQ contracts select a limited number of firms and have the potential to decrease competition which would have undesirable economic consequences, most notably higher prices paid by the owner. This concern is reflected in the FAR (U.S. GSA 2015) which explicitly favors multiple-award contracts and the ability to maintain competition throughout the life of the contract (as compared to single award IDIQs). However, it remains unclear how much competition is enough, or if existing multiple-award contracts actually impact competition or price at all.

Previous studies have also used this theory in the context of framework agreements in the U.K. For example, Lam and Gale (2014a) used it to structure their study of frameworks for highway projects, noting the industry is highly competitive with a large number of producers (i.e. contractors) who understand the market are readily available to provide the services desired by the owner. Tennant and Fergie (2014) used neoclassical economic theory to explain market trends with respect to a decline in the use of framework agreements.

I apply this framework in Chapters 3 and 4 of this dissertation, which investigates the relationship between IDIQ contracting, competition, and price.

Transaction Cost Economics: Understanding Owner Choices in Procurement

The third theoretical framework for exploring IDIQ contracts is transaction cost economics (TCE). Built on the seminal works of Coase (1937) and Williamson (1975, 1979, 1985), TCE is an interdisciplinary field that incorporates elements of economics, contract law, and organizational theory. TCE uses the transactions between firms as the unit of analysis and provides a framework for examining the "make or buy" decision. At one extreme, firms will rely on markets to acquire ("buy") needed goods and services as long as the transaction costs of doing so are low. At the other extreme, when transaction costs of relying on markets are high, a firm is more likely to rely on hierarchy (e.g. vertical integration) and "make" the product themselves. In between are mixed forms of governance, which would be especially relevant for construction contracting. For most public agencies, the general "make or buy" decision has already been made; few governments want to run their own construction companies. However, various contract relationships fit on a continuum between pure markets and pure hierarchies. TCE can help compare the differences between these contract relationships, in this case between traditional stand-alone contracts and IDIQ contracts.

Construction literature employs the term "transaction costs" in two broad categories. The first is more aligned with Williamsonian TCE as described above, in which researchers use TCE as a framework for describing the nature of the construction industry. For example, Reve and Levitt (1984) were among the earliest to apply TCE to construction, positing that construction contracts generally lie between the extremes of market and hierarchy.

A second group of literature applies transaction costs in a related but more specific manner. In this group, transaction costs are generally defined as those measurable costs of establishing and monitoring a contract, which would be a subset of the transaction costs considered in the first group of literature. These costs are primarily owner personnel costs. This second type of analysis would be the most applicable for the current study. TCE may provide a framework for understanding why owners use IDIQ contracts, such as to save owner personnel time and effort (i.e. lower transaction costs), which presumably is equal to or greater than any premium paid for construction (i.e. higher production costs).

The findings of Chapter 4, which relate to the cost implications of IDIQ contracting, lay the groundwork for examining IDIQ related transaction costs. Thus, I use TCE primarily as a framework for future research further described in Chapter 5. I also apply concepts from TCE heavily in the conference paper in Appendix A.

Coopetition: Understanding the Balance between Cooperation and Competition

The final theoretical framework I considered was "coopetition." As the name implies, coopetition represents a middle ground between competition and cooperation. It also has some relation to paradox theory as described previously. Both frameworks recognize the idea of balancing requirements and trying to achieve multiple objectives simultaneously.

The term "coopetition" was introduced in a popular book (Brandenburger and Nalebuff 2011), but has been the subject of numerous scholarly studies in business and management literature (e.g. Bengtsson and Kock 2000; Padula and Dagnino 2007; Tsai

2002). The concept was built upon game theory and was initially applied to business firms that would normally compete against one another, but often choose to cooperate instead.

Eriksson (2008) introduced the concept to construction literature by examining how owner procurement choices affect the balance between competition and cooperation amidst the owner-contractor relationship. He analyzed several aspects of the procurement process and how different decisions would relate to greater competition, cooperation, or a middle ground of coopetition. For example, in the source selection process, owners emphasizing price would align with greater competition, those emphasizing qualifications would align better with cooperation, and owners choosing a mix of the two would best reflect coopetition.

Chin et al. (2008) developed a hierarchical model of coopetition strategy management. They argue that successful coopetition is built upon three categories of factors. First is management commitment, which is reflected in factors like vision, mission, long-term commitments, and organizational learning. Second is relationship development, which includes development of trust and knowledge and risk sharing. Third is communication management which would include information system support and conflict management systems.

Several of these categories would lend themselves to an examination of IDIQ contracting. For example, IDIQs are long-term contracts compared to traditional alternative and involve organizational learning by owners and especially contractors on how to work together. IDIQ contracts also offer the potential for stronger relationships, greater levels of trust, and knowledge sharing among both sides. While coopetition is not included directly in the body of this dissertation, I have used these factors to frame future case study work.

Point of Departure and Research Questions

In light of existing literature, several gaps remain in our understanding of IDIQ contracting. Additionally, construction literature only recently has offered a critical look at IDIQ contracts, despite the risks identified from the legal community. This suggests that a robust and critical review of IDIQ contracting from a construction perspective is warranted. At least five areas related to IDIQ contracts are ripe for examination, shown schematically in Figure 2.

Previous Work		Opportunities
Few empirical studies	→	Empirical performance study of IDIQ
Recent case study work on DoT / transportation sector	→	Focus on other sectors or perspectives
Little work on competition or costs	→	Quantify impact on competition, cost
Studies limited in number of projects or cases	→	Large data set comparison of IDIQ and traditional contracts
Few studies exploring IDIQ with alternative delivery methods	→	Examine relationship between contract type and delivery method

Fig. 1-2. Point of Departure

First, there is a dearth of empirical studies on IDIQ contract performance, with the exceptions of Henry and Brothers (2001) and Lam and Gale (2014a), the latter being an examination of framework contracts in the UK. Gransberg et al. (2015) also shed some light on the perceived advantages of IDIQ construction contracts through a survey of state DoT officials. Further research in other settings and scales is needed to expand, validate, and better quantify each of these findings.

Nor have many studies addressed the critiques of limited competition and higher costs through an empirical analysis. I saw this as the most immediate and potentially important gap in literature, and thus focused a large portion of my efforts in this area, as described in Chapters 3 and 4. Previous empirical studies were limited in scope, such as: two military installations (Henry and Brothers 2001), one U.K. county (Lam and Gale 2014a), and one U.S. state (Rueda-Benavides 2013). This study offers an analysis on the largest dataset of IDIQ or framework projects to date.

Additionally, there has been little work examining the relationship between contract type and delivery method, which are both critical parts of a procurement strategy. The decision on delivery method and contract type are typically made in combination for a given project requirement. Given that this dissertation considered the implications on competition and cost, delivery method was an appropriate variable to include as well. Delivery methods have been shown to correlate with varying levels of cost in previous studies (e.g. Konchar and Sanvido 1998), and were shown to be closely integrated with contract and payment type by Franz and Leicht (2016). Delivery methods, design-build in particular, also use different contractor selection methods such as two-step, which would directly relate to the amount of competition on a given project.

Based on these gaps, the following research questions are posed:

- What are the principal characteristics and applications of IDIQ contracts for construction?
- In the absence of clearly defined project requirements, how are IDIQ contractors selected?

- How does the use of IDIQ contracting for construction influence competition in public sector procurement?
- How does the use of IDIQ contracting for construction influence price in public sector procurement?

Dissertation Organization

This dissertation is organized in a three-paper format. Figure 3 shows the format and the research questions for each paper. Figure 3 also reflects the fact that each chapter builds on the previous chapter's contributions.

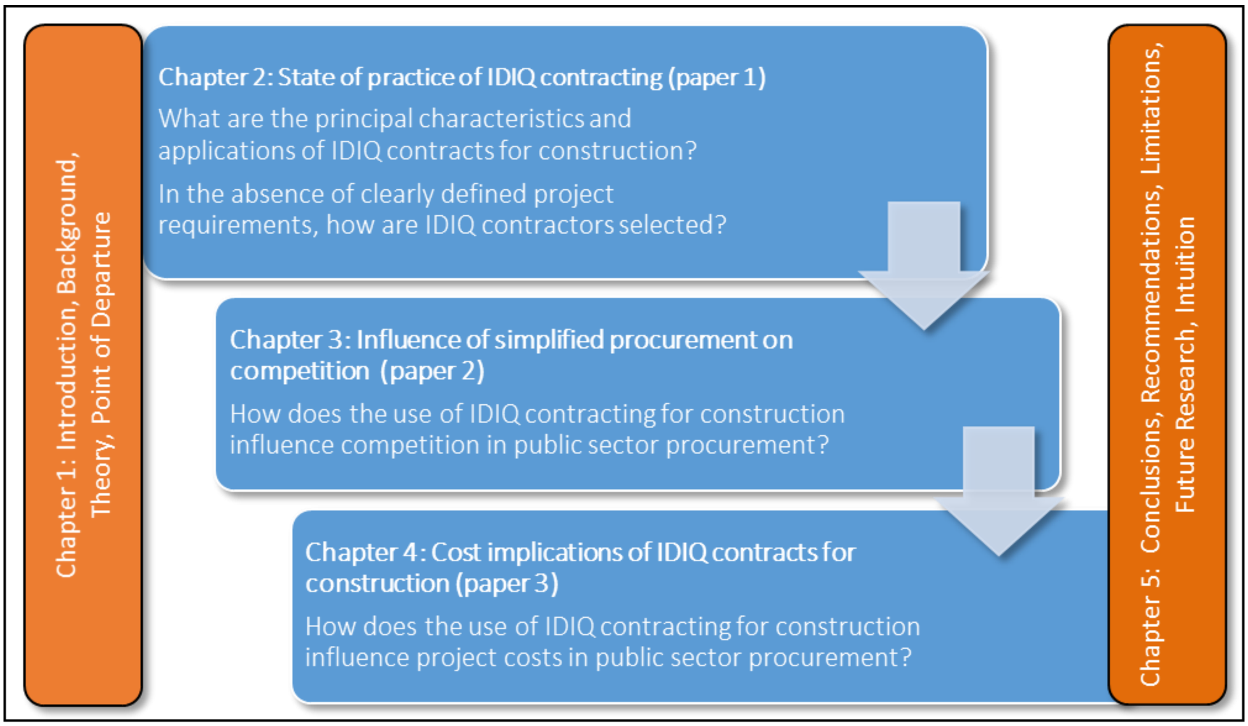

Fig. 1-3. Dissertation Organization and Research Questions

Chapter 2 (Paper 1) is a manuscript published by *the ASCE Journal of Management in Engineering*. This paper examines the state of practice of IDIQ contracting at the federal level—where the practice has been most used—through an extensive literature review and a content analysis of procurement documents. This paper provides a deeper understanding of how construction contracts can reflect the paradoxical organizational tensions between contracting parties. It also explains the principal characteristics of IDIQ contracts and how contractors are most often selected given the lack of defined requirements at contract award. The findings of this paper lay the groundwork for Chapters 3 and 4.

Chapter 3 presents a statistical analysis of IDIQ contract performance in the context of DoD projects, specifically an attempt to measure the effect of IDIQ contracting on competition. This paper also examines the relationship between contract type and delivery method. The framework for this chapter is built on neoclassical economics, and the methods include univariate and multivariate analysis of a large sample (n>900) of DoD construction projects.

Chapter 4 consists of a cost analysis of IDIQ contracting using 315 U.S. Air Force construction projects. The paper is also built upon a neoclassical economic framework and analyzes three normalized cost metrics through statistical analysis: award growth, post-award cost growth, and total cost growth.

Chapter 5 presents a summary of findings, contributions, limitations, and opportunities for future work. The chapter also closes with my intuitions about IDIQ contracting gained from nearly three years of studying this tool.

CHAPTER II: APPLICATION OF INDEFINITE DELIVERY-INDEFINITE QUANTITY CONSTRUCTION STRATEGIES AT THE FEDERAL LEVEL (PAPER 1)

This chapter published in *ASCE Journal of Management in Engineering* 2016;
DOI: 10.1061/(ASCE)ME.1943-5479.0000437. Co-authors: Keith R. Molenaar and Kelly Sheeran.

Abstract

Indefinite delivery-indefinite quantity (IDIQ) construction contracts use an overarching master contract between an owner and contractor for multiple projects over a specified time period. The practice is widespread in the federal government but its efficacy has been the subject of relatively few studies. Content analysis of 90 federal requests for proposal advertised between 2010 and 2014 reveals IDIQ contracting use for a wide range of facility types and construction services. Owners most often use best-value procurement methods, emphasize qualifications over price to initially select the IDIQ pool of contractors, and use seed projects for initial price evaluations. Findings also suggest that IDIQ contracts reflect the inherent paradoxical organizational tensions in public sector procurements. On one hand, IDIQ contracts reflect a desire for flexibility, simplified procurement processes, and finding the most qualified contractors for long-term performance. On the other hand, public owners must put control mechanisms in place to obtain a fair price, protect the public interest, and comply with regulations. The findings of this study have practical implications for public owners with large asset portfolios and for contractors interested in pursuing IDIQ contracts. The findings also provide requisite knowledge for researchers to study IDIQ performance at an aggregate level.

Introduction

The adversarial and fragmented nature of the construction industry is well documented along with the negative implications for project performance, productivity, innovation and industry reputation (Dubois and Gadde 2002; Egan 1998; Howard et al. 1989). Being that the U.S. public construction sector is a $270 billion per year market (U.S. Census Bureau News 2014), such inefficiencies can result in poor stewardship of tax dollars and the erosion of the public's trust in government. In response to such problems, construction practice and research of the past three decades has explored numerous solutions relating to project delivery, procurement, and teamwork. Examples include partnering, alliancing, supply chain management practices, alternative delivery methods and others. However, one innovative strategy that has received relatively little attention in literature is the use of indefinite delivery-indefinite quantity (IDIQ) contracting.

IDIQ contracts allow a government agency to establish an initial master contract, or "umbrella" contract, with upper and lower limits on the contract capacity (Subpart 16.5, U.S. GSA 2015). Under this agreement, the owner then executes individual projects by task orders as requirements materialize over the duration of the contract, usually from one to five years before agencies re-compete them. IDIQ contracts represent 28% of all U.S. federal government spending, a number which has doubled since 1990 (Brodsky 2011). A conservative estimate extrapolating from U.S. Census construction data (2015) suggests the public sector IDIQ construction market is likely in the tens of billions of dollars annually.

The major perceived advantages of IDIQ contracts include: reduced procurement time (Moore and Stout 1988; Rueda-Benavides and Gransberg 2014), reduced owner administrative burden (Moore and Stout 1988), reduced schedule growth (Henry and Brothers 2001), and increased flexibility for the owner (Rueda-Benavides and Gransberg 2014). From the owner's perspective, such benefits can make IDIQ contracts an attractive option.

However, IDIQ contract use has also raised legal concerns, which are well summarized by Kipa, et al. (2008) and Wong (2006). These legal concerns reflect the inherent tension between control and flexibility in public sector procurement. One prominent concern is the use of overly broad statements of work, which can be subject to abuse. Such instances make it difficult for contractors to bid or propose on the initial contract if they are not clear on the possible range of work required (Benjamin 2001; U.S. Government Accountability Office 1997). Yukins (2007) posits that both IDIQ contracts and their European counterpart, framework agreements, have been widely adopted by contracting officials to gain flexibility at the expense of competition. He further argues that procurement decisions should be based in part on how they will affect the larger economy, not just on what is most convenient for government personnel. Similarly, Thornton (2001) and Benjamin (2001) each describe the improper use of sole sourcing and bypassing preferences for small businesses as serious problems in IDIQ contracting based on their reviews of government reports and litigation. In particular, federal agencies can inadvertently use IDIQ contracts to inappropriately bundle smaller orders of goods or services, making the total contract value greater than small businesses can effectively handle. Although their arguments are not strictly about construction services, each of the above authors cite numerous examples involving construction claims.

Given the widespread use of IDIQ contracts, criticism of their use, as well as the relatively limited amount of literature on their use in construction, the purpose of this study is to examine the state-of-practice of IDIQ contracts in order to better inform construction researchers and practitioners about its applications, benefits, and limitations. To date, only Gransberg et al. (2015) have described IDIQ contracting trends in the U.S., and their analysis was primarily focused on transportation projects at the state level. The present study examines IDIQ contracts for a range of construction services at the federal level by addressing two questions. What are the principal characteristics and applications of IDIQ construction contracting practices? In the absence of clearly defined project requirements, how are IDIQ contractors selected? By answering these questions, this study will provide researchers and practitioners with the requisite knowledge for improving IDIQ contracting practices. Additionally, and perhaps more importantly, the study provides researchers with the fundamental knowledge required to study IDIQ performance at an aggregate level.

The study addressed these questions through an extensive literature review and a content analysis of 90 U.S. federal requests for proposal. The results of the literature review are shown in the next section, which include typical characteristics, applications, and procurement methods for IDIQ contracts. The literature review also includes a comparison of IDIQ contracting with European framework agreements, followed by a discussion of how IDIQ contracts reflect paradoxical organizational tensions. The sections following the literature review present the content analysis methodology, results, and discussion. The final section offers conclusions, recommendations for practical application, and needs for future research.

Literature Review

Principal Characteristics and Applications of IDIQ Contracts

IDIQ contracting for the procurement of goods and services originated with the U.S. federal government and can be traced to the creation of the General Services Administration in 1949 (Comptroller General of the United States 1979). Systematic use of IDIQ contracts for construction purposes has been in place since at least the early 1980s (Moore and Stout 1988). Today the procedures for federal agency use of IDIQ contracts are well codified in federal law and policy including the Federal Acquisition Streamlining Act of 1994 and Subpart 16.5 of the Federal Acquisition Regulation (U.S. GSA 2015).

IDIQ contracts are structured in two primary forms as shown in Figure 1. IDIQ contracts can be used for both goods and services, but the emphasis of this study is on construction services, which fall in the category of task order contracts (versus delivery orders for goods) (Subpart 16.501, U.S. General Services Administration 2015). Owners choose either single award task order contracts (SATOC) or multiple award (MATOCs) depending on the desired number of contractors to be selected. Under MATOCs, as detailed requirements materialize, the pre-selected contractors typically compete for individual task orders. Such competition is the reason multiple award contracts are preferred at the federal level (Subpart 16.5, U.S. General Services Administration 2015). The construction sector also has a unique form of IDIQ contract called a job order contract (JOC), which utilizes a unit-price guide like RSMeans (2015) and a contractor coefficient for determining project price. The contractor coefficient is submitted as part of the master contract proposal and provides a way for the contractor to include their overhead, bonding, and profit (Center for Job Order Contracting Excellence 2014).

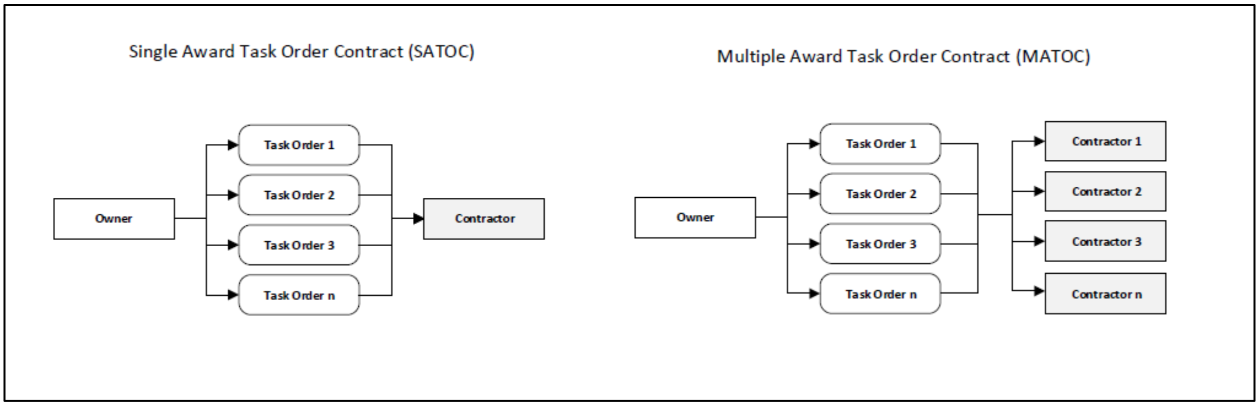

Fig. 2-1. Types and Structure of IDIQ Contracts (adapted from Rueda-Benavides 2013)

Previous studies describe the use of IDIQ contracts to some extent at the federal, state, and municipal levels in the U.S. (Gianakis and McCue 2012; Henry and Brothers 2001; Rueda-Benavides and Gransberg 2014; The Gordian Group 2014b). Similar contract forms are also in use in the private sector. In 2014 the American Institute of Architects developed a new contract template for IDIQ-type agreements (AIA 2014) in response to market research suggesting a demand for this type of agreement (J. Balance, AIA, personal correspondence, 2015).

Literature further reveals that public owners have employed IDIQ contracts for a range of construction services, including: facilities construction and renovations (Center for Job Order Contracting Excellence 2014; Henry and Brothers 2001; The Gordian Group 2014), horizontal construction and highway maintenance (Rueda-Benavides and Gransberg 2014), and utilities infrastructure (Williamson and Burton 2014). Owners have also established standby IDIQ contracts for both domestic emergency repair programs (Gransberg and Loulakis 2012; Jeffrey and Menches 2008) and multi-billion dollar international defense programs (Air Force Civil Engineer Center 2014; Department of the Army 2012; NAVFAC 2015).

European governments use framework agreements, which are similar to IDIQ contracts. While this study does not collect data from framework agreements, a brief discussion of the similarity between these two forms of contracting is warranted to illustrate the generalizability of the present study's results. Yukins' (2007) criticism of the improper use of IDIQ contracts and framework agreements provides one of the few direct comparisons of these two contract tools available in literature. Examining European Union (EU) and United Kingdom (UK) procurement regulations (European Commission 2005; Office of Government Commerce 2008) with the U.S. Federal Acquisition Regulation (U.S. GSA 2015) reveals additional comparisons. For example, both allow multiple and single-award schemes, and both allow for a variety of procurement methods to be used. The typical length of a framework is four years compared to five years for IDIQ. Like IDIQ contracts, frameworks are also believed to simplify the procurement process and reduce owner transaction costs (Lam and Gale 2014a).

IDIQ contracts and frameworks also have differences. Perhaps the most significant difference is that IDIQ contracts are considered binding with a minimum guaranteed amount of work, but framework agreements are usually non-binding. Another notable difference is the extent to which construction framework agreements have been discussed as a mechanism for strategic partnering (Constructing Excellence 2005; Office of Government Commerce 2008). In the U.K., Tennant and Fernie (2014) attribute adoption of framework agreements as a response to the Latham (1994) and Egan (1998) reports, which called for greater cooperation and transparency in the construction industry. Other studies describe case studies of construction framework agreements as examples of "client-contractor collaboration" (Bresnen and Marshall 2000) and "innovating for supply chain integration" (Khalfan and McDermott 2006). In contrast, the U.S. IDIQ literature cited in the previous sections tends to focus on the practical advantages for owners related to administrative burden and flexibility as opposed to the advantages of collaboration and integration.

Selection of IDIQ Contractors

Given the criticisms of IDIQ contracts with respect to competition, fair pricing, and small business utilization, the authors sought to examine IDIQ procurement practices. A project procurement method defines how the construction contractor will be selected, often with respect to the balance between price and non-price factors. The most common approaches use competitive procedures, such as: low bid or sealed bidding (only price-related factors), qualifications-based selection (only non-price factors), or best value (combination of price and non-price factors). Non-price factors typically include a contractor's record of performance, their specialized experience that relates to the project under consideration, and their technical approach to the project. Many public sector best-value procurements also involve a tradeoff procedure, in which the owner can select a higher priced offeror with superior qualifications or technical proposal. However, an important and growing subcategory of best-value selection is lowest price-technically acceptable, which does not allow for tradeoffs. A fourth option is less competitive, the use of sole-source selection, in which the contract terms are negotiated directly between the owner and a contractor of choice (American Bar Association 2007; Subpart 2.101 U.S. GSA 2015).

In most cases, U.S. public sector agencies are required to use competitive selection procedures and include price considerations with respect to a defined scope of work. This requirement raises an interesting hurdle for IDIQ contracts, since the scope of work is not defined when the IDIQ master agreement is awarded and therefore project prices cannot be determined at the time of award of the master contract. Additionally, contractors are unable to submit detailed technical proposals about the how they would address the project specifics, as is common with discretely procured projects.

This discrepancy suggests that owners must use a different approach for selecting IDIQ contractors, however literature offers only a few studies that discuss IDIQ procurement processes. Mulcahy (2000) compared the performance of single-award job order contracts from 34 public agencies. Seven of the contracts were procured using low bid (i.e. lowest coefficient), and the remainder were acquired through a best-value approach. However the study did not investigate what specific factors were used for selection. Gransberg et al. (2015) provided a more in-depth analysis of selection procedures, analyzing IDIQ use for construction and maintenance services by 25, mostly state-level, transportation agencies. These agencies tended to use pre-established unit pricing for price evaluations, and used a variety of non-price factors in their evaluations, including technical capabilities and composition of the management team. Especially relevant for the current study, they describe one federal agency which used a best-value approach in which the price consideration was based on the price of the first task order.

Paradoxical Tensions of IDIQ Contracting

Considering the above advantages, disadvantages, comparisons, and criticisms, the various views of IDIQ contracts reflect the paradoxical organizational tensions found in public sector procurement. Paradoxical tensions have been used in organizational studies to "describe conflicting demands, opposing perspectives, or seemingly illogical findings" (Lewis 2000). Paradoxes emerge from elements that are related but seemingly contradictory due to underlying tensions in the system. In the case of organizational tensions, Lewis' seminal work (2000) characterizes the underlying tension as one between control and flexibility. Various management theories tend to emphasize either control or flexibility, but paradox theory explains the presence of both simultaneously (Smith et al. 2010).

Construction projects are filled with such paradoxical tensions. Both Koppenjan et al. (2011) and Szentes and Eriksson (2015) used paradoxical tensions as part of a framework to examine organizations involved in construction megaprojects. They conclude that control and flexibility must be balanced and managed simultaneously at multiple interfaces by project managers to ensure project success. More broadly, a traditional understanding of the "iron triangle" acknowledges the tension between achieving cost, schedule and quality outcomes. Owners ideally want the best of all three, but recognize that an improvement in one area, e.g. lower cost, can result in negative consequences for other areas, e.g. lower quality. In procurement of construction contracts as described previously, owners may face tension between achieving the lowest cost and finding the most qualified contractor for the job.

Reviewing IDIQ and framework agreement literature in this light reveals several paradoxical tensions in the contract structure and terms. For example, Yukins (2007) highlights that owners can face tension between wanting to lessen their administrative burden in the contracting process versus maintaining competition and fair price. Likewise, Benjamin (2001) calls attention to the tension between owners gaining flexibility through broad statements of work and contractors facing more uncertainty in the bidding process. As shown in the discussion of procurement methods above, public sector procurements also reflect tension between selecting the most qualified contractor and the one with the lowest price, an additional challenge for IDIQ contracts since the scope of work is not defined at the time of contract award. Recognition of these paradoxical tensions provides additional motivation and a theoretical lens for examining the contract terms of master IDIQ agreements that this study revisits in the conclusions.

Research Methods

The literature review addressed the research questions by qualitatively identifying key characteristics, typical applications, and possible procurement methods in practice for IDIQ contracts. The authors then conducted a content analysis of IDIQ requests for proposal to help quantify these trends and provide a more complete picture of the state-of-practice.

Content analysis is a technique for systematically and objectively analyzing message characteristics, particularly for large volumes of written material (Neuendorf 2002; U.S. General Accounting Office 1996). The technique often involves coding the message(s) of interest by identifying content categories and then counting or characterizing the data within those categories. Several prior studies have conducted content analysis of RFPs to examine project delivery and procurement trends, most often for design-build delivery and best-value procurement (Bogus et al. 2013; Gransberg and Barton 2007; Gransberg and Molenaar 2004; Molenaar et al. 2010; Xia et al. 2013). The content analysis for this study involved five tasks as described in the following paragraphs: developing the coding scheme; collecting the requests for proposal; analyzing the documents with the coding scheme; establishing inter-rater reliability; and using descriptive statistics to characterize the results.

The authors developed a coding handbook to guide the content analysis and enable replication of the effort. The handbook consisted of step-by-step coding procedures, variables of interest, recommended search terms, and examples of expected typical results. Initially more than 20 variables of interest were drawn from literature that related to the research questions. After examining initial results, one variable was added and several others were eliminated, ultimately reducing the number to the ten variables shown in Table 1. The first five variables address the first research question: what are the principal characteristics and applications of IDIQ construction contracting practices? The last five address the second question: in the absence of clearly defined project requirements, how are IDIQ contractors selected?

The search included RFPs posted during calendar years 2010-2014 inclusive in order to capture the most recent trends. The search was limited to construction solicitations with a total capacity greater than $5 million using standard government classification codes and common IDIQ terminology. After eliminating solicitations for individual task orders (versus the master contract), those not governed by the Federal Acquisition Regulation (e.g., U.S. Postal Service), and those primarily for routine maintenance, the search concluded with over 250 qualifying solicitations. To obtain a more reasonable number of RFPs for this analysis, the search results were grouped by both maximum contract capacity and owner agency, sampling representative percentages from each. The final dataset consisted of 90 RFPs used for the full content analysis.

Table 2-1. Variables Used in the Coding Process with Measures of Agreement

Area	Variables	Source Literature	Definition	Inter-Rater Reliability (min=0.80)
Principal characteristics and applications of IDIQ contracts	Type of Work	North American Industry Classification System (U.S. Census Bureau 2014)	Type of work (vertical, horizontal, electrical, etc.).	κ = 1.0
	Range of contract values	(Rueda-Benavides 2013)	Minimum (or guaranteed) and maximum contract values.	PA_o=0.92
	Range of task order values	(Rueda-Benavides 2013)	Minimum and maximum task order values.	PA_o=0.88
	Duration and option periods	(Henry and Brothers 2001)	Duration of the contract, including base period and any option periods.	κ = 1.0
	Alternative delivery methods included	(Gransberg and Barton 2007; Xia et al. 2013)	Whether the contract requires a design-build or CM/GC capability from the contractor.	κ = 0.80
	Formal partnering requirement	(Cheng et al. 2000; Mulcahy 2000)	Whether the contract includes any language about partnering between the government and contractor(s).	κ = 1.0
Selection of IDIQ Contractors	Initial award method	(Gransberg and Barton 2007; Xia et al. 2013)	How successful bidder(s) will be selected: qualifications only, price only, or a combination (best value).	κ =0.84
	Means of price proposal evaluation	(Gransberg and Barton 2007; Xia et al. 2013)	How price is evaluated given that requirements remain undefined.	κ =0.86
	Use of job order contract (JOC) pricing	(Center for Job Order Contracting Excellence 2014; Henry and Brothers 2001)	Whether the contract pricing is based on a unit price guide and coefficient, or other terms.	κ = 1.0
	Number of contracts to be awarded	FAR Part 16	Single award or multiple award.	κ = 0.84
	Competitive category	FAR Parts 6 and 19	Whether the contract is for full and open competition or set aside for small and disadvantaged businesses.	κ = 0.89

The authors then executed steps three and four, coding the RFPs and establishing inter-rater reliability. To begin the process, two coders (or raters) examined the same five documents to refine the coding process and ensure consistency. Then 12 of the RFPs were randomly selected for independent coding to measure inter-rater reliability. For the continuous variables, the authors calculated the percent agreement between raters, PA_o or proportion agreement observed, which is a widely used and easily understood measure for determining inter-rater reliability (Neuendorf 2002). Proportion agreement observed is simply calculated as the number of agreements between raters divided by the total number of units coded by both raters. For the discrete variables, Cohen's kappa (1960) was selected, which is also widely used and has the additional benefit of accounting for chance agreements between raters selecting between pre-defined categories (Neuendorf 2002). Kappa is calculated as:

$$\kappa = (PA_o - PA_g) / (1 - PA_g)$$

where PA_o is the proportion agreement observed and PA_g is the proportion agreement expected by chance. (For additional details on the calculation of PA_g, see Cohen (1960)). Both measures, PA_o (for continuous) and κ (for discrete), range from 0.0 to 1.0, with a 1.0 meaning perfect agreement. Although there is no consensus on what constitutes a minimum acceptable value, values of 0.80 and above are often considered satisfactory (Neuendorf 2002). Inter-rater reliability initially proved unsatisfactory for two of the nine discrete variables, so the team re-coded the RFPs and compared results until reaching consensus. The final results for inter-rater reliability for the variables of interest are shown in Table 1.

After completing the coding process, the authors consolidated and prepared the data for statistical analysis to examine relevant trends and draw conclusions.

Results and Discussion

Sample Characteristics

The dataset includes 90 RFPs representing a wide variety of geographical areas and government agencies. The documents represent a total contracting capacity of $11.4B in value from 45 states and seven countries. Three documents allowed for work anywhere in the U.S. and another three allowed for work anywhere in the world. Texas was the most-listed state, listed as a place of performance in 16 of the documents followed by California with nine. Seventeen major federal agencies and a combined 64 discrete procurement offices are represented in the dataset, with almost two-thirds (58 of 90) of the RFPs originating from the Department of Defense.

The remaining results and discussion are arranged largely in order of the coding variables presented in Table 1. First, the principal applications and characteristics of IDIQ contracting are discussed (research question 1) followed by the analysis of procurement trends (research question 2), including findings of both technical (non-price) and price related factors. The final section presents a discussion of how these findings reflect paradoxical organizational tensions.

Principal Applications and Characteristics of IDIQ Contracts for Construction

The content analysis found that a defining characteristic of IDIQ contracts is flexibility for the owner, which confirms previous case study analyses (Rueda-Benavides and Gransberg 2014; Wilkinson 2007). Such flexibility is manifest in at least five areas: type of work, contract size, project (task order) size, contract duration, and delivery method.

Type of Work

Nearly two-thirds (59 of 90 as shown in Figure 2) of the IDIQ contracts solicited contractors for multi-craft building (vertical) construction and/or supporting specialty trades for building construction, specifically mechanical, electrical, or roofing contractors. A single contract could include a variety of facility types, such as multi-family residential, office buildings, and light industrial. Another nine RFPs were developed exclusively for horizontal construction work. The remaining eight RFPs included both horizontal and vertical construction, giving the owner a wider range of choice on what types of projects they can execute under this agreement. In short, almost any construction task or trade could be included under a single agreement. This highlights the risk of owners writing the scope of work so broadly that contractors cannot accurately bid on the master contract (Benjamin 2001; U.S. Government Accountability Office 1997). As a result, at least one federal owner specifically recommends splitting vertical and horizontal construction into separate IDIQ contracts (Air Force FAR Supplement 2014).

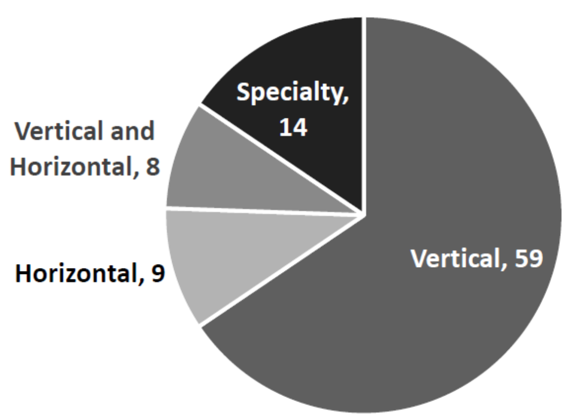

Fig. 2-2. RFP Collection by Project Type (n=90)

Size of Contract

Additional flexibility is reflected in the range of contract sizes. IDIQ contracts state a minimum and maximum contract value over the life of the contract (rows 1-2 of Table 2), giving an indication of the total amount of work to be expected. In this sample, owners established contracts with orders of magnitude ranging from hundreds of dollars up to hundreds of millions of dollars over the life of the contract. In an extreme case of a wide range of values, the contract capacity for an overseas U.S. Agency for International Development multiple-award contract put the minimum guarantee at $200 and listed a maximum of $210M over the life of the contract. Even more typical RFPs still contained a wide range of contract capacities. For example, one U.S. Air Force single-award contract contained a $2,000 minimum guarantee and a $25M maximum. Rueda-Benavides and Gransberg (2014) noted that such wide ranges can accommodate fluctuations in annual budgets and also provide a convenient avenue for committing end-of-fiscal-year funding.

Table 2-2. Range of Contract and Task Order Values

Contract Feature		Lowest Value Found	Highest Value Found	Median
Master Contract Value	Minimum	$200	$50,000	$3,000
	Maximum	$6,500,000[a]	$2,500,000,000	$45,000,000
Task Order Value	Minimum	$100	$10,000,000	$2,500
	Maximum	$30,000	$100,000,000	$5,000,000

[a] Only those with >$5.0M capacity included in the content analysis

Size of Projects

IDIQ contracts also specify expected minimum and maximum task order values (rows 3-4 of Table 2), giving an indication of possible project sizes. At the task order level, the median value for task order minimum was $3,000 and the median value for task order maximum was $5M. The third quartile (75%) of the maximum value was $10M and only six of 90 RFPs allowed for projects in value of $50M or more.

Thus, federal owners primarily craft these contracts for executing smaller projects, but can include a large range of project sizes. This finding is consistent with the types of projects examined in the few empirical studies in this area (Henry and Brothers 2001; Lam and Gale 2014). The use of IDIQ for smaller projects especially makes sense for contracts using unit pricing, whether supplied in a unit price book like RSMeans (2015) or by the contractor as part of the initial proposal. Negotiating quantities of materials for each task order becomes more cumbersome as the size of the project increases. This finding also suggests that owners may prefer to execute larger or more complex projects through a traditional one-off procurement process.

Duration of Contract

Owners also have considerable latitude over how long the contract can extend. The content analysis found a range of 2-7 years with the use of a base year and up to four option years as the most common practice. Although not stated in the RFPs, the option years protect the owner against a long term commitment with a poorly performing contractor(s) or in the case that sufficient task order funding is not available. With respect to contract duration, federal owners are overwhelmingly (76 of 90) using a five year maximum duration, the longest term allowed by the FAR in most circumstances. The preference for using the five year maximum is pragmatic from an owner's perspective and supports the perception of reduced administrative burden as a significant benefit (Moore and Stout 1988; Rueda-Benavides and Gransberg 2014).

Delivery Methods

Federal owners have the flexibility to use different delivery methods under the master contract, as shown in nearly two-thirds of the RFPs examined (54 of 90) which allowed for both design-bid-build and design-build delivery. The requirement for design-build delivery was especially correlated with larger maximum project sizes (point biserial coefficient, r_{pb}=0.275, p=0.010) and the use of multiple awards (Pearson's phi, ϕ=0.327, df=1, p=0.002). The preference for including design-build appears consistent with the industry trend of the continued growth of alternative delivery methods (McGraw Hill Construction 2014).

Procurement Method Trends

Figure 3 shows that public owners are consistently using a best-value approach, or a combination of price and non-price factors, to procure these contracts. The most prevalent approach (53 of 90) involved weighting qualifications (i.e. non-price factors) "significantly more important" than price when selecting the contractor. Emphasizing qualifications over price is logical given: the contract's multi-project nature; the government's preference for multiple awards over single awards; and particularly the lack of defined requirements in IDIQ contracts that are usually required for accurate fixed-price proposals.

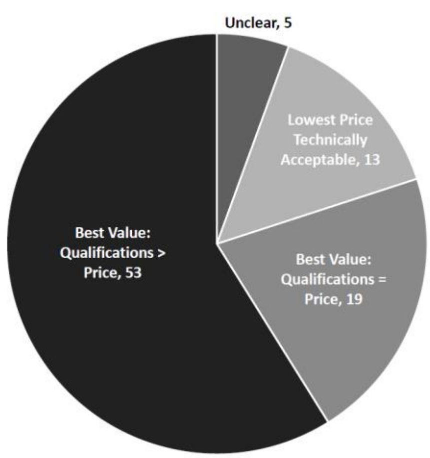

Fig. 2-3. RFP Collection by Procurement Method (n=90)

Owners gave equal or greater weight to price in about one third of the sample. Thirteen RFPs used a lowest price-technically acceptable approach, which is considered a "best-value" technique in the FAR, although there is no provision for selecting a more qualified firm as long as the low bidder meets the minimum qualifications. Another 19 RFPs employed a best value award algorithm with price and qualifications considered equal. It is worth noting that Gransberg and Barton (2007) recommend contractors treat this last category the same as a lowest price-technically acceptable proposal. If price equals 50 percent of the weighted evaluation criteria, and the non-price criteria consists of more than one factor (e.g. past performance, technical approach, management, etc.) then price automatically becomes the single most important factor in the evaluation.

Evaluation of Qualifications (Non-Price Factors)

The most common non-price qualification factor in the sample was past performance, followed by experience, management plan/organization, and key personnel, shown in Figure 4. These types of qualifications also appeared in previous analyses of design-build RFPs (Gransberg and Barton 2007; Xia et al. 2013), although they were categorized somewhat differently in those studies. One notable difference is that owners valued past performance and relevant experience more often in this study of IDIQ contracting, while project-specific technical approaches were more important in the other studies of design-build delivery methods. This difference can be attributed to a lack of project definition in IDIQ solicitations, which would therefore tend to rely more heavily on other factors like past performance. Also, the other studies only encompassed one-off design-build proposals, which would logically depend more heavily on the project specific technical solution.

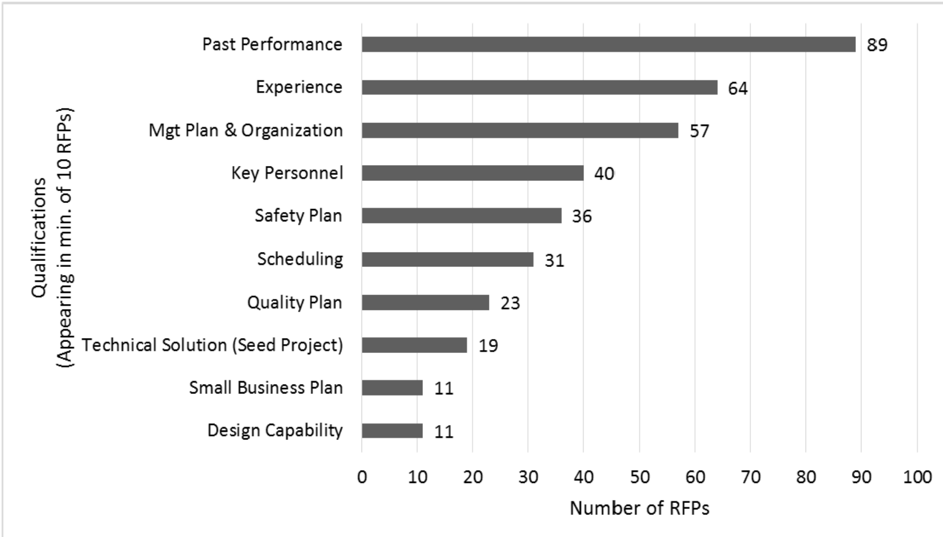

Fig. 2-4. Most Common Non-price Qualification Factors for IDIQ Contracts (n=89)

Evaluation of Price Proposals

In order to develop and evaluate price proposals, federal owners used three primary approaches, often independently but occasionally in combination (Figure 5). First and most commonly, they included a "seed project" that in most cases would be awarded immediately after the master contract was signed. This method is similar to one of the transportation agency case studies examined by Rueda-Benavides and Gransberg (2014). In the case of multiple-award contracts, the project would be awarded to the qualified contractor who best met the specific requirements of the project. In other words, a contractor could be selected for inclusion in the master contract, but not necessarily be awarded the seed project. In other cases, the seed project was simply hypothetical and used only to evaluate the contractor's pricing procedures. Choosing an emblematic seed project is therefore important both for owners to use in price evaluations, and for contractors to judge the type of work to expect over the duration of the contract.

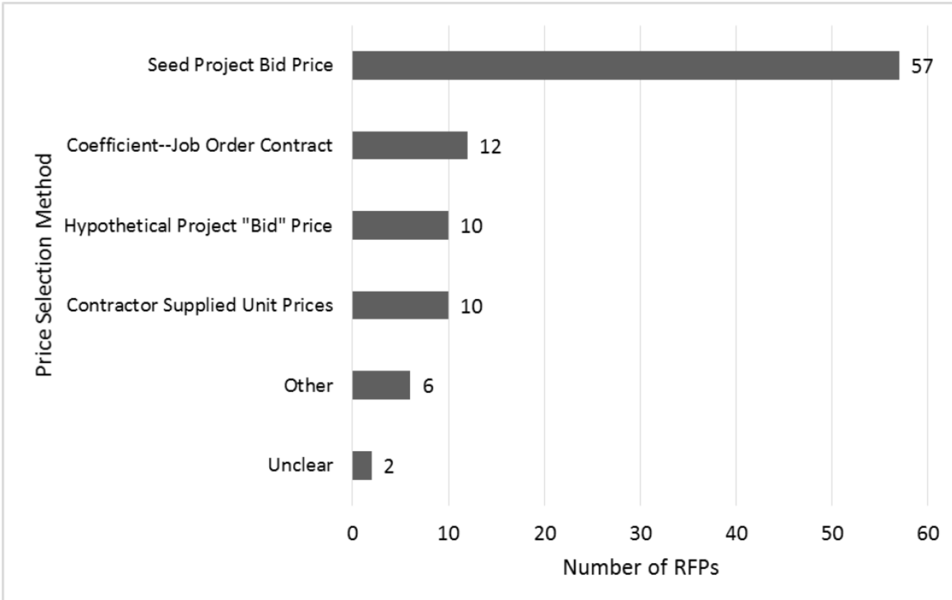

Fig. 2-5. Means of Price Evaluation for IDIQ Contracts (n=90)

Twelve of the RFPs' price proposals were based on the contractor's proposed coefficient, which would be applied to all line items from a unit price book consistent with the definition of a job order contract (JOC). Another ten of the RFPs required the contractor to provide their own unit pricing for a given number of construction line items, from several dozen to a few hundred. While JOC pricing was only used for building construction, contractor-submitted unit pricing was used primarily for roofing and horizontal construction work.

Owners largely relied on the use of seed projects for price evaluation when qualifications were considered more important than price. This strategy allowed the public owner to meet the requirement for considering price reasonableness, while not placing unwarranted emphasis on the price of a single project. In contrast, five other RFPs evaluated seed project pricing under a lowest price-technically acceptable selection method. The obvious concern here is that the contractor could underbid the seed project in order to be selected for the contract, and then mark up their pricing on subsequent projects once competition was eliminated. Therefore, using the price proposal for a single project as the most important selection factor could handicap the owner in selecting the best long-term partners.

Number and Size of Selected Contractors

About three quarters (71 of 90) of the RFPs in this study used a multiple-award scheme, reflecting the preference explicitly stated in U.S. procurement regulations (Subpart 16.504(c), U.S. GAO 2015). This means that most, if not all, task orders will be competed among the contractors selected under the master contract. The number of projected awards varied considerably in this sample, but ranges of 3-6 firms per master contract were common. Of note, the contracting officer does have the option to bypass competition for task orders in select cases, such as when only one contractor can perform the job or in an emergency situation, but the contract language suggests these provisions are meant to be the exceptions rather than the rule (U.S. GAO, FAR Subpart 16.505(b)(1-2), 2015). Therefore, some level of competition is usually preserved beyond the initial contract award.

For single award contracts, only one contractor will have the opportunity to perform the work over the life of the master contract. Thus, ensuring fair pricing in this situation requires additional diligence on the part of the owner. The owners in this study appear to be aware of this concern as revealed by the fact that 15 of the 19 single award contracts used pre-established unit pricing in the master agreement. In other words, contractors seeking to take advantage of the lack of competition would already be locked into unit prices and would therefore be left with the more difficult task of trying to manipulate the quantities of work required when negotiating each task order. Successfully managing this type of contract however may require a more sophisticated or experienced owner. The Department of Defense, which developed nearly all (18 of 19) of the single-award unit priced contracts in this sample, originally pioneered this procurement approach for construction and has over 20 years of experience managing it on a large scale (Moore and Stout 1988).

Examining the RFPs by the level and type of competition added additional insight, especially with respect to small business utilization. Of the 82 RFPs representing work in the U.S., only seven were "unrestricted" by company size or socioeconomic status. The remaining 75 (91%) were either partially or completely set aside for small and disadvantaged businesses. The most common set-aside category was for any small business (n=27), typically defined as a firm averaging less than $33.5M in annual revenues (U.S. Small Business Administration 2012). The remaining 44 contracts were set aside for one or more specific categories of small business, such as firms participating in the Small Business Administration's 8(a) business development program (2015a). Therefore, not only do small businesses have an opportunity to compete in IDIQ contracts, but they were the only firms allowed to compete in nearly 90% of the opportunities in this sample. Of the 11 procurements which allowed larger firms, ten required the large firm to develop a small business subcontracting plan.

The use of IDIQ for small business is logical considering the bulk of the projects executed under these RFPs were small in nature, often ten million dollars or less in magnitude. These findings are also consistent with government preferences for small business (U.S. Small Business Administration 2015b) as well as a previous government report finding no negative impact on small businesses from Army JOC practices (Moore and Stout 1988).

A couple of possibilities might explain the difference in these findings with concerns around competition and small business opportunities raised earlier in this paper (Benjamin 2001; Thornton 2001; Yukins 2007). One explanation is that concerns about competition often represent contract administrative problems after contract award rather than before, such as not allowing selected contractors to fairly compete for task orders (Benjamin 2001). Another possibility is that litigation related to competition or small business utilization under IDIQ contracts, while seemingly a widespread problem to some scholars, may ultimately be exceptions rather than the norm when considering the large number of IDIQ contracts executed nationally.

Analysis of Paradoxical Organizational Tensions

The content analysis highlights four sources of tension between control and flexibility (Lewis 2000) as shown in Figure 6.

Flexibility: Commitment, Trust, Creativity	TENSIONS	Control: Efficiency, Discipline, Order
Broad scope of work provides flexibility for owner	←→	Contractors must be able to develop coherent proposals on a clear scope of work; owners must be able to adequately evaluate proposals
Less contracts and fewer bid evaluations reduce owner administrative burden/transaction costs	←→	Procurement regulations require competition; using a select pool of contractors has potential to impact competition and increase capital costs
Maximum duration of five years offers potential for strategic partnering	←→	Use of option years protects the owner but could be seen as an escape clause or lack of commitment
Owners may desire the most qualified firm(s) for long term engagement regardless of initial price considerations	←→	Procurement regulations require evaluation of a price component at initial contract award, even if requirements are undefined

Fig. 2-6. Paradoxical Organizational Tensions in IDIQ Contracting

Flexibility versus Uncertainty

The first tension evident in IDIQ contracting is between the amount of flexibility for owners versus the potential uncertainty for contractors. The flexibility of these contracts has been described at length in the previous section. Yet, the vast majority of these RFPs offer no guarantee that selected contractors will be awarded even a single project under these agreements. They could potentially receive only the minimum amount of a few thousand dollars and no more, reflecting one of the concerns often raised with IDIQ contracts. For example, Thornton (2001) argues that contract clauses such as nominal guaranteed minimums—consider the case of the $200 minimum guarantee found in this study—potentially undermine contractor confidence in the government's procurement system, causing them to assume more risk, and in turn increase prices.

Reduced Administrative Burden versus Competition and Fair Price Provisions

As procurement officials seek to simplify the procurement process through the use of tools like IDIQ, they can potentially decrease the level of competition, in turn potentially increasing their costs. This content analysis of federal RFPs cannot conclude definitively whether competition has been reduced under this set of contracts, but it does suggest that owners have taken additional measures to manage the tension between simplifying the procurement process and preserving competition and fair pricing. These measures include widespread use of multiple-award schemes, which maintain a level of completion beyond the contract award, as well as the use of pre-established unit pricing for single-award contracts. Additionally, IDIQ contracts appear to promote, at least in aggregate, small business utilization since nearly 90% of the opportunities were set-aside for small and disadvantaged business enterprises.

Strategic Partnering versus Perceived Lack of Commitment

Further tension was expected between the owners' desire to use IDIQ contracts for strategic partnering versus protecting the owner's interest. For example, most IDIQ contracts adopted the five year maximum contract term, which could signal a long-term intent. Yet, most also only offered a one-year initial term with four option years, which could protect the owner against having to work with an under-performing contractor but could also be viewed as a lack of commitment. Option year clauses are generally thought to promote performance as a motivator for receiving future work (Army Contracting Agency 2003), but examining the RFPs in this collection offered no consistent details on how contractors could earn extensions or the exercise of option years. Furthermore, less than a third of the contracts (26 of 90) included formal partnering language, which appeared to be largely driven by the preference of the local procurement office. Given the considerable emphasis on partnering over the past 25 years across the industry (Bresnen and Marshall 2000; Chan et al. 2004; Hong et al. 2012) combined with multi-year, multi-project nature of IDIQ contracts, the use of partnering is lower than what might be expected. In other words, the tension between strategic partnering and protecting the owner's interests appears to favor the latter.

Long Term Performance versus Short Term Price

Finally, these findings reflect the paradoxical tension between obtaining the most qualified firm(s) and the government requirement to evaluate an initial price. Such tension is inherent in balancing price and non-price factors in best-value procurements. For this collection of RFPs, most owners have addressed this tension by placing greater weight on qualifications while meeting the requirement for price evaluation through bidding a real or hypothetical seed project. For multiple award contracts, owners also maintain the ability to award task orders based their preferred weighting of price and non-price factors for individual projects.

Conclusions and Recommendations

This study presents a content analysis of IDIQ procurement practices focused at the federal level, where the practice has historically been the most utilized. It synthesizes the findings from construction management and legal literature, and also presents a comparison of U.S. IDIQ contracts and European framework agreements. This study extends the findings of previous IDIQ research from the state transportation sector (Gransberg et al. 2015; Rueda-Benavides and Gransberg 2014). Given the overlap in results between state and federal agencies, along with the similarities in IDIQ contracts and framework agreements, there is good reason to believe that the findings are generalizable to other levels of government in the U.S. as well as internationally.

This study also contributes to the body of literature on paradoxical organizational tensions in the construction industry by reflecting on the tensions inherent in public sector procurement. Consistent with the description offered by Lewis (2000), paradoxical organizational tensions can be summarized as managing the balance between control and flexibility. On the one hand, public owners must put control mechanisms in place to obtain a fair price, protect the public interest, and comply with regulations. On the other hand, IDIQ contracts reflect a desire for flexibility, simplifying the procurement process, and finding the most qualified contractors.

These findings also offer several practical implications for construction owners and contractors. Owners with large asset portfolios and a continuing need for smaller construction projects can consider using IDIQ as a contracting strategy with the potential to increase their flexibility while maintaining competition. Given that many of these projects are smaller in nature, IDIQ contracts can serve as a means for helping public owners achieve their small and disadvantaged business participation goals (Gianakis and McCue 2012) or efficiently use end of fiscal year funding (Rueda-Benavides and Gransberg 2014).

With the potential long-term nature of these contracts, owners should carefully examine the selection criteria they use for the master contract. The data shows that owners most often evaluate qualifications using factors like past performance and experience and most often evaluate price through seed projects. Thus, the RFP should have a clear statement of work that lines up closely with the desired qualifications and also include a representative seed project. These measures can help ensure the owner is getting the best contractors for the scope of work and that contractors have a clear idea of the work involved.

Owners that want to place an emphasis on low price can still protect their interests by placing additional weight on price considerations at the task order level of multiple award contracts. This is roughly analogous to a two-step source selection procedure in which the most qualified firms are short-listed in step one (Dorsey 1997), only in this case the "second step" is repeated for multiple projects. An important caveat is to consider the technical complexity and amount of design required for the project. Higher complexity, design-build projects generally warrant the evaluation of technical solutions in addition to price (Design-Build Institute of America 2014; El Wardani et al. 2006).

For a single award contract, owners can still emphasize qualifications while competing price through JOC or other forms of pre-established unit pricing. Such single award contract projects in at least one previous study were found to have no significant difference in either unit cost or cost growth from similar one-off procured projects (Henry and Brothers 2001). In contrast, using the bid cost of the seed project as the only basis of price evaluation for the master contract could lead to contractors under-bidding the first project and then acting opportunistically once competition has been eliminated. Of course, owners could always respond by choosing to terminate the contract, but they will be left restarting the process sooner than expected and in turn negating one of the major perceived advantages of this contract method.

With respect to contractors and design-build firms seeking to enter the IDIQ market, IDIQ contracts may represent an opportunity for lowering the administrative costs of bidding due to repeat interactions and familiarity with owner procedures and preferences. For public owners with perennially large construction budgets, successfully securing an IDIQ contract could also offer a regular source of revenue.

On the other hand, contractors are advised to read the details of the RFP carefully, particularly if unfamiliar with this contract form. Contractors should be aware of the minimum guaranteed amount of work offered by the government as well as the number of anticipated contractors that will be awarded a contract. In the case of low guarantees and numerous contractors being offered a master contract—up to 25 in one example from this study—IDIQ contracts may prove to be a smaller than expected source of revenue (Thornton 2001). Additionally, under agreements with pre-priced items, including JOC agreements which can include over 100,000 line items (RSMeans 2015), the contractor will be locked into those prices for the duration of the contract. Such risk should be built into the initial coefficient or unit prices as appropriate (Farris 2002).

This study is subject to limitations that provide the impetus for further research. First, the RFPs examined in this study were limited to the U.S. federal sector. The use of IDIQ contracting at the state and municipal level appears to be growing, and future studies could provide insight on how the practice compares to the federal level. Differences between U.S. IDIQ contracts and Europe's framework agreements, or between public sector and private sector use of similar contracts could also be further examined. A second limitation comes from determining the makeup of the sample. Although search results from the government's single source procurement site were largely consistent, it is possible that some RFPs were mischaracterized by the posting agency, excluding them from the search results. Additionally, not all solicitations included the complete RFP document, which prohibited their use in the content analysis. As such, this study cannot claim a truly random sample, a limitation also shared or not addressed by the previous content analyses of RFPs (Bogus et al. 2013; Gransberg and Barton 2007; Gransberg and Molenaar 2004; Molenaar et al. 2010; Xia et al. 2013). Therefore, future studies of a similar nature should strive to validate the results. Third, content analysis of RFPs does not address issues related to IDIQ contract administration after award of the master contract. Future research could explore post-contract award trends using other methods such as owner surveys, interviews, case studies or analysis of owners' project data. Finally, future studies should empirically examine the impact of IDIQ contracting on project performance, similar to previous research on framework agreements (Lam and Gale 2014). Such studies could examine cost performance, owner transaction costs, schedule performance, quality, and overall value for money.

All references consolidated at the end of this document.

CHAPTER III: INFLUENCE OF SIMPLIFIED PROCUREMENT METHOD ON COMPETITION FOR PUBLIC SECTOR CONSTRUCTION (PAPER 2)

An earlier version of this chapter has been submitted to *ASCE Journal of Construction Engineering and Management*. Co-author: Keith R. Molenaar.

Abstract

In response to problems of cumbersome regulations and understaffed public agencies, governments have worked to simplify procurement statutes and streamline processes. One of the most widely used simplified processes in the United States public sector is a subclass of agreements known as indefinite delivery-indefinite quantity (IDIQ) contracts. Some scholars and practitioners have criticized their use, suggesting public officials have taken advantage of simplified procedures at the expense of protecting the public's interest. Specifically, IDIQ contracts have been seen as limiting competition with adverse consequences for markets and price. However, no studies to date have empirically examined the claims of limited competition from simplified procurement tools like IDIQ. This paper seeks to address that gap by evaluating the use of IDIQ contracts in the context of federal construction procurement. Using univariate and multivariate statistics, this study examined the bid data from 935 U.S. Department of Defense construction projects awarded between 2008 and 2015. The results show that IDIQ contracting corresponds with lower levels of competition as measured by the number of bids, even when controlling for factors like delivery method and market conditions. Using microeconomic theory and traditional assumptions of low-bid contracting, such limits on competition could have negative economic consequences. However, multiple award IDIQ contracts also appear to be effective at maintaining a minimal level of competition needed to protect the public's interest, while potentially lowering the cost and administrative burden of both proposers and government agencies. For design-build projects in particular, IDIQ contracts may serve as a streamlined alternative to two-step source selection. This study serves as the largest empirical analysis of IDIQ contracting to date and adds to the bodies of

knowledge on public procurement and competition in the construction industry. The findings lay the groundwork for researchers to explore the production and transaction cost tradeoffs of IDIQ contracting. The study will also prove useful for public policy makers overseeing procurement regulations and for practitioners that develop or bid on IDIQ contracts.

Introduction

Critiques of government procurement systems often describe these processes as cumbersome, inflexible, and laden with "red tape" for both government and industry personnel (HM Government 2013; Office of Federal Procurement Policy 2004). Another concern relates to under-resourced public procurement agencies, which manage greater levels of public funds and contracts while staffing levels remain constant or decline (DBIA 2016; NCMA 2015). In response to problems of cumbersome regulations and understaffed procurement agencies, governments have attempted to simplify their statutes and streamline their procurement processes to make them easier to interpret and implement. Well-known examples include the Federal Acquisition Streamlining Act (FASA) (1994) in the United States and Directive 2004/18/EC in Europe (European Parliament 2004). The latest edition of the American Bar Association's Model Procurement Code for Infrastructure also highlights inclusion of revised, streamlined processes (2007).

One of the most widely used simplified processes in the U.S. system is a subclass of agreements known as indefinite delivery-indefinite quantity (IDIQ) contracts, sometimes referred to as task-order contracting. The European Union has a similar tool known as framework agreements. These types of agreements enable public owners to enter an agreement with a supplier(s) to purchase goods or services over a multi-year period as requirements and funding become available. Once requirements are finalized, the government places delivery orders (for goods) or task orders (for services) as needed. In the context of the present study on building construction, task orders are typically placed for each unique construction project. Public owners can use single-award task order contracts (SATOCs) when they only want to retain a single contractor. They may also choose multiple-award task order contracts (MATOCs) if they want to maintain competition for subsequent requirements among a pre-selected pool of two or more contractors.

The major advantage of this approach is that public officials do not have to start a new procurement process for every requirement. Once the initial IDIQ contract is established, the owner can use the pre-selected contractor(s) for additional requirements over the life of the contract, which is most often up to five years, without re-advertising to all eligible firms. Even if the initial contract has five or more contractors who compete for all subsequent requirements, the process is often still seen as quicker and less cumbersome for government officials. The process is also considered advantageous for quickly obligating government funds against previously unfunded requirements or in emergency repair situations. In either case, funds can become available on short notice with a short timeline for obligating against a requirement. If a public agency already has IDIQ contracts in place, they can leverage them quickly in such situations (Moore and Stout 1988; Rueda-Benavides and Gransberg 2014).

While simplified procurement procedures offer several advantages to public officials, they are also subject to limitations. In addition to streamlining, each of the statutes cited previously also highlight the need to promote competition, maintain transparency, and protect the public interest. Thus, procurement officials are challenged to balance many competing considerations in order to successfully acquire goods and services on behalf of the public. In the case of IDIQ contracts, some scholars and practitioners have criticized their use, suggesting public officials have taken advantage of simplified procedures at the expense of protecting the public's interest. For example, one argument describes how the overuse of IDIQ contracts has limited competition, which in turn may increase the prices paid by the government (e.g. Payne 2011; Yukins 2007). Concerns about competition are also reflected in U.S. procurement law, which explicitly favors multiple award IDIQ contracts over single award (Subpart 16.5, U.S. GSA 2015). Other critiques include the use of IDIQ contracts for improper sole sourcing, bundling multiple requirements to make the dollar value out of reach of small businesses, and an inability to protest award of task orders (Benjamin 2001; Thornton 2001; Wong 2006).

To summarize, literature suggests competing claims for the impact of simplified procurement processes like IDIQ contracts. On one hand, streamlined processes can enable quicker procurements and less administrative burden on the government. On the other hand, such tools may limit competition and adversely affect the market. However, few studies to date have empirically examined the claims of limited competition from simplified procurement methods.

This paper seeks to address that gap by evaluating the use of IDIQ contracts in the context of construction procurement at the U.S. federal level. Construction presents an interesting context, because unlike the acquisition of routine goods or services, each construction project is unique. Furthermore, the U.S. government procures thousands of construction projects worth several billion dollars annually (U.S. Census Bureau News 2014), providing a data source large enough for meaningful statistical analysis. Additionally, a sizable portion of these projects are procured through IDIQ contracts, making possible a defensible comparison with more traditional "stand-alone" (or "one-off") contracts. Therefore, the purpose of this study is to determine the influence of IDIQ contracting on competition. More specifically, this paper will focus on multiple-award IDIQ contracts which preserve a level of competition beyond the initial agreement. Some of these agreements can include up to 20 contractors, which would presumably offer sufficient competition for any requirement. Other multiple award contracts select only two or three contractors. Thus, comparing multiple award IDIQ agreements against unrestricted "stand-alone" procurements offers the chance to determine if IDIQ contracts restrict competition. This study also provides the opportunity to explore if there is an optimum level of competition, particularly in the context of design-build projects where it may be desirable to limit the number of firms preparing full technical and price proposals. This study also lays the groundwork for future studies to determine if restricting competition under IDIQ does in fact result in higher prices paid by the owner.

Literature Review

Competition in Construction Contracting

Several studies from construction management literature have explored the concept of competition in construction contracting. Many of these studies approach competition from the contractor's point of view. For example, R. Carr (1983) examined the bidding behavior of contractors based on the anticipated number of competitors bidding on the same work. He argues that an increasing number of competitors affects bidder's profit in two ways. First, more competitors means a lower probability of winning the job; second, contractors are likely to reduce their own markups in order to offer a lower price.   Drew and Skitmore (1997) also examined bidder behavior through regression modeling. They found that bidder competiveness, measured by the ratio of a given bid to the lowest (winning) bid, was affected by the facility type and project size. In other words, bidders are strategic about the types and sizes of projects they pursue, which influences how competitive their bids are.

Other studies have offered an owner's view of the procurement process and competition. Ngai et al. (2002) proposed a theoretical model for identifying the minimum number of bidders that should be offered a chance to bid on any given project. This analysis assumed that the market had a large number of potential bidders for any given project and that the owner may not want to evaluate bids from all possible bidders. In other words, similar to IDIQ contracts, the goal would be to strike a balance between promoting competition and reducing administrative burden.   Using data from the Hong Kong construction industry, their model suggested there is not a universal minimum, but that the minimum number of bidders should be varied according to market conditions.

Li et al. (2008) examined the bid opening details of over 900 building projects in Utah to explore the potential impacts of using prequalification on competition. Prequalification would presumably have a similar effect as IDIQ contracting by limiting the number of potential bidders. They did not compare projects using prequalification to those not using prequalification, but framed their results in the context of potential implications of prequalification. They argue that around six bidders would be the target level of competition for typical projects in their data set. For larger and more attractive projects, fewer bidders may be acceptable; for smaller projects, more bidders may be required to get the desired results. They offer two suggestions to deal with the possible adverse consequences of using prequalification. First, owners should consider spreading out their opportunities between peak and off-peak seasons to encourage greater competition. Second, bundling smaller projects together may make the opportunity more attractive to firms, in turn increasing the number of bids.

Background on IDIQ Contracting

The origins of IDIQ contracting came out of legislation in the late 1940s, which was an early effort to consolidate and standardize federal procurement (Comptroller General of the United States 1979). In the construction sector, IDIQ contracting has been used since at least the 1980s, originating in the Department of Defense (Moore and Stout 1988). Early IDIQ construction contracts were largely for smaller projects using job-order-contracting procedures with pre-negotiated line item prices. Since then, use of IDIQ contracting has grown in terms of overall use and in larger scopes of work. For 2014, the National Contract Management Association and Bloomberg Business (2015) estimated that roughly half of all federal spending was obligated under various forms of indefinite delivery contracts.

Previous research on IDIQ construction contracts is limited to only a few studies. Gransberg et al. (2015) provided a state of practice of IDIQ contracting in the highway sector, with particular focus on the Minnesota Department of Transportation. They found that the main advantages of IDIQ are reduced project delivery timelines, greater flexibility for the owner, and quicker response to emergency situations. IDIQ projects in the highways sector tend to be used for smaller and less complex projects, although they acknowledge that they could also be appropriate for larger projects if planned appropriately. Stanford et al. (2016) similarly conducted a state of practice study of IDIQ contracting at the U.S. federal level. They found that most federal IDIQ contract solicitations were multiple-award in nature, preserving a level of competition beyond the initial contract award. Their study identified the tension between competition and flexibility that arises when procuring publicly funded projects through IDIQ processes. However, that study did not further examine the impact on competition. Henry and Brothers (2001) examined projects awarded under two contracts that use pre-established unit pricing, known as job order contracts. This is one of the only empirical comparisons of IDIQ projects against traditional contract forms, but since these were single award contracts using only one contractor, the study did not explore the role of competition.

Competition and the Use of Alternative Delivery Methods

Delivery methods and contractor selection methods are other procurement choices that can influence competition. For example, design-bid-build projects have historically been procured through unrestricted, low-bid procedures. Design build projects may also use low-bid, but many agencies use a best-value selection based on a combination of price and qualifications. Furthermore, some agencies implement two-step best value procedures, where only a short list of firms end up offering a price and technical proposal. The Design-Build Institute of America (DBIA) recommends selecting three firms in Phase I

(DBIA 2015), while the Federal Acquisition Regulation recommends no more than five (Subpart 36.3, U.S. GSA 2015). In the absence of more empirical data, three to five is used as a target benchmark for design-build projects in the study.

The primary rationale for limiting competition in two-step design-build projects is to save proposing firms the time and expense of preparing extensive proposals. A policy memorandum from the U.S. Army Corps of Engineers (2015) cites this concern as the reason for moving to greater use of two-step selection. Ramsey et al. (2016) showed that one-step procedures total cost to industry (i.e. bidders) is about five times the cost of two-step procedures. Similarly, the greater the number of bids, the greater effort on public owners to review and select the winning firm. Thus, under alternative delivery methods, additional competition is not always viewed as advantageous.

Other Factors Influencing Competition

Several other factors can influence the level of competition on a given construction project. For example, public agencies often have goals to award a certain percentage of work to small or disadvantaged business enterprises. Procurement officers may "set-aside" a certain portion of their work for such businesses, which can also restrict competition. Stanford et al. (2016) found that a majority of IDIQ procurements at the U.S. federal level are set-aside, either in part or in whole, for small and disadvantaged businesses. Perhaps counter intuitively, Denes (1997)found that small business set-asides on federal dredging contracts yielded a slight increase in the number of bidders. In either case, the level of competition could be affected.

In other cases, the owner can justify the use of a sole source acquisition in which the price is directly negotiated with the selected firm in the absence of competition. This might include the use of single-award IDIQ contracts in which only one contractor is selected for the life of the contract. Therefore, the use of sole-source contracting, to include single-award IDIQ contracts, as well as small business contracting were considered in the design of this study.

Other factors may influence the level of competition such as market conditions (Ngai et al. 2002). In slow markets, firms may be willing to bid on more projects simply to keep their teams employed. During peak market conditions, firms may be more selective on which opportunities they want to pursue, resulting in fewer bidders for a given project. In the federal market, which is the subject of this study, the flow of funding tends to fluctuate throughout the year and often peaks near the end of the fiscal year (Liebman and Mahoney 2013). This trend could also influence the ability of firms to respond quickly with qualified offers. As a result, both an index representing market conditions and the timing of project award were included as control variables in the study.

Point of Departure

Research to date provides only limited analyses of simplified procurement processes like IDIQ contracting, and none have examined measures of competitiveness. Other studies have examined competition in the construction industry, but none has specifically sought to compare a group of projects using a simplified procurement process versus a comparable group of projects using traditional, one-off procured contracts. While multiple-award IDIQ contracts are designed to maintain competition, it is unclear to what extent competition may be restricted or if a minimal level of competition has been maintained. This paper examines the influence of multiple-award IDIQ contracting on competition in the context of construction procurement. This study also includes the largest empirical examination of IDIQ projects to date. Furthermore, while previous

IDIQ studies were limited to projects in specific geographic regions, this study strives to compare projects across the United States in order to increase the generalizability of the findings.

Research Methods

Variable Selection and Criterion Measures

The unit of analysis for this paper is a U.S. Department of Defense project for construction of a new facility (vertical construction). The independent variable of interest is the contract type, classified as either ***stand-alone*** (the traditional, one-off contract form) or ***IDIQ***. The dependent variable of interest is competition. The level of competition was measured by the number of bidders on any given project, consistent with previous studies (P. Carr 2005, R. Carr 1983). One critique of IDIQ contracts is that the method keeps potential bidders out of the market (Yukins 2007), which would presumably be reflected in a lower number of bidders. (This paper uses the terms "bids" and "bidders" to remain consistent with previous studies, while recognizing that design-build projects are typically associated with "proposals" and "proposers.")

Data Collection

The authors retrieved the data set from a Department of Defense (DoD) project database known as Historical Analysis Generator, Second Generation (HII) in September 2016. HII includes historical unit costs and bidding information for construction projects, and serves as the primary source for developing future DoD cost estimates. The data set included projects of new (vertical) facilities between $1M and $100M that were awarded during federal fiscal years 2009-2015 (October 2008 – September 2015). Only design-bid-build and design-build projects were considered; construction manager/general contractor (also known as early contractor involvement) is a relatively new option for DoD with too few completed projects to include in this study. Projects not using competitive procedures, such as sole source procurements or single-award IDIQ contracts, were removed.

After filtering the data set, the authors examined the distribution of IDIQ contracts against stand-alone contracts to ensure the groups were comparable. Previous studies suggest that IDIQ contracts may be most effectively used for specific types of projects, for example, for less complex projects or those with repetitive scopes of work (Gransberg et al. 2015). Therefore, distributions were compared between the two groups for factors that may indicate differences in scope or complexity, specifically: facility type, size (SF or SM), budgeted cost, and delivery method.

Data Analysis

The authors then employed univariate and multivariate statistical methods to test the hypotheses of interest. First, stand-alone projects were compared to IDIQ projects in terms of number of bidders. Given the ordinal nature of the data, the appropriate test was the rank-sum test, also known as the Mann-Whitney U-test (Ramsey and Schafer 2012).

Second, given the anticipated influence of delivery method on the number of bidders, a Chi-Square test was conducted on the combinations of delivery method and contract type. DoD managers advising this study noted that the decision on contract type (stand-alone versus IDIQ) and the decision on delivery method (design-bid-build versus design-build) are often made as part of the same procurement strategy. Therefore, examining the combinations of these choices should provide a deeper level of insight.

Third, the authors acknowledged that other variables are known to influence the number of bids that might be received on a given project. Therefore, multivariate approaches were used to analyze the number of bidders while controlling the effects of variables other than contract type. As with the univariate test, the primary variable of interest is contract type, categorized as IDIQ or stand-alone. Other variables were included based on previous research and input from DoD project managers advising this study. For reasons described in the Literature Review section, these variables included: delivery method, whether the project was awarded to a small-business, market conditions as measured by a DoD-specific building cost index (NAVFAC 2016), award timing, and project characteristics such as facility type, size, budget, and duration.

The authors created a generalized linear model (GLM), which is a broad family of regression modeling to include traditional linear regression, logistic regression, and others (McCullagh and Nelder 1989). Like traditional regression models, GLMs can be used for prediction, although the primary purpose here was to incorporate the effect of confounding variables on an ordinal response variable. The basic form of a GLM is given by

$$\eta_i = g(\mu_i) = x_i^T \beta \quad (1)$$

where, η is the linear predictor of the model, x is a set of predictors, β is a vector of regression coefficients, and $g(\mu)$ is the link function . The link function transforms the expected value of the response variable depending on the type of distribution selected. Given that the response variable in this study was for count data, the authors chose a Poisson distribution with a log link function (Fahrmeir and Tutz 2001):

$$g(\mu_i) = \log(u_i) = x_i^T \beta \quad (2)$$

A separate GLM was developed with a Gamma family model and an inverse link function, which is often employed for non-negative, positively skewed data. This model yielded similar results, so only the Poisson model is discussed in the remainder of the paper for simplicity.

Once specifying the family of model, variables in the model were selected using a "best subset" method by minimizing the Akaike Information Criterion (AIC) score. AIC provides an objective measure for selecting the most parsimonious model by balancing the number of predictor variables against the goodness of fit. Goodness of fit was evaluated through R^2 and the root mean square error (RMSE). Model diagnostics included checking the residuals for linearity, normality, and equality of variance, as well as examining influential observations using Cook's distance (Fahrmeir and Tutz 2001). R (R Core Team 2013) was the primary statistical software, with *bestglm*

(McLeod and Xu 2014) used to select the variables of the "best" model, and the base R function *glm* used to fit the final model.

The GLM's predictive ability was evaluated through k-fold cross validation. Traditionally, regression models are evaluated by dividing the data into a single training set and a single testing set of observations, typically 80/80 or 70/30. K-fold cross validation randomly partitions the data into subsamples (or folds), 10 in the case of this study. One fold (10% of observations) is "dropped" from the data set, the model fitting is performed on the other 90 percent, and then the model is tested on the dropped 10 percent. This process is repeated a number of times, 500 in this case, which provides a distribution of goodness of fit parameters such as R^2 and RMSE . Thus, k-fold cross validation offers a robust technique of assessing model skill (James et al. 2013).

The authors then conducted a second multivariate analysis that used the same predictors, but analyzed the dependent variable by using categories, which is also known as multinomial logistic regression. Multinomial logistic regression is similar to the more familiar logistic regression, but with the dependent variable having more than two categories (Agresti and Kateri 2011). Three categories were selected based on the rationale provided in previous sections: 3-5 bidders was used as the target range, 1-2 bidders was used as a "low" category, and 6-8 bidders was used as a "high" category. Cases with more than eight bidders were removed from this section of the analysis, since only three IDIQ projects received nine bids, and none received 10 or more. The goal was to see what variables would be most influential in predicting group membership from these three categories. In general, the same model selection procedures were used as for the GLM described in the preceding paragraphs. The primary R function for multinomial regression was *multinom* from the *nnet* package (Venables and Ripley 2002).

Validation of the multinomial regression model was based on the rank probability skill score (RPSS). RPSS is a measure often used in weather forecast comparisons (Epstein 1969; Murphy 1971), which quantifies the model's predictive ability versus a model based on chance predictions

(Wilks 2011). RPSS has also been used in construction applications, such as developing models for optimizing building window controls (May-Ostendorp et al. 2011) and construction injury severity (Esmaeili et al. 2015). RPSS values can range from negative infinity to positive 1.0. An RPSS value of 0.0 predicts exactly the same as chance observations whereas a value of, for example, 0.15 would predict 15% better than chance. One technique for making the RPSS approach more robust is to compare the model's predictive ability not just against chance (in this case of 3 categories, against 0.33/0.33/0.33) but against the observed probabilities. This approach was also used by May-Ostendorp (2011) and Esmaeili et al. (2015).

To recap, statistical testing involved two univariate and two multivariate approaches. The null statistical hypotheses for this study were:

$H_{0,1}$: *There is no statistical difference between the numbers of bidders on IDIQ and stand-alone building projects.*

$H_{0,2}$: *There is no statistical difference in the numbers of bidders between combinations of contract type and delivery method.*

$H_{0,3}$: *Contract type (IDIQ versus stand-alone) has no relationship to the number of bidders when accounting for other relevant variables.*

After completing the statistical analysis, the authors then developed preliminary conclusions which were presented to a group of DoD managers in December 2016 for feedback and revisions.

Description of the Data Set

The final data set consisted of 935 projects for new facility construction awarded between October 2008 and September 2015. The projects had a cumulative budgeted cost of $22.2 billion, adjusted to July 2015 values using the DoD's Building Cost Index (NAVFAC 2016). Table 1 provides an overview of the size, cost, and contract duration of projects in the sample. The table shows that most of these facilities can be considered small to medium in size, with median measures of 36,616

SF (3402 SM), $16.1M, and 540 days. IDIQ contracts comprised 42 percent of the sample by number of projects and 40 percent by total budgeted cost.

Table 3-1. Project Size and Scope Characteristics (n=935)

Characteristic	Mean	Std Dev	Low	Median	High
Size (SF)	53,576	47,903	2,300	36,616	295,960
Budgeted Cost ($ thousands)	$22,812	$19,581	$1,257	$16,138	$99,410
Contracted Construction Duration (Days)	553	152	165	540	1183

Figure 1 shows the breakdown of facility type. When totaled across contract form, administrative offices and facilities with high technology and/or high security features (e.g. air traffic control facilities, intelligence centers, communications hubs) were the most common types in the data set, followed by dormitories. The figure shows a relatively equal distribution by facility type between IDIQ and stand-alone projects, with three notable exceptions. Administrative offices were delivered in greater proportion using IDIQ contracts, while training and medical facilities were both delivered more often using stand-alone contracts.

Figures 2 and 3 show the comparisons across metrics of size (SF) and budgeted cost. IDIQ projects tend to skew slightly toward smaller sizes (less than 20K SF and $10M) but were still represented in each bin of size and cost.

In terms of delivery method, 63% of projects were delivered through design-build, and the remainder through design-bid-build. When sorted by contract type, the proportions change somewhat, with design-build comprising about 57% of the stand-alone projects and 72% of IDIQ projects.

In summary, both IDIQ and stand-alone projects were well represented across delivery method, facility type, project size, and budget. Since the distributions varied slightly in each case, these factors were included in the multivariate analysis that follows.

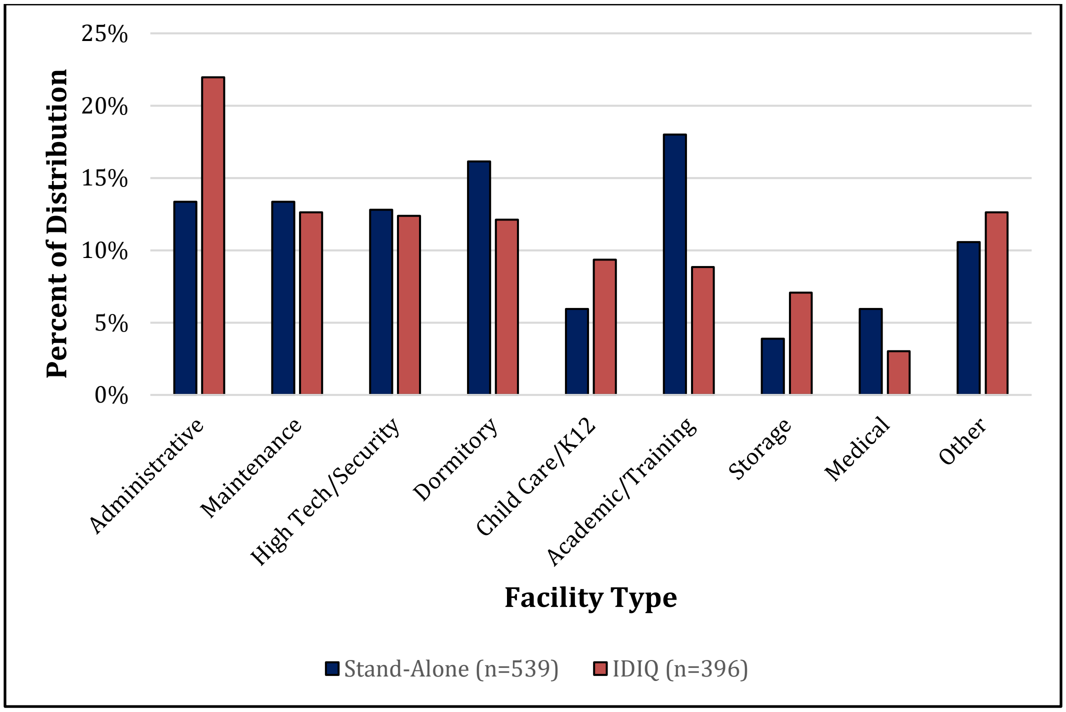

Fig. 3-1. Facility Type Breakdown by Contract Type

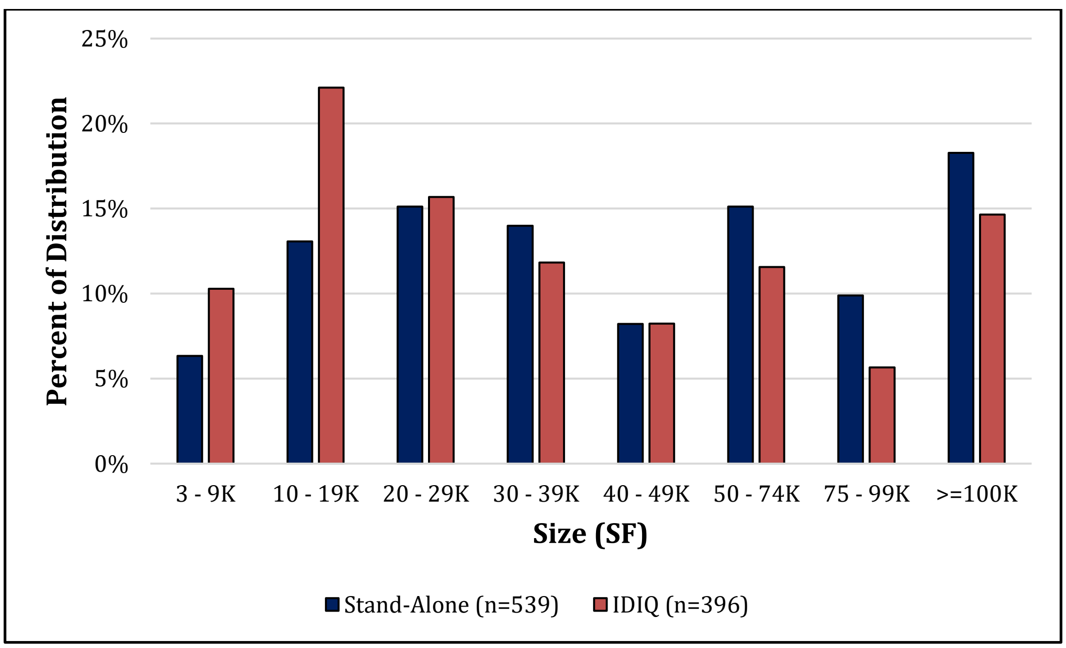

Fig. 3-2. Project Size Breakdown by Contract Type

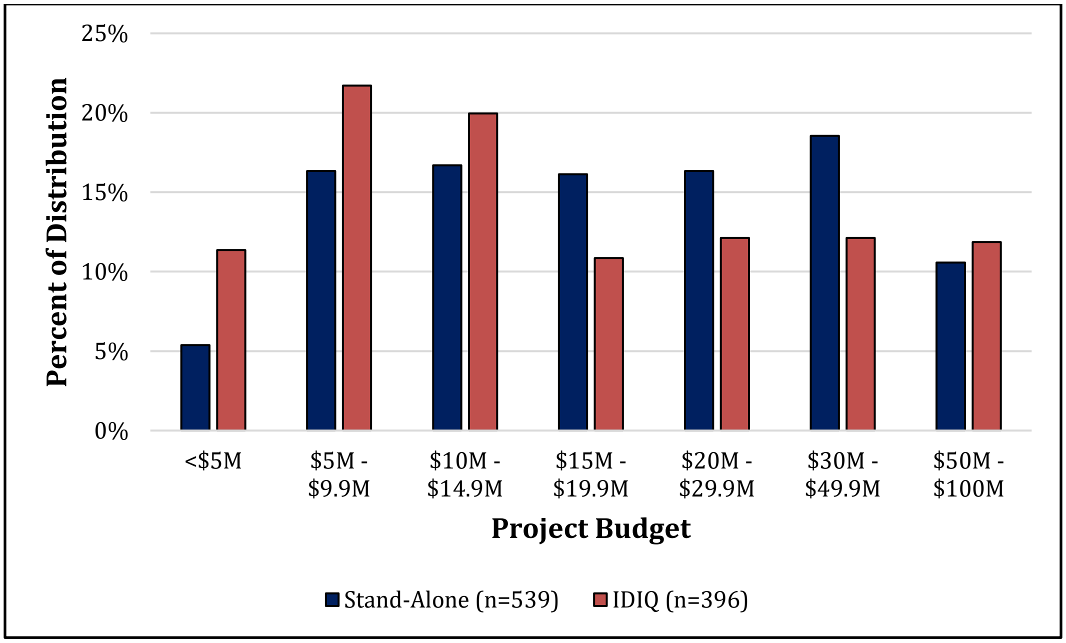

Fig. 3-3. Project Budget Breakdown by Contract Type

Results

Univariate Analysis

Figure 4 provides histograms of the distributions of numbers of bidders by contract type, and Table 2 provides a summary of the key descriptive statistics. The results show that stand-alone projects on average receive 3.4 more bids than IDIQ projects. The difference in medians is two bidders. When directly comparing the two groups using the Mann-Whitney U test, the difference proves to be statistically significant. Therefore, $H_{0,1}$ is rejected.

Perhaps more noteworthy, the maximum number of bids received for an IDIQ project was nine compared to 25 bids received on one stand-alone project. Nearly a quarter (131 of 536) of stand-alone contracts received at least 10 bids.

As described previously, delivery methods were also considered as a potential influencing variable on competition. Table 3 groups the number of bidders by delivery method, totaling to 100 percent across rows. To ease in interpretation of the results, the numbers of bidders were divided into four categories, split around the "target" category of 3-5 bids. Again, the "target" was based on recommendations from government and industry (DBIA 2015; U.S. GSA 2015). When comparing the four possible groupings of delivery method and contract against the groups of bidders (essentially the four rows of Table 3 that are not bold), the differences in groupings are statistically significant (x^2=230.8, p <0.001). Therefore, $H_{0,2}$ is rejected. This provided further motivation for including delivery method in the multivariate model below.

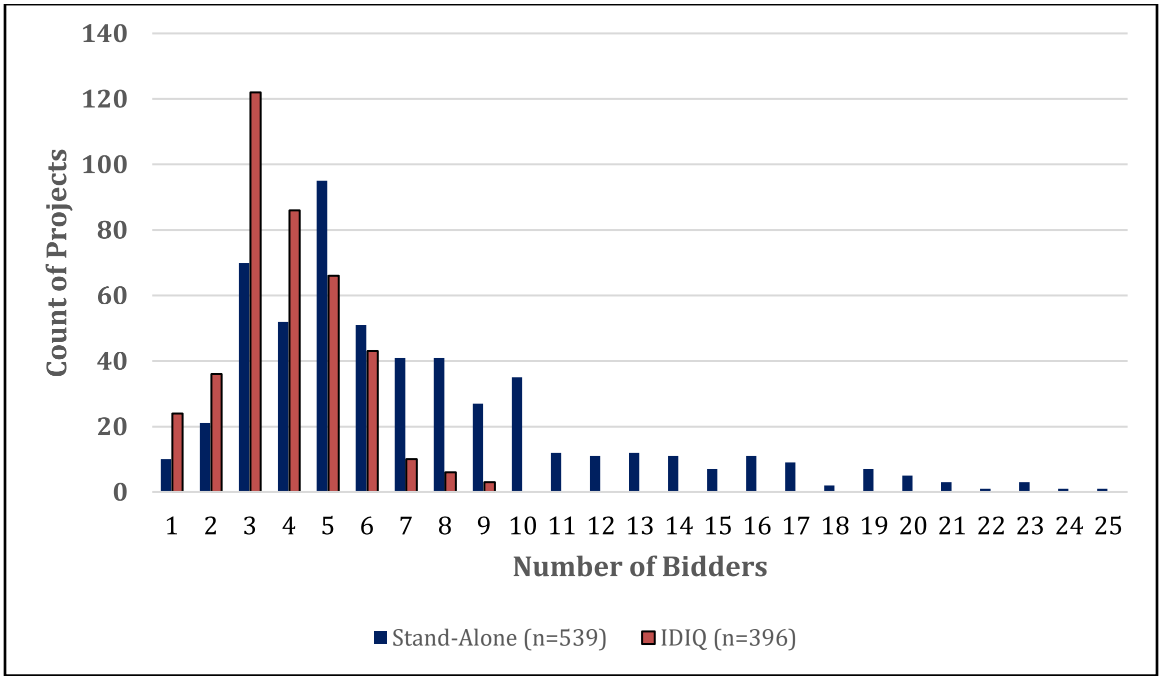

Fig. 3-4. Histograms of Number of Bidders by Contract Type

Table 3-2. Comparison of Number of Bidders by Contract Type (n=935)

							Mann Whitney U-Test Comparison		
Contract Type	n	Mean	Std. Dev	Low	Median	High	Mean Rank	Statistic, z	p-value
Stand-Alone	539	7.3	4.6	1	6	25	570.7	13.695	<0.001
IDIQ	396	3.9	1.6	1	4	9	328.2		

Under both delivery methods, IDIQ contracts were slightly more likely to receive only one or two bids than stand-alone contracts. For design-bid build projects, the ranges of 3-5 bidders and 6-9 bidders are the most common, with a significant minority (21%) of projects receiving at least 10 bids. For design-build projects, the recommended range of 3-5 bidders indeed proves to be the most common grouping using either contract type. However, over a quarter of design-build projects received at least six bids, 59 of which received at least 10. When comparing across contract type, half of stand-alone design build projects fell in the range of three to five bids. The percentage jumps to 70 percent under a combination of IDIQ and design-build.

Table 3-3. Number of Bidders by Delivery Method and Contract Type

Delivery Method	Contract Type	1-2 Bids	3-5 Bids	6-9 Bids	10+ Bids
Design-Bid-Build	**All**	**19 (6%)**	**135 (39%)**	**119 (35%)**	**72 (21%)**
	Stand-Alone	7 (3%)	60 (26%)	95 (41%)	72 (31%)
	IDIQ	12 (11%)	75 (68%)	24 (22%)	0 (0%)
Design-Build	**All**	**72 (12%)**	**356 (60%)**	**103 (17%)**	**59 (10%)**
	Stand-Alone	24 (8%)	157 (51%)	65 (21%)	59 (19%)
	IDIQ	48 (17%)	199 (70%)	38 (13%)	0 (0%)

Multivariate Analysis

The above univariate analysis shows that IDIQ projects on average receive a significantly lower number of bids than stand-alone projects, and that delivery methods are likely influential as well. However, it was unclear to what extent delivery method or other factors were influencing the results.

The parameters of the generalized linear model that incorporated additional relevant variables are shown in Table 4. As noted in the Methods section, the model uses a Poisson family of model with a log link function, which must be considered when interpreting the coefficients.

Table 4 shows that even if the presence of other factors that might influence the number of bidders for a given project, contract type remains a statistically significant factor. Therefore, $H_{0,3}$ is rejected. When examining the coefficients, test statistics, and significance levels, then contract type is also the most influential factor in this model. Other factors are discussed in greater detail in the following section.

The GLM explains about 28 percent of the variance in number of bidders and has a RMSE value of 0.72. During k-fold cross validation, the model shows a slight drop in R^2 values (R^2_{Mean} = 0.24; R^2_{StdDev} = 0.06), but a larger increase in mean RMSE values ($RMSE_{Mean}$ = 2.05; $RMSE_{StdDev}$ = 0.18).

Table 3-4. Summary of Generalized Linear Model Results for Number of Bidders[a]

Predictors	Estimate[b]	Std. Error	z	Pr(>|z|)
(Intercept)	4.854	0.394	12.320	<0.001
Contract type (IDIQ)	***-0.740***	***0.054***	***-13.825***	***<0.001***
Delivery method (DB)	-0.302	0.034	-8.875	<0.001
Building cost index/1000	-0.535	0.087	-6.122	<0.001
Awarding to small business	-0.129	0.032	-4.042	<0.001
Duration (100 days)	-0.040	0.012	-3.382	<0.001
Time of award during fiscal year	-0.170	0.052	-3.292	<0.001
Contract*Delivery	0.209	0.066	3.152	0.002
Size (1000 SF)	0.012	0.005	2.560	0.010
Budget ($10M)	-0.023	0.012	-1.940	0.052

[a] Model Null Deviance 1948.4 on 874 df; residual deviance 1352.6 on 865 df
[b] Coefficient estimates based on GLM with Poisson model family and log link function

The second multivariate analysis was a multinomial logistic regression model used to determine how well a model could predict project "membership" in one of three categories: low numbers of bidders (fewer than three), target (3-5), or high (6-8). The potential predictor variables were the same to the previous model as shown in Table 5. Again, the model shows that contract type is an important factor in determining the numbers of bids. The model's predictive ability was also acceptable, with and RPSS score of 0.32, or 32 percent better than predicting based strictly on observed probabilities.

Table 3-5. Summary of Multinomial Logistic Regression Model for Categories of Bidders

Model Variable[a]	LR ChiSq	p-value
Contract Type	***49.693***	***<0.001***
Delivery Method	49.205	<0.001
Award to Small Business	6.411	0.041
Building Cost Index / 1000	8.788	0.012

[a] Model significance (vs. null model) Chi Square = 112.13, p < 0.001

Discussion

The results show that DoD used IDIQ contracting to acquire a substantial amount of its construction services between 2008-2015, about 42 percent by contract count for projects between $1M and $100M. The 40 percent of construction obligations (in dollars) using IDIQ contracts is the first national level estimate known to the authors. The National Contract Management Association

(2015) estimated 49% percent of all federal contract obligations were procured through various forms of indefinite delivery agreements, a number which included all government spending, not just construction. Therefore, the implications of IDIQ related procurement policy are potentially far-reaching at the U.S. federal level.

IDIQ also appear to be used in slightly greater proportion on smaller projects—those under $15M and 20K SF (1860 SM). When examining facility type, IDIQ contracts appear to be used in greater proportion on less complex projects, such as administrative offices and warehouses, and used in lower proportion on higher complexity projects such as medical facilities. These findings are consistent with a study of IDIQ requests for proposal conducted by Stanford et al. (2016) which showed that IDIQ contracts are generally used in greater proportion for projects under $10M. Despite these minor differences, IDIQ contracts in this study were still employed in every major type of facility, and across the entire examined range of project sizes and budgets.

Additionally, 72 percent of IDIQ projects used design-build delivery, 15 percent higher than in stand-alone. The group of DoD managers consulted in this study suggested that some DoD personnel may perceive increased cost certainty with this arrangement. Because design-build projects are typically solicited for firm-fixed price solicitations with a 15-30 percent design, the owner is potentially vulnerable to greater cost uncertainty when compared to a fully designed design-bid-build approach. To offset the uncertainty, having a group of contractors that is familiar with owner preferences and DoD processes, such as a pool of IDIQ contractors, may decrease this risk. Cost certainty is a prime objective for DoD projects of this magnitude which require Congressional approval. Projects that require substantial revision to the budget may require reauthorization by Congress, a lengthy process. Therefore, the desire for cost certainty may drive a higher use of combing IDIQ contracting with design-build delivery, but this explanation requires further research to verify.

When examining the number of bids received, multiple-award IDIQ contracting yielded fewer bids on average than traditional, stand-alone contracting. The difference of bidders (average difference of 3.4; median difference of 2) is both statistically significant, and—as confirmed by the panel of DoD managers—meaningful in terms of source selection processes. This difference remained statistically significant when accounting for other relevant factors. When the coefficient estimates are interpreted in light of the log link function of the GLM, the data show that using design-build delivery is associated with fewer bidders. Investigating the interaction term shows that this difference is most important for stand-alone contracts, which is supported by the H2 test above. Additionally, a higher cost index—implying a more robust market—and awarding to small businesses are both correlated with fewer bidders in this model. The remaining predictor variables were: the time of award during the fiscal year, and the project characteristics of duration, size, and budget. These were statistically significant but of lesser importance. Other factors that were considered but ultimately not included in the model included year of award and facility type. These factors were either not statistically significant and/or did not improve the model using the "best subsets" approach described in the Methods.

Examining the standard deviation and maximum number of bids received in Table 2 reveals one of the greatest differences between IDIQ and stand-alone projects seen in this study. The maximum number of bidders for a stand-alone project was 25, and nearly a quarter of stand-alone projects received at least ten bids. This is in contrast to IDIQ projects, with the maximum number of bids for any project being nine. This trend is logical given the fact that stand alone projects have a potentially unlimited number of bidders for any given project while IDIQ contracts have a pre-established bidding pool. The largest confirmed number of contracts in any multiple award pool in this data set was nine, with many having four to six contracts in place, although data on the size of the eligible pool was not available for all contracts.

The significance of examining the maximum number of bids relates the time and cost expended both by bidding firms and by the owners' staffs (Ramsey et al. 2016). Nearly two-thirds of this data set is comprised of design build projects, which typically require greater effort for proposal development and evaluation than design-bid-build projects. In this data set, 162 projects, about a quarter of those using design-build, received at least six full technical and price proposals. In these cases, substantial investments were likely made by proposers, and government selection panels would have likewise devoted tremendous effort to selecting the winning firm. Projects with this many proposals probably reflect the fact that U.S. federal government agencies like the U.S. Army Corps of Engineers (USACE) have previously made heavy use of one-step proposals for design-build projects. Only since late 2012 has USACE policy (2015) stated a preference for two-step procedures, which would have influenced only about 15-20% of this sample. Regardless, if a public agency does favor one-step selection procedures, then IDIQ contracts have the potential to result in significant time savings to both design-build firms and the public agency simply by limiting the number of prospective bidders. Essentially, the first step of a two-step process takes place when the initial pool of IDIQ contracts is established, offering a potential alternative to traditional two-step procedures.

One final observation regarding the number of bidders is both contract methods appear to be largely effective at generating a minimum of three bids. About 94 percent of stand-alone projects received at least three bids, compared to about 85 percent of IDIQ projects. If one assumes that getting three bids is a minimum amount of competition desired, then IDIQ contracting is only slightly less effective than stand-alone contracting. Additionally, over 70 percent of design-build IDIQ projects received 3-5 bids, compared to half of stand-alone design-build projects, putting IDIQ contracting more in line with the recommendations from DBIA (2015) and the FAR (U.S. GSA 2015). When using a multinomial logistic regression model to predict a range of bidders, contract type and delivery method were the most important factors. Awards to small business and an index of market conditions were also significant, but interestingly project characteristics such as size, duration, or budget were not significant predictors of the range of bidders. This finding suggests that owners have a high level of influence over the amount of competition to expect based on their choice of delivery method and contract type.

Three factors in particular might explain why multiple award IDIQ projects appear to consistently maintain a minimum number of bidders despite concerns about its ability to limit competition. First, contracting agencies can cancel or restart a solicitation if they do not believe they have received a sufficient level of competition or reasonable prices. Such cancellations would not necessarily be reflected in this data, since it is only for awarded projects. Second, some contracting agencies expect, either explicitly in the contract or implicitly, that contract holders will bid on most if not all opportunities. Third, contractors may see IDIQ projects as an opportunity with higher chances of winning the job. They already know who the eligible firms are and may have a sense of their probability of putting together a winning bid, which would influence their bid/bid-no bid decision making (Carr 1983).

To summarize the findings, IDIQ projects are associated with significantly fewer numbers of bidders than stand-alone contracting, even when accounting for other factors that would be known to the owner at the time of procurement. Despite this restriction, multiple-award IDIQ contracting typically yields at least three bids, thereby maintaining a minimum level of competition in at least 85% of opportunities. With respect to delivery methods, if assuming that design-bid-build projects usually benefit from greater numbers of bidders, then stand-alone contracting may be more advantageous. If assuming that 3-5 bids is the ideal range for design-build projects, then IDIQ contracting appears to be a better choice, limiting both contractor and owner effort in the procurement process.

Limitations

This study was focused on vertical construction for the U.S. Department of Defense. Even though the DoD is the largest purchaser of construction services at the federal sector, future work should examine projects from other organizations and levels of government as well.

A second limitation is the number and type of variables included in the multiple regression model. The models confirm that contract type is the most important variable studied in determining the number of bidders, followed by delivery method, but predictive capability could be improved with additional data. Those factors that generally might be known to the owner at time of award were included, but other factors such as those influencing a contractor's decision to bid might also be relevant (Drew and Skitmore 1997). Future studies could attempt to better incorporate the contractor's perspective to see if contract type remains a critical factor in influencing a bid/no-bid decision and in turn, the number of bids received on a given project.

A third limitation is based on the criterion measure for competition, that is, the number of bidders. The view of competition in this study was mainly that of a public owner charged with maintaining competition to protect the public's interests. This view does not account for firms who fail to secure IDIQ contracts and may consider themselves "locked out" of a local market for up to five years.

This study was also unable to delineate between best-value and low bid solicitations, or between one-step and two-step solicitations of design build projects. With a large enough sample size, the authors were forced to assume that the two groups of interest (IDIQ and stand-alone contracts) used a similar proportion of best-value and low bid, as well as similar proportions of one-step versus two-step procurements. This is not unreasonable since procurement strategies for DoD are developed using the same overarching regulations and because the a stated preference for two-step selection was a relatively new phenomenon in the DOD (U.S. Army Corps of Engineers 2015). In any case, this data would prove beneficial for refining the results.

Similarly, this study examined whether projects were awarded to a small business, which is not the same as whether the project was set-aside for only small businesses in competition. Small businesses may have successfully had the winning bid against larger firms in some of these projects. Knowing which projects were set-aside for small and disadvantaged business enterprises, which was not available in this study, would further strengthen or clarify the findings.

Conclusions

This study serves as the largest empirical analysis of IDIQ contracting to date. It is also the first to test the influence of using IDIQ contracting on competition. As such, it adds to the body of knowledge on competition in construction contracting (P. Carr 2005, R. Carr 1983; Drew and Skitmore 1997; Ngai et al. 2002). These findings extend previous studies of IDIQ in the buildings (Henry and Brothers 2001; Stanford et al. 2016) and transportation (Gransberg et al. 2015) sectors. The study also addresses the implications of using prequalification on competition raised by Li et al. (2008).

The findings should prove useful for a range of practitioners in the public sector. The federal construction market is worth $20-$30 billion annually (U.S. Census Bureau 2015), and this study suggests that IDIQ contracts represent a significant portion of that market, perhaps close to half. IDIQ contracts or similar forms are also used at the state and local levels, as well as in Europe. Government procurement officials at all levels must seek to navigate public law and policy while protecting the public's interest and simultaneously managing their own workload. This analysis showing how simplified procurement methods like IDIQ can influence competition and workload will be valuable information in that context.

The implications of this paper for adopting simplified procurement methods—when appropriately combined with additional studies—may also prove useful for policy makers. The need for streamlining procurement and reducing the burden on short-staffed contracting offices is well-documented (DBIA 2015; NCMA 2015; U.S. Congress 1994). Yet, knowledge that such streamlining can reduce competition could mean higher costs (Yukins 2007). For a given procurement strategy, any premiums in construction costs should be able to be offset by savings in transaction costs, schedule savings, or other demonstrable benefits.

Using the findings of this study, owners should recognize that under multiple-award task order contracts, they can still maintain a minimum level of competition often required to meet procurement laws and policy. However, owners must also recognize that they are potentially influencing the local market by excluding some potential competitors when they use IDIQ contracts. The extent to which the market may be affected will depend on the size of the IDIQ contract capacity compared to the overall size of the local or regional market. For example, at large government installations in remote locations, IDIQ contracts may have greater impacts than at smaller installations near population centers. Public owners should also recognize that using IDIQ contracts can limit the maximum number of bids or proposals received on any project, potentially lessening their workload if a large number of bids is expected.

The authors are developing a future study to focus on the price implications of using IDIQ contracts. Traditional microeconomic theory suggests that limiting competition tends to result in higher prices. Given that IDIQ contracts appear to restrict but not eliminate competition, it will be worth understanding whether such restriction comes at a price. A total-cost analysis with both transaction and production costs of IDIQ contracts, similar to Lam and Gale's (Lam and Gale 2014a) for U.K. frameworks, would further contribute to the body of knowledge and prove useful for practitioners and policy makers. Likewise, an analysis of any differences in procurement durations would be a valuable contribution, since IDIQ contracts are presumed to enable quicker award and delivery of projects.

Future work should also target more qualitative aspects of IDIQ contracting. Some of the advantages or disadvantages of this tool may be better reflected in latent variables, such as trust, or team integration and group cohesion (Franz et al. 2016). The authors are preparing to examine such variables through multiple case studies of specific IDIQ contracts.

All references consolidated at the end of this document.

CHAPTER IV: COST IMPLICATIONS OF INDEFINITE DELIVERY INDEFINITE QUANTITY CONTRACTING FOR CONSTRUCTION (PAPER 3)

Abstract

Public sector procurement policies are designed to maximize competition in order to ensure a fair price, consistent with the tenets of neoclassical economic theory. Yet many public agencies also deliberately use procurement strategies that restrict competition in order to obtain other benefits. One such tool in U.S. public sector construction is the indefinite delivery-indefinite quantity (IDIQ) contract, which selects a limited number of firms to compete for subsequent construction requirements, generally over a five-year period. Since IDIQ contracts by design limit competition after initial award, the purpose of this study was to analyze the production cost premiums or savings of using IDIQ contracts in the context of construction procurement. This study analyzed three cost metrics across 316 completed projects from the U.S. Air Force military construction program. The results show a five percent cost premium when using IDIQ contracts based on differences at contract award, and no statistically significant difference in costs after contract-award. The findings suggest that public sector owners should carefully consider and justify the cost tradeoffs of using IDIQ contracts. The findings also contribute the largest empirical study of IDIQ contracts to a small but growing body of knowledge on IDIQ contracting, while establishing a path forward for researchers to examine transaction costs and total value for money in using these procurement tools.

Introduction

In public sector construction procurement, purchasers often view competition as the primary mechanism for ensuring a fair price. Procurement policies are usually designed to avoid a situation where one or a small number of firms can control market prices, consistent with the tenets of neoclassical economic theory. This is reflected in regulations that tend to emphasize the role of competition in order to protect the public interest (American Bar Association 2007; Recitals (2) (29), European Parliament 2004; FAR Subpart 1.102.b, U.S. GSA 2015). Thus, public agencies strive to solicit their needs in a way that is open, fair, and maximizes competition.

Yet many public agencies also deliberately use procurement strategies that restrict competition. These can include set-aside contracts for small and disadvantaged enterprises, prequalification processes, and sole-source contracting. Public agencies typically choose one of these techniques for a specific reason, such as promoting the growth of small businesses (S.B.A 2017) or expediting the purchasing process in emergencies (Jeffrey and Menches 2008). Some of these approaches have come under scrutiny for creating an uneven playing field for potential competitors and resulting in higher prices paid by the public agency, occasionally with great controversy (e.g. Jehl 2003; Tucker 2015).

This study seeks to examine one such tool that limits the number of firms eligible for a given requirement, indefinite delivery-indefinite quantity (IDIQ) contracting. Traditional contracting approaches tend to solicit each requirement separately and award the contract to a potentially different firm each time, as shown on the left of Figure 1. In contrast, IDIQ contracting is used to preselect a smaller number of firms who may then be awarded subsequent requirements over a given time frame, typically up to five years. IDIQ contracting can be thought of as a robust prequalification process, but with a binding contract that guarantees a minimum dollar amount over the life of the contract (FAR Subpart 16.5, U.S. GSA 2015). The IDIQ structure is shown in its most common form, that of multiple award task order contract, on the right of Figure 1.

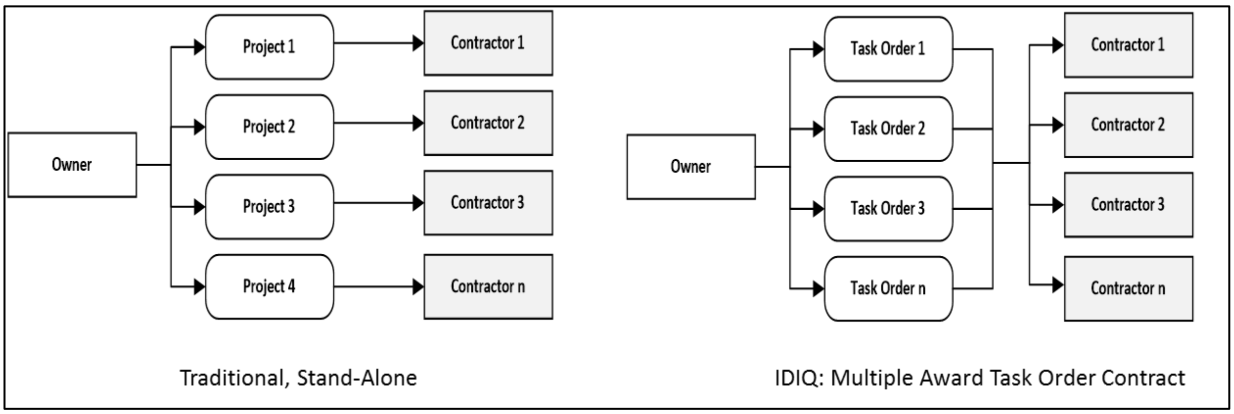

Fig. 4-1. Comparison of Traditional and IDIQ Contract Forms (adapted from Gransberg et al. 2015)

Many public owners tend to see IDIQ contracts in a positive light since they simplify the procurement process (Rueda-Benavides and Gransberg 2014). Such agreements limit the numbers of bids or proposals submitted for any given requirement, in turn reducing the burden on public owners to evaluate those proposals. Such contract forms also provide the opportunity to work together on multiple projects, which offers the potential to improve partnering and collaboration between contracted parties (Back and Sanders 1996; Eriksson 2008). Purchasing agencies can also use IDIQ contracts for short-notice and emergency requirements, as well as a mechanism to obligate end-of-fiscal year funding (Gransberg et al. 2015). Many contractors likewise appreciate the advantages of IDIQ contracts, since they offer greater chances of winning a job and can offer a more predictable stream of work.

IDIQ contracting in the U.S. dates back to the birth of the General Services Administration in the late 1940's (Comptroller General of the United States 1979) and has been used for federal construction since at least the 1980's (Moore and Stout 1988). Procedures for IDIQ contracting are now solidified in law and policy, most notably as summarized in the Federal Acquisition Regulation (U.S. GSA 2015). At the federal level, estimates of IDIQ contracting put use of this method at around 30-40% of construction projects, or tens of billions of dollars annually (Brodsky 2011; see Chapter 3 as well). The European equivalent, framework agreements, are likewise codified in procurement regulations (European Parliament 2004) and are commonly used in the construction sector in the UK, typically for smaller projects under £5M (RICS 2012).

While U.S. agencies regularly employ IDIQ contracts for acquiring a variety of goods and services, few scholars have empirically examined their use. In particular, only a few studies have directly examined the cost implications of these tools, each in the context of limited geographical areas such as a county or state (Henry and Brothers 2001; Lam and Gale 2014a; Rueda-Benavides 2013).

The purpose of this study is to analyze production cost premiums or savings of using IDIQ contracts in the context of construction procurement. This study builds upon previous work on IDIQ contracting as well as a body of work on the economic aspects of competition and price in the construction industry. By examining a large public agency that procures billions of dollars of construction services annually, the results will have implications for a variety of public owners. By comparing the costs associated with IDIQ contracting against those of traditional contracting, owners will better understand the transaction costs or tradeoffs they should achieve for different procurement options. The results may also prove insightful to public agencies and researchers in other countries employing framework agreements.

This paper begins by proposing an economic framework for analyzing IDIQ contracts based on competition and price, followed by reviews of previous research on the cost implications of IDIQ contracts and framework agreements. These sections lay the groundwork for the three hypotheses of interest for the study. The next sections then cover the methodology, results and discussion. The final section presents contributions, limitations, and opportunities for future research.

Economic Framework

Neoclassical economics provides a helpful framework for understanding the potential influence of IDIQ contracting on cost in this paper. A review of the entire field is beyond the scope of this paper and is available in numerous texts on microeconomics (e.g. Ferguson 1975), but in summary, neoclassical economic theory provides a basis for the concepts of supply and demand, markets, and rational choice. Buyers purchase goods or services with the goal of maximizing utility; producers sell goods (services) to maximize profits. Under the condition of perfect competition, markets determine the price at which the good or service can be offered. However, restricting competition can impact markets and provide an opportunity for producers to increase their profits, and in turn prices paid by the consumer. An extreme case, dubbed as an example of market failure by economists, is a monopoly in which only one supplier is available and prices will dramatically increase.

Several authors have employed neoclassical microeconomic theory as a useful lens for analyzing the construction industry (e.g. Runeson and Raftery 1998; Skitmore et al. 2006). For example, the construction industry is highly sensitive to market conditions, and raw material prices such as steel or labor rates for highly specialized trades can result in quickly drastic changes in price over the life of a typical construction project. More specific to this paper, Tennant and Fergie (2012) used neoclassical economic theory to explain why UK owners shied away from framework agreements in a slow market to take advantage of perceived lower prices. Lam and Gale (2014a) also used it to frame their study of 120 framework agreement projects, noting the industry is highly competitive with a large number of producers (i.e. contractors) who understand the market are readily available to provide the services desired by the owner.

Additional studies have sought to quantify the relationship between competition and price in the construction industry. Carr (2005) investigated bid price competition by measuring the number of bidders and actual bid prices compared to the owner's pre-bid estimate. His analysis included modeling the bid deviation from project estimate (or low bid to estimate ratio) as a function of the number of bidders. His regression analysis confirmed that, on average, additional bidders yield lower bid prices. Shrestha and Pradhananga (2010) performed a similar study on public street projects in a U.S. city and likewise showed that a larger number of bidders was correlated with lower bid prices.

As noted previously, IDIQ contracts select a limited number of firms as part of a streamlined procurement process. Previous work shows that IDIQ contracting is associated with a noticeable restriction on competition, as measured by the number of bids received on construction projects (see Chapter 3). Such restrictions according to neoclassical economics would generally lead to higher prices paid by the owner.

Cost Performance of IDIQ Contracting

Three studies have either directly or indirectly examined the cost implications of using IDIQ contracts or framework agreements for construction, each in the case of a limited geographic region. First, Henry and Brothers (2001) examined 46 U.S. Air Force projects for interior renovations from a three-year period using job-order-contracting (JOC). JOC is a type of IDIQ contract in which the owner uses a pre-established price book with thousands of construction line items. Contractors usually win the contract by bidding the lowest coefficient that will be multiplied against all line item prices in the price book. They compared 31 JOC projects to 15 traditional design-bid-build projects. To control for scope related factors, they compared only interior renovation projects with similar characteristics at two military installations. They found lower unit costs and higher cost growth under the JOC method, but neither difference was statistically significant.

Lam and Gale (2014a) looked at the cost implications of frameworks in the U.K. They compared the use of 60 framework agreement projects with 60 discretely procured projects, examining highway maintenance projects from a U.K. county government over a three-year period. They found that framework agreement projects had no significant impact on awarded construction costs compared to similar one-off projects. They acknowledge their results contradict neoclassical economic theory, which would imply that restrictions on competition would result in higher prices. They suggest the difference may be due to continuity of workload for suppliers, among other factors, that helped keep prices manageable. Additionally, they found that frameworks resulted in lower owner transaction costs, particularly those costs incurred prior to contract award. Transaction costs post-award were comparable to traditional contract forms.

Rueda (2013) developed a model for determining when IDIQ contracting would be financially beneficial when aggregating requirements over a three year period as well as how to escalate costs over the contract period. The study was for a state department of transportation and did not otherwise compare the cost implications of a group of IDIQ projects to projects using other contract forms.

IDIQ contracts for construction may also offer less tangible benefits that indirectly affect price. For example, IDIQ contractors can be more familiar with the owner's requirements due to working together over a longer period of time (Gransberg et al. 2015). Such familiarity could presumably result in fewer change orders and lower cost growth during the contract period. If IDIQ contracting proves to result in higher prices at contract award, then the contractor may be less inclined to use change-orders as a means to recover their margins (Lo et al. 2007). IDIQ contractors are also less likely to be selected for future task orders if their performance on an early task order is sub-par. Finally, procurement methods that repeatedly used the same suppliers in long term relationships have been described as "collaborative partnering," which encourages greater trust, increased sharing of information, and continuous improvement (Thompson and Sanders 1998). Similarly, Eriksson (2008) described such agreements as examples of "coopetition", or finding a good balance between cooperation and competition. Such benefits could manifest themselves in improved project performance.

Hypotheses

In summary, neoclassical economic theory indicates that competition limiting tools like IDIQ contracting should lead to higher prices paid by the owner. In contrast, construction literature cites several benefits of IDIQ contracts with few drawbacks. Two small-scale studies to date have contradicted economic assumptions by showing no cost premium in IDIQ or frameworks (Henry and Brothers 2001; Lam and Gale 2014a), and several others have described a number of qualitative benefits that might reduce costs for the owner (Eriksson 2008; Gransberg et al. 2015; Rueda-Benavides and Gransberg 2014; Thompson and Sanders 1998).

These findings frame the following three hypotheses, which will be evaluated in the following sections. Based on the economic framework, Hypothesis 1 is:

> *H1: Construction projects procured through IDIQ contracts will have higher bid prices than comparable projects procured through traditional contracts.*

Based on the benefits of IDIQ contracts described in construction literature, Hypothesis 2 is:

> *H2: Projects procured through IDIQ contracts will have lower post-award cost growth than comparable projects procured through traditional contracts.*

Assuming that the cost premium at award (H1), if any, would be less than any cost savings during contract administration (H2), then the total cost growth (the growth from estimate to final cost) of IDIQ contracting should be less than traditional contracting. Restated as Hypothesis 3:

> *H3: Projects procured through IDIQ contracts will have lower total cost growth than comparable projects procured through traditional contracts.*

Methodology

The independent variable of interest for this study is the contract type, which consisted of two categories, *IDIQ* and *traditional*. Traditional refers to the baseline contract method of allowing any qualified firm to bid or propose on the project, also known in U.S. federal contracting as stand-alone contracting.

The first dependent variable is award growth calculated as:

$$Award\ Growth = \frac{Awarded\ contract\ cost}{Pre\text{-}bid\ owner's\ estimate} - 1 \qquad [1]$$

Using this metric based on the pre-bid estimate normalizes for other factors that influence cost such as location, time, facility type, and market conditions which on average would already be captured in the estimate. Carr (2005), Shresthra and Pradhananga (2010), and Lam and Gale (2014a) all employed a similar approach in order to normalize price for various sized projects.

Post-contract award cost growth (or simply cost growth) is used as the criterion measure for post-award cost trends. Cost growth is another metric for determining whether the project stays on budget, one of the most commonly used project performance indicators in construction literature (Chan and Chan 2004; Gransberg and Villarreal Buitrago 2002; Toor and Ogunlana 2010).

$$Post\text{-}Award\ Cost\ Growth = \frac{Final\ contract\ cost - Awarded\ contract\ cost}{Awarded\ contract\ cost} \qquad [2]$$

Total cost growth is growth from the pre-bid estimate to the final contract cost.

$$Total\ Cost\ Growth = \frac{Final\ contract\ cost - prebid\ estimate}{Prebid\ estimate} \qquad [3]$$

The data sources for this study are two U.S. Department of Defense (DoD) databases used for tracking construction projects, both of which were made accessible to the authors for this study. The projects chosen for this study were all funded by the U.S. Air Force (USAF), which executes about three billion dollars annually in construction at locations around the globe (USAF 2017). The first database is the Automated Civil Engineer System –

Project Management (ACES-PM), which is used to track progress of all USAF construction projects, including the cost growth metric examined in this study. The authors built a database query that retrieved projects with the following characteristics: funded in fiscal years 2006-2015 (October 2005 – September 2015) to capture 10 years of recent activity; with budgeted costs of at least $1M to remove extremely small projects; constructed inside the U.S. to remove the influence of international environments; and excluding family housing in order to focus on more typical military construction projects (e.g. administrative buildings, light industrial, airfields, etc.). The second database is known as Historical Analysis Generator, Second Generation (or HII), which is the primary data source for generating conceptual cost estimates for DoD construction. HII provides contract award information including the information needed to calculate award growth. The authors cross-referenced projects between the two databases using organizational project and contract numbers.

The authors also verified the quality of the data by contacting 25 DoD project managers who were directly involved with 50 projects, or 16 percent of the data set. The project managers were asked to confirm data from the key fields for accuracy. The research team contacted the project managers through email and telephone and provided pre-filled questionnaires with scope and cost information from the database. Project manager feedback indicated that nearly all (over 98%) of the data fields of interest were accurate.

Previous work noted that IDIQ contracting is sometimes used on different types of projects than traditional contracting, for example smaller or less complex projects (Gransberg et al. 2015). Therefore, the two groups of project distributions were compared in terms of project budget, size (SF/SM), duration, facility type, and choice of delivery method.

The authors then conducted a series of statistical tests, primarily t-tests for central tendency. Based on the hypotheses above, the null statistical hypotheses were:

$H_{0,1}$: $\overline{AWARD\ GROWTH}_{IDIQ} = \overline{AWARD\ GROWTH}_{TRADITIONAL}$

$H_{0,2}$: $\overline{COST\ GROWTH}_{IDIQ} = \overline{COST\ GROWTH}_{TRADITIONAL}$

$H_{0,3}$: $\overline{TOTAL\ COST\ GROWTH}_{IDIQ} = \overline{TOTAL\ COST\ GROWTH}_{TRADITIONAL}$

Finally, the authors conducted 10 supplemental interviews with senior project managers and procurement officials involved in U.S. federal government contracting. The objective of the interviews was to assess trends in IDIQ contracting that could help explain the results from the statistical analysis above and in turn improve the internal and external validity of conclusions. The protocol involved semi-structured interviews either in-person or over the phone that typically lasted an hour. Interviewees were offered anonymity to encourage frank discussion, and the interview protocol was vetted through an institutional review board in advance.

The interviewees were selected based on their position and experience with public sector procurement to include experience with IDIQ contracting. Members primarily had experience in government and industry rather than in academia, in order to gain insight from people making the decisions on when and how to use (owners) or pursue (contractors) IDIQ contracts. Each member had a minimum of 20 years of experience in federal contracting with the Department of Defense, the original source of the data described above. To gather a variety of perspectives, the pool of interviewees included two management-level owners' procurement officers, three owners' project managers, three program managers for general contractors, and two independent consultants. Several members had experience in more than one of these roles.

Description and Comparison of Data Set

The data set consisted of 316 projects valued at a combined $6.3B when adjusted to July 2015 values using a DoD specific Building Cost Index (NAVFAC 2016). IDIQ projects comprised 22% (71 of 316) of the sample, with the remainder being traditional. The major project types are shown in Figure 2, with the vast majority being for vertical construction and eight projects for airfield or road pavements. The projects were predominantly for new construction (91%), but did include 30 major renovation projects as well. About two-thirds of projects (204 of 316) were completed using the design-build delivery method—using a single contract for design and construction (Barrie and Paulson 1992)—with the remainder using the more traditional design-bid-build method. The most common types of facilities were administrative offices, light industrial buildings, and facilities with high technology or security requirements (intelligence centers, communications hubs, etc.). The median measures of project size were: budgeted cost of $12.9M, construction duration of 540 calendar days, and facility size (excluding horizontal projects) of 30,000 square feet.

To ensure the two groups were comparable, the authors compared the distributions of traditional and IDIQ contract along five metrics. The results are shown in Table 2 for delivery method, facility type, size, duration, and cost. For comparisons of categorical variables, tests based on the Chi-squared statistic were employed (Howell 2014). For comparisons of continuous variables, the Kolmogorov–Smirnov test for two distributions was used (Massey 1951). When tested at a 95 percent confidence level, the results show that we cannot reject the hypotheses that the two groups of projects come from the same underlying distributions. Choice of delivery method showed some potential for concern (p=0.082) with IDIQ projects using a slightly higher proportion of design-build, but in sum, these results confirm that both IDIQ and traditional projects were employed on projects of similar size and scope.

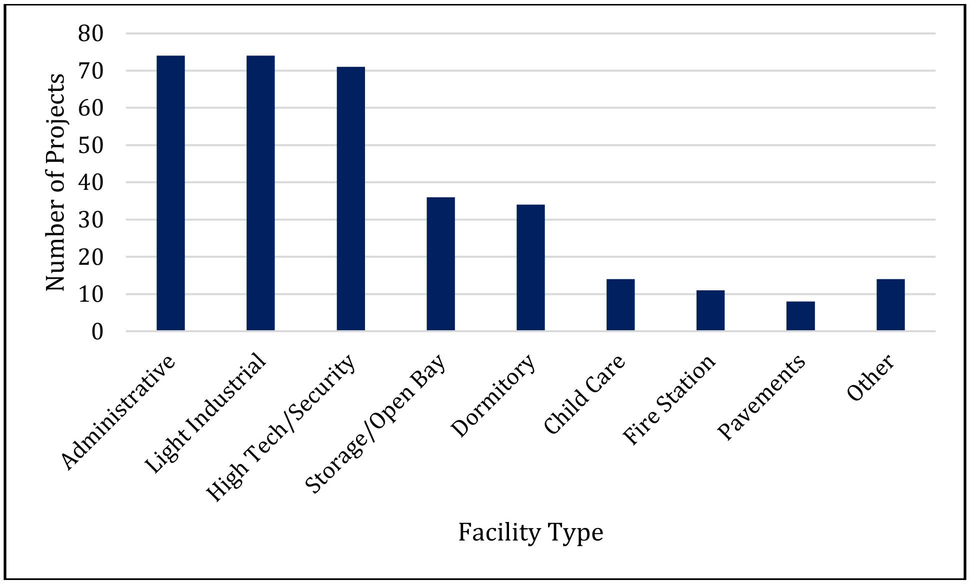

Fig. 4-2. Description of Data Set by Facility Type (n=316)

Table 4-1. Comparison of Traditional and IDIQ Distributions on Project Characteristics

Project Characteristic	**Test Statistic**	**Value**	**p-value**
Delivery Method	Pearson's Phi (χ^2)	Φ = 0.098	0.082
Facility Type	Cramer's V (χ^2)	V = 0.154	0.383
Size (K SF)	Kolmogorov-Smirnov	D = 0.150	0.181
Contracted Construction Duration (days)	Kolmogorov-Smirnov	D = 0.127	0.345
Budgeted Cost ($M, adj. to July 2015)	Kolmogorov-Smirnov	D = 0.120	0.407

Results and Discussion

Summary of Statistical Results

Table 2 contains the results of analyzing all three cost metrics by contract type. The major comparisons of interest are for the means, in bold. The authors also compared variance using Levene's test, but for ease of interpretation, standard deviations are provided in the table. The results are discussed in more detail in the following sections, which are supplemented by comments from the interviews.

Table 4-2. Results of Hypothesis Testing on Cost Metrics

Hypothesis / Metric	Statistic	Traditional (n=245)	IDIQ (n=71)	Statistic (t)	p-value
1. Award Growth	**Mean**	**-0.061**	**-0.016**	**-2.094**	**0.038**[1]
	Std. Dev.	0.160	0.155	0.533	0.595
2. Post-Award Cost Growth	**Mean**	**0.064**	**0.061**	**0.281**	**0.779**
	Std. Dev.	0.090	0.089	0.548	0.584
3. Total Cost Growth	**Mean**	**-0.006**	**0.046**	**-2.067**	**0.040**[1]
	Std. Dev.	0.172	0.200	-0.930	0.353

[1] Statistically significant at 95% confidence level

Analysis of Award Growth

Analyzing the means for award growth (line 1) shows a statistically significant difference between traditional and IDIQ contracts. Therefore, $H_{0,1}$ is rejected. IDIQ projects on average yield bids 4.5% higher than the traditional contract method. This finding is consistent with traditional neoclassical economic assumptions, which posit that measures limiting competition will result in higher prices. Also, it is in contrast to previous studies that have examined IDIQ and framework contracting which found no statistically significant difference in costs (Henry and Brothers 2001; Lam and Gale 2014a). One possible reason for the difference between this study and previous work could be the scope of the studies. This study focused on a large national data set involving multiple contracting offices and contractors. The others focused on a single county or military installation with a small number of firms. Also, the two previous studies focused on agencies that had very narrow scopes of work: highway maintenance and interior renovations. These factors may have allowed for greater consistency and control of costs across projects. Regardless, this study yielded results as expected: the contract mechanism associated with limiting competition is also associated with greater costs.

Perhaps more interesting is the fact that both means showed negative award growth, meaning that bids tended to be below the owner's pre-bid estimate. Supplemental interviews revealed that owners may be overly conservative in their estimates to ensure there is some contingency for the project after contract award. Another noted that IDIQ contractors, although higher on average, are closer to the pre-bid estimate (-1.6% versus -6.1%), which means those contractors probably have a better idea of the true cost of doing business with the U.S. federal government.

When comparing the variance in award growth, there was no difference between the two methods (t=0.533; p=0.595). As just mentioned, interviewees noted that IDIQ contractors should be more familiar with the owner's requirements and in turn have a stronger understanding of what is needed to successfully complete a project, which is also supported by literature (Gransberg et al. 2015). In that case, one might expect IDIQ contract bids to show less variation than traditional methods. Yet both forms have comparable variation in their winning bid data, suggesting other factors may also influence the bid prices offered by contractors on any given project.

Analysis of Post-Award Cost Growth

Analyzing post-award cost growth (Table 3, bolded line 2) revealed no difference between the means or variances between the two contract methods, meaning a failure to reject $H_{0,2}$. This finding is surprising given the positive perceptions in literature regarding IDIQ, such as the potential to improve cooperation between owners and contractors (Rueda-Benavides and Gransberg 2014). If such advantages were present in these IDIQ contracts, they did not result in lower costs post-award. One possible reason for the lack of difference is that there are other causes for cost growth that are not related to opportunism or poor planning by the contractor (Rosenfeld 2014). These would include changes due to differing site conditions or poor scope definition which would not necessarily be related to the choice of contract. As one procurement officer noted, "contract type doesn't matter (after award). It's all execution at that point."

Supplemental interviews yielded another potential reason for similarity in cost growth between the two methods. Most military construction projects carry a five percent contingency for post-contract cost growth. Exceeding five percent requires obtaining more money from within the DoD enterprise (usually from other projects) and exceeding 25 percent cost growth requires reauthorization by Congress, a lengthy process. Thus, owner project managers have a strong incentive to control cost growth. As evidence, only about three percent (11 of 316) projects exceeded 25% cost growth. Having five percent contingency may also allow owners to make value-adding changes late in the project if the project is at or under budget. The projects in this study averaged about six percent post-contract award cost growth, which is consistent with the DoD project managers' explanation.

Analysis of Total Cost Growth

The total cost growth shows IDIQ contracting at five percent higher than traditional (Table 3, bolded line 3). This difference is statistically significant, so $H_{0,3}$ is rejected. As with the previous metrics, there is no difference in the variance between the two contract forms. The variances are also relatively high, as shown in Table 2 with standard deviations around 17-20 percent.

Put differently, these results show there is about a five percent total cost premium associated with IDIQ contracting. This difference is driven almost entirely by the award costs and not by post-award cost increases. The authors anticipated that the numerous perceived advantages of IDIQ contracting would yield overall cost savings or at least show no cost premium due to better performance after contract award. However, the finding of IDIQ showing greater total cost growth is not consistent with the authors' expectations.

Despite the cost premium, the vast majority of interviewees believed IDIQ was still a value-adding tool. Some noted that the advantages associated with IDIQ may be better reflected in other metrics, a limitation revisited below. For example, one of the contractors saw the primary advantage of IDIQ in schedule performance. One of the government contracting officers also noted that IDIQ contracting is considerably easier to administer for the owner, resulting in cost or time savings which are not captured here. Others believed that even if there is a price premium, the owner would be receiving greater value with the pool of IDIQ contractors because they would be more familiar with the owner's expectations. As one contractor (who was also a former government project manager) noted: "as long as you are getting multiple bids, then the process works (and) you're getting your value." This contractor thought that compared to more traditional methods, IDIQ contracts mostly ensure the owner gets qualified firms who will bid responsibly. This individual's firm would not risk trying to make up cost through change orders because they have to work with client again and want future work under the IDIQ structure. This dynamic helps ensure better value.

Conclusions and Recommendations

This paper is the largest study to date to examine the relationship between IDIQ contracting and project costs in the U.S. As such, it adds to a body of knowledge on the cost implications of IDIQ and framework agreements (Henry and Brothers 2001; Lam and Gale 2014a; Rueda-Benavides 2013). This study also contributes to the literature examining the role of competition and procurement methods in the construction industry (Runeson and Raftery 1998; Skitmore et al. 2006; Tennant and Fernie 2012). The findings of this study are consistent with the basic propositions of neoclassical economic theory, which states that measures known to restrict competition tend to be correlated with greater costs. It contradicts two related studies from construction literature, which showed no cost premium associated with similar contract forms (Henry and Brothers 2001; Lam and Gale 2014a). This study also lays the groundwork for further analysis of IDIQ contracting, particularly an examination of transaction costs and total value for money.

The major contribution of this study is establishing that IDIQ contracting is associated with about five percent higher costs than the traditional one-off contracting approach in the context of U.S. DoD funded construction. This five percent difference is driven by higher award costs, measured as a ratio against the pre-bid estimate. Project costs after award show no difference between the two methods, so the cost premium of IDIQ is not returned through other production costs.

These findings point towards a few recommendations for practitioners using IDIQ contracts. For example, agencies seeking to begin use of IDIQ contracts should recognize there may be a production cost premium for doing so. New and experienced agencies should examine their own data to see if IDIQ is yielding a cost premium to their organization as it is with this dataset. If so, they should examine and discuss whether the cost premium is worth the benefits of IDIQ. With proper records, some benefits could be easy to quantify such as transaction costs, or those internal costs of managing the contract. Multiple experienced practitioners interviewed for this study believed that IDIQ contracting was more streamlined and required far less effort in preparation of bid documents and evaluating proposals. As documented by interviews in this study, owners may also find value in having more qualified firms who are more familiar with owner processes under IDIQ. Additionally, owners should recognize that the benefits of IDIQ may not translate into lower cost growth after project award. In this study, cost growth appears to be driven by factors other than contract type.

Readers should keep a few limitations kept in mind when interpreting the results of this paper. First, the paper examines the relationships between cost and contract type, but does not show causality. Future research through other methods or in other contexts will be needed to corroborate the findings. Second, this data sample had a low percentage of IDIQ projects (22%) compared to another DoD dataset (42%) that also included other military services' projects (see Chapter 3). While there were still a sizable number of IDIQ projects for analysis, additional work with even larger data sets is advisable. Third, the projects were limited to a single public agency, the U.S. Air Force. This agency largely follows the same procurement guidance as other federal agencies, but conducting a similar study at another level of government or of equivalent contract forms in the private sector would also provide valuable contributions. Fourth, the distribution of delivery methods was sufficiently similar but not identical between the two methods, as shown by the statistical results in Table 1. IDIQ projects had a slightly higher proportion of design-build delivery than did traditional projects. Fifth, two of the primary metrics of cost were award growth and total cost growth in this study. The limitation of these metrics is the need to rely on the pre-bid estimate, which may vary in accuracy (Flyvbjerg et al. 2002). However, this is a common method of assessing cost performance literature (Carr 2005; Lam and Gale 2014a; Shrestha and Pradhananga 2010), and the authors sought to further address this limitation by examining a large sample size. Regardless, a study using comparable unit costs would also be valuable for better understanding the cost implications of IDIQ.

Other future work should include a transaction cost analysis of IDIQ similar to that done on U.K. framework agreements by Lam and Gale (Lam and Gale 2014a). Such costs were not available in this study. Finally, a study of total value for money is needed to provide more insight on the other benefits or limitations of IDIQ contracting, such as those related to schedule, quality, or client satisfaction. With these types of analyses, researchers and practitioners will gain a more complete understanding of the tradeoffs involved in this procurement tool.

All references consolidated at the end of this document.

CHAPTER V: CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

Research Summary

To restate, the purposes of this dissertation are to:

- systematically examine and document the state of practice of IDIQ contracting, and;
- empirically evaluate the competition and cost implications of IDIQ contracting.

A review of the chapters and research questions is shown again in Figure 1, along with contributions that are more fully explained in the following sections.

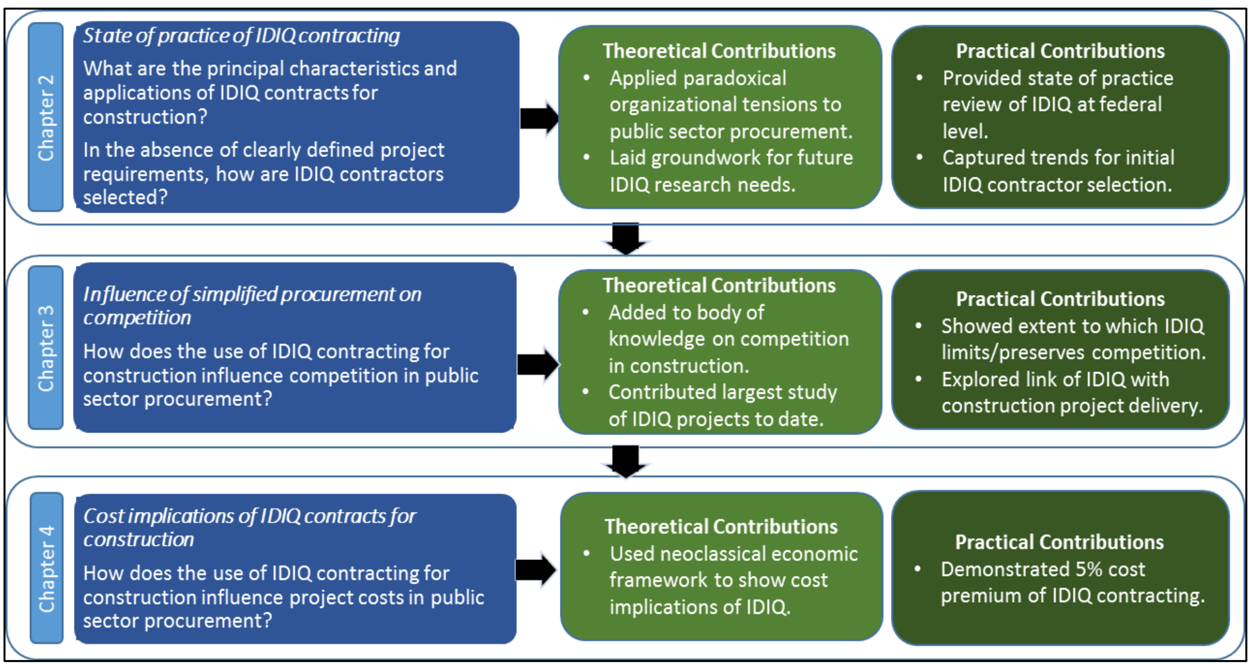

Fig. 5-1. Dissertation Organization and Contributions

Chapter 2 provides a state of practice of IDIQ contracting through a comprehensive literature review and content analysis of 90 requests for proposal. It quantifies trends related to how IDIQ contracts are most often structured, and how contractors are selected for the initial contract given the lack of project definition. Chapter 2 also concludes that

IDIQ contracts provide a good example of paradoxical organizational tensions in the construction industry. These conclusions lay the groundwork for Chapters 3 and 4.

Chapter 3 examines the influence of using simplified procurement procedures like IDIQ contracts on competition. Previous research offered no empirical analysis of how much simplified methods like IDIQ might impact competition, or if a minimal level of competition was maintained under multiple award task order contracts (MATOCs). This study analyzes over 900 Department of Defense construction projects focusing on the number of bids received on these projects. The statistical analysis was able to control for other confounding variables, like delivery method, use of small business contracting, and market conditions. Chapter 3 shows that IDIQ contracts were used on the same types, sizes, and scopes of projects as stand-alone contracts, and represent about 40 percent of DoD construction contracts. Additionally, multiple award IDIQs limit the maximum numbers of bids or proposals, but generally maintain a minimum level of competition almost as often as traditional contracts. Additionally, IDIQ contracts appear to be an effective streamlined alternative for two-step design-build selection.

Chapter 4 builds on the previous chapters by examining the cost implications of IDIQ contracts for construction. This study examines three cost related measures: award growth, post-award cost growth, and total cost growth. The method consists of statistical analysis of 316 completed Air Force construction projects, supplemented with 10 practitioner interviews. The analysis shows that IDIQ contracting is associated with a five percent price premium, which is primarily driven by higher award growth. IDIQ and traditional contract methods showed no statistical difference in post contract-award cost growth.

Contributions

Theoretical Contributions

This dissertation adds to a small but growing body of literature on IDIQ (or similar forms of) contracts (Gransberg et al. 2015; Henry and Brothers 2001; Lam and Gale 2014a). It provides the most comprehensive analysis of IDIQ contracting to date by focusing at the federal level, where IDIQ contracting has historically been most utilized. While most construction literature on the subject describes IDIQ in a positive light, legal literature tends to be more critical of its shortcomings. This study sought to incorporate both perspectives and provide a balanced, critical analysis. Future work on IDIQ will benefit from this analysis that thoroughly describes the tool in a construction context and analyzes its most prominent advantages and disadvantages, specifically those of flexibility, competition, and cost.

This dissertation also adds to a small number of studies applying paradoxical organizational tensions to the construction industry (Koppenjan et al. 2011; Szentes and Eriksson 2015), by reflecting on the tensions inherent in public sector procurement. As described in the seminal work in this area (Lewis 2000), paradoxical organizational tensions can be summarized as managing the balance between control and flexibility. On the one hand, public owners must put control mechanisms in place to obtain a fair price, protect the public interest, and comply with regulations. On the other hand, IDIQ contracts reflect a desire for flexibility, simplifying the procurement process, and finding the most qualified contractors.

Although the paradox framework is only highlighted in Chapter 2, the theme runs throughout the dissertation, making this a novel contribution to the body of knowledge that can help shape IDIQ related research for years to come. For example, the analysis of competition in IDIQ contracts shows the tension between limiting competition—which is usually seen negatively—and being able to hit a desirable target level of competition in order to minimize costs and burden of owners and contractors. Likewise, the analysis of cost demonstrates that IDIQ is associated with higher award costs, but future research may show that those costs are more than offset by savings in transaction costs, schedule acceleration, quality, or other benefits.

The paradox framework also helped explain findings that were perhaps the most surprising. Critics, even within government, often acknowledge the onerous and restrictive nature of public sector contracting (HM Government 2013; Office of Federal Procurement Policy 2004). Yet, the paradox framework shows how public sector procurement can simultaneously show great flexibility. For example, public owners have a wide range of latitude over contract duration, scope of work, quantity of work, the number of firms involved, and more. This tension between control and flexibility not only has implications for project performance, but has the potential to influence the relationship between owners and contractors, which is part of the future research described in the following sections.

Additional contributions to theory are shown above in Figure 1, organized by chapter. Chapter 2 synthesizes the findings from construction management and legal literature. It also presents a comparison of U.S. IDIQ contracts and European framework agreements, a related tool with its own growing body of knowledge (Lam and Gale 2014a; b, Tennant and Fernie 2010, 2012). This study extends the findings of previous IDIQ research from the state transportation sector (Gransberg et al. 2015; Rueda-Benavides and

Gransberg 2014) and adds to a previous study of military use of JOC style IDIQ contracts (Henry and Brothers 2001).

Chapters 3 and 4 add to the body of knowledge on neoclassical economics as applied to the construction industry, particularly articles focusing on competition in construction contracting (P. Carr 2005, R. Carr 1983; Drew and Skitmore 1997; Ngai et al. 2002). It is the largest empirical study to examine the influence of IDIQ contracts for construction on both competition and cost. Chapter 3 shows that, in the context of DoD construction, IDIQ contracting does limit the maximum amount of competition, but can do so in a way that maintains at least three to five bids in most cases. Despite maintaining such competition, IDIQ contracting is associated with a cost premium in Chapter 4, which is consistent with microeconomic theory. This work lays the foundation to further validate the link between contract type, competition, and price.

Additionally, Chapter 3 overlaps with delivery methods research, particularly studies related to design-build procurement (El Wardani et al. 2006; Ramsey et al. 2016). The decisions on delivery method and contract type are often made as part of the same acquisition strategy. Thus, the interaction of these two choices was of interest in this study. Chapter 3 highlights how DoD agencies have heavily relied on the combination of IDIQ contracting and design-build delivery. It suggests that IDIQ contracting can act as a streamlined alternative to two-step design build projects.

Practical Contributions

Findings from this dissertation will offer several practical implications for construction owners and contractors, provided on the right of Figure 1 above.

Chapter 2's state of practice provides insight on common uses of IDIQ contracts and how to structure the source selection process. These measures can help ensure the owner is getting the best contractors for the scope of work and that contractors have a clear idea of the work involved. For owners with large asset portfolios and a continuing need for construction projects, they can consider using IDIQ as a contracting strategy with the potential to increase their flexibility while maintaining competition. IDIQ contracts can also serve as a means for helping public owners achieve their small and disadvantaged business participation goals (Gianakis and McCue 2012) or efficiently use end of fiscal year funding (Rueda-Benavides and Gransberg 2014). For contractors, successfully securing an IDIQ contract could also offer a regular source of revenue. On the other hand, contractors are advised to read the details of the RFP carefully, particularly if unfamiliar with this contract form (Farris 2002).

Chapter 3 offers practitioners an idea of the level of competition they can expect under IDIQ contracts, and suggests that IDIQ contracting is effective at maintaining a minimal level of competition. This analysis shows that owners who properly employ IDIQ contracting can both maintain the required competition and reduce their workload by limiting the number of proposals received on any given project. This part of the study also highlights the benefit of MATOCs when using design-build delivery. Since owners conduct a one-time shortlisting of firms at the start of the IDIQ contract, they can use these qualified firms to skip the Request for Qualifications and jump to the Request for Proposal (step 2) when awarding task orders. Contractors may also find that IDIQ contracting offers a better chance of submitting winning bids, since there are on average fewer firms, and the competing firms will be known ahead of time.

Chapter 4 extends the analysis of competition by exploring how IDIQ contracts can impact costs. This study shows that IDIQ contracting comes at about a five percent cost premium as compared to traditional contract forms, a difference driven by higher award growth. For public agencies on tight budgets, procurement officials should be able to justify any additional costs for their agency with savings in staff personnel costs or benefits in schedule or quality.

Limitations and Future Opportunities

This study is subject to several limitations, which are described in detail in the previous chapters, and provide the impetus for future work in this area. A brief summary is provided again here.

First, this study relied largely on the U.S. federal sector, particularly DoD, and in the case of Chapter 4, the U.S. Air Force. These factors potentially limit the generalizability of the findings. However, this study will still prove useful to those outside the DoD as IDIQ contracts are also used at the state and local levels. Additionally, the U.S. private sector has similar forms of agreement, as well as the European Union (E.U.), which uses framework agreements. These factors offer reason to believe that the findings will be generalizable beyond one agency or level or government. Regardless, future studies should be more focused on capturing the use of IDIQ at other levels, or on comparing U.S. agreements with those in the E.U.

Likewise, Chapters 3 and 4 were unable to account for all possible confounding factors through multivariate analysis. In construction studies, there tend to be a large number of potential variables that influence the outcome of construction projects (Chan et al. 2004; Chua et al. 1999; Sanvido et al. 1992), not all of which are readily available. For this study, additional variables of interest not captured here include the following: which projects were one-step versus two-step design-build (Ramsey et al. 2016); which projects used best-value versus lowest price-technically acceptable selection procedures (Watson 2015); a better indicator of local market conditions, as opposed to the national level indicator used (NAVFAC 2016); the number of firms selected for any given IDIQ master contract, and; which projects were set-aside for small and disadvantaged businesses (Denes 1997). Portions of this information were available on some projects, but not in sufficient quantity or quality to incorporate in the study.

This study was also heavily reliant on the quality of data available from DoD sources and public agency websites. To compensate, I conducted numerous quality checks on the data, such as consulting with database managers, comparing common fields across different databases, and cross-checking in some cases with budget approval documents. I also validated the data quality on a smaller subset of 50 projects with the project managers, finding that over 98% of fields were accurate (data used in Chapters 3 and 4). Regardless, some amount of smaller errors related to data entry or missing values likely remain regardless of the level of effort devoted to resolving them.

Finally, this dissertation is heavily focused on the owner's perspective. Contractors, of course, have direct influence over the levels of competition and cost examined in this and related studies (Carr 1983). I had both formal interviews and many informal conversations with contractors throughout the scope of my work, which is only indirectly reflected in the findings thus far. I am still conducting case studies that will better account for the contractors' perspective in the future. This area remains ripe for investigation by other researchers as well.

Future Research

In addition to those opportunities related to the limitations outlined in the last section, there are also areas that were outside the scope of this dissertation. Three areas not covered by this dissertation, in particular, stand out for near-term investigation.

First is the area of transaction costs, or those costs of developing and administering the contract for the owner (Li et al. 2013; Walker and Kwong Wing 1999; Williamson 1979). Chapter 4 shows that, for IDIQ construction contracts, DoD appears to be paying an award premium of about five percent on average. Therefore, I would like to understand whether DoD is gaining back five percent in some other way. The most obvious way to examine that question is to look at the transaction costs of IDIQ contracts versus those of comparable stand-alone contracts. I spent considerable time exploring how to conduct this analysis, but ultimately decided to address it in future research. In many cases, data at the level of detail required do not exist; in others, it may exist but simply wasn't available. The analyses conducted to date by other authors that have shaped my approach were that of Lam and Gale (2014a) and Whittington (2012), both of whom had access to owner records of transaction costs. In the absence of records, simulation modeling may be able to provide some partial answers based on examining owner processes (East et al. 2009; Sterman 1992). I have outlined, in Appendix A, a conference paper more detailed thoughts on how to conduct this analysis.

Related to transaction costs, an even better approach would be to conduct a full value-for-money (VFM) analysis of IDIQ contracting for construction. The VFM analysis should include production and transaction costs, and add other components valuable to owners or contractors (Lam and Gale 2014b). These components could include an analysis of any of the following: schedule performance, procurement duration, change orders, claims, and potentially quality. I have acquired elements of these data and intend to pursue it in the future.

The third major area ripe for examination is an analysis of the organizational and team dynamics present in IDIQ contracting. Team dynamics, such as those often described by team integration, group cohesion, trust, relational contracting, or partnering principles are well established as enablers for construction project success (Franz et al. 2016; Kadefors 2004; Pinto et al. 2009; Rahman and Kumaraswamy 2004; Weston and Gibson, Jr. 1993). When organizations and individuals have the opportunity to work together over time, they can leverage relationships to achieve success (Eriksson 2008; Thompson and Sanders 1998). IDIQ contracting offers the potential to gain organizational efficiencies for both owners and contractors (Gransberg et al. 2015). However, success is not guaranteed simply by the existence of a certain form of contract or delivery method (Franz et al. 2016). Thus, work in this area should examine what conditions are necessary to create an environment for success under IDIQ contracting.

Intuition Informing Future Research and Practice

As a scholarly work, this dissertation was built on previous literature and empirical findings. This final section adds my intuition based on having studied this tool for the last two and half years. My intent is twofold: 1) to offer practical recommendations for ensuring IDIQ contracts are successful, and 2) to guide future research, be it mine or someone else interested in the field.

Recommendations for Using IDIQ Contracts for Construction

IDIQ contracts can be highly effective when a series of conditions exist. The benefits that owners gain from IDIQ are worth at least a five percent cost difference over stand-alone contracts, as long as they are properly structured and managed. If some or all of these conditions do not exist, then they are likely to be far less effective or even fail. These recommended conditions for success are outlined in the following paragraphs.

1) Use a well-trained and experienced contracting force to structure and oversee the contract. Successful procurement starts with the owner. The contracting officer and support team are essential for maintaining communication among all parties and ensure equitable treatment of all parties. I have heard numerous critiques about short-staffed and inexperienced contracting personnel writing and managing government contracts, sometimes for very large contracts. In many cases, these critiques were from the government contracting officers themselves (former and current). When this element is not in place, then both owners and contractors struggle to find success under any contract form. IDIQ almost certainly saves on human resource costs for the contracting staff, but this staff must still be properly equipped to manage these long term arrangements.

2) Ensure clear and consistent expectations from the owner from one project (task order) to the next. Again, owners are key to getting a procurement effort off on the right foot. The contractors I interviewed seem eager to please the owner and comply with their desires (even "pet-peeves") to ensure they can compete for future work. However, the federal government is a large organization and, despite having an overarching legal and policy framework (the FAR), there is still some variation between agencies. Additionally, many of the large IDIQs I examined are used at multiple sites with multiple stakeholders,

including scopes that are national, international, and/or spread across multiple government agencies (i.e. one federal agency will allow another to use their contract vehicle). Contractors noted that it is difficult to have one overarching contract while attempting to cater to multiple government clients under that contract.

3) Maintain formal and informal feedback at regular intervals over the life of the contract. Having an initial partnering session or kickoff meeting was identified as a "best-practice" after initial award of the contract so that all interested parties are on the same page. This is similar to a kick-off meeting for an individual project, but in this case it's at the beginning of what is usually a five-year relationship. Another "best practice" was having review meetings initiated by the owner on an annual or semi-annual basis with all the contractors involved. This allowed for feedback to flow both directions and allow all parties to make adjustments. Some contractors also make a point of visiting their client a couple of times a year at their home office to review ongoing work and discuss performance. Such feedback and constant communication, primarily at the program level, helps both sides to achieve their goals. These forums also allow for stronger relationships which can help diffuse tensions and solve problems before they escalate

4) Communicate pending or future IDIQ requirements in a timely and transparent manner. Contractors noted that having an idea of what projects are coming the following year is very helpful for their planning purposes and allows them to put together better proposals. In many cases, the government does not know which projects it will have money to fund, but even a tentative list is usually viewed positively. Additionally, both government and contractor personnel saw benefits from sending draft RFPs to the pool of contract holders when a project is likely to get funding. Then firms could then provide

feedback on the scope before the final RFP was issued, resulting in fewer RFIs and better procurement documents. Not all agencies do this, but this is a unique benefit of IDIQs that is not available under stand-alone contracts. As much previous research has shown, the earlier you can get key players involved, the better the project tends to perform.

5) Develop IDIQ agreements with limited and repetitive scopes of work. Owners will see a benefit from putting together an IDIQ pool (for MATOCs) based on the type of work to be performed. For example, one of my case studies is strictly for medical renovation projects. Another is strictly for petroleum, oils, and lubricants (mostly fuel tank) projects. This enables agencies to get a pool of small firms with specialized experience in health care or energy or pavements, etc. When the IDIQ is broader in scope, then it is more difficult to get the expertise you need for any given requirement. If, for example, one project is for a concrete taxiway and the next is for a building renovation, then the pool of contractors may not have expertise in both. Having overly broad scopes of work is one critique levied by legal scholars about IDIQ contracts. Although these scopes of work are all construction-related and thus not pushing any legal boundaries, there could be a loss of efficiency when the IDIQ scope of work includes any and all types of construction.

6) Avoid overly complex, one-of-a-kind, or very large projects under IDIQs. This is related to the previous recommendation. Unique and especially complex projects are better candidates for stand-alone contracting because owners may not have the expertise in an existing IDIQ pool that they need. Additionally, exceptionally large projects are likely to eat up a large portion of the IDIQ contract's capacity, meaning the contract will no longer be available for smaller requirements and may not last the entire expected duration.

7) Use best-value on the initial IDIQ procurement. In most cases, initial procurement for the IDIQ should emphasize qualifications over price. It appears that most federal agencies share this opinion (see Chapter 2). Owners can use IDIQ contracts as an opportunity to build strong teams with their industry partners if they take this approach. Having cost as a major deciding factor at the start of a five-year contract relationship invites obvious problems. There is one exception: using cost as a large component, even a majority of the weight, for a small JOC style contract could be appropriate as long as there is still a qualifications component involved. For this exception, the pre-priced line items and a competent negotiator can protect the owner's interests while ensuring the contractor is paid a fair price.

8) Minimize qualifications requirements at the task order level. When it comes to task orders, owners should require very little on firm qualifications in the RFP. If the owner has done a good job up front, they already have a pool of highly qualified firms. In that case, they can emphasize the technical approach for the project, especially if design-build, or perhaps even emphasize price for design-bid-build projects. This simplifies the procurement process for everyone, which is the main purpose of IDIQ.

9) Limit MATOCs to a maximum of 3-5 firms. Some MATOCs have 10-20 firms, but most owners (and contractors) seem to prefer 3-5. The owner needs to find the balance between having enough firms to maintain competition and keeping firms interested in the opportunities afforded by the contract. In a busy market, difficult owners (those with demanding requirements) or those IDIQs with large numbers of contractors may see fewer firms interested because they know there's plenty of competition and a low chance of getting the job. Perhaps even more importantly, an owner can only develop a strong

relationship with so many firms, because relationship building takes time. These relationships can be key to resolving problems and enabling successful project completion. Owners should also consider not having too few firms. If there are only two firms on the contract, and one goes bankrupt, the owner is left with no competition. An exception to this recommendation of 3-5 firms might be for a large international contract, where having 10-15 firms might be advantageous. In that case, the owner should recognize that they are likely trading away some of the qualitative benefits of IDIQ (e.g. developing strong relationships) in order to gain a broader geographical reach. They will also likely find that firms will pursue their own "niche markets" within such large IDIQs, such as certain countries or regions where they prefer to do work.

10) Contractors should be willing to endure a steep learning curve at the start of IDIQs. Contractors, of course, are also critical to making an effective contract relationships. As noted above, when working with a new government agency or even a new local office within that agency, contractors must invest time and effort to know how that office does business if they want to be successful. For small firms or those new to government business, the first few task orders will typically involve a very steep learning curve.

11) To the extent possible, owners and contractors should maintain consistency in the key players. Of course keeping the same people in place for five years is difficult for most organizations, but to the extent that managers can afford to do so, the IDIQ will benefit from the relationships developed. There's a growing body of research that relationships matter in construction, and properly managed IDIQs can be a mechanism to build and leverage these relationships. Of the cases of large IDIQs I've examined, continuity at the project level is very difficult to achieve because projects tend to be spread out across

the country or in several countries. Where continuity proved to be more realistic was at the program level. These more senior managers were able to leverage relationships and informally resolve disputes before escalating too far.

Expected Outcomes for Future Research

For future research, I fully expect that, if it can be accurately measured, IDIQs will result in statistically significant transaction cost savings. These savings at the task order (or project) level could be substantial. However, over the entire 5-10 year life of the contract, that savings may not be as large as anticipated because of the amount of time and effort it takes to create an initial IDIQ contract. Large IDIQs can take up to two years to put in place, starting with market research, proceeding through RFP development, advertising, source selection, and ending with contract award. In some cases, there will be a protest after award, making the process even longer. Even small IDIQs like JOCs may take several months if not a year or more to put in place. More than one government project manager with whom I discussed this research lamented how long it took to put a new IDIQ in place, and a few even wondered whether the effort was worthwhile.

For a future analysis of schedule performance or value for money, I anticipate IDIQ contracting to show quicker procurement durations, especially for smaller projects. One of the biggest advantages for IDIQs in the federal sector is the ability to execute public money on short notice. Federal funding often flows to the executing agency with a very limited amount of time to spend it. In many cases, there is less than a month for end-of-fiscal-year funding, which means organizations that can award projects quickly can get their priorities funded first. This advantage would especially be true for a JOC agreement where a catalogue of pre-priced line items is already in place. JOC projects tend to be smaller and less complex as well, meaning these can often be awarded in a few weeks or less if needed. For larger IDIQs, such as those used in the Military Construction program, there is less of a time advantage. These projects are congressionally approved and are subject to longer timelines for funding. Preliminary statistical tests from the Air Force Military Construction program show no time difference in awarding IDIQs versus stand-alone contracting, when measured from the point of initial advertising. There is probably time savings in developing the RFP prior to that date, which is another aspect that could be studied.

Closing Comments

In closing, employment of IDIQ contracts is like many other choices in construction or procurement: it represent a series of tensions and tradeoffs. That is why I found the frameworks of paradox theory, transaction costs, and "coopetition" helpful. They all recognize that decisions are complex and usually involve tradeoffs. As noted in Chapter 2, procurement decisions involve tradeoffs between maintaining control and flexibility. In saving on transaction costs, owners may be paying a premium in production costs, as implied in Chapter 4. Contractors are often making tradeoffs as well, such as between which bidding opportunities to pursue. Both owners and firms are constantly assessing the balance between cooperation and competition (i.e. coopetition), to get the best results without sacrificing their own vital interests. Therefore, these frameworks will be useful in helping to develop a decision-support tool in the future, which would ideally include elements of all the research I've described in this chapter, both completed and future. Such a tool could advise owners on when and how to best employ IDIQ contracts.

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APPENDICES

A. Supplemental Paper: Measuring Owner Transaction Costs in Construction Contracting

Presented at 2016 ASCE Construction Research Congress, San Juan, Puerto Rico

ABSTRACT

Numerous studies have examined the impact of project delivery strategies on project objectives such as cost, schedule, quality and satisfaction. Additional literature has applied the principles of transaction cost economics to investigate organizational structures in the construction industry. However, little research has examined the impact of project delivery strategies on the owner's transaction costs, those internal costs of developing, procuring, and administering construction contracts. This paper discusses the challenges of capturing owner transaction costs and examines the potential for simulation modeling to estimate such costs. The authors describe and evaluate the three major simulation paradigms—discrete event simulation, system dynamics, and agent-based modeling—in the context of construction contracting transaction costs. Simulation modeling offers the ability to quantify uncertainty and examine the sensitivity of numerous variables of existing contract processes. Methods of organizational analysis for this study include: a high-level, top-down analysis that supports a system dynamics approach, and; a step-by-step, bottom up process analysis that supports discrete event simulation. As a part of a larger research effort, these results will be incorporated into a decision support tool for public owners to select appropriate project delivery strategies in order to optimize allocation of both human and financial resources.

INTRODUCTION

Construction owners can select from a variety of project delivery, procurement, and contracting methods. Often this choice is based on what has worked for the owner in the past, what may be easiest for the owner, and/or what is deemed to be most suitable the current project's objectives such as cost, schedule, quality, and/or owner satisfaction. However, little research has examined the impact of project delivery strategies on the owner's transaction costs, those internal costs of developing, procuring, and administering the contract.

The purpose of this paper is to examine appropriate methods to quantifying owner transaction costs, which are not typically considered in detail in project financial analyses. In particular, the authors describe and evaluate simulation modeling approaches for their potential to estimate transaction costs in the absence of existing owner transaction cost data. The results will prove useful for further research examining the impact of delivery strategy selection on transaction costs. For example, the choice of delivery methods (e.g. design-bid build, design-build, construction manager at risk) is known to qualitatively require different levels of owner involvement (CMAA 2012). Another example is the choice of contract form. Owners may choose (among many options) fixed-price contracts with unrestricted competition for every project requirement or task-order contracts that use a single pre-selected contractor for multiple requirements. Such use of differing delivery, contract, and procurement methods is likely to impact the workload of owner agency personnel, in turn impacting transaction costs. However, there is little data informing owners about the relationship between these variables, which if provided could help them optimize use of limited human and financial resources.

This paper discusses transaction cost economics and previous applications to the construction industry. It explains the challenges of capturing owner transaction costs, particularly in the absence of reliable owner records. The paper then provides an examination of simulation modeling paradigms that may prove useful in estimating transaction costs. It concludes with a discussion of potential organizational analysis methods and opportunities for future research.

BACKGROUND

Transaction Cost Economics

Transaction cost economics (TCE) is an interdisciplinary field that incorporates elements of economics, contract law, and organizational theory. Transaction costs are the costs incurred when exchanging good or services. Transaction cost economics uses the transactions between firms as the unit of analysis and provides a framework for examining the "make or buy" decision. At one extreme, firms will rely on markets to acquire ("buy") needed goods and services as long as the transaction costs of doing so are low. At the other extreme, when transaction costs of relying on markets are high, a firm is more likely to rely on hierarchy (e.g. vertical integration) and "make" the product themselves. In between are numerous mixed forms of governance (Williamson 1975, 1979).

Williamson (1979) posits that three factors determine which of these governance structures (markets, hierarchies, mixed) are most efficient in a given application. The first is the uncertainty of the environment under which the transaction is made. Second is the frequency of interaction between the firms. Third is the level of asset specificity involved in the transaction, that is, the non-recoverable investments made by the firms in this transaction. In a construction context, asset specificity usually involves investments in human capital rather than equipment or physical infrastructure. In general, greater levels of uncertainty, higher frequency of interaction, and higher levels of asset specificity tend to increase transaction costs.

Transaction Cost Economics and Construction

Transaction cost literature related to construction can be classified into two groups. First, several authors have used traditional TCE theory as a framework for describing the nature of the construction industry (Bajari and Tadelis 2001; Chen et al. 2013; Reve and Levitt 1984; Winch 1989).

A second group of studies tend to use the term "transaction costs" to describe the owner agency costs of establishing and monitoring a contract. The present study aligns with this second body of literature. Of particular interest from this group, Walker and Wing (1999) proposed a relationship between TCE and project management principles. They synthesize key elements of these two fields to help better explain and analyze project management choices. They argue that, in contrast to traditional management approaches that focus only on production costs, project management should seek to minimize the sum of both production and transaction costs. They also recognize that doing so presents "a situation which has the potential for conflicts of interest," e.g. minimizing transaction costs could raise production costs or vice versa.

Several studies have also defined and classified the types of transaction costs in construction (Chen et al. 2013; Lam and Gale 2014a; Turner and Simister 2001; Whittington 2012). While these studies have proposed numerous classification schemes of transaction costs, all can be simplified into two basic categories. The first is those owner costs incurred prior to and through contract award, such as defining the requirements, drafting the request for proposal (RFP) or invitation for bid (IFB), selecting the delivery strategy, and managing the procurement process. The second category is those owner costs incurred after the contract award, to include contract administration, field inspections, responding to requests for information (RFIs), and managing disputes.

At least three attempts have been made to capture, either qualitatively or quantitatively, transaction costs of construction owners. Li et al. (2013) developed structural equation models from a survey of construction owners in which owners estimated the impacts of various actions on transaction costs. According to their findings, owners can minimize their own transaction costs through factors such as adopting integrated project delivery methods and agreeing to share certain risks normally assumed entirely by the contractor. Lam and Gale (2014a) examined transaction costs in the context of a United Kingdom framework agreement. In their case study of 120 county highway repair projects, framework agreement projects yielded a significant reduction in total transaction costs compared to one-off projects by the same owner. Finally, Whittington (2012) captured transaction costs in a case study comparison between a design-build project and a design-bid-build project. She found that both projects had similar total costs—the sum of transaction and production cost—at completion. However, the costs were distributed differently between various categories of transaction and production costs.

CHALLENGES OF MEASURING TRANSACTION COSTS OF CONSTRUCTION CONTRACTS

As previously noted, differing project delivery strategies are likely to impact transaction costs. Yet, only a limited number of studies have measured or quantified the impact of delivery strategies on owner transaction costs. There are at least three possible reasons for such a lack of evidence.

First, economists have primarily used TCE for evaluating the "make or buy" decision, not necessarily for evaluating owner process efficiency. (This difference is reflected in the two bodies of construction literature described above). Should a company make a product (or offer a service) itself? Or should it outsource to another firm? Or should it select some mix of the two? Each option has its transaction and production costs, the sum of which will help determine the best option. In the case of construction project strategies, the basic "make or buy" decision has already been made for all but the simplest of construction projects. Owners typically want to focus on their core mission, not running their own construction companies. In this case, TCE would be helpful for examining different "mixed" options on the continuum between markets and hierarchies rather than at the extremes.

Second, not every owner organization tracks their transaction costs by project, which in a construction context would primarily be the personnel costs associated with developing, procuring, and monitoring the contract. The previously cited examples where transaction costs were directly measured involved access to the owner's personnel databases (Lam and Gale 2014a; Whittington 2012). This is likely the best means of evaluating transaction costs of a contracted construction project, but is not always available.

Third, in the case of the public sector, owner personnel costs are typically funded from a different budget than production costs (i.e. capital construction costs). Transaction cost economics suggests that the best course of action is the one that minimizes the sum of production and transaction costs, but those two sources of money are rarely combined in government accounting of construction spending. Therefore, saving on transaction costs would not necessarily lead to savings directly attributable to the project.

To summarize, the previous sections have highlighted the need for determining owner transaction costs and the challenges of doing so. In light of these challenges, estimating owner transaction costs requires a methodological approach that can examine complex systems, accommodate uncertainty, and examine process sensitivity to input variables. As a result, the authors chose to investigate simulation modeling as a method that can address these requirements. The remainder of this paper addresses the question: How can simulation modeling techniques be employed to estimate owner transaction costs of contracted construction projects?

ESTIMATING TRANSACTION COSTS THROUGH SIMULATION MODELING

Literature cites three major paradigms for simulation modeling, as summarized in Table 1: discrete event simulation; system dynamics; and agent-based modeling. The following sections describe and evaluate each approach for their potential to estimate transaction costs in a construction contracting context.

Table 1. Simulation Modeling Paradigms (adapted from Behdani 2012; Borshchev and Filippov 2004; Brailsford and Hilton 2001)

Approach	Discrete Event Simulation	System Dynamics	Agent Based Modeling
Level of modeling	System/process at a detailed level	System at a relatively general/abstract level	Agents/entities at a detailed level
Treatment of Time	Discrete	Continuous	Discrete
Driver of simulation model	Event occurrence or completion	Feedback loops	Agent decisions and interactions
Behavior of model entities	Passive behavior	Not modeled	Active behavior; agents interact with each other
System/process structure	Fixed by the model creator	Fixed by the model creator	Not fixed, developed by the activity of the agents
Typical purposes	Decisions: Comparison of alternatives, optimization, prediction	Policy making: understanding of complex system interactions	Understand emergent phenomena

Discrete Event Simulation Modeling

Discrete event simulation (DES) analyzes processes that contain easily separable, or discrete, steps. The simulation driver is the completion of a step in the process, combined with the availability of necessary resources, which automatically triggers the next step in the process. Most DES software can conduct deterministic or probabilistic analyses, depending on the variability of input data. Discrete event simulation is most often used as a tool for comparing alternatives and optimizing processes, particularly as a preliminary step to reduce risk before implementing a new process (Laguna and Marklund 2013).

Discrete event simulation is perhaps the most common of the three paradigms for simulating processes, particularly in the business and healthcare sectors (Jun et al. 1999; Laguna and Marklund 2013). For example, the repetitive processes of examining how a manufactured component moves through a production line or how a patient is admitted to an urgent care clinic lend themselves to easily identifiable, discrete steps. Discrete event simulation has also been employed on numerous studies using industry-specific software (Hajjar and AbouRizk 2002; Halpin 1977; Martinez 2010), often related to modeling a construction process like earthmoving. Particularly relevant to this study, East et al. (2009) used DES to model a government construction owner's process of responding to bid inquiries.

Therefore, DES could be a suitable approach for this research effort since the steps in the subject process are easily identifiable. Having a simulation technique designed to inform decision making and predict outcomes would also be desirable. DES could also prove advantageous in handling the uncertainty associated with estimating transaction costs. The data used for this model will likely be more probabilistic in nature, due to the methods of data collection further described below.

On the other hand, the potential level of uncertainty in the data set for this DES could yield a large variance in estimated transaction costs, such that a final comparison between contract methods could prove fruitless. As with other methods mentioned below, DES would also have to address the specifics of the organization being studied, potentially limiting its value to other owner organizations.

System Dynamics

System dynamics is a second simulation approach, built on the seminal work of Forrester (1961) in the 1950's for understanding and improving industrial processes. In comparison to DES which is driven by completion of tasks in discrete steps, system dynamics models are continuous processes driven by balancing and reinforcing feedback loops. System dynamics establishes relationships between its components in the form of differential equations, which enable simulation to occur through incremental units of time. System dynamics is well suited for simulating highly complex processes with non-linear relationships. It is often applied at a more abstract level than DES, in order to inform broad policy decisions rather than optimization of individual process steps (Borshchev and Filippov 2004).

Numerous studies have applied system dynamics to the field of project management, including construction project management as summarized by Lyneis and Ford (2007). For example, Taylor and Ford (2008) used system dynamics to model and assess policy decisions related to complex construction projects. More relevant to this study, Ogunlana et al. (1998) created a system dynamics model for managing the design process of civil engineering projects. They evaluated the impact of various policies on four interrelated subsystems of the design process, two of which overlap with this study: human resource allocation and project planning.

A system dynamics approach could provide insight into the transaction cost problem by taking a "high level" view of the organization over time. If accurate high-level data on an organization's input and output rates can be obtained (e.g. the number, size, and type of projects executed in a given time period), then a system dynamics model could infer the transaction costs involved over a period of time. Examining the problem over a three to five year period would prove advantageous because certain federal contract forms last up to five years.

However, system dynamics would also have its limitations in estimating transaction costs. System dynamics models require an understanding of how the variables interact in the model, which are defined through differential equations. Such specific relationships may be difficult to define mathematically in this case. For example, to know how long an engineer takes to write a statement of work for a given project may depend on a number of factors, such as the project size and complexity as well as the engineer's workload and experience.

Agent Based Modeling

Agent based simulation modeling is the newest of the three simulation paradigms, developed largely since the 1990s. Agent based modeling starts by defining the behavior of individual "agents" (e.g. people, firms) within a system, and then examines how the agents interact and what outcomes they produce. In contrast to the pre-defined systems (or processes) that are modeled in DES and system dynamics, agent based models are decentralized meaning global system behavior is undefined when creating the model. Agents are assumed to be autonomous, adaptive, and heterogeneous. These models are often used for understanding the emergent phenomena from a group of interacting individuals (Behdani 2012; Borshchev and Filippov 2004).

Several scholars have applied agent based modeling to the construction industry. Among those more relevant to this study, the Virtual Design Team platform (Jin and Levitt 1996) simulates the behavior of agents in project organizations, enabling analysis of the relationships between organizational structure, team dynamics, and project performance. Xue et al. (2005) developed a multi-agent framework for coordinating construction supply chains. Furthermore, Du and El-Gafy

(2012) developed a new agent-based framework, VOICE, for exploring "how construction performance emerges from microlevel construction processes and work-related behaviors."

Agent based modeling could provide indirect insights into transaction costs by simulating the behavior of owner project managers, inspectors, contract administrators, and other parties involved the construction contracting process. Such models might be able to explain qualitatively how different behaviors, experience levels, or skills contribute to differing outcomes of the process. This approach could, for example, help explain why one organization might have higher transaction costs than another for similar projects.

However, in the context of the current goal to estimate transaction costs of an owner organization, agent based modeling would likely yield limited insight into the quantitative outcomes like transaction costs associated with completed projects. Additionally, agent based modeling is designed for modeling individual behaviors, assuming that the resulting system of interactions is not well defined. In this case, the process of managing a contract, while filled with complexities, does largely follow a prescribed process in most organizations. As a result of these limitations, the remainder of the paper focuses on organizational analysis in support of the other two methods, discrete event simulation and system dynamics.

ORGANIZATIONAL ANALYSIS FOR SIMULATION MODELS

To ensure the creation of a valid simulation model, the model developer must consider the type of organizational analysis as well as the type and quality of available data. Table 2 describes two possible approaches for data collection and organizational analysis for this study along with the potential benefits and challenges of each. In either case, the model will require validation of model components and results with the involved parties.

"Top-Down" System Analysis

The first option is to capture details about the amount and type of construction executed by an owner agency over a given time period. This would involve a top-down analysis of the organization, looking at the total volume of work executed in a given year (or five years) and the size of staff devoted to the task. As described above, this approach could lend itself to system dynamics modeling, which tends to abstract systems at a higher level.

The advantage of this method is the necessary data could potentially be collected from the right manager(s), which is less intrusive than the bottom-up approach described below. A top-down approach could also offer an increased ability to capture the up-front costs of developing long term, multi-project task-order contracts. This initial investment of owner resources is only worthwhile if there's a payback in efficiency over the life of the contract. This method could potentially identify the payback period for given organizational workloads.

The disadvantage of this method is that it requires discerning the amount of owner resources devoted to specific contract types. If the owner has dedicated staffs devoted to each type of contract, a comparable analysis is relatively straightforward. If however, the same staff simultaneously manages both types of contracts, discerning the amount of time devoted to each may be more difficult. Additionally, a top down approach would provide less detail into the source of transaction costs.

Table 2. Organizational Analysis Approaches

Type of Organizational Analysis	Benefits	Challenges
"Top-down" system analysis: examine process inputs and outputs over a period of time; infer the costs involved	• Potentially less burdensome on owner staff • Capture up-front costs of task-order contracts	• May be difficult to sort out resource allocation by contract/delivery type over 1-5 years • Lack of detail on source of transaction costs

"Bottom-up" process analysis: examine transaction costs at each step in the process and calculate the sum	• Obtain quantitative range (stochastic approach) of transaction costs for an organization • Can translate worker time into costs relatively easily	• Potentially intrusive on project staff • Based on perceptions/ memory of those involved at each step • Could involve high levels of uncertainty

"Bottom Up" Process Analysis

Another approach entails a step-by-step analysis of organizational processes to estimate their transaction costs by office or person. This could include mapping out the process and then estimating the amount of resources devoted to each step in the process. Obtaining estimates would either involve direct observations or interviews with key personnel involved in the process. This approach lends itself to DES modeling.

The advantage of this method is that is provides more granularity than relying on a single source of top-level information as the above methods do. This method would also likely incorporate a stochastic approach to data collection, soliciting e.g. best, worst, and average durations for tasks. A major disadvantage includes the time period available for data collection versus the time involved in project procurements. The process of developing and administering a contract often takes several years. The limitation of relying on people's memories or rough estimates of their time allocation also remains.

CONCLUSIONS

In the absence of reliable owner data capturing transaction costs, simulation modeling offers a means to estimate these costs retrospectively. To date, the challenges of measuring these costs have largely limited inclusion of transaction costs into project estimates or decision making processes about which delivery, procurement or contract forms to use. Examining the major paradigms for simulation modeling revealed two possible approaches for quantifying owner transaction costs of contracted construction projects. A top-down analysis of the owner's contract development and monitoring processes could enable development of a system dynamics model. A bottom-up analysis of the owner's step-by-step processes lends itself to a DES model.

Developing and examining either or both of these models will enable further research into the impact of various construction contract methods on public owner transaction costs. The next step will be to analyze the processes of a large public construction owner, develop the appropriate model depending on the type of data available, and analyze the results. As a part of a larger research effort, these results will be incorporated into a decision support tool for public owners to select appropriate project delivery strategies in order to optimize allocation of both human and financial resources.

See previous list of integrated references.

B. Listing of Requests for Proposal Used for Content Analysis (Chapter 2)

Solicitation	Date of Solicitation	Owner Organization	Single or Multiple Award	Contract Capacity (Millions)
10-0002	26-Feb-2010	Dept of Treasury	multiple	$ 30
10-0004	5-Mar-2010	Dept of Treasury	multiple	not stated
HQ0034-10-R-0025	25-Jun-2010	Dept of Defense--Other	multiple	$ 30
FA4407-10-R-0009	7-Jul-2010	Dept of Defense--USAF	multiple	$ 40
W91238-10-R-0046	9-Jul-2010	Dept of Defense--Army	single	$ 15
W912DY-10-R-0005	22-Sep-2010	Dept of Defense--Army	multiple	$ 585
GS-03P-10-DX-D-0049	25-Oct-2010	General Services Administration	multiple	$ 75
W9126G11R0054	26-Oct-2010	Dept of Defense--Army	multiple	$ 100
W9126G11R0057	26-Oct-2010	Dept of Defense--Army	multiple	$ 405
W912LA-11-R-0001	4-Nov-2010	Dept of Defense--Army	multiple	$ 20
FA4486-10-R-0016	22-Dec-2010	Dept of Defense--USAF	single	$ 25
W9126G-11-R-0052	19-Jan-2011	Dept of Defense--Army	multiple	$ 495
W912GB-11-R-0028	17-Feb-2011	Dept of Defense--Army	single	$ 30
W912DY-11-R-0002	29-Mar-2011	Dept of Defense--Army	multiple	$ 65
GS-07P-07-HHD-0096Oc	3-May-2011	General Services Administration	multiple	$ 20
W9126G11R0056	26-May-2011	Dept of Defense--Army	multiple	$ 495
FA3089-11-R-0011	30-Jun-2011	Dept of Defense--USAF	multiple	$ 100
VA26211RP0082	14-Jul-2011	Dept of Veterans Affairs	multiple	$ 400
W9124X-11-R-0004	15-Aug-2011	Dept of Defense--Army	multiple	$ 20
GS-03P-11-DX-D-0022	30-Aug-2011	General Services Administration	multiple	not stated
NIHOF2011367	29-Sep-2011	Dept of Health Human Services	multiple	$ 800
N6945011R0778	30-Sep-2011	Dept of Defense--Navy	multiple	$ 95
W912HP-12-R-0002	12-Dec-2011	Dept of Defense--Army	multiple	$ 49
W912PQ-12-R-0011	9-Feb-2012	Dept of Defense--USAF	multiple	$ 20
VA24711RP0205	16-Feb-2012	Dept of Veterans Affairs	multiple	$ 50
W912BV-12-R-0031	13-Mar-2012	Dept of Defense--Army	single	$ 25
VA244-12-R-0029	10-Apr-2012	Dept of Veterans Affairs	multiple	$ 30
FA5000-12-R-0001	18-Apr-2012	Dept of Defense--USAF	single	$ 100
W912BV-12-R-0027	19-Apr-2012	Dept of Defense--Army	single	$ 10
VA260-12-R-0353	11-May-2012	Dept of Veterans Affairs	multiple	$ 50
SB1341-12-RP-0009	18-May-2012	Dept of Commerce	multiple	$ 50
VA25612R0053	13-Jun-2012	Dept of Veterans Affairs	single	$ 25
FA5004-12-R-C004	15-Jun-2012	Dept of Defense--USAF	single	$ 10
FA3089-12-R-0002	25-Jul-2012	Dept of Defense--USAF	single	$ 7
AG-7604-S-12-0020	25-Jul-2012	Dept of Agriculture	multiple	$ 11
W9126G-12-R-0043	22-Aug-2012	Dept of Defense--Army	multiple	$ 140
N62473-12-R-2805	24-Aug-2012	Dept of Defense--Navy	single	$ 8
FA4686-12-R-0006	30-Aug-2012	Dept of Defense--USAF	single	$ 15
W912DW-12-R-0041	11-Oct-2012	Dept of Defense--Army	single	$ 30
VA25612R0259	12-Dec-2012	Dept of Veterans Affairs	multiple	$ 25
saqmma12r0098	13-Dec-2012	Dept of State	multiple	$ 2,500
VA24413R0010	17-Dec-2012	Dept of Veterans Affairs	multiple	$ 30
VA257-12-R-1472	28-Dec-2012	Dept of Veterans Affairs	multiple	$ 40
W9126G-13-R-0017	26-Feb-2013	Dept of Defense--Army	multiple	$ 49
W912HN-13-R-0008	6-Mar-2013	Dept of Defense--Army	multiple	$ 49
DTFH68-13-R-00002	14-Mar-2013	Dept of Transportation	multiple	$ 35
W912L3-13-R-0001	28-Mar-2013	Dept of Defense--Army	multiple	$ 10
GS-03P-13-CD-D-0018	10-Apr-2013	General Services Administration	multiple	$ 30
W9126G-13-R-0084	19-Apr-2013	Dept of Defense--Army	single	$ 24
SOL-623-13-000014	1-May-2013	US Agency for Intl Development	multiple	$ 210
W912DR-13-R-0033	3-May-2013	Dept of Defense--Army	single	$ 49
W9126G-13-R-0089	10-May-2013	Dept of Defense--Army	multiple	$ 64
FA4801-12-R-0005	14-May-2013	Dept of Defense--USAF	single	$ 45
FA4830-12-R-0004	10-Jun-2013	Dept of Defense--USAF	multiple	$ 225
FA4484-13-R-0005	26-Jun-2013	Dept of Defense--USAF	multiple	$ 10
FA4803-13-R-0005	25-Jul-2013	Dept of Defense--USAF	multiple	$ 150
HSFE50-13-R-0010	6-Aug-2013	Dept of Homeland Security	multiple	$ 39
N62473-13-R-3011	20-Sep-2013	Dept of Defense--Navy	multiple	$ 99
W912CN-14-R-0002	16-Oct-2013	Dept of Defense--Army	multiple	$ 20

GS-07P-13-HH-D-0057	24-Oct-2013	General Services Administration	multiple	$ 13
N40085-14-R-0004	6-Nov-2013	Dept of Defense--Navy	multiple	not stated
W912NS-14-R-0001	12-Nov-2013	Dept of Defense--Army	multiple	$ 20
N33191-14-R-1005	5-Dec-2013	Dept of Defense--Navy	multiple	$ 48
N62473-14-R-2201	11-Dec-2013	Dept of Defense--Navy	single	$ 25
N4008514R8103	11-Dec-2013	Dept of Defense--Navy	multiple	$ 95
N39430-14-R-1405	29-Jan-2014	Dept of Defense--Navy	multiple	$ 800
GS-07P-13-HH-D-0063	13-Feb-2014	General Services Administration	multiple	$ 10
W911KB-14-R-0027	25-Feb-2014	Dept of Defense--Army	multiple	$ 48
N62473-14-R-0004	6-Mar-2014	Dept of Defense--Navy	multiple	$ 99
DJF-14-2100-PR-0006101	26-Mar-2014	Dept of Justice	multiple	$ 500
N40084-14-R-0102	11-Apr-2014	Dept of Defense--Navy	multiple	$ 45
GS-07P-14-HH-D-0006	24-Apr-2014	General Services Administration	multiple	$ 15
FA4620-14-R-B001	24-Apr-2014	Dept of Defense--USAF	multiple	$ 25
N69450-14-R-0761	6-May-2014	Dept of Defense--Navy	single	$ 20
NNC14ZFD020J	13-May-2014	NASA	multiple	$ 250
N40083-14-R-3213	27-May-2014	Dept of Defense--Navy	multiple	$ 15
FA4484-14-R-0006	30-May-2014	Dept of Defense--USAF	multiple	$ 28
N4008514R8138	6-Jun-2014	Dept of Defense--Navy	multiple	$ 95
VA24514R0101	10-Jun-2014	Dept of Veterans Affairs	multiple	$ 150
FA5685-14-R-0013	13-Jun-2014	Dept of Defense--USAF	multiple	$ 45
N44255-14-R-9010	24-Jun-2014	Dept of Defense--Navy	single	$ 75
SB1341-14-RP-0046	30-Jun-2014	Dept of Commerce	multiple	$ 50
FA2823-14-R-4019	16-Jul-2014	Dept of Defense--USAF	single	$ 45
VA25114R0126	8-Aug-2014	Dept of Veterans Affairs	multiple	$ 150
W912GB-14-R-0030	2-Sep-2014	Dept of Defense--Army	multiple	$ 250
GS-04P-14-EZ-D-0006	17-Sep-2014	General Services Administration	multiple	$ 25
FA5270-14-R-0019	21-Nov-2014	Dept of Defense--USAF	multiple	$ 96
DE-SOL-0005473	25-Nov-2014	Dept of Energy	multiple	$ 9
N44255-14-R-9022	5-Dec-2014	Dept of Defense--Navy	multiple	$ 99
FQ14111/MDG	16-Dec-2014	Washington Metro Area Transit	multiple	$ 45

C. R Code for Statistical Analysis (Chapter 3)

General Linear Model with Poisson Family

```
##### HII Data: General Linear Model (GLM) -- Bid Count Model

# Libraries
library(lolcat)
library(car)

### Import Data, Create Variables, Initial Visuals-------------------------------------

milcon = read.delim("filename", na.strings="-999")
milcon = milcon[,-(1),drop=FALSE]
milcon = milcon[,-(2:6),drop=FALSE]
milcon = milcon[,-(6),drop=FALSE]
#milcon=subset(milcon, BidCount<=8) #if only want to model 8 or less
milcon=na.omit(milcon)

milcon$FQ[milcon$FQ == 2]=1  # only 4th quarter showed difference; consolidate FQ 1-3
milcon$FQ[milcon$FQ == 3]=1
milcon$FQ[milcon$FQ == 4]=1
milcon$FQ[milcon$FQ == 5]=4
summary(milcon$FQ)

## Ind Variables
milcon$FQ=as.factor(milcon$FQ)
milcon$AwardFY=as.factor(milcon$AwardFY)
milcon$AllSmall=as.factor(milcon$AllSmall)
milcon$Duration=milcon$Duration / 100
milcon$SF = milcon$SF /10000
milcon$PANorm = milcon$PANorm / 10000000
milcon$SPI = milcon$SPI / 1000

# If Transforming, do it here
#milcon$BidCount=milcon$BidCount ^ 0.072
# end transforming

### Initial Descriptives ---------------------------------
summary.continuous(milcon)

boxplot(milcon$BidCount)
hist(milcon$BidCount,breaks=25) #breaks=25 for full set

par(mfrow=c(2,2))
boxplot(BidCount~Contract, data=milcon, main="Contract Type")
```

```
boxplot(BidCount~Delivery, data=milcon, main="Delivery")
boxplot(BidCount~AwardFY, data=milcon, main="Award FY")
boxplot(BidCount~FQ, data=milcon, main="FQ")
boxplot(BidCount~AllSmall, data=milcon, main="Small Bus")
boxplot(BidCount~ConstrType,data=milcon, main="Construction Type")
plot(BidCount~SF, data=milcon, main="SF/10000")
plot(BidCount~SPI, data=milcon, main="SPI/1000")
plot(BidCount~PANorm, data=milcon, main="Budget/$1M")
plot(BidCount~Duration, data=milcon, main="Duration/100")


### Pick "best" model ------------------------------------

## Fit initially using all factors and all data points
#family=Gamma(link="inverse")
#family=Gamma(link="log")
#family=gaussian(link="inverse")
#family=gaussian(link="log")
#family=gaussian(link="identity")
family=poisson
lambda=sum(milcon$BidCount) / length(milcon$BidCount) # distribution parameters
qpois(0.5,lambda=lambda)  # median of the distribution
y.pois = qpois(0.5,milcon$BidCount, log.p=FALSE)

#milcon=na.omit(milcon) # only if you want to omit entire entries with an NA

#lmo=glm(qpois(0.5,milcon$BidCount) ~ Contract * Delivery +  FQ + AwardFY
 #            + ConstrType + AllSmall + SF +
  #             PANorm + Duration + SPI , data=milcon, family=family)
lmo=glm(qBidCount ~ Contract * Delivery +  FQ + AwardFY
      + ConstrType + AllSmall + SF +
        PANorm + Duration + SPI , data=milcon, family=family)
summary(lmo)

## Backward Selection
library(MASS)
backward.lmo=stepAIC(lmo)

## Forward Selection
(null <- (glm(BidCount ~ 1, family=family, data = milcon)))
(full <- lmo)
(lmo.forward <- step(null, direction="forward"
               , scope = list(upper=full)))
summary(lmo.forward)

## Stepwise "Both"
```

```
(lmo.stepwise <- step(full, direction="both"))
summary(lmo.stepwise)

## All subsets
# can't use for glm like this

## bestglm--have to put Y at far right of data frame
library(bestglm)
Xy=milcon[,2:12]
Xy=cbind(Xy,milcon$BidCount)
best=bestglm(Xy,family=family,IC="AIC",TopModels=5,method="exhaustive",intercept=TR
UE)
best$Subsets

## compare the various models and pick "best" model

### refit the model using only those factors needed--------------------
## rebuild dataframe if needed

milcon2=milcon
Y=milcon2$BidCount

bestmodel=glm(BidCount ~ Contract + Delivery + AllSmall + SF + PANorm,
data=milcon2,family=family)
#bestmodel=glm(BidCount ~ Contract * Delivery + AllSmall + SPI + FQ,
data=milcon2,family=family)
summary(bestmodel)


### GLM Diagnostics----------------------------------------
dev.off()
plot(bestmodel)

#marginalModelPlots(bestmodel, id.n=4)    # Ignoring plots
#residualPlots(bestmodel)

## VIF if needed
vif(bestmodel)

## Check p-values on Pearson and Deviance for fit
# Pearson
pearson=sum(residuals(bestmodel, type = "pearson")^2)
(pvalue = 1-pchisq(pearson,bestmodel$df.residual))
# Deviance
(pvalue = 1-pchisq(bestmodel$dev,bestmodel$df.residual))
```

```
## Assess residuals
ei=residuals(bestmodel)
eSi=rstandard(bestmodel)
eTi=rstudent(bestmodel)
res.all=data.frame(cbind(ei, eSi, eTi))
scatterplotMatrix(~ ei + eSi + eTi)
cor(res.all)


## Check residuals for linearity--do this a little different for a GLM:
plot(predict(bestmodel, type="response"), residuals(bestmodel, type= "deviance"))
print(sum(eTi^2)) # SS of residuals

plot(bestmodel$fitted.values ~ Y, xlim=c(0,8),ylim=c(0,8)) #set limits depending on data
subset used

## Homoscedasticity
spreadLevelPlot(bestmodel)
#ncvtest requires lm object

## Normality
# see residual plots above too

qqnorm(eTi)
qqline(eTi)

# The actual statistics for normality
res.all=data.frame(cbind(ei, eSi, eTi))
library(lolcat)
summary.all.variables(res.all)


## Influence
library(car)
influenceIndexPlot(bestmodel)
influencePlot(bestmodel,id.n=5)

### Assess how deviance is affected-----------------------------
dev=bestmodel$deviance
ndev=bestmodel$null.deviance
pseudor2 = 1 - (dev/ndev)

library(MASS)
(myshape <- gamma.shape(bestmodel))
gampred <- predict(bestmodel , type = "response", se = T, dispersion = 1/myshape$alpha)
summary(bestmodel, dispersion = 1/myshape$alpha)
```

```
milcon3=na.omit(milcon2)
plot(gampred$fit,milcon3$BidCount)#, xlim=c(0,9),ylim=c(0,9))
(r2=(cor(gampred$fit,milcon3$BidCount))^2)

## Model fit----------------------------
Yest=bestmodel$fitted.values
r=cor(Y,Yest)
(r2=r^2)
(rmse=mean(((Y-Yest)/sd(Y))^2))

#avg.pct.error=mean(100*Yest/Y)

## k-fold Cross Validation----------------------------------
# Set up function for RMSE and R
nsim = 500        # to run 500 simulations
rmseskill = 1:nsim
corskill=1:nsim
N=length(Y)
N10 = round(0.10*N)    #drop 10% of points
index=1:N
X1=milcon2[,2:11]
for(i in 1:nsim){
  drop=sample(c(1:N),N10)
  keep=setdiff(index,drop)

  # defining x and y for remaining 90%
  x=X1[keep,]
  y=Y[keep]
  zz=glm(y ~ x$Contract * x$Delivery + x$AllSmall + x$Duration +
         x$SPI + x$FQ  + x$SF + x$PANorm,family=family)
  # fitting the model to 90%, use glm function if needed

  #redefine x for 10% that were dropped
  x = X1[drop,]
  yhat=predict(zz,newdata=data.frame(x)) # predicting on remaining 10%

  # compute rmse and R value (correlation)
  rmseskill[i]=mean(((Y[drop]-yhat)/sd(Y[drop]))^2)
  corskill[i]=cor(Y[drop],yhat)
}


R_squared=corskill^2  # get R^2

## Plot skill results--boxplots
par(mfrow=c(1,2))
```

```
boxplot(rmseskill,xlab="K-fold CV",ylab="RMSE", ylim=c(0,5))
points(rmse,col="red",pch=19,bg="red") #add model rmse
boxplot(R_squared,xlab="K-fold CV",ylab="R^2", ylim=c(0,1.0))
points(r2,col="red",pch=19,bg="red") #add model r^2

mean(R_squared)
sd(R_squared)
mean(rmseskill)
sd(rmseskill)

### Explore Interaction -------------
summary.impl(BidCount ~ Contract + Delivery, data=milcon2, stat.n = T,stat.mean = T,
stat.var = T)
#par(mfrow=c(1,1))
dev.off() # reset plot
interaction.plot (x.factor = milcon2$Contract, trace.factor = milcon2$Delivery, response =
milcon2$BidCount)
```

Multinomial Logistic Regression Model

```
########### Multinomial Logistic Regresssion for Bidders and Bid Ratios
########### HII Data, 804 data points when maxing out at 8 bidders

# Prep utilities
#options(show.signif.stars=FALSE)
options(tibble.print_max=Inf)    # Makes it so you can see a whole data frame
# Libraries
library(lolcat)
library(car)

### Import Data, Create Variables, Initial Visuals-------------------------------------
milcon = read.delim("filename", na="-999")

milcon$FQ[milcon$FQ == 2]=1
milcon$FQ[milcon$FQ == 3]=1
milcon$FQ[milcon$FQ == 4]=1
milcon$FQ[milcon$FQ == 5]=4
summary(milcon$FQ)

#make factors
milcon$FQ=as.factor(milcon$FQ)
milcon$AwardFY=as.factor(milcon$AwardFY)
milcon$AllSmall=as.factor(milcon$AllSmall)
milcon$BidCountmax8=as.factor(milcon$BidCountmax8)
milcon$BidCount35max8=as.factor(milcon$BidCount35max8)
milcon$BidCountGroup14max8=as.factor(milcon$BidCountGroup14max8)
```

```
milcon$BidCount35=as.factor(milcon$BidCount35)
milcon$BidCountGroup14=as.factor(milcon$BidCountGroup14)
milcon$Duration=as.numeric(milcon$Duration / 100)
milcon$SF = milcon$SF / 1000
milcon$PANorm = milcon$PANorm / 1000000
milcon$SPI = milcon$SPI / 1000

milcon2=milcon[,-(1:3),drop=FALSE]

## For multinomial
milcon2=milcon2[,-(2:5),drop=FALSE]


### Descriptives and explore data--------------------------------------------
summary.continuous(milcon2)
scatterplotMatrix(milcon2[,9:13],span = 0.8) # cont variables only
round.object(cor(milcon2[,9:13]),4)

## Examine DV
#(milcon2$BidCountGroup)
par(mfrow=c(2,2))
plot(BidCountGroup~Contract, data=milcon, main="Contract Type")
plot(BidCountGroup~Delivery, data=milcon, main="Delivery")
plot(BidCountGroup~AwardFY, data=milcon, main="Award FY")
plot(BidCountGroup~FQ, data=milcon, main="FQ")
plot(BidCountGroup~AllSmall, data=milcon, main="Small Bus")
plot(BidCountGroup~ConstrType,data=milcon, main="Construction Type")
plot(BidCountGroup~SF, data=milcon, main="SF/10000")
plot(BidCountGroup~SPI, data=milcon, main="SPI/1000")
plot(BidCountGroup~PANorm, data=milcon, main="Budget/$1M")
plot(BidCountGroup~Duration, data=milcon, main="Duration/100")

## Multicollinearity analysis
# Build full model first
# Base on ordinal data for simlicity, not categorical

lmo0 = lm(BidCount ~ Contract + Delivery + AwardFY + FQ +
        Facility + AllSmall + ConstrType + Duration + SF +
        PANorm + SPI + ACF, data=milcon)
summary(lmo0)
vif(lmo0)

### For "base" multinomial---------------------------------------------------
#Dep variable
milcon2=na.omit(milcon2)
#Y=milcon2$BidCountGroup
```

```
library(nnet)
lmo=multinom(BidCountGroup ~ Contract + Delivery + Facility + FQ + AwardFY
             + ConstrType + AllSmall +  SF +
              PANorm + Duration + SPI, data=milcon2)
summary(lmo)
Anova(lmo)


### Select model ------------
## StepAIC  # backwards unless otherwise specified
library(MASS)
N = log(length(milcon2$BidCountGroup))
lmo.backward=stepAIC(lmo,k=N)

## Forward Selection
(null <- (multinom(BidCountGroup ~ 1, data = milcon2)))
(full <- lmo)
(lmo.forward <- step(null, direction="forward"
           , scope = list(upper=full)))
summary(lmo.forward)
Anova(lmo.forward)

## Stepwise "Both"
(lmo.stepwise <- step(full, direction="both"))
summary(lmo.stepwise)
Anova(lmo.stepwise)

## All subsets
library(leaps)
all.subsets <- regsubsets(BidCountGroup ~ Contract + Delivery
              + FQ + AwardFY  +  AllSmall +  SF +
               PANorm + Duration + SPI,
              data=milcon2, method="exhaustive")
(sum.all.subsets <-summary(all.subsets))
plot(all.subsets, scale="Cp",main = "Cp")

### Choose "best" model-------------------------
bestmodel=multinom(BidCountGroup ~ Delivery + Contract + AllSmall  + SPI,
data=milcon2, Hess=T)
summary(bestmodel)
z <- summary(bestmodel)$coefficients/summary(bestmodel)$standard.errors
p <- (1 - pnorm(abs(z), 0, 1))*2
p

# or
```

```
Anova(bestmodel)

### Check model significance---------------
library(lmtest)
lrtest(bestmodel)

### Check predictive capability----------------------------

#ypred = predict(zy, type = "probs")
ypred=predict(bestmodel,type="probs")

# Empirical probabilities
N=length(milcon2$BidCountGroup)
p1 <- length(milcon2$BidCountGroup[milcon2$BidCountGroup == "Low"])/N
p2 <- length(milcon2$BidCountGroup[milcon2$BidCountGroup == "Target"])/N
p3 <- length(milcon2$BidCountGroup[milcon2$BidCountGroup == "High"])/N

# RPSS of models
probs <- c(p1, p2, p3)
library(verification)
rpss.full=rps(milcon2$BidCountGroup, ypred, baseline=probs)$rpss
rpss.full
```

D. Project Manager Questionnaire (Chapter 4)

Project Performance Questionnaire v.1

Purpose: The University of Colorado Boulder is conducting a survey of construction projects to investigate the role of project delivery methods, contracting terms, team behavior and front-end planning in project success. Please help us by completing the survey for the identified project below. The questionnaire should take about 20 minutes to complete.

Confidentiality: The project information you provide will be kept in strict confidentiality, within a password protected database. Only the primary investigators and their research assistants will see and have access to your information. In the event of a publication or presentation based on the results of this study, no personally identifiable information will be shared.

Participation: Your decision to participate in this research is voluntary and you may withdraw at any time. There is no direct compensation. Participants may request a copy of the final reports. If you have any questions, please contact Lt Col Scott Stanford at 609-752-2135 or matthew.stanford@colorado.edu.

Instructions: The next tab has a questionnaire related to a specific project. Several fields on this questionnaire are provided from existing databases, shown in grey. We ask you to "double check" these fields for reasonableness, and identify any discrepancies that stand out. If you have more accurate information than what is provided, please unhighlight the cell and provide corrections. In the orange cells, we are asking for additional information, not available in the database. Please provide your best assessment based on your knowledge of the project.

To summarize:

1. On the next tab, please check provided data in grey cells. If 'ok', leave as-is. If you recognize an error, please unhighlight the cell and make corrections.
2. Please provide requested data in orange cells.

Project Performance Questionnaire v.1

I. Programming Information

Please indicate over which phase(s) of the project you served as the project ☐ Planning ☐ Design ☐ Construction

Please confirm information provided below for the specified project. making corrections where necessary. ***Please unhighlight field if a change is made.***

1. Project Name:	BASE LOGISTICS FACILITY			2. Project #:	FTEV043016
3. Installation:	HURLBURT FIELD	4. MAJCOM:	AFSOC	5. Prog. Amount:	$ 24,000,000.00
6. Contract Mod Amt:	$ 1,133,465	7. Funded FY:	2011	8. Final Cost:	$ 19,303,167.67
9. Scope (SF)	155,054	10. Cat Code	442758	11. Delivery:	Design-Bid-Build

Please provide information for the fields in orange.

12. Approximate % breakdown of scope (by cost or schedule)--should total to 100% ____ % New construction ____ % Repair/ renovation ____ % Demo / Other

13. Special features--check all that apply ☐ SCIF/high security ☐ Deep foundations ☐ Advanced tech or comm. systems ☐ Special elec/ power ☐ Other (specify):

14. Was this project funded by Congressional insert? ☐ Yes ☐ No

15. Type of mission supported by this project? ☐ New Mission ☐ Existing Mission

II. Design

Please provide the following information about the contracted or agency design, to include designs primarily completed in-house by USACE or NAVFAC. For Design-Build projects, please provide any contracted design information completed PRIOR to the primary design-build contract.

1. Design Start:	13-Feb-09	5. Formal value engineering review?	☐ Yes ☐ No
2. Design Complete:	31-Aug-10	6. Use of BIM in design (select all that apply):	☐ BIM Not used
3. Design Firm Name:	STOA Architects	☐ Conceptual Design ☐ Arch/structural systems	☐ MEP systems ☐ Other
4. Design Cost:	$ 1,983,477.63	7. Use of standardized design (select one):	(click to select best option)

III. Procurement

1. Advertise Date:	22-Sep-10	7. Num. of bid options awarded (if any)?	4
2. Award Date:	6-Jun-11	7a. Approx. value of bid options awarded:	$ 1,138,450
3. Contract Type:	IDIQ	8. Did first soliciation "bust bids"?	☐ Yes ☐ No
4. Contract No.:	W9127807D00370002	9. Was there a bid protest?	☐ Yes ☐ No
5. # Bids Received	5	10. Did project require reprogramming?	☐ Yes ☐ No
6. Level of design development when RFP reached 100%:	(click here for options)	11. If yes to Q8, Q9, or Q10, please provide a brief description.	(enter text here)

11. Can you provide the Solicitation document (portion of RFP with Instructions to Bidders and Evaluation Criteria)? ☐ Yes ☐ No

Note: We are only requesting the primary solicitation document, which usually includes SF 1442 and "Division 00" instructions. We are NOT requesting drawings, full sets of specs, or other supporting documentation.

If full RFP provided, skip to the next section. Please attach RFP document (instructions to bidders/evaluation criteria only) to email response.

12. Source Selection Method:	(click to select best option)	14. Formal partnering used?	☐ Yes ☐ No
13. Set Aside Type (if any):	(click to select best option)		

IV. Construction

1. Prime contractor	Sauer Incorporated	7. Was this, or any, construction contract terminated prematurely on this project?	☐ Yes ☐ No
2. Construction start	19-Jul-11		
3. Construction complete	28-Mar-14	8. Was the Prime construction contract suspended at any point?	☐ Yes ☐ No
4. ACES Cost Growth	7%	9. Did this contract involve a show-cause or cure-notice letter?	☐ Yes ☐ No
5. ACES Schedule Growth	47%	10. If yes, to Q7, Q8, or Q9, please briefly explain.	(enter text here)
6. Number of modifications	51		

V. Other Information

1. Please rate this project **in comparison to other projects you have managed** (1=below average, 6=above average).

	Below average		*Average*	*Above Average*	
	1	2	3	4	5
Design complexity *[Above average = multiple unique design features or unusual engineering req'ts]*	☐	☐	☐	☐	☐
Construction complexity *[Above average = multiple unusual issues related to materials/methods for contractor]*	☐	☐	☐	☐	☐
Site/security access for contractor(s) *[Above average=easier access]*	☐	☐	☐	☐	☐
Adequacy of project definition in the programming documents	☐	☐	☐	☐	☐
Competitiveness of local bidding environment during bid stage *[Above average = more competitive]*	☐	☐	☐	☐	☐
Administrative burden for you as the project manager	☐	☐	☐	☐	☐
Your overall satisfaction with the project from start to finish	☐	☐	☐	☐	☐

2. To what extent, if any, did **changes in mission or user requirements** affect cost and schedule during the following stages? “Negative impact” means changes required additional time or cost; “positive impact” means changes resulted in time or cost savings. “Major” means the change, by itself, exceeded contingency funding and/or float in the schedule. “Moderate” means that the change, by itself, was accommodated through contingency funding and/or float in the schedule. “Minor” means the changes created greater/lesser administrative burden for PMs but no impact on cost or schedule.

	Negative			No such changes	Positive		
Timing of change	Major	Moderate	Minor		Minor	Moderate	Major
Planning and early design (≤30% design complete)	☐	☐	☐	☐	☐	☐	☐
Late design (>30% design complete)	☐	☐	☐	☐	☐	☐	☐
Procurement stage	☐	☐	☐	☐	☐	☐	☐
Early construction (1-50% complete)	☐	☐	☐	☐	☐	☐	☐
Late construction (51-100% complete)	☐	☐	☐	☐	☐	☐	☐

2a. For any "major" or "moderate" responses, please provide brief description of change(s) and whether mission or user driven. (click here to enter text)

3 . Please rate your personal level of interaction with the following parties PRIOR to this project.

a. I have worked with this Air Force DM/CM prior to this project.	☐ Yes	☐ No
b. I have worked with representatives at this installation prior to this project.	☐ Yes	☐ No

4. Please rate the project team in the following areas (use drop downs).

All responses are confidential; individual responses are not shared with anyone but the principal investigators. (See 1st Tab).

	AE	GC or DB	User	Base Engr.
Responsiveness of communication (Poor to Excellent)	click for drop down	click for drop down	click for drop down	click for drop down
Timeliness of deliverables (Poor to Excellent)	click for drop down	click for drop down	click for drop down	click for drop down
Commitment to shared project goals (Not at all to Extremely)	click for drop down	click for drop down	click for drop down	click for drop down
Willingness to compromise to achieve project goals (Never to Frequently)	click for drop down	click for drop down	click for drop down	click for drop down

5. During design or construction, was initial project scope altered *specifically to meet budget and/or schedule requirements* ? (This might include cutting or adding features to the building or supporting facilities. Do not include bid options awarded with initial contract here.) ☐ Yes ☐ No

6. Were parties in this project subject to any litigation or legal proceedings? ☐ Yes ☐ No

7. If “Yes” to Q5 or Q6, please provide a brief explanation. Provide any other relevant comments here as well.

Click here to enter text.

V. Key Personnel

Please provide contact information for key personnel involved in the project. Please include any other AF PM’s that managed the project as well.

Role	Organization	Office/District	Name	Contact info (Phone/Email)
Design Manager/Construction Manager				
Construction Agent				
Design Agent (if different from CA)				
Other DM/CMs				