NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL PROJECT

INVESTIGATING THE RELATIONSHIP BETWEEN THE INDEPENDENT GOVERNMENT COST ESTIMATE AND ACTUAL CONTRACT COSTS FOR KNOWLEDGE-BASED SERVICE CONTRACTS

December 2020

By: **Charles B. Wilson**
Nathaniel T. Buck

Advisor: **Rene G. Rendon**
Co-Advisor: **Marcus A. Ballard**

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2020	**3. REPORT TYPE AND DATES COVERED** MBA Professional Project

4. TITLE AND SUBTITLE INVESTIGATING THE RELATIONSHIP BETWEEN THE INDEPENDENT GOVERNMENT COST ESTIMATE AND ACTUAL CONTRACT COSTS FOR KNOWLEDGE-BASED SERVICE CONTRACTS	**5. FUNDING NUMBERS**
6. AUTHOR(S) Charles B. Wilson and Nathaniel T. Buck	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

The DoD remains on the Government Accountability Office's (GAO) High-Risk List for contract management, and the DoD Inspector General (DoD IG) declared that DoD contract management is a top ten management challenge. One of the significant causes to acquisition program risks is cost overruns, which can be mitigated by establishing an accurate and reliable independent government cost estimate (IGCE). Although the IGCE provides a baseline for contract cost, many DoD acquisition professionals believe that the IGCE has little to no value in determining the actual contract cost. However, per the DoD's Independent Government Cost Estimate Handbook for Services Acquisitions, the IGCE serves as the best estimate of a contract's potential costs and is an essential factor in awarding and administering service contracts. Using multiple linear regression and correlation techniques, this study aimed to identify the relationship between IGCE and actual contract costs and how other procurement variables affect that relationship. One of the key findings was IGCE has a strong relationship to and is a good predictor of actual contract costs. Additionally, this relationship is affected when additional explanatory variables are introduced to the model. Overall, this study deepened our understanding of the relationship between the IGCE and actual contract costs, providing insight into the need for accurate and reliable cost estimates for government contracting.

14. SUBJECT TERMS Independent Government Cost Estimate, IGCE, performance variables, actual contract costs	**15. NUMBER OF PAGES** 75
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release. Distribution is unlimited.

INVESTIGATING THE RELATIONSHIP BETWEEN THE INDEPENDENT GOVERNMENT COST ESTIMATE AND ACTUAL CONTRACT COSTS FOR KNOWLEDGE-BASED SERVICE CONTRACTS

Charles B. Wilson, First Lieutenant, United States Air Force
Nathaniel T. Buck, Captain, United States Air Force

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
December 2020

Approved by: Rene G. Rendon
Advisor

Marcus A. Ballard
Co-Advisor

Rene G. Rendon
Academic Associate, Graduate School of Defense Management

THIS PAGE INTENTIONALLY LEFT BLANK

INVESTIGATING THE RELATIONSHIP BETWEEN THE INDEPENDENT GOVERNMENT COST ESTIMATE AND ACTUAL CONTRACT COSTS FOR KNOWLEDGE-BASED SERVICE CONTRACTS

ABSTRACT

The DoD remains on the Government Accountability Office's (GAO) High-Risk List for contract management, and the DoD Inspector General (DoD IG) declared that DoD contract management is a top ten management challenge. One of the significant causes to acquisition program risks is cost overruns, which can be mitigated by establishing an accurate and reliable independent government cost estimate (IGCE). Although the IGCE provides a baseline for contract cost, many DoD acquisition professionals believe that the IGCE has little to no value in determining the actual contract cost. However, per the DoD's Independent Government Cost Estimate Handbook for Services Acquisitions, the IGCE serves as the best estimate of a contract's potential costs and is an essential factor in awarding and administering service contracts. Using multiple linear regression and correlation techniques, this study aimed to identify the relationship between IGCE and actual contract costs and how other procurement variables affect that relationship. One of the key findings was IGCE has a strong relationship to and is a good predictor of actual contract costs. Additionally, this relationship is affected when additional explanatory variables are introduced to the model. Overall, this study deepened our understanding of the relationship between the IGCE and actual contract costs, providing insight into the need for accurate and reliable cost estimates for government contracting.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ANCOVA	analysis of covariance
AWF	acquisition workforce
CPARS	Contractor Performance Assessment Reporting System
CMBOK	*Contract Management Body of Knowledge*
DIB	Defense Industrial Base
DoD	Department of Defense
DoN	Department of the Navy
FY	fiscal year
IDIQ	Indefinite Delivery/Indefinite Quantity
IGCE	Independent Government Cost Estimate
KBS	Knowledge-Based Services
MFT	Multifunctional Team
LPTA	Lowest-Price Technically Acceptable
MANCOVA	multivariate analysis of covariance
NAVWAR	Naval Information Warfare Systems Command
NCMA	National Contract Management Association
PALT	Procurement Acquisition Lead Time
PWS	Performance Work Statement
SAT	Simplified Acquisition Threshold
SME	subject matter expert
SOW	statement of work
SPAWAR	Space and Naval Warfare Systems Command

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

First, I would like to offer praise to my God Almighty for the peace and grace He bestowed upon me during this research. Without Him, this accomplishment would not be possible, and I give thanks for that.

My greatest appreciation goes to my family—my beautiful wife, Brittney, and my lovely, energetic, sons, Jude and Jonah—for their love, support, and patience during this academic tenure. My educational journey has come with many challenges, yet you have provided your confidence and joy energizing me throughout this process. We were faced with many trials during this turbulent time, but we have grown together and developed an even stronger bond. I am proud to be a part of something so magical.

I would also like to thank NAVWAR Headquarters and staff for assisting us with our data collection. Without your enthusiastic support, we would not have been able to complete this project.

Finally, I would like to share my gratitude for our advisors, Dr. Rene G. Rendon, Lt Col, USAF (Ret), and Dr. Marcus "Alan" Ballard. Your guidance and professionalism are valued. Thank you for accepting our project and challenging us along the way.

—Byron Wilson

First, I would like to thank the love of my life, Blair, and our two beautiful children, Caden and Isla. You have been my motivation and support throughout this journey. You have endured the long hours and stress just as much as I have. This accomplishment was a team effort, and I could not ask for a better team.

Second, I would like to thank my teammate on this project, Byron. I have learned so much from you during this process. You are articulate, intelligent, and a fantastic leader. I cannot wait for our paths to cross in the future. We did it!

Third, I want to thank our cohort. The professionalism of this group is unmatched and so impressive. I cannot wait to see where you all go in your careers. Specifically, to

the SOCC, this year was one of the hardest of my life, and you guys made this year one to remember. I will cherish your support for the rest of my life.

Lastly, I want to thank our advisors, Dr. Ballard and Dr. Rendon. Your mentorship and guidance throughout our MBA project have been invaluable. We have learned a ton from you and wish you luck in your future endeavors.

—Nate Buck

I. INTRODUCTION

In this chapter, we provide an overview of the conducted research, including a background of the problem and the purpose of the study. Additionally, we examine our research questions and describe the research benefits and limitations. Finally, we discuss the organization of this paper, followed by a summary of the chapter.

A. BACKGROUND

The U.S. Department of Defense (DoD) has long struggled with cost overruns in major acquisition programs (Gideon & Wasek, 2015). Researchers have attempted to identify the cause of these overruns, but the numerous independent variables involved make this a difficult task. Additionally, the DoD remains on the Government Accountability Office's (GAO) High-Risk List for contract management, and the DoD Inspector General (DoD IG) declared that DoD contract management is a top 10 management challenge. The DoD has made some contract management improvements in services acquisitions since 2017, via strong leadership support, but continues to face challenges with requirements definitions, acquisition strategies, and budgets (GAO, 2019). The GAO (2019) provided several recommendations that may improve this high-risk area, including that the DoD needs to "establish milestones … to include projected spending on services in its future-years defense programs" (p. 11). Adhering to this customary recommendation becomes complex when program requirements evolve ex post (post-award), stifling the overarching goal of resource stability and mission effectiveness.

To manage federal contracting more effectively, in 1992, the GAO added DoD Contract Management to the High-Risk List, where it has remained ever since. The DoD experiences difficulties in defining, strategically managing, and budgeting for contracted services, which consistently account for approximately $150 billion—half of the Department's annual obligations (GAO, 2019). The GAO (2019) identified several critical skills gaps, including DoD contract management staffing challenges, that is, the inability to recruit talent for acquisition management. The DoD contract and acquisition

leaders must address challenges within the acquisition workforce, services acquisitions, and operational contract support to circumvent the GAO's high-risk list. The DoD has made progress in some of these areas but still needs improvement overall. It is also essential to consider the DoD's increased weapons systems acquisition investments, which cost an estimated $1.66 trillion to develop and procure 86 major defense acquisition programs (GAO, 2019). Coupling the increasingly complex, highly technical systems requirements with the reduced size of the skilled acquisition workforce makes for a potential challenge for effective contract negotiation and management, "falling short of cost, schedule, and performance goals" (GAO, 2019, p. 143). Subsequently, the DoD will pay more, buy less, and deliver fewer warfighter capabilities than expected.

Furthermore, acquisition and contract management are within the top 10 management challenges in the DoD Inspector General's (IG) report in 2020, due in part to cost overruns. According to the DoD IG (2019), "Acquisition and contract management have been high-risk areas for the DoD for many years, and the DoD and Congress have sought to improve the acquisitions of major weapon systems" (p. 112). As the DoD seeks to implement acquisition reform, many programs will fail to meet schedule, cost, and performance goals. The DoD has found enduring issues with DoD contract pricing due to the lack of available cost data, which results in contracting officers awarding bad deals that provide exorbitant profits to the contractor. "Contracting officers need to obtain the information to ensure that the DoD gets the best price for the warfighter" (DoD IG, 2019, p. 118). The DoD IG (2019) report also echoes the major systems acquisition challenges associated with requirement complexity. The DoD lacks consistency in precise requirements definition, which regularly results in cost overruns. An acquisition program's overarching goal is to deliver a capability that meets the warfighter's need, on time, at or below the budgeted price. The DoD has frequently exceeded program budgets and established timelines due to inadequate requirements development and contractor oversight.

The DoD has long relied on contractor support to provide many goods and services, including weapons systems, modernization and maintenance, and operational support. Historically, the DoD obligates more contract dollars than all the other

government agencies combined. As reported by the Moshe Schwartz and the Congressional Research Service (2018), in fiscal year (FY) 2017, the DoD spent $380 billion on contracts, roughly 63% of the total government spending of $507 billion. The same report noted that services contracts accounted for 41% of the complete contract spend for the DoD in FY17. Concurrently, declining budgets and increased national security concerns posed by China, Iran, North Korea, and other states confront U.S. leadership with challenging decisions concerning force posture and supply security within the U.S. defense industrial base (DIB). Without the DIB support, the United States would struggle to maintain a competitive advantage militarily (Watts, 2013). There is a reliance on defense contractors and a mandate to "deliver, on a timely basis, the best value product or service to the customer, while maintaining the public's trust and fulfilling public policy objectives" (FAR 1.102(a)). These issues force contracting organizations to do due diligence, ensuring that each acquisition provides goods and services at a fair and reasonable price.

The root causes of significant acquisition program correlated risks, according to Gideon and Wasek (2015), are within one of four categories: programmatic/business, technical, schedule, and cost. Instead of focusing on the causes of the cost overruns, this research examines the relationship between the Independent Government Cost Estimate (IGCE) and the actual cost of products and services procured by the U.S. government, specifically the DoD. This research focuses on the relationship between IGCEs and actual contract costs and how that relationship is affected by other procurement variables. With the fiscal constraints that the DoD is consistently subject to and the substantial amount of resources allocated to this organization, the DoD is responsible for ensuring that the government is getting maximum value from its services contracts. The DoD views a service contract's value from three lenses: cost, schedule, and performance (Cooley & Ruhm, 2014). The DoD's measurement tool for a service contract's cost is the IGCE, which generates an overall assessment of the product or service's cost a contractor provides to the government. As Ipsaro (2011) noted, "A credible IGCE will result in the avoidance of, or mitigation against, major risks and adverse consequences improving the probability of acquisition and program management success" (p. 50).

B. PROBLEM STATEMENT

The problem addressed in this research is the disparity between estimated contract cost, contract award amount, and actual contract cost upon completion. Naval Information Warfare Systems Command (NAVWAR) acquisition professionals have come to expect the IGCE to be significantly higher than the proposal and subsequent contract award. Additionally, they have observed that the actual contract costs are much closer to the IGCE than the award amount. This delta between estimated and actual costs causes budgeting issues and inefficiencies between the distinct programs for which NAVWAR is responsible. Overall, a study of the relationship between these different costs and how they affect each other provides insight into the need for accurate IGCEs in government contracting and the best practices for generating them.

C. PURPOSE STATEMENT

The purpose of our research is to understand the relationship between the IGCE and actual contract costs and how other procurement variables, such as contract award amount, number of modifications, and contractor business size affect this relationship. Understanding these relationships will potentially help contracting organizations gain the best value for the taxpayer dollar by structuring contracts that result in increased capability while obtaining the estimated cost, schedule, and performance thresholds.

D. RESEARCH QUESTIONS

The following questions are the basis for our research:

1. What is the relationship between IGCEs and actual contract costs?
2. How do the following procurement variables affect that relationship?
    - Contract award amount
    - Number of modifications
    - Business size

E. BENEFITS AND LIMITATIONS

This research provides DoD and U.S. Navy acquisition professionals with insight and awareness of the importance and validity of IGCEs and how they relate to actual contract costs and contractor performance. Additionally, this research provides awareness of the effects of other procurement variables (source selection method, award fees, contract award amount, business size) on the relationship between IGCEs (procurement variable) and actual costs and contractor performance (performance variables). Overall, this research provides perspective leading to streamlined acquisitions and contracts that provide goods and services at the best value to the government and, in turn, to the taxpayer.

There are multiple limitations to this research that could hinder its application to the DoD as an enterprise-wide solution. First, the data comes from one source, NAVWAR, during a 5-year window (2014−2019), limiting the research scope to one contracting organization in a specific military branch and excluding many relevant contracts outside of our time frame. Secondly, the contract data utilized for analysis is derived only from knowledge-based services contracts, narrowing the scope of research to a specific set of government requirements, and not providing a holistic analysis of other contract data. Lastly, similar studies will need to be conducted in other government organizations and their contracting offices to gain a more comprehensive analysis of the problem.

F. SCOPE AND ORGANIZATION

This report is organized into six chapters, including this introductory chapter. The second chapter of this report contains a literature review of the applicable contract management frameworks, reviews contract management standards and applicable policy and guidance, and examines previous research on procurement variables and their relationships and effects on associated performance variables. The third chapter provides background information for Department of the Navy (DoN) and NAVWAR acquisitions, including its mission, contract portfolio, and IGCE procedures and guidance. The fourth chapter presents the methodology used to obtain and analyze the

data. Next, the fifth chapter contains our analysis results, including a discussion of whether the results and findings answer the research questions and the implications of the findings. Lastly, the final chapter provides a summary of the research conducted for this paper, a conclusion of the results, and offers areas of further research.

G. SUMMARY

This chapter discussed the background and purpose of our research, and it outlined the questions this report seeks to answer. This chapter also discussed the benefits and limitations of our research to provide context to this complex problem and provided the report's organization as an overview of our research.

II. LITERATURE REVIEW

A. INTRODUCTION

The purpose of this literature review is to explicate the relationship between the IGCE and the actual contract costs, along with how other procurement variables, such as business size, product service code, contract award amount, and the number of modifications, affect this relationship. It begins with an overview of the agency and auditability theories, then discusses the *Contract Management Body of Knowledge* (CMBOK), the DoD *IGCE Handbook for Services Acquisition*, and previous research conducted in this area of study, concluding with a summary of the discussion. Our industry partners tend to know more about the products and services they sell, and the costs associated; the government knows less about the costs, therefore yielding asymmetrical information. The government establishes a cost estimate to reduce information asymmetry. Acquisition professionals can use Agency Theory to mitigate information asymmetry, specifically adverse selection, as discussed in the next section.

B. AGENCY THEORY

In principal–agent relationships, especially when involved in complex contracts with higher uncertainty levels, the government, and the contractor's available information is commonly asymmetrical (Rendon, 2015). The government will most likely have more information regarding the agency's specific needs. In comparison, the contractor may have more information on market trends and costs of products and services. The combination of existing conflicting objectives and information asymmetry causes increased complexity in contract negotiations (Rendon, 2015). Agency theory suggests that agencies can overcome information asymmetry by adopting the appropriate means to select contractors (to prevent adverse selection) and monitor contractor performance (to prevent moral hazard). "Adverse selection refers to the misrepresentation of ability by the agent" (Eisenhardt, 1989, p. 61). For example, the agent may include in the proposal that they have the expertise necessary to meet the requirement needs when, in fact, they lack the essential skills.

Additionally, a moral hazard is when the principal cannot determine whether the agent behaves appropriately during contract performance (Eisenhardt, 1989). The government can use the government estimate to resolve these problems.

According to agency theory, conflicting objectives and asymmetrical information drive perfunctory behavior, causing cost risks in a contract. Thus, government agencies must provide incentives to promote consummate behavior and guidelines to prevent perfunctory behavior, pay attention to detail, and display vigor in establishing the IGCE to overcome these concerns. Second, agency theory explains the relationship between a principal and an agent (Eisenhardt, 1989). In the context of this research, the principal (government) enters into a relationship (contract) with an agent (contractor) to perform a task on the principal's behalf. This relationship is complicated as both parties have conflicting objectives. Monczka et al. (2016) proposed that the government's objectives "include obtaining the product or service at the right quality, right quantity, right source, right time, and right price … procured in accordance with public policy and statutory requirements" (Rendon, 2015, p. 1483). This research is most concerned with the right price, attempting to discover how the IGCE affects the actual contract cost. Contractors, conducting business as the agents, are more interested in increasing profits, gaining market share, promoting company growth, and improving cash flow (Rendon, 2015). These objectives should be managed appropriately and sustained to ensure a long-term contract relationship that results in a win-win. Ex post and ex ante contract success depend on quality market research and accurate IGCEs. It is essential that the government do its due diligence when conducting market research and ultimately establish the IGCE.

Additionally, government agencies must complete thorough market research and cost estimation to minimize the asymmetrical information and lower the associated cost risks. In addition to conflicting objectives, asymmetrical information fortifies the principal–agent relationship complexity. In higher-risk contracts, there is an elevated level of uncertainty, information asymmetry, and conflict of interests (King & Sekerka, 2017). This higher level of uncertainty encourages risk aversion in both the principal and agent and urges both parties to gain competitive advantages that meet self-interests. On

the one hand, the government attempts to satisfy the requirement's owner, military leaders, and the public while attempting to obtain a fair and reasonable price. Therefore, it must depend on ex ante activities to grasp an enhanced understanding of the associated procurement costs and utilize adept market research to establish an IGCE that will positively predict the requirement's actual contract costs. However, since contractors are privy to this information, they may exploit the asymmetric information to achieve and maximize organizational and personal objectives depending on the number of uncertainties. As a result, the government's ex ante and ex-post procurement success depend on quality market research and an accurate IGCE.

Agency Theory states that contracting agencies must obtain additional information and mitigate adverse selection and moral hazard problems. Quality market research and accurate IGCEs are sources of information that can combat these problems. However, the DoD we must have competent people, capable processes, and effective internal controls to succeed in this endeavor. These elements come from Auditability Theory, as discussed in the next section.

C. AUDITABILITY THEORY

For organizations to be successful, they must have competent people, capable processes, and effective internal controls. The variance found between the IGCE and actual contract cost could be due to a lack of competent people, incapable processes, and lack of internal controls. Today, public and private organizations are increasingly concerned with governance and analysis within their business processes and practices (Rendon & Rendon, 2016). Because of this, organizations are underscoring the ability to audit such components, establishing some form of accountability. Consequently, as referenced by Rendon and Rendon (2016), Powers stated that organizations are transforming by introducing data collection methodology and documentation systems to establish auditability of the processes and practices. Additionally, Rendon and Rendon (2016) stated that auditability encompasses segments of governance that include competent people, capable processes, and effective internal controls, which, combined, construct the auditability triangle, as shown in Figure 1.

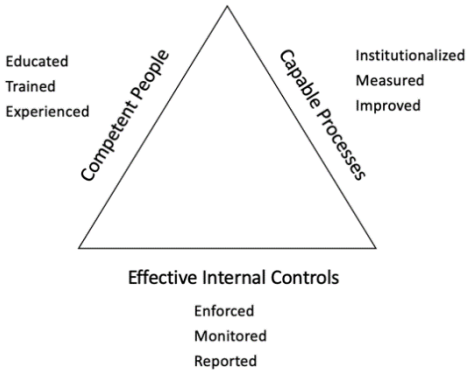

Figure 1. Auditability Triangle. Source: Adapted from Rendon and Rendon (2016).

1. Competent People

One of the components of Auditability Theory is *competent people*. This refers to people within an organization who are educated, trained, and experienced. Organizations determine what type of education, training, and experience level personnel need to be successful. Within the DoD, specifically in contract management, Defense Acquisition Workforce Improvement Act (DAWIA) requirements are used to determine personnel education, training, and experience levels required for organizational and personnel success.

Rendon and Rendon (2016) defined *competent personnel* as follows:

> The competent personnel component refers to the education, training and experience of the DoD contracting officers performing contract management activities. The required education, training and experience standards of DoD contracting officers are mandated by the DAWIA federal statute, which was established in 1990. DAWIA requires members of the DoD contracting workforce to have earned a college degree with courses in business administration, completed training courses in contract management and have experience within the contracting profession. (p. 754)

Competent personnel are essential in this study, as the relationship between the evaluated variables may be due to personnel incompetence and the inability to execute an IGCE properly. An acquisition professional's competence is foundational to an accurate cost estimate. The career's fluidity requires contracting professionals to be

abreast of the constantly changing policies, procedures, and guidance that affect everyday business. As the executive vice president and counsel of the Professional Services Council stated, “Successful acquisition programs depend on a highly trained, highly skilled workforce in the government and the support contractors, especially for complex technology and professional services contracts” (Bublé, 2019, p. 2). To address some of the managerial and technical skill gaps in government procurement, the DoD must reevaluate and restructure education and training programs. Although government procurement professionals must be educated, trained, and experienced, the individual’s competence cannot be the sole focus. There must also be an emphasis on the organization’s competence through capable processes (Rendon & Rendon, 2016).

2. Capable Processes

Another Auditability Theory component is capable processes. For an organization to be successful, processes must be institutionalized, measured, and improved. Organizations determine what processes need to be performed to ensure organizational success. Within the DoD, specifically in contract management, processes are institutionalized, measured, and improved within the three contract phases: pre-award, award, and post-award as defined in the CMBOK discussed later.

Rendon and Rendon (2016) defined *capable processes* as follows:

> The capable process component of auditability reflects DoD contract management processes and related activities performed by the contracting workforce. Contracting processes are typically discussed in terms of the contracting life cycle, which include pre-award, award and post-award processes. (p. 754)

Without clear IGCE guidance and methodologies, acquisition agencies may be missing out on the full benefit of this vital acquisition tool (GAO, 2017). Organizational processes must be institutionalized as they set the intellectual and innovative boundaries of an organization. Without capable processes and a mechanism to measure progress, an organization cannot achieve its maximum potential of cost estimation and procurement success. Regulation and bureaucracy heavily burden government procurement by making contracting professionals’ jobs more challenging and cumbersome. Top officials

support the DoD's acquisition endeavor to cut some of this red tape by delegating contracting authority to contracting agencies and combatant commanders (Williams, 2020). Therefore, it is imperative to continuously improve these processes, molding them to meet the mission's flexibility. Contracting organizations must have processes to optimize and effectively exercise this authority in processes throughout the contracting life cycle (pre-award, award, and post-award). Furthermore, these established processes must be institutionalized, measurable, and continuously improved to meet the requirements owners' ever-changing demands and ultimately, to meet the needs of the warfighter (Rendon & Rendon, 2016). In addition to competent people and capable processes, organizations must also have effective internal controls.

3. Effective Internal Controls

The last component of Auditability Theory is effective internal controls. Effective internal controls are enforced, monitored, and reported. Organizations know which internal controls are needed to ensure that personnel, and the organization as a whole, are in compliance with policy, procedure, laws, and regulations. Effective internal controls are especially important within the DoD, specifically in contract management, as non-compliance with the multitude of contract policies can lead to mission failure.

Rendon and Rendon (2016) defined *effective internal* controls as follows:

> The effective internal controls component of auditability refers to the objectives of enforcing internal control policies to ensure compliance with laws and regulations, monitoring procedures to assess enforcement and reporting any material weaknesses. (p. 754)

DoD IG (2015) found material weaknesses in internal controls over financial reporting that could lead to the lack of management oversight and material misstatement prevention in financial statements. The same report stated that without effective internal controls, the management systems that the DoD relies upon could be compromised (DoD IG, 2015). According to federal internal control standards, the GAO (2017) stated, acquisition agencies should provide clear guidance in acquisition planning by providing quality information to achieve acquisition objectives. In the same report, the GAO

recommended that agencies revise or clarify guidance to improve the usefulness of IGCEs. An IGCE can furnish effective communication of these objectives; however, if there are no internal controls in place, continuity and consistency of IGCE guidance and procedures can be lost across the enterprise. Internal controls are vital in the DoD's effort to provide an "interoperable and data-centric procurement environment" (Assad & Easton, 2011, p. 1).

The internal controls support government procurement strategic goals by providing accountability, transparency, and integrity to the procurement process. They can also provide a foundation for managing contractor costs by establishing a comprehensive IGCE. Internal controls can be ineffective if procurement personnel are going through the procurement process with an inaccurate IGCE. Although cost estimates are an essential piece of the contract award process and used for negotiations, there has not been much research to support their use. Next, we will be discussing some of the research conducted on IGCE and actual costs.

D. PREVIOUS RESEARCH

The following section provides examples of studies conducted on the relationships between different variables in the procurement process. Some of these variables included contract type, source selection method, and CPARS ratings. An overview of the previous research provides context to the problem and identifies the subject's gaps, allowing this research to illustrate how to fill the gap. Overall, there have been multiple studies and research methods that identify relationships between procurement and performance variables, but the following are especially pertinent to our research focusing on IGCEs.

Multiple studies have analyzed the relationship between procurement variables (IGCEs, contract award amount), and performance variables (CPARS ratings, actual contract cost). One example of such a study conducted by Landale et al. (2017) examined the source selection method's effects on procurement outcomes. Structured similarly to our research, the researchers gathered contract data from 124 DoD contracts. They ran a regression analysis to test the source selection method (procurement variable)

on pertinent procurement outcomes (performance variables). Furthermore, the authors' research began discussing ex ante (pre-award) and ex post (post-award) evaluation of value based on multiple components, including price. The study found that the trade-off (TO) source selection method, number of evaluation factors, and number of proposals received all increase the procurement lead time (PLT). Additionally, the research found TO source selections results in better supplier performance. Overall, the study conducted by Landale et al. (2015) provided a roadmap for our research structure, but the variables examined differ from ours.

Another example of research conducted to understand the relationship between procurement and performance variables was Ban et al. (2017). Their study examined and analyzed the relationship between source selection method and contractor performance. In addition to contractor performance, they looked at the source selection method and its relationship to procurement acquisition lead time (PALT). Much like the study conducted by Landale et al. (2015), these authors used a multiple regression model and multivariate and univariate analysis of covariance (MANCOVA and ANCOVA) techniques to determine contractor performance variance. The procurement variable examined was based on Lowest Price Technically Acceptable (LPTA) and trade-off source selection strategies and their corresponding CPARS ratings. The findings, in this study, also showed that TO source selection procedures may result in more positive contract performance outcomes. Overall, this research provided a proof of concept and the effectiveness of statistical analysis in identifying relationships between procurement and performance variables and how each variable affects another.

Borbath et al. (2018) evaluated contractor performance using an empirical approach. The authors used quantitative measures of contractor performance to improve supplier selection decisions (Borbath et al., 2018). Additionally, the authors conducted data analysis using summary statistics, including mean and standard deviation, to answer their research questions on the technical performance, schedule, and cost regarding contract performance. Furthermore, the authors used summary statistics to conclude the level of correlation between the procurement variables (an obligated dollar amount) and the subsequent performance variable (CPARS ratings). This methodology used by

Borbath et al. (2018) is a guide for the research conducted in this paper. This research focuses on the cost aspect of the contract, as opposed to the performance. It uses a similar model to understand the relationship between IGCEs, actual contract cost, and the number of modifications conducted throughout the performance period. The findings indicate a strong correlation between contractor past and subsequent cost, schedule, and technical performance scores. Overall, using the same methodology will aid in the government's understanding of IGCEs, the importance of their accuracy, and the relationship they have to actual contract cost. This information could drive contracting, budgeting, and cost estimation decisions in the future.

In 2020, the GAO conducted a study on different contract types and how they affect contractor performance and schedule. They "analyzed government contracting data on obligations by contract type for FY 2011 through FY 2019 on contracts in DoD's portfolio of major acquisition programs" (GAO, 2020, p. 2). The GAO did not find a clear relationship between these outcomes and contract types used. However, programs that completed certain knowledge-based acquisition practices generally had better cost and schedule outcomes than programs that did not implement those practices (GAO, 2020). Furthermore, this report's significance to our research reveals that researchers have studied contract type, a procurement variable, and its relationship to cost and schedule in the past. Our research seeks to understand how cost performance and IGCEs relate to actual versus estimated contract costs and to gain a clearer understanding of the disparity between the two. Overall, DoD acquisition professionals across the enterprise recognize a delta between actual and estimated contract costs but have not identified the relational effects they have on each other.

The previous research discussed adds relevant conversation to the CMBOK in terms of relationships between the procurement variables and performance variables. The next section provides an overview of the CMBOK as prescribed by the National Contract Management Association (NCMA).

E. THE CONTRACT MANAGEMENT BODY OF KNOWLEDGE

It is critical to understand the core concepts of contract management to grasp the role of IGCEs in the government procurement process. The most comprehensive and accurate source to understanding contract management's core concepts is the *Contract Management Body of Knowledge* (CMBOK), developed by the NCMA. The CMBOK "explains the seven core competencies that serve as essential building blocks for successful contracting practitioners and leaders" (National Contract Management Association [NCMA], 2020, p. 1).

As outlined in Figure 2, the CMBOK provides seven core competencies critical to individual and organizational success with a central mission of contracting and acquisition. Understanding these roles and responsibilities is imperative when conducting a study on IGCEs, their relationships to contractor performance and overall actual contract cost, and how other procurement variables change those relationships. Furthermore, the CMBOK provides a methodology and mindset for the measurement of success. This is achieved through activities that require direct interaction and in situations where there is no direct contact (i.e., planning) (Contract Management Standard [CMS], 2019, p. 2). The direct and indirect interactions in the contracting process entwine with the IGCE development process.

Figure 2. CMBOK's Seven Core Competencies. Source: NCMA (2019a).

Of the seven core competencies, three are particularly crucial to IGCEs and actual contract cost: (1) pre-award, (2) award, and (3) post-award. These are considered life-cycle phases in the contract management process. The following are explanations and descriptions of these three different phases and their relation to this report's research.

The pre-award competencies cover different areas that are critical to the contract management process. Although they occur at the beginning of the contract management process, these competencies are relevant throughout the contract's life cycle and influence decision-making. Before the contract management process begins, each of the pre-award competencies must be fundamentally understood (CMBOK, 2019, p. 2). The following excerpt from NCMA's *Contract Management Standard* (CMS) publication describes the pre-award phase:

> Pre-Award is the first phase of the contract life cycle. The pre-award process for the buyer includes assisting the customer in defining the requirement. Additionally, the process includes developing a comprehensive plan for fulfilling the requirement in a timely manner at a reasonable price. This is accomplished by developing and executing an overall strategy for the purchase, which is accomplished through researching the marketplace, developing contracting strategies, preparing solicitations, and requesting offers. The pre-award process for the seller includes developing and executing a strategy for obtaining the award for a contract, including pre-sales activities, market strategies, and responding to the solicitation. (2019b, p. 10)

The IGCE is an integral part of the pre-award phase, playing a role in acquisition planning, evaluation of offerors, and determination of price fairness and reasonableness. The pre-award phase of the contracting life cycle begins with acquisition planning. This portion of the acquisition process includes forming the right team to build a requirements package. Subject matter experts (SMEs) of the particular field comprise the requirement's multifunctional team (MFT). This team includes members of the requiring activity, the contracting officer, the comptroller, and legal representatives, to name a few. One crucial piece of the requirements package is the IGCE. In conjunction with the requirement's owner, the contracting officer ensures the requirement is clearly defined in order to estimate the cost of the product or service correctly.

Additionally, the importance of the IGCE cannot be understated because it is used by the contracting officer to determine whether a price in a proposal is fair and reasonable. Furthermore, an IGCE has a pivotal role in the budgeting process by ensuring the requiring activity has the funding to execute a particular contract. Overall, the MFT generates the IGCE during the pre-award phase of the contracting process, and its accuracy is instrumental in the contract's success throughout its life span. Figure 3 is a visual representation and explanation of the use of an IGCE throughout the contracting life cycle.

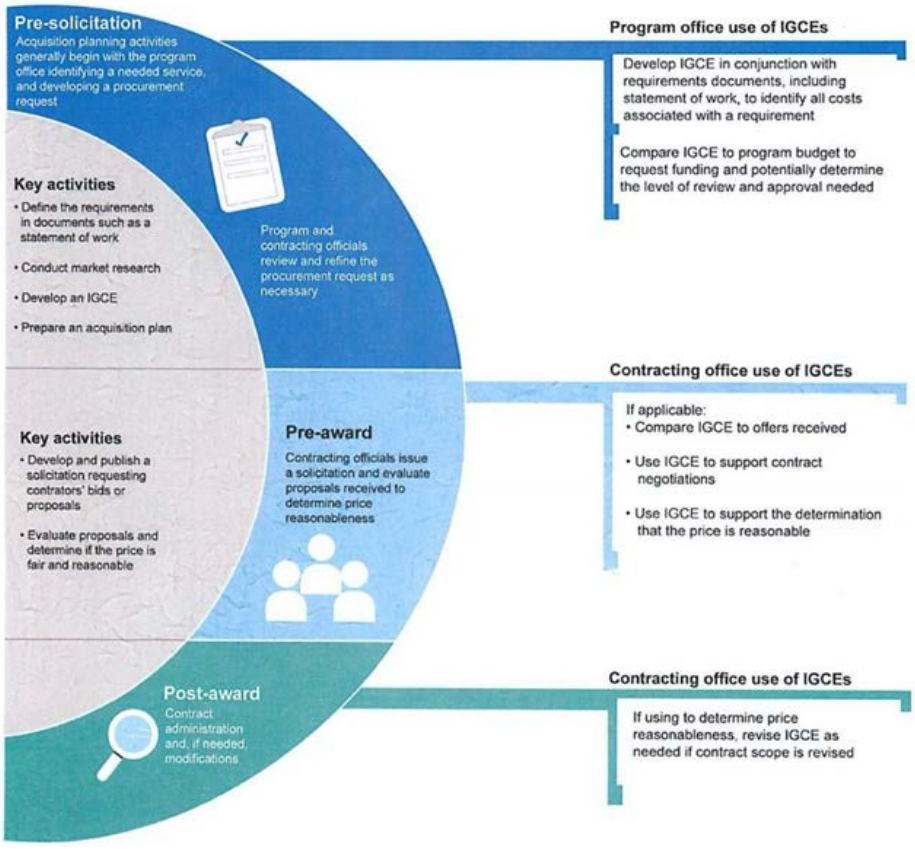

Figure 3. Use of IGCEs in All Phases of the CM Process.
Source: Schwartz et al. (2018).

Once all documentation has been gathered and reviewed, the contracting officer posts a solicitation on the government-wide point of entry, or BetaSAM (Beta.SAM.gov), which allows the government to post a solicitation for goods or services in a public manner to encourage competition and allows each interested party to

have a chance to do business with the government. The contracting officer is now ready to evaluate proposals in preparation for source selection and the award phase.

The IGCE is the document used as a baseline for comparing an offer with the amount that the requirement's owner, in unison with the contracting officer, thinks the government should pay. If there is a large delta between the IGCE and industry offers, the contracting officer and the requirement's owner have to reassess what they are asking for and ensure they have a proper understanding of the costs associated with delivering that requirement. The second phase of the contract life cycle is the award phase. The CMS states, "The award process involves all the work performed by both the buyer and seller that produces an awarded contract. Some contracts are straightforward, and others are exceedingly complex, but the majority fall somewhere in between" (NCMA, 2019b, p. 13).

Once the offers are received, the award process begins. Responsibilities for the buyer (government) include price or cost analysis, evaluating offers, conducting negotiations (as applicable), selecting the source, awarding the contract(s), debriefing offerors, and addressing mistakes in offers and seller challenges to the selection process (NCMAb, 2019). Responsibilities for the seller (contractor) include clarifying offers, participating in negotiations, and preparing final offers (NCMAb, 2019, p. 13). One required criterion for making a contract award is the contracting officer's determination that the offer's price is fair and reasonable. Overall, the IGCE plays a pivotal role in the award process, and its accuracy is essential for success.

When the contract is awarded, the acquisition moves directly into the post-award phase of the contract management process. According to the CMS publication (NCMA, 2019b), the post-award phase involves the following. Post-award contract management functions are known as "contract administration" and "contract closeout." The contract administration functions will vary greatly depending on the complexity of the contract. Both the buyer and seller are actively involved in contract administration to ensure satisfactory performance and bring the contract to a successful conclusion (NCMA, 2019b, p. 16).

Analyzing the IGCE in the post-award phase can reveal multiple observations about the effectiveness of the contract structure established in the pre-award and award phases. While administering the contract in the post-award phase, contracting professionals can look back at the IGCE to determine how accurate the government's expected costs were to the actual finalized contract amount after the performance. Furthermore, the IGCE can be used in the post-award phase to develop lessons learned to estimate the cost of future contracts more accurately. There are many roles and responsibilities that both the buyer and seller must fulfill to ensure the success of the acquisition and ultimately, the integrity of the contracting process. The buyer must conduct some of the tasks effectively by addressing any issues arising during contract performance that might increase performance risk, executing contract modifications, monitoring compliance of contract terms, making payment(s), and closing out the contract (NCMAb, 2019, p. 16). Additionally, the seller has a responsibility to conduct similar tasks: overseeing contract performance, invoicing, engaging in subcontracting activities, managing contract changes, and bringing the contract to a successful conclusion (NCMAb, 2019, p. 16). Overall, the IGCE is a relevant and vital document throughout the three contract management process phases. Because the IGCE is a critical tool for all contract management phases, it is imperative that acquisition workforce leaders provide clear guidance describing how to effectively establish the IGCE. This research, as explained in later sections, will be focusing on services acquisitions. The following section discusses the *DoD IGCE Handbook for Services Acquisition*.

F. DOD IGCE HANDBOOK FOR SERVICES ACQUISITION

The DoD *IGCE Handbook for Services Acquisition* provides fundamental guidance for the DoD's acquisition workforce (AWF), focusing on the cost elements commonly found in the IGCEs of services contract acquisitions. This guide helps explain the purpose and importance of the IGCE. The information and examples provided are at the most basic level, which allows the AWF's least experienced professionals and non-DoD acquisition professionals to understand the IGCE better. Additionally, this handbook provides an appendix of thought-provoking examples that

present a starting point for creating the cost estimate (DoD, 2018, p. 2). Because this handbook is thought of as the government's most transparent and confident source of the contract's potential costs, the DoD AWF must understand how this instrumental tool can be appropriately used during the planning and award phases of services contracts (DoD, 2018). This section provides a discussion of the purpose of IGCE, principles, cost estimation methods, and general best practices, as discussed in the DoD *IGCE Handbook for Services Acquisition*.

The DoD (2018) stated that the IGCE is a cost estimate created by the requirement's owner, based on the performance work statement (PWS) or statement of work (SOW), for all new requirements with anticipated costs above the simplified acquisition threshold (SAT). The IGCE is an essential tool that can assist the DoD AWF in determining the probable cost of a services acquisition and also the reasonableness of an offeror's proposal and understanding of the work to be completed. As shown in Figure 4, IGCE development occurs during the 7-Step Services Acquisition Process requirements definition phase. During this phase, it is imperative that the requirement's MFT has a clear understanding of the requirement and access to prior acquisition history or similar acquisitions, and that the MFT conducts thorough market research that can provide the foundation of IGCE preparation.

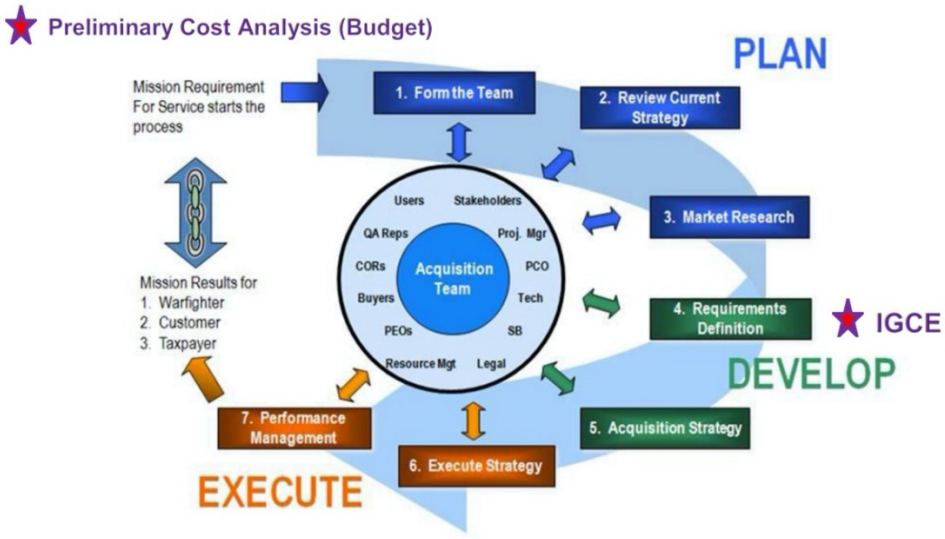

Figure 4. Seven-Step Services Acquisition Process and IGCE. Source: DoD (2018).

The IGCE is used to project and anticipate the probable cost or price of federal acquisitions during all phases of a program, including the life-cycle cost and total operating cost. With no contractor input, agencies use the IGCE to achieve the best value and address contract risk. It is based on market research and can be used to analyze cost and pricing data. The established IGCE is also used to reserve funds during the acquisition planning phase—this can become an issue as an inaccurate IGCE can mean a decreased budget for other programs. When contractors submit proposals to perform these services, there are instances when the proposed prices vary significantly from the IGCE. This variance presents a problem because the contract's negotiated cost may be higher than the IGCE. The program office has to reallocate resources when the awarded contract costs are above the budget reflected by the IGCE.

G. SUMMARY

This chapter discussed the agency and auditability theories, previous research regarding IGCE and actual contract costs, the CMBOK, and the *DoD IGCE Handbook for Services Acquisitions*. Now that the foundation of our research is set, the next chapter provides an overview of the Naval Information Warfare Systems Command (NAVWAR).

III. NAVAL INFORMATION WARFARE SYSTEMS COMMAND (NAVWAR)

A. INTRODUCTION

This chapter lays the foundation for our analysis by providing background information for DoN and NAVWAR acquisitions, including NAVWAR's mission, contract portfolio, and IGCE procedures and guidance. This section provides context to this organization's importance and how effective and efficient contract cost estimation processes and procedures are imperative to mission success.

B. NAVWAR STRUCTURE AND SYSTEMS

NAVWAR is aligned by competency as shown in Figure 5. The eight major competencies are "patterns of skills, knowledge, abilities, behaviors and other characteristics that an individual needs to perform work roles or occupational functions successfully" (NAVWAR, 2020, para. 1). Of these competencies, our study is focused on 2.0 Contracts. The 2.0 Contracts competency provides NAVWAR with contracting officers and support staff, who are responsible for conducting contracting functions for PEOs.

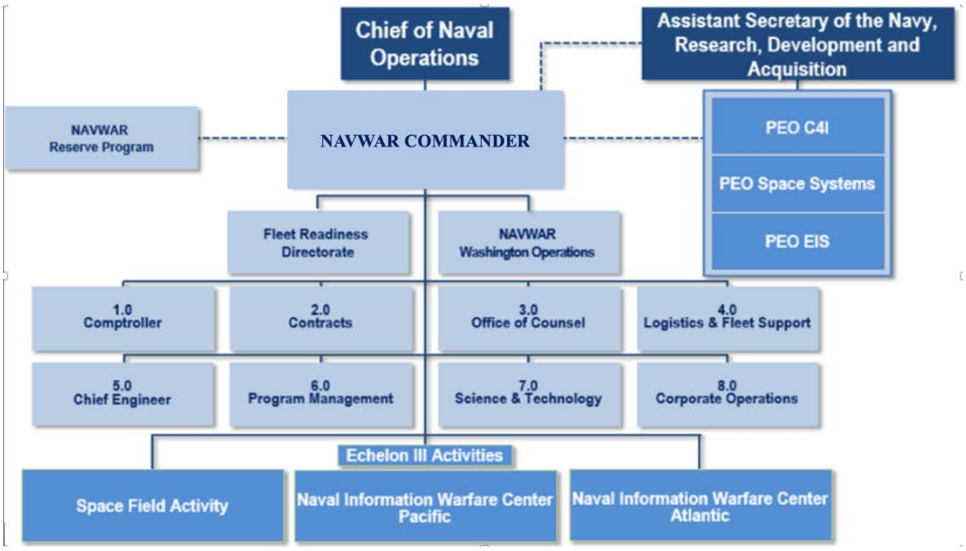

Figure 5. NAVWAR Structure and Systems. Source: NAVWAR (2020).

C. MISSION

NAVWAR changed its name in June 2019 (from Space and Naval Warfare Systems Command, or SPAWAR) to acknowledge the power of information warfare and its impact on global competition (Rosenberg, 2019). NAVWAR (2020) stated, "Over the last decade, information has emerged as a warfighting domain, joining land, sea, and air as a critical, contested battlespace" (para. 3). NAVWAR serves as the Navy's information and technology arm, charged with developing, delivering, and sustaining communications and information warfare capabilities, connecting warfighters to the fight anytime, anywhere. This large, complex organization expands worldwide, employing more than 10,000 active duty and civil service professionals. NAVWAR provides "research and development, systems engineering, testing and evaluation, technical, in-service and support services to the program executive offices (PEOs) during all phases of a program's life cycle" (NAVWAR, 2020, para. 7). Their specialty is computer cybersecurity and many other electronic systems (Graves, 2019).

NAVWAR provides direct support to three Navy PEOs: PEO Command, Control, Communications, Computers and Intelligence (PEO C4I), PEO Enterprise Information Systems (PEO EIS), and PEO Space Systems (NAVWAR, 2020). These PEOs seek to close the naval capability gap by increasing the Navy's "capacity, security, and reliability," and also by "being affordable and on schedule for delivery to the fleet" (NAVWAR, 2020, para. 10). NAVWAR, besides some in-house capabilities, sources a large portion of the work through contracts with various defense contractors. With the extensive contract portfolio and sustained budget for knowledge-based services, the accuracy and integrity of the IGCE become an even more integral part of mission success.

As an organization, NAVWAR spends billions of dollars per year on contracts to support the warfighter. One central area of spend that we are focusing on in this research is services, specifically knowledge-based services. The services with the highest dollar amount obligated at NAVWAR include engineering services (NAICS 541330), with roughly $2.5 billion spent in FY 2018 and computer systems design services (NAICS 541512) with $380 million spent (NAVWAR, 2020). With such a large investment of

taxpayer dollars devoted to services contracts, it is imperative to understand any inefficiencies associated with services procurement and how they can be diminished, or even eliminated. Overall, the magnitude of NAVWAR's contract portfolio, specifically services contracts, further emphasizes the importance of accurate cost estimation processes and procedures.

Our study investigates how small and large businesses can affect the delta between the IGCE and the actual contract costs. NAVWAR has served as a nucleus of the local economy as businesses flock around this information technology command (Graves, 2019). According to Graves (2019), NAVWAR awarded $1.3 billion in contracts to San Diego companies in 2018. With a significant portion of this investment being in knowledge-based services, it is imperative to understand the relationship between estimated costs versus actual costs of these contracts using taxpayer dollars.

D. SPEND ANALYSIS

To provide context to NAVWAR's portfolio, we conducted a spend analysis using pivot tables in Excel. The table explains the total spend between 2013 and 2019, top vendors (by dollar value) utilized, and other spend data. The following shows the total spend by year:

Table 1. Total Spend by Calendar Year (2013-2019)

Year	Total Spend
2013	$1,198,353,688.14
2014	$1,434,011,001.26
2015	$1,458,566,621.87
2016	$900,370,798.53
2017	$524,408,228.32
2018	$517,927,699.40
2019	$553,619,094.03
Grand Total	**$6,587,257,131.55**

The total contract spend from the data provided was $6,587,257,131.55. While understanding the total amount of money obligated by NAVWAR is an effective surface-level look at this spend data, identifying the specific vendors and PSC code is crucial to established focus areas for resourcing decisions. The following shows the top 10 PSCs procured in the data set provided.

Table 2. Total Spend by PSC (2013-2019)

PSC	**Total Spend**
R425	$ 3,787,500,470.78
R408	$ 934,748,079.12
R707	$ 908,591,611.87
R414	$ 203,700,387.94
R706	$ 190,526,070.66
R499	$ 181,619,747.73
R426	$ 114,075,201.55
R710	$ 93,475,710.14
R799	$ 62,952,148.12
R699	$ 30,954,868.38
Grand Total	**$ 6,508,144,296.29**

This data is an important observation because four of the six PSCs analyzed in this study are in the top five in the above list. The total spend across these four PSC accounted for 88% of the total spend in the 7-year period analyzed. While understanding the spend data based on PSCs is important, identifying the top vendors and their top PSCs used on their contracts is crucial to provide context to NAVWAR's portfolio. An interesting observation from the spend analysis was when analyzing the top 20% of the suppliers, 48% of the obligated funds across the 7 fiscal years resided within those top suppliers. Finally, the spend analysis revealed that 31.6% of the obligated funds went to small businesses. The below table represents this data point and provides total numbers of contracts obligated to both small and large businesses.

Table 3. Total Spend by Business Size (2013-2019)

Business Size	**Total Spend**
OTHER THAN SMALL BUSINESS	$4,392,852,556.27
SMALL BUSINESS	$1,388,042,008.45
(blank)	$806,362,566.83
Grand Total	$6,587,257,131.55

Overall, conducting a spend analysis on the data provided for this study by NAVWAR enables a general picture and understanding of contract spend across the fiscal years. Additionally, this analysis provides context for preliminary observations before conducting a more in-depth review of the data. The more in-depth analysis is conducted in the subsequent chapters.

E. IGCE PROCEDURES

The policy currently in place at NAVWAR is that any contract action over the SAT will require an IGCE. During the market research phase of the acquisition, the contracting officer will contact vendors with the explicit purpose of cost estimation. The Navy Cost Estimating Guide is a resource used at NAVWAR to identify key considerations for IGCEs and to understand the elements that comprise an IGCE. Additionally, NAVWAR uses a cost estimating team to establish IGCEs for the different program offices, including KBS Indefinite Delivery/Indefinite Quantity (IDIQ) task order contracts. Overall, the IGCE process is an important task in the market research phase of an acquisition, as well as in the post-award administration of the IDIQ contract.

The DoN Cost Estimating Guide is used at NAVWAR to produce these estimates. The purpose of the DoN Cost Estimating Guide (2010) is to encourage concise, dependable, and timely cost estimates within the DoN, delivering the right systems to the warfighter at the right time. The guide provides Navy acquisitions, contracting, and cost estimation professionals with best practices for systems and weapons acquisitions programs. The guide seeks to improve and standardize cost estimating processes within the DoN while providing organizations with strategic latitude, accounting for various levels of complexity within the defense cost analysis field. The guide is a culmination of best practices, identified across the enterprise, for

cost analysis practitioners, and other stakeholders, to use within their respective organizations (Kunc, 2010). The guide emphasizes the importance of "getting the cost right" while balancing cost, capabilities and risks within an environment of scarce resources in order to effectively meet the public procurement reform demands (Kunc, 2010, para. 4).

The DoN provides six major steps vital for completing a sound independent government cost estimate. The first step is to establish needs with stakeholders. Within this first step, cost analysts, along with the stakeholders, define the requirement and manage cost-analysis activities throughout the life of the requirement. The second step is to establish a baseline, where the team develops the program including all of the technical specifications and other information needed to complete the cost estimate. The third step is to generate the cost estimate baseline. Based on the information produced in the second step, the team develops a cost estimate incorporating collected data, models, and the associated risks and uncertainties. Afterward, the team conducts risk and uncertainty analysis as step four. There is no mention of a preferred technique, as the guide encourages organizations to use an acceptable objective technique. The fifth step requires the team to verify and validate the cost estimate by critically analyzing the inputs, outputs, and methods used in the cost estimating creation phase. Organizations can perform the fifth step via peer review and cross-checks. Last, in the sixth step, the team presents and defends the estimate; the team is required to document the generated cost estimate in preparation for presenting the cost estimate to key decision-makers.

This research intends to identify the relationship between the IGCE and the actual contract cost. Understanding the Navy's strategic documents regarding IGCE development will assist our analysis of the data found. NAVWAR contracting organizations have access to guides, policies, and procedures that can be tailored to meet the strategic acquisition needs of their respective organizations—the analysis may prove that the organizations did not use the documents effectively and efficiently.

F. SUMMARY

Overall, this chapter provided an overview of NAVWAR as an organization. It discussed their mission, contract portfolio, and IGCE procedures, adding context to the reasoning behind our research and its importance to the DoD, U.S. Navy, and NAVWAR. Furthermore, understanding the mission of NAVWAR and how they spend their dollars provides a ground-level perspective on their organizational mission focus and priorities. Finally, gaining knowledge of the cost-estimating processes and procedures in this organization's acquisition process is critical to understanding the relationships analyzed in this research.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. METHODOLOGY

A. INTRODUCTION

This chapter presents the methodology used for data identification and collection methods used to answer this study's research questions. By describing our approach, we hope that it motivates contracting professionals to study this topic across all military branches. This chapter further describes the sources of data, types of data retrieved, and the process in which the data was collected, specifying the data collection criteria using the data collection worksheet.

B. SOURCE OF DATA

The research data collection efforts focus on NAVWAR, specifically within the 2.0 Contracts competency. With the increasing importance of information technology emerging as a warfighting domain, combined with the immense contractor support NAVWAR maintains, contracting efficiency and value deliverance is vital. Due to the increased emphasis on information technology as a new battlespace, balanced with reducing budgets, NAVWAR made for a great case of study—exemplifying buying power of critical assets under overwhelming cost constraints.

On February 18, 2020, the secretary of the Navy issued a memorandum enacting the Stem-to-Stern (S2S) commission, an effort to garner $40 billion in cost savings over FY 2022–2026. The strategy is a "structural change ... to increase naval capabilities" in other segments, shipbuilding being one area of focus (Modly, 2020, pg. 2). Increased combat capability needs and decreasing budgets impact procurement leaders' decision-making and may cut both existing and new procurement programs. Modly (2020) stated in the memorandum that there will be "significant reductions in service support contracts," highlighting the importance of controlling costs within NAVWAR knowledge-based services contracts.

NAVWAR Headquarters, San Diego, CA, provided contract data consisting of a diverse set of contract actions supporting NAVWAR's information technology mission. As stated, NAVWAR provides direct support to three Navy PEOs: PEO C4I, PEO EIS,

and PEO Space Systems (NAVWAR, 2020). PEO C4I provides affordable and integrated information warfare capability to the fleet, comprised of a front office and 10 program offices, focusing on affordability, interoperability, and capability. PEO EIS's mission is to deliver cost-effective enterprise information technology, including network, business, and fleet support to the DoN and comprises 10 program offices. Last, PEO Space Systems is the executive agent to "develop, deploy, sustain, provide engineering support and influence space-based capabilities for naval, joint and allied operations" (NAVWAR, 2020, para. 2). The following sections provide an overview of the structures and systems NAVWAR Headquarters business analytics team used to provide the contract data for this research.

1. Federal Procurement Data System-Next Generation

According to FAR 4.603, all agencies must use the Federal Procurement Data System-Next Generation (FPDS-NG) to report all contract actions exceeding the micro-purchase threshold, including all modifications to those contracts' actions. The contract action information is input via a Contract Action Report, or CAR, which involves various inputs such as contract type, contract award amount, number of offers received, and competition level involved in the acquisition. These elements are captured and maintained within FPDS-NG, making for efficient access and assessment by contracting personnel. NAWAR Business Analytics used FPDS-NG as a tool to identify contract actions that met the data collection criteria for this research.

2. Standard Procurement System Procurement Desktop Defense

The Standard Procurement System (SPS) is the foundation of the DoD's initiative for paperless acquisition (Consolidated Analysis Center, Inc. (CACI), 2020). Procurement Desktop-Defense (PD^2) provides contract management professionals with streamlined acquisition support, enabling a holistic, end-to-end approach to the acquisition process. PD^2 offers the contracting professional cradle-to-grave support, "from requirements definition/initiation through solicitation, offer evaluation and award to contract administration and closeout" (CACI, 2020, p. 2). For this research, PD^2 was used to obtain contract data to meet data request requirements.

3. SeaPort-e

SeaPort-e is the premier electronic contracting platform, providing acquisition support for support services in 22 functional areas such as Engineering, Financial Management, and Program Management (SeaPort, 2020). NAVWAR, as part of the DoN's Systems Commands, competes services support contracts against the SeaPort-e Indefinite-Delivery Indefinite Quantity (IDIQ) multiple-award contract, consisting of over 1,800 contractors. SeaPort-e, much like PD^2, was used to obtain data to meet the data collection criteria needed to accomplish this research.

C. DATA COLLECTION

NAVWAR Business Analytics generated reports, using FPDS-NG, identifying knowledge-based services contracts that met the research data criteria. NAVWAR 2.0 Data Security inspected the data to ensure there were no security risks or vulnerabilities and agreed to release the data. The resultant report contained 175,330 contract actions from FY 2014–2020 to examine.

1. Data Collection Criteria

Although the structures and systems mentioned above provided valuable data relevant to the research, additional data was needed to meet the research objectives. The data provided by NAVWAR Business Analytics did not include IGCE, the most crucial procurement variable in our research, requiring a manual search and recovery of information by the PCOs supporting this effort. Understanding that combing through 175,330 physical contracts could be unduly burdensome, we generated a random sample of the provided contract actions to identify contracts meeting the following criteria:

- Knowledge-based services contracts
- Product Service Codes (PSCs)
    - R408, Program Management Support
    - R425, Professional Engineering and Technical Services
    - R609, Stenographic Services

- R706, Logistics Management Support Services
- R707, Contract and Procurement Management Support Services
- R799, Other Management Support Services

- Fiscal Years 2014 through 2020
- High dollar contract actions, valued above $2,000,000

Based on the above criteria, we identified 257 contracts awarded to large businesses and 78 contracts awarded to small businesses. The randomized list of contracts was provided to NAVWAR 2.0 Contracts procurement contracting officers and contract specialists to locate the IGCE. Of the sample provided, NAVWAR 2.0 Contracts personnel could only locate 21 of the small business contract files and 10 of the large business contract files. Only 14 contained the IGCE.

We reexamined the original data set provided by NAVWAR Analytics to ensure the data restrict NAVWAR 2.0 Contracts' ability to locate the identified contract files. We determined that the sample size was large enough for proper access. However, we ran another random sample and increased the sample size by decreasing the dollar value threshold from $2 million and above to $250,000 and above for small and large business contracts. Upon this new sample, 120 contracts (60 small businesses, 60 large businesses) were randomly selected. This list was provided to NAVWAR 2.0 Contracts to locate the IGCEs. NAVWAR 2.0 Contracts could only locate 21 contract files (14 large businesses, seven small businesses) that contained the IGCE. The original data set and the second data set were combined to make the final data set. Therefore, our final data set consisted of 35 contracts containing the IGCE (14 from the original data set and 21 from the second data set).

2. Procurement and Performance Variables

As stated, many studies have investigated the relationships between source selection method (procurement variable) and contractor performance (performance variable); thus, we did not employ those variables for this study. Our research questions aimed to identify the relationship, if any, between the procurement variables and

performance variables for knowledge-based services. A data collection worksheet was constructed and provided to NAVWAR 2.0 Contracts to gather procurement and performance variables for the identified contracts.

As shown in Figure 6, we collected procurement and performance variable data to analyze the relationship between the Actual Contract Cost and the Independent Government Estimate (IGCE) by exploring how three other procurement variables affect this relationship: (1) business size, (2) contract award amount, and (3) number of modifications.

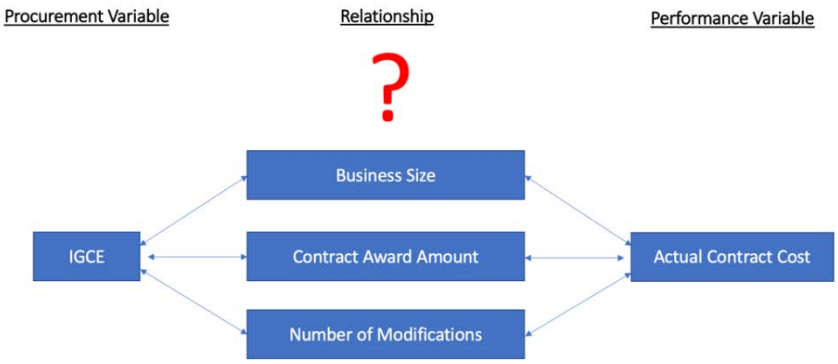

Figure 6. Relationship between Procurement Variables (Inputs) and Associated Performance Variable (Output) for Knowledge-Based Services (KBS) Contracts

Independent Government Estimate (IGCE). The procurement variable *IGCE* refers to the amount, in dollars, the requiring activity team believed the contract would cost, as determined by specific IGCE methodology and market research.

Business Size. The *Business Size* procurement variable refers to the contractor's business size (Small or Other than Small Business, i.e. "Large"), as determined by the U.S. Small Business Administration's table of small business size standards. Each business is responsible for assessing their business size—this is discussed as a limitation to our study, as we did not verify the contractor claim to be true. The business size is a secondary procurement variable, in the context of Figure 6, as the IGCE may affect acquisition personnel decision-making on the acquisition method.

Contract Award Amount. The variable *Contract Award Amount* is the initial dollar amount the government and contractor agreed the requirement was worth. In other words, it is the amount the buyer and the seller agreed to upon the date the contract was signed. Contracting professionals use the IGCE to negotiate contract awards; therefore, this variable is also affected by the IGCE and is considered a secondary procurement variable.

Number of Modifications. The *Number of Modifications* procurement variable refers to the number of modifications the contract has had over its lifetime. The number of modifications is another variable that is secondary to the IGCE. The idea is that the contract's dollar value can correlate with contract complexity, thus increasing the likelihood of contract modification.

Actual Cost. The *Actual Cost* refers to the amount of money the organization paid to acquire the contracted services. Understanding that the contract action may not be expired, it is also the current obligated amount under the contract action.

D. SUMMARY

This chapter discussed the methodology for data identification and collection methods used to answer this study's research questions. This chapter further described the sources of data, types of data retrieved, and the process in which the data was collected, specifying the data collection criteria using the data collection worksheet.

Although there were challenges in obtaining the number of inputs originally desired, overall, we managed to acquire enough data to proceed with our analysis and answer our research questions. NAVWAR 2.0 Contracts provided us with data representing an appropriate mix of small and large business contracts with varying contract award amounts. The following chapter specifies the results of our data analysis.

V. DATA ANALYSIS

A. INTRODUCTION

This chapter explains the data analysis and results based on linear regression and correlation techniques to identify a significant difference in the actual contract cost based on business size, contract award amount, and the number of modifications. Furthermore, the next section offers a discussion of descriptive statistics for each variable, followed by issues with the data and results of the data analysis.

B. DATA DESCRIPTION

We used one dependent variable (DV) for analysis of the data: the contract's actual cost (ACTCOST). The contract's actual cost refers to the amount of money obligated against the contract when the data was accessed. We propose that the actual cost, DV, is directly affected by the procurement variable, IV, and covariate variables described later. This variable is continuous. Our proposed model has one independent variable (IV): IGCE. We desire to test the relationship between the IGCE and the actual cost of the contract.

1. Data Limitations

As stated, there are three additional variables of interest: (1) Business Size of the Awardee (BIZSIZE), (2) Contract Award Amount (AWARDAMT), and (3) Number of Modifications (NUMMODS). Unfortunately, NAVWAR 2.0 Contracts was unable to provide a complete data set for all requested variables. Therefore, the sample size was limited to 35 cases that provided the necessary data to complete the analysis. Additionally, the 35 cases offered an unbalanced distribution of BIZSIZE cases (i.e., 25 small business cases, 10 large business cases). Furthermore, as subsequently discussed, two cases were removed from the sample due to incomplete ATCOST data, and two were removed for being outliers in the graphical illustrations, further limiting the pool (i.e., 23 small business cases, eight large business cases).

Although some contracts contained IGCE data, several were missing the ACTCOST and NUMMODS (contract award amount was present for all). We collected the missing data from FPDS-NG and the original data set to populate the missing data. Collecting the data from FPDS-NG and the original dataset was more efficient given our limited data collection time. However, data within both channels are subject to human error—the data retrieved is only as good as the data input.

FPDS-NG was also used to access missing data points for NUMMODS and ACTCOST for all contracts—with IGCE information. We removed two cases from the data set because we could not identify the respective ACTCOST and regarded the cases as incomplete. We ran a regression for the updated data set; Y: ACTCOST, X1: IGCE, X2: AWARDAMT, X3: NUMMODS. Furthermore, we discussed creating another variable out of the dependent and independent variables (i.e., the delta between ACTCOST and IGCE). However, we concluded that it would not add value to our analysis. Nevertheless, there were various subsets of data that could support some supplemental data analysis as indicated in Table 1, Descriptive Statistics.

2. Descriptive Statistics

Table 1 provides basic descriptive statistics for the procurement variables. Within the table, each variable presents three figures: (1) the total for the subset, (2) the total for large business awards, and (3) the total for small business awards.

Table 4. Descriptive Statistics

Variable	Obs	Mean	Median	StdDev	Min	Max
IGCE	**35**	**$12,297,382.42**	**$3,982,000.00**	**$18,986,692.67**	**$588,679.71**	**$87,660,013.00**
	10	*$6,680,612.63*	*$4,082,564.00*	*$6,331,040.96*	*$588,679.71*	*$21,260,458.00*
	25	$14,544,090.34	$3,963,197.00	$21,846,434.48	$896,000.00	$87,660,013.00
Contract Award Amount	**164**	**$5,880,413.57**	**$1,780,688**	**$16,709,272.83**	**$22,965.03**	**$174,727,318.00**
	82	*$3,417,455.91*	*$780,878.18*	*$6,371,673.66*	*$22,965.03*	*$42,557,744.68*
	82	$8,343,371.23	$2,963,760.55	$22,560,278.81	$291,815.77	$174,727,318.00
Number of Modifications	**146**	**102.48**	**9**	**183.75**	**1**	**527**
	65	*215.58*	*12*	*230.06*	*1*	*527*
	81	11.72	9	10.94	1	66
Actual Contract Cost	**122**	**$8,291,937.10**	**$1,430,787.72**	**$33,980,875.07**	**$163,464.42**	**$253,927,214.63**
	61	*$10,522,024.90*	*$862,395.64*	*$44,424,374.76*	*$163,464.42*	*$253,927,214.63*
	61	$6,061,849.31	$2,610,479	$18,574,372.32	$291,815.77	$142,876,639.00

Bold: Data subset total, *Italicized*: large business awards, Non-Italicized: small business award

C. ANALYSIS

We used multiple linear regression, also known as multiple regression, to perform our data analysis. The objective of multiple regression is to model the linear relationship between the explanatory variables (IGCE, AWARDAMT, and NUMMODS) and the response variable (ACTCOST).

1. Assumption Testing

Multiple regression possesses the following assumptions: (1) Linear Relationship—there is a linear relationship between the explanatory variables and the response variable, (2) Multivariate Normality—there are independent, normally distributed errors with a mean of 0, (3) Homoscedasticity—variance in errors is constant across the independent variables, and (4) Non-Multicollinearity—There are no highly correlated independent variables. Before observing the multiple regression model, we validated the assumptions mentioned above to support the model's validity.

First, we evaluated the linear relationship between each independent variable with the dependent variable by inspecting scatter diagrams determine linearity. In each scatter diagram, two significant outliers were influencing the data—we removed those two outliers. Subsequently, we found that each independent variable had a linear relationship with the dependent variable. Second, we checked the normality of the individual independent variable, by examining standardized residuals (i.e., model errors) and residual plots. We used the residual plots to check the constant variance of the errors and independence assumptions. The normal probability plots inform us whether errors within the data set are normally distributed. Based on the graphical representation, the errors were not normally distributed. Because multiple regression expects the errors to be normally distributed, we resolved the non-normally distributed errors by transforming the dependent variable (ACTCOST), creating a new variable using natural logarithm transformation, LN(ACTCOST). After doing so, we determined that the errors were normally distributed.

Third, we checked for homoscedasticity by using a scatterplot of the residuals versus each of the independent variables. There was no evidence in the scatterplots to indicate a violation of the constant variance assumption. Overall, it appears that this plot satisfies the assumption that the variance in our errors has to be constant. There is no cone shape, and the errors are frequently hovering zero. Hence, we found that the plots were homoscedastic.

Fourth, we checked for multicollinearity using a correlation matrix, Figure 7. Calculating the correlation between each of the DVs and the IV is imperative to confirm that each explanatory variable has a linear relationship with the response variable. However, it is also vital to check the correlation between each DV (i.e., X1 correlated with X2, X1 correlated with X3, X2 correlated with X3). Having strongly correlated independent variables can lead to unreliable parameter estimates in the model.

As shown in Table 2, IGCE and AWARDAMT are positively correlated (r=0.978). However, it is essential to note that the correlation between the IGCE and the contract award amount is near perfect and suggests the IGCE is informing the contract

award amount decision. However, there are issues post-award in controlling the cost; hence a possible reason the ACTCOST vs. IGCE is not as correlated (r=0.81).

Table 5. Correlation Matrix

Variable	ACTCOST	IGCE	AWARDAMT	NUMMODS
ACTCOST	1			
IGCE	0.81748702	1		
AWARDAMT	0.845343487	0.980276321	1	
NUMMODS	0.682453463	0.690028423	0.618481178	1

According to Kutner et al. (2005), in nonexperimental business situations, explanatory variables tend to be correlated with other variables in the model and with other variables that have a relationship with the response variable that are not included in the model. Such is true in this model. Because AWARDAMT and IGCE are highly correlated, we decided to run multiple regression on a sample with and without the AWARDAMT data. Upon validating all of the assumptions, we performed multiple linear regression (MLR)—the results are in the following section.

D. RESULTS

Before we discuss the results, we wanted to first establish the relationship between IGCE and ACTCOST. Table 3 shows that IGCE and ACTCOST have a strong relationship, and IGCE (p=.00000002) is a reliable predictor of ACTCOST. The purpose of this study was to find whether there is a relationship between IGCE and ACTCOST, which we find to be true based on the data provided. Additionally, we are interested in finding how other procurement variables such as AWARDAMT, NUMMOD, and BIZSIZE effect this relationship.

Table 6. LR with only IGCE

Variable	Coefficient	StdErr	t	P>|t|	95% CI	
IGCE	0.25302509	0.03310292	7.64358902	1.9902E-08	0.18532202	0.32072816
	*p<.10 **p<.05 ***p<.01 Number of Observations = 31 R^2 = 0.67 Adjusted R^2 = 0.66					

Having validated the assumptions described above, we performed the MLR analysis, and the following sections discuss the results.

1. Results with Contract Award Amount Included

The results of this model, as a whole, indicate that there is a significant relationship between the explanatory variables (IGCE, AWARDAMT, and NUMMOD) and the response variable (ACTCOST) with the contract award amount included. We conducted the MLR two-step testing process by first testing the model as a whole. The F-test result suggests that at least one of the variables in the model would be useful in predicting ACTCOST (p=.000005). The second test is to investigate the individual variables in the model, as shown in Table 4. We found that IGCE (p=.09), AWARDAMT (p=.01), and NUMMOD (p=.02) have a relationship with the ACTCOST and may have the ability to predict ACTCOST. The result is meaningful, and it suggests that IGCE, AWARDAMT, and NUMMOD are variables useful to forecast correctly, and budget for, ACTCOST. BIZSIZE, however, does not have a significant effect on ACTCOST (p = 0.66).

Table 7. MLR Results with AWARDAMT

Variable	Coefficient	StdErr	t	P>|t|	95% CI	
IGCE	-6.445E-08*	3.6695E-08	-1.7564122	0.09079213	-1.399E-07	1.0976E-08
AWARDAMT	1.2674E-07**	4.8134E-08	2.63299326	0.01405781	2.7796E-08	2.2568E-07
NUMMOD	0.02992912**	0.01192403	2.5099834	0.01863138	0.00541892	0.05443932
BIZSIZE	0.08885252	0.20009673	0.44404786	0.66068186	-0.3224522	0.50015724
	*p<.10 **p<.05 ***p<.01 Number of Observations = 31 $R^{2=}$ 0.67 Adjusted R^2 = 0.62					

Because there is multicollinearity between IGCE and AWARDAMT, we decided to run MLR excluding the AWARDMT, results are provided in the next section.

2. Results without Contract Award Amount Included

By eliminating the potential collinear effect of the AWARDAMT variable, we find, overall, that at least one of the variables in the model have a significant relationship with ACTCOST (p=.00002). When delving deeper into the results, in Table 5, we found that the IGCE and ACTCOST relationship is more substantial, and IGCE becomes a better predictor of ACTCOST (p=.002), when AWARDAMT is excluded from the model. Additionally, we find that NUMMOD (p=.16) has a moderately weak relationship with ACTCOST and may not be a reliable factor for ACTCOST predictability. This makes sense because contracting professionals accomplish modifications for various reasons, some of them not associated with scope changes and increased cost. In other words, the number of modifications performed on a contract does not unveil the purpose of the modification or how the modification alters contract funding. Furthermore, the MLR results suggest that BIZSIZE does not significantly affect ACTCOST (p=.67).

Table 8. MLR without AWARDAMT

Variable	Coefficient	StdErr	t	P>|t|	95% CI	
IGCE	2.9868E-08***	8.7851E-09	3.39987307	0.00211103	1.1843E-08	4.7894E-08
NUMMOD	0.0172113	0.01204022	1.42948329	0.16433485	-0.0074932	0.0419158
BIZSIZE	-0.0878894	0.2081835	-0.4221729	0.67624168	-0.5150467	0.33926783
	*p<.10 **p<.05 ***p<.01 Number of Observations = 31 R^2 = 0.59 Adjusted R^2 = 0.54					

3. Results without Contract Award Amount and Business Size Included

Exhibited in the first two MLR models, BIZSIZE does not illustrate a significant relationship with ACTCOST (p=.66, p=.67, respectively). When we run linear regression with only BIZSIZE as the explanatory variable, Table 6, the model reveals that BIZSIZE and ACTCOST have no significant relationship. Based on this dataset, BIZSIZE (p=.84), on its own, has no significant relationship with ACTCOST and therefore, would not be a good predictor of ACTCOST. This finding is understandable, based on the data provided by NAVWAR. As referenced in the Spend Analysis section of Chapter III, nearly 32% of NAVWAR's total spend went to small businesses. Additionally, the data shows a broad range of IGCEs and contract award amounts, trumping the idea that only large businesses receive large contract awards. Because there was a high variance in contract award amount and actual costs, it makes it difficult to predict actual contract cost based solely on a contract awardee's business size.

Table 9. LR with only BIZSIZE

Variable	Coefficient	StdErr	t	P>|t|	95% CI	
BIZSIZE	-389092.07	1862330.78	-0.2089275	0.83596548	-4197986.2	3419802.04
	*p<.10 **p<.05 ***p<.01 Number of Observations = 31 R^2 = 0.001 Adjusted R^2 = -0.03					

Due to the BIZSIZE variable's poor performance, we decided to accomplish an ad hoc analysis to determine whether the models' explanatory variables become stronger predictors of ACTCOST when removing BIZSIZE. Overall, the model reveals that at least one of the variables (IGCE and NUMMOD) is a reliable predictor of ACTCOST. When examining the variables closer, as exhibited by Table 7, IGCE (p=.002) has a significant relationship with ACTCOST and may be a reliable predictor of ACTCOST. NUMMOD, however, presents a moderately weak relationship with ACTCOST (p=.16).

Table 10. MLR without AWARDAMT and BIZSIZE

Variable	Coefficient	StdErr	t	P>|t|	95% CI	
IGCE***	2.9718E-08	8.6481E-09	3.43631182	0.00185965	1.2003E-08	4.7432E-08
NUMMOD	0.01684097	0.0118307	1.4234971	0.16564046	-0.0073931	0.04107506
	*p<.10 **p<.05 ***p<.01 Number of Observations = 31 R^2 = 0.59 Adjusted R^2 = .55					

E. FURTHER DISCUSSION

To determine which of the MLR models to use for the best data interpretation, we referenced their adjusted R^2 values to compare goodness-of-fit because they contain various independent variables. The adjusted R^2 adjusts for the number of variables within the model. Therefore, as the number of variables increases, the adjusted R^2 only increases if the added variable increases the model fit. Table 4, the three-variable MLR model that only excluded AWARDAMT, had an adjusted R^2 of r=0.54. Table 6, the two-variable MLR model, excluding both AWARDAMT and BIZSIZE, has an adjusted R^2 of r=0.55. These values suggest that adding BIZSIZE to the model does not increase the model fit, further supporting that BIZSIZE does not have a significant relationship with ACTCOST.

Based on the evidence provided, we chose to use MLR without AWARDAMT and BIZSIZE for our final analysis. Based on the data provided, there is a strong relationship between IGCE and ACTCOST. Although a strong relationship exists, the

IGCE's effect on the ACTCOST is minor; this is observed by exponentiating the IGCE coefficient. We found that for every one-unit increase in the IGCE, there is approximately a .000003% increase in ACTCOST. This poor result may be due to the small sample size, possibly not sufficiently representing NAVWAR as a whole. Finally, there is also a moderately weak relationship between NUMMOD and ACTCOST—there should be a supplementary study to better measure this relationship.

F. SUMMARY

This chapter discussed the data analysis and results based on linear regression and correlation techniques to identify a significant difference in the actual contract cost based on business size, contract award amount, and the number of modifications. Furthermore, this chapter discussed descriptive statistics for each variable, followed by issues with the data and results of the data analysis. The following chapter provides our conclusions and recommendations based on our findings.

VI. SUMMARY, CONCLUSION, AND AREAS FOR FURTHER RESEARCH

A. SUMMARY

The DoD has long struggled with cost overruns in major acquisition programs (Gideon & Wasek, 2015). Researchers have attempted to identify the cause of these overruns, but the numerous independent variables involved make this a difficult task. Additionally, the DoD remains on the Government Accountability Office's (GAO) High-Risk List for contract management, and the DoD Inspector General (DoD IG) declared that DoD contract management is a top 10 management challenge. Furthermore, the root causes of significant acquisition program correlated risks, according to Gideon and Wasek (2015), are within one of four categories: programmatic/business, technical, schedule, and cost. Instead of focusing on the causes of the cost overruns, this research examined the relationship between the Independent Government Cost Estimate (IGCE), and the actual cost of products and services procured by the U.S. government, specifically the DoD. Overall, this research focused on the relationship between IGCEs and actual contract costs and how that relationship is affected by other procurement variables.

The problem addressed in this research was the disparity between estimated contract cost, contract award amount, and actual contract cost upon completion. Naval Information Warfare Systems Command (NAVWAR) acquisition professionals have come to expect the IGCE to be significantly higher than the proposal and subsequent contract award. Additionally, they observed that the actual contract costs are much closer to the IGCE than the award amount. This delta between estimated and actual costs causes budgeting issues and inefficiencies between the distinct programs for which NAVWAR is responsible. Overall, a study to understand the relationship between these different costs and how they affect each other provided insight into the need for accurate IGCEs in government contracting and the best practices for generating them.

B. CONCLUSION

Based on the results of our data analysis, we are now able to answer the research questions presented in Chapter I.

1. What is the relationship between IGCEs and actual contract costs?

For the first research question, our data analysis concluded that the relationship between IGCE and actual contract cost is significant. By using MLR, we determined that IGCE has a strong relationship with and is a reliable predictor of actual contract cost. The strength of this relationship changed as we introduced other procurement variables, such as business size, contract award amount, and number of modifications. This strong relationship is significant because it reemphasizes the importance of accurate IGCEs and the government's ability to predict the actual cost of their contracts.

2. How do the following procurement variables affect that relationship?

For the second research question, our data analysis revealed that the relationship between the three different procurement variables observed is as follows:

i. Contract Award Amount

Based on our analysis, when contract award amount is included as an explanatory variable in our model, the relationship between IGCE and actual contract cost weakens. This may be explained by the multicollinearity between the two explanatory variables. Based on the data, the correlation between IGCE and contract award amount is near perfect, suggesting that the IGCE informs the contract award amount. Additionally, this is a positive finding for contracting organizations because they want IGCEs to influence negotiations with contractors and inform contract award decisions. However, this finding does not support NAVWAR's initial concern that there are major variances between the IGCE and contract award, based on the data provided. Overall, when incorporating both IGCE and actual contract cost as explanatory variables, the model becomes a better predictor of the actual contract costs.

ii. Number of Modifications

Based on our analysis, the number of modifications has a moderately significant relationship with actual contract costs. However, when the contract award amount and business size explanatory variables are removed from the model, the number of modifications present a moderately weak relationship with actual contract costs. This moderately weak relationship with actual contract cost means that number of modifications may not be a reliable factor for actual contract cost predictability. This could be due to the wide range of reasons for contract modifications. While some modifications could be large in scope, some could be simple administrative modifications that are small in scope and low in cost. Furthermore, introducing number of modifications to the model weakens the relationship between the IGCE and actual contract cost. In procurement planning, future modifications are not included as a line item in an IGCE for a particular requirement. While modifications are common, the government does not predict the amount of modifications and/or their cost when an generating an IGCE. Overall, when incorporating both IGCE and number of modifications as explanatory variables, the model becomes a less reliable predictor of actual contract costs.

iii. Business Size

Based on our analysis, business size has an insignificant relationship with actual contract costs. This may be explained by the number of small businesses that were awarded large dollar contracts and conversely, the number of large businesses that were awarded relatively small dollar contracts. Furthermore, with roughly 39% of NAVWAR's contracts being awarded to small businesses and the variance between IGCEs and contract award amounts so broad, business size as a lone explanatory variable is unreliable. Overall, it is difficult to predict actual contract cost based solely on a contract awardee's business size.

C. AREAS FOR FURTHER RESEARCH

Although our research added understanding of the relationship between IGCEs and actual contract costs and how different procurement variables affect that relationship, there are areas of further research that we recommend. While these recommended areas for further research are not fully comprehensive, we believe they will result in a better understanding of the importance of accurate cost estimation across the DoD's agencies, and the U.S. government as an enterprise. The following explains our recommendations for areas for further research.

First, our research focused on a specific type of services contracts. We conducted data analysis on specific product service codes (PSC) that were only associated with knowledge-based services contracts. Further research could include a larger number of PSCs to get a broader view using a larger portion of the NAVWAR's total contract portfolio. Additionally, analyzing exclusively knowledge-based services aided our understanding of the relationship between IGCEs and actual contract costs for that specific area, but other types of services may glean different cost estimation challenges. Further research into these other types of services could deepen our understanding of the challenges the DoD faces in cost estimation.

Second, our research focused on one specific Navy organization's contract data for our analysis. Further research could be conducted on other Navy systems commands (e.g., NAVSEA, NAVAIR, etc.). Additionally, further research could analyze other DoD agencies, including non-defense-related service contracts. This would provide a data set that would ensure more robust data analyses to broaden our understanding of this topic from a government enterprise level. Overall, including more organizations in further research will result in a better understanding of trends among government organizations regarding cost estimation and could reinforce the importance of accurate IGCEs to program offices across the enterprise.

Third, our research utilized a data set from a snapshot in time of 7 fiscal years. Further research could cast a wider net for the spend data to allow for a larger, more robust data set for analysis. Broadening the scope of contract data analyzed will provide

a larger picture for data and trend analysis for cost estimation accuracy and its relationship to the actual cost of the contracts awarded by the government. Overall, the more data available for analysis, the more accurate the sight picture will be to understand the relationships between all the variables discussed throughout our research.

Lastly, our researched analyzed three different procurement variables: (1) business size, (2) contract award amount, and (3) number of modifications. Further research could either incorporate a larger number of procurement variables or modify the three variables being analyzed. Incorporating more procurement variables will allow the research to analyze more relationships and how they are affected with changes in the variables. Furthermore, changing the variables being analyzed could provide a deeper understanding of the relationship between procurement and performance variables and their relationship with the government's ability to accurately estimate the cost of their contracts.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Assad, S., & Easton, M. (2011, May 25). *Intern.al controls for procurement systems* [Memorandum]. Department of Defense. https://www.acq.osd.mil/dpap/policy/policyvault/USA003224-09-DPAP.pdf

Ban, R. W., Barnes, B. O., & Comer, M. B. (2015). *Analysis of source selection methods and performance outcomes: Lowest price technically acceptable vs. tradeoff in Air Force acquisitions* [Master's thesis, Naval Postgraduate School]. NPS Archive: Calhoun. http://hdl.handle.net/10945/47869

Borbath, M., Blessner, P., & Olson, B. (2018). An empirical approach to the evaluation of defence contractor performance. *International Journal of Logistics: Research and Applications, 22*(2), 138–153. https://doi.org/10.1080/13675567.2018.1497148

Bublé, C. (2019). *Experts praise new acquisition workforce training requirements.* Government Executive. https://www.govexec.com/management/2019/12/experts-praise-new-acquisition-workforce-training-requirements/161894/

Cooley, W. T., & Ruhm, B. C. (2014). *A guide for DoD program managers: What Department of Defense program managers need to know to run an effective and efficient program*. https://acqnotes.com/wp-content/uploads/2014/09/A-Guide-for-DoD-Program-Managers.pdf

Consolidated Analysis Center, Incorporated (CACI). (2020). *Standard procurement system (SPS).* https://kb.caci.com/products.cfm

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of Management Review*, *14*(1), 57–74.

Esaias, F. (2011). *Overview of doing business with SPAWAR Systems Command (SPAWAR).* Space and Naval Warfare Systems Command.

Department of Defense. (2018). *Independent government cost estimate (IGCE) handbook for services acquisition* (1st ed.) [Handbook]. https://www.dau.edu/cop/ace/DAU%20Sponsored%20Documents/DoD_IGCE_for_SA_Handbook.pdf

Department of Defense Inspector General. (2015). *Summary of DoD Office of the Inspector General audits of DoD financial management challenge* (DoDIG-2015-144). https://www.dodig.mil/reports.html/Article/1119180/summary-of-dod-office-of-the-inspector-general-audits-of-dod-financial-manageme/

Department of Defense Inspector General. (2019). *Fiscal year 2020 top DoD management challenges.* Washington, DC: DoD.

Department of the Navy. (1994). *Department of the navy cost estimating guide.* https://www.ncca.navy.mil/references/DoN_Cost_Estimating_Guide.pdf

FAR 1.102(a), Statement of Guiding Principles for the Federal Acquisition System. (2020). https://www.acquisition.gov/far/part-1#FAR_1_102

FAR 4.603, Policy. (2020). https://www.acquisition.gov/far/4.603

Gideon, A. K., & Wasek, J. S. (2015). Predicting the likelihood of cost overruns: An empirical examination of major Department of Defense acquisition programs. *Journal of Cost Analysis and Parametrics*, *8*(1), 34−48.

Government Accountability Office. (2017). *Services contracts: Agencies should take steps to more effectively use independent government cost estimates* (GAO-17-398).

Government Accountability Office. (2019). *High-risk series: Substantial efforts needed to achieve greater progress on high-risk areas* (GAO-19-157SP).

Government Accountability Office. (2020). *Procedures needed for sharing information on contract choice among military departments* (GAO-20-352).

Graves, B. (2019, October 21). Navy's I.T. arm awards $1.56B in deals. *San Diego Business Journal, 40*(42), 14. https://www.sdbj.com/news/2019/oct/21/navys-it-arm-awards-156b-deals/

Ipsaro, M. (2011, June). How an independent government cost estimate can help you determine how much your contract should cost. *Contract Management Magazine*, 2–9.

King, D. R., & Sekerka, L. E. (2017). Managing competing interests: A review of ethics in military procurement. *Public Integrity*, 444−468. https://doi.org/10.1080/10999922.2016.1276789

Kutner, M., Nachtsheim, C., Neter, J., & Li, W. (2005). *Applied linear statistical models* (5th ed.). McGraw-Hill Irwin.

Kunc, W. (2010). *Department of the Navy Cost Estimating Guide—A compendium of best practices for the Department of the Navy cost analysis community*. https://www.ncca.navy.mil/references/DoN_Cost_Estimating_Guide.pdf

Landale, K. A., Rendon, R. G., & Hawkins, T. G. (2017). Examining the effects of source selection method on procurement outcomes. *Journal of Defense Analytics and Logistics*, *1*(1), 47–68. https://doi.org/10.1108/JDAL-05-2017-0006

Modly, T.B. (2020, February 18). *Department of the navy stem-to-stern capability-based strategic review* [Memorandum]. Department of the Navy https://media.defense.gov/2020/May/18/2002302050/-1/-1/1/SECNAV%20STEM%20TO%20STERN%20STRATEGIC%20REVIEW.PDF

Monczka, R., Handfield, R., Giunipero, L., & Patterson, J. (2016). *Purchasing and supply chain management*. Cengage Learning.

National Contract Management Association. (2019a). *Contract management body of knowledge* (6th ed.).

National Contract Management Association. (2019b). *The contract management standard.* https://www.ncmahq.org/docs/default-source/standards-certification-files/the-contract-management-standard.pdf

Naval Information Warfare Systems Command. (2020). *About NAVWAR.* https://www.secnav.navy.mil/smallbusiness/Pages/navwar.aspx

Rendon, J. M., & Rendon, R. G. (2016). Procurement fraud in the U.S. Department of Defense: Implications for contracting processes and internal controls. *Managerial Auditing Journal*, 748−767.

Rendon, R. (2015). Benchmarking contract management process maturity: A case study of the U.S. Navy. *Benchmarking: An International Journal*, *22*(7), 1481−1508. http://hdl.handle.net/10945/57703

Rogerson, W. P. (1994). Economic incentives and the defense procurement process. *Journal of Economic Perspectives*, *8*(4), 65−90.

Rosenberg, B. (2019, June 5). *Why is SPAWAR now NAVWAR? Networks & cyber warfare.* Breaking Defense. https://breakingdefense.com/2019/06/why-is-spawar-now-navwar-networks-cyber-warfare/

Schwartz, M., Sargent, J. F., & Mann, C.T. (2018). *Defense acquisitions: how and where DoD spends its contracting dollars* (CRS Report No. R44010). Congressional Research Service. https://fas.org/sgp/crs/natsec/R44010.pdf

SeaPort. (2020). *About seaport-e. https://www.seaport.navy.mil*

Watts, B. D. (2013). *Sustaining the U.S. defense industrial base as a strategic asset.* Center for Strategic and Budgetary Assessments. https://csbaonline.org/uploads/documents/Sustaining-the-U.S.-Defense-Industrial-Base.pdf

Williams, L. C. (2020, April 10). *DoD cuts red tape to support fast prototyping*. https://fcw.com/articles/2020/04/10/dod-ota-lord-prototype.aspx

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California