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Analyzing Contract Performance at Defense Logistics Agency

December 2022

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

Disclaimer: The views expressed are those of the author(s) and do not reflect the official policy or position of the Naval Postgraduate School, US Navy, Department of Defense, or the US government.

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ABSTRACT

The Department of Defense (DOD) has emphasized agility, the speed of learning, and operational readiness, based on the National Defense Strategy, with priority on deterring aggression from near-peer competition of China. The timely preparation of requirements, proper contracting methodology, enforcement of spare parts contracts, and contracted vendor performance are essential to ensuring stability of the DOD's supply chain and maintaining warfighting readiness. The DOD faces challenges with on-time delivery rates, a direct impact to material readiness for operational requirements and DOD's ability to remain relevant.

This research explores potential relationships between Contract Value, Contract Quantity, and Awarding Office and their effects on the Delta in Delivery Date. Given Defense Logistics Agency's (DLA) sphere of influence, managing 4.2 million spare parts, they were an ideal source of data to explore these potential relationships. The findings of our research suggest that there is no correlation between Contract Value and Contract Quantity and the Delta in Delivery Date. However, our research shows that there is a possible qualitative factor that was not measured, which is affecting intraoffice performance at DLA L&M and DLA Aviation. This research concludes with recommendations to improve upon the research in the area of on-time delivery at DLA.

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We would be remiss in not mentioning the support of our spouses, Diana, Jennifer, and Kelli, as well as our children for their tremendous understanding and encouragement throughout our exploration and learning.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of variance
COI	Captains of Industry
COVID	Coronavirus
CPI	Consumer Price Index
DAU	Defense Acquisition University
DLA	Defense Logistics Agency
DOD	Department of Defense
DoDAAC	Department of Defense Activity Address Code
DoDAAD	Department of Defense Activity Address Directory
E2E	end-to-end
FAR	Federal Acquisition Regulations
FY	Fiscal Year
GAO	Government Accountability Office
HSD	honestly significant difference
IPS	Integrated Product Support
L&M	Land and Maritime
LPTA	lowest price technically acceptable
NSN	National Stock Number
PMI	Purchasing Managers' Index
TO	trade-off
XLD	Extreme Long Down

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I. INTRODUCTION

The Department of Defense (DOD) has emphasized agility, the speed of learning, and operational readiness, based on the National Defense Strategy, with priority on deterring aggression from near-peer competition of China (Department of Defense, 2022). The timely preparation of requirements, proper contracting methodology, enforcement of spare parts contracts, and contracted vendor performance are essential to ensuring stability of the DOD's supply chain and maintaining warfighting readiness. The DOD faces challenges with on-time delivery rates, a direct impact to material readiness for operational requirements and DOD's ability to remain relevant.

In Fiscal Year (FY) 2022, DOD obligated $346.2 billion dollars on contractual services and supplies supporting various weapons systems (USAspending.gov, n.d.). Defense Logistics Agency (DLA) Land and Maritime (L&M) located in Columbus, Ohio is one of the biggest suppliers of weapons systems spare parts that support land and sea-based operations ensuring end-to-end (E2E) supply chain management. Managing nearly 2.5 million spare parts supporting over 2,000 weapon systems, DLA awards over 330,000 contracts while processing more than 10 million orders with sales in excess of $3.9 billion annually (Defense Logistics Agency [DLA], n.d.-b). DLA Aviation, located in Richmond, VA supports more than 13,500 joint aircraft, 450 intercontinental ballistic missiles, and other customers through management of 1.7 million spare parts. As an organization, DLA Aviation sales in 2021 totaled $5 billion, processing 3.9 million customer requisitions (Defense Logistics Agency [DLA], n.d.-a).

DLA, by sheer volume and legislative action, is positioned to be the leader in defense supply. Recognizing their buying power, in 2012 DLA set out on a quest to leverage their position, "When I meet with captains of industry from our supply chains, I tell them, 'We're all in this together.' We need to be effective, as a team, so let's work together at the strategic level and decide how we're going to meet this challenge."(*DLA Director Talks "Big Ideas" at Annual Defense Logistics Conference*, n.d.) With this goal in mind, DLA's Captains of Industry (COI) program was inaugurated, as a method of

employing long-term contracts to maximize supply chain efficiency from defense contractors.

There is a wealth of academic research around contracts for major weapons systems and services, but our study is the first that we know of that delves into the knowledge gap that exists in this space. Relevant non-defense literature primarily covers studies surrounding inventory management and modeling such as measuring fill rate (Thomas, 2005), measuring performance based contracting outcomes (S.-H. Kim et al., 2010), and the effects of contract types on spare parts inventory control (Lamghari-Idrissi et al., 2020). Since DLA awards a large number and volume of contracts, we narrowed the scope of our study to focus on contracts awarded and subsequently closed by DLA L&M and DLA Aviation, helping to bridge the knowledge gap that currently exists. We explore whether a relationship exists between Contract Value, Contract Quantity, Awarding Office, and the difference between scheduled versus actual delivery, which we categorized as Delta in Delivery Date, as seen in Figure 1.

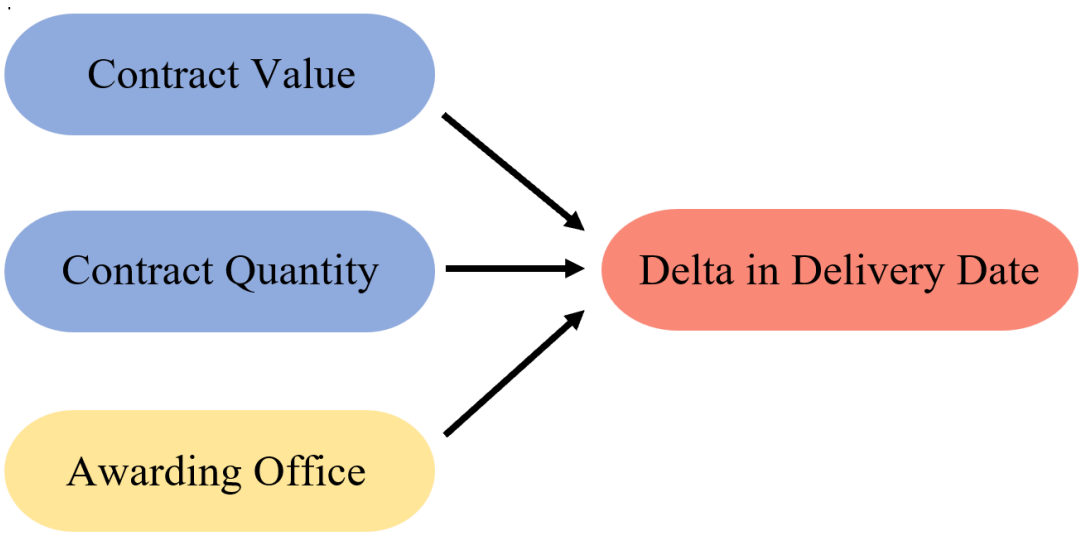

Figure 1. Research Model

A. PURPOSE

The purpose of our research is to discern potential relationships between Awarding Office, Contract Value, Contract Quantity and resultant outcomes measured by the Delta in Delivery Date. We aim to provide insight into the variation between the scheduled and actual delivery date of spares contracts awarded by DLA L&M and DLA Aviation. Through examination of contracts specific to the Maritime and Aviation assets under the DLA L&M and DLA Aviation organizations, we help bridge the gap and identify any correlations and potential relationships between contract inputs, both within and outside the control of key decision makers, and contract outcomes. The findings of this research help leaders within DLA L&M and DLA Aviation identify strategies to leverage the best outcomes for spares contracts in the future.

B. RESEARCH QUESTIONS

1. What contract variables noticeably affect the on-time delivery of DLA L&M and Aviation spares contracts?

   This question leads to two secondary research questions which delve further into the topic of timeliness of delivery of spares contracts:

2. Does Contract Value or Contract Quantity have any correlation with the amount of time a spares contract delivered earlier than promised, on-time, or after the promised date?

3. Is there a relationship between the different Awarding Offices and the amount of time a spares contract delivered earlier than promised, on-time, or after the promised date?

C. METHODOLOGY

The research methodology consists of a literature review, data collection, data analysis, a determination of findings, and recommendations for further research. We reviewed data for 490,826 spares contracts closed by DLA L&M and DLA Aviation between January 2017 and May 2022. Our research examined the difference in the contracted versus the actual delivery date of these contracts, as well as any potential

relationship between this difference and other contract variables. The literature review was initiated for the purpose of examining and considering the available knowledge from the current body of literature about spares contracting, pertinent variables that impact on-time delivery, and research on outcomes of contracting practices.

Further, we used analysis of variance (ANOVA) to analyze the data to determine if a statistically significant difference exists between the means of two or more groups of data and a multiple regression analysis to predict the value of one variable based on the value of another variable (Laerd Statistics, n.d.).

D. BENEFITS AND LIMITATIONS

Our analysis identifies potential relationships between Contract Value, Contract Quantity, and Awarding Office with the Delta in Delivery Date from a sample of DLA L&M and DLA Aviation spare parts procurement contracts from January 2017 to May 2022. The benefits include insight into how the decisions made in the Pre-Award and Award phases of the procurement process can translate to superior vendor performance.

There are clear and identifiable limitations with the scope of this research. This research is narrowly focused on spares contracts for consumable parts closed by DLA L&M and DLA Aviation. This study provides a glimpse into effect of on-time delivery of spare parts, which broadly impacts the DOD and individual service components' ability to meet mission tasking requirements, especially given the size and scope of DLA.

E. RESEARCH LAYOUT

Our project is organized into five chapters. The first chapter contains background information; the second chapter includes a review of the literature we found pertinent on the spares contract procurement process and closely looks at previous studies on comparing procurement decisions with outcomes; the third chapter provides details on the research methodology; the fourth chapter includes our analysis of the research, and lastly the fifth chapter provides a summary, conclusions, and recommendations for further research.

F. SUMMARY

In this chapter we discussed the background of our research, the problem we are addressing, the questions we intend to answer, our methodology, and the benefits and limitations of the project.

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II. LITERATURE REVIEW

A. INTRODUCTION

This purpose of this chapter is to review the spare parts literature and provide an overview of the spare part procurement process. It begins with an examination of the role spare repair parts play into the product support of a weapon system and highlights the importance of the process for generating requirements for spare repair parts. Then we step through the variables of our analysis; Contract Quantity, Contract Value, Contract Awarding Office, and the difference between contracted and actual delivery dates. Additionally, this chapter provides a discussion on previous studies conducted in this research space. The analysis of the related research delves into similar research projects on how decisions made in the procurement process impacted overall procurement process outcomes.

B. SPARE PART PROCUREMENT PROCESS

Spare parts play a critical role in the support of DOD weapon systems, they are defined as the "building blocks from which systems are created" having direct influence on reliability, dependability, and readiness (DAU Acquipedia: Parts Management, n.d.). The Defense Logistics Agency Parts Management Guide plainly defines a part as "One piece, or two or more pieces joined together, that is normally subject to disassembly without destruction or impairment of its design purpose"(Defense Logistics Agency [DLA], 2013). Further, DLA is generally responsible for 80% of spare parts purchases for all the DOD (DiNapoli, 2021). This research does not include repair parts that are managed independently by the military services or those that are produced organically by industrial depots.

As such, supply support and the availability of spare parts are one of the 12 Integrated Product Support (IPS) elements used in the product support of DOD weapons systems. The goal of the supply support of spare parts is ensuring the weapon system is supported by having the right spare part available at the right time needed for preventative or corrective maintenance (Integrated Product Support Elements Guidebook,

2021). Products need support to function per their design across the intended lifespan of the weapon system. The method for supporting complex systems is defined by Defense Acquisition University (DAU) and further supported by academia. A study authored by researchers in 2012 details the importance of repair and spare parts in the support of industrial products and machines, seen in Figure 2 (Ghodrati et al., 2012). Repairable parts and spare parts are part of a holistic approach to support a complex system. Much like the IPS elements directed by defense acquisition policy, spare parts are complemented by other important factors as well. Maintenance and provision and service delivery are needed to fully support a system.

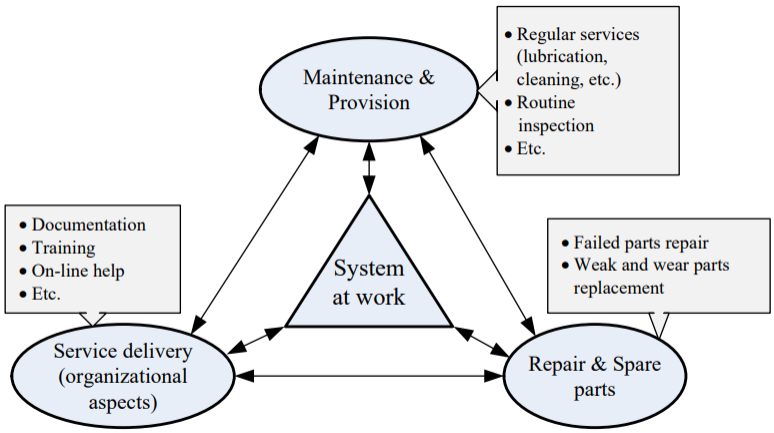

Figure 2. Concepts of Support to Industrial Products/Machines. Source: Ghodrati et al. (2012).

The role of DLA L&M and DLA Aviation is to use demand modeling to forecast the need for spare parts to be carried as wholesale system spares available to their respective customers. The spare parts procured by DLA L&M and DLA Aviation support various weapon systems and products across the DOD. Further, within the organizations we are researching are various contracting divisions that procure spare parts..

C. PREVIOUS STUDIES

Within academia there exists research that delves into the management of spare parts and some studies which look at contracting implications as well. In 2020,

researchers looked at services contracts for spare parts and the related performance metrics (Lamghari-Idrissi et al., 2020). This research focused on private sector service contracts for the sustainment and maintenance of capital goods that included provisions for spare sparts support. Traditionally, these types of contracts featured performance metrics that focused on fill rate. Aggregate fill rate is the probability that pre-determined group of spare parts will be fulfilled immediately when demanded. The fill rate metric falls short of measuring the time in which a customer may wait for a demand to be filled. The researchers devised a new service metric called "Extreme Long Down service measure" (XLD) and tested its impacts along with different types of contract length. The researcher's key assumption is that value of the repair service contract is the reduced the time to repair the capital good. To that end, the XLD service measure is a fixed number, a "set number of hurtful long outages" due to not having a spare (Lamghari-Idrissi et al., 2020). This type of contractual arrangement is very similar to performance-based logistics contracts leveraged by the DOD to support critical weapon systems.

Douglas Thomas has done extensive research in the area of demand management and the fill rate metric for inventory management. As in the previously mentioned study, this research looks deeply into the application and practice of inventory management theory (Thomas, 2005). This study and the research conducted by Lamghari-Idrissi et al. bring supply chain service level and fill rate implications to the forefront of parts management. Ultimately, the research conducted by Lamghari-Idrissi is about optimization of supply chain metrics and stocking decisions to improve the customer outcome. These two studies are different from the work we are doing in that Douglas and Lamghari-Idrissi et al. focus on how supply chain management decisions and metrics influence overall supply chain performance as defined by those metrics. Conversely, our research is aimed at the contractual outcome of procurement actions after the supply chain decision makers have already decided to initiate a procurement action. Additionally, from our vantage point, we believe that on-time delivery is the contractual outcome that needs to be the focus of this research.

The Government Accountability Office (GAO) conducted research on the spare parts contracting processes at DLA. In a recent report delivered to Congress in 2021,

GAO conducted research on how often DLA contracting officers attain certified cost and pricing data for sole source spare parts contracts (DiNapoli, 2021). The research suggests that DLA contracting officers will meet resistance from vendors to provide certified cost and pricing data. This forces the DLA contracting officers to make a determination to exempt the vendor from providing certified cost and pricing data and only rely on data other than certified cost and pricing data (DiNapoli, 2021).

Existing research about the relationships between contracting methods and outcomes suggest there are ways to address the problems of contracting outcomes. In 2015, researchers looked at how decisions made during the procurement process were associated with a vendor's delivered quality of service (Hawkins et al., 2015). The researchers were able to quantitatively determine that definition of the requirement and communication quality between the vendor and buyer produce a higher level of service quality, whereas monitoring the vendor does not. This research shows how decisions made in the source selection method impact the outcome of the overall source selection process (Hawkins et al., 2015). Further, in 2016, researchers studied how source selection methods, lowest price technically acceptable (LPTA) and trade-off (TO), affected the time-to-contract award in the Pre-Award and Award phases of contracting (Landale and Rendon, 2016).

The contracting process is delineated into three distinct phases: Pre-Award, Award, and Post-Award as seen in Figure 3. The Pre-Award phase focuses on the development of the solicitation and offer, and the Award phase is defined by forming a contract (National Contract Management Agency [NMCA], 2022). The outcome of the study did not affirm the widely held opinion that using a source selection method based on LPTA results in speed to award (Landale and Rendon, 2016). Both papers provide evidence that decisions and actions made during the procurement process may produce outcomes that are different from the generally held opinion or experience. Our research involved studying empirical data comparing factors that may affect the outcome of the delivery of spare parts.

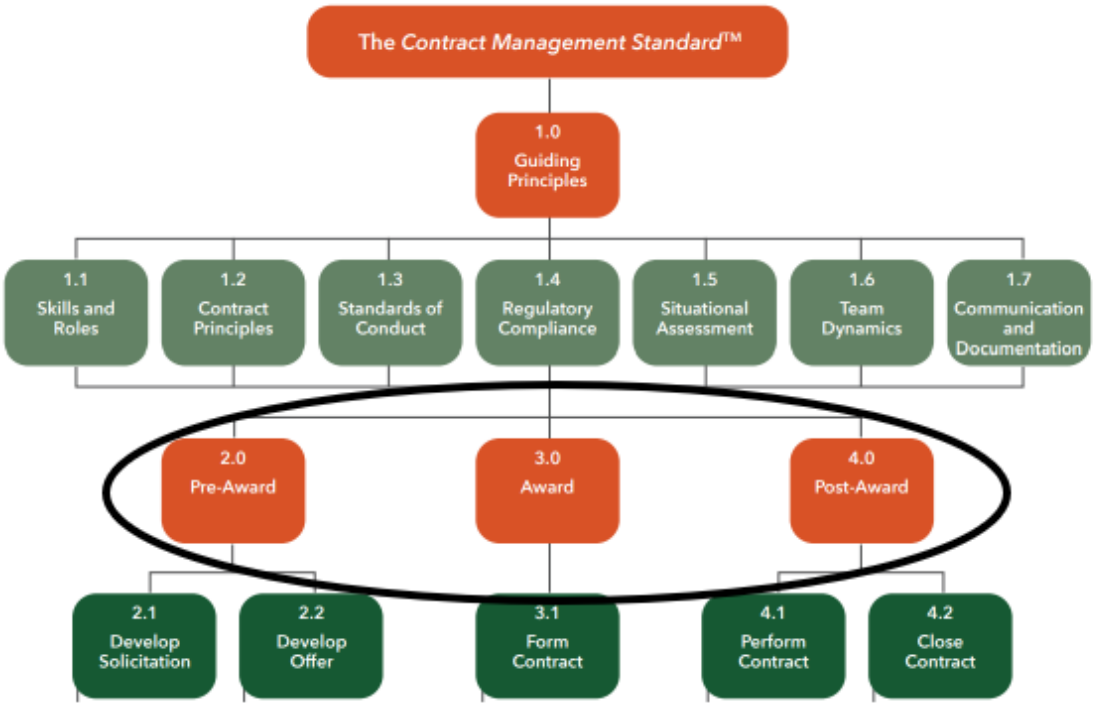

Figure 3. The Contract Management Standard. Source: National Contract Management Agency (2022).

D. CONTRACT QUANTITY

Our research looked at the impact that contract quantity has on the performance of the vendor. A commonly held viewpoint within the procurement industry and supply chain managers alike is that a price discount is realized as the contracted quantity increases through economies of scale. In fact, in 2007, researchers studied the discounts behind increasing the contracted quantity in comparison with the challenges behind a firm determining costs of purchasing above their demand models (Shin and Benton, 2007). The researchers called these costs "hidden" in nature. The types of costs that must be considered are inventory holding cost, ordering cost, and transportation cost (Shin and Benton, 2007). Shin and Benton went on to create a quantity discount model that "capitalizes on the buyer's and the supplier's economic lot sizes and that allows the supplier to share the buyer's potential overstocking risk" (2007).

Previous research around the U.S. Air Force's Flying Hour Program has shown "Demand that runs lower than forecast levels results in excess parts; demand that runs

higher results in shortages and reduced readiness" (Mills et al., 2018, p. iii). This is similar to the bullwhip effect that exists in supply chain management (Lee et al., 1997). This is an anomaly that occurs when inaccurate demand forecasting, inappropriate use of batch ordering, fluctuations in price, and rationing cause confusion in the quantities needed between the retailer and wholesaler. These types of disruptions in quantity and demand could also be based on a perceived demand forecast and could cause a vendor not to react to a smaller order as well. In constrained fiscal environments, the impact to readiness is greater as the allocation of what to buy and how much of it comes under closer scrutiny. Our research examined when there is an increased demand on National Stock Number (NSN) item quantity there could possibly be an affect upon on delivery time.

E. CONTRACT VALUE

Contract Value, the amount paid by DLA to the seller, inclusive of the base contract awarded total cost plus or minus any modifications. The most basic definition of the value of a contract is the consideration provided for a given product or service. Consideration is defined as the "promise, performance, or forbearance bargained by a promisor in exchange for their promise. Consideration is the main element of a contract" (Cornell Law School, n.d.). Previous literature pointed to a correlation between total contract dollar value and delays. As noted in The Importance of Contract Design, DOD customers have typically experienced contract value growth and delays and should consider the consequences of such growth (Y. W. Kim and Brown, 2012). In Kim and Brown's research, the authors pointed to the expanding growth in terms of modifications and additions to the scope of the original contract, which increased the overall contract cost and resulted in contract delays. Our research intended to determine, based on the initial contract, if a relationship existed between Contract Value and Delta in Delivery Date.

F. CONTRACT AWARDING OFFICE

Another factor that we explored was the awarding office within both DLA L&M and DLA Aviation. As previously mentioned in the beginning of this report, both

organizations are considerably large and multiple contracting offices support various commodities and types of requirements to award contracts for spare parts. Another commonly held view is that different contracting offices can achieve better results than other contracting offices or are better at following policy and guidance than others. For example, after the historic response to the Coronavirus (COVID) pandemic, GAO compared the contracting efforts of the DOD, Department of Health and Human Services, Department of Agriculture, Department of Veterans Affairs, Department of Homeland Security, and other U.S. federal government agencies (Mak, 2021). The research depicted the number of contract obligations each agency made to vendors without any prior federal contracting experience (see Figure 4). The research compared how well the different agencies followed Federal Acquisition Regulation (FAR) doctrine against each other and provided lessons learned that each agency could implement as a result of the analysis. This type of research compares how different agencies perform against each other. Similarly, we assessed performance between different Awarding Offices within DLA L&M and DLA Aviation.

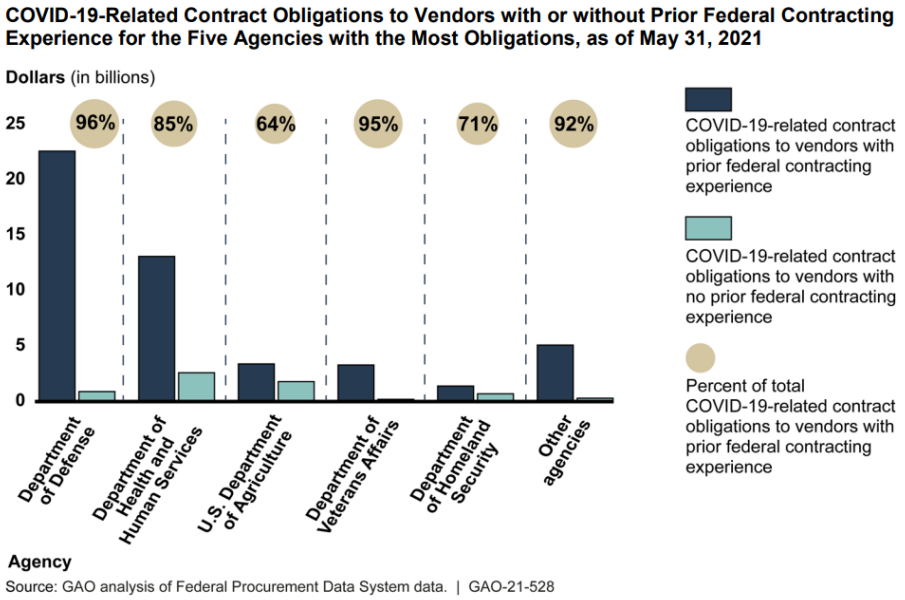

Figure 4. COVID-19 Related Contract Obligations to Vendors. Source: Mak (2021).

Our research looked at the contractual outcomes vis-à-vis the difference in actual delivery date and the contracted delivery date for each office. Our research in this area was limited to exploring heterogeneity across awarding offices performance in regards to contracted delivery date.

G. DELIVERY DATE

Timely delivery by the vendor was determined to be a good outcome for a spare parts contract. We assumed that the delivery date defined at the time of award is reflective of the most realistic and positive outcome for the Awarding Office. Anything earlier is assumed to be an unexpected positive outcome and anything later is considered an unexpected negative outcome. This is an important measure in private industry that impacts the global supply chain. The Purchasing Managers' Index (PMI) publishes an index to document supplier delivery times by conducting business surveys in 44 countries (Williamson, 2021). The survey asks, "Are your suppliers' delivery times slower, faster or unchanged on average than one month ago?"(Williamson, 2021, p. 1). In addition, the companies are asked for a reason, if known, for any changes. The responses are then "weighted to derive a 'diffusion index' using the formula as seen in Figure 5. For example, if 30% of respondents report 'faster' delivery and 50% report the 'same' then the PMI Suppliers' Delivery Index would be 55 and considered 'faster' overall.

$$\text{Index} = \begin{array}{c}\text{Percentage of Survey}\\ \text{Panel Responding}\\ \text{'Faster'} * 1.0\end{array} + \begin{array}{c}\text{Percentage of Survey}\\ \text{Panel Responding}\\ \text{'Same'} * 0.5\end{array}$$

Figure 5. PMI Suppliers Delivery Index Formula. Source: Williamson (2021)

The global PMI Suppliers' Delivery Index, Figure 6, is an industry standard to depict "supply delays, capacity constraints and price pressures" as shown below

(Williamson, 2021, p. 1). Since the 1990s the index has been followed closely by private industry and even the past Federal Reserve Chair Alan Greenspan (Williamson, 2021).

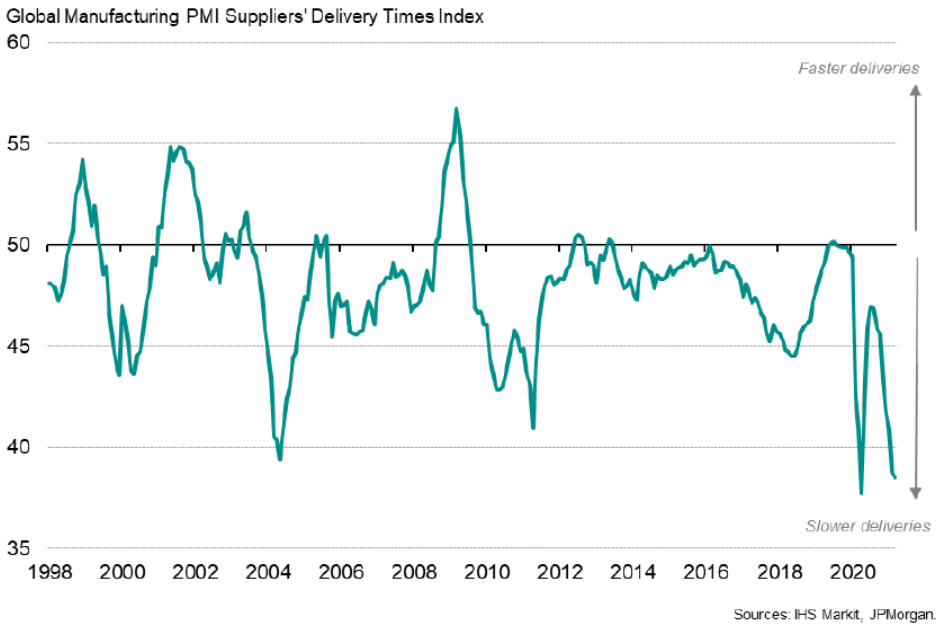

Figure 6. Global PMI Suppliers' Delivery Index 1998–2021. Source: Williamson (2021).

By inverting the PMI Suppliers' Delivery Index and overlaying a chart detailing U.S. Inflation (US Consumer Price Index, annual percentage change) one can easily see the relationship that delays in delivery time has with inflation by noting that as inflation rises suppliers' delivery times become increasingly delayed, as shown in Figure 7. The inverted PMI Suppliers' Delivery Times index tracks consistently with the Consumer Price Index (CPI) (Williamson, 2021).

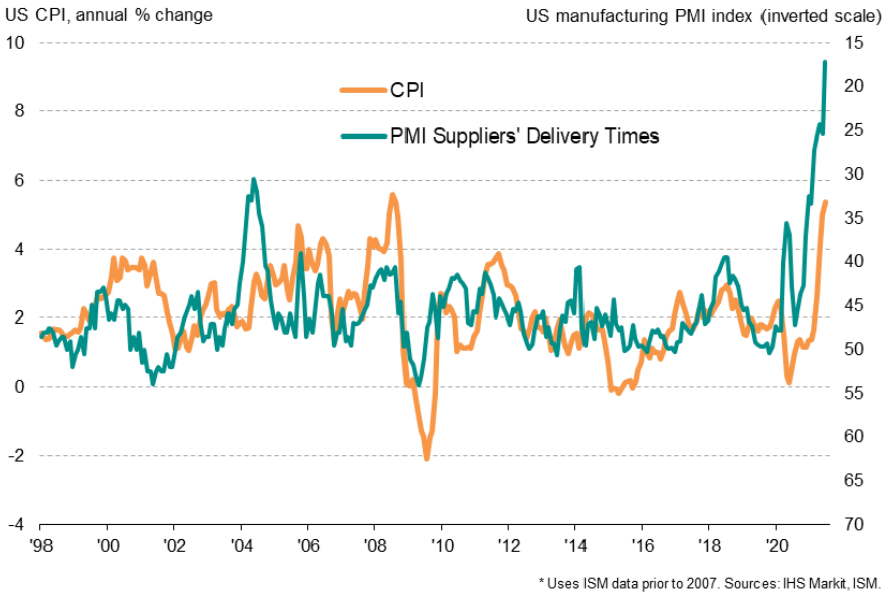

Figure 7. U.S. Inflation and the Suppliers' Delivery Time Index. Source: Williamson (2021).

The same relationship is noted to occur with global output (via the JPMorgan Global PMI Output metric) and with global input prices (via the PMI Input Prices index) (Williamson, 2021). This results in a "simple rule" that states when "output grows at a rate which is sufficiently strong to cause a widespread lengthening of supplier delivery times, production costs will tend to rise as suppliers hike their prices, and vice versa" (Williamson, 2021). The PMI Suppliers' Delivery Times index "can therefore be considered as a gauge of the extent to which supply and demand are in equilibrium, and the impact any imbalance may have on future prices" (Williamson, 2021, p. 2).

This matters because DLA L&M and DLA Aviation exist within their own supply chains and economies as well. DLA is the buyer for wholesale system stock, intended to support DOD customers and private industry vendor base, which produce DOD weapon system consumable spare parts. To that end, the contractual agreement between buyer and seller has a tangible outcome: the delivery of the material contracted for. Our research is based on the intent that on-time delivery of material is the cornerstone of equilibrium within DLA's supply chain.

H. SUMMARY

This chapter included a review of existing literature on spare parts and related contracting methods. We presented an overview of how spare parts support the reliability and sustainability of weapon systems. Further, this chapter presented other studies that influence the methods by which our research has been conducted. The next chapter examines the research methodology and provides details into how our research was conducted.

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III. RESEARCH METHODOLOGY

A. INTRODUCTION

In this chapter we cover the research methodology utilized to analyze and respond to our research questions posed in the first chapter. We explain the source of the data, provide an overview of the data, and discuss the methodology employed.

B. OVERVIEW OF THE DATA

This research explored potential relationships between Contract Value, Contract Quantity, and Awarding Office and the effect on the Delta in Delivery Date. Given DLA L&M and DLA Aviation spheres of influence, managing a combined 4.2 million spare parts, they were an ideal source of data to explore these potential relationships.

1. Data Source

The data source was provided in whole by the Office of the Chief of DLA Acquisition Programs within DLA Headquarters. During the period of January 2017 to May 2022 DLA L&M and DLA Aviation closed 490,826 contracts valued at $4.1 billion displayed in Figure 8. These contracts are critical to the proper functioning of the DLA wholesale supply chain. Consequently, the support that DLA L&M and DLA Aviation provide to the joint warfighter is critical to readiness as well. During the period reviewed, 24.4% of total contracts delivered after the contracted delivery date.

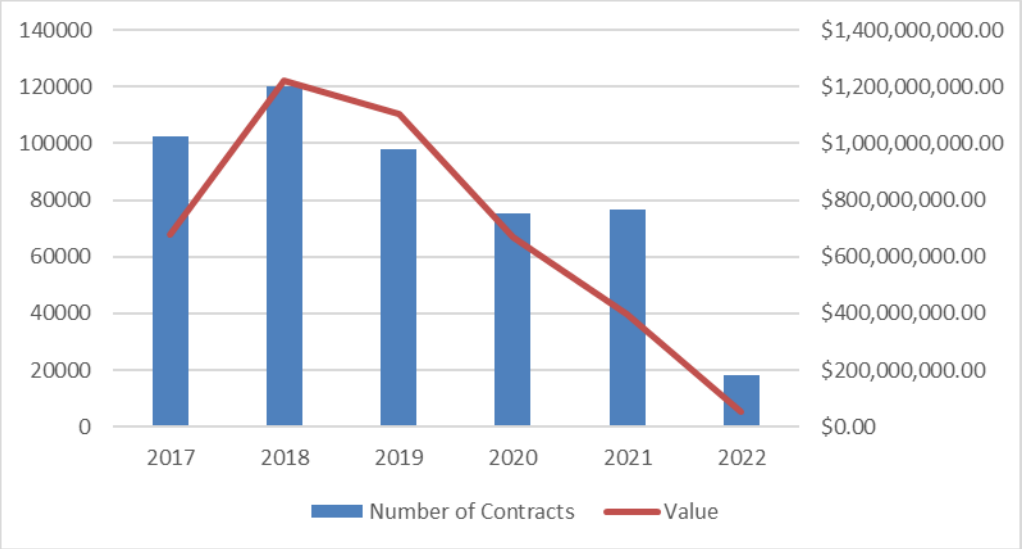

Figure 8. Contracts Closed by DLA L&M and DLA Aviation

2. Data Description

The data provided by DLA encompassed 490,826 closed contracts from 3 January 2017 to 9 May 2022. The data set included 25 unique Department of Defense Activity Address Codes (DODAACs) which awarded contracts (i.e. Awarding Offices). The DODAAC is "a six-character, alpha-numeric code that uniquely identifies a unit, activity, or organization within the Department of Defense Activity Address Directory (DODAAD)," an interactive, relational database serving as a single authoritative source of identification, routing, and address information (Defense Logistics Agency, 2014, p. C2-2). The awarding DODAAC, Parent Agency, Awarding Office Nomenclature, and Numbers of Observations by DODAAC are displayed below in Table 1.

Table 1. DODAAC List

Awarding DODAAC	Parent Agency	Awarding Office Nomenclature	Number of Observations
SPE4A0	DLA Aviation	BSM	5,415
SPE4A1	DLA Aviation	AVIATION SUPPLY CHAIN	2,510
SPE4A2*	DLA Aviation	ASC SMSG DIV SPECIAL ACQUISITION	22
SPE4A4	DLA Aviation	SUPPLIER OP SUPPLIER SPT DIV	30,972
SPE4A5	DLA Aviation	ASC SUPPLIER OPER OEM DIVISION	14,504
SPE4A6	DLA Aviation	ASC COMMODITIES DIVISION	114,160
SPE4A7	DLA Aviation	ASC SUPPLIER OPER AE AND AF DIV	15,923
SPE4A8*	DLA Aviation	ASC INDUSTRIAL PLANT EQUIPMENT	150
SPE4A9*	DLA Aviation	ASC PUBLIC MFR	1
SPE4AC	DLA Aviation	CCAD DETACHMENT	123
SPE4AK*	DLA Aviation	SO ASC SMSG DIV P R BRANCH KITTING	14
SPE4AL	DLA Aviation	LANGLEY AIR FORCE BASE DETACHMENT	418
SPE4AN	DLA Aviation	NAS NORFOLK DETACHMENT	265
SPE4AX*	DLA Aviation	SMSG AVIATION SUP CH CORPORATE LTC	91

SPE7M0	DLA L&M	MARITIME SUPPLY CHAIN ESOC BUYS	52,905
SPE7M1	DLA L&M	MARITIME SUPPLY CHAIN	58,840
SPE7M2	DLA L&M	ELECTRICAL DEVICES DIV	10,417
SPE7M3	DLA L&M	FLUID HANDLING DIV	26,932
SPE7M4	DLA L&M	FLUID HANDLING DIV	25,110
SPE7M5	DLA L&M	ACTIVE DEVICES DIV	56,554
SPE7M7*	DLA L&M	CONNECTORS DIV	1
SPE7M8	DLA L&M	ELECTRICAL DEVICES DIV	14,704
SPE7M9	DLA L&M	ELECTRICAL DEVICES DIV	3,479
SPE7MC	DLA L&M	MARITIME HARDWARE/ ELECTRICAL	57,286
SPE7MX*	DLA L&M	LAND SUPPLIER OPERATIONS SMSG	30

After reviewing the spreadsheet, we noted erroneous data, Awarding Offices with insufficient observations for comparison, or items ordered without an NSN for which we were unable to identify the item received by DLA. Following our review, 1,845 observations were removed, and 488,981 observations remained as the data set used in the ANOVA analysis. The quantity of observations, and their basis for removal are provided in Table 2 and Table 3. An asterisk (*) was placed in the 'Awarding DODAAC' column of Table 1 to denote DODAACs that were removed due to insufficient contract actions, which we defined as less than 100 closed contracts, during the timeframe analyzed, which resulted in 18 distinct DODAACs remaining for our analysis.

Table 2. Contracts Removed for ANOVA Testing

Basis of Removal	**Quantity of Contracts Removed**
Erroneous Dates in Contract Data	121
Quantity Received = 0	215
Non-NSN Items	1,315
Inadequate Contract Actions	194
Total Contracts Removed (ANOVA)	1,845

Further, for our regression analysis of Contract Value, we removed an additional 81 contracts due to zero total dollar value input, as seen in Table 3. This was not required for our ANOVA tests that were solely focused on the outcome variable of delivery delta heterogeneity across offices.

Table 3. Contracts Removed for Regression Analysis

Basis of Removal	**Quantity of Contracts Removed**
Total Contracts Removed (ANOVA)	1,845
$0.00 Value Contracts	81
Total Contracts Removed (Regression)	1,926

After removal of erroneous data, 488,981 closed contract actions remained as part of the data analysis for ANOVA testing, and 488,900 closed contract actions remained as part of the data analysis for regression testing.

C. METHODOLOGY

In this section, we described our data, looked deeper into the data set, and discussed the methodologies utilized to analyze the data.

1. Variable Description

Our research had one outcome, or dependent variable, which was Delta in Delivery Date. This was the difference in number of days between the date identified by the contracting office that the contract was to deliver by and the actual delivery date. The dependent variable is continuous and given in number of days from zero, with zero defined as a contract which delivered exactly on the contracted delivery date. The further from zero in either the positive or negative direction corresponded with earlier or later delivery, respectively.

Our research had three independent variables – Awarding Office, Contract Quantity, and Contract Value. Awarding Office was a categorical variable used for ANOVA analysis. Contract Quantity and Contract Value were used in our regression analysis. Our discrete variable, Contract Quantity, was treated as continuous for purposes of our research as we experienced 5,330 discrete levels of observation of quantity ordered from 1 to 800,000 each. Contract Value was continuous in our data.

D. SUMMARY

This chapter provided insight into the data set used to conduct our research. The chapter began with an overview of the data, described the data source, and the methodology we used for our analysis. The next chapter presents the analysis and results of the research.

IV. ANALYSIS

A. INTRODUCTION

This chapter discusses the results and analysis of our multiple regression and ANOVA testing, beginning with assumption testing to ensure we are able to draw conclusions from our results.

B. MULTIPLE REGRESSION ANALYSIS

We began our analysis by running a multiple regression in order to determine if the Delta in Delivery Date can be predicted based on Contract Quantity or Contract Value. Our intent was to determine how much of the variance of our dependent variable, the Delta in Delivery Date, was based on Contract Quantity and/or Contract Value.

1. Assumption Testing

First, we ensured our data was normally distributed as shown below in Figure 9.

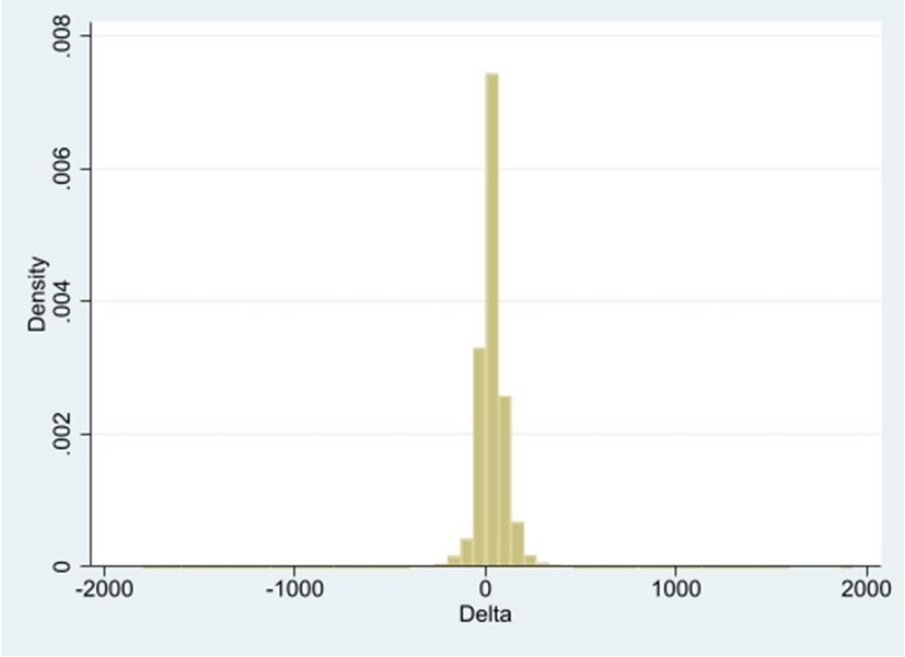

Figure 9. Distribution of Observations of the Delta in Delivery Dates, n=488,981

Next, we tested the linear relationship between Delta in Delivery Date and Contract Quantity as well as Delta in Delivery Date and Contract Value, as seen in Figure 10. To stabilize the variance in the independent variable, Contract Value, we log transformed the data. Finally, we checked for multicollinearity and had previously removed any significant outliers as discussed in the previous chapter. Controlling for outliers had no impact on our findings.

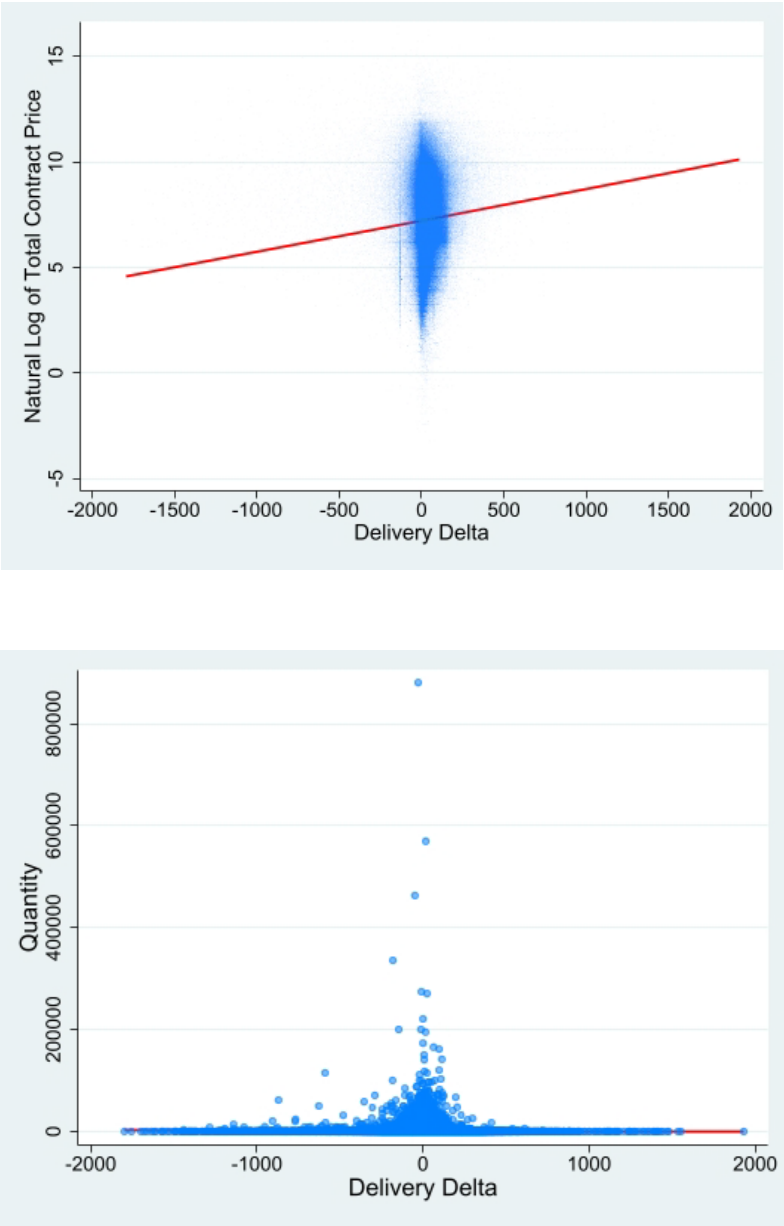

Figure 10. Linear Regression of Contract Value and Contract Quantity

2. Multiple Regression Results

A multiple regression was run to predict Delta in Delivery Date from Contract Quantity and Contract Value. Surprisingly, utilizing Contract Quantity and Contract Value as independent variables produced no significant findings; $F(2, 488897) = 158.75$, $R^2 = .0006$. We found that our independent variables do not explain the variability of Delta in Delivery Date. Disappointedly, our regression testing showed there is no influence on Delta in Delivery Date by our independent variables. Notably, however, Figure 10 shows that there is more disparity in the Delta in Delivery Date as the Contract Quantity decreases, and vice versa. This means that as the Contract Quantity increases, the delivery date as set in the contract may be more reliable. However, Contract Quantity is not a driver of Delta in Delivery Date. Next, we looked at our third independent variable, Awarding Office, through ANOVA testing.

C. ANOVA TESTING

We tested our final independent variable, Awarding Office, utilizing ANOVA, to determine whether the mean of Delta in Delivery Date is the same across the 18 Awarding Offices.

1. Assumption Testing

First, we ensured that our dependent variable, Delta in Delivery Date, is a continuous variable measured in days. Our independent variable, Awarding Office, consisted of 18 categorical, related groups. Significant outliers had been previously removed as discussed in Chapter III. Finally, we ensured that the distribution of Delta in Delivery Date was approximately normally distributed.

2. ANOVA Results

We ran a one-way repeated measures ANOVA on 18 Awarding Offices to determine if there was any difference in Delta in Delivery Date, depicted in Figure 11. The results showed that there is an overall difference between the Awarding Offices and elicited statistically significant differences in mean Delta in Delivery Date; $F(17, 488963)$, $p < 0.05$. P-value is less than the significance value of 0.05, meaning we

rejected the null hypothesis and concluded that there were statistically significant differences in the mean of the Delta in Delivery Date between Awarding Offices.

We followed the ANOVA testing with a post hoc test, utilizing Tukey's honestly significant difference test (HSD). The Tukey HSD pairwise test told us exactly where the difference in the means of Delta in Delivery Date between Awarding Offices lie, comparing all pairs of means amongst all Awarding Offices. Of the 153 pairwise comparisons between Ordering Offices, 75 had confidence intervals that included zero, meaning there is a possibility that there is no difference in the means between Ordering Offices. The remaining 78 observations showed a difference in mean Delta in Delivery Dates, as seen in Appendix A. These observations had a confidence interval that did not include zero, therefore we concluded there was a significant difference in mean Delta in Delivery Date between these offices. While we were able to observe differences in Delta in Delivery Date between Awarding Offices, we could not ascertain the root cause based on the data provided by DLA. As such, we turned to an industry best practice and analyzed the data set further based on the PMI Suppliers' Delivery Index.

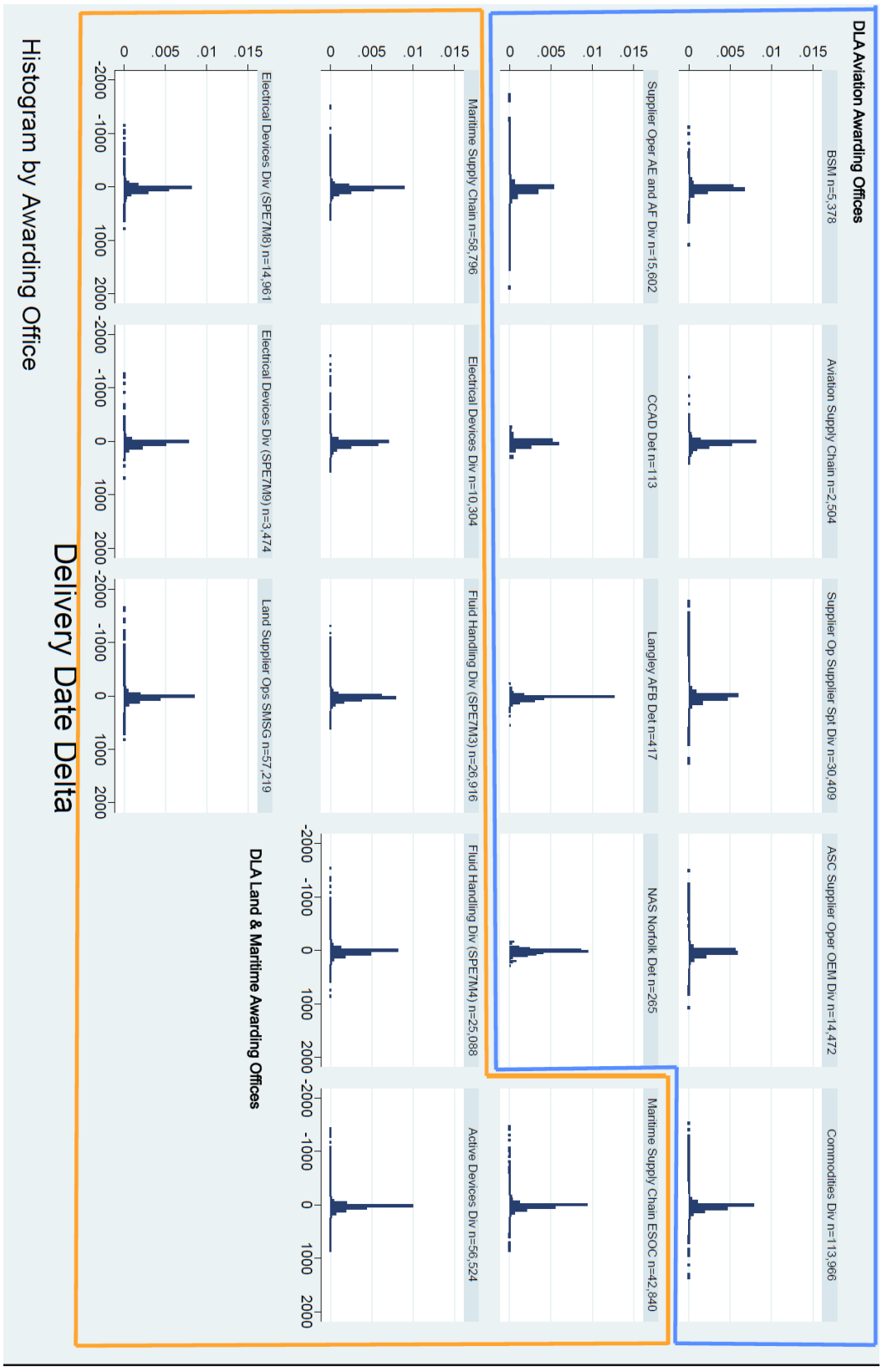

Figure 11. Awarding Office Delta in Delivery Date Histograms

D. PMI TESTING

Unsatisfied with the results from the regression and ANOVA testing, we chose to apply a novel approach to the data based on our literature review. PMI Suppliers' Delivery Index is a metric used by corporations to evaluate the performance of on-time delivery rates by their suppliers. The data they utilize is based on survey results and can be subject to human error in recall. Our index is based on raw data extracted from DLA's system of record for contract data. For the purpose of our study, we applied the same values to the delivery data as used in industry - '0' for late deliveries, '0.5' for on-time deliveries, and '1' for early deliveries. Utilizing this method, we were able to track DLA's performance compared to the industry average as shown in Figure 12 below. This showed that while DLA struggled with the on-time delivery of their contracts, they continuously outperformed industry averages.

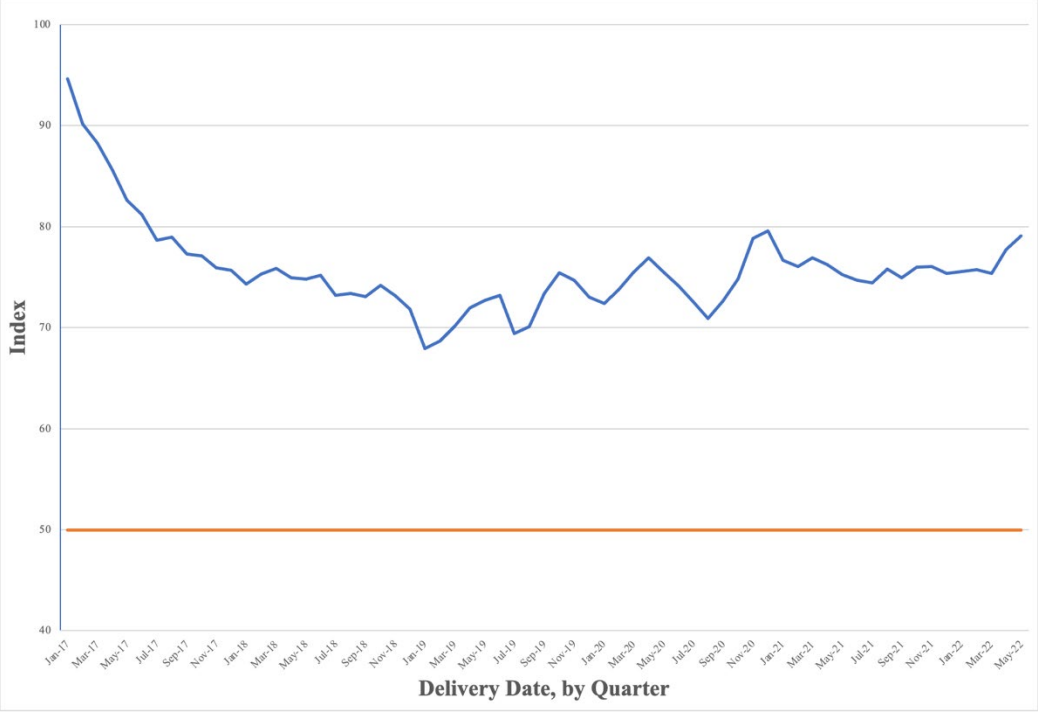

Figure 12. PMI Supplier's Delivery Index DLA L&M and DLA Aviation

We then created a heat map of PMI Suppliers' Delivery Index by Awarding Office, Figure 13, which highlights trends and differences between Awarding Offices which cannot be explained by the data provided. The heat map is displayed as an across office analysis from 2017 though 2022, with red denoting the worst performing index and green connotating the better performing index based on the PMI Suppliers' Delivery Index model. Of note, the data for calendar year 2022 is only comprised of data from January to May.

Ordering Office	2017	2018	2019	2020	2021	2022
SPE4A0	77.38	68.01	78.39	81.03	78.35	82.04
SPE4A1	78.48	71.51	77.59	78.66	80.34	86.80
SPE4A4	71.28	67.02	70.97	76.79	79.44	80.73
SPE4A5	78.40	76.54	75.61	76.27	78.55	87.24
SPE4A6	75.89	72.38	75.32	76.26	76.34	87.63
SPE4A7	73.20	68.83	72.72	78.01	79.97	89.83
SPE4AC	79.41	86.36	68.75	61.11	100.00	No Data
SPE4AL	84.62	74.21	78.65	81.43	78.57	81.40
SPE4AN	84.38	67.74	76.79	67.57	64.00	66.67
SPE7M0	70.56	68.31	71.83	72.09	72.46	79.67
SPE7M1	78.26	73.71	76.27	78.36	78.81	88.91
SPE7M2	77.86	71.85	81.11	81.80	83.14	90.37
SPE7M3	72.43	72.62	77.28	78.54	78.54	88.93
SPE7M4	70.31	69.56	72.82	75.70	73.88	91.78
SPE7M5	77.76	72.63	76.58	79.80	79.95	87.89
SPE7M8	77.38	75.21	76.73	77.81	76.82	94.68
SPE7M9	78.33	76.17	75.74	74.61	74.76	91.22
SPE7MC	74.80	71.45	73.24	77.10	76.84	88.57

Figure 13. PMI Suppliers' Delivery Index by DLA Awarding Office

As shown in Figure 14, we applied the PMI Suppliers' Delivery Index to our data set from DLA for the period of January 1, 2017 through December 31, 2021. We selected a higher performing Awarding Office and plotted it against a lower performing Awarding

Office, as well as the average of all Awarding Offices. This allowed us to see the performance trend over time and how the performance trend stood against the average of Awarding Offices' performance.

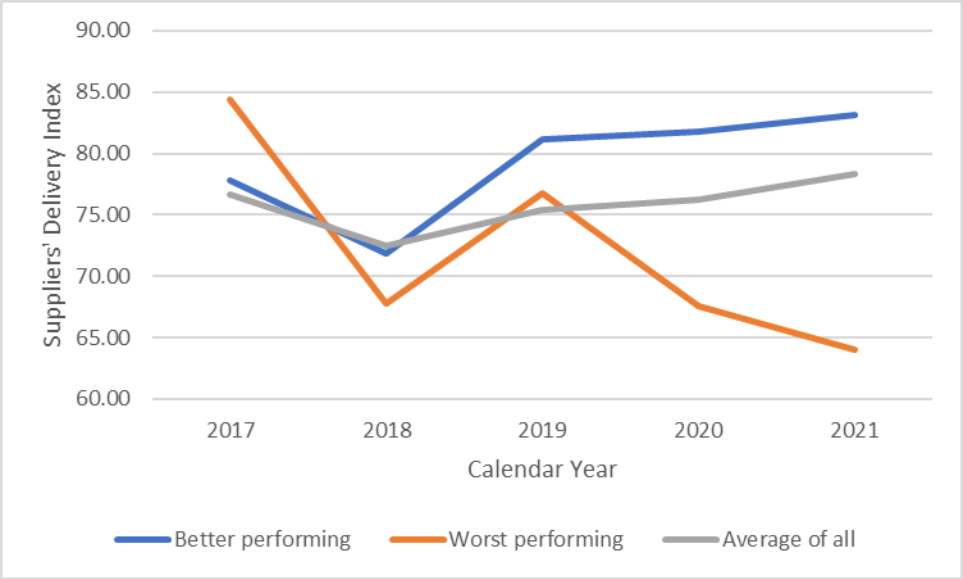

Figure 14. Comparison of Awarding Offices applying PMI Suppliers' Delivery Index

E. SUMMARY

This chapter provided the results of our analysis. We conducted assumption testing on our data to ensure we could correctly draw conclusions from the results, then performed regression analysis and an ANOVA test. The regression was inconclusive in our search for correlation between our variables. The ANOVA test showed that differences lie in the means of Delta in Delivery Date between Awarding Offices. In order to further present the data, we utilized the PMI Suppliers' Delivery Index as discussed in the Literature Review and applied it to our dataset, giving DLA insight into variances between Awarding Offices. The final chapter includes a summary of the research, conclusions, and areas for further research.

V. CONCLUSIONS, RECOMMENDATIONS, AND AREAS OF FURTHER RESEARCH

This chapter summarizes our research, provides the answers to our research questions, and provides our recommendations for areas of further research.

A. INTRODUCTION

Our research was based on a very simple concept: understanding what causes a vendor to deliver on-time. As students of acquisition management, we decided to look at this concept and tailored our research from a procurement contracting aspect. Our primary research question was what contract variables impacted, the on-time delivery of DLA L&M and DLA Aviation spare parts? We also asked secondary questions about the correlation between the variables of Contract Value and Contract Quantity and their impact on delivery, then looked at the differences in on-time delivery rates across the Awarding Offices. We partnered with DLA who provided a breadth of data to assist us in answering our research questions.

Our research questions led us to conduct a literature review on the subject of repair parts inventory management, contracting practices, the importance of contract quantity, price, and delivery date. Within the literature review we also looked at other studies within the acquisition management body of research that used models to predict contractual outcomes. The literature review led us to apply our research via three different methods. First, we utilized a regression model with Contract Value and Contract Quantity as our independent variables and used the Delta in Delivery Date as the dependent variable. We then conducted an ANOVA test by looking at the different Awarding Offices and determined there is much disparity between the performance of each Awarding Office when compared vis-à-vis the difference between on-time delivery rates. Lastly, the results of the ANOVA testing led us to create an index based on the PMI Suppliers' Delivery Index using the data provided from DLA.

B. FINDINGS AND CONCLUSIONS

From our research, we noted the below findings and conclusions:

Research Question #1: What contract variables noticeably affect the on-time delivery of DLA L&M and DLA Aviation spare part contracts?

Finding: Through our review of pertinent literature, we found that Contract Value, Contract Quantity, and the Awarding Office could have a possible impact on the outcome variable of Delta in Delivery Date.

Conclusion: While no strong correlation between the variables tested and on-time delivery existed, utilizing ANOVA we visualized a difference in the means of Delta in Delivery Date between Awarding Offices across DLA L&M and DLA Aviation. We were unable to determine a quantitative variable that elicited these differences but believe there may be one or more qualitative factors that drove the disparities between Awarding Offices.

Research Question #2: Does Contract Value or Contract Quantity have any correlation with the amount of time a spare parts contract delivered earlier than promised, on-time, or after the promised date?

Finding: There was no explicit relationship between the independent variables of Contract Quantity or Contract Value, and the dependent variable of Delta in Delivery Date.

Conclusion: While we were unable to find a strong correlation between Contract Value or Contract Quantity to Delta in Delivery Date, we were able to identify a weak correlation that showed as Contract Quantity increased, the reliability of the original contracted delivery date also increased, and vice versa.

First, the existence of a correlation, however weak, does show us that there may be another, untested variable related to the Contract Quantity that could be driving the correlation (for instance, frequency or length of time between orders). These additional variables could be tested by other researchers. Second, the increased reliance on original contract delivery date as Contract Quantity increases should be studied as it could impact

DLA's ordering strategy moving forward, putting more effort into batch ordering vice processing individual orders as they are received.

Our research did not yield the exact reason why there isn't a strong correlation between our test variables. However, there are numerous external factors that affect the performance of a given vendor or contract and ultimately the on-time delivery. Some examples of those factors are vendor performance, vendor supply chain issues, sub-contractor management, shipping and transportation delays, et cetera. These factors are above and beyond the decisions made by the contracting team and may represent an area of further research. Although we can't explain why a strong correlation doesn't exist between Contract Value, Contract Quantity, and Delta in Delivery Date, these are the types of external factors that could have affected the on-time delivery of the contract.

Another factor that could explain the late delivery of a spares contract is the agreed upon delivery date in the base contract was inaccurate. Often this date is proposed by the vendor and may only be an estimate of the time needed to deliver the promised spare(s). One area that our research did not look was at contract modifications. Researchers may want to look deeper into these contracts to determine if the delivery date in the base contract changed as the result of a modification to the contract.

Research Question #3: Is there a relationship between the different Awarding Offices and the amount of time a spare part contract delivered earlier than promised, on-time, or after the promised date?

Finding: We found that there was statistically significant variance in the mean of Delta in Delivery Date between Awarding Offices.

Conclusion: We showed that the Awarding Office had an impact on the Delta in Delivery of spare part contracts. Unfortunately, we were not able to tease out the cause of this impact based on the data provided by DLA and it remains an area for further research.

C. RECOMMENDATIONS AND AREAS OF FURTHER RESEARCH

1. Further Data Required to Analyze Delivery Delays

We uncovered many unknowns and were unable to discern a specific driver for delivery delays. There are a host of other variables that could be valuable to study if the data was collected and easily retrievable. To uncover this, we recommend DLA develop a method by which to record or annotate via their systems of record additional data points in order for others to conduct analysis. Examples, and our rationale for selecting these variables, are listed below.

1. Competition or sole source information. We believe that by annotating if each contract record was solicited under a full and open competition or if it was determined to be a sole source procurement would provide insight into the impacts of competition or lack thereof. By easily being able to discern if the contract was competed or not, researchers would be able to quickly assess if competition between vendors has any impact on the outcome variable of Delta of Delivery Date.

2. FAR provisions utilized. We also feel it would be insightful to know if FAR Part 12 – Commercial Acquisition Procedures, FAR Part 15– Contracting by Negotiation, or FAR Part 14 – Sealed Bidding were utilized. Further research in this area could inform DLA and researchers which acquisition strategies impacted the outcome variable of Delta of Delivery Date. An example of this could be assessing whether the use of FAR Part 12, implemented to streamline the contracting process and free up industry to quickly respond to government requirements, affects the outcome variable of Delta of Delivery Date.

3. Availability of Certified Cost and Pricing Data. In our Literature Review, we noted that GAO studied the impacts of DLA contracting officers facing challenges to attain cost and pricing data from vendors. In line with that study, we feel that having this information available to decision makers and researchers would help determine the impacts of having this

information and a potential relationship with the outcome variable of Delta of Delivery Date.

2. Conduct Organizational Behavior Study

Conduct an internal organizational behavioral study to map processes amongst awarding offices to document any potential efficiencies or otherwise. There are many human factors that need to be accounted for in the Pre-Award and Award phases of the contract that we believe impacted the differences in awarding office performance. These differences and areas of further research could include studying overall workload, workforce experience, manning, et cetera. Our research was conducted on a strictly quantitative basis and aimed to remove any human biases out of the process.

3. Utilization of PMI Suppliers' Delivery Index Method to Measure Performance

Utilize a metric, such as the PMI Suppliers' Delivery Index, to compare on-time delivery rates across awarding offices. This can further be broken down by supplier or timeframe, and easily compared to other industry standards and indexes. This type of data could be translated into a dashboard and provide unique trend analysis to inform decision makers. It should be mentioned that any formulation of a new dashboard product should be implemented with applicable training on utilization and interpretation of the information it provides.

As an example, by utilizing this metric to track suppliers' delivery time data, we pulled one of DLA's COI vendors, Boeing, Inc., and compared them to the whole of DLA's index across our dataset, as seen in Figure 15. In 26 of the 65 total months of data we gathered, or 40%, Boeing, Inc. has an index higher than that of all of DLA's suppliers. Conversely, 60% of the time Boeing, Inc. operates at a lower index than all of DLA's suppliers. Also, by comparing Figure 15 to Figure 6, we saw that during roughly 4 quarters between 2018 and 2019, Boeing, Inc. operates below the industry average as reported by PMI.

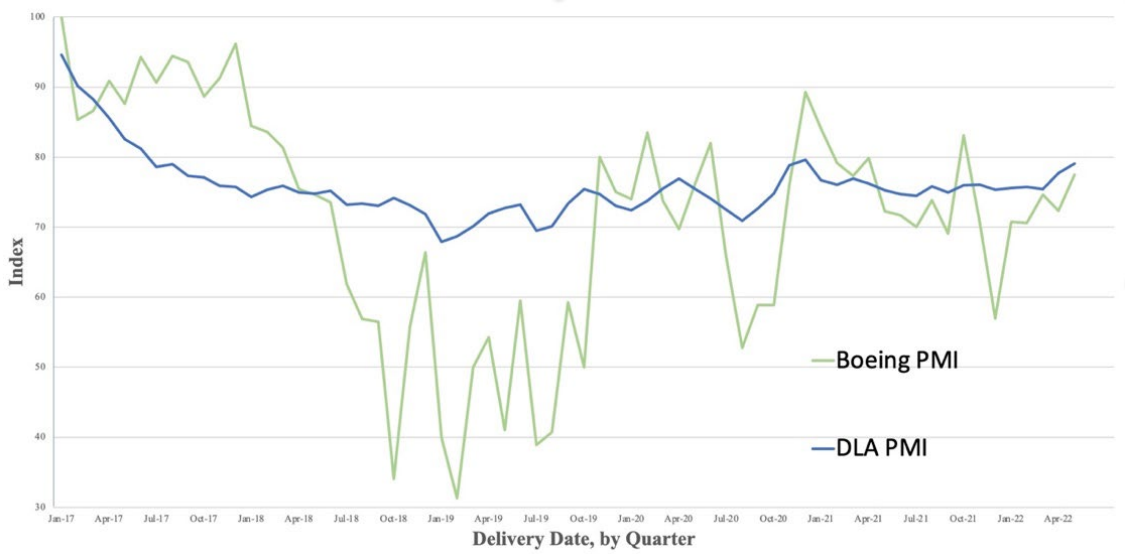

Figure 15. Boeing PMI vs. DLA PMI

Of note, we were unable to verify that all contracts in our dataset with 'Boeing' in the 'Vendor Name' field were part of DLA's COI program. One of the limitations we faced with utilizing this index is that we do not have the raw industry data to reconstruct their index and accurately compare it to our data. Moving forward, DLA could acquire the raw data and have accurate month-to-month comparisons.

D. SUMMARY

Health of the DOD industrial base and supply chains are of upmost concern of senior defense officials. Additionally, through the COVID-19 pandemic we have become familiar with the impacts of strained supply chains throughout the private sector. While our study did not show that the variables we tested had an overwhelming correlation with on-time vendor delivery, there is merit to continued research about this important subject.

We provided substantive areas for future researchers, logisticians, and contracting officers to focus in on and further explore the drivers of delays in spare part procurement contracts. We believe that leveraging the PMI Suppliers' Delivery Index as a tool in assessing vendor performance would aid in DOD supply chain organizations management of its industrial base.

The COVID pandemic highlighted the current vulnerability of global supply chains. With the on-time delivery of spare part contracts making up the cornerstone of DLA's mission, it is critical for contracting professionals to have insight into vendors on-time delivery rates. This insight would help contracting professionals anticipate issues related to vendors' ability of meeting on-time delivery, take appropriate actions, and, in turn, better support the warfighter.

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APPENDIX.

A. TUKEY TEST DATA

Ordering Offices			Confidence Interval (95%)	
SPE7M0	vs	SPE4A7	-22.55381	-17.31326
SPE4A4	vs	SPE4A1	-22.47836	-10.52052
SPE7M0	vs	SPE4A1	-21.9173	-10.15414
SPE7M4	vs	SPE4A7	-18.67959	-12.8154
SPE7M4	vs	SPE4A1	-17.87665	-5.822718
SPE7M4	vs	SPE7M2	-17.75922	-11.0294
SPE7M0	vs	SPE4A5	-16.14851	-10.75246
SPE7M5	vs	SPE4A7	-15.07766	-9.876184
SPE7M5	vs	SPE4A1	-14.45202	-2.706211
SPE7M5	vs	SPE7M2	-14.20421	-8.043268
SPE7M9	vs	SPE4A7	-14.14273	-3.352618
SPE7M3	vs	SPE4A7	-13.92566	-8.138328
SPE7M3	vs	SPE4A1	-13.14255	-1.12582
SPE7M9	vs	SPE7M2	-13.03648	-1.752497
SPE7M3	vs	SPE7M2	-13.01029	-6.347329
SPE7M4	vs	SPE7M1	-12.5818	-8.244519
SPE7M4	vs	SPE4A5	-12.26623	-6.262671
SPE7MC	vs	SPE4A7	-12.10282	-6.908177
SPE7M0	vs	SPE4A6	-11.94608	-8.919001
SPE7MC	vs	SPE7M2	-11.2299	-5.074728
SPE4A4	vs	SPE4A0	-10.22386	-1.715647
SPE7M0	vs	SPE4A0	-9.622216	-1.389859
SPE7M5	vs	SPE7M1	-8.836599	-5.448582
SPE7M8	vs	SPE4A7	-8.799555	-2.187406

Ordering Offices			Confidence Interval (95%)	
SPE7M5	vs	SPE4A5	-8.672934	-3.314824
SPE7M4	vs	SPE4A6	-8.252029	-4.240976
SPE7M1	vs	SPE4A7	-7.924168	-2.744495
SPE7M8	vs	SPE7M2	-7.835645	-0.44495
SPE7M3	vs	SPE7M1	-7.814057	-3.581267
SPE7M3	vs	SPE4A5	-7.513203	-1.584697
SPE7M4	vs	SPE7M3	-7.239197	-2.191801
SPE7MC	vs	SPE7M8	-6.67186	-1.352172
SPE7MC	vs	SPE7M1	-5.85992	-2.48241
SPE7MC	vs	SPE4A5	-5.69819	-0.3467175
SPE4A6	vs	SPE4A5	-5.555638	-0.4802547
SPE7M5	vs	SPE4A6	-4.455391	-1.496474
SPE4AL	vs	SPE4A4	0.2256907	28.58377
SPE7MC	vs	SPE4A0	0.8203952	9.0236
SPE7M2	vs	SPE7M1	0.9098755	7.052422
SPE4A6	vs	SPE4A0	0.9135933	8.939416
SPE7M5	vs	SPE7M4	1.088921	5.452219
SPE7MC	vs	SPE7M5	1.265999	4.676852
SPE7M2	vs	SPE4A5	1.423057	8.836663
SPE7M8	vs	SPE4A6	1.486579	6.528439
SPE7M9	vs	SPE7M4	1.793824	12.20581
SPE7M4	vs	SPE7M0	1.981135	6.390943
SPE7M4	vs	SPE4A4	2.19698	7.102534
SPE7M8	vs	SPE7M3	2.588597	8.488428
SPE7M1	vs	SPE4A6	2.706449	5.626867
SPE4A7	vs	SPE4A5	3.164169	9.801917
SPE4A5	vs	SPE4A0	3.351849	12.53705

Ordering Offices			Confidence Interval (95%)	
SPE4A1	vs	SPE4A0	3.572269	17.4871
SPE7MC	vs	SPE7M4	4.064423	8.419568
SPE7M8	vs	SPE7M5	4.320259	9.646624
SPE7M8	vs	SPE4A0	4.350652	13.51738
SPE7M1	vs	SPE4A0	4.996295	13.19003
SPE7M2	vs	SPE4A6	5.189454	11.10616
SPE7M5	vs	SPE7M0	5.716419	9.1968
SPE7M5	vs	SPE4A4	5.875144	9.96551
SPE7M9	vs	SPE7M0	6.148889	16.22283
SPE7M9	vs	SPE4A4	6.499278	16.79987
SPE7M3	vs	SPE7M0	6.748001	11.05508
SPE7M3	vs	SPE4A4	6.95855	11.77196
SPE4A7	vs	SPE4A6	7.04612	11.95586
SPE7M8	vs	SPE7M4	7.26639	13.24163
SPE7M2	vs	SPE4A0	8.236547	17.91208
SPE7MC	vs	SPE7M0	8.692959	12.16311
SPE7MC	vs	SPE4A4	8.850919	12.93259
SPE4A6	vs	SPE4A4	9.040103	12.75242
SPE4A7	vs	SPE4A0	9.880132	18.97486
SPE4A5	vs	SPE4A4	11.0101	16.81832
SPE7M8	vs	SPE7M0	11.75779	17.12232
SPE7M8	vs	SPE4A4	12.01429	17.79324
SPE7M1	vs	SPE7M0	12.87535	16.32305
SPE7M1	vs	SPE4A4	13.03162	17.09422
SPE7M2	vs	SPE7M0	15.48336	21.67733
SPE7M2	vs	SPE4A4	15.76598	22.32215
SPE4A7	vs	SPE4A4	17.56523	23.22927

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