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The Effect of Company Financial Health on the Likelihood of Cost Overruns

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THESIS

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Abstract

Financial ratio analysis has long been used to determine the financial health of firms and project business performance. Despite the usefulness of financial ratio analysis, risk analysis in defense acquisitions largely ignores these indicators of company financial well-being. This research performs contingency table statistical analysis to determine if a relationship exists between company financial ratios and their future cost performance on Air Force contracts. The general findings are that poor financial ratios at the time of contract start are related to increased likelihood of cost overruns on that contract. Specifically, recent trends of a company's current ratio in comparison to the long-term average current ratio of that company are especially linked with the Cost Performance Index (CPI). The results of this research justify further exploration into financial ratio analysis of offering companies as a means to better assess the cost overrun risk of DoD programs.

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I. Introduction

Background

Historically, the Air Force has been inaccurate when assessing risk of major defense acquisition programs. This assessment inadequacy is evidenced by a sustained record of cost and schedule growth (Lorell, Leonard, & Doll, 2015; U.S. Government Accountability Office, 2019; Younossi, et al., 2007). A cost growth occurs when the final cost of a project is larger than its initial budget. Cost growth can be due to many possible reasons, which include major requirement changes, inaccurate or overly optimistic cost estimates, and poor management decisions (Bolten, Leonard, Arena, Younossi, & Sollinger, 2008). A subset of cost growth, cost overruns occur when the actual cost of the completed work is larger than the budget for the completed work (Christensen & Gordon, 1998). Government cost estimators and acquisition professionals use their experiences and many tools and procedures to mitigate the likelihood of cost overruns throughout the acquisition process. Even so, there is clear room for improvement. With government spending eclipsing 682 billion dollars on federal contracting in 2020 (BGOV200 - Federal Industry Leaders, 2021), it is vital to find better ways to identify program risk.

Choosing an offeror to fulfill a Request for Proposal (RFP) is an extremely important factor in the quality of product received as well as the ability to stay within the budget and schedule timeline. This is called the source selection process, and it entails reviewing proposals to determine which company can best fulfill the stated requirements—i.e., performance, cost, and schedule objectives. Technical risk, past performance, and small business participation

concerns also contribute to the source selection evaluation and decision process (Department of Defense Source Selection Procedures, 2011). Additionally, personal informal influential factors--such as relevant past experience with a contractor and personal evaluations of previous work—have been shown to play a large role in source selections (Blevins, 2005). While all of this information is beneficial in selecting the best offeror to fulfill a contract, perhaps a new risk measure – company financial health - could be implemented to capture another source of risk that comes from selecting a particular offering company. This research does not aim to create or implement a new risk metric; instead, it intends to serve as the initial exploration into whether there is statistical evidence to support performing company financial health analysis before the start of a contract.

Currently, the only financial consideration or requirement listed in the Federal Acquisition Regulation (FAR) with regard to source selection is that the company "have adequate financial resources to perform the contract, or the ability to obtain them" (9.104-1 [a]). This lack of financial consideration could result in an oversight of available information that could influence the likelihood of a successful acquisition. Not only could available financial information be implemented in source selection, but perhaps also in the DoD cost estimation process. Although each cost estimate is unique, the overarching process is not (DoD Cost Estimating Guide, 2020). This process could incorporate some method of company financial analysis as a metric to better assess potential costs and capture uncertainty in the various stages of the DoD cost estimation.

The theory driving this analysis is the idea that a company may take on more risk and bid lower than they otherwise would on a contract during times of financial distress in order to receive an influx of cash flows to retain employees, suppliers, and creditors. This theory is

corroborated by evidence in Austrian construction procurements, where markups of winning bids were shown to decrease by 3.3 percentage points during an economic crisis (Gugler, Weichselbaumer, & Zulehner, 2015). Although the Austrian study analyzes a market-wide economic crisis rather than individual company financial health, there are parallels to be drawn. The idea analogous to DoD contracts is that smaller markups result in lower bid prices, which then lead to an increase in cost overruns. Furthermore, cost overruns could be more likely to occur from companies in poor financial health if they are unable put the proper resources towards the contracts they are performing. This inability to employ adequate resources (employees, equipment, suppliers, and even subcontractors) could come from an inability to match salary or pay for limited resources in a bidding environment.

Some public-private partnerships and some units within the Air Force consider financial health through financial ratios when reviewing companies to fulfill their contracts (Zhang, 2005; Overman & Williams, 2021). Despite this use, a thorough examination of previous research has revealed that no efforts have been undertaken to determine if company financial health is a factor in DoD contract performance. Considerable research has been performed detailing the predictive abilities of certain financial ratios and their value in assessing company health. Additionally, researchers have thoroughly assessed which characteristics of DoD programs and contracts indicate higher likelihoods of going over budget. However, no one has merged these two ideas to see if financial ratios of a company could lead to a higher or lower likelihood of going over budget.

Problem Statement

A poor record of programs meeting cost targets may indicate an inadequate assessment of risk. One possible area that is being overlooked is the specific financial risk associated with the

company performing the contract. This effort is an exploratory analysis to determine if it could be useful to incorporate financial health through the use of financial ratios as an additional risk metric in DoD Acquisitions.

Research Questions

1. To what extent is the financial health of the contracted company at the time of contract start correlated with the cost performance of that contract?
2. Which financial ratios are the most strongly correlated with contract cost performance?
3. What time periods best represent the current financial health of a company?
4. What are the proper benchmarks to use for comparison to recent financial ratios?

Methodology

The methodology being employed in this research is contingency table analysis. Data for cost performance on Air Force programs is drawn from the Earned Value Management Central Repository (EVM-CR). Historical financial statements are obtained from Yahoo Finance, which are then used to calculate historical financial ratios. Categorical variables are created using the data drawn from these two sources. The two-way contingency table analysis will test for dependence of these categorical variables. In other words, dependence implies that there is a statistical relationship between the categorical variables of cost performance (through CPI) and financial health (through financial ratios).

Limitations

This research has a variety of limitations. One of these is the availability of data. Only large contracts are analyzed due to the availability of cost performance data. Furthermore, viewing only cost performance as the measure of a successful effort leaves out both schedule and

quality targets (Nicholas & Steyn, 2017). Additionally, only publicly traded companies are included due to the availability of financial statements from which ratios can be calculated.

In regard to the theory of this research, there is a hesitancy to claim that the financial ratios of an entire company would tangibly and noticeably affect their cost performance on individual efforts within contracts. The amount of uncertainty in each contract due to complexity, cost estimating techniques, outside influences, requirement changes, and more may lead to the notion that company-wide financial ratios may be uncorrelated with performance. To elaborate, the lack of inclusion of some of these variables, along with not controlling for some other factors such as length of the contract and size of the contract, may confound the true relationship.

Finally, there is a limitation in the method used. Two-way contingency table analysis requires setting breakpoints and categorizing variables into one of two categories. This sometimes results in separating variables that are very close in absolute value into two separate categories. It also does not draw distinction between variables that are very bad (or good) and those that are only slightly bad (or good).

Expected Contributions

This research aims to be exploratory analysis of whether it could be useful to further analyze company financial ratios at the time of contract start. Correlations are expected to be drawn between financial ratios at the time of contract start and cost overruns of those contracts. Acquisition professionals could then use these results to perform their own analysis and better inform their decisions. Future research could use these correlations to determine which ratios and time periods should further be analyzed and included in models to better predict the likelihood of cost overruns and contract success in general. Ultimately, those models could then be tailored to

develop risk metrics for DoD acquisitions, either in the source selection or cost estimation process.

Preview

Chapter 2 of this thesis will be a review of relevant literature. This will include discussion on financial ratios, factors currently shown to influence cost overruns in DoD programs, and earned value management. Chapter 3 will describe the data and methodology used in this research. Chapter 4 will show the results of the statistical analysis and discuss the implications of the findings. Lastly, chapter 5 will answer the research questions and offer recommendations for future research. The thesis will conclude with a synopsis of the overall findings and the significance of this research.

II. Literature Review

Chapter Overview

The purpose of this chapter is to define financial ratios and their ability to predict and assess risk for a company. Previous research will be analyzed to provide insight into which financial ratio categories and individual ratios best identify financial risk. Then, there will be discussion on how financial ratios are currently being used in project source selection and the Air Force, along with some of the limitations of financial ratio analysis. Next, previous research detailing which aspects of programs result in higher likelihood of poor performance will be explored. Finally, the Earned Value Management System (EVMS) will be examined and the usefulness of Cost Performance Index (CPI) as a measure of contract performance will be discussed.

Financial Ratios

When assessing a firm's performance, publicly available financial information is often used to analyze a company's value, health, and risk. More specifically, these indications of financial health and risk are calculated as ratios that measure the relationship between two or more components of a company's financial statements. Financial ratios are used by banks, managers, and investors alike to assess the ability of a company to repay debts, evaluate and regulate business performance, and project future performance (Barnes, 1987).

Although there is not complete consensus, it is generally agreed that financial ratios lie within 4 basic categories: liquidity, efficiency, solvency, and profitability. Liquidity ratios have long been used as the key considerations in assessing eligibility for a loan or general creditworthiness (Lemke, 1970). Efficiency ratios are commonly scrutinized by managers to

assess how effectively their firm is utilizing their assets (Schmidgall & DeFranco, 2016). Solvency ratios are used by managers and potential creditors alike to assess financial stability, long term debt-paying capacity, and whether a restructuring of debt may be necessary (Simlai & Guha, 2019). Profitability ratios are often seen as a good measure of company performance, demonstrating the firm's ability to generate earnings against cost (Bordeianu, 2020). Summaries of these categories, as well as some examples of commonly use ratios are provided in Table 1 (Reale, 2011).

Table 1: Financial Ratio Categories and Common Ratio Equations

Financial Ratio Categories	Examples
Liquidity – Ability to meet short-term obligations, or cash available for immediate use	**Current Ratio** = $\frac{Current\ Assets}{Current\ Liabilties}$
	Quick Ratio = $\frac{Current\ Assets - Inventories}{Current\ Liabilties}$
	Operating Cash Flow Ratio = $\frac{Operating\ Cash\ Flow}{Current\ Liabilties}$
	Cash Flow to Debt = $\frac{EBITDA^{*}}{Total\ Debt}$
Efficiency (Turnover) – Ability to meet short and long-term obligations, or how effectively a firm is turning over inventory and accounts receivable.	**Accounts-receivable Turnover** = $\frac{Net\ Credit\ Sales}{Average\ Accounts\ Receivable}$
	Inventory Turnover = $\frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}$
Solvency (Leverage) – Ability to meet long-term obligations	**Debt to Equity** = $\frac{Total\ Debt}{Total\ Equity}$
	Debt to Assets = $\frac{Total\ Debt}{Total\ Assets}$
Profitability – Ability to generate a profit	**Return on Assets** = $\frac{Net\ Income}{Total\ Assets}$
	Return on Equity = $\frac{Net\ Income}{Shareholder's\ Equity}$

** Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) is often used as a proxy to measure cash flow for a given period.*

An important note for this research is that many financial ratios attempt to incorporate cash flows. Earnings before interest, taxes, depreciation, and amortization (EBITDA) and earnings before interest and taxes (EBIT) are two commonly used proxies for cash flows. EBITDA is typically viewed as a useful proxy for cash flows when capital expenditures are low, as depreciation and amortizations are insubstantial (Iotti & Bonazzi, 2012). EBIT may be more

appropriate for companies that have higher capital expenditures, as these expenditures (that are represented by depreciation and amortization) are necessary to run the company and thus more accurately represent usable cash flows. However, the main criticism of EBIT is that depreciation accounting methods are often viewed as discretionary and capital expenditures can be unevenly represented in corresponding time periods. In fact, EBITDA has been shown to be a better metric than EBIT in explaining stock prices and market value of companies (Nissim, 2019). Nonetheless, this research will specify throughout which measure (EBITDA or EBIT) is being used as the proxy for cash flow.

Financial ratios can be a quick and effective means of identifying trends within a company and making comparisons to other companies within an industry. Additionally, ratios (as opposed to interval values) are often used in financial analysis as they control for the size of the firms being compared. Considerable research has used these ratios to assess financial health.

Financial Ratios to Predict Company Failure

First, liquidity and solvency financial ratios in particular have long been shown to consistently help predict the likelihood of company failure. As early as 1942, the current ratios of failed firms were determined to be lower than those of the industry as a whole (Merwin, 1942). Decades later, Beaver (1966) was among the first to develop an effective model using multiple financial ratios as variables to predict company failure. Company failure in this model is defined as either bankruptcy, a bond default, an overdrawn bank account, or a nonpayment of a preferred stock dividend. He found that cash flow (EBITDA) to debt and debt to assets were the among most useful ratios to predict company failure. While this model was most effective in the year immediately preceding failure, it showed predictive ability up to 5 years prior to failure.

Since Beaver in 1966, countless other models have been developed that corroborate the utility of using financial ratios to predict company failure. In viewing just bankruptcy as the measure for failure, Altman (1968) developed a multiple discriminant analysis model that included significant ratios such as working capital to assets and cash flow (EBIT) to assets. Later, a logit regression model to predict bankruptcy was created using data from more than 2000 firms, resulting in significant ratios such as liabilities to assets and net income to assets (Ohlson, 1980). In addition to industry effects, Chava and Jarrow (2004) incorporated financial ratios such as cash flow (EBIT) to assets and the current ratio to predict bankruptcy of U.S. firms. Ciampi and Gordini (2008) successfully predicted loan defaults of 1,000 small Italian manufacturing firms using financial ratios including debt to equity, quick ratio, and cash flow (EBIT) to assets. Five years later, Zeytinoglu and Akarim (2013) found that equity to assets and working capital to assets were significant variables in a model to predict bankruptcy or liquidation of firms traded on the Istanbul Stock Exchange. Most recently, Heba and Chlebus (2020) developed a logistic regression model to predict bankruptcy using 109,000 Polish firms and found that equity to current liabilities and the current ratio were among the most significant financial ratios. These models are summarized in Table 2.

Table 2: Highlights of Research Using Financial Ratios to Predict Company Failure

Researcher(s) (Year)	Failure Definition	Statistical Method	Data Years and Data Set	Most Significant Ratios
Beaver (1966)	Bankruptcy, bond default, overdrawn bank account, or nonpayment of a preferred stock dividend	Univariate Discriminant Analysis with a Paired-sample Design	1954-1964 79 failed firms and 79 non-failed firms	- EBITDA/ Debt - Net Income/ Assets - Debt/ Assets - Working Capital/ Assets - Current Ratio
Altman (1968)	Bankruptcy	Multiple Discriminant Analysis	1946-1965 33 failed manufacturing firms and 33 non-failed manufacturing firms	- Working capital/ Assets - Retained Earnings/ Assets - EBIT/ Assets - Equity/ Debt - Sales/ Assets
Ohlson (1980)	Bankruptcy	Logit Regression	1970-1976 105 bankrupt firms and 2058 non-bankrupt firms	- Liabilities/ Assets - Net Income/ Assets - Working Capital/ Assets
Chava & Jarrow (2004)	Bankruptcy	Logistic Regression	1962-1999 1461 bankrupt U.S. firms	- EBIT/ Assets - Current Ratio - Net Income/ Assets - Working Capital/ Assets - Debt/ Assets
Ciampi & Gordini (2008)	Loan Defaults	Multiple Discriminant Analysis and Logistic Regression	2001-2005 1,000 Small Italian manufacturing firms	- Debt/ Equity - Quick Ratio - EBIT/Assets - Net Profit/ Equity - Bank Loans/ Turnover
Zeytinoglu & Akarim (2013)	Bankruptcy or Liquidation	Discriminant Analysis	2009-2011 115 firms traded on the Istanbul Stock Exchange	- Equity/ Assets - Working Capital/ Assets
Heba & Chlebus (2020)	Bankruptcy	Logistic Regression	2010-2019 109,000 Polish firms	- Profit Before Taxation/ Current Liabilities - Equity/ Current Liabilities - Current Ratio - Cash/Current Liabilities

Working Capital = Current Assets – Current Liabilities

It is important to note that the models outlined in Table 2 are just a few examples of the numerous research efforts using financial ratios to predict company failure undertaken over the last eighty years. The models in Table 2 were chosen because they represent the breadth of the research as a whole. The research not included in Table 2 found some combination of the same significant ratios using similar failure definitions and statistical methods, albeit over varying time periods, industries, and countries (Deakin, 1972; Blum, 1974; Elam, 1975; Libby, 1975; Shumway, 2001; Tinoco & Wilson, 2013; Charalambous, Martzoukos, & Taoushianis, 2020).

Despite the variety of ratios found to be significant in modeling company failure, there are still some overarching themes that can be drawn from this research. Various liquidity and solvency ratios are prevalent in these models, as opposed to efficiency and profitability ratios. This intuitively makes sense as poor liquidity and solvency ratios indicate increased likelihood of inability to pay liabilities which could lead to bankruptcy or loan defaults (Mossman, Bell, Swartz, & Turtle, 1998). EBITDA and EBIT as proxies for cash flow are consistently included in ratios that are found to be significant. Current assets and current liabilities are also often part of the ratio calculation–e.g., working capital, quick ratios, and current ratios. Total assets are often used as denominators in significant ratios. The ratios that are most commonly significant include current ratio, quick ratio, debt to assets, EBITDA to assets, EBITDA to debt, and working capital to assets. While the likelihood of company failure is only tangentially related to the desired outcome of this research, insight into which financial ratios generally signal company health provides a good starting point to consider including in contract performance analysis.

Note, financial ratio analysis can lead to considerable confusion due to the large number of candidate variables that can be derived from financial statements. Also contributing to this confusion is the lack of standardization—e.g., some variables and ratios go by multiple names or

use slight variations in how they are calculated. Similarly, some variables and ratios attempt to measure the same characteristic of a company but do so in slightly different ways. This effect is amplified over time as financial analysis evolves and standards change (Beaver & McNichols, 2005). Evidence of this complexity can be seen in the variety of significant ratios found throughout the research conducted on failure prediction in Table 2. Additionally, research shows that many financial ratios are correlated, even ratios within different categories. These correlations found throughout research are discussed in the following section.

Financial Ratio Correlation and Impact on Program Quality, Profitability, and Competitiveness

Financial ratios have not only been used to predict company bankruptcy, but they have also been utilized as indicators of future success. Dakic et al. (2020) performed a regression analysis in an attempt to model factors of business success using various financial ratios. This research used panel data on the food processing industry in the Republic of Serbia from 2007-2015 and used company profitability as the dependent variable as a proxy of business success. The financial ratios that were found to be statistically significant included quick ratio, debt ratio, and capital turnover ratio. Other research has shown that the cash flow to debt ratio is effective in indicating future returns on capital employed (Fadel & Parkinson, 1978). In recent research using data from 2015-2018, liquidity ratios such as the current ratio and operating cash flow ratio were shown to be connected to the competitiveness of defense industry enterprises (Antczak, Horzela, & Nowakowska-Krystman, 2021). Using share price as the measure of performance, the return on assets ratio, the total asset turnover ratio, and the current ratio were found to be

significant when analyzing Malaysian consumer industry companies from 2004-2019 (Hashim, 2020).

Further research has been conducted linking financial ratios to one another, as well as future business success. Profitability ratios were shown to be the most significant variables to explain performance (through operating income margin) of publicly traded manufacturing companies from 2012 to 2016 (Baranes, Palas, Shnaider, & Yosef, 2021). This is seemingly obvious; profitability ratios that represent relative measures of earnings are going to have the closest association with the earnings themselves. It is important to note that liquidity and solvency ratios were also significant variables in this model (Baranes, Palas, Shnaider, & Yosef, 2021). Erdoğan, Erdoğan, and Ömürbek (2015) used panel data to analyze continuously traded companies in Istanbul between 2002-2013. Using net profit margin as the dependent variable as a proxy for corporate performance, they found that the previous year's current ratio, debt to asset ratio, and corporate size to be the significant independent variables. Research analyzing family farms has shown correlation between liquidity and profitability ratios, using the current ratio to measure liquidity and return on assets to measure profitability (Bereznicka, 2014).

In the realm of nonprofit health and human service organizations, Bunger et al. (2019) showed that better financial health was a significant indicator of program quality. However, it is important to note that better financial health in this study was indicated by revenue, operating reserve, and markup rate (analogous to operating margin in for-profit firms). Furthermore, program quality in the study was operationalized by using an organizational survey that resulted in analysis of the quality in the organizations' structure, processes, and demographics.

Current Use of Financial Ratios in Source Selection or the Air Force

In the realm of source selection methodology, public-private partnerships in international infrastructure development have long used financial evaluation as a criterion. Zhang (2005) gathered worldwide public-private partnership expert opinions through a structured questionnaire survey. The expert opinions of that survey indicated that the financial evaluation package was the most important; more so than technical, environmental, and managerial evaluations of proposals. Out of the 35 criteria within the financial evaluation package, "financial strength of the participants in the project company" and equity to debt ratio were ranked as the sixth and ninth most important criteria according to the public sector. These criteria fell behind others such as "sound financial analysis," net present value, and "total investment schedule." In contrast to this research's empirical analysis, Zhang's (2005) study merely reflects expert opinion and relative importance of contractor financial health. Additionally, Zhang (2005) mentions that public-private partnerships are often more long-term and involve contracts that contain more uncertainty, risk, and overall complications than "traditional design-bid-build contracts" (p. 631). Despite these differences, the value of reviewing financial strength of potential contractors in the source selection phase should not continue to be overlooked by DoD contractors.

Some units within the Air Force Material Command do see the benefit in analyzing profitability, liquidity, and solvency ratios of their commonly contracted companies to indicate any red flags. For example, the Air Force Life Cycle Management Center published a Corporate Financial Health Assessment as a critical acquisition decision support tool (Overman & Williams, 2021). This report shows that some units consider financial health of contractors, albeit without any objectively actionable metrics. Perhaps a reason for this lack of defined

metrics is that no empirical analysis has been completed to demonstrate that these ratios are actually indicative of how well a company may perform on a given contract.

Financial Ratio Analysis Weaknesses

It is important to identify potential weaknesses and pitfalls in performing financial ratio analysis. As previously mentioned, ratios are used in financial analysis to control for size and allow for direct comparisons both over time and between different companies. Some studies and researchers have argued that size may not be properly controlled due to a lack of strict proportionality between the two financial variables used in some financial ratios (Lev & Sunder, 1979; Taffler & Sudarsanam, 1995). Yet, others have shown that accounting for the differences in industry explains most of the departure from proportionality (Fieldsend et al., 1987). Furthermore, it has been demonstrated that differences in financial ratios are related to the particular industry and that subindustry group ratio averages can effectively help evaluate firm performance (Gupta, 1969; Gupta & Huefner, 1972). Others disagree however, and claim that using subindustry ratio averages based on similar firms within the same industry may not be valid or useful in evaluating firm performance (Cowen & Hoffer, 1982). Despite the contradicting findings, using an industry average as a benchmark should be included in any financial analysis; however, a benchmark calculated using historical data from the same company may be a better comparision metric.

Some other issues of using company financial ratios include determing which ratios to analyze. As mentioned previously, the number of possible variables and ratios is large. Additionally, there is redundancy in many of the over 65 accounting ratios commonly in use (Chen & Shimerda, 1981), leading many researchers to question which financial ratios are the most useful while reducing the effects of correlation between variables (Pindado & Rodrigues,

2004). In fact, this redundancy can be so severe as to make determing which ratios to use impossible by reason alone (Barnes, 1987). Regardless of the difficulty in choosing the most appropriate ratios, previous research has shown that there are still clear benefits to performing analysis on company financial ratios.

Factors Currently Shown to Influence Cost Growth and Schedule Overruns in DoD Programs

So far, this literature review has focused on the usefulness of financial ratios. The other half of this statistical analysis is focused on influences on contract performance. Numerous studies have been undertaken in an attempt to determine which factors of programs and contracts drive schedule and/or cost growth. However, none of these studies have examined the financial health of the contracted company at the time of contract start. Hastings and Joseph (2020) used ANOVA (Analysis of Variance) and logistic regression to determine the likelihood of schedule slips based on various features of Major Defense Acquisition Programs (MDAPs). They concluded that mean schedule slip and the odds of schedule slip were different based on acquisition program baseline (APB) phase, commodity type, milestone category type, and service type. The GAO (2019) published an annual assessment that determined that demonstrating critical technologies before starting development, completing a preliminary design review prior to starting development, and releasing at least 90% of design drawings by critical design review led to significantly lower cost and schedule growth. It has also been shown that longer programs are more likely to experience cost growth, while electronics programs tend to have lower cost growth (Arena, et al., 2006). Furthermore, programs are more likely to show cost growth at completion compared to while in-process (Arena, et al., 2006). Viewing 35 mature

DoD programs, Bolten et al. (2008) found that more than two-thirds of cost growth is attributable to decisions such as quantity changes, additional requirements, and schedule changes. Errors such as cost estimate errors account for the other third cost growth instances.

Trudelle et al. (2017) performed logistic regression techniques in an attempt to estimate an acquisition program's likelihood of exceeding cost and schedule estimates. They found that electronic system programs, extremely large programs, programs procuring smaller quantities of units, and programs with shorter schedules experience smaller percentages of cost growth and schedule slippage (Trudelle et al., 2017). Their findings indicated that the company selected for the contract did not affect the chances of cost growth. This may suggest that the financial wellness of the selected contractor then has no impact on the chances of success. However, Trudelle et al. (2017) only analyzed 49 Department of Defense programs and did not differentiate based on any financial aspects of the companies evaluated over different time periods. This research focuses on cost overruns instead of the more general cost growth, explores a broader data set, and analyzes the specific financial health of the contracted companies at the time of contract start.

As discussed above, most of the research conducted with regards to predicting the likelihood of cost or schedule growth has been considering factors internal to the program. Some research, however, has viewed broader political and economic variables. The amount of raw funding and changes in defense acquisition reform policy have been found to be statistically significant predictor variables of schedule slips (Jimenez, et al., 2016; Brown, et al., 2015). Certain acquisition reforms, as well as whether the United States is in a time of war have been shown to both exacerbate and reduce cost growth (Ritschel, 2014; Smirnoff & Hicks, 2008). Increases in real gross domestic product and the number of lobbyists decrease cost growth

(Ritschel, 2014), while funding instability and unexpected inflation have been shown to increase cost growth (Smirnoff & Hicks, 2008). Cost growth is also shown to be more common in bust phases of DoD funding. Competition for funds is more intense in these bust phases, which provides project managers incentives to propose unrealistic and optimistic baselines (McNicol, 2020).

Most of the above-mentioned research utilized Selected Acquisition Reports (SARs) as their database and typically view performance at a program level, taking all components of cost growth into account (Cancian, 2010). Earned Value Management (EVM) data, on the other hand, can be used to specifically track and calculate schedule and cost overruns (a subset of cost growth) on specific contracts within programs. This research will be using Cost Performance Index (CPI) to analyze cost overruns as the proxy for contract performance. The following section discusses EVM and CPI in detail.

EVM and CPI

The Earned Value Management System (EVMS) is a set of management and accounting procedures that originated in the DoD in the 1960s. This system has since been used to provide closer control over projects and better assess project performance, allowing for meaningful comparisons between planned and completed work (Christensen D. S., The Costs and Benefits of the Earned Value Management Process, 1998; Shannon, 2018; Abba, 2017). Components of the EVMS involve tracking the completed work packages against the Performance Measurement Baseline (PMB) budgets. The value of the completed work in terms of this PMB budget is the earned value metric, otherwise known as the Budgeted Cost of Work Performed (BCWP) (DAU, 2020). The Actual Cost of Work Performed (ACWP) is the cost actually incurred while

accomplishing the work performed over a given period (Department of Defense, 2019). From these two components, cost variance and CPI can be calculated. Cost variance is simply BCWP minus ACWP, whereas CPI is BCWP divided by ACWP. Anytime the BCPW is less than the ACWP, the project has a negative cost variance and a CPI of less than one. This instance, as demonstrated in Figure 1, indicates that there has been cost overruns and the project is over budget.

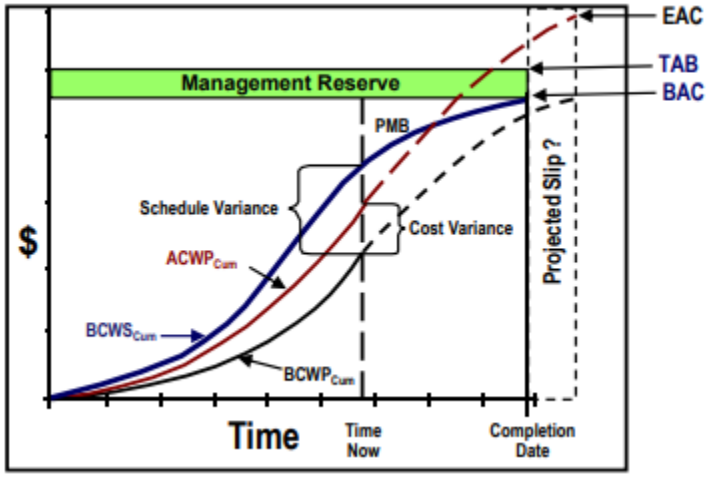

Figure 1: EVM Cost Variance Calculation for Overbudget Project (DAU, 2012)

The EVMS is prominently implemented in DoD; as of 2020, EVM is required on contracts with 18 months or greater period of performance and exceed $20M in work scope (DoD Instruction 5000.02: Operation of the Adaptive Acquisition Framework, 2020). The EVMS is intended to objectively measure performance of a program, putting into account practices that are typically beyond or different to the earned value methods that a company may typically perform. These added requirements on the contracted company result in a marginal cost increase of 0.43% to 1.63% of the contract cost (Lampkin , 1992). Because of the cost and difficulty of implementing the EVMS, it is typically employed on cost reimbursable or incentive

contracts, rather than fixed price contracts (DoD Instruction 5000.02: Operation of the Adaptive Acquisition Framework, 2020).

There are some clear limitations in using the EVMS. This research will omit analyzing the potential impact financial ratios have on schedule performance due to the limitations of the Schedule Performance Index (SPI). Even though both CPI and SPI are often seen as the best indicators of whether a project is deviating from the initial plan (de Koning & Vanhoucke, 2016; Kim, 2009), SPI becomes an ineffective measure of performance towards the end of a project. SPI fails to provide good information towards the final 1/3 of a project, as it converges to a value of 1, regardless of whether the project is being completed on time (Lipke, 2003). With regard to CPI specifically, it is important to note that it is capturing only cost properties of a project, forgoing schedule and technical performance aspects.

Despite the added costs of implementing the EVMS and the limitations of the metrics, there are clear benefits as well. The main benefits are summarized in Table 3.

Table 3: Ten Benefits of EVMS (Christensen, 1998)

1. A single management control system providing reliable data
2. The integration of work, schedule, and cost using a Work Breakdown Structure
3. A database of completed projects useful for comparative analysis
4. The cumulative Cost Performance Index as an early warning signal
5. The Schedule Performance Index as an early warning signal
6. The Cost Performance Index as a predictor for the final cost of the project
7. An index-based method to forecast the final cost of the project
8. The To-complete performance index to evaluate the forecasted final cost
9. The periodic (e.g., weekly or monthly) Cost Performance Index as a benchmark
10. The management by exception principle can reduce information overload

The most relevant benefit to this research effort listed in Table 3 is the availability of performance data on completed projects. Chapter 3 includes a discussion on the database used to

perform this analysis. Although not explicitly listed in Table 3, implied is the idea that CPI is a valuable metric for detailing performance on a contract and whether or not the government has to pay more than the originally estimated cost. Because of this, CPI will be used in this research as the measure of cost overrun to operationalize contract cost performance.

Summary

Financial ratios have long been effective measures of a company's financial health; if extreme compared to historical levels or to industry averages, ratios can exhibit when a company does not have liquid assets to pay current liabilities, is not effectively using assets to generate profits, has taken on too much long-term debt, or many other indications of well-being. Research has corroborated these ideas, illustrating the predictive ability of financial ratios. Liquidity and solvency ratios have consistently been shown to help predict the likelihood of company failure. Financial ratios are also effective variables to predict future company success as measured by proxies such as profit margin, share price, program quality, and more.

Despite the lack of research showing that financial ratios are predictive of how well a company will perform on a contract, they are occasionally still considered. For example, financial ratios are currently being used as evaluation criteria in public-private partnerships in international infrastructure development. Additionally, some units within the Air Force also review commonly contracted companies' financial ratios as a decision support tool. This review of financial ratios shows the belief in the importance of financial ratios as a measure of risk in selecting companies in poor financial health, even though no research has specified the relationship between financial ratios and performance on contracts.

Considerable research has been conducted to determine which factors in DoD contracts and programs increase cost growth. Longer programs, non-electronic system programs, and

programs with initial higher technology readiness levels are just some of the internal aspects of programs that increase the likelihood of cost growth. Some external factors that increase the likelihood of cost growth include funding instability, unexpected inflation, and acquisition reforms, to name a few; however, company financial health has not yet been analyzed in detail. Finally, the difference between cost growth (in increase the final cost compared to its initial budget) and cost overruns (an increase in the actual cost of the completed work compared to the budget for the completed work) is highlighted. Cost overruns are the focus of this research, which is encapsulated by using CPI to operationalize cost performance.

III. Methodology

Chapter Overview

The intent of this chapter is to provide a description of the data and methodology of this research. The purpose of this research is to determine if the financial health of the contracted company at the time of contract start is related to cost performance on that contract. The means to complete this objective is contingency table analysis. The financial ratios used to assess financial health are discussed, along with specific efforts to prepare the data for this type of analysis.

Data

Contract performance data for this research was obtained through the EVM-CR. The EVM-CR is a database managed by the Integrated Program Management (IPM) division of the Office of Acquisition Data and Analytics. Programs with IPM reporting requirements on their contract are required to submit their EVM data to the EVM-CR. As of 2020, EVM is required on contracts with 18 months or greater period of performance and exceed $20M in work scope (DoD Instruction 5000.02: Operation of the Adaptive Acquisition Framework, 2020). EVM data in this database is maintained at the Contract Line-Item Number (CLIN) level, which are useful in defining deliverables or organizing information about deliverables (FAR § [4.10], 2021). CLINs are referred to as “efforts” in the terminology of the EVM-CR. Updated EVM data on each effort are added monthly. All Air Force programs and contracts with any data in the EVM-CR were initially included in this analysis. Only Air Force programs were included in this analysis due to the initial limited scope of this research. Future research could look at other branches or all DoD data, which may be useful given that previous research has shown that there

are not statistically significant differences in cost growth among the services (Trudelle et al, 2017; Younossi, et al., 2007).

The financial data from companies in this analysis was obtained from Yahoo Finance. Yahoo Finance contains historical data of both quarterly and annual financial statements (income statement, balance sheet, and cash flow statement) from all publicly traded companies. These financial statements were then used to calculate both quarterly and yearly historical financial ratios for the companies with contracts within the EVM-CR. The financial ratios used in this analysis were those that were available at the time of contract start. The reason for this is due to the theory that poor financial health at the time of contract start may lead companies to accept a future risk of going over budget. Thus, this research could indicate the usefulness of financial ratios as a risk measure of contract performance in DoD acquisitions. Specifically, cost estimators or source selection officials may be able to use financial data that is available at the time of contract start to assess the likelihood of cost overruns on that contract.

Exclusion Criteria

Only efforts that are effectively complete are included in the analysis. This criterion is implemented mainly due to two reasons. First, this research is testing the theory that a company may be taking on greater risk of going over budget by bidding less than they typically would have in times of financial distress; the effect of the company accepting more risk may not be apparent in the CPI data until the end of the effort. Second, the true cost performance of the contract, and ultimately what affects the likelihood of the government overpaying, is fully realized only at the end of a contract. Previous research has shown that completed programs (compared to in-process programs) have a higher likelihood of cost growth (Arena, et al., 2006). For the function of this research, any effort with a completion percentage of 92.5% or greater is

considered complete. This definition is based on prior research which showed the final cost of a program is accurately predicted when the program is 92.5% complete (Tracy & White, 2011). Also consistent with previous research analyzing CPI (Christensen & Payne, 1992), the percentage complete was calculated by using the last available month's cumulative BCWP divided by the final Budget at Completion (BAC).

Unfortunately, only publicly traded companies have historical financial statements available. Therefore, many of the contracts that were performed by private companies had to be excluded from this analysis. Table 4 provides an overview of the exclusion criteria and the associated number of programs, contracts, and efforts that remain in the analysis. Note, the analysis was conducted at the effort level; the number of contracts and programs associated with the efforts are provided for reference purposes only.

Table 4: Dataset Exclusions

Category	Number of Efforts Removed	Remaining Efforts	Number of Contracts	Number of Programs	Number of Companies
Efforts Obtained from the EVM-CR		384	151	75	26
Company Financial Data Unavailable	57	327	125	55	10
Efforts less than 92.5% Complete	158	169	73	43	8
Final Data Set		**169**	73	43	8

Of note, 157 of the 169 efforts in the final dataset are from 4 companies: Northrop Grumman, Boeing, Lockheed Martin, and Raytheon. The 12 other efforts are from a mix of BAE

Systems, General Electric, L-3 Communications, and Leidos. There was consideration in removing BAE Systems, a British company, from the analysis due to the reporting requirement differences of non-United States companies. However, BAE Systems yearly financial ratio analysis was chosen to remain in the analysis due to the findings that the International Financial Reporting Standards are not significantly different than the US generally accepted accounting principles (Grossman, Smith, & Tervo, 2013). However, quarterly financial statements are unavailable for BAE systems. This results in the removal of the 7 efforts completed by BAE Systems for analysis when using quarterly financial ratios--leaving 162 efforts.

Of the 57 efforts removed due to being completed by private companies with unavailable financial data, almost half (26) were performed by General Atomics. These 26 efforts performed by General Atomics were contained within 7 contracts in 2 programs. An interesting note is that because unavailable financial data was the first exclusion criteria analyzed, less than 57 of the efforts were removed solely due to unavailable financial data. For example, of the 26 efforts removed due to not having financial data for General Atomics, 11 of them would have been removed regardless, due to being less than 92.5% complete None of the other 16 companies with data in the EVM-CR individually accounted for more than 5 efforts. The two public companies that did have financial data available but did not have any completed efforts were IBM and Honeywell International. Both of these companies had one Air Force effort in the EVM-CR that was less than 92.5% complete.

Financial Ratios Analyzed

Financial ratios from the liquidity category will be the main focus of this analysis. The reason for this is due to both theory and previous research. Potential problems with meeting short-term obligations (liquidity) are more likely to lead to a company taking risks to obtain cash

flows and revenues rather than long term obligations (solvency), asset turnover efficacy (efficiency), or the ability to generate a profit (profitability). Previous research [e.g., (Antczak, Horzela, & Nowakowska-Krystman, 2021; Erdoğan, Erdoğan, & Ömürbek, 2015; Bereznicka, 2014)] has shown the continued significance of liquidity ratios in predicting the short-term future bankruptcy and company success, as measured by profitability, competitiveness, share price, program quality, and more. The current ratio and the quick ratio were the most commonly used liquidity ratios for firm financial health analysis. These ratios are expected to be correlated as they have the same denominator and similar numerators; the quick ratio attempts to remove some of the less liquid assets (inventory) included in the numerator.

Liquidity ratios capturing cash flows may also be important based on theory and previous research. Because there are multiple different methods to measure cash flows, as well as possible denominators to assess them against, six different cash flow ratios were included in the analysis. The operating cash flow ratio and the cash ratio were included as a measure of available cash against the current liabilities of that period. These two ratios, respectively, are measuring further subsets of progressively more liquid assets than in the numerator of the current ratio while maintaining the same denominator. The purpose is to determine if cash and cash flow are the current assets that are most important considerations of company liquidity against short term liabilities. Additionally, the operating cash flow ratio was shown to be significantly linked to competitiveness of defense industry companies (Antczak, Horzela, & Nowakowska-Krystman, 2021). The final 4 liquidity ratios are included to measure cash flow against proxies for the size of the company. Using total assets as the denominator is a common measure of company size, while using total debt allows for cash flow comparison to long-term liabilities. The two ratios that use EBITDA as a proxy for cash flows were included due to their prevalence in the

literature. EBITDA to assets was particularly common. Finally, the two ratios that use free cash flow in the numerator were included to take advantage of some nuanced accounting methods that may be able to capture cash flow better than EBITDA.

Lastly, the most prominently used solvency ratio and profitability ratio in previous research were included. These were included due to some research showing connection between these ratios and future success, as well as a thoroughness check. Debt to assets ratio is a good indicator of total liabilities of a company to its assets and was shown to be significant predictors of future bankruptcy (Beaver, 1966) and profit margin (Erdoğan, Erdoğan, & Ömürbek, 2015). Return on assets has long been one of the most commonly used measure of profitability and operating performance. This is consistent for the defense industry (Department of Defense, 1985; Zhong & Gribbin, 2009) and non-defense industry companies (Brown & Caylor, 2008). All of the ratios included in the analysis are shown in Table 5.

Table 5: Financial Ratios Included in Analysis

Ratio (Equation)	**Category**
Current Ratio (Current Assets / Current Liabilities)	Liquidity Ratio
Quick Ratio ((Current Assets - Inventories) / Current Liabilities)	Liquidity Ratio
Operating Cash Flow Ratio (Operating Cash Flow / Current Liabilities)	Liquidity Ratio (Cash Flow)
Cash Ratio (Cash and Cash Equivalents / Current Liabilities)	Liquidity Ratio (Cash Flow)
EBITDA to Debt Ratio (EBITDA / Total Debt)	Liquidity Ratio (Cash Flow)
EBITDA to Asset Ratio (EBITDA / Total Assets)	Liquidity Ratio (Cash Flow)
Free Cash Flow to Debt Ratio (Free Cash Flow / Total Debt)	Liquidity Ratio (Cash Flow)
Free Cash Flow to Asset Ratio (Free Cash Flow / Total Assets)	Liquidity Ratio (Cash Flow)
Debt to Asset Ratio (Total Debt / Total Assets)	Solvency Ratio
Return on Assets (Net Income/Total Assets)	Profitability Ratio

Note, a higher value signifies better financial health for all the ratios in Table 5 except the solvency ratio. For the debt to asset ratio, lower debt in comparison to the assets that the firm has on their books signifies better health; therefore, a lower debt to asset ratio is desirable.

Contingency Table Analysis

Due to the exploratory nature of this research, it is beneficial to determine if there is a simple statistical relationship between two variables: the company financial health (as measured by financial ratios) at the time of contract start and the cost performance on that contract (as measured by CPI). This research is exploratory for many reasons. First, to the best of the researcher's knowledge, the question has never been asked before. Second, there are significant and varying time lags between the two variables. Finally, complications exist in determining a relationship between macro company level financial ratios to smaller, effort level performance. For these reasons, contingency tables are well suited to investigate this relationship.

A two-way contingency table is utilized to determine if two categorical variables are related. The chi-square distribution is used to calculate the test statistic, which can then be used to determine the significance. The significance, or p-value, will be calculated using the Pearson's chi-squared test of independence. Pearson's chi-squared test will be used due to its prevalence of use in research and the large sample size of this research that eliminates the need to use others, such as Fisher's exact test. If a statistically significant relationship exists, an odds ratio will then be calculated as a measure of association between the two variables. The odds ratio provides a quantitative measure of how much more likely an outcome is to be expected given the presence of a variable.

Because the variables in this analysis are initially continuous, methods to categorize and operationalize both CPI and the financial ratios must be developed. Generally, this

operationalization of CPI and financial ratios involves sorting them each into categories of good or bad. Ultimately, better cost performance is indicated by a higher CPI. Also, for all of the ratios used in this analysis except for the debt to asset ratio, better financial health is indicated by higher ratio values. The specific methods employed to categorize these variables is covered in the following sections.

Categorizing CPI

Categorizing CPI is simply based on whether or not there was a cost overrun. In other words, an effort with a final CPI of less than 1 has incurred a cost overrun, while an effort with a CPI of 1 or greater has been successful from a cost performance standpoint. Robustness checks of some of the most significant ratios will be completed to determine if there are inconsistencies by using slightly different CPI breakpoints. This will be completed by calculating the odds ratio of the most significant financial ratios in comparison to benchmarks at CPI breakpoints of 0.95, 0.975, 1.025, and 1.05 in addition to a CPI of 1.

Categorizing Financial Health (Point Analysis)

Categorizing financial ratio values to establish if a company is financially healthy is a much more difficult task. The purpose of categorizing the financial ratios is to establish if a ratio (and thus the company's financial status) is healthy or unhealthy at the beginning of a contract. Therefore, the financial ratio of the most recent time period at the time of contract start must be compared to a benchmark. Comparison of the single most recent (relative to the contract start date) period's financial ratio to a benchmark will be referred to as a point analysis.

The most recent period will be analyzed using both quarterly and annual data. Most previous research reviewing the relationship of financial ratios to company success use only

yearly financial ratios. Conversely, this research will also review quarterly ratios to capture time periods closer to the time of contract start. For example, if a contract were to start in December, using yearly financial ratios will establish a ratio as healthy or unhealthy based on the financials of the end of the previous year (11 months prior). In contrast, using quarterly ratios on that same contract, the ratio will be established as healthy or unhealthy based on the financial statements that concluded at the end of September (just 2 months prior). Additionally, some research has suggested that monthly (as opposed to yearly) observations of financial ratios better predict bankruptcy (Chava & Jarrow, 2004). Note, while the recency that quarterly analysis provides has benefits, there are also disadvantages. A positive ratio based on the most recent quarterly financial statements could simply be an anomaly during a longer period of financial distress. To account for this potential issue, trend analysis is conducted on quarterly data and will be discussed later.

Choosing Benchmarks for Categorizing Financial Health Variables (Point Analysis)

In addition to performing point analysis on both quarterly and yearly financial ratios, these variables must be categorized as better or worse than a benchmark. As the categorization of the variables depend on the value of the benchmark, several different values will be considered. Using an industry average is a natural first benchmark. Unfortunately, historical industry averages for the financial ratios being analyzed are unavailable; thus, proxies for industry averages were calculated and used as benchmarks. Yet, some research has argued that industry average may not be a good metric of comparison due to the uniqueness of each company (Cowen & Hoffer, 1982; Beaver & McNichols, 2005). Therefore, benchmarks were also created using historical data of the particular company that performed the effort. Here, there is no clear time

period to use to calculate a typical or average financial ratio of an individual company. For this reason, multiple historical time periods were used to calculate a benchmark for an individual company. Table 6 summarizes the benchmarks used for quarterly point analysis.

Table 6: Benchmarks for Quarterly Point Analysis

Benchmarks	Reason for comparison against the most recent quarterly financial ratio
Mean Financial Ratio of the 4 Largest Companies (In Most Recent Quarter)	Industry average proxy
Median Financial Ratio of the 4 Largest Companies (In Most Recent Quarter)	Industry average proxy (hedge against extreme values)
Mean Financial Ratio of all Companies in the Sample (In Most Recent Quarter)	Industry average robustness check
Median Financial Ratio of all Companies in the Sample (In Most Recent Quarter)	Industry average robustness check (hedge against extreme values)
Mean Quarterly Financial Ratio of Individual Company Since Data Available (Prior to the Most Recent Quarter)	Long term historical average of that company
Median Quarterly Financial Ratio of Individual Company Since Data Available (Prior to the Most Recent Quarter)	Long term historical average of that company (hedge against extreme values)
Mean Quarterly Financial Ratio of Individual Company in the 6 Quarters Prior to the Most Recent Quarter	Shorter term historical average of the individual company
Median Quarterly Financial Ratio of Individual Company in the 6 Quarters Prior to the Most Recent Quarter	Shorter term historical average of the individual company (hedge against extreme values)
Mean Quarterly Financial Ratio of Individual Company in the 2 Quarters Prior to the Most Recent Quarter	Very short-term average of the individual company

In Table 6, the highlighted benchmarks are proxies for the industry average at the time of contract start. The four largest companies (Boeing, Raytheon, Lockheed Martin, and Northrup Grumman) were chosen as the basis of the industry average proxy for two main reasons. First, the use of the largest defense contractors is less arbitrary than choosing the ones that happened to be in this sample and can be easily repeated by researchers and acquisition professionals.

Second, 157 out of the 162 efforts analyzed against quarterly ratios were completed by these four companies. Thus, the averages of the sample were included as a robustness check for the industry average benchmark.

The date range of available data used for the long-term historical average varies depending on the company, the financial ratio, and whether it was yearly or quarterly financial statements being used. Most yearly historical data generally went as far back as 1985, except for Lockheed Martin and Leidos, whose data went back to 1994 and 2003 respectively. Further details on historical data availability can be found in Table 38 in the Appendix.

Table 7 lists the benchmarks analyzed for the yearly point analysis.

Table 7: Benchmarks for Yearly Point Analysis

Benchmarks	Reason for comparison against the most recent yearly financial ratio
Mean Financial Ratio of the 4 Largest Companies (In Most Recent Year)	Industry average proxy
Median Financial Ratio of the 4 Largest Companies (In Most Recent Year)	Industry average proxy (hedge against extreme values)
Mean Financial Ratio of all Companies in the Sample (In Most Recent Year)	Industry average robustness check
Median Financial Ratio of all Companies in the Sample (In Most Recent Year)	Industry average robustness check (hedge against extreme values)
Mean Yearly Financial Ratio of Individual Company Since Data Available (Prior to Most Recent Year)	Long term historical average of that company
Median Yearly Financial Ratio of Individual Company Since Data Available (Prior to Recent Year)	Long term historical average of that company (hedge against extreme values)
Mean Yearly Financial Ratio of Individual Company in the 5 Years Prior to the Most Recent Year	Shorter term historical average of the individual company
Median Yearly Financial Ratio of Individual Company in the 5 Years Prior to the Most Recent Year	Shorter term historical average of the individual company (hedge against extreme values)
Mean Yearly Financial Ratio of Individual Company in the 2 Years Prior to the Most Recent Year	Short-term average of the individual company

Similar to the quarterly analysis, the highlighted benchmarks in Table 7 indicate the proxy measures for the industry average at the time of contract start. For the yearly analysis, 157 out of the 169 efforts analyzed were completed by the 4 largest companies. Alternatively, the non-highlighted benchmarks in Table 6 and Table 7 represent the historical average of the particular company completing the effort. These tables are very similar, but with differences in the time periods used to establish the benchmark. The time periods used to establish the benchmarks all begin with the quarter/year immediately preceding the most recent quarter/year.

Categorizing Financial Health (Trend Analysis)

The main disadvantage of point analysis is that the most recent period's financial ratio may not fully capture the financial health of the company at the time of contract start. For this reason, the averages of the financial ratio over two or more of the most recent time periods are also used. Comparison of the averages of the most recent time periods' financial ratio to a benchmark are referred to as trend analysis. In fact, longer term trend analysis of financial ratios may be the best indicator of financial health. This hypothesis is due to previous research that has shown that financial ratios can be predictors of company failure up to 5 years before a failure event (Beaver, 1966). However, the most recent years were shown to be more predictive than those 5 years out. For this reason, weighted means will be calculated to incorporate the longer trends while emphasizing the most recent time periods' ratios. Additionally, the trend analysis is conducted using the median values when more than the two most recent time periods are used. The median values are included in attempt to diminish the effect of extreme values. Median values of recent trends will need to be compared to median values of the company's historical data for benchmarks.

For trend analysis of quarterly ratios, five calculations for each ratio were used to capture the health of the company in the time leading up to the start of the contract; all of these calculations start with the quarter immediately preceding the contract start date. Table 8 summarizes these calculations.

Table 8: Calculations to Capture Recently Quarterly Trends of Financial Ratios

Mean of the 2 most recent quarters.
Weighted mean of the 2 most recent quarters. The most recent quarter was calculated as twice as important as the quarter before it (weights of $\frac{2}{3}$ and $\frac{1}{3}$ respectively).
Mean of the 6 most recent quarters.
Weighted mean of the 6 most recent quarters. The most recent quarter was weighted at $\frac{6}{21}$. The second most recent quarter was weighted at $\frac{5}{21}$. The third most recent quarter was weighted at $\frac{4}{21}$. The fourth, fifth, and sixth most recent quarters were weighted at $\frac{3}{21}$, $\frac{2}{21}$, and $\frac{1}{21}$, respectively. Thus, the quarter immediately preceding the contract start was weighted as 6 times as important as the one 6 quarters prior to contract start.
Median of the 6 most recent quarters.

Note, two and six quarters were chosen so the time period prior to contract start differs from the yearly analysis. Consider if four quarters were chosen to be the time period analyzed. For any contract that started in January through March, the average financial ratios of the preceding four quarters would equal the previous yearly financial ratio.

For the trend analysis of the yearly ratios, again five calculations for each ratio were used. These are similar to the quarterly calculations but will obviously capture longer periods of time.

Table 9: Calculations to Capture Recently Yearly Trends of Financial Ratios

Mean of the 2 most recent years.
Weighted mean of the 2 most recent years. The most recent year was calculated as twice as important as the year before it (weights of $\frac{2}{3}$ and $\frac{1}{3}$ respectively).
Mean of the 5 most recent years.
Weighted mean of the 5 most recent years. The most recent year was weighted at $\frac{5}{15}$ (or $\frac{1}{3}$). The second most recent year was weighted at $\frac{4}{15}$. The third, fourth, and fifth most recent years were weighted at $\frac{3}{15}$, $\frac{2}{15}$, and $\frac{1}{15}$, respectively. Thus, the year immediately preceding the contract start was weighted as 5 times as important as the one 5 years prior to contract start.
Median of the 5 most recent years.

Choosing Benchmarks for Categorizing Financial Health Variables (Trend Analysis)

For trend analysis, only historical data of the individual company will be used as benchmarks. The reason for this is twofold. First, as mentioned previously, research has shown that historical data of the individual company is a better benchmark due to the unique properties of each company. Second, the sheer number of contingency tables to be run including industry averages for each time period analyzed in trend analysis could make results overwhelming for this exploratory analysis. Similar to the point analysis though, the time periods used to establish the benchmarks all begin being calculated immediately preceding the time period of interest. However, the period of interest in the trend analysis is not just the preceding quarter or year, but an average of two or more of the preceding periods (as outlined in Table 8 and Table 9). Table 10 summarizes the benchmarks that will be used in the quarterly trend analysis.

Table 10: Benchmarks Used for Quarterly Trend Analysis

Mean of the company's quarterly current ratio since data available prior to the trend period being analyzed.
Mean of the company's quarterly current ratio of the 6 quarters prior to the trend period being analyzed.
Median of the company's quarterly current ratio since data available prior to the trend period being analyzed.
Median of the company's quarterly current ratio of the 6 quarters prior to the trend period being analyzed.

As a reminder, the discussion of "the trend period being analyzed" (in Table 10) are those that are listed in Table 8. Similarly, Table 11 summarizes the benchmarks to be used in the yearly trend analysis.

Table 11: Benchmarks Used for Yearly Trend Analysis

Mean of the company's yearly current ratio since data available prior to the trend period being analyzed.
Mean of the company's yearly current ratio of the 5 years prior to the trend period being analyzed.
Median of the company's yearly current ratio since data available prior to the trend period being analyzed.
Median of the company's yearly current ratio of the 5 years prior to the trend period being analyzed.

Again, the discussion of "the trend period being analyzed" (in Table 11) are those that are listed in Table 9. As previously discussed, median values were included as a means to diminish the effect of extreme values and will be used as a benchmark only for median values of the financial ratio of interest.

Hypothesis Test

Now that the categorization methods have been described, formalization of the hypotheses for contingency tables are provided. Following is the general hypothesis test for the point analysis that will be used for both quarterly and yearly time periods for each of the financial ratios:

H_o: Cost overrun/underrun is independent of the financial ratio in the most recent time period preceding contract start

H_a: Cost overrun/underrun is related to the financial ratio of the most recent time period preceding contract start

The general hypothesis test for the trend analysis that will be used for both quarterly and yearly time periods for each of the financial ratios is very similar:

H_o: Cost overrun/underrun is independent of the average financial ratio of the most recent time periods preceding contract start

H_a: Cost overrun/underrun is related to the average financial ratio of the most recent time periods preceding contract start

This analysis will be completed using an alpha of 0.05. Even though much exploratory research uses an alpha of 0.1, this research is exploratory due to the method, time lag between variables, and attempting to draw relationships between company level metrics to smaller, effort level performance. For these reasons, a higher alpha could obfuscate the results with increased chances of discussing effects such as spurious relationships. This type of relationship could be one due to an unknown factor or simply a coincidence that results in the association seen in the results. Therefore, results with a p-value of 0.05 or less will be highlighted and discussed. Odds ratios and their associated confidence intervals will also be calculated for these significant results. Odds ratios are used to quantify the likelihood that an effort which experiences a cost overrun is associated with a company that has either good or poor financial health.

Summary

This chapter described the methodological approach of this research. Contract performance data was obtained from the Earned Value Management Central Repository EVM-CR, while company financial data was obtained from Yahoo Finance. The exclusion criteria that led to the final dataset, as well as which financial ratios to analyze was discussed. Contingency table analysis is being used, and the methods for creating breakpoints was explained. This analysis will attempt to determine if there is a relationship between the two variables: CPI at effort completion and the company's financial ratio at the time of contract start. As an indication of whether or not there was a cost overrun, a breakpoint of 1 for CPI at complete will be used, with variation analysis being conducted on other breakpoints. Financial ratio breakpoints will not

be set numbers, but instead must be compared to benchmarks. In summation, contingency tables of four main sets within two types of analysis will be completed for each financial ratio:

- Most Recent Period (Point Analysis)
    - Comparing the most recent quarter's financial ratio to benchmarks
    - Comparing the most recent year's financial ratio to benchmarks
- Average of Two or More of the Most Recent Periods (Trend Analysis)
    - Comparing recent quarterly trends of the financial ratio to benchmarks
    - Comparing recent yearly trends of the financial ratio to benchmarks

The following chapter will provide the results and analysis revealed from this research.

IV. Analysis and Results

Chapter Overview

The analysis and results chapter will first view some of the descriptive statistics of the final dataset. Specifically, the distribution of the CPI at complete is of consequence. This is because each contingency table incorporates a CPI breakpoint to define an effort as successful from a cost performance standpoint. Then, significant results from the current ratio analysis will be reviewed. Because the current ratio is hypothesized to be the ratio that is most correlated with performance, odds ratios for some of these significant results using different CPI breakpoints will be calculated and presented. Then, the results of the quick ratio and each of the 6 cash flow ratios will be analyzed. Finally, the results of the solvency ratio and profitability ratio will be presented and discussed.

Effort CPI Descriptive Statistics

In the methodology section, it was discussed that the breakpoint for categorizing CPI at complete would be whether or not the effort incurred a cost overrun. In other words, if the CPI at complete was one or greater, the effort was considered successful; if CPI was less than one it was considered unsuccessful. As shown in Figure 2, this classification also splits the number of efforts into two almost identically sized categories of successful and unsuccessful efforts, as both the mean and median CPI of the efforts at complete hover close to one.

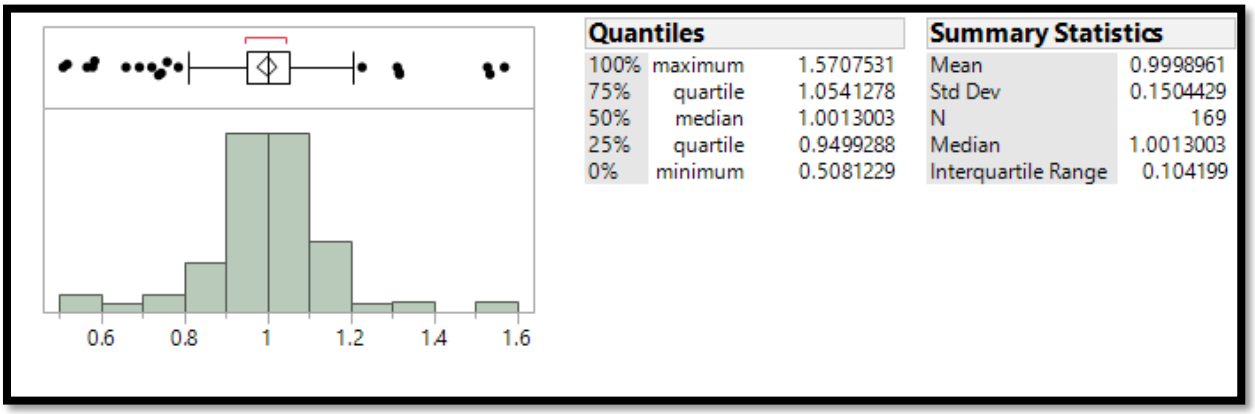

Figure 2: Distribution of CPI at Complete (if over 92.5%)

Of the 169 efforts in the final data set, 86 were under budget, while 83 were over budget. This balanced categorization indicates that there will be higher expected counts; small expected cell counts could result in violation of assumptions needed to perform the chi-squared test. While some of the data points on the extremes in regard to CPI may seem doubtful from a practitioner viewpoint, there was no indication of any problems with the data. It is also important to note that many of these datapoints are capturing cost performance on efforts within contracts, rather than entire contracts themselves. This could result in higher divergence than typically seen from a contract management perspective.

An interquartile range of only 0.1 reveals that most of the efforts lie close to the chosen inflection point. This indicates that many of the differences between a cost overrun and a cost underrun is very small in regard to CPI. However, with most of these contracts having multi-million-dollar budgets, this outcome of these differences is often millions of dollars in overruns. Furthermore, some of the more significant financial ratios will be analyzed using varying CPI breakpoints. Nonetheless, this is another limitation to note about this analysis.

A final note is that 30 of the 169 efforts incurred an Over Target Baseline (OTB). An OTB occurs when there is no change in the work scope, but the original budget is unfeasible for the remaining work to be completed (Thickstun, 2010). To implement an OTB, the contractor must perform a lengthy process which then adjusts the Performance Measurement Baseline, resetting the cost variance to zero (Cukr, 2001). This is done to provide new goals for management purposes (DAU, 2021). Of the 30 efforts in the final dataset with an OTB, 23 of these still incurred a cost overrun at complete. However, 7 efforts that incurred an OTB obtained a CPI at complete of greater than 1. This calls into question whether these 7 efforts have been placed into the correct category. The majority of this analysis is conducted by disregarding the fact that an effort incurred an OTB and leaving the efforts in the category that the CPI at complete dictates. However, robustness checks are completed by performing the analysis by both removing the 7 efforts with an OTB and a cost underrun and also recategorizing those 7 efforts into the cost overrun category. This will be further discussed, but the synthesized results of these robustness checks can be found in Table 40 and Table 41 in the Appendix.

Contingency Table Results

This analysis begins by reviewing the results of the contingency table analysis by specific ratio. Later in this chapter, results are aggregated to view higher level takeaways. As previously discussed, a level of significance of $\alpha = 0.05$ will be used; any result with a p-value less than 0.05 from the Pearson's chi-squared test will be identified. For all instances in which the p-value is 0.05 or less, an odds ratio will be calculated. An odds ratio of exactly 1 would indicate that a financial ratio being higher or lower than the benchmark at contract start does not affect the odds of an effort incurring a cost overrun. Even though this research is using a lower α than most exploratory research, there is still a strong possibility of one or more significant results due to

spurious relationships. This is due to the large number of contingency tables generated in this analysis. For this reason, discussion will focus on the larger trends observed in the results.

Current Ratio Results

Quarterly Point Results

The first set of contingency tables is to determine if the current ratio of the most recent quarter before contract start is related to the CPI of that effort. Table 12 includes the one significant contingency table result from this analysis.

Table 12: Current Ratio Quarterly Point Significant Results

Benchmarks	Most Recent Quarter	
	P- Value	Odds Ratio
Median Quarterly Current Ratio of Individual Company Since Data Available (Prior to Recent Quarter)	0.0196*	2.103

** = Significant at an alpha of 0.05*

The significant result shown in Table 12 was found by comparing the most recent quarter to the long-term median of that company. These first results indicate that there may be a relationship between a company's current ratio at the time of contract start and their cost performance on the efforts of that contract in the direction hypothesized. To specify, if a company's most recent quarterly current ratio at time of contract start was bigger than the long-term median value of that company, an effort in that contract was 2.103 times more likely to be under budget. More succinctly, a better current ratio at the time of contract start was shown to lead to better cost performance on that contract. However, this result was not consistent across varying benchmarks. As previously discussed, this minimal result may be due to the hypothesis that the most recent quarterly ratio does not accurately capture the financial health of the

company; the most recent quarter could be too short of a timeframe to analyze. The following section will look at point analysis for the current ratio using the most recent year's financial data.

Yearly Point Results

Using the current ratio of the most recent year as the variable of interest results in 2 significant associations when compared to 2 different benchmarks. These results are shown in Table 13.

Table 13: Current Ratio Yearly Point Significant Results

Benchmarks	Most Recent Year	
	P- Value	Odds Ratio
Mean Yearly Current Ratio of Individual Company Since Data Available (Prior to Most Recent Year)	0.0025**	2.586
Median Yearly Current Ratio of Individual Company Since Data Available (Prior to Recent Year)	0.0112*	2.204

** = Significant at an alpha of 0.05*
*** = Significant at an alpha of 0.01*

This time, one of the associations was significant at a p-value of less than 0.01. These results indicate that if a company's most recent yearly current ratio is greater than their long-term mean, they are 2.586 times more likely to not incur a cost overrun. However, it is important to note that this is simply a point estimate. To expound, this data reveals at a 95% confidence level that the true odds ratio is between 1.388 and 4.818. Again, the benchmarks that were calculated using longer time periods of the individual company seem to be better indicators of what is a normal current ratio for that company. As discussed, these point analysis calculations of financial ratios may not be an accurate representation of the financial health of the company due to the limited time periods being used. Trend analysis of more than just the most recent period could rectify this weakness.

Quarterly Trend Results

In the quarterly trend analysis of the current ratio, all 4 of the different methods to capture the recent trends of the companies' quarterly current ratios were significant when compared to the long term mean of the company. This corroborates the hypothesis that the recent trends of the current ratio may better capture the health of the company at contract start compared to just the most recent quarter. Again, the longer-term average of the company was shown to be the better benchmark. All of the significant results (including p-values and odds ratios) of this analysis can be seen in Table 14.

Table 14: Current Ratio Quarterly Trend Significant Results

(Benchmark)	**Mean of 6 Most Recent Quarters**	**Weighted Mean of 6 Most Recent Quarters**	**Mean of 2 Most Recent Quarters**	**Weighted Mean of 2 Most Recent Quarters**
Mean of the Company's Quarterly Current Ratio Since Data Available Prior to the Trend Period in the Column Header	0.0426* (1.903)	0.0443* (1.896)	0.0196* (2.103)	0.0186* (2.114)
Mean of the Company's Quarterly Current Ratio of the 6 Quarters Prior to the Trend Period in the Column Header			0.0129* (2.213)	

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

The median of the 6 most recent quarters was not shown to be significant when compared to the median of the 6 prior quarters (quarters 7-12 prior to contract start) nor the long-term median of the company. Contingency tables were calculated using these median values as both a robustness check and as a hedge against extreme values. This absence of significance may indicate a lack of consistency of the results and brings into question the stability of this analysis. A contrary explanation could be that trends using mean values are better indicators of company health because the financial ratio values that are more extreme influence whether a company

financial health is categorized as good or bad. For example, if a company had a current ratio in 1 or 2 quarters in the 6 most recent quarters that was very poor, that could increase the likelihood of a cost overrun. Median values of the 6 most recent quarters would not capture these more extreme values. Nonetheless, to further test the robustness of these results, different CPI breakpoints will be tested.

Odds Ratio Change with Changes in Breakpoint for CPI (Quarterly Trend)

The trend results of the quarterly current ratios were shown to be significant for all measures of recent performance compared to the long term mean of the company. If recent quarterly trends of the current ratio are related with CPI at complete, one would expect this to be the case for multiple CPI values. Therefore, further contingency table analyses are conducted for different categorizations of cost performance. To do this, different breakpoints for CPI were implemented and tested. The odds ratios of this analysis are shown in Figure 3.

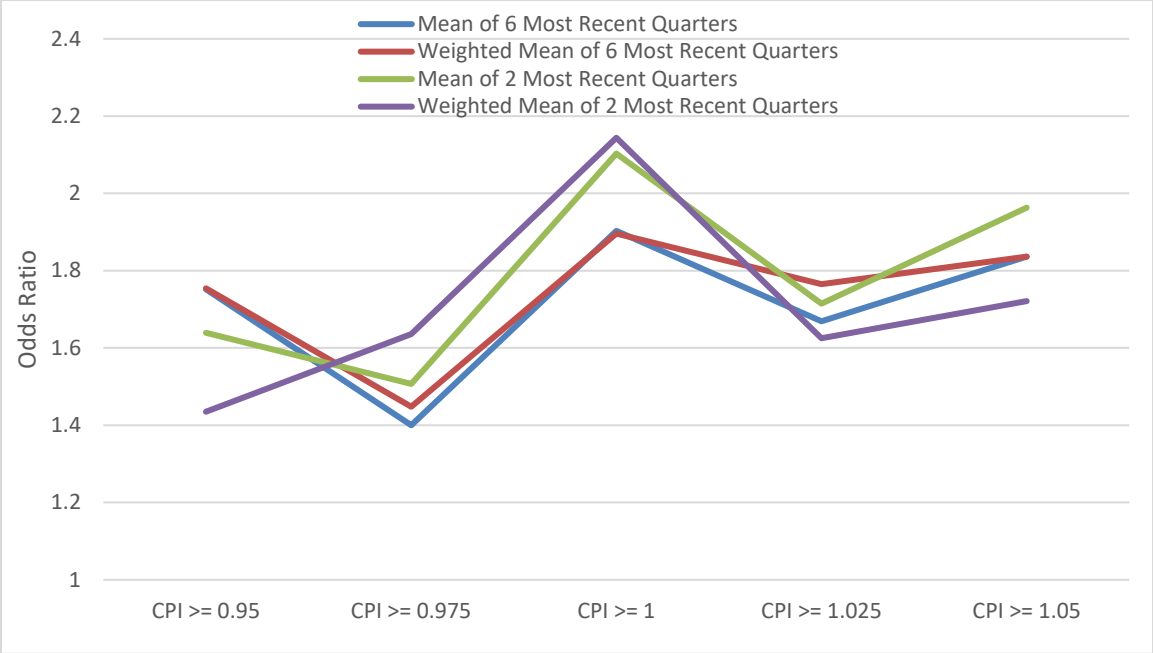

Figure 3: Contingency Table Odds Ratios by Varying CPI Break Points; Current Ratio Quarterly Trend Analysis Compared to Long Term Company Mean

All quarterly current ratio trends in Figure 3 were compared to the mean of the company's quarterly current ratio since data available prior to the trend period used. As you can see, the odds ratio values at CPI >= 1 in Figure 3 match up with the values listed in Table 14. All of the other breakpoints used result in odds ratios at 1.4 or above. Thus, for the data used and regardless of which CPI marked a successful effort, there was a higher likelihood of the CPI being higher if the trending quarterly current ratio was higher at contract start. However, none of the other breakpoints resulted in odds ratios that were significant at an alpha of 0.05. This is further evidence that the findings are not markedly robust. However, one possible explanation is the importance of the initial CPI breakpoint used. For instance, if a company had an effort near completion that is hovering around a CPI of 1, a better current ratio may indicate that they could put forth the effort to employ resources effectively to avoid a cost overrun. To further explain,

increasing CPI from 0.974 to 0.976 would not have the implication to the company that an increase from 0.999 to 1.001 would. A company with a healthy current ratio could make the necessary adjustments, while a company without the proper liquid assets would be unable to do so. The next section will analyze the yearly trends of the current ratios.

Yearly Trend Results

The final analyses of the current ratio will attempt to determine if using yearly trends of the current ratio are effective measures of company financial health. Thus, this analysis uses the longest time periods to measure the financial health of the company at the time of contract start. The significant results from these analyses are shown in Table 15.

Table 15: Current Ratio Yearly Trend Significant Results

(Benchmark)	Weighted Mean of 5 Most Recent Years	Mean of 2 Most Recent Years	Weighted Mean of 2 Most Recent Years
Mean of the Company's Yearly Current Ratio Since Data Available Prior to the Trend Period in the Column Header			0.0048** (2.436)
Mean of the Company's Yearly Current Ratio of the 5 Years Prior to the Trend Period in the Column Header	0.0029** (2.659)	0.0306* (2.022)	0.0306* (2.022)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*
*** = P-value significant at an alpha of 0.01; Odds Ratio in parentheses*

As shown in Table 15, four contingency tables showed significant results. This time however, the benchmark that was consistently significant as a measure of comparison was the mean of the 5 years prior to the time period used in the trend calculation. This is still a relatively long-time horizon that could effectively measure what is considered normal for the company in question. This benchmark has the added benefit of being standardized and more easily obtained;

future research and potential risk measures could be implemented using this benchmark without the need for acquiring extremely long term historical financial statements from companies.

Similar to the quarterly trend results, the median value of the yearly financial ratios of the 5 most recent years was not significant. This was true against both the long term historical current ratio of the company, as well as the median of the 5 years prior to the most recent 5 years. Again, this may draw into question the robustness of these results or corroborate the hypothesis that mean values that capture more extreme values are better indicators of financial health. This time however, it may also be due to the idea that the most recent 5 years is too long of a time period to accurately capture the current financial health of a company at any given time. This idea is corroborated by the results that the most significant time periods in Table 15 are the mean of the 2 most recent years and the *weighted* mean of the 5 most recent years.

Odds Ratio Change with Changes in Breakpoint for CPI (Yearly Trend)

Similar to the varying odds ratio calculations done for quarterly current ratio trends, Figure 4 analyzes odds ratio calculations for yearly current ratio trends.

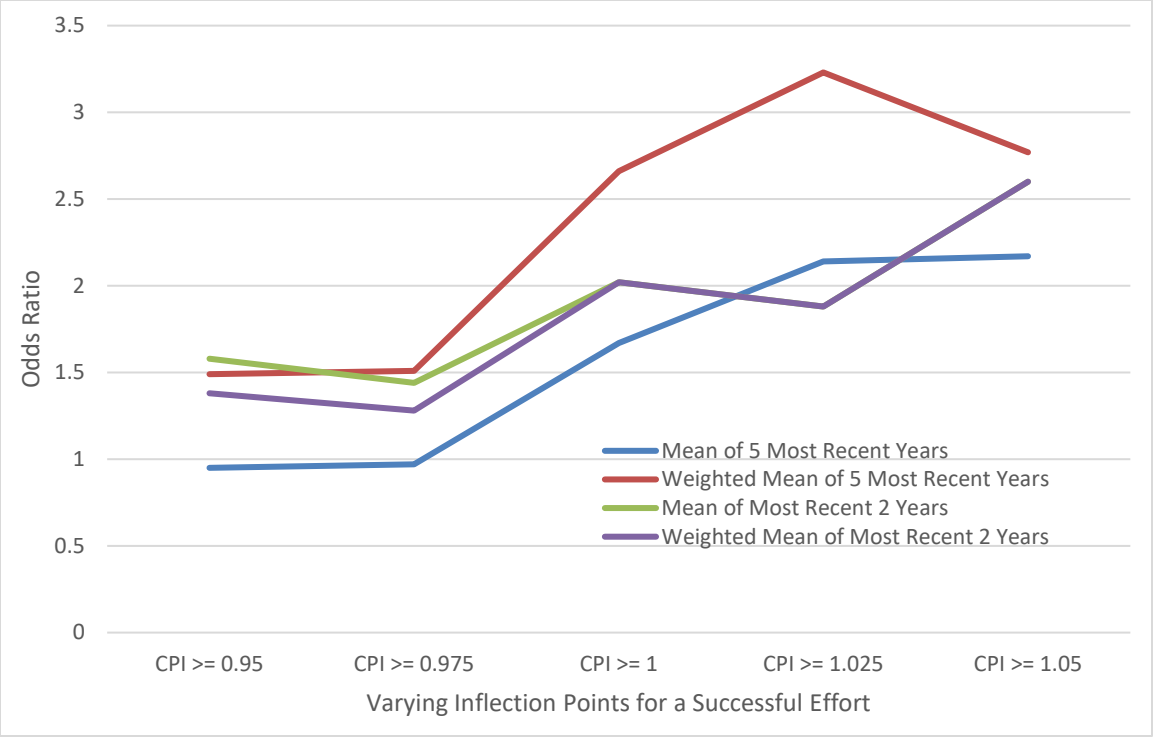

Figure 4: Contingency Table Odds Ratios by Varying CPI Break Points; Current Ratio Yearly Trend Analysis Compared to Medium-Long Term Company Mean

The benchmark used in the calculation of these odds ratios was the mean of the company's yearly current ratio of the 5 years prior to the trend period of interest. Figure 4 exposes that there are again inconsistencies in the results. This time, when using CPI breakpoints of 0.95 and 0.975, it was more likely that a higher mean current ratio in the most recent 5 years would result in a worse CPI at complete. However, as previously discussed, the *weighted* 5 year mean and the averages of the most recent 2 years more accurately capture current financial health.

Interestingly, none of the results using CPI breakpoints of less than 1 were significant, while using breakpoints of more than 1 led to some odds ratios that were more significant than the findings using a CPI breakpoint of exactly 1. This may indicate that poor current ratios are

not necessarily leading to very poor cost performance on contracts. Instead, this evidence suggests that significant results are being found because healthy current ratios are actually leading to very good cost performance on contracts. This does not coincide with the theory that companies may bid lower in times of poor financial health, which then leads to higher likelihood of cost overruns. The alternative explanation is that companies that are in good financial health have the resources (employees, equipment, etc.) to deploy in order to perform very well on the contracts they undertake.

Although the current ratio was expected to be the ratio that most accurately tracked a company's financial health, the number of significant results was much higher than expected. There is a clear relationship between a company's financial ratio at the time of contract start and the likelihood of cost overrun. The main takeaway from the analysis on the current ratio is that practitioners should incorporate analysis on companies' current ratios as a risk metric and decision support tool. Additionally, future research should focus on the current ratio when attempting to determine the true marginal effects of financial ratios on contract performance.

Quick Ratio

The next analysis uses the quick ratio. The current ratio and the quick ratio are somewhat strongly correlated in the dataset; the quarterly and yearly correlations are 0.5894 and 0.559, respectively. This is expected as these ratios use the same denominator and current assets in the numerator; the only difference is that the quick ratio removes the inventory from the current assets in the numerator.

Quarterly Point Results

The first set of contingency tables to analyze is the quarterly point results. Table 16 shows the significant results at an alpha of 0.05.

Table 16: Quick Ratio Quarterly Point Significant Results

Benchmarks	Most Recent Quarter	
	P- Value	Odds Ratio
Median Quick Ratio of the 4 Largest Companies (In Most Recent Quarter)	0.0110*	2.253
Mean Quarterly Quick Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)	0.0268*	2.022

** = P-value significant at an alpha of 0.05*

Interestingly, the most significant result was the most recent quarter's quick ratio in comparison to the median of the industry average proxy. This indicates that there could be some merit to using industry average as a benchmark. To interpret Table 16, if the company's quick ratio in the most recent quarter prior to contract start is better than the median of the 4 main companies (Boeing, Lockheed Martin, Northrop Grumman, and Raytheon) in that quarter, that effort is 2.253 times more likely to result in a CPI of greater than 1. Also significant was the most recent quarter in comparison to the long term mean of the individual company. This is consistent with the current ratio and the hypothesis that the long-term average of the company is the best benchmark for comparison.

Yearly Point Results

While the quarterly point analysis of the quick ratio resulted in two significant contingency table results, the yearly point analysis did not result in any significant findings. However, CPI at complete was shown to be dependent on the most recent yearly quick ratio in comparison to two proxies for industry average at p-values of just over 0.05. This shows that the

most recent yearly quick ratio may be useful but was found to be just outside the level of significance chosen for this research.

Quarterly Trend Results

The quarterly trend results also did not show significant results. Similar to the yearly point results, two contingency tables found p-values slightly higher than the chosen alpha. The lack of significant results from both the yearly point and quarterly trend analysis may be due to a few reasons. First, perhaps the current ratio is a much better indicator of financial health for a company in regard to future cost performance. This could be due to the importance of including inventory to measure the true liquidity of a company. Second, as discussed previously, these shorter time frames are not capturing the financial health of the company as well as yearly trend analysis. However, it was unexpected that the quarterly point analysis was more significant than the quarterly trend analysis. The following section will further test if long-term trends better capture financial health and its influence on cost performance of the efforts.

Yearly Trend Results

The final sets of analysis to be completed on the quick ratio are those capturing quarterly trends. Table 17 and Table 18 show the significant results of this analysis.

Table 17: Quick Ratio Yearly Trend Significant Results

(Benchmark)	Mean of 5 Most Recent Years	Weighted Mean of 5 Most Recent Years	Weighted Mean of 2 Most Recent Years
Mean of the Company's Yearly Quick Ratio Since Data Available Prior to the Trend Period in the Column Header			0.0468* (1.860)
Mean of the Company's Yearly Quick Ratio of the 5 Years Prior to the Trend Period in the Column Header	0.0083** (2.297)	0.0288* (1.986)	

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*
*** = P-value significant at an alpha of 0.01; Odds Ratio in parentheses*

Table 18: Quick Ratio Yearly Trend Significant Results (Median Values)

(Benchmark)	Median of 5 Most Recent Years
Median of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years	0.0128* (2.188)

** = P-value significant at an alpha of 0.05 (Odds Ratio)*

The results shown in Table 17 and Table 18 show both some consistencies as well as surprises in relation to hypotheses and the current ratio results. The higher number (4) of significant results corroborate the hypothesis that longer term trends of the company are the best indicators of financial health. However, the fact that the most significant results were those comparing the most recent 5 years to the prior 5 years is contrary to the conclusion that the longest-term average of the company is the best benchmark. It is also unexpected that the weighted mean of the 5 most recent years was less significant than both the mean and median of the 5 most recent years. This is contrary to the analysis from the current ratio that the median values may be less important because they do not capture more extreme values. The pessimistic conclusion is that the lack of consistency in these aspects highlights the shortcomings of this type

of analysis. The optimistic view is that the number of significant results show that there is some type of correlation between cost performance on contracts and a company's financial ratio at the time of contract start, especially when viewing longer term trends of these commonly used liquidity ratios.

Cash Flow Ratios

Although not as prominently used as the current and quick ratio, liquidity ratios capturing cash flows are hypothesized as also being effective means of capturing the financial health of a company. Three of the six cash flow ratios analyzed showed no significant results in any of the analyses. These three ratios were the operating cash flow ratio, free cash flow to total debt, and free cash flow to total assets.

It was surprising that the operating cash flow ratio was insignificant as it was shown to be significant in the competitiveness of defense industry companies (Antczak, Horzela, & Nowakowska-Krystman, 2021). However, the lack of significance in this research may be due to the tendency for recent operating cash flows to fluctuate independently of the overall company health, such as if a company embarks on projects that temporarily compromise on cash flows. This temporary compromise on cash flows could lead to substantial returns in the future, especially if the company still retains the current assets to cover current liabilities (as shown in the current ratio). In fact, in the final dataset, the yearly current ratio and the yearly operating cash flow ratio were shown to have only a slight correlation of 0.1739 (p-value of 0.0237), but the quarterly ratios were essentially uncorrelated with a value of -0.0249 (p-value of 0.7530). This difference in the correlation of the two ratios corroborates the idea that operating cash flow fluctuates independently of a company's practical liquidity.

The lack of significance in both ratios using free cash flow is less surprising. No research had previously linked free cash flow ratios to either bankruptcy or future performance of a company. These ratios were included as a way to use more nuanced accounting methods to more accurately capture usable cash flows of a company in a given period. With cash flow ratios generally being less significant than the other liquidity ratios (current ratio and quick ratio), the lack of relationship is unsurprising.

Cash Ratio (Yearly Trends)

The cash ratio captures just the most liquid assets (cash and cash equivalents) in comparison to the current liabilities. The numerator of the cash ratio is a subset of the numerator of both the current ratio and the quick ratio, while maintaining the same denominator. The relationships between the cash ratio and both the current and quick ratio are further supported by the strong correlation between the ratios. In the final dataset, the correlation between the yearly cash ratio and the yearly current ratio is 0.7158, while the correlation between the yearly cash ratio and the yearly quick ratio is 0.7428. Despite these strong correlations, the current ratio still exhibits the best relationship with cost performance. Table 19 and Table 20 show both of the significant contingency table results when analyzing the cash ratio.

Table 19: Cash Ratio Yearly Trend Significant Results

(Benchmark)	**Weighted Mean of 5 Most Recent Years**
Mean of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years	0.0189* (2.388)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

Table 20: Cash Ratio Yearly Trend Significant Results (Median Values)

(Benchmark)	Median of 5 Most Recent Years
Median of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years	0.0020** (2.946)

*** = P-value significant at an alpha of 0.01; Odds Ratio in parentheses*

As expected from the high correlation, two significant results from the cash ratio coincide with two significant results from the analysis of the quick ratio. Therefore, any conclusions drawn from the cash ratio results could be similarly explained by the analysis of the results of the quick ratio. While viewing cash and cash equivalents as the measure of liquidity could be useful, it seems that all current assets in comparison to liabilities is the best measure of a company's ability to execute on a contract from a cost performance standpoint.

EBITDA to Total Debt

The EBITDA to total debt ratio was included as a liquidity ratio to capture cash flows in relation to the total debt of a company. Early research has shown that this ratio was a predictor of future bankruptcy (Beaver, 1966) and future returns on capital employed (Fadel & Parkinson, 1978). As shown in Table 21 and Table 22, only two results were significant.

Table 21: EBITDA to Total Debt Quarterly Point Significant Result

Benchmarks	Most Recent Quarter	
	P- Value	Odds Ratio
Median Quarterly EBITDA/ Total Debt Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)	0.0426*	2.025

** = P-value significant at an alpha of 0.05*

Table 22: EBITDA to Total Debt Quarterly Point Significant Result

Benchmarks	Most Recent Year	
	P- Value	Odds Ratio
Median Yearly EBITDA/ Total Debt Ratio of Individual Company Since Data Available (Prior to Most Recent Year)	0.0247*	2.060

** = P-value significant at an alpha of 0.05*

The only two contingency table results that were significant were viewing the most recent time periods (point analysis) to the long-term median of the company. It can be argued that long-term median values, as opposed to long term mean values, are a more appropriate benchmark. This is because benchmarks using median values are not drastically affected by anomalies such as sharp economic downturns, large acquisitions, or an atypical business failure that can have a severe impact on the financial ratio, but do not accurately capture what is a typical ratio for the company. Unexpectedly, trend analysis showed no significant results. Therefore, these results do not corroborate the premise that longer term trends are better indicators of current financial health.

EBITDA to Total Assets

The final cash flow ratio analyzed is the EBITDA to asset ratio. The EBITDA to total asset ratio was included as a cash flow ratio because it was previously shown to be significant predictors of bankruptcy (Altman, 1968) and loan defaults (Ciampi & Gordini, 2008). In contrast to EBITDA to total debt, the significant results for EBITDA to total assets were found in the trend analysis. The significant results from trend analysis are shown in Tables 23-25.

Table 23: EBITDA to Asset Quarterly Trend Significant Results

(Benchmark)	Mean of 6 Most Recent Quarters	Weighted Mean of 2 Most Recent Quarters
Mean of the Company's Quarterly EBITDA to Asset Ratio Since Data Available Prior to the Trend Period in the Column Header	0.0321* (2.284)	0.0160* (3.066)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

Table 24: EBITDA to Asset Yearly Trend Significant Result

(Benchmark)	Weighted Mean of 5 Most Recent Years
Mean of the Company's Yearly EBITDA to Asset Ratio of the 5 Years Prior to the 5 Most Recent Years	0.0440* (1.940)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

Table 25: EBITDA to Asset Yearly Trend Significant Result (continued)

(Benchmark)	Median of the 5 Most Recent Years
Median of the Company's Yearly EBITDA to Asset Ratio of the 5 Years Prior to the 5 Most Recent Years	0.0323* (1.954)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

The reason that Table 23 shows such a high odds ratio despite a p-value of greater than 0.01 is due to the lower expected counts, and thus actual counts observed. The reason for this is that in only 24 out of the 162 quarterly data points was the company's weighted mean EBITDA to asset ratio of the 2 most recent quarters less than the long-term mean of that company. Therefore, if there is no dependency, 11.5 of these efforts were expected to have a CPI of less than 1 and 12.4 were expected to have a CPI of greater than 1. The actual counts of the data were 17 that had a CPI of less than 1 and only 7 that had a CPI of greater than 1. Consequently, from this dataset, a CPI of less than 1 was 3.066 times more likely if the EBITDA to asset ratio was less than the benchmark. However, the 95% confidence interval of these results is a true odds

ratio between 1.195 and 7.865. Of all of the significant results, this analysis had both the lowest expected and actual counts. Figure 9 in the appendix showcases these results. The purpose of this discussion is to demonstrate that this analysis has avoided statistical assumption violations of small expected and actual counts, giving credence to the results of these Pearson's chi-squared tests of independence.

Ultimately, cash flow ratios were shown to be less related to cost performance than the current and quick ratio. While there was some dependency in the direction hypothesized, the results were not markedly robust. Generally, however, longer term trends compared to benchmarks using long-term averages of the individual company still seem to be the best metrics of company health and their relationship with cost performance.

Solvency and Profitability Ratio Analysis

Both the solvency ratio (debt to assets) and the profitability ratio (return on assets) were included as a secondary analysis. The theory is that liquidity ratios are likely better predictors of shorter-term contract performance as ability to pay long term debts and ability to return a profit are only tangentially related to shorter-term financial health.

Total Debt to Total Assets

Despite the belief that the debt to asset ratio would be unrelated to cost performance on efforts, 5 contingency table analyses were shown to be significant. All 5 of the significant results were found by performing quarterly analysis. Table 26 and Table 27 show these significant results.

Table 26: Debt to Asset Ratio Quarterly Point Significant Results

Benchmarks	Most Recent Quarter	
	P- Value	Odds Ratio
Mean Debt to Asset Ratio of the 4 Largest Companies (In Most Recent Quarter)	0.0312*	0.4914
Mean Quarterly Debt to Asset Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)	0.0190*	0.4492
Median Quarterly Debt to Asset Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)	0.0437*	0.5000

** = P-value significant at an alpha of 0.05*

Table 27: Debt to Asset Ratio Quarterly Trend Significant Results

(Benchmark)	Mean of 2 Most Recent Quarters	Weighted Mean of 2 Most Recent Quarters
Mean of the Company's Quarterly Debt to Asset Ratio Since Data Available Prior to the 2 Most Recent Quarters	0.0190* (0.4492)	0.0190* (0.4492)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

Notice, the significant odds ratios shown in Table 26 and Table 27 are less than 1. The reason for this is, as previously discussed, is that a lower debt to asset ratio signifies better health. Therefore, if the company has a debt to asset ratio in the most recent quarter that is higher than the median historical value of that company, they were shown to be half as likely to obtain a CPI greater than 1. This example is shown in Figure 10 in the Appendix. These results are consistent with the previous findings that better financial ratios at the time of contract start are related to better cost performance on Air Force efforts.

All of the significant results of the debt to asset ratio come from viewing the very short term (either most recent quarter or average of the two most recent quarters). An interesting note is that the debt to asset ratio had many contingency table results close to the cusp of the significance level threshold. For example, if α=0.1 instead of 0.05, 9 more contingency table results would have flagged as significant. These results would include both yearly point and

yearly trend analyses. The relatively high number of significant and only marginally insignificant results may be partially explained by the correlation of the debt to asset ratio to the current ratio. With p-values less than 0.0001, the quarterly and yearly correlation between the current ratio and the debt to asset ratio is 0.4152 and 0.3627, respectively.

Return on Assets

The profitability ratio, return on assets, is analyzed due to its prominence of use and its ability to predict future success as measured by share price (Hashim, 2020) and operating income margin (Baranes, Palas, Shnaider, & Yosef, 2021). This previous research has shown return on assets can help determine future profitability, but not necessarily other metrics of success that could be akin to contract performance. Previous research viewing family farms did show a correlation between return on assets and the current ratio (Bereznicka, 2014). However, in this dataset, there was no correlation between these two ratios—the p-value of the correlation between the current ratio and the return on assets was 0.8765 in the quarterly data and 0.3495 in the yearly data. Despite the lack of correlation and the hypothesis that the return on assets ratio at contract start would be unrelated to the cost performance of an effort in the contract, two significant results were found. These results are shown in Table 28 and Table 29.

Table 28: Return on Assets Ratio Quarterly Trend Significant Results

(Benchmark)	**Weighted Mean of 2 Most Recent Quarters**
Mean of the Company's Quarterly Return on Assets Ratio Since Data Available Prior to the 2 Most Recent Quarters	0.0492* (2.4516)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

Table 29: Return on Assets Ratio Yearly Trend Significant Results

(Benchmark)	Mean of 5 Most Recent Years
Mean of the Company's Yearly Return on Assets Ratio of the 5 Years Prior to the 5 Most Recent Years	0.0365* (2.076)

** = P-value significant at an alpha of 0.05; Odds Ratio in parentheses*

Unlike the debt to assets ratio, a longer-term trend analysis (Table 29) did result in significant findings. Unfortunately, this result was when comparing just the mean of the 5 most recent years to the benchmark calculated using the mean of the 5 years prior to that time period. As discussed, weighted trends and trends compared to benchmarks using the longest-term average are expected to be the most important. This lack of uniformity with both the hypothesis and the current ratio results suggests the limitations of using profitability ratios as a measure of financial health in relation to contract performance. This concludes the significant results found in this research.

Interpretation of Results

Both the current and quick ratio were shown to have more significant results than any of the cash flow ratios. This could be due to the prominence of both the current and quick ratio as a measure of analysis by loan officers and financial analysts within companies. This close eye on these ratios may make companies react more quickly (perhaps by bidding lower on contracts to receive income) when they trend downwards. Another interpretation is that the current ratio is most prominently used because it is the best indicator of a company's liquidity, and thus the ability to move and utilize resources to perform on contracts.

Summary

The cost performance of Air Force contracts seems to be related to the financial health of the company as measured by financial ratios at the start of that particular contract. The implication of all of the significant results shows that there is a correlation between the financial health of a company at contract start and the likelihood of that company going over budget on those efforts within that contract. It is important to remember that results were not strikingly robust, likely due to the limitations of both the data and the methodology. Nonetheless, these results imply that further analysis should be done to determine how to best incorporate financial ratio analysis to better assess cost risk of DoD programs. The following chapter will aggregate the results to get an overview of the number of significant results by ratio, time periods, and benchmarks to answer the research questions more directly. Table 39 in the Appendix offers an alternative summary of the significant results.

V. Conclusions and Recommendations

Chapter Overview.

This chapter will reiterate the gap in the research that this investigation attempts to fill. From there, the research questions will be restated and answered. To facilitate answering these questions, tables that aggregate the results revealed in Chapter 4 will be utilized. Then, limitations specific to the answers to these research questions will be reviewed. Finally, paths for future research will be recommended, and the overall implications of this research will be summarized.

Summary of Research Gap

Countless researchers have scrutinized the predictive ability of financial ratios on bankruptcy and future company success. Additionally, numerous articles have examined the factors that lead to cost overruns on Air Force and DoD programs. However, no research has merged these two overarching topics. In other words, despite the idea that financial ratios are important to review when selecting companies to fulfill Air Force contracts (Overman & Williams, 2021) or complete projects (Zhang, 2005), no research has determined that there is actually a relationship, let alone detailing the effect of these ratios on performance. This analysis takes the first step in determining if there is a statistical relationship between company financial health (through financial ratios) and cost performance on Air Force efforts (through CPI).

Research Questions and Answers

1. To what extent is the financial health of the contracted company at the time of contract start correlated with the cost performance of that contract?

The financial health of a contracted company is strongly correlated with the likelihood of a cost overrun. Viewing the significant results by ratio and type of analysis will allow for a further understanding of overall findings and main conclusions. Table 30 shows these aggregated results.

Table 30: Aggregated Significant Results by Ratio and Type of Analysis

Financial Ratio	Quarterly Point	Yearly Point	Quarterly Trends	Yearly Trends	Total
Current Ratio (Current Assets / Current Liabilities)	1 (0)	2 (1)	5 (0)	4 (2)	**12 (3)**
Quick Ratio ((Current Assets - Inventories) / Current Liabilities)	2 (0)	0	0	4 (1)	**6 (1)**
Operating Cash Flow (Operating Cash Flow / Current Liabilities)	0	0	0	0	**0**
Cash Ratio (Cash and Cash Equivalents / Current Liabilities)	0	0	0	2 (1)	**2 (1)**
EBITDA / Total Debt	1 (0)	1 (0)	0	0	**2 (0)**
EBITDA / Total Assets	0	0	2 (0)	2 (0)	**4 (0)**
Free Cash Flow / Total Debt	0	0	0	0	**0**
Free Cash Flow / Total Assets	0	0	0	0	**0**
Total Debt / Total Assets	3 (0)	0	2 (0)	0	**5 (0)**
Return on Assets (Net Income/Total Assets)	0	0	1 (0)	1 (0)	**2 (0)**
Total	**7 (0)**	**3 (1)**	**10 (0)**	**13 (4)**	**33 (5)**

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

These aggregated results are very encouraging. All 33 of the significant results were shown to be in the direction hypothesized; a financial ratio better than the benchmark was more likely to lead to a CPI greater than 1. Another way to translate these results is that a financial ratio worse than the benchmark was more likely lead to poor cost performance. Again, this may

be a proper time to reiterate that these results simply show correlation. Because no other variables were incorporated into this analysis, it would be incorrect to claim that poor financial ratios cause poor performance. Nonetheless, there is clear merit in the conclusion that financial ratio analysis could be effective in assessing risk in DoD programs.

The robustness checks that were conducted due to the 7 contracts that incurred an OTB but finished with a CPI of greater than 1 yielded similar results. In fact, there were more significant results when both removing those 7 efforts and when recategorizing them as cost overruns. When removing these 7 efforts from the analysis, the number of significant results jumped up to 45 total at an α=0.05, 8 of which were significant at an α=0.01. When recategorizing the 7 efforts with an OTB to a cost overrun, there were 47 significant results at an α=0.05, 12 of which were significant at an α=0.01. This further corroborates the relationship between company financial health at the beginning of a contract and the cost performance on that contract. These synthesized results are summarized in Table 40 and Table 41 in the Appendix.

2. Which financial ratios are the most strongly correlated with contract cost performance?

Table 30 also gives an overview of the answer to this question. The current ratio seems to be the best indicator of financial health, at least with regard to performance on an upcoming contract. As shown in Table 30, 12 contingency tables were significant at α=0.05, 3 of which were significant at α=0.01. Other ratios also showed significant results; however, many of these other ratios are strongly correlated with the current ratio. This brings into question which financial ratios are important on their own, and which ones simply coincide with the more appropriate ratios. This weakness of financial ratio analysis (Chen & Shimerda, 1981; Pindado &

Rodrigues, 2004; Barnes, 1987) was noted in Chapter 2. The correlation and corresponding p-value between the current ratio and the other ratios used in this analysis are shown in Table 31.

Table 31: Correlation Between Current Ratio and All Other Ratios

	Quarterly Current Ratio Correlation	Quarterly Current Ratio P-Value	Yearly Current Ratio Correlation	Yearly Current Ratio P-Value
Quick Ratio	0.5894**	<0.0001	0.5593**	<0.0001
Operating Cash Flow Ratio	-0.0249	0.7530	0.1739*	0.0237
Cash Ratio	0.8121**	<0.0001	0.7158**	<0.0001
EBITDA to Debt Ratio	-0.1884*	0.0163	-0.1412	0.0670
EBITDA to Asset Ratio	0.0869	0.2715	0.1121	0.1466
Free Cash Flow to Debt Ratio	-0.0843	0.2864	-0.0960	0.2145
Free Cash Flow to Asset Ratio	-0.0748	0.3444	-0.0004	0.9962
Debt to Assets Ratio	0.4152**	<0.0001	0.3627**	<0.0001
Return on Assets Ratio	0.0123	0.8765	0.0724	0.3495

** = P-value significant at an alpha of 0.05*
*** = P-value significant at an alpha of 0.01*

As shown in Table 31, three ratios (quick ratio, cash ratio, and debt to assets ratio) are strongly correlated with the current ratio. Thus, it is difficult to say that each of these ratios are important to view on their own merits. The current ratio may be the catalyst that causes these correlated ratios to also be significant based on the prevalence of its use in previous research and higher number of significant results in this analysis. Interestingly, the EBITDA to asset ratio, the return on assets ratio, and the EBITDA to debt ratio also gave significant results despite not being correlated or even slightly negatively correlated with the current ratio. For these reasons, cost performance may be dependent on these ratios of their own merit.

3. What time periods best represent the current financial health of a company?

Again, as shown by Table 30 and as hypothesized, the trend analysis, and especially yearly trend analysis, showed the most significant results. For the current ratio, 9 out of the 12 significant results were obtained by trend analysis. For comparison, only 10 total contingency tables showed significant results when performing point analysis for both quarterly and yearly ratios. Tables 32-35 show the number of significant results obtained by the type of trend analysis.

Table 32: Number of Significant Quarterly Results by Trend Period and Benchmark

(Benchmark)	Mean of 6 Most Recent Quarters	Weighted Mean of 6 Most Recent Quarters	Mean of 2 Most Recent Quarters	Weighted Mean of 2 Most Recent Quarters
Mean of the Company's Quarterly Financial Ratio Since Data Available Prior to the Trend Period in the Column Header	2 (0)	1 (0)	2 (0)	3 (0)
Mean of the Company's Quarterly Financial Ratio of the 6 Quarters Prior to the Trend Period in the Column Header	0	0	1 (0)	0

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Table 33: Number of Significant Quarterly Results by Trend Period and Benchmark

(Median Values)

(Benchmark)	Median of 6 Most Recent Quarters
Median of the Company's Quarterly Financial Ratio Since Data Available Prior to the 6 Most Recent Quarters	1 (0)
Median of the Company's Quarterly Financial Ratio of the 6 Quarters Prior to the 6 Most Recent Quarters	0

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Unfortunately, in the quarterly trend analysis, there is not one trend period that is clearly a better gauge of company financial health. However, it does seem to be that the longer-term benchmarks are better comparisons. This may be due to the fact that the other benchmark for comparison (6 quarters prior to period used to calculate the trend) is too short of a time period to capture the typical value of the financial ratio for that company.

Table 34: Number of Significant Yearly Results by Trend Period and Benchmark

(Benchmark)	Mean of 5 Most Recent Years	Weighted Mean of 5 Most Recent Years	Mean of Most Recent 2 Years	Weighted Mean of Most Recent 2 Years
Mean of the Company's Yearly Financial Ratio Since Data Available Prior to the Trend Period in the Column Header	0	0	0	2 (1)
Mean of the Company's Yearly Financial Ratio of the 5 Years Prior to the Trend Period in the Column Header	2 (1)	4 (1)	1 (0)	1 (0)

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Table 35: Number of Significant Quarterly Results by Trend Period and Benchmark

(Median Values)

(Benchmark)	Median of 5 Most Recent Years
Median of the Company's Yearly Financial Ratio Since Data Available Prior to the 5 Most Recent Years	0
Median of the Company's Quarterly Financial Ratio of the 5 Years Prior to the 5 Most Recent Years	3 (1)

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Similar to the discussion of the quarterly trend results, there is not one clear yearly trend period that provides the most significant results. However, it does seem that weighted means of recent years better captures current financial health. These results are insightful yet expected;

trends that incorporate the most recent periods and more heavily weight periods immediately preceding the contract start date would be expected to more accurately capture the financial health of the company. Surprising though, the benchmarks that were most commonly significant were not those that captured the longest history of the company, but instead the ones that captured the 5 years prior to the trend period analyzed. This may indicate instability of the results and uncertainty in determining the best benchmark. However, perhaps averages that start 7 to 10 years prior to contract start is a long enough time to capture the typical value of a financial ratio of the company.

4. What are the proper benchmarks to use for comparison to recent financial ratios?

The answer to the question of proper benchmarks for trend analysis was discussed in the answer to question 3 and through the results shown in Tables 32-35. Even though it has been determined that point analysis does not represent the best means for capturing the financial health of the company at the time of contract start, the results that are significant still may be able to identify the best benchmarks for comparison. The number of significant point results by the benchmark used for comparison are shown in Table 36 and Table 37.

Table 36: Number of Significant Quarterly Point Results by Benchmark

Benchmarks	Most Recent Quarter
4 Largest Companies Mean	1 (0)
4 Largest Companies Median	1 (0)
Sample Mean	0
Sample Median	0
Mean of Company Since Data Available Prior to the Most Recent Quarter	2 (0)
Median of Company Since Data Available Prior to the Most Recent Quarter	3 (0)
Mean of the 6 Quarters Prior to the Most Recent Quarter	0
Median of the 6 Quarters Prior to the Most Recent Quarter	0
Mean of the 2 Quarters Prior to the Most Recent Quarter	0

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Table 37: Number of Significant Yearly Point Results by Benchmark

Benchmarks	Most Recent Year
4 Largest Companies Mean	0
4 Largest Companies Median	0
Sample Mean	0
Sample Median	0
Mean of Company Since Data Available Prior to the Most Recent Year	1 (1)
Median of Company Since Data Available Prior to the Most Recent Year	2 (0)
Mean of the 5 Years Prior to the Most Recent Year	0
Median of the 5 Years Prior to the Most Recent Year	0
Mean of the 2 Years Prior to the Most Recent Year	0

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

As hypothesized based on previous research, using industry average proxies as a benchmark of a healthy ratio at the time of contract start appeared to be ineffective. Only 2 contingency tables obtained significant results when compared to proxies for industry averages. The long-term average of the individual company again showed to be the best benchmark.

Study Limitations

The main limitations include correlating company-wide financial ratio variables to effort level cost performance, the considerable and varying time lags between variables, and the method that required categorizing continuous variables. As previously discussed, this analysis is unable to claim causation or determine the marginal effects of these financial ratios on cost performance. In regard to a possible model that may be able to quantify the true effects, this research was unable to obtain many of the potential variables that have been shown to be significant in determining whether a contract will incur a cost overrun. The reason for this is that much of the previous research utilized Selected Acquisition Reports which are only required for the largest of defense acquisition programs. These missing variables include information such as

raw funding amount, the use of preliminary design reviews, percentage of RDT&E funding, and more. Additionally, a model using absolute values of financial ratios may not accurately capture the financial health of a company as different companies have different operating averages and standards that also evolve over time (Cowen & Hoffer, 1982; Beaver & McNichols, 2005).

Recommendations for Future Research

Future research could use similar methods but with different periods for both trends and benchmarks. For example, perhaps a longer period of 10 quarters could best capture the financial health of the company before contract start. As for benchmarks, one could perform trend analysis and compare it to benchmarks of the industry average for that same time period. This was not incorporated into this research due to some complexities of the calculations and hypotheses of previous research. However, it could show to be a good indicator of the trends of an individual company against what is deemed as typical for other companies within that industry over the same time period. Additionally, comparison of recent trends could also use a benchmark of longer periods of that individual company, without going as far back as a relatively arbitrary year due to data availability. For example, an average of the financial ratio of the 10 years prior to the trend being analyzed may be the best benchmark for comparison; 10 years may be long enough to capture what is typical for that company. Additionally, using a definitive, shorter time period may avoid the influence of historical ratios that are more impacted by long-term macroeconomic fluctuations.

This research was limited by the data used; researchers could include analysis of all DoD programs, rather than just Air Force. Additionally, smaller contracts could be utilized if cost performance data on contracts from specific units could be obtained. Alternatively, further research may be able to use the Contractor Performance Assessment Reporting System (CPARS)

as the database to collect alternate variables to measure contract success. However, access to this information is often restricted to individuals who are working on source selections. Furthermore, financial data may be available on non-publicly traded companies through Dun & Bradstreet (D&B). Closer scrutiny may need to be paid to this data due to differences in accounting standards and reporting requirements between publicly and non-publicly traded companies (Kell, 2017). Still, D&B data is available to the public, albeit at a high monetary cost.

Future research could also attempt to determine if financial ratios affect cost performance before the completion of the contract. Previous research has determined that CPI is stable long before the contract is complete. This CPI stability has been found to be as early as the 20% completion point (Christensen & Templin, 2002) and as late as the 60% completion point (Henderson & Zwikael, 2008). Future research could attempt to determine if financial ratio analysis could be a cause of early poor performance or possibly the reason some contracts exhibit an unstable CPI later in the contract. Additionally, it could be beneficial to find a link between financial ratios and schedule performance. As previously discussed, SPI becomes an ineffective measure of performance towards the end of a contract. Implementing the earned schedule metric (Lipke, 2003) could be a means of tracking schedule performance throughout the life of a contract.

Significance of Research

This research has shown that there is a correlation between a company's financial health at the time of contract start and the likelihood of cost overruns. Companies had a higher likelihood of performing well on efforts when their financial ratios were healthy. At the very least, this research has shown that further investigation into this topic is warranted. This could lead to implementation of financial ratio analysis in acquisition and program management to

better assess risk of DoD programs and ultimately save the United States Government millions of dollars in weapon systems acquisitions.

In the meantime, acquisition professionals should do their due diligence of analyzing company financial ratios at both the source selection phase and throughout the cost estimation process. These results indicate that the current ratio is an especially important indicator in a company's ability to perform on a contract from a cost performance standpoint. When analyzing the current ratio of a company, practitioners should incorporate a weighted mean of the most recent 5 years (or fewer) to capture the trends of that company's financial health. Comparing this recent trend to the long-term average of that individual company should provide an effective gauge of their current financial health. This will provide a risk metric that can be used to assist in determining the likelihood of a cost overrun.

Appendix

Table 38: Historical Data Availability by Company

Company	Quarterly	Yearly
BAE Systems	None	1985
Boeing	1988	1985
General Electric	1988	1985
L-3 Communications Harris	1988	1985
Leidos	2006	2003
Lockheed Martin	1994	1994
Northrop Grumman	1988	1985
Raytheon	1988	1985

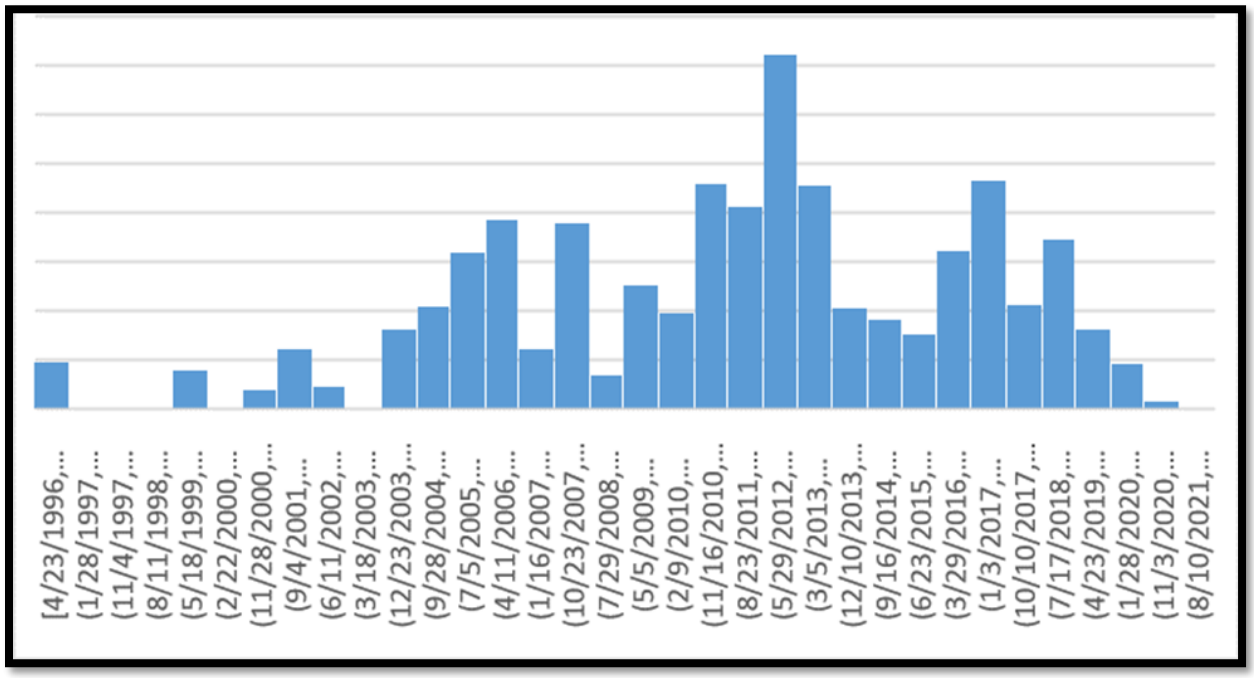

Figure 5: Distribution of Contract Start Dates

Figure 5 shows that the distribution of the contract start dates in the final dataset. The start dates seem to be centered around 2012, with a few contracts starting before 2002.

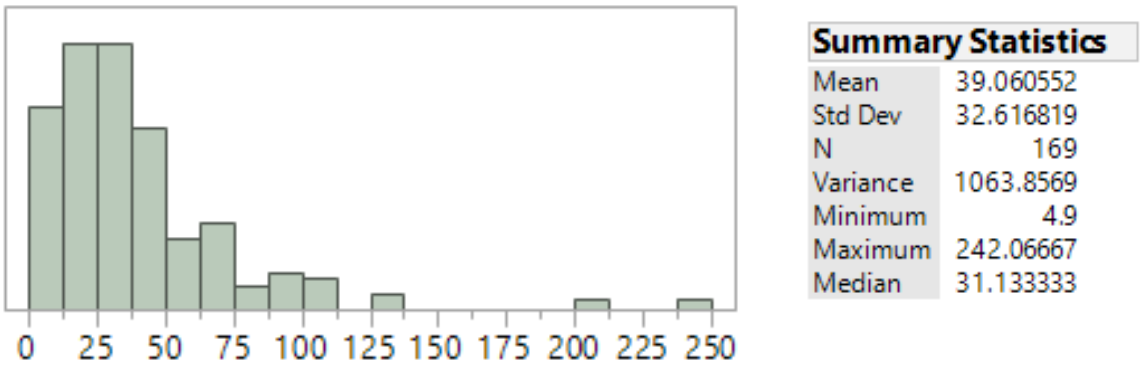

Figure 6: Distribution of Estimated Length of Effort at Beginning of Contract (In Months)

Figure 6 shows the time lags in months between the time that the financial ratios are calculated and the completion of the effort.

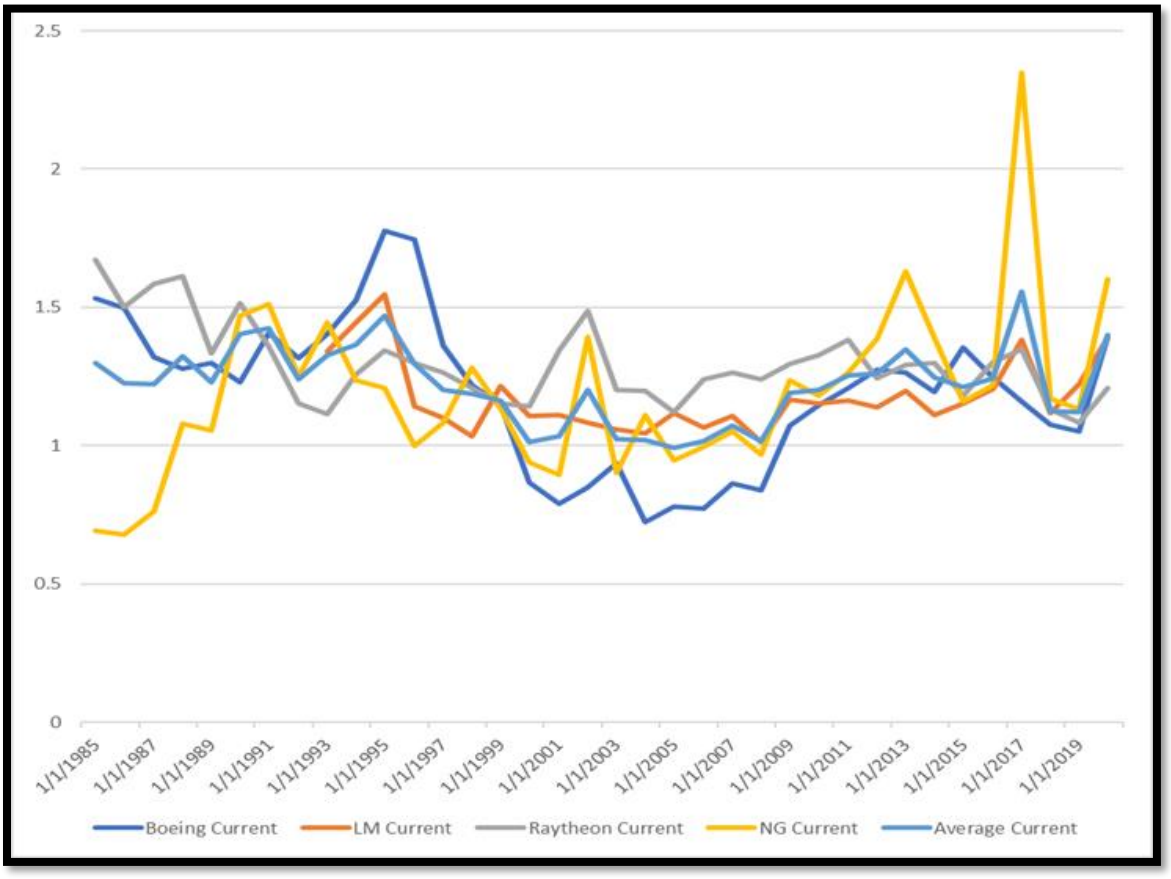

Figure 7: Yearly Current Ratio Trends by Company

Figure 7 shows the yearly current ratio calculations of all available data for the 4 largest companies used in this research. This chart is interesting because there is not one company that consistently has a current ratio that is above or below the average. This could lead to the hypothesis that the industry average proxy may actually be a valuable benchmark for comparison, despite previous research and the findings of this research.

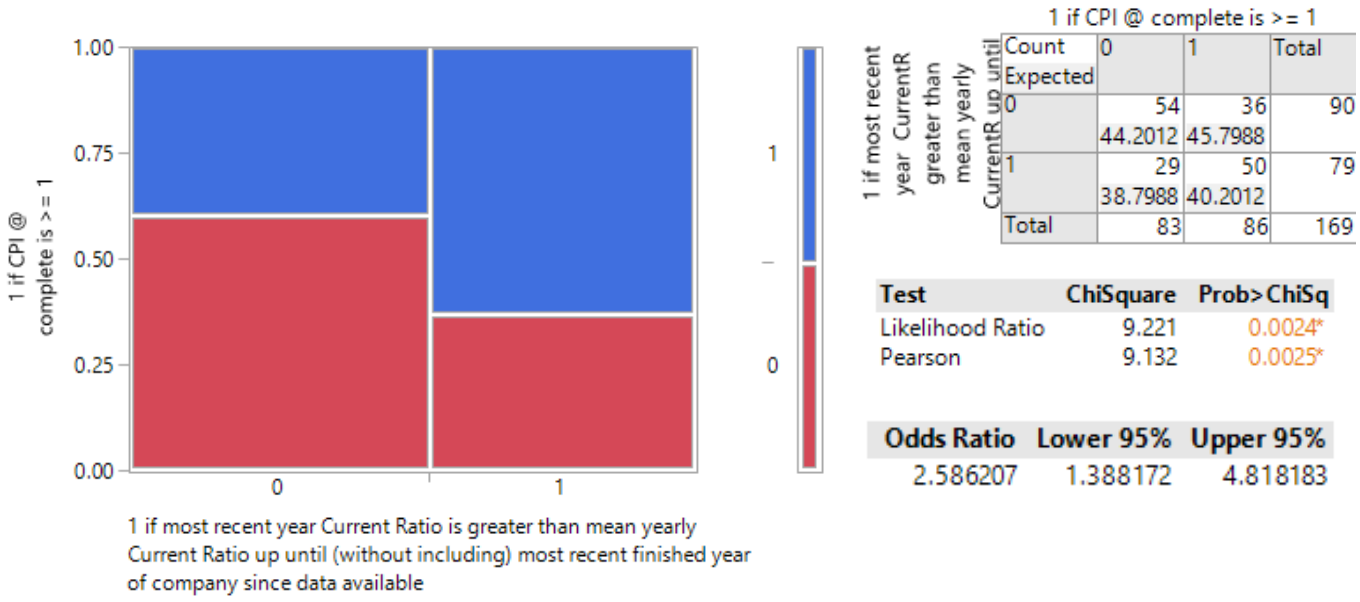

Figure 8: Example Contingency Table Result: Current Ratio Yearly Point Analysis

Figure 7 is an example of a significant result from this analysis. Visible from the table in the upper right, 83 of the efforts were over budget while 86 were under budget. Additionally, the company's most recent year's current ratio was better than the long-term historical average of that company in 79 of the 169 efforts. If there is no relationship between the most recent current ratio and the CPI at complete 40.2012 of these 79 are expected to have a CPI at complete greater than 1; the true results showed that 50 efforts resulted in a CPI of greater than 1 when the current ratio was greater than the long-term average of the company. The results show an odds ratio of

2.586. The Pearson test and the likelihood ratio are very close in value, which is consistent with all significant results in this research.

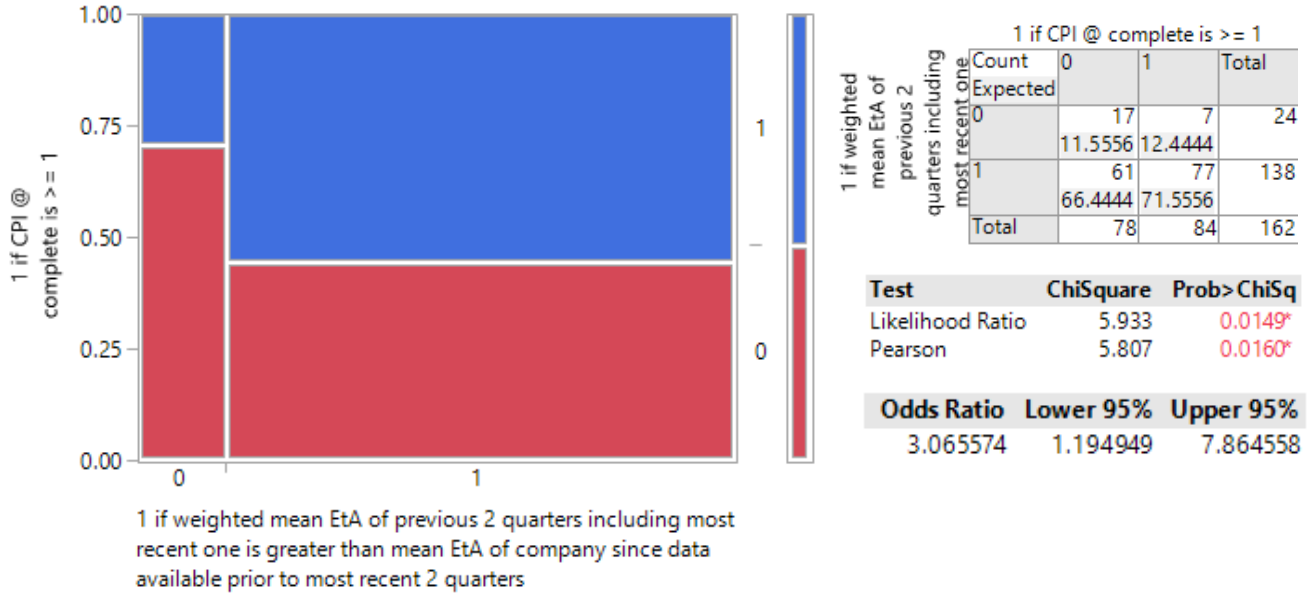

Figure 9: EBITDA to Asset Contingency Table Results: Lowest Observed Counts

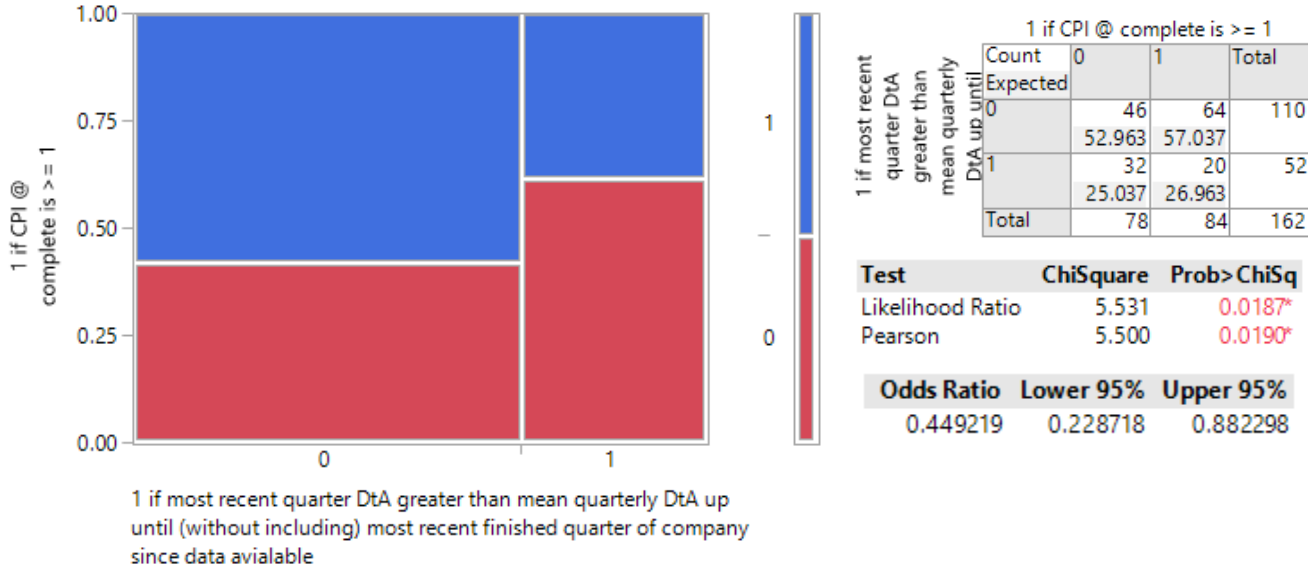

Figure 10: Debt to Asset Contingency Table Results: Lower Value of Financial Ratio Signifies Better Financial Health

Table 39: Significant Results by Ratio, Financial Performance Period Analyzed, and Benchmark

Ratio	Financial Performance Period	Benchmark
Current	Most Recent Quarter	Median Quarterly Current Ratio of Individual Company Since Data Available (Prior to Recent Quarter)
Current*	Most Recent Year	Mean Yearly Current Ratio of Individual Company Since Data Available (Prior to Most Recent Year)
Current	Most Recent Year	Median Yearly Current Ratio of Individual Company Since Data Available (Prior to Recent Year)
Current	Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly Current Ratio Since Data Available Prior to the 2 Most Recent Quarters
Current	Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly Current Ratio of the 6 Quarters Prior to the 2 Most Recent Quarters
Current	Weighted Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly Current Ratio Since Data Available Prior to the 2 Most Recent Quarters
Current	Mean of 6 Most Recent Quarters	Mean of the Company's Quarterly Current Ratio Since Data Available Prior to the 6 Most Recent Quarters
Current	Weighted Mean of 6 Most Recent Quarters	Mean of the Company's Quarterly Current Ratio Since Data Available Prior to the 6 Most Recent Quarters
Current	Mean of 2 Most Recent Years	Mean of the Company's Yearly Current Ratio of the 5 Years Prior to the 2 Most Recent Years
Current*	Weighted Mean of 2 Most Recent Years	Mean of the Company's Yearly Current Ratio Since Data Available Prior to the 2 Most Recent Years
Current	Weighted Mean of 2 Most Recent Years	Mean of the Company's Yearly Current Ratio of the 5 Years Prior to the 2 Most Recent Years
Current*	Weighted Mean of 5 Most Recent Years	Mean of the Company's Yearly Current Ratio of the 5 Years Prior to the 5 Most Recent Years
Quick	Most Recent Quarter	Median Quick Ratio of the 4 Largest Companies (In Most Recent Quarter)
Quick	Most Recent Quarter	Mean Quarterly Quick Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)
Quick	Weighted Mean of 2 Most Recent Years	Mean of the Company's Yearly Quick Ratio Since Data Available Prior to the 2 Most Recent Years
Quick*	Mean of 5 Most Recent Years	Mean of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years
Quick	Weighted Mean of 5 Most Recent Years	Mean of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years

Quick	Median of 5 Most Recent Years	Median of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years
Cash	Weighted Mean of 5 Most Recent Years	Mean of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years
Cash*	Median of 5 Most Recent Years	Median of the Company's Yearly Quick Ratio of the 5 Years Prior to the 5 Most Recent Years
EBITDA to Debt	Most Recent Quarter	Median Quarterly EBITDA/ Total Debt Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)
EBITDA to Debt	Most Recent Year	Median Yearly EBITDA/ Total Debt Ratio of Individual Company Since Data Available (Prior to Most Recent Year)
EBITDA to Asset	Weighted Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly EBITDA to Asset Ratio Since Data Available Prior to the 2 Most Recent Quarters
EBITDA to Asset	Mean of 6 Most Recent Quarters	Mean of the Company's Quarterly EBITDA to Asset Ratio Since Data Available Prior to the 6 Most Recent Quarters
EBITDA to Asset	Weighted Mean of 5 Most Recent Years	Mean of the Company's Yearly EBITDA to Asset Ratio of the 5 Years Prior to the 5 Most Recent Years
EBITDA to Asset	Median of the 5 Most Recent Years	Median of the Company's Yearly EBITDA to Asset Ratio of the 5 Years Prior to the 5 Most Recent Years
Debt to Asset	Most Recent Quarter	Mean Debt to Asset Ratio of the 4 Largest Companies (In Most Recent Quarter)
Debt to Asset	Most Recent Quarter	Mean Quarterly Debt to Asset Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)
Debt to Asset	Most Recent Quarter	Median Quarterly Debt to Asset Ratio of Individual Company Since Data Available (Prior to Most Recent Quarter)
Debt to Asset	Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly Debt to Asset Ratio Since Data Available Prior to the 2 Most Recent Quarters
Debt to Asset	Weighted Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly Debt to Asset Ratio Since Data Available Prior to the 2 Most Recent Quarters
Return on Assets	Weighted Mean of 2 Most Recent Quarters	Mean of the Company's Quarterly Return on Assets Ratio Since Data Available Prior to the 2 Most Recent Quarters
Return on Assets	Mean of 5 Most Recent Years	Mean of the Company's Yearly Return on Assets Ratio of the 5 Years Prior to the 5 Most Recent Years

** = P-value significant at an alpha of 0.01*

Table 40: Aggregated Significant Results by Ratio and Type of Analysis: Any CPI > 1 with OTB Removed

Financial Ratio	Quarterly Point	Yearly Point	Quarterly Trends	Yearly Trends	Total
Current Ratio (Current Assets / Current Liabilities)	2	2 (2)	5 (1)	4 (2)	**13 (5)**
Quick Ratio ((Current Assets - Inventories) / Current Liabilities)	3	1	2	5 (2)	**11 (2)**
Operating Cash Flow (Operating Cash Flow / Current Liabilities)	1	2	0	0	
Cash Ratio (Cash and Cash Equivalents / Current Liabilities)	0	0	0	2 (1)	**2 (1)**
EBITDA / Total Debt	1	1	0	2	**4**
EBITDA / Total Assets	0	0	1	2	**3**
Free Cash Flow / Total Debt	0	0	1	0	
Free Cash Flow / Total Assets	2	0	0	0	
Total Debt / Total Assets	2	1	2	2	**7**
Return on Assets (Net Income/Total Assets)	0	1	1	3	**5**
Total	**8**	**6 (2)**	**11 (1)**	**20 (5)**	**45 (8)**

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Table 40 shows all of the significant results when completely removing the 7 problematic efforts that incurred an OTB but finished with a CPI greater than 1. The general results are ultimately analogous to those of the main analysis. In fact, for the 7 ratios that were shown to be significant in the main analysis, there were more significant results found both at an α=0.05 and α=0.01. However, the red results are those that were significant in the direction opposite as

hypothesized. For example, the significant result in the quarterly point analysis of the operating cash flow ratio showed that if the most recent quarter's operating cash flow ratio was higher than sample median at the time of contract start, that effort was more likely to incur a cost overrun.

It is important to note that all of the significant results found in the opposite direction as hypothesized were found in the three ratios (operating cash flow ratio, free cash flow to debt, and free cash flow to assets) that had zero significant results in the initial analysis. This leads to the conclusion that these ratios are insignificant and that these contrary results may be spurious correlation. Another explanation is that these three ratios are indicators of a company's ability to perform, albeit in the direction contrary to initial theory. To elaborate, these three ratios all capture cash and cash flow that is not being used. Therefore, higher levels of these ratios could indicate that a company is not adequately using their capital towards resources that make them more effective, such as equipment and employees. Consequently, higher values of these ratios could actually indicate that a company may be more likely to incur a cost overrun.

Table 41: Aggregated Significant Results by Ratio and Type of Analysis: Any OTB Considered a Cost Overrun

Financial Ratio	Quarterly Point	Yearly Point	Quarterly Trends	Yearly Trends	Total
Current Ratio (Current Assets / Current Liabilities)	2	2 (2)	5 (1)	5 (4)	**14 (7)**
Quick Ratio ((Current Assets - Inventories) / Current Liabilities)	3	2	3	7 (2)	**15 (2)**
Operating Cash Flow (Operating Cash Flow / Current Liabilities)	1 - 2 (1)	1(1)	0	0	
Cash Ratio (Cash and Cash Equivalents / Current Liabilities)	0	0	0	2 (1)	**2 (1)**
EBITDA / Total Debt	2	1	0	2	**5**
EBITDA / Total Assets	1	0	0	2	**3**
Free Cash Flow / Total Debt	2	1	1 (1)	0	
Free Cash Flow / Total Assets	3 (1)	0	1	0	
Total Debt / Total Assets	1 (1)	1	0	2	**4 (1)**
Return on Assets (Net Income/Total Assets)	0	1 (1)	0	3	**4 (1)**
Total	**9 (1)**	**7 (3)**	**8 (1)**	**23 (7)**	**47 (12)**

Number of significant results at α=0.05; Number of significant results at an α=0.01 in parentheses

Table 41 shows all of the significant results when recategorizing the 7 problematic efforts that incurred an OTB but finished with a CPI greater than 1 as cost overruns. Again, for the 7 ratios that were shown to be significant in the main analysis, there were more significant results found both at an α=0.05 and α=0.01. As in Table 40, the red results are those that were significant in the direction opposite as hypothesized. Once again, it is important to note that all of the significant results found in the opposite direction as hypothesized were found in the three

ratios (operating cash flow ratio, free cash flow to debt, and free cash flow to assets) that had zero significant results in the initial analysis. This time, there were even more significant results opposite the direction hypothesized. This lends greater credence to the explanation that these three ratios are indicators of a company's ability to perform in the direction contrary to initial theory. This is further evidence that these ratios may be capturing a company's inability to effectively use capital on productive resources.

Bibliography

Abba, W. F. (2017, March 1). The Evolution of Earned Value Management. *Defense AT&L*, pp. 1-5.

Altman, E. I. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *The Journal of Finance*, 589-609.

Antczak, J., Horzela, I., & Nowakowska-Krystman, A. (2021). Influence of Financial Liquidity on the Competitiveness of Defense Industry Enterprises. *European Research Studies Journal*, 257-273.

Arena, M. V., Younossi, O., Galway, L. A., Fox, B., Graser, J. C., Sollinger, J. M., . . . Wong, C. (2006). *Impoossible Certainty: Cost Risk Analysis for Air Force Systems.* Santa Monica, CA: RAND Corporation.

Baranes, A., Palas, R., Shnaider, E., & Yosef, A. (2021). Identifying Financial Ratios Associated with Companies' Performance Using Fuzzy Logic Tools. *Journal of Intelligent & Fuzzy Systems*, 117-129.

Barnes, P. (1987). The Analysis and Use of Financial Ratios: A Review Article. *Journal of Business Finance and Accounting*, 449-461.

Beaver, W. H. (1966). Market Prices, Financial Ratios, and the Prediction of Failure. *Journal of Accounting Research*, 179-192.

Beaver, W. H., & McNichols, M. (2005). Have Financial Statements Become Less Informative? Evidence from the Ability of Financial Ratios to Predict Bankruptcy. *Review of Accounting Studies*, 1-53.

Bereznicka, J. (2014). Financial Liquidity and Profitability of Family Farms - Interdependence Dilemma. *Research Papers of the WSroclaw University of Economics*, 9-18.

(2021). *BGOV200 - Federal Industry Leaders.* Bloomberg Government.

Blevins, J. E. (2005, March). Informal Influences in the Process of IDIQ Contractor Selection for Task Award. *Theses and Dissertations*. Retrieved from https://scholar.afit.edu/etd/3789

Blum, M. P. (1974). The Failing Company Doctrine. *Journal of Accounting Research*, 1-25.

Bolten, J. G., Leonard, R. S., Arena, M. V., Younossi, O., & Sollinger, J. M. (2008). *Sources of Weapon System Cost Growth.* Santa Monica, CA: RAND Corporation.

Bordeianu, G. (2020). Basic Types of Financial Ratios Used to Measure a Company's Performance. *Economic Transdisciplinarity Cognition*, 53-58.

Brown, L. D., & Caylor, M. L. (2008). Corporate Governance and Firm Operating Performance. *Review of Quantitative Finance and Accounting*, 129-144.

Cancian, M. F. (2010). Cost Growth: Perception and Reality. *Defense Acquisition University*, 389-404.

Charalambous, C., Martzoukos, S. H., & Taoushianis, Z. (2020). Predicting Corporate Bankruptcy Using the Framework of Leland-Toft: Evidence from U.S. *Quantitative Finance*, 329-346.

Chava, S., & Jarrow, R. A. (2004). Bankruptcy Prediction with Industry Effects. *Review of Finance*, 537-569.

Chen, K. H., & Shimerda, T. A. (1981). An Empirical Analysis of Useful Financial Ratios. *Financial Management*, 51-60.

Christensen, D. S. (1998). The Costs and Benefits of the Earned Value Management Process. *Acquisition Review Quarterly*, 373-385.

Christensen, D. S., & Gordon, J. A. (1998). Does a Rubber Baseline Guarantee Cost Overruns on Defense Acquisition Contracts. *Project Management Journal*, 43-51.

Christensen, D., & Payne, K. (1992). Cost Performance Index Stability: Fact or Fiction. *Journal of Parametrics*.

Christensen, D., & Templin, C. (2002). EAC Evaluation Methods: Do They Still Work? *Acquisition Review Quarterly*, 105-116.

Ciampi, F., & Gordini, N. (2008). Using Economic-Financial Ratios for Small Enterprise Default Prediction Modeling: An Empirical Analysis. *Oxford Business & Economics Conference Program*, (pp. 1-21). Oxford.

Colombi, J., Miller, M. E., Schneider, M., McGrogan, J., Long, D. S., & Plaga, J. (2012). Predictive mental workload modeling: implications for system design. *Journal of Systems Engineering*, *15*(4), 448-460.

Cowen, S. S., & Hoffer, J. A. (1982). Usefulness of Financial Ratios in a Single Industry. *Journal of Business Research*, 103-118.

Cukr, A. (2001). *When is an Over Target Baseline (OTB) Necessary?* The Measurable News.

Dakic, S., Mijic, K., & Jaksic, D. (2020). Multiple Regression Approach to Modelling Determinanats of Business Success Based on Financial Statements: Evidence From Food Processing Companies in the Republic of Serbia. *Custos e @gronegocio*, 485-501.

DAU. (2021). Over Target Baseline (OTB). Fort Belvoir, Virginia.

de Koning, P., & Vanhoucke, M. (2016). Stability of Earned Value Management: Do Project Characteristics Influence the Stability Moment of the Cost and Schedule Performance Index. *The Journal of Modern Project Management*, 9-25.

Deakin, E. B. (1972). A Discriminant Analysis of Predictors of Business Failure. *Journal of Accounting Research*, 167-179.

Defense Acquisition University (DAU). (2020, June 1). *Earned Value Management Gold Card.* Retrieved from https://www.dau.edu/tools/t/EVM-General-Reference-(Gold-Card)

Department of Defense. (1985). *Defense Financial and Investment Review Final Report.* Washington, D.C.: Touche Ross & Company.

Department of Defense. (2019, January 18). Earned Value Management Implementation Guide . *DoD EVMIG*. Under Secretary of Defense for Acquisition and Sustainment.

(2011). *Department of Defense Source Selection Procedures.* Washington, DC: Office of the Under Secretary of Defense.

(2020). *DoD Cost Estimating Guide.* Washington, DC: Office of the Secretary of Defense.

(2020). *DoD Instruction 5000.02: Operation of the Adaptive Acquisition Framework.* Washington, D.C.: Office of the Under Secretary of Defense for Acquisition and Sustainment.

Elam, R. (1975). The Effect of Lease Data on the Predictive Ability of Financial Ratios. *The Accounting Review*, 25-43.

Erdoğan, E. O., Erdoğan, M., & Ömürbek, V. (2015). Evaluating the Effects of Various Financial Ratios on Company Financial Peformance: Application in Borsa Istanbul. *Business and Economics Research Journal* , 35-42.

Fadel, H., & Parkinson, J. M. (1978). Liquidity Evaluation by Means of Ratio Analysis. *Accounting and Business Research*, 101-107.

Federal Acquisition Regulation (FAR). (2021). *48 C.F.R. 4.10*.

Grossman, A. M., Smith, L. M., & Tervo, W. (2013). Measuring the Impact of International Reporting Standards on Market Performance of Publicly Traded Companies. *Advances in Accounting*, 343-349.

Gugler, K., Weichselbaumer, M., & Zulehner, C. (2015). Competition in the Economic Crisis: Analysis of Procurement Actions. *European Economic Review*, 35-57.

Gupta, M. C. (1969). The Effect of Size, Growth, and Industry on the Financial Structure of Manufacturing Companies. *The Journal of Finance*, 517-529.

Gupta, M. C., & Huefner, R. J. (1972). A Cluster Analysis Study of Financial Ratios and Industry Characteristics. *Journal of Accounting Research*, 77-95.

Hashim, S. L. (2020). Random Effect Model: Financial Ratios and Performance of Consumer Companies in Malaysia. *Global Business and Management Research: An International Journal*, 477-483.

Hastings, C., & Joseph, B. (2020). Using ANOVA and Multinomial Logistic Regression to Analyze Defense Acquisition Executive Summary (DAES) and Acquisition Program Baseline (APB) Milestone Estimates to Determine Contributing Factors to Schedule Slips. *Proceedings of the Seventeenth Annual Acquisition Research Symposium* (pp. 1-17). Monterey, California: Naval Postgraduate School.

Heba, M., & Chlebus, M. (2020). *Impact of Using Industry Benchmark Financial Ratios on Performance of Bankruptcy Prediction Logistic Regression Model.* Warsaw: University of Warsaw; Faculty of Economic Sciences.

Henderson, K., & Zwikael, O. (2008). Does Project Performance Stability Exist? A Reexamination of CPI and Evalution of SPI(t) Stability. *CrossTalk - The Journal of Defense Software Engineering*, 7-13.

Iotti, M., & Bonazzi, G. (2012). EBITDA / EBIT and Cash Flow Based ICRs: A Comparative Approach in the Agro-Food System in Italy. *Financial Assets and Investing*, 19-31.

Kell, L. (2017). SEC Reporting Requirements for Publicly Traded Companies Should Not Be Expanded Despite Advances in Information Technology. *Duke Law & Technology Review*, 196-215.

Kim, S.-c. (2009). Project Success Indicators Focusing on Residential Projects: Are Schedule Performance Index and Cost Performance Index Accurate Measures in Earned Value? *Canadian Journal of Civil Engineering*, 1700-1710.

Lampkin , E. D. (1992). *The Marginal Cost and Practicality of Cost/Schedule Control Systems Criteria Implementation.* Dayton, OH: Aeronautical Systems Center.

Lemke, K. W. (1970). The Evaluation of Liquidity: An Analytical Study. *Journal of Accounting Research*, 47-77.

Lev, B., & Sunder, S. (1979). Methodological Issues in the Use of Financial Ratios. *Journal of Accounting and Economics*, 187-210.

Libby, R. (1975). Accounting Ratios and the Prediction of Failure: Some Behavioral Evidence. *Journal of Accounting Research*, 150-161.

Lipke, W. (2003). *Schedule is Different.* Oklahoma City: The Measurable News.

Lorell, M. A., Leonard, R. S., & Doll, A. (2015). *Extreme Cost Growth: Themes from Six U.S. Air Force Major Defense Acquistion Programs.* Santa Monica, CA: RAND Corporation.

McNicol, D. L. (2020). *Root Causes of Cost Growth in Major Defense Acquisition Programs.* Alexandria, VA: Institute for Defense Analyses.

Merwin, C. L. (1942). *Financing Small Corporations in Five Manufactuing Industries, 1926-36.* Cambridge: National Bureau of Economic Research.

Mossman, C. E., Bell, G. G., Swartz, L. M., & Turtle, H. (1998). An Empirical Comparison of Bankruptcy Models. *The Financial Review*, 35-54.

Nicholas, J. M., & Steyn, H. (2017). *Project Management for Engineering, Business, and Technology (5th ed.).* New York: Routledge.

Nissim, D. (2019). *EBITDA, EBITA, or EBIT?* New York: Columbia Business School.

Ohlson, J. A. (1980). Financial Ratios and the Probabilistic Prediction of Bankruptcy . *Journal of Accounting Research*, 109-131.

Overman, T. J., & Williams, L. J. (2021). *Corporate Financial Health Assessment: Air Force Life Cycle Management Center Cost and Economics Division.* Dayton, OH: Air Force Life Cycle Management Center Cost and Economics Division.

Pindado, J., & Rodrigues, L. F. (2004). Parsimonious Models of Financial Insolvency in Small Companies. *Small Business Economics*, 51-66.

Reale, K. (2011, March 14). Financial Ratios: Understanding This Powerful Tool for Managing for Success. *Banking & Financial Services*, pp. 46-48.

Ritschel, J. D. (2014). Impact of Political-Economy Variables on Cost Growth in Military Weapon System Contracts. *Journal of Public Procurement*, 516-538.

Schmidgall, R. S., & DeFranco, A. (2016). How to Best Use Financial Ratios in Benchmarking and Decision Making in Clubs: Review of the Decade. *International Journal of Hospitality & Tourism Administration*, 179-197.

Shannon, D. (2018, November 19). *Are We Asking Too Much From EVM?* Retrieved from Linkedin.com: https://www.linkedin.com/in/donshannon/

Shumway, T. (2001). Forecasting Bankruptcy More Accurately: A Simple Hazard Model. *The Journal of Business*, 101-124.

Simlai, D., & Guha, M. (2019). Financial Stability, Profitability and Growth Analysis: A Study on Select Indian Automobile Companies. *Journal of Commerce & Accounting Research*, 21-34.

Smirnoff, J. P., & Hicks, M. J. (2008). The Impact of Economic Factors and Acquisition Reforms on the Cost of Defense Weapon Systems. *Review of Financial Economics*, 3-13.

Taffler, R. J., & Sudarsanam, S. P. (1995). Financial Ratio Proportionality and Inter-Temporal Stability: An Empirical Analysis. *Journal of Banking and Finance*, 45-60.

Thickstun, K. E. (2010). *Predicting over Target Baseline (OTB) Acquisition Contracts.* AFIT Theses and Dissertations.

Tinoco, M. H., & Wilson, N. (2013). Financial Distress and Bankruptcy Prediction Among Listed Companies Using Accounting, Market, and Macroeconomic Variables. *International Review of Financial Analysis*, 394-419.

Tracy, S. P., & White, E. D. (2011). Estimating the Final Cost of a DoD Acquisition Contract. *Journal of Public Procurement*, 190-205.

Trudelle, R., White, E. D., Koschnick, C., Ritschel, J. D., & Lucas, B. (2017). Estimating An Acquisition Program's Likelihood of Staying Within Cost and Schedule Bounds. *Defense ARJ*, 600-625.

U.S. Government Accountability Office. (2019). *Weapon Systems Annual Assessment: Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments.* Washington, DC: United States Government Accountability Office.

Younossi, O., Arena, M. V., Leonard, R. S., Roll, C. R., Jain, A., & Sollinger, J. M. (2007). *Is Weapon System Cost Growth Increasing? A Quantitative Assessment of Completed and Ongoing Programs.* Santa Monica, CA: RAND Corporation.

Zeytinoglu, E., & Akarim, Y. D. (2013). Financial Failure Prediction Using Financial Ratios: An Empirical Application on Istanbul Stock Exchange. *Journal of Applied Finance & Banking*, 107-116.

Zhang, X. (2005). Criteria for Seclecting the Private-Sector Partner in Public-Private Partnerships. *Journal of Construction Engineering & Management, 131*(6), 631-644.

Zhong, K., & Gribbin, W. D. (2009). Are Defense Contractors Rewarded for Risk, Innovation, and Influence? *Quarterly Journal of Finance and Accounting*, 61-73.

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14. ABSTRACT

Financial ratio analysis has long been used to determine the financial health of firms and project business performance. Despite the usefulness of financial ratio analysis, risk analysis in defense acquisitions largely ignores these indicators of company financial well-being. This research performs contingency table statistical analysis to determine if a relationship exists between company financial ratios and their future cost performance on Air Force contracts. The general findings are that poor financial ratios at the time of contract start are related to increased likelihood of cost overruns on that contract. Specifically, recent trends of a company's current ratio in comparison to the long-term average current ratio of that company are especially linked with the Cost Performance Index (CPI). The results of this research justify further exploration into financial ratio analysis of offering companies as a means to better assess the cost overrun risk of DoD programs.

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