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A panel data regression model for defense merger and acquisition activity

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Logistics

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Abstract

Purpose – This paper examines the relationship between a prime contractor's financial health and its mergers and acquisitions (M&A) spending in the defense industry. It aims to provide models that give the United States Department of Defense (DoD) indications of future M&A activity, informing decision-makers and contributing to ensuring competitive markets that benefit the consumer.

Design/methodology/approach – The study uses panel data regression models on 40 companies between 1985 and 2021. The company's financial health is assessed using industry-standard financial ratios (i.e. measures of profitability, efficiency, solvency and liquidity) while controlling for economic factors such as national productivity, defense budgets and firm size.

Findings – The results show a significant relationship between efficiency and M&A spending, indicating that companies with lower efficiency tend to spend more on M&As. However, there was no significant relationship between M&A spending and a company's profitability or solvency. These results were consistent with previous research and the study's hypotheses for profitability and solvency. However, the effect of liquidity was the opposite of the expected result, possibly due to the defense industry's different view on liquidity compared to previous research.

Originality/value – The paper provides insights into the relationship between a prime contractor's financial health and its M&A spending, a topic with limited research. The findings can inform policymakers and regulators on the industrial base's future M&A activity, ensuring competitive markets that benefit the consumer.

Keywords Merger, Acquisition, Profitability, Solvency, Liquidity, Efficiency, Financial ratio, Financial health, Defense industrial base

Paper type Research paper

1. Introduction

The Department of Defense (DoD) expected budget reductions at the end of the Cold War. That stark fiscal reality sparked a meeting subsequently coined the “Last Supper” (Tirpak, 1998). The “Last Supper” occurred in 1993, when DoD policymakers invited defense industry leaders to dinner at the Pentagon. During the meal, the Secretary of Defense (SecDef)

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informed the defense industry chiefs that impending budget cuts were expected to be large and expedited. The implication was that the DoD would not be able to support the Defense Industrial Base (DIB) at its current size. Only a few large contractors could be financed simultaneously (Higgs, 1990). The SecDef, therefore, encouraged the acceleration of Mergers and Acquisitions (M&As). Through M&A activity, the DIB could consolidate and reduce the assets the DoD needed to support and maintain (Deutch, 2001). The primary intent was reducing tangible assets like properties, plants, and equipment where savings would be split between the government and its partners.

The recommended consolidation triggered a second wave of M&As—the first having started around 1980. Tellingly, what was 75 firms in 1980 consolidated to the top-five prime contractors of today (CFUSAI, 2002), and the top-six defense contractors increased their share of total defense contract obligations by over 20% between 1990 and 2014 (Ellman and Bell, 2014). This concentration was even more pronounced at the sector level with the top-six contractors awarded nearly 70% of aircraft manufacturing contracts—up from roughly 30% in 1990 (Ellman and Bell, 2014). Moreover, M&As can affect new product areas, such as hypersonic weapons and lithium-ion batteries (OUSD Acquisition and Sustainment, 2022).

Consolidations can cause a reduction in capability, capacity, and depth of competition that severely affects national security (Freling and Hastings, 2022). These acquisitions by primes limit new entrants and increase supply chain security concerns (OUSD Acquisition and Sustainment, 2022). Consolidation in the 1990s left many weapons categories with limited competition. Tactical missiles witnessed a drawdown from 13 to 3, fixed-wing aircraft from 8 to 3, satellites from 8 to 4, surface ships from 8 to 2, and tracked combat vehicles from 3 to 1. While the consolidation has not always led to increased program pricing, risks related to supply availability, system innovations, and vendor performance may manifest (OUSD Acquisition and Sustainment, 2022). Thus, with a smaller DIB, future M&A activity necessitates ever closer monitoring to ensure a robust and resilient DIB. Analyzing past M&A activity and the characteristics of the acquiring company at the time of the M&A can inform future policy decisions. The GAO (2023a) has identified the current lack of understanding of the risks of M&A as a focus area. More specifically, developing a model to examine the relationship between M&A spending and a company's financial health can help the DoD better understand the risks and benefits of M&As—thus informing the DoD's regulatory role along with the Federal Trade Commission (FTC) and Department of Justice (DOJ). This promotes a balance between industry competitiveness and stability.

This paper proposes a novel (to the DoD) approach of utilizing financial ratios as a M&A monitoring mechanism. Financial ratio analysis has been applied to various industries, like randomly sampled markets (Amano, 2022; Gozali and Panggabean, 2019), banking (Rashid, 2021), fuel industries (Mboroto, 2013), and even households (DeVaney, 1994). These industries have utilized financial ratios to analyze company failures, acquisitions, and the results of post-consolidation synergy. However, little research has been conducted on the relationship between financial ratios and M&A spending within the U.S. defense sector. This paper seeks to inform that discussion.

2. Mergers and acquisitions

The DIB is a vast set of over 100,000 companies providing goods and services to support the DoD's mission (Cybersecurity and Infrastructure Security Agency (CISA), n.d.; Peters, 2021). These companies include prime contractors, sub-contractors, suppliers, small businesses, and foreign and domestic contractors. Prime contractors act as the primary system integrators for the DoD's complex weapon systems (Susman and O'Keefe, 1998). These primes often subcontract or collaborate with non-prime contractors to complete a project (U.S. Small Business Administration, n.d.). Primes can also be identified by the number or

value of the contracts they receive from the DoD (Bernal, 2022). Thus, prime contractors have a central role in the structure of the DIB.

While the government has seen a high level of consolidation since the early 80s and began explicitly promoting M&As within the DIB in 1993, economy-wide M&A activity has also grown. Overall, the number of U.S. M&A transactions has approximately doubled between 1991 and 2019 (IMAA, 2024). Businesses globally have used consolidation efforts to change ownership, increase product and service variety, add to their current asset mix, foster alliances, maximize shareholder value, and improve firm performance (Mboroto, 2013). Companies also resort to M&As in industries where circumstances prevent typical organic growth (Tikhomirov *et al.*, 2019). Note that the DIB struggles with organic growth due to a monopsony with the DoD as the primary customer acting as a gatekeeper for access to other customers (Driessnack and King, 2004) and so M&As are the primary method for DIB companies to grow (Mahoney, 2021).

The multitude of reasons for consolidation is also reflected in how companies combine. While the terms merger and acquisition are often used interchangeably, they have subtle differences (Kovacic and Smallwood, 1994). A merger occurs when two businesses in similar lines of business combine their organizations with mutual consent, often under a new name to reflect the new partnership (CFI Team, 2022). On the other hand, an acquisition happens when one company, usually larger, buys out another company, and the acquiring company completely takes over the target company's operations (CFI Team, 2022). Acquisitions often involve hostile takeovers where the buyer purchases 51% or more of the target company's shares potentially leading to the dissolution of the target company (Inoti, 2014). In amicable cases, the target company may retain its name but operates under the new parent company's hierarchy—as in Lockheed Martin's acquisition of Sikorsky in 2015.

Furthermore, the Federal Trade Commission (2013) has identified different types of consolidation, two of which are: horizontal and vertical M&As. A horizontal M&A occurs when two companies consolidate within the same line of business, like two aircraft manufacturers. Horizontal M&As usually involve a merger of primes rather than an acquisition. In contrast, vertical consolidation happens when a manufacturer combines with a supplier in its chain. This type of consolidation typically takes place through acquisition rather than a merger. Though horizontal mergers can be concerning due to price increases or reduced innovation, in recent years the defense industry has seen an increase in vertical mergers. Firms that vertically integrate may reduce access to necessary inputs for competitors (i.e. foreclosure), raise rivals' costs, or limit competitor access to sensitive information (OUSD Acquisition and Sustainment, 2022).

To justify M&A activity, acquirers often report synergies as the primary reason for consolidation to regulating agencies (Amano, 2022; Blonigen and Pierce, 2016; Tikhomirov *et al.*, 2019). These synergies can lead to benefits such as rapid access to technology and products, an extended customer base, and enhanced market positions (Mboroto, 2013). Synergies are further classified into operational and financial synergy (Dewi and Mustanda, 2021).

Defense companies pursue M&As for a variety of self-serving reasons—some of which include benefits to the government. Understandably, the government is also concerned about the risks associated with M&A activity—especially threats to competition but also risks to innovation, affordability, and capacity (GAO, 2023a). Unfortunately, the DoD has poor insight into defense M&As and often has to use its limited resources to focus on major defense suppliers and high-value transactions (GAO, 2023a). One reason for the poor insight is limited information. Figure 1 shows defense M&A activity for 2007-2017, but specific details of these overall levels is not available; additionally DoD's M&A assessments in recent years have only involved a small portion of the total defense M&As (GAO, 2023a).

In the spirit of GAO's (2023a) recent report, this study focuses on gaining better insight into M&A activity involving defense industry prime contractors. The prime contractors play a pivotal role in the delivery of weapons systems, and as publicly traded companies,

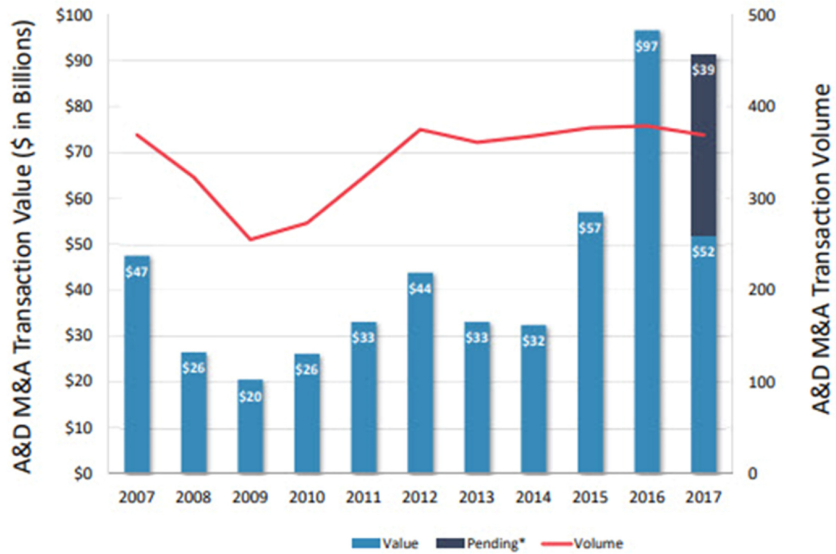


Figure 1.
M&A activity in the
defense sector –
2007-2017

Source(s): Figure by OUSD (2017)

information pertaining to their M&A activity is more accessible than smaller or private companies. Furthermore, the relationship between corporate structure and financial interests for publicly traded defense companies is relatively unexplored (Mahoney, 2021). Specifically, this research uses common financial ratios to define a company’s structure and M&A spending as a measure of its financial interest. The following section provides a literature review of how financial ratios are used to understand company performance and behavior.

3. Literature review

3.1 Financial ratios

Financial ratios are used to analyze the relationship between two or more financial variables using fractions or percentages (Suthar, 2018). Ratios provide insights into a company’s financial health and allow for meaningful comparisons between companies of different sizes (Barnes, 1987). Financial ratios are commonly grouped into one of the following categories: *profitability*, *solvency*, *efficiency*, and *liquidity* (Budiantoro et al., 2022). Financial reporting practices are standardized for organizations through federal tax codes, the Federal Reserve System, and the Securities Exchange Commission (SEC) allowing for the calculation of financial ratios (Horriagan, 1968).

The first category, *profitability*, measures a company’s financial health by reflecting the effective management and productive use of resources (Burja, 2011). Profitability ratios can be further categorized as margin and return ratios. Margin ratios include gross or net profit, cash flow, and operating profit margin; while return ratios include return on assets (ROA), return on invested capital (ROIC), and return on equity (ROE).

The second category, *solvency* (or leverage) ratios, measure a company’s financial stability and ability to meet its long-term debts and financial obligations. Companies with assets that are greater than the sum of their liabilities are considered solvent (U.S. Code, 2011); insolvency is an important indicator of company failure and often becomes an essential determinant in

bankruptcy declaration (Ghosh and Chaudhuri, 2017). Common ratios used to study solvency include interest coverage, debt to assets, and debt to equity.

The third category, *efficiency*, measures how effectively managers of a company utilize their assets to generate sales (Adedeji, 2014). Efficiency can be analyzed qualitatively or quantitatively. While qualitative measures focus subjectively on company goals, quantitative measures provide objective data across companies using financial ratios (Zietlow *et al.*, 2018). Some common examples of quantitative efficiency measurements include total assets turnover, accounts receivable turnover, fixed asset turnover, and inventory turnover.

Lastly, *liquidity* ratios measure a company's ability to meet its short-term financial obligations and are a vital indicator of its financial standing (Kritsonis, 2005; Tikhomirov *et al.*, 2019). Investors and creditors assess the risk of lending money to or investing in the company (Beaver, 1966). Some common liquidity measures include the current, quick, and net working capital ratios.

3.2 Limitations of financial ratios

While valuable for analyzing a company's performance, financial ratios have several limitations. First, the numerical value of a ratio can vary depending on the specific values used from the financial statements. This discrepancy arises from multiple profit figures disclosed in income statements such as operating profit, net profit before interest and taxation, and net profit after taxation (Frecknall-Hughes *et al.*, 2007). Thus, companies facing financial troubles may manipulate ratios to meet creditor and investor expectations, rendering them unreliable until a crisis occurs (Lev, 1969; Wilcox, 1971).

Furthermore, the choice of which ratios to analyze can be challenging due to the numerous ratios available; it is impractical to examine all of them in a single study (Murphy *et al.*, 1996). It is important to note that not all ratios measure a company's performance equally well. To obtain a comprehensive understanding, it may be necessary to consider a combination of ratios alongside other economic factors (Gadoiu, 2014). Moreover, the usefulness of financial ratios can vary depending on their application or the specific sample being analyzed, and researchers sometimes overuse ratios, leading to over-fitting and overstated predictability (Palepu, 1986).

Another limitation is that the importance of different financial ratios may vary across industries. Different industries prioritize certain categories of ratios based on their specific needs. For example, creditors may emphasize debt payment ratios more while managerial accounting practices focus more on profitability measures (Horrihan, 1968). Examining how financial institutions evaluated debt ratios for creditworthiness in industries reliant on debt financing, such as defense contractors in the 1990s, can provide valuable insights (Beaver, 1966; Deutch, 2001).

Despite these limitations, financial ratios remain valuable for assessing a company's health. Ensuring consistency in the calculation process can minimize variations caused by different financial statement values. Selecting the most relevant ratios for a specific industry or context is vital and combining them with other economic considerations can enhance their value. By avoiding known biases and building on previous studies, accurate modeling procedures can be developed to give interested parties a more accurate picture of a company's financial health over time.

3.3 Financial ratios and acquisition activity

This paper seeks to discern a contractor's financial health as measured by various financial ratios and their impact on acquisition spending. The linkage can be analyzed from the viewpoints of both the acquirer and the target. It may be that the financial strength of an

acquiring company would be reflected in the economic difficulties faced by the target company in the years leading up to the acquisition. Previous studies have indicated that some companies choose to be acquired strategically to avoid bankruptcy or other distress (Officer, 2007; Pastena and Ruland, 1986). Other researchers found that acquisitions caused by distress were less common (Camerlynck *et al.*, 2005; Higson and Elliott, 1993).

Assuming struggling companies were the targets, successful companies would be the presumed acquirers. A company's profitability could be one measure of its health or success. The company may save its excess funds, pay debts, distribute dividends, or acquire businesses with these profits. However, according to research by Yang *et al.* (2019), successful companies with strong operating performances were less likely to pursue external acquisitions. Although, companies with higher growth opportunities may rely more on external investments to fund their expansion (Yang *et al.*, 2019).

The impact liquidity and solvency have on acquirer's M&A activity has been a subject of debate among researchers. Some argue that companies with excess cash prefer to utilize their funds instead of seeking external financing, while others contend that acquisitions financed with additional debt are more favorable, particularly in the defense industry (Bruner, 1988; Deutch, 2001; Myers, 1984). There has been a significant time gap between the studies by Myers (1984) and Yang *et al.* (2019), making it challenging to determine any potential shifts in the utilization of liquid assets for M&As. However, recent research suggests that higher liquidity tends to increase the likelihood of M&As (Erel *et al.*, 2021; Shleifer and Vishny, 1992). Furthermore, a company's acquisition strategy may involve transitioning from internal assets to external debts and eventually equity financing, with variations based on the company's experience (Fourati and Affes, 2013). The free cash flow theory concept suggests that companies with substantial liquidity may engage in self-interested, low-benefit acquisitions (Jensen, 1996; Yang *et al.*, 2019).

Various ratios and metrics, such as liquidity, solvency, growth-resource imbalances, and non-liquid asset ratios, have been studied to determine the likelihood of a company becoming an acquisition target. Cudd and Duggal (2000) discovered that when there are imbalances between sales and resources within target firms, their acquirers can invest the excess resources more profitably in their projects or finance the acquired firms' projects at a lower cost of capital. Belkaoui (1978) found that non-liquid asset ratios best-predicted takeovers in Canadian industries. Additionally, comparing a company's financial ratio to the industry average has proven helpful in predicting failures and acquisitions (Barnes, 1990; Camerlynck *et al.*, 2005).

In summary, previous literature has examined the relationship between financial ratios and acquisition activity. That literature provides insights into the expected impacts of various financial health measures. Those efforts inform variable selection for this paper. Missing from that literature, however, is an analysis of the defense sector M&A activity which this paper undertakes.

3.4 Economic factors

Macroeconomic factors such as national productivity, inflation, and interest rates may influence M&A activity. Previous research has found that national productivity in particular, measured by gross domestic product (GDP), can significantly impact M&As. Companies are more likely to engage in M&As during strong economic conditions and less likely to do so during weak economic conditions (Ji, 2016). Cordeiro (2014) observed that the number of M&As sharply declined in 2007 due to the subprime crisis and the subsequent recession in the U.S., yet it rose globally in 2014 after the economy recovered. Additionally, Carbonara and Caiazza (2009) and Wang (2009) found that national productivity growth was the most significant economic factor influencing M&As in Italian and Chinese markets.

Previous studies have shown that financial ratio analysis is most effective when comparing companies within similar industries (Barnes, 1990; Beaver, 1966; Cudd and Duggal, 2000; Edmister, 1972). For example, the government's budget drawdowns and pro-consolidation policy recommendations from 1993 to 1998 threatened contractor revenue, prompting some companies to seek M&As to secure DoD contracts. These conditions are unique to the defense sector and may not be captured at a macroeconomic level.

Lastly, *microeconomic* considerations, particularly size is a prevalent influence on company failure and M&A activity. There are various proxies for the size of a company, like market capitalization, sales, resources, or employees—each capturing different aspects of the firm. Market capitalization is market-oriented and forward-looking, while total sales are more related to the product market and not forward-looking, and total assets measure the firm's total resources (Dang *et al.*, 2018). Nevertheless, the correlation among these proxies is high (Shalit and Sankar, 1977). The growth of a company demonstrated unusual findings where larger firms tend not to fail as frequently (Beaver, 1966), but growth-to-asset imbalances can increase the likelihood of failure and becoming an acquisition target (Camerlynck *et al.*, 2005; Cudd and Duggal, 2000; Palepu, 1986; Yang *et al.*, 2019). Companies often became acquisition targets when their assets were insufficient to maintain their observed growth and acquirers typically had higher asset growth rates than their targets (Camerlynck *et al.*, 2005). Each of these economic levels (macro, and micro) will be accounted for in this study's models.

4. Hypothesis development

The literature has mixed findings regarding the link between financial health and M&A activity. For example, Camerlynck *et al.* (2005) studied profitability and found that acquirers often had higher profitability than their industry peers. However, Yang *et al.* (2019) found that companies with higher profitability tended to rely on internal investments over M&As. Similar mixed results were seen for liquidity and solvency. Some found that cash-rich or liquid firms were more likely to attempt acquisitions (Bruner, 1988; Erel *et al.*, 2021; Jensen, 1996; Myers, 1984), but Camerlynck *et al.* (2005) found evidence to support the contrary, finding acquirers often reported below industry-average liquidity and were highly leveraged. High leverage has also been shown to be related to bankruptcies (Beaver, 1966), but the link between a target company's distress and their potential for being acquired is unclear (Camerlynck *et al.*, 2005; Officer, 2007).

Less controversial theories were seen for efficiency. Researchers suggest that larger, less efficient firms seek to acquire smaller, more efficient firms to improve the acquiring company's efficiency (Inoti, 2014; Jensen and Ruback, 1983). Thus, efficiency and M&A activity appear to have an inverse relationship.

Economic factors have been shown to influence M&A activity; this research controls for both micro and macroeconomic effects. First, national productivity is used as a proxy for the economy's overall health. Increases in national productivity, or GDP, have increased M&A activity in American, Chinese, and Italian markets (Carbonara and Caiazza, 2009; Wang, 2009). Second, industry-specific effects have also influenced M&A activity (Cordeiro, 2014; Palepu, 1986). Although the defense budget's impact has not been explicitly studied alongside M&A spending, this variable is used to control for the effects specific to the defense industry—the logic being that as budgets decrease, as they did in the 1990s, M&A activity will increase (OUSD Acquisition and Sustainment, 2022). The final economic control variable is company size. As the size of a company grows, acquisition spending tends to grow (Dang *et al.*, 2018; Shalit and Sankar, 1977). Thus, the four hypotheses for the relationship between M&A spending and the financial health categories are as follows:

- H1. Defense contractors with higher profitability are associated with increased spending on M&As.
- H2. Defense contractors that are highly leveraged are associated with increased spending on M&As.
- H3. Companies with lower efficiency are associated with increased spending on M&As.
- H4. Defense contractors with greater liquidity are associated with increased spending on M&As.

5. Methodology

This analysis required the identification of prime contractors as well as the collection of their annual 10-K reported financial data and M&A activity. The financial data was used to calculate the financial health ratios. At the same time, M&A activity was used as the response variable for the models. This study used various databases and this section will define the processes used to build the final dataset. The collected data was used to develop the independent variables (IVs) to test the hypotheses. A panel data model was utilized since the experiment studies M&A activity on a cross-section of contractors over several years.

5.1 Sample

Two reports were critical in identifying whom the DoD classified as prime contractors within its weapons categories (OUSD Acquisition and Sustainment, 2022; U.S. GAO, 1998a, b). Between these reports, 42 prime contractors were identified for 1990, 1998, and 2020. The 42 initial contractors fall into the “DoD Identified Contractors” category in Table 1. Although the DoD provided the initial foundation for prime contractor identification, several contractors have entered or exited their market through M&A activity. This entry and exit required additional contractors to be added as primes or removed from the analysis. Additionally, some data could not be obtained due to financial reporting requirements and database limitations.

Several M&As transpired between the release of the GAO (1998a, b) and the *State of Competition* (OUSD Acquisition and Sustainment, 2022) reports causing some primes to be absent in either report. It is assumed that if a company acquired a prime contractor, the acquirer becomes a prime themselves, as indicated by “M&A of DoD Prime.” Models with and without the acquirer were assessed to ensure the acquirer’s data did not influence the results. M&As also spurred two spin-off companies that still serviced their previous sectors within the industry. All defense industry spin-offs identified in this research were acquired or no

Contractor inclusion/Exclusion criteria	# of contractors
DoD Identified Contractors*	42 Initial
M&A of DoD Prime	5 Added
Spin-Off Companies	2 Added
Parent of Subsidiary	8 Added
Subsidiary	9 Removed
Private Companies	7 Removed
Missing Financials	1 Removed
Total	40 Contractors

Table 1.
Data sample

Note(s): *Contractors identification based on the GAO’s 1998a, b report
Source(s): Table by authors

longer considered primes as of the *State of Competition* report (OUSD Acquisition and Sustainment, 2022). However, they still required tracking in this analysis due to their strong influence within their sectors.

Nine DoD-identified prime contractors were subsidiaries of a larger parent company. Since financial data for a parent company is rarely reported at the subsidiary level, limited financial data could be found. Therefore, eight parent companies were added to the analysis as a proxy for the prime contractor they represent. Similarly, private companies' financial data are rarely made public. Although databases like Techsalerator, Mattermark, Crunchbase, and PitchBook provide private company financials, seven private prime contractors were omitted from this study due to database access limitations. Finally, most databases have limited financial data for companies that merged before 1995. Since Northrop merged with Grumman in 1994, Grumman's financial data could not be obtained.

M&A activity can cause contractors to come and go, making it hard to balance the dataset. Equalizing would reduce the sample size to only seven contractors. While the dataset is unbalanced due to these comings and goings during sample selection, the statistical modeling software R corrects for unbalanced biases mitigating the threat to identification.

Table 1 summarizes the aforementioned data inclusion and exclusion process for this research. The final sample includes 40 companies from 1985 to 2021, totaling 666 observations. Notably, the number of firms in this study parallels that of previous GAO analyses. However, unlike prior research, we examine both cross-sectional and longitudinal variations in the data across three distinct models. This approach ensures a level of robustness apropos to the modest sample size. A complete list of the contractors and their categories within Table 1 can be seen in Appendix 1.

5.2 Data

The financial data used in the ratio calculations were retrieved from each company's annual 10-K report. The 10-K data were collected primarily from Mergent Online. Yahoo Finance, Compustat, SEC's EDGAR, and S&P Capital IQ were used to gather and cross-check any missing data. M&A spending was collected from various sources: Yahoo Finance, SEC's EDGAR, Mergr, and Mergent Online.

5.3 Testing of hypotheses

Three models were used to test the relationship between financial ratios and a DoD prime contractor's annual M&A spending: (1) Pooled ordinary least squares (OLS); (2) fixed-effects (FE) regression; and (3) random-effects (RE) regression. OLS differs from fixed and random-effects models by treating the panel as one large cross-section and assuming each data point is independent of the next (Hilmer and Hilmer, 2014). Fixed and random effects models can often improve upon the pooled cross-section parameter estimates by recognizing that the same entities enter into the panel across time and controlling for the unobserved heterogeneity associated with each entity.

Unobserved heterogeneity is the unobserved characteristics associated to each entity in the panel (Armstrong, 2021). It can be caused by company culture, management styles, and geographical regions, or other various unobserved characteristics specific to each entity. Unobserved heterogeneity can be correlated with, and thus influence the predictor variables (i.e. a company's business practices may influence its stock price). The assumptions surrounding unobserved heterogeneity and how it is controlled vary between fixed and random effects models. In fixed effects modeling, it is assumed that entity characteristics have a time invariant relationship with IVs. Mathematically, fixed effects controls for time invariant heterogeneity by averaging all IVs and the DV for each entity and differencing that average from the data and the net effect of the IVs on the DV can be explored. This removes

all time invariant heterogeneity from the data but also removes all time invariant IVs from the data as well, including the parsimonious intercept. In a sense, fixed effects isolates and calculates a unique intercept for each entity and reveals the marginal effect of deviations from the mean in the IVs.

Random effects, however, control for time invariant heterogeneity as if the unobserved heterogeneity were just another random independent variable. While still controlling for the heterogeneity, the random effects model makes the inherent assumption that the heterogeneity is uncorrelated with the other IVs. In this way, random effects can calculate the average effect of the heterogeneity across all entities, allowing for random deviations from the average, and controlling for it as if it were another observed IV. The time invariant IVs are not differenced out and the random effects is able to calculate a parsimonious model with a common intercept across all entities and an interpretability akin to more traditional regression models. An advantage of random effects is that the time-invariant aspect of the error term can also be included in the model, which is powerful when it is otherwise inappropriate to completely remove time-invariant properties from the data. For example, a company's culture or manufacturing processes may not change significantly over time, but they are not fixed. Random-effect models assume that entity-specific unobserved heterogeneity effects are random yet uncorrelated with the IVs. These effects then allow time-invariant effects to play a role as explanatory variables. This results in more precise and reliable estimations of the model parameters compared to a pooled OLS model without forcing the strict limitations of a fixed effects model. Whether to *employ* fixed or random effects, however, depends on whether the unobserved entity effects are correlated with the regressors in the model (Greene, 2008). Should they be, then the assumption of independence is violated, and the random effects estimator biased.

Without an extensive deep dive into each contractor's management structures, processes, and other company-specific characteristics, it is hard to rule out that an uncontrolled variable has zero correlation with any predictor variables, meaning fixed effects models would be preferred. Additionally, fixed effect models are typically preferred for small (Borenstein, 2009) and non-random samples (Dougherty, 2011), both of which were used in this study. However, for models focusing on business decisions influenced more by external market factors than internal entity characteristics, it is reasonable to assume no correlation between regressors and those entity characteristics. Due to this, both fixed and random effects models were considered in addition to the more naïve pooled OLS model for robustness. Finally, heteroskedasticity and autocorrelation are common concerns in panel data. To account for this and calculate unbiased standard errors, White's heteroskedasticity-consistent covariance estimators are commonly used for random effects, and the Arellano method of clustered standard errors for fixed effects (Arellano, 1987; Greene, 2008).

5.4 Variables and model

In order to balance parsimony and completeness in exploring the relationship between financial ratios and M&A spending, we use only one ratio for each of the four financial categories identified by Budiantoro *et al.* (2022). The selection of the specific ratios was based on commonality in financial accounting textbooks as well as the prevalence and statistical relevance from the literature review. The authors fully recognize the abundance of alternative ratios that could be chosen and address this limitation later in the paper. For the control variables, GDP and the U.S. defense budget are used as proxies for the overall economy and industry-specific health, respectively. Although an optimal size proxy has not been discovered (Lev and Sunder, 1979), this study uses total sales as a proxy for company size (Zhong and Gribbin, 2009). The variables and model are presented in Table 2.

IVs	Definition
Profitability (P)	ROA (%) measures a company's profitability by dividing net income by average total assets. Average total assets are calculated by averaging the current and previous year's total assets
Solvency (S)	The debt-to-equity ratio (%) measures a company's solvency by comparing its long-term debt to shareholder equity
Efficiency (E)	Total asset turnover (%) measures a company's efficiency by comparing its revenue to its average total assets
Liquidity (L)	The current ratio (%) measures a company's liquidity by comparing its current assets to its current liabilities

Control variables:

National Productivity (GDP)	Represents macroeconomic factors as measured by U.S. GDP in billions of dollars (Office of Management and Budget, n.d.a)
Defense Budget (DB)	Represents defense industry factors as measured by the U.S. defense budget in billions of dollars (Office of Management and Budget, n.d.b)
Size (Sz)	Represents the contractor's size measured by year-end sales in billions of dollars

DV:

M&A Spending (MA)	Represents the millions of dollars a contractor spends on annual M&As
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Model:

$$MA_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 S_{it} + \beta_3 E_{it} + \beta_4 L_{it} + \beta_5 GDP_{it} + \beta_6 DB_{it} + \beta_7 Sz_{it} + \epsilon_{it}$$

Source(s): Table by authors

Table 2.
Variable definitions
and model structure

6. Empirical results and discussion

[Table 3](#) reports the relationship between the contractor's financial health ratios and M&A spending. Hausman and *F*-tests conducted post hoc favored random effects over fixed effects and pooled OLS models; however findings are generally robust across all three models [1].

These results reveal several noteworthy insights. First, M&A spending increases with higher profitability (H1) and solvency (H2), but the results were insignificant. The lack of significance could stem from a relatively small sample size by panel data standards. Additionally, the opposing theories about the impact of profitability and solvency on M&A activity and the unique environment of the defense industry could also contribute to the lack

IVs	Pred	Models		
		Random-effects Coef. (Std. error)	Fixed-effects Coef. (Std. error)	Pooled OLS Coef. (Std. error)
Intercept		694.527** (239.487)		799.454*** (222.721)
Profitability	+	4.846 (3.784)	1.792 (2.945)	7.700* (3.907)
Solvency	+	0.030 (0.101)	0.015 (0.126)	0.026 (0.100)
Efficiency	-	-3.381** (1.057)	-2.826* (1.548)	-3.632*** (0.941)
Liquidity	+	-0.853** (0.265)	-0.728 (0.671)	-0.945*** (0.247)
National productivity (GDP)	+	0.039 (0.028)	0.037 (0.026)	0.036 (0.027)
Defense budget	-	-1.093 (0.839)	-1.184 (0.934)	-1.103 (0.027)
Size (Sales)	+	11.402*** (3.350)	22.254 (14.752)	10.682*** (2.747)
No. observations		666	666	666
R^2		0.073	0.057	0.098
Adjusted R^2		0.063	-0.013	0.088

Note(s): Significant at: ***0.001, **0.01, *0.1 italics denote statistical significance

Source(s): Table by authors

Table 3.
Empirical results

of significance. For example, ROA is commonly used as a profitability measure in defense-related research, but the government’s augmentation of a contractor’s available assets (e.g. government furnished equipment and government owned contractor operated facilities) may increase the ambiguity of ROA’s relationship to M&A spending. As for solvency, government primes have several financing advantages compared to many industries (e.g. progress payments, cost-plus contracts, subsidized R&D funding, systematic importance to national security, etc.) that may mitigate the impact that solvency has with respect to purchasing other companies. As predicted, lower efficiency (H3) is significantly related to higher M&A spending. The theory that acquirers seek to improve efficiency via M&A is supported by these model results. While total asset turnover (TAT) is used as the measure of efficiency and could be subject to the same asset augmentation that may have impacted ROA’s significance, TAT is not highly correlated with ROA.

In contrast to the previous three hypotheses, liquidity did not align with the hypothesized positive effect (H4). Not only do the results show an opposite effect, but the results were also significant in two of the three models. Recall, the literature review highlighted conflicting findings with respect to the impact liquidity has on M&As. While financial ratios have been used to analyze various industries, little ratio analysis has been conducted in the defense industry which has its unique features. For instance, the way the government provides funds to prime contractors may impact the relationship between liquidity and M&A spending differently than other industries. Evidence shows that the DoD offers subsidies to troubled contractors through research and development contracts, loan guarantees, tax breaks, and possible strategic selection for new contracts (Higgs, 1990). A defense prime contractor may be somewhat insulated from the usual concerns about liquidity; liquid assets may not be viewed as they would have been in markets without these subsidies thus explaining the deviation from the expected relationship. Furthermore, this study is focused on prime defense contractors that receive funding directly from the government as opposed to most of the prime’s subcontractors and suppliers who receive funding from the prime; primes may be able to squeeze their subcontractors/suppliers and not pass through the benefits from the way DoD funds the prime (e.g. progress payments and cost-plus contracts). A study of a wider swath of defense contractors may identify a different relationship with respect to liquidity.

While the control variables were not the focus of the study, they were consistent with expectations and the stated theory. GDP and the defense budget were insignificant but displayed an elevated degree of multicollinearity which possibly contributed to the insignificance. Company size had a positive relationship with M&A.

6.1 Robustness

All variables of interest were assessed for multicollinearity by calculating the variance inflation factors (VIFs). VIFs are provided in Table 4 below. Generally, the VIFs for profitability, solvency, efficiency, and liquidity were low, indicating that multicollinearity does not significantly affect the estimates. In the fixed effects model, the VIF for efficiency

Model	Variables						
	P	S	E	L	GDP	DB	Sz
POLS	1.058	1.017	1.288	1.086	7.178	6.804	1.339
FE	1.048	1.017	1.346	1.072	5.937	4.986	1.869
RE*	1.048	1.015	1.335	1.075	6.024	5.484	1.333

Note(s): *Calculated by OLS on quasi-demeaned data using median theta value

Source(s): Table by authors

Table 4.
VIFs for models in
Table 3

was slightly elevated, but the consistency and significance of results across all three models suggest that this minor multicollinearity is not problematic. It's crucial to note that multicollinearity does not inherently bias estimates in linear models. Thus, the consistent results across models alleviate concerns about modest multicollinearity in the fixed effects model.

Given the inherent limitation on sample size, three econometric models were used to analyze the effects of contractor financial health on M&A spending. Each model addresses variation due to entity characteristics differently. The pooled OLS model treats each observation as conditionally independent, ignoring entity characteristics and the time dimension, and regresses the data as a cross-section of 666 observations. In contrast, the fixed effects model removes all time-invariant entity effects, focusing on residual variation. The random effects model falls between pooled OLS and fixed effects, accounting for some, but not all, variation due to entity characteristics. By employing these three models, our analysis captures variation in M&A spending across a broad spectrum. Demonstrating consistency across these models underscores the robustness of our results and suggests that omitted variable bias is unlikely to be a significant concern.

Lastly, the three-model analysis was repeated once more by modifying the model to control for interest rates to test whether the results were robust to alternate measurements of external economic effects. The results presented in [Table 3](#) were robust when interest rate was used as a proxy (instead of GDP) for the macroeconomic environment. In other words, despite the change in external economic modeling, the results were consistent with previous findings. In all, six econometric models were conducted yielding consistency across all.

7. Conclusion

A diverse business base helps ensure competition between firms. As a customer, the DoD should benefit from a larger selection of both prime and sub-contractors. Metrics indicate that small businesses foster innovation, represent a large fraction of new defense industry entrants, and develop new suppliers of equipment for DoD. These smaller firms generate a disproportionately larger share of high-tech positions, patents, and economic activity than their larger counterparts ([OUSD Acquisition and Sustainment, 2022](#)). Additionally, GAO reports have determined the DIB to be a high-risk area ([GAO, 2023b](#)) and that the DoD has limited insight into the DIB ([GAO, 2022](#)). Lastly, [GAO \(2023a\)](#) has noted that the DoD often lacks the resources or information to conduct assessments on lower dollar-value M&As, which is where models using publicly available data may be of use.

This research investigated the relationship between a company's financial health and M&A spending. The study utilized common industry ratios to assess a company's profitability, solvency, efficiency, and liquidity as measures of financial health. Panel data regression models were employed and reveal a significant negative association between a company's efficiency and M&A spending. Although the regression models did not indicate a significant relationship between M&A spending and a company's profitability or solvency, the signs of the estimated coefficients aligned with expectations. Surprisingly, liquidity shows a negative association with M&A spending which was in contradiction to the expected direction. These results suggest several future research areas that can help the DoD gain better insight into M&A of the defense sector.

First, the results are not generalizable beyond the specific ratios chosen to represent the four financial categories. This research used common ratios associated with the categories based on prevalence in reviewed journal articles and commonality in textbooks. While this choice may be sufficient for an initial exploration of the topic, future research should use a range of different ratios for each category beyond these. For example, while debt-to-equity is one of three leverage ratios presented in a common textbook ([Pratt and Peters, 2020](#)), Moody's

uses debt-to-EBITDA, retained cash flow-to-net debt, and EBIT-to-interest expense to evaluate the leverage of defense companies (Moody's Investor Service, 2021). Assessing the relationship of other ratios to M&A activity can evaluate the robustness of this article's results.

Second, while the sample size was not very large, it was naturally limited because of the focus on prime contractors. Future research could explore whether the same relationships between financial health and M&A activity are seen among non-prime defense companies. This could especially be important because it might give a cursory indication of if and how prime contractors exploit their financing advantages compared to subcontractors and suppliers.

Third, this article focused on the relationship between a company's internal financial health and its M&A activity. Future research could study the impact of the government's actions, such as budget reductions or contract awards, on M&As within the industry. Furthermore, the control variables used in this research provide an idea of how external factors may impact a company's internal decisions. Higher national productivity and smaller defense budgets were associated with more M&A spending. While neither of these variables was significant, the high degree of correlation between them may have impacted the ability to identify an effect. Future research could also consider different ways to operationalize national and industry-specific economic factors.

Finally, this study identified potential indicators which may lead to M&As in the defense sector. The impacts of these M&As are an important area of research. A comprehensive assessment of defense contractors' performance before and after M&As would help further identify the degree to which M&A activity threatens the competitiveness of the DIB.

Pending future research that further establishes the relationship between financial ratios and M&A spending, these results can be used by DoD regulatory organizations to help inform their recommendations to the FTC and DOJ. The disadvantages of consolidation through M&A have been well noted, but research such as this article helps to identify potential advantages (e.g. possible improvement in a company's efficiency). Better understanding the pros and cons of a pending M&A could improve the DoD's input to the regulatory process. As the DoD's Office of Industrial Base Policy (IBP) has only been able to review approximately 10% of defense related M&As in recent years (GAO, 2023a, b), this type of research might support the IBP in their review efforts.

Additionally, understanding the financial conditions in which a company might be seeking external sources to improve its health might extend to major acquisition decisions such as source selections or Nunn-McCurdy breaches. Evaluating efficiency and liquidity measures at these critical decision points could help potential partners assess the risk of moving forward with a planned M&A much as the regulatory bodies assess the risk to the industrial base of an M&A.

This paper demonstrates that companies with lower efficiency and liquidity engage in more M&A spending; the impact of profitability and solvency are inconclusive. The findings hold implications for DoD policymakers by providing insight into the financial conditions that may exist within a company as they pursue M&As. This insight can help the DoD perform its assessments of potential M&A actions, which was recently recommended as an area of need by the GAO (2023a). In addition, the financial condition insight could inform policies aimed to balance the benefits of M&A with national security implications. As an illustration, understanding that consolidation spending increases among defense contractors as efficiency decreases provides insight into a potential benefit to the industry; assessing the risk of industry consolidation can then be considered against this potential benefit (better efficiency). To this end, the findings illuminate the relationship of certain financial health measurements and their relationship to M&A activity; however future research should

further explore the effects of M&A on the national defense sector and the implications on DoD Journal of Defense
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Notes

1. A model that removed parent companies and non-GAO identified primes was also evaluated. It consisted of only 22 companies over 27 years (352 observations). Model results were generally robust to this more stringent dataset.

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(The Appendix follows overleaf)

DoD identified (Start)

1. Alliant Techsystems	16. Hughes Electronics	28. Northrop
2. AM General	17. Hughes Network	29. Northrop Grumman
3. Avondale Shipyard	18. Huntington Ingalls	30. Oshkosh
4. Bath Iron Works	19. Ingalls	31. Raytheon Company
5. Bell Helicopters	20. Lockheed	32. Raytheon Technologies
6. Bethlehem Steel	21. Lockheed Martin	33. Rockwell International
7. Boeing	22. Loral	34. Sikorsky
8. Food Machine Corporation (FMC)	23. Ling-Temco-Vought (LTV)	35. Stewart and Stevenson
9. Ford Aerospace	24. Martin Marietta	36. Tampa Shipbuilding
10. General Dynamics	25. McDonnell Douglas	37. Tacoma Shipbuilding
11. General Electric	26. NASSCO (National Steel and Shipbuilding Company)	38. Teledyne Continental Motors
12. GM Canada	27. Newport News Shipbuilding	39. Texas Instruments
13. General Motors		40. TRW, Inc
14. Grumman		41. United Defense Limited Partnership (UDLP)
15. Harsco BMY		42. Westinghouse

M&A of DoD prime (Add)

Spin-off companies (Add)

Parent of subsidiary (Add)

1. Armor Holdings	1. Loral Space Systems/Space and Communications	1. Bell Textron (Proxy for Bell Helicopters)
2. BAE Systems	2. Rockwell Collins	2. General Electric (Proxy for General Electric Aviation)
3. Orbital ATK		3. Texas Instruments (Proxy for Defense Division of TI)
4. Orbital Sciences		4. General Motors (Proxy for Hughes Electronics/ Aircraft and GM Canada)
5. United Technologies		5. Litton (Proxy for Ingalls)
		6. Teledyne (Proxy for Teledyne Continental Motors)
		7. Ling-Temco-Vought (LTV) Corporation (Proxy for Vought Aircraft and Missiles Business)
		8. Ford (Proxy for Ford Aerospace)

Subsidiary (Remove)

Private company (Remove)

Missing data (Remove)

1. Bell Helicopters	1. Sikorsky	1. Grumman
2. Ford Aerospace	2. NASSCO (National Steel and Shipbuilding Company)	
3. GM Canada	3. Westinghouse	
4. Ingalls	4. Alliant Techsystems	
5. Teledyne Continental Motors	5. Bath Iron Works	
6. LTV Missiles Division	6. Hughes Network	
7. Rockwell Space and Defense Division	7. Tampa Shipbuilding	
8. Texas Instruments Defense Division		
9. Vought Aircraft		

Source(s): Table by authors

Table A1.
List of contractors in categories

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