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The Impact of the Defense Industry Consolidation on the Aerospace Industry

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THE IMPACT OF THE DEFENSE INDUSTRY CONSOLIDATION ON THE AEROSPACE INDUSTRY

THESIS

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Abstract

The purpose of this research was to investigate the impact of the defense industry consolidation on the aerospace industry. The defense industry is comprised of twelve sectors that impact different industries. This research focused on the formal aspects of the aerospace industry which supports six of the twelve defense sectors. The aerospace industry is identified by six North American Industry Classification System (NAICS) or Standard Industrial Classification (SIC) codes. Using the structure-conduct-performance paradigm, a method in industrial organization, this thesis analyzed how the defense consolidation affected the structure and behavior of the aerospace industry. For structure, this study examined the industry concentration, buyers and sellers, vertical integration, and product differentiation. Barriers to entry, asset specificity, capital investment, and research and development intensity were analyzed for conduct. Profitability ratios, returns to scale, and impact on cost overruns of government contracts were analyzed for the area of performance. Finally, this study identified trends by comparing the aerospace industry to the total manufacturing industry, and by comparing the large surviving downstream firms to both the aerospace industry and total manufacturing industry.

Dedication

To my husband and my sons for their love, patience, sacrifice, support, and understanding.

Acknowledgement

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THE IMPACT OF THE DEFENSE INDUSTRY CONSOLIDATION ON THE AEROSPACE INDUSTRY

I. Introduction

Background

"With profits and equity prices falling, companies have to move to reduce capital and cut discretionary R&D" was one of the primary reasons that the Clinton administration explicitly encouraged the consolidation of the defense industry (Deutch, 2001: 142). The Reagan-era buildup resulted in defense contractors investing in huge production capacity that was no longer needed after the end of the Cold War (Gholz and Sapolksy, 1999: 5). The government paid for the excess defense industrial base capacity through overhead rates on government contracts (Eland, 2001: 5). In 1993, after a "bottoms-up review" of the defense industry, the government announced to industry leaders at the "Last Supper" its consolidation policy for restructure and reduction of excess capacity (Deutch, 2001: 137-138). The defense firms were allowed to claim the restructuring costs of their business combinations, as long as they met the predetermined criteria of long-term savings to the government exceeded costs, and the merger preserved critical capability (GAO/T-NSIAD-94-247, 1994: 1). Approximately 50 significant business combinations occurred during the defense industry consolidation period (Harper, 1999: 337).

Problem Statement

In its final report, the General Accountability Office (GAO) reported the Department of Defense (DOD) realized an estimated net savings of $2.2 billion from the restructuring activities; however, the GAO stated that it was unable to apply a standard methodology to account for restructuring costs from other costs impacting contract prices (GAO/NSIAD-99-22, 1999: 5). Although the government realized savings, it is unknown how the defense consolidation impacted on the structure and behavior of the aerospace industry. The GAO reports focused mainly on the financial aspects and status of the business combinations. In addition, the government established two separate Defense Science Board (DSB) Task Force studies during the defense consolidation, one for investigating antitrust aspects and the other to investigate the impact of vertical integration on suppliers. Both studies identified focus areas and provided recommendations; however, neither study focused on an empirical analysis of the structure, conduct, and performance of the aerospace industry. This study examines the structure and behavior of the aerospace industry before, during, and after the defense consolidation.

Research Objective and Methodology

The research objective is to determine how the defense industry consolidation affected the structure, conduct, and performance of the aerospace industry. Industrial organization is the study of the structure of firms and their interactions in the market (Perloff and van't Veld, 1994: 1). The structure, conduct, and performance (SCP) paradigm method will be used to provide an overview of the industrial organization of the aerospace industry and to analyze the effects of the defense consolidation.

Database

The database employed in this research consists of time series data collected from the U.S. Bureau of Census, Aerospace Industries Association's (AIA) *Facts & Figures*, Standard & Poor's (S&P) *Compu$tat* database, and the *National Defense Budget Estimates for FY2006*. Depending on the availability of the data, the time period covered is from 1972 to 2002. Industry data was collected for both downstream and upstream aspects of aerospace manufacturing. Industry data was collected by North American Industry Classification System (NAICS) or Standard Industrial Classification (SIC) codes from U.S. Bureau of Census. Prior to 1997, the industry data was collected by SIC codes. From 1997 and forward, industry data was collected by NAICS codes. The *Materials Consumed Summary Report* or *Table 7. Materials Consumed by Kind* found in the aerospace manufacturing industry subject series reports identifies the upstream NAICS/SIC codes for the industries that provide materials and intermediate goods for the final products. Aerospace industry specific data was collected from the AIA *Facts & Figures*. The S&P *Compu$tat* database was used to collect financial statement data of selected companies. Defense budget data for the military services was collected from the *National Defense Budget Estimates for FY2006*. Finally, the Gross Domestic Product (GDP) deflator was used to normalize cost data to current year 2006.

Research Focus

The defense industry is comprised of twelve sectors that impact different industries. This research focuses on the formal aspects of the aerospace industry that support six of the twelve defense sectors. Research will focus on the upstream and downstream aspects of the aerospace industry. Upstream represents firms that produce raw materials or intermediate goods for the final product. Downstream represents the firms that produce the final product. The aerospace industry is identified by six NAICS or their equivalent SIC codes. The U.S. Bureau of Census uses these codes to collect industry level data for its Economic Censuses.

Investigative Questions

The primary research question addressed in this research study is: "How did the defense industry consolidation affect the structure, conduct, and performance of the aerospace industry?" The secondary questions are as follows:

- Did industry concentration increase as a result of the defense consolidation?
- Did subcontractor activity increase?
- Are the firms performing more efficiently?
- How did it affect vertical integration or vertical disintegration?
- Did the average firm size change?
- What are the returns to scale for the industry?

Organization

This thesis is divided into four chapters. Chapter I provides the background information, description of the research problem, research objective, research focus, and investigative questions. Methodology used and a description of the database is also presented. Chapter II presents a more detailed background of the defense industry consolidation, a description of the defense industry and its unique characteristics. The aerospace industry is discussed in detail to include industrial organization, movement of labor, market definition and basic conditions of the aerospace market. In addition, a literature review summarizing related research is provided. Chapter III presents the findings and results of the research to include supporting figures and tables. Chapter IV provides a summary and conclusion based on the analyses performed along with recommendations for future research.

II. Literature Review

Overview

This chapter reviews the current research for the consolidation of the defense industry and its impact on the aerospace industry. There are a plethora of management articles written about the restructuring of the defense industry, most of which is focused on the large downstream firms who are the final integrators of the weapons systems. However, no empirical studies have been done to estimate the impact of defense consolidation on the different industry sectors that produce defense related products. This review examines the defense industry, the characteristics of the defense industry, and its impact on related industries (especially civilian aerospace industry). Finally, a summary is presented on related research that is applicable for the development of this study.

Consolidation of the U.S. Defense Industry

History

The defense industry reacted differently to the termination of the Cold War than it did to previous military conflicts. Historically, the production capacity built up to support the production of critical mission equipment needed by the military for a war demobilized at the end of the conflict. During the Cold War, private production capacity expanded as a response to increases in defense funding; however, in periods of defense funding troughs, the contractors cut less production capacity than they had built up

(Gholz and Sapolsky, 1999: 6). The defense industry is represented by unstable consumer demands, the skills and facilities of most of the suppliers were highly specialized, and many of the large defense contractors produce defense products only (Boezer and others, 1997: 26). The decline in defense spending since the late 1980's resulted in reduced sales by defense contractors (GAO/NSIAD-95-115, 1995: 2). Maintenance of the overcapacity in the defense industrial base from the Reagan-era buildup exacted substantial domestic costs (Gholz and Sapolsky, 1999: 7). The expected decrease of DOD procurement expenditures by approximately 68% from 1985 to 1995 resulted in an increase in the number of proposed mergers and joint ventures in the defense industry (DOD DSB Task Force, 1994: 1). The Clinton Administration's explicit encouragement of mergers and acquisitions characterized the post-Cold War defense industry with massive consolidations by contractors driven by economies of scale in reaction to the overcapacity (Kim, 2000: 56). Since the 1990's, more than 50 companies have consolidated into the large surviving five firms: Boeing, General Dynamics, Lockheed Martin, Northrop Grumman, and Raytheon (Aerospace Commission, 2002: 9).

Purpose

"The purpose of the consolidation was to encourage mergers that would reduce physical assets allocated to defense" (Deutch, 2001: 138). On July 21, 1993, the Under Secretary of Defense for Acquisition provided a powerful tool to encourage defense industry consolidations by issuing a memorandum allowing the contractor to claim restructuring costs incident to a merger or acquisition, if it met the criteria that savings to the government exceeded costs, and the merger preserved a critical defense capability

(GAO/T-NSIAD-94-247, 1994: 1). During the fiscal years of 1993-2001, the federal procurement spending dropped 35% for aircraft systems, 50% for missile systems, and 46% on space systems in absolute dollars (Aerospace Commission, 2002: 7). However, it is unknown if the restructuring activities from the defense consolidation reduced costs within the industry. Merger activity reduced the number of firms and decreased the number of personnel employed by defense firms but, DOD reports consistently showed industry capacity did not reach equivalent reductions (Driessnack and King, 2004: 64). Also, the GAO substantiated DOD's position that it was not feasible to precisely isolate restructuring factors from other factors that impacted contract prices (GAO/NSIAD-98-225, 1998: 6-7).

Unique Characteristics of the U.S. Defense Industry

The defense industry and its market are characterized by the key elements of monopsony, multi-product firms, technology, and regulation. The government as the primary buyer of the goods is also the regulator of the market in its monopsonistic relationship with the firms in the defense industry (Driessnack and King, 2004: 65). The typical producer of defense products is a multi-product firm with various products at different stages of product life in production settings that include complex manufacturing technology, learning, and hybrid organization forms (Demski and Magee, 1992: 732). In addition, the defense industry is composed of firms from various sectors in the manufacturing industry that produce defense products in the following twelve sectors: fixed-wing aircraft, rotary wing aircraft, tactical missiles, strategic missiles, expendable launch vehicles, satellites, surface ships, tactical wheeled vehicles, tracked combat vehicles, torpedoes, submarines, and ammunition (Kim, 2000: 62 and GAO/T-NSIAD-98-112, 1998: 6-7). In order to produce products in these different categories of weapons systems, multiple unique technologies are required (Driessnack and King, 2004: 66). Finally, the industry is heavily regulated with the government determining the firms' customer lists, price setting, profits and source selection procedures for contracts, and in terms of long-term relationships, the movement of key personnel between buyer and seller (Demski and Magee, 1992: 733).

Impact on the Aerospace Industry

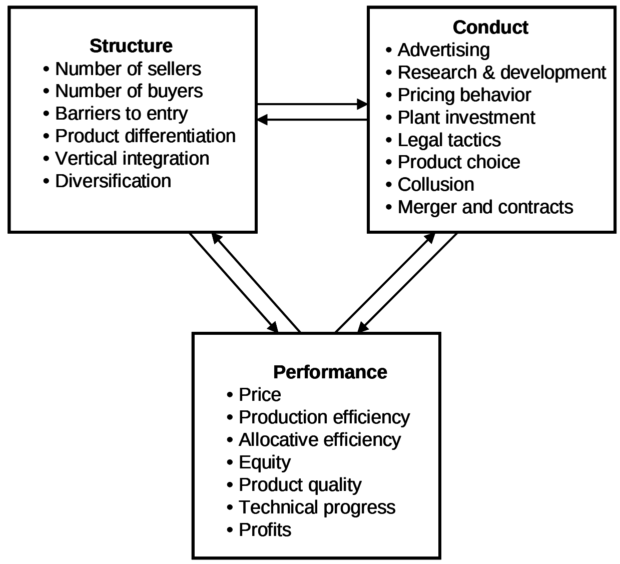
The impact of defense consolidation in the aerospace industry will be discussed as an industrial organizational study to include the government policy. The longevity of the U.S. Cold War defense production effort fundamentally changed the industrial organization of the defense industry (Gholz and Sapolsky, 1999: 6). The aerospace industry produces products for six of the twelve defense sectors (see Table 1).

Table 1. Defense Sectors in Aerospace Industry

Defense Sector	SIC Code	NAICS Code	Description
Fixed-wing aircraft	3721	336411	Aircraft
Rotary wing aircraft	3724	336412	Aircraft engine and engine parts
	3728	336413	Other aircraft parts and auxiliary equipment
Tactical missiles	3761	336414	Guided missile and space vehicle
Strategic missiles	3764	336415	Guided missile and space vehicle propulsion unit and propulsion unit parts
Expendable launch vehicles	3769	336419	Other guided missile and space vehicle parts and auxiliary equipment

Source: U.S. Bureau of Census

Industrial organization is the study of the structure and behavior of industries in an economy at the microeconomic level (Stigler, 1968: 1). The SCP paradigm reflects a causal and feedback behavior relationship of firms in an industry (Baye, 2003: 249). The structure part refers to the concentration, technology, and the market conditions of the industry. Conduct refers to the firms' behavior in terms of strategic planning of its respective resources in response to the structure of the industry. Performance refers to the firms' resulting profits and social welfare it achieves in the market. These three factors of industry are integrally related (see Figure 1).



Source: *Modern Industrial Organization*, 2nd Edition, Perloff and van't Veld, p.4

Figure 1. Structure-Conduct-Performance Paradigm

Movement of Labor

One of the effects of the restructuring of the defense industry is decrease in labor as a result of consolidating or closing contractor facilities. From 1986-1996, industry experienced a decline of 305,000 jobs in defense-related employment due to decreases in defense funding (Thomson, 1998: 29). However, the employment gains during the 1977-1987 defense build-up in engineering and architectural, miscellaneous business, and personnel supply service industries did not experience the same cutbacks (Thomson, 1998: 26). The two main shifts in the industrial composition of employment in the research and development (R&D) intensive high tech sector were the growth in service industry employment and the decline in defense-dependent manufacturing employment

(Luker, Jr. and Lyons, 1997: 16). From 1988 to 1996, the service industries' share of all R&D intensive high technology employment rose from 28% to 38.9%; whereas, the manufacturing's share fell from 70% to 60% (Luker, Jr. and Lyons, 1997: 16). The highly skilled labor from the defense consolidation may have moved from the aerospace to the service industries, simply rearranging employment, not actually changing production costs.

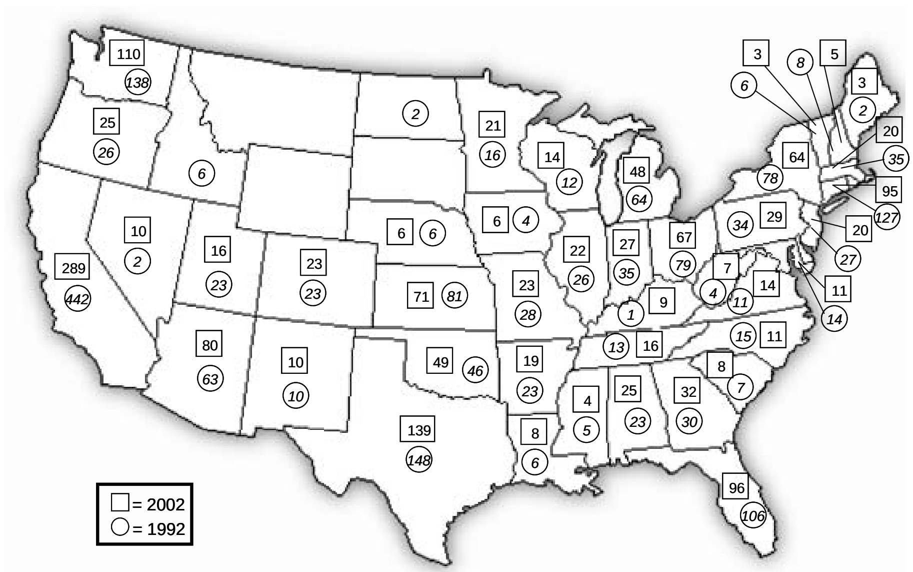
Defining the Market

According to the *1992 Merger Guidelines*, defining the market consists of product market definition, geographic market definition, and identification of market participants and market shares.

> "A market is defined as a product or group of products and a geographic area in which it produced or sold such that a hypothetical profit-maximizing firm, not subject to price regulation, that was the only present and future producer or seller of those products in that area likely would impose at least a "small but significant and nontransitory" increase in price, assuming the terms of sale of all other products are held constant" (Merger Guidelines, 1992: 4).

In 1994, the Under Secretary of Defense for Acquisition & Technology and the General Counsel established a DSB Task Force to investigate the antitrust aspects of the defense industry consolidation which included a market definition.

For the relevant product market, DOD determines if there are substitutable products with similar end uses or development of a new product is required to meet mission needs (DOD DSB Task Force, 1994:17). The relevant geographic market is limited to the United States (DOD DSB Task Force, 1994:18). For reasons of national security, the DOD limits its pool of qualified suppliers to domestic companies even when technically capable foreign bidders may exist (see Figure 2). The number of establishments in the aerospace industry has decreased by approximately 17% from 1992 to 2002.



Source: U.S. Bureau of Census, Economic Census 1992 and 2002

Figure 2. Geographic Distribution of Aerospace Manufacturing Establishments

Because high levels of project-specific investments in physical and human capital is required for the development and production phases of major weapon systems, there is a limited number of firms that can compete in the market (Gholz and Sapolsky, 1999: 16). DOD is knowledgeable of the defense firms’ ability to design and develop new weapons systems based on the companies’ past performance on government contracts. DOD may limit the number of competitors that bid on a future development and production of new weapon systems making it difficult to assign precise market shares to individual firms (DOD DSB Task Force, 1994: 20-21). Competition in the defense industry may focus on non-price competitions where quality and technological components are considered for best value or price where lowest cost technically acceptable is more important (McNutt, 1998: 99 and DOD DSB Task Force, 1994: 28). Depending on what is selected by the Source Selection Authority, the choice may limit effectiveness of DOD's controls during the early phases of the program when competitive procurement contracts are awarded (DOD DSB Task Force, 1994: 28).[1]

Basic Conditions of the Aerospace Market

Consumer Demand

The government is the primary customer for the defense products produced in the U.S. aerospace industry. In order to preserve the defense industrial base, DOD purchases the majority of its defense related products from U.S suppliers (DOD DSB Task Force, 1994:19). The characteristics of a monopsonistic relationship exist between the government and the defense firms in the industry. Through regulation and oversight, the government attempts to extract a lower price from its suppliers and to apply those lower costs to future contracts (Blair and Harrison, 1993: 41). In addition, the aerospace industry has military and commercial business sectors. For example, the civilian aircraft

[1] The Source Selection Authority (SSA) approves the source selection plan that describes the process used to evaluate proposals. After recommendations from the Source Selection Advisory Council (SSAC) and the Source Selection Evaluation Board (SSEB), the SSA selects the winner of the contract at the end of the source selection.

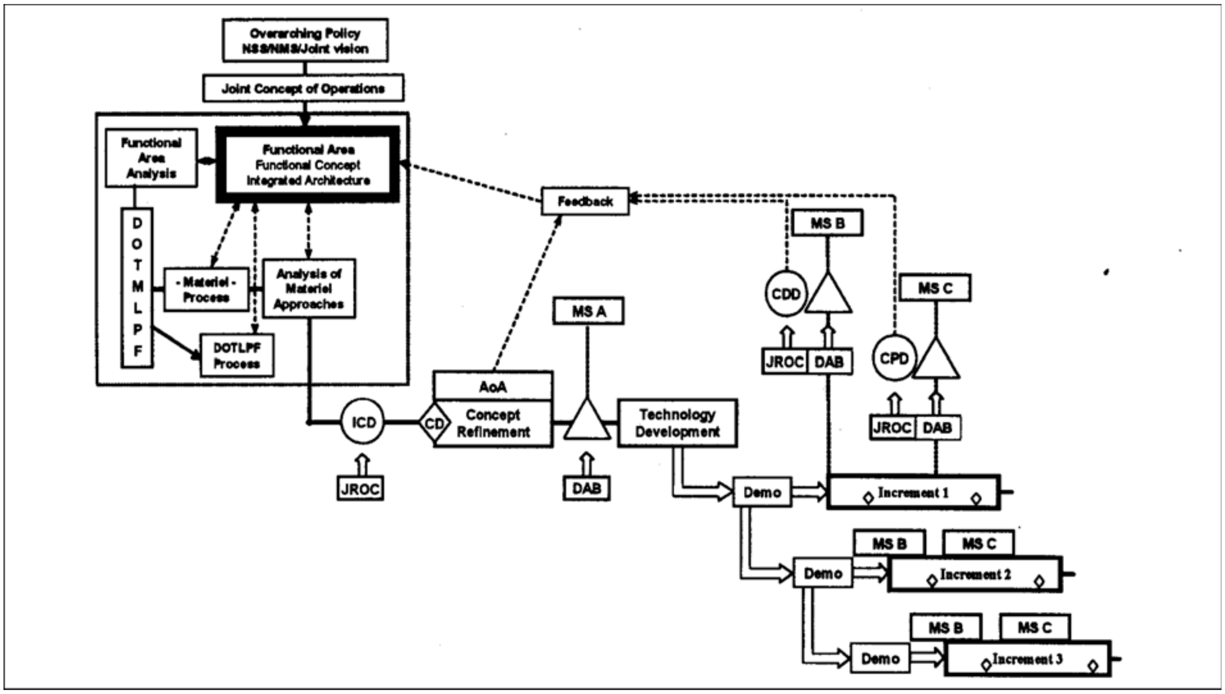
sector exports 60% of its total production even though it represents approximately 20% of the overall U.S aerospace industry (Environmental Protection Agency, 1998: 16).

Elasticity of Demand

National defense is a public good because it is supplied by the government and made available to others (U.S. citizens) at no cost. It is difficult to price national defense; however, it may be the case that we reveal our preferences based on the defense budgets appropriated by Congress. Thus, the assumption is made that the demand for products such as weapons systems required for national defense is relatively inelastic.

Substitutes

New weapons systems are produced to support specific mission capabilities. The Chairman of the Joint Chiefs of Staff with the assistance of the Joint Requirements Oversight Council, assess and provide advice regarding military capability needs for the defense acquisition programs (DODI 5000.2, 2003: 5). Representatives from multiple DOD communities examine multiple concepts and material approaches to determine the best way that DOD can provide the needed capabilities. The joint concepts of integrated architectures, analysis of doctrine, organization, training, material, leadership, personnel, facilities (DOTMLF) are used in an integrated and collaborative process to define desired capabilities to guide the development of affordable systems (see Figure 3). The assumption is made that there is some substitutability in fielded weapon systems for meeting mission capabilities. In contrast, the need to develop a new weapon system or product to support a mission capability implies that there are no substitutes available.



Source: DODI 5000.2, *The Defense Acquisition System*

Figure 3. Requirements and Acquisition Process

Method of Purchase

Since the government is the primary customer for defense products, the basic method of purchase is a contractual vehicle. Government contracts for major weapon systems differ from other contracts. These contracts are continually modified during the development and production of the weapon system due to user requirement changes, availability of newer technology, or changes in levels of funding in the annual projected defense budgets (McNutt, 1998: 101). Furthermore, the complexity of weapon systems determines contract type and requires the government to negotiate with contractors on *ex* *post* costs based on *ex ante* cost calculations by both government and contractors (Rogerson, 1992: 674 and Reichelstein, 1992: 713).

Contracts fall into two basic categories: cost reimbursement and fixed-price. For cost reimbursement contracts, the risk is assumed by the government and pays the cost incurred by the contractor subject to the limitations on allowability, allocability, and reasonableness in accordance with the Federal Acquisition Regulation (FAR), Section 31. In fixed-price contracts, the risk is assumed by the contractor and the government pays the price subject to a fixed maximum "ceiling" amount if a sharing incentive for costs is used. The common types of contracts are Firm Fixed Price (FFP), Fixed Price Incentive (FPI), Cost Plus Incentive Fee (CPIF), Cost Plus Award Fee (CPAF), and Cost Plus Fixed Fee (CPFF).

The fee structure in which firms earn profit is dependent upon the type of contract used by the government. In a FFP contract, the fee is included in the negotiated fixed price the government will pay regardless of the contractor costs to produce the product. A FPI contract is used to encourage the contractor to control costs and the profit is inversely related to cost. The profit earned by the contractor is based on key elements of target cost, target profit, share ratios, and the ceiling price. Unlike the fixed price contracts, cost reimbursement contracts allow the contractor to recover all allowable costs incurred. To encourage the contractor to control costs, the majority of the profit is paid through incentive and/or award fees. FAR 15.404-4 states the maximum fees for cost contracts is 10% of target cost for production contracts, and 15% of target cost for research and development contracts; however, waivers can be requested. The contractor earns its fee based on the criteria set for cost, technical, schedule, and/or quality performance. The difference between CPIF and CPAF, is the former must have cost as one of the performance factors incentivized.

Government Policy

As the primary customer, the government can exercise profound influence in its monopsonistic relationship with the aerospace industry. The government uses a highly regulated acquisition process to procure new weapon systems. Congress sets the dollar amounts and the quantities of the weapon systems DOD will procure in its appropriations. The DOD 5000 Series is just one of many regulations which address the oversight levels and requirements of the acquisition process to develop and procure weapon systems. Furthermore, the FAR governs the contracting process between the government and the contractors. This regulatory environment directly impacts the firms with government contracts in the aerospace industry.

Historically, the average length of a new weapon system from program initiation to required assets availability is approximately 6-21 years (McNutt, 1998: 37). The duration of the government contract can adversely impact the returns to scale of the firm and at an aggregate level, the aerospace industry. Congress authorizes the start and continuation of weapons programs and appropriates the funding on an annual basis. During times of lean budgets, Congress reduces the quantities of weapon systems on procurement contracts. In turn, DOD reduces production quantities and stretches out production schedules. In 1997, the DOD procurement appropriation of $43.8 billion was 67% less than the $134.3 billion (in constant fiscal year 1997 dollars) appropriated in

1985 (GAO/NSIAD-97-23, 1997:1). For example, the Advanced Medium Range Air-to-Air Missile (AMRAAM) program average annual production rate of 484.4 missiles was 83.9% below the planned annual production rate of 3,000 missiles (GAO/NSIAD-97-23, 1997: 16). Changing quantities in response to variations in procurement funding make it difficult for firms to achieve returns to scale. The profitability of the firm depends fundamentally on the accuracy of its estimation of the price and the accounting practices used (Redman, 1998: 12).

The effects of regulation may not be what the government expected. DOD can use programs and funding to sustain competition, promote competition, and/or promote entry of commercial firms into the defense sector. DOD procurement practice is consistent with the actions of an industry-captured regulator, who manages the competition among defense contractors for the good of the entire industry; thus, the environment has resulted in asymmetric information, with the contractor and DOD better informed than outsiders (Leitzel, 1992: 44).

Because DOD encouraged the defense industry to consolidate facilities, eliminate excess capacity and to remain competitive and financially viable, the increase in concentration in the aerospace manufacturing industry was not unexpected (GAO/NSIAD-98-141, 1998: 2). Excess capacity does not drive prices down in cost-based procurement contracts. It has the opposite of effect since overhead is allocated over shrinking volume (quantities) which resulted in higher unit costs for hardware (DOD DSB Task Force, 1994: 8). Due to barriers of entry, it is unlikely new firms will enter the market without DOD taking action to encourage the entry of new firms (DOD DSB Task

Force, 1994: 23-24). From the downstream aspect, the business combinations during the 1990's significantly reduced DOD's ability to use competition to motivate suppliers, improve quality, or reduce prices for new weapon systems (Kovacic, 1999: 423).

Summary of Related Research

Defense Consolidation

Deutch (2001) discussed the purpose, consequences, and the outcome of the defense industry consolidation. Gholz and Sapolsky (1999) reviewed the restructuring of the defense industrial base to include the politics of defense firms and contracting, and the qualitative results of defense consolidation, and the government's recommended solution of conversion and acquisition reform as a solution for industrial overcapacity. Harper (1999) analyzed and compared the consolidation of the defense industries in the U.S. and Europe. Boezer, et al (1997) reviewed the key components of the defense technology and industrial base to include the various sectors, research and development, government regulations, and competition of firms at prime and lower tier levels.

GAO Reports

The GAO provided reports to Congress during the defense consolidation period. The reports focused on the status of business combinations, the certification process of the estimates from the contractors, and the estimated restructuring costs and potential savings at the aggregate level to the government for current and future contracts (see Table 2).

Table 2. GAO Reports Pertaining to Defense Consolidation

Report Number	Report Type	Title
GAO/T-NSIAD-94-247	Testimony	Defense Industry Consolidation: Issues Related to Acquisition and Merger Restructuring Costs
GAO/NSIAD-95-106	Report to Congressional Committees	Defense Restructuring Costs: Payment Regulations Are Inconsistent With Legislation
GAO/NSIAD-95-115	Report to Congressional Requesters	Overhead Costs: Defense Industry Initiatives to Control Overhead Rates
GAO/NSIAD-96-19BR	Briefing Report to Congressional Requesters	Defense Contractors: Pay, Benefits, and Restructuring During Defense Downsizing
GAO/NSIAD-96-80	Report to Congressional Committees	Defense Contractor Restructuring: First Application of Cost and Savings Regulations
GAO/NSIAD-96-191	Report to Congressional Committees	Defense Restructuring Costs: Projected and Actual Savings From Martin-Marietta Acquisition of GE Aerospace
GAO/NSIAD-97-97	Report to Congressional Committees	Defense Restructuring Costs: Information Pertaining to Five Business Combinations
GAO/T-NSIAD-97-141	Testimony	Defense Industry Restructuring: Cost and Savings Issues
GAO/PEMD-97-3	Report to Congressional Requesters	Defense Industry: Trends in DOD Spending, Industrial Productivity, and Competition
GAO/T-NSIAD-98-112	Testimony	Defense Industry Consolidation: Competitive Effects of Mergers and Acquisitions
GAO/NSIAD-98-141	Report to Congressional Committees	Defense Industry: Consolidation and Options for Preserving Competition
GAO/NSIAD-98-156	Report to Congressional Committees	Defense Industry Restructuring: Updated Cost and Savings Information
GAO/NSIAD-98-162	Report to Congressional Committees	Defense Contractor Restructuring: DOD Risks Forfeiting Savings on Fixed-Price Contracts
GAO/NSIAD-98-225	Report to Congressional Requesters	Defense Contractor Restructuring: Benefits to DOD and Contractors
GAO/NSIAD-99-22	Report to Congressional Committees	Defense Industry: Restructuring Costs Paid, Savings Realized, and Means to Ensure Benefits

Competition in Defense Industry

With respect to the impact of the defense consolidation on competition in industry, four studies were notable. In the first study, Kim (2000) examined the industry concentration of the fixed-wing aircraft and guided missile defense sectors after the defense consolidation period. The Herfindahl-Hirschman Index (HHI) was calculated using procurement data from Individual Contracting Action Report, DD350 database for DOD prime contract awards over $25,000 (Kim, 2000: 56). The results showed no substantial change in market concentration which indicates the market was already concentrated prior to consolidation (Kim, 2000: 61). Another explanation may be due to the pressures of technical uncertainty and financial risk, where many small prime contractors received insignificant amounts of government contracts to share the spiraling R&D costs of consolidation (Kim, 2000: 61).

The second study, Kovacic (1999) analyzed the advantages and disadvantages of the defense consolidation and its impact on competition. Due to the reduction of many industry segments to two or one remaining contractor, the future of competition in the defense industry will depend less on antitrust oversight but, more on DOD's ability to make significant changes to acquisition policy (Kovacic, 1999: 425). DOD will need to develop innovative techniques to use program and funding choices to sustain competition, increase recourse to foreign suppliers, and promote entry of commercial firms into the defense sector (Kovacic, 1999: 427).

The third study, a DSB Task Force established in 1994, performed an antitrust analysis of mergers and joint ventures in the defense industry. The study reviewed market power, barriers to entry, competitive effects, efficiency claims, national security claims, failing firm and distressed industry, and provided conclusions and recommendations. The study concluded that the competition in the defense industry was significantly different from other sectors of industry and the *1992 Merger Guidelines* were flexible enough to take into consideration the special circumstances of a defense consolidation (DOD DSB Task Force, 1994: 4). Recommendations included the DOD act as the primary gatherer of information for the mergers and improved coordination between DOD and antitrust agencies (DOD DSB Task Force, 1994: 5).

The fourth study, in 1997, a second DSB Task Force was established to examine the effects of defense industry vertical integration and supplier decisions. The report identified the need to expand the monitoring of vertical supply relationships of selected important defense products and technologies to ensure the access of unintegrated systems integrators to essential inputs is not reduced (DOD DSB Task Force, 1997: viii-xii). Similar to the Kovacic study, a recommendation suggested DOD revise its policy and practices to increase focus on retaining competition and innovation in its acquisition and technology programs (DOD DSB Task Force, 1997: xii). Finally, it noted the need to develop measures to help DOD personnel to identify, address, and scrutinize potential harms of vertical integration (DOD DSB Task Force, 1997: xiii-xvi).

Research & Development (R&D)

Driessnack and King (2004) reviewed technology and institutions in conjunction with the defense industry consolidation. Discussion focused on the possibility that the defense consolidation may not be based on the traditional explanations of changes in the defense budget which followed a cyclical pattern of decreases and increases in spending since 1952 (Dreissnack and King, 2004: 64). Even though mergers have decreased both the number of firms and personnel, the industry capacity has not undergone equivalent reductions (Dreissnack and King, 2004: 64). An important implication of the defense consolidation may be that defense firms have specialized to focus on the transactions with the government (buyer) and not on a product or technology (Dreissnack and King, 2004: 65). Thus, it may be the interaction of technology, changing institutions, procurement policy, procurement process, and government procurement organizations on transaction costs in the defense industry may better explain the forces driving the defense consolidation (Dreissnack and King, 2004: 73).

In 2003, King and Driessnack reviewed the performance of firms after mergers and acquisitions and the possible implications for industrial policy. The first research question asked if firms used acquisitions as a tool to gain access to technology. The second research question analyzed the firms' stock performance. The research model consisted of the following variables: diversification, relative size of firm, acquisition experience, method of accounting, R&D expenditures, friendliness of acquisition, debt level, form of acquisition, and target firm performance (King and Driessnack, 2003: 264). The authors concluded that there was clear evidence of firms using acquisitions to gain access to technology; however, in regards to the second question, the acquiring firms' stock performance on average did not improve (King and Driessnack, 2003: 272).

Linster, et al (2002) examined the impact of the defense consolidation on the research and development (R&D) expenditures. Mergers from the defense consolidation reduced the number of major companies doing defense aerospace work from 21 to five which has resulted in the formations of partnerships among defense contractors (Linster, et al, 2002: 144). Partnerships among firms affect competition and strongly influence internal R&D (IR&D) based on the expected distribution of work and profit among the firms and the prime contractor selected (Linster, et al, 2002: 144). A model was developed to test the predictions in a three-firm case where two firms share a common interest and all three firms are expending R&D in an effort to win a contract. The hypothesis tests results showed strong evidence of reduced spending by partnerships as the "publicness" of IR&D expenditures, when firms rely more on profit sharing of the prize (the contract) increases. Partnerships among firms affected competition and strongly influenced internal R&D based on the expected distribution of work and profit among the firms and the prime contractor selected (Linster, et al, 2002: 145 and 148).

Labor

Acemoglu (2002) examined the effects of technical change on the labor market, particularly, the impact on skilled and unskilled labor. Skilled labor increases in lieu of technological advances was a twentieth century phenomenon which resulted in an inequality of wages between skilled and unskilled labor (Acemoglu, 2002: 14-16). Thomson (1998) reviewed the relationship between defense-related employment and defense spending. Luker, Jr. and Lyons (1997) and Hetrick (1996) analyzed the trends and shifts of employment in high-technology industries. Structural changes in high-tech industries allowed for shifts of highly specialized labor from defense to service industries (Luker, Jr. and Lyons, 1997: 16).

Summary

In this chapter, we reviewed the characteristics of the defense industry and the background and purpose of the defense consolidation. The discussion continued with the impact of the defense consolidation on the industrial organization of the aerospace industry and defense-related employment. In addition, market definition and the basic conditions of the aerospace market were addressed. Basic conditions of aerospace market include discussions on consumer demand, elasticity of demand, substitutes, method of purchase, and the importance of government policy. Finally, a summary of related literature and research was presented.

III. Analysis and Results

Chapter Overview

This chapter discusses how the consolidation of the defense industry during period of 1993-1998 affected the structure, conduct, and performance in the aerospace industry. Industrial organization is the study of the structure and behavior of firms, the effects of concentration on competition, and the investments and markets and its interactions in which these firms operate (Perloff and van't Veld, 1994: 2). The SCP paradigm is used in the analysis of this research project.

The SCP paradigm provides a descriptive overview of the industrial organization of firms in the aerospace industry. The first part of this analysis looks at the structure of the aerospace industry, which is the market structure defined by the concentration of market share of the firms. The second part focuses on the conduct or the behavior of the firms based on the market structure. The third part analyzes the performance or social efficiency of the firms as defined by their market power and influenced by both the market structure and conduct. Finally, a summary is provided for these three interrelated factors of industry.

Structure

Concentration

Industry concentration is a measure of the degree of market share of the largest firms in the market. Concentration provides evidence regarding the competitiveness of the market. The degree of industry concentration is reflected in barriers of entry for new firms and buyer concentration. Measures of concentration include the four-firm concentration ratio (CR4) and the Herfindahl-Hirschman index (HHI). Even though both the CR4 and the HHI measure the market shares of firms in the industry, there is a difference between these two measures. The CR4 is based on the market shares of the four largest firms in the industry. Concentration ratios provide a rough measure of the size structure of an industry (Baye, 2003: 234). The HHI is based on the market shares of all the firms in the industry. The equation for HHI is as follows:

$$HHI = 10{,}000 \sum w_i^2 \quad (1)$$

where w_i is *firm i's total market output* as represented in equation:

$$w_i = S_i / S_T \quad (2)$$

where S_i is *firm i's sales* and S_T is *total sales for industry* (Baye, 2003: 234).

Overall, defense consolidation increased the degree of concentration in the aerospace industry. The restructuring of the defense industry after the Cold War resulted in a dramatic decrease in the number of prime contractors (companies). Anecdotal evidence reveals that the consolidation of the defense industry may have further exacerbated an already highly concentrated market. Since 1993, 12 out of 25 large defense firms were acquired or merged into five gigantic corporations due to the Clinton Administration's encouragement of the restructuring of the defense industry to achieve gains in efficiency (Kim, 2000: 56). There are 12 defense sectors in the manufacturing industry. Six of the 12 defense sectors are in the aerospace manufacturing industry. The number of prime contractors declined in these six defense sectors (see Table 3). The sectors of tactical missiles, fixed wing aircraft, and expendable launch vehicles each decreased by approximately two-thirds in the number of prime contractors. Since there are only two prime contractors remaining for expendable launch vehicles and strategic missiles, these sectors reached duopoly markets.

Table 3. Reduction of Prime Contractors 1990-1998

Sector	Reduction in Contractors	1990 Contractors		1998 Contractors
Tactical Missiles	**13 to 4**	Boeing Ford Aerospace General Dynamics Hughes Lockheed Loral LTV	Martin-Marrietta McDonnell Douglas Northrop Raytheon Rockwell Texas Instruments	Boeing Lockheed Martin Northrup Grumman Raytheon
Fixed Wing Aircraft	**8 to 3**	Boeing General Dynamics Grumman Lockheed	LTV-Aircraft McDonnell Douglas Northrop Rockwell	Boeing Lockheed Martin Northrup Grumman
Expendable Launch Vehicles	**6 to 2**	Boeing General Dynamics Lockheed	Martin Marrietta McDonnell Douglas Rockwell	Boeing Lockheed Martin
Satellites	**8 to 5**	Boeing General Electric Hughes Lockheed	Loral Martin Marrietta TRW Rockwell	Boeing Lockheed Martin Hughes Loral Space Systems
Strategic Missiles	**3 to 2**	Boeing Lockheed Martin Marrietta		Boeing Lockheed Martin
Rotary Wing Aircraft	**4 to 3**	Bell Helicopters Boeing McDonnell Douglas Sikorsky		Bell Helicopters Boeing Sikorsky

Source: U.S. General Accounting Office (GAO), "Defense Consolidation: Competitive Effects of Mergers and Acquisitions," GAO/NSAID-98-141, Table 1.1, (Washington D.C., March, 1998).

To further examine evidence of an increase in industry concentration and decrease of competitiveness in the market, the U.S. Bureau of Census data from Economic Censuses 1972-1997 show an increase in the concentration measures (see Table 4).

Table 4. Concentration Measures for Aerospace Industry

NAICS	Description	Year	Number of Companies	CR4 (%)	HHI	Number of Symmetric Firms
336411	Aircraft	1997	172	81	2526	4
		1992	151	79	2717	4
		1987	137	72	1686	6
		1982	139	64	1358	7
		1977	151	59	NA	NA
		1972	141	66	NA	NA
336412	Aircraft engines and engine parts	1997	281	74	1754	6
		1992	340	77	2378	4
		1987	372	77	2201	5
		1982	281	72	1778	6
		1977	226	74	NA	NA
		1972	189	77	NA	NA
336413	Other aircraft and auxiliary equipment	1997	1049	55	1126	9
		1992	1028	44	772	13
		1987	925	42	652	15
		1982	912	38	598	17
		1977	681	45	NA	NA
		1972	649	33	NA	NA
336414	Guided missile and space vehicles	1997	15	92	D	D
		1992	24	71	1570	6
		1987	19	58	1220	8
		1982	16	71	1578	6
		1977	20	64	NA	NA
		1972	23	62	NA	NA
336415	Guided missile and space vehicle propulsion units and parts	1997	19	79	2056	5
		1992	28	71	1446	7
		1987	27	73	1570	6
		1982	20	68	1402	7
		1977	18	69	NA	NA
		1972	22	59	NA	NA
336419	Other guided missile and space vehicle parts and auxiliary equipment	1997	48	72	2327	4
		1992	54	75	2034	5
		1987	61	62	1350	7
		1982	45	95	D	D
		1977	41	76	NA	NA
		1972	45	70	NA	NA

Source: Bureau of the Census, "Concentration Ratios in Manufacturing" for 1972-1997.
HHI Herfindahl-Hirschman Index for the 50 largest companies.
NA Not available
D Withheld to avoid disclosing data for individual companies.

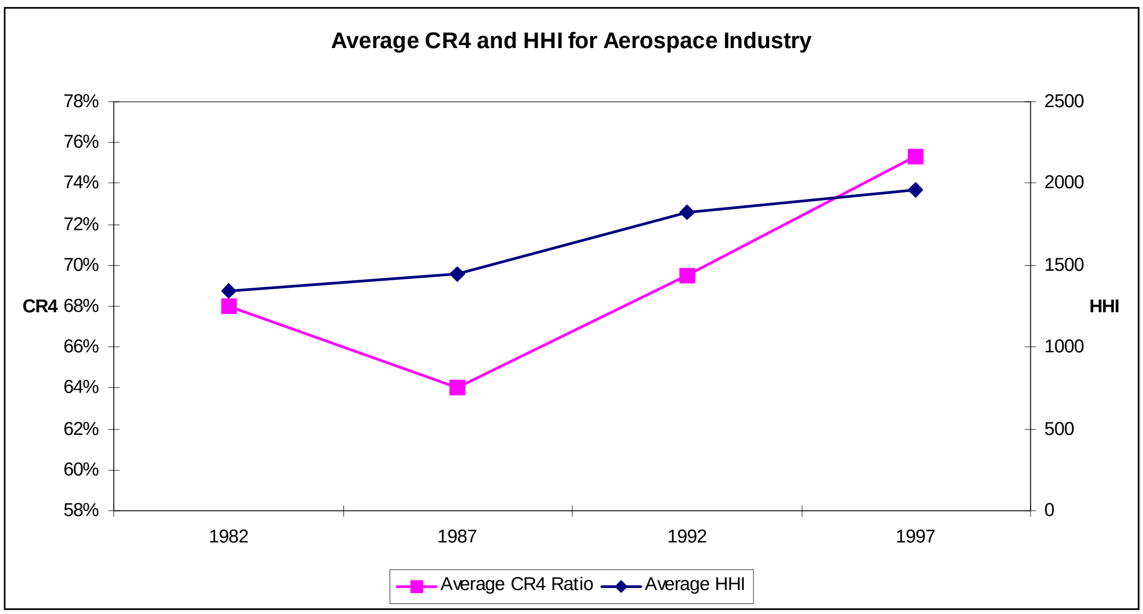
In comparing the data in Tables 3 and 4, the decrease in prime contractors appeared to have caused an increase in the CR4 and HHI for NAICS codes that represent the defense sectors within the aerospace industry. The number of companies decreased for each of the six NAICS codes. The defense sectors of fixed wing aircraft, tactical missiles, expendable launch vehicles, and satellites decreased by 5, 9, 4, and 3 prime contractors, respectively (see Table 3). With the exception of NAICS codes 336412 and 336419, in which their respective CR4 decreased by 3%, the other four NAIC codes showed increases (see Table 4). These decreases may be due to the reclassification of establishments when the SIC codes from the 1992 Economic Census changed to NAICS code in the 1997 Economic Census.

The closer the CR4 percentage is to 0%, the less concentrated the industry; the closer the CR4 is to 100%, the more concentrated the industry. The CR4 percentages in Table 4 range from 55% - 92% which indicates a highly concentrated industry. From 1992 to 1997, the CR4 for NAICS codes 336411, 336413, 336414, and 336415 increased by 2%, 11%, 21%, and 8% respectively. Therefore, based on the CR4, concentration has increased approximately by 11% for the aerospace industry overall.

According to the *1992 Merger Guidelines*, market concentration measured by HHI is characterized as unconcentrated (HHI below 1,000), moderately concentrated (HHI between 1,000 and 1,800), and highly concentrated (HHI above 1,800) (DOJ and FTC Merger Guidelines, 1992:14). The HHI for NAICS codes 336411, 336415 and 336419 indicate highly concentrated subsectors of the aerospace industry (see Table 4). The HHI for NAICS code 336414 was withheld to avoid disclosing data of individual companies which is an indication the subsector is also highly concentrated. The HHI for NAICS codes 336412 and 336413 indicate the subsectors are moderately concentrated.

Furthermore, it should be noted that the HHI of 1,754 for NAIC 336412 is near the highly concentrated range.

In summary, concentration increased and competition decreased in the market during the period of the defense industry consolidation. The six defense sectors in the aerospace industry saw a significant decrease in the number of downstream companies. Overall, the concentration measures have increased in the aerospace industry (see Figure 4).



Source: U.S. Bureau of Census, *Concentration Ratios in Manufacturing*

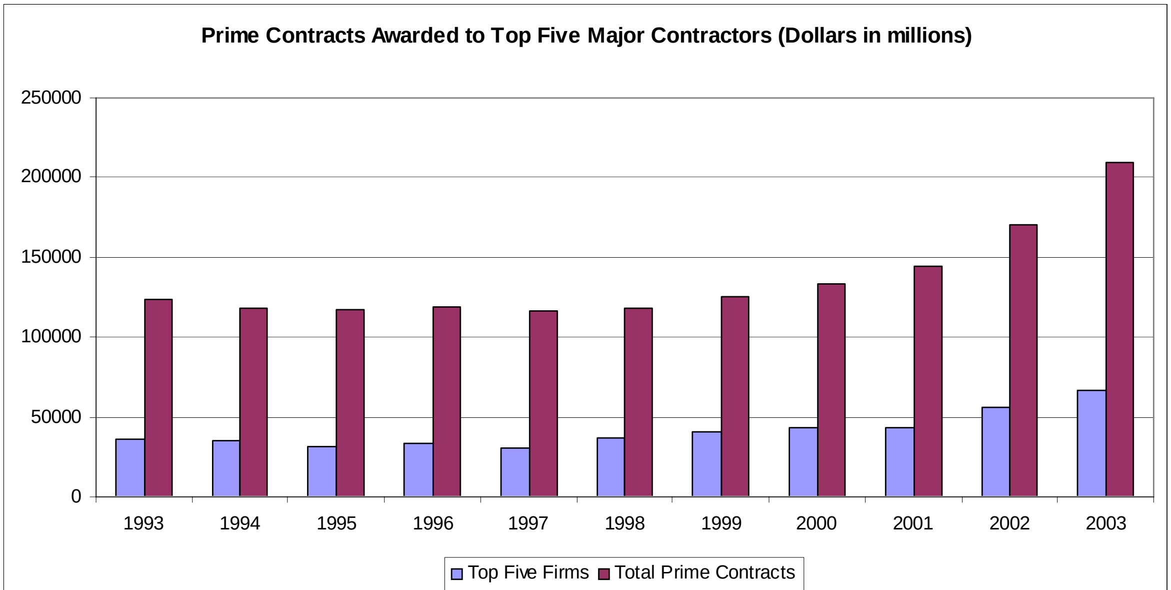
Figure 4. Concentration Measures for Aerospace Industry

Buyers and Sellers

The DOD is the single customer for many of the products aerospace companies produce for the defense industry. As a buyer with monsoponist powers, DOD can shift its purchases to other sellers or even enter the market itself (DOD DSB Task Force, 1994: 27). The federal government controls the firms' customer lists and its accounting practices along with regulating the "arm's length" encounter between itself and the industry (Demski and Magee, 1992: 733). The firms in the aerospace industry operate in a highly regulated environment because they produce products for six of the 12 defense sectors.

In determining the number of sellers, the aerospace industry was decomposed into downstream and upstream aspects for this analysis. There is a distribution of spending across industrial segments based on subcontractor activity even though the available data is only available at the prime contract level (GAO/PEMD-97-3, 1997: 4). Subcontractor data at the firm level is not available. The average size of the firm and shifts in labor are proxies used to represent subcontractor activity. The discussion begins with the definition of downstream and upstream aspects, followed by the labor identification process, and finally, an analysis of subcontractor activity.

The downstream firms are the five large remaining firms of the defense consolidation. These large firms are the integrators of the final products and they have total system program responsibility for the final weapon systems. Their production rates are low but, the value of each of their products greatly surpasses that of the supporting industries (Environmental Protection Agency, 1998: 7). As compared to the top 100 companies receiving the largest dollar volume of prime contract awards from the government, these downstream firms rank in the top positions (see Figure 5).



Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Top 5 Firms	35,728	35,164	31,522	33,236	30,634	36,883	40,498	43,511	43,664	56,259	66,544
Total Contracts	123,713	118,114	117,552	119,556	116,680	118,139	125,037	133,232	144,635	170,783	208,964
% of Top 5	29%	30%	27%	28%	26%	31%	32%	33%	30%	33%	32%

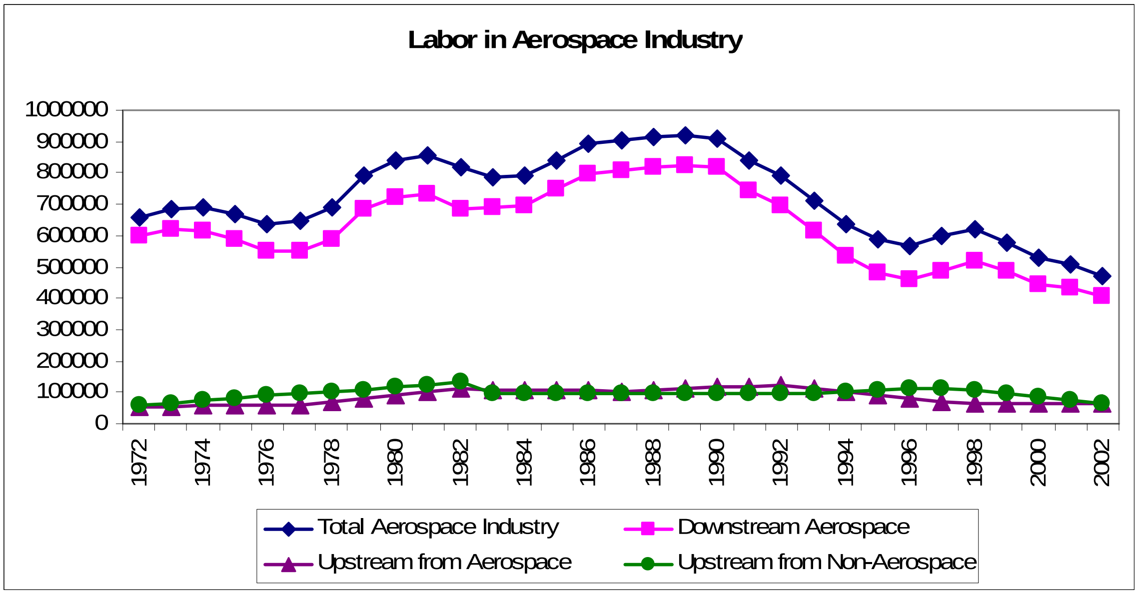
Source: Aerospace Industries Association

Figure 5. Prime Contracts Awarded to Top Five Defense Contractors

However, these large companies do not manufacture all the materials or intermediate goods needed to produce the weapon system. They contract with other companies (subcontractors) for the necessary services, materials, and intermediate goods required for producing the final products for the government.

Upstream firms are decomposed into two separate parts. The first part consists of firms from industries other than aerospace that provide raw materials or intermediate goods (e.g., sheet metal, aluminum, nonferrous alloys, valves, actuators, fluid power pumps, communications equipment, and etc.) to the aerospace companies to produce defense products. The second part consists of firms within the aerospace industry that provide necessary materials, parts, and services to the downstream firms to produce defense products. For example, a company with a primary NAICS code 336412 produces "aircraft engines and engine parts" also produces materials or intermediate goods for a company with a primary NAICS code 336411 that produces "aircraft manufacturing."

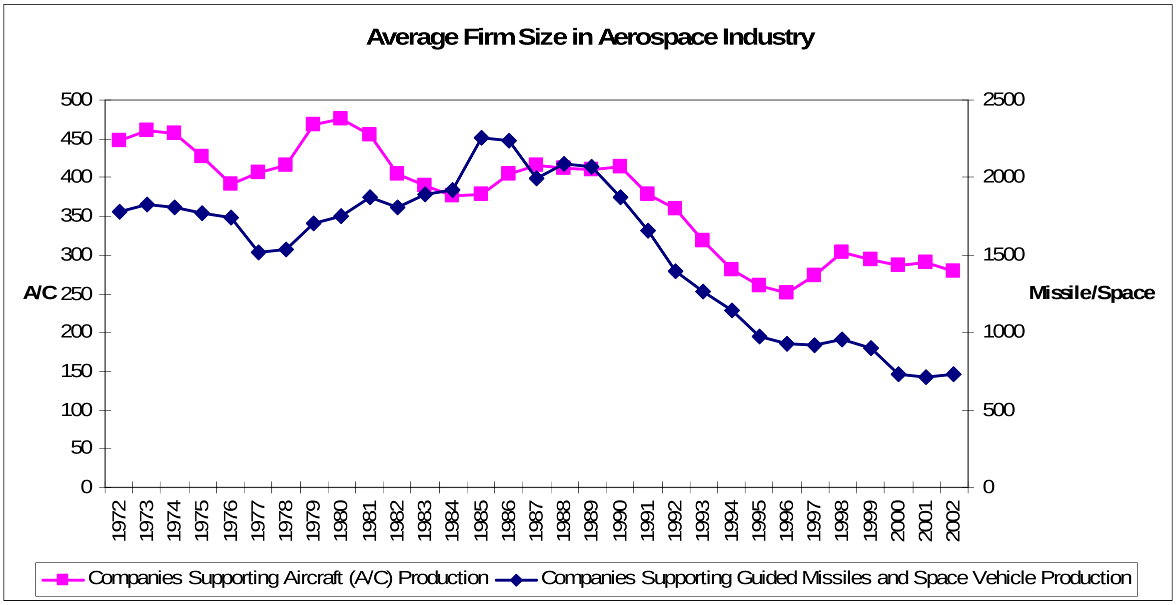
Data from the U.S. Bureau of Census, *Census of Manufactures, Table 7. Materials Consumed in Kind* was used as the basis to identify the labor in the different SIC and NAICS codes for upstream and downstream firms. The labor was identified as downstream only, upstream labor from aerospace SIC or NAICS codes, and upstream labor from non-aerospace SIC or NAICS codes (see Figure 6). Total aerospace labor is the sum of the total aerospace downstream labor and the non-aerospace industry upstream labor. The assumption is made that the upstream aerospace labor is a subset of the total downstream aerospace labor.



Source: U.S. Bureau of Census, *Census of Manufactures*

Figure 6. Labor in Aerospace Industry

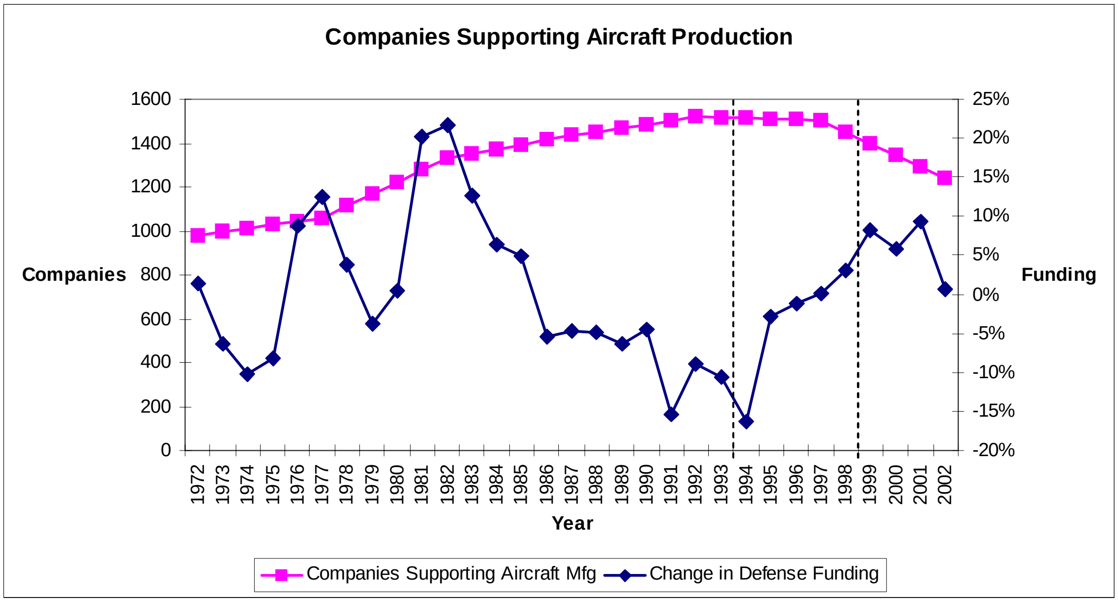
To maintain comparability, the calculations for total companies and average firm size were divided into two categories: companies supporting aircraft production and companies supporting guided missile and space vehicle production (see Figure 7). The aircraft portion comprises of 97% of the total establishments in the aerospace industry with the remaining establishments in guided missile and space vehicle manufacturing (Environmental Protection Agency, 1998: 7). The total number of companies includes both the companies that produce the intermediate goods and the final products (e.g., aircraft, missile, space launch vehicles, and etc.) in the aerospace industry (see Appendix D, Table 16). It does not include companies from non-aerospace industries.



Source: U.S Bureau of Census, Economic Censuses, 1972-2002

Figure 7. Average Firm Size in Aerospace Industry

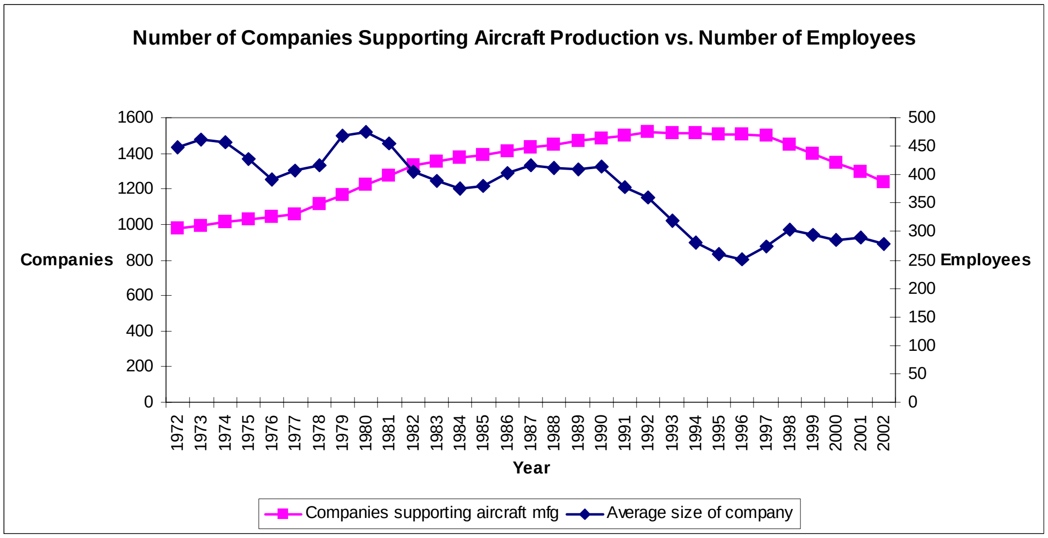
Over the last 20 years, the aggregate procurement and Research, Development, Test & Evaluation (RDT&E) contracts for aerospace products out-paced spending for all other equipment by over 3 to 1 (GAO/PEMD-97-3, 1997: 3). The total number of companies supporting aircraft production did not decrease during the period of the steepest reductions in defense funding (see Figure 8). Defense funding is defined as the total approved budget authority received by the military services RDT&E and procurement funding (DOD National Defense Budget Estimates for FY 2006, 2005: 148-177). The number of downstream companies supporting the defense sectors for fixed-wing aircraft and rotary wing aircraft was reduced by 50% during the defense industry consolidation. During this same period, the total aerospace companies supporting aircraft production had an average decrease of only 3.3%.



Source: U. S. Bureau of Census, Economic Censuses 1972-2002

Figure 8. Companies Supporting Aircraft Production

An indicator of possible increase in subcontractor activity is the average firm size. Since the total number of aerospace firms did not decrease at the same rate as the larger downstream firms, the highly specialized labor may have shifted to upstream firms or industries supporting the aerospace industry. The data reflects the total number of aerospace companies remained constant in aircraft production during the defense consolidation period (see Figure 8). The assumption is made that labor shifted from the larger firms to meet the needs of the smaller firms. The decreasing trend in average firm size may indicate the redistribution of labor from downstream firms to the upstream firms; thus, increasing the available subcontractor pool for the remaining large downstream firms (see Figure 7 and Figure 9).

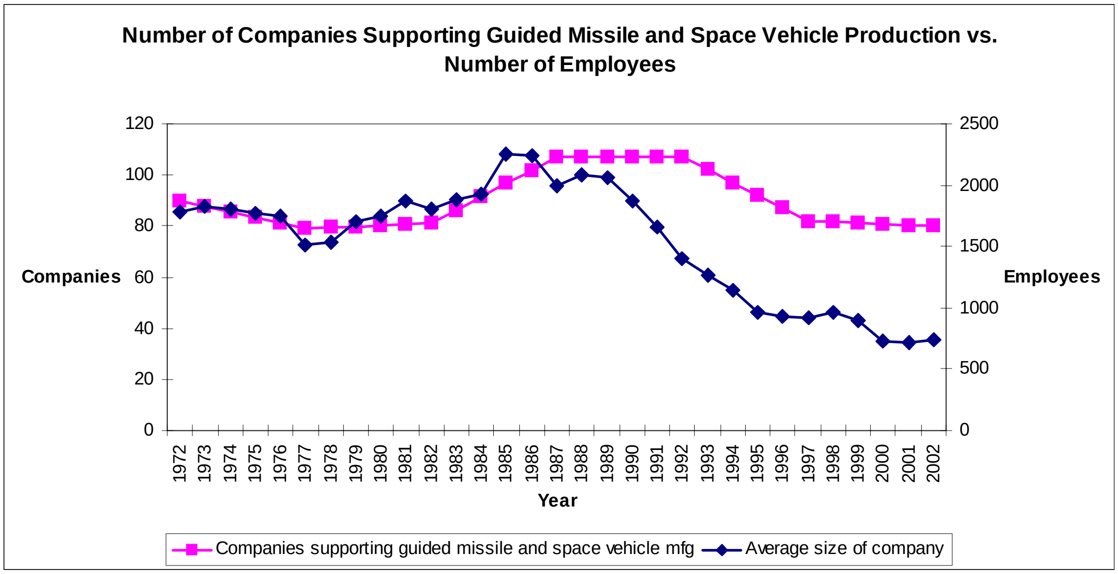


Source: U. S. Bureau of Census, Economic Censuses 1972-2002

Figure 9. Average Firm Size for Aircraft Production Companies

The defense industry consolidation focused on the large companies (e.g., McDonnell Douglas, Martin Marrietta, Lockheed, Boeing, and etc.). While the number of large downstream companies decrease by approximately 52% (see Table 3) during the defense industry consolidation, the total number of companies in the aerospace manufacturing industry supporting aircraft production only decreased by about 0.5% for the same period.

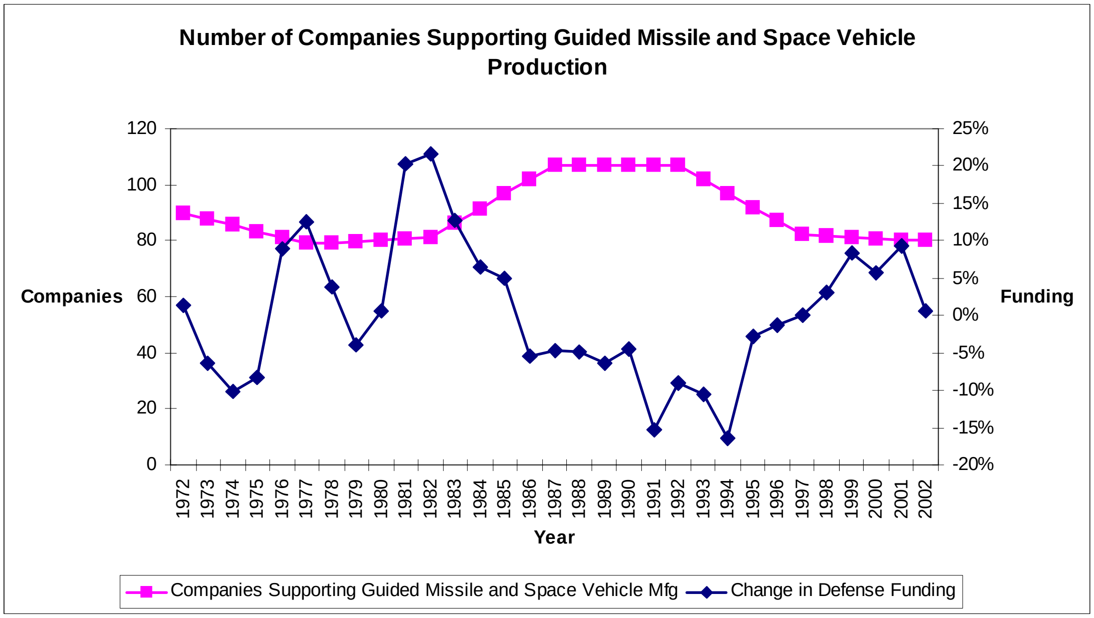
In reviewing the total number of companies for guided missile and space vehicle production, the number of companies stayed constant from 1987-1992. There was an average decrease of 53% in the number of downstream firms supporting the defense sectors of tactical missiles, expendable launch vehicles, satellites, and strategic missiles. During the same period, the total number of aerospace companies for guided missile and space vehicle production decreased an average of 3.8%. Similar to the trend identified in the aircraft production companies, the decreasing trend in average firm size also indicates possible labor redistribution and an increase in subcontractor pool available to the remaining downstream firms (see Figure 9 and Figure 10).



Source: U.S. Bureau of Census, Economic Censuses 1972-2002

Figure 10. Average Firm Size for Guided Missile and Space Vehicle Production

Furthermore, the data representing guided missile and space vehicle production may have revealed a cyclical trend. The SIC codes for these three subsectors in the aerospace industry were established in 1972. The total number of companies leveled out in 1977 and the cycle appears to have repeated itself in 1997 (see Figures 10 and 11). This may indicate a relationship between the cyclical trend of the U.S. defense budget and these subsectors of the aerospace industry (Driessnack and King, 2004: 64). If this is a cyclical trend, then, efficiencies may have been gained through market forces without DOD's encouragement of a defense consolidation.



Source: U.S. Bureau of Census, Economic Censuses 1972-2002

Figure 11. Companies Supporting Guided Missile and Space Vehicle Production

To meet DOD's defense consolidation intent of reducing excess capacity and overhead costs, aerospace firms were acquired or merged. Firms restructure themselves by outsourcing those value-added elements that do not build upon their strengths and are more cost effectively procured from suppliers (Christensen, et al, 2002: 960). When consolidation of facilities or outsourcing of value added elements occurs, labor is shed from the firms. The labor used to produce defense products is highly specialized. This specialized labor may redistribute itself into the upstream firms within the aerospace industry or into other industries that support the production of defense products; thus, increasing the subcontractor pool available to the downstream firms.

Vertical Integration

Vertical integration occurs when a firm participates in more than one successive stage in the manufacturing or distribution of its products. Generally, firms vertically integrate to reduce transaction costs and maximize profits. A primary determinant in integration is asset specificity. Asset specificity occurs when an upstream firm and a downstream firm make investments in a manner such that the greatest value of exchange occurs only with each other and not with other firms (Perry, 1989: 188). Firms integrate backwards to acquire key inputs for its products. They integrate forward to increase market power. An industry will move through the phases of vertical integration and vertical disintegration in its life cycle (see Figure 12).

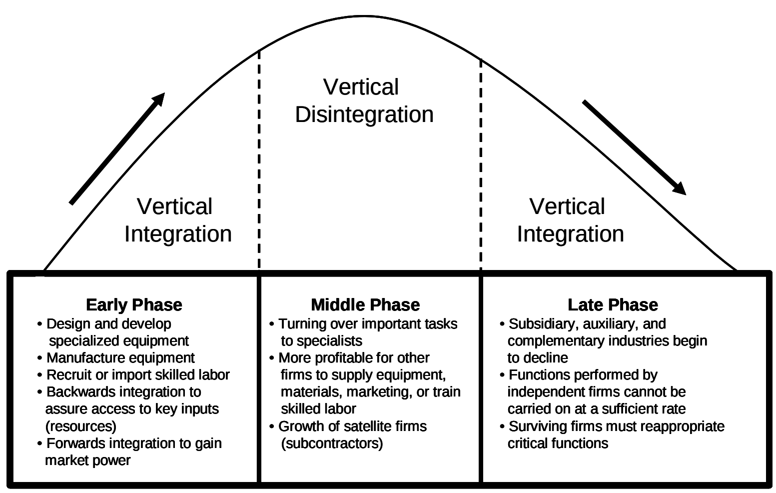


Figure 12. Industry Life Cycle

Firms in an industry will integrate in the early part of its life, disintegrate when it reaches a certain level in the middle part of its life, and when it declines in the later part of its life, the surviving firms will reacquire those functions which are no longer carried on at a sufficient rate to support independent firms (Stigler, 1968: 135-136).

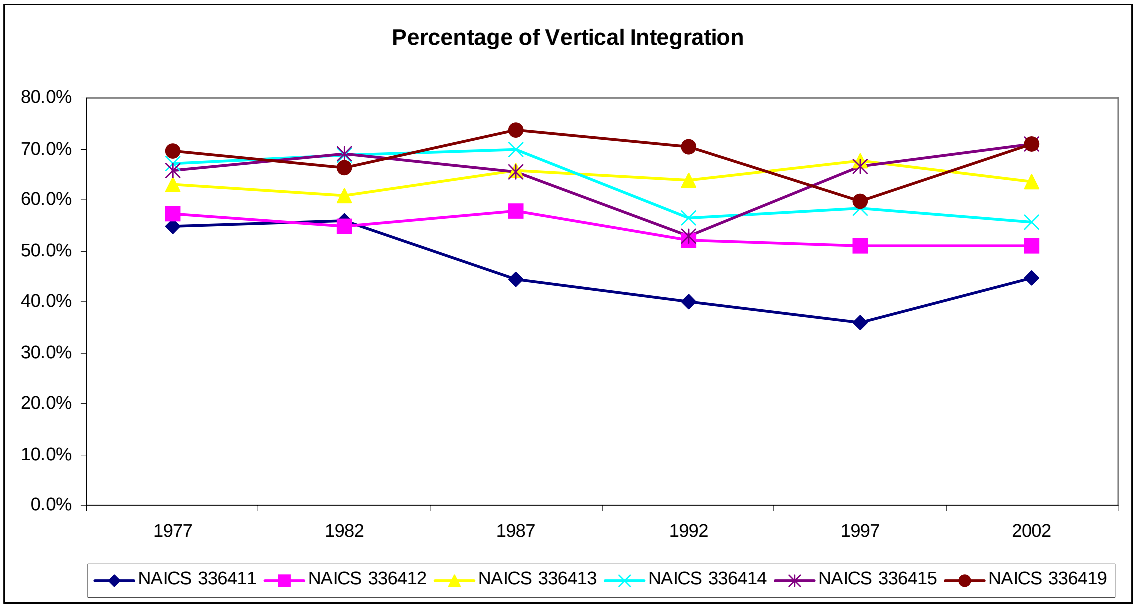
Although, there is no distinct measure to determine the level of vertical integration, there is a crude measure based on the concept of "value added" which reflects that the larger share of the manufacturing output came from vertically integrated firms (Stigler, 1968: 135). Percentage of vertical integration is calculated as a ratio by dividing the value added by the value of shipments. Value added by manufacture is an estimate of the economic contribution industry makes by transforming the raw materials into the finished product (Boettcher and Gaines, 2004: 185). It is calculated by subtracting the cost of materials, supplies, containers, fuel, purchased electricity, and contract work from the value of shipments. Value of shipments is the total value of the products shipped out excluding freight and taxes but, includes the primary products, secondary products, and installation and/or repair work related to the product shipped (Boettcher and Gaines, 2004: 186). Anecdotal evidence of the aerospace industry moving through its life cycle can be seen in the percentage of vertical integration compared to selected sectors in the manufacturing industry (see Table 5).

Table 5. Percentage of Vertical Integration in Selected Industries

Year	Total Manufacturing	Aerospace	Shipbuilding and Repair	Tank and Tank Components	Cigarettes	Pharmaceutical Preparations	Canned Fruits and Vegetables	Corrugated and Solid Fiber Boxes
2002	48.3%	50.8%	65.9%	56.4%	88.1%	73.3%	50.0%	37.1%
1997	47.6%	47.9%	58.8%	51.1%	79.8%	71.7%	43.9%	37.7%
1992	47.4%	49.0%	61.7%	56.9%	83.4%	73.8%	46.2%	34.0%
1987	47.1%	57.0%	61.3%	38.4%	74.7%	74.4%	45.8%	34.0%
1982	42.0%	59.1%	58.2%	49.2%	66.8%	71.0%	38.3%	34.7%
1977	43.1%	59.0%	58.9%	46.8%	59.6%	71.7%	38.2%	36.8%

Source: U.S. Bureau of Census, Economic Censuses 1992-2002

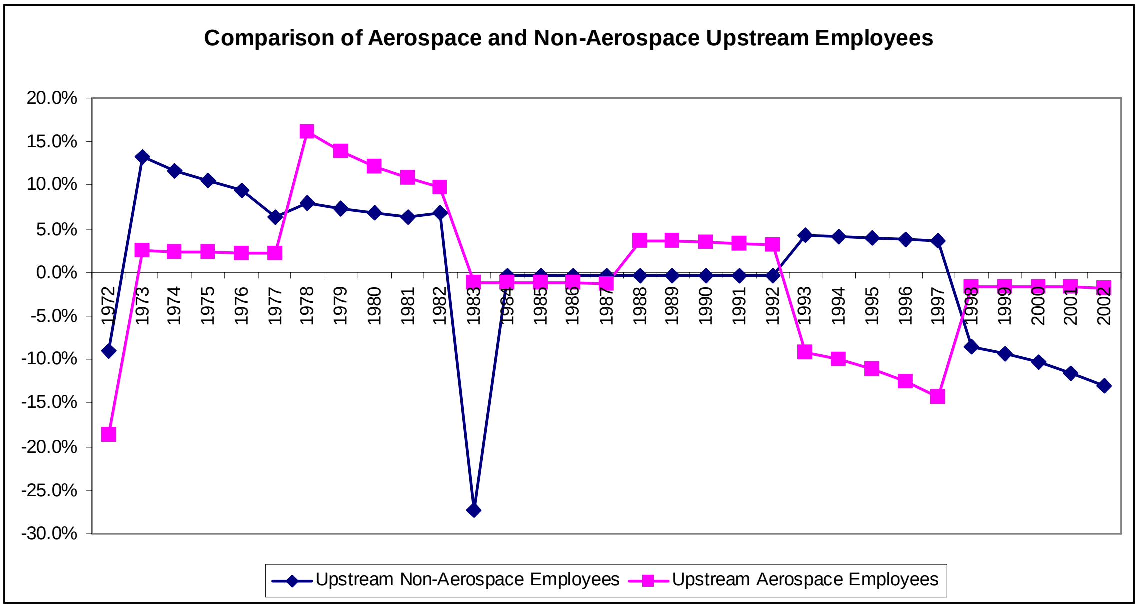
Overall, the aerospace industry is not as vertically integrated as other industries. The other industries show a trend of increasing vertical integration where aerospace does not. Vertical disintegration appears to have occurred during the defense industry consolidation period covered by the 1992 and 1997 Economic Censuses. However, half of the subsectors in the aerospace industry became more vertically integrated after the defense consolidation period as seen in the 2002 Economic Census (see Figure 13).



Source: U.S. Bureau of Census, Economic Census, 1977-2002

Figure 13. Percentage of Vertical Integration within the Aerospace Industry

Further evidence of vertical disintegration and integration can be seen in the movement of upstream aerospace labor. There appears to be two distinct periods in which the movement of labor suggests that when the labor decreases in aerospace, the subcontractor (non-aerospace) labor increases (see Figure 14). The assumption is made that vertical disintegration occurs during the periods when non-aerospace upstream labor increases and aerospace upstream labor decreases.



Source: U.S. Bureau of Census, Economic Census 1972-2002

Figure 14. Percentage Change in Non-Aerospace and Aerospace Upstream Labor

During the defense consolidation period, it appears that the aerospace industry became more vertically disintegrated. The vertical disintegration may indicate more subcontractor activity. An increase in subcontractor activity may also indicate more competition beyond the prime contractor level. An increase in the pool of subcontractors allows the prime contractors to be the “Wal-Marts” of the defense industry. As the final integrators of the end product, the large downstream firms can promote competition among the subcontractors. Unfortunately, this trend appeared temporary since half of the subsectors have reached or exceeded their pre-consolidation vertical integration levels by 2002. Therefore, it is unknown if there were restructure savings particularly in future transaction costs for government contracts.

Product Differentiation

Product differentiation is evident in the aerospace industry. Within each of the six defense sectors, there are related products that have similar characteristics but, they are not viewed as perfect substitutes by the government. For example, a C-17 and a C-5 are both transport aircraft with similar characteristics. However, in supporting mission requirements, they are not perfect substitutes for each other. The defense products produced by the aerospace industry are heterogeneous (see Table 6).

Table 6. Products Included in the Aerospace Industry

Category	Products	
Military Fixed-Wing Aircraft	Attack Bombers Cargo/Transport/Refueling Early Warning Electronic Warfare Fighters	Observation Patrol ASW Reconnaissance Research/Test Bed Training Utility
Commercial Fixed-Wing Aircraft	Narrow Body Turbofans Wide Body Turbofans Turboprops	
Rotary-Wing Aircraft	Naval Scout/Attack Tiltrotor	Training Transport Utility
Business & General Aviation Aircraft	Turbofan Turboprop Reciprocating Engine-Powered	
Gas Turbine Engines		
Unmanned Aerial Vehicles and Drones		
Space/Launch Vehicles	Manned Systems Unmanned Systems	
Missiles	Air-to-Air Air-to-Surface Anti-Armor Anti-Ballistic	Anti-Ship Anti-Submarine Surface-to-Air Surface-to-Surface

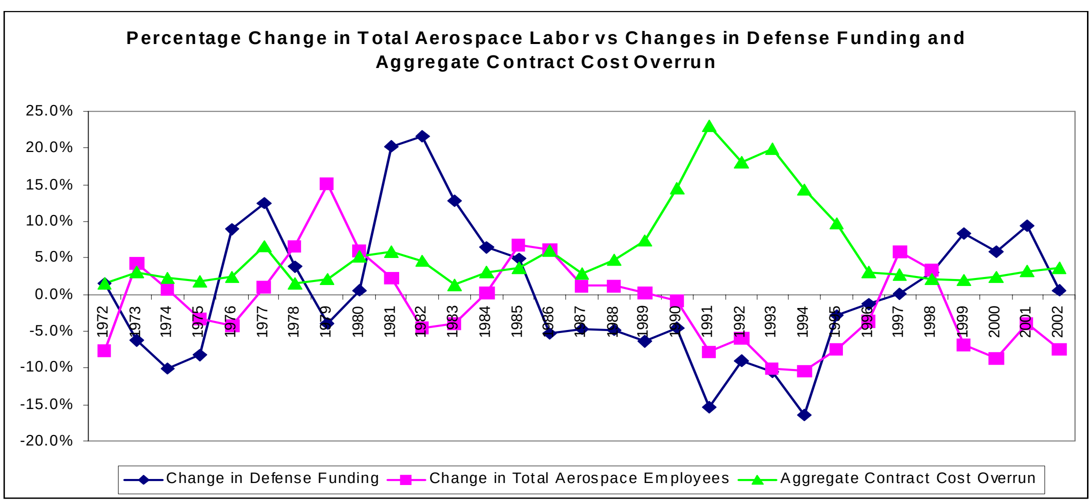
Source: Environmental Protection Agency (EPA) Sector Notebook Project, 1998

In summary, the defense industry consolidation increased concentration and decreased competition in the aerospace industry. The impact of defense consolidation on vertical integration is unknown. Product differentiation is not affected since the product decision is determined by the primary customer and not the sellers.

Conduct

Specificity of Assets

As an industry that operates in the high end of technology, the assets in the aerospace industry are highly specific. An indication of high asset specificity is the 90% increase in constant dollars from 1980 to 1987 in defense spending on major physical capital and research and development (Hetrick, 1996: 58). The amount of human capital in the aerospace industry appears to have an impact on the firms' performance. During the period of 1990-1996, the aerospace industry shows a decreasing trend in the number of employees and an increasing trend in the percentage of aggregate annual cost overruns for government contracts (see Figure 15).



Sources: Aerospace Industries Association, 2004/2005
National Defense Budget Estimates for FY 2006, Office of the Undersecretary of Defense (Comptroller), April 2005

Figure 15. Comparison of Cost Overrun to Change in Labor and Defense Funding

Another indication of high asset specificity is the cost of labor in the aerospace industry. As a group, the average hourly wage of the unionized production workers is 53% above the average of all total private industries and 41% above the manufacturing average (Hetrick, 1996: 60). The high wages reflect the superior technical skills required to manufacture high-tech defense products such as weapon systems. This trend is also reflected in the labor costs of R&D scientists and engineers employed in the aerospace industry (see Table 7).

Table 7. Employment and Costs of R&D Scientists and Engineers

Employment and Cost of R&D Scientists and Engineers for All Industries and Aerospace Industry					
Year	Employment in All Industries (Thousands)	Employment in Aerospace (Thousands)	Aerospace as % of All Industries	Cost Per Employee for All Industries	Cost Per Employee in Aerospace
1982	509.8	91.1	17.9%	111,600	148,800
1983	540.9	103.1	19.1%	116,000	143,600
1984	584.1	111.5	19.1%	124,000	156,000
1985	622.5	130.2	20.9%	130,200	161,700
1986	671.0	144.8	21.6%	128,500	149,800
1987	695.8	136.3	19.6%	128,800	180,400
1988	708.6	136.4	19.2%	132,300	193,300
1989	722.5	134.8	18.7%	134,500	207,300
1990	743.6	115.3	15.5%	141,300	213,700
1991	773.4	100.2	13.0%	148,600	177,000
1992	779.3	92.9	11.9%	157,912	180,552
1993	764.7	97.9	12.8%	153,336	176,450
1994	768.5	72.8	9.5%	157,459	186,898
1995	746.1	63.5	8.5%	167,339	213,328
1996	832.8	95.5	11.5%	168,362	170,733
1997	885.7	94.6	10.7%	171,499	208,217
1998	951.5	77.0	8.1%	173,589	228,159
1999	997.7	66.4	6.7%	179,997	237,058
2000	1033.7	55.3	5.3%	192,327	256,692
2001	1041.3	25.1	2.4%	188,917	356,018
2002	1060.2	19.1	1.8%	179,475	374,186

Source: Aerospace Industries Association, *Facts & Figures*

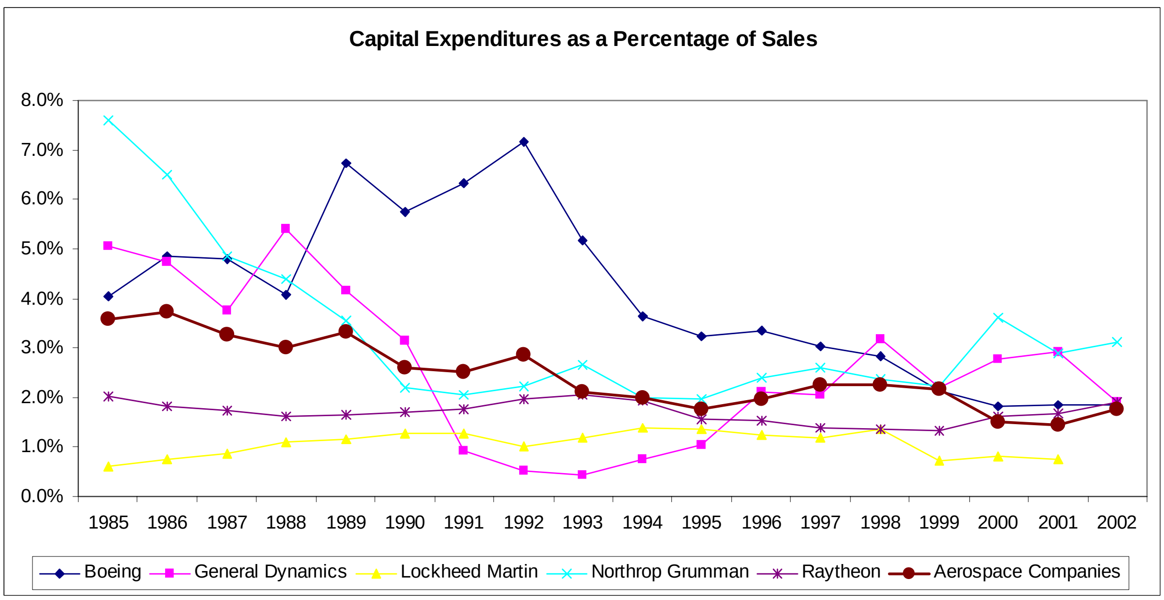
Barriers to Entry

The barriers to entry for a new firm entering into the aerospace industry are high. Factors such as competition, entry costs, and asset specificity contribute to barriers of entry. One of the key factors that cause barriers to entry is competition. Competition determines the number of firms in the market and the market power of those firms. The DOD worked with the Department of Justice (DOJ) on mergers and established task forces to study the impact of the defense consolidation on competition and vertical integration in the industry. Another key factor is the explicit cost of a firm entering the aerospace industry. Since large amounts of capital are needed for preparing contract proposals, gaining access to scientific and engineering talent, and acquiring specialized production equipment, the likelihood that a new defense firm will enter the market is low (GAO/PEMD-97-3, 1997: 21).

The degree of asset specificity is also a barrier to entry. The five types of asset specificity are: site specificity, physical assets specificity, human assets specificity, dedicated assets, and brand name capital (Williamson, 1989: 143). The need to maintain critical capability in the U.S defense industrial base, at a minimum, requires a level of asset specificity in the aerospace industry. The uniqueness of the different weapon systems requires firms to dedicate specific assets for their development and production.

Capital Investment

Because the entry barriers are high for the aerospace industry, it is expected that large capital expenditures are required to support economies of large scale production. The ratio of capital expenditures to net sales was used to analyze the level of plant investment for the aggregate of aerospace firms and the five large downstream firms. However, the data shows that the level of capital expenditures has decreased after the defense consolidation period (see Figure 16). Prior to the defense consolidation period the average capital investment as a percentage of fixed assets was 15.8%. After defense consolidation, the percentage was 10.0%. Since the large downstream firms are systems integrators, the decrease in capital expenditures may be representative that these firms do not have large scale production.



Sources: Aerospace Industries Association, *Facts and Figures*, 1985-2002
Standard and Poor's Compu$tat Database

Figure 16. Comparison of Capital Expenditures as Percentage of Fixed Assets

Research and Development (R&D)

Firms that produce major weapons systems such as combat aircraft operate at the high-end of technology (Harper, 1999: 336). Although there is considerable variation found within each industrial sector, in the manufacturing of aircraft and missiles, R&D tends to be conducted primarily by the large firms (National Science Foundation, 2003: 31). The development of technologies needed to support the production of new weapon systems is funded by the companies' industrial research and development (IR&D) and the funds received from federal agencies. For most firms, R&D is considered a discretionary expense since it cannot be related to short-term revenues nor does it produce revenues as in production expenses. Companies with a larger volume of DOD sales will capture a larger share of IR&D because public subsidies for IR&D are tied to total sales (Kovacic, 1999: 435). R&D plays a crucial role in future growth and competitiveness; therefore, as a discretionary expense, it is immune to some degree of reduction when a company's profits fall or when the economy is faltering (National Science Foundation, 2003: 33).

The early 1980's saw a surge in industry's defense-related R&D efforts with its share of performance reaching its peak of 71.8% in 1985 (National Science Foundation, 2003: 25). However, this trend did not continue. During the period of 1985-2000, IR&D performance only grew 1.4% in real terms for the first nine years and averaged 5.4% for the remaining six years for all industry sectors combined (National Patterns of R&D Resources, 2003: 25). Industry continues to provide the largest share of the R&D spending.

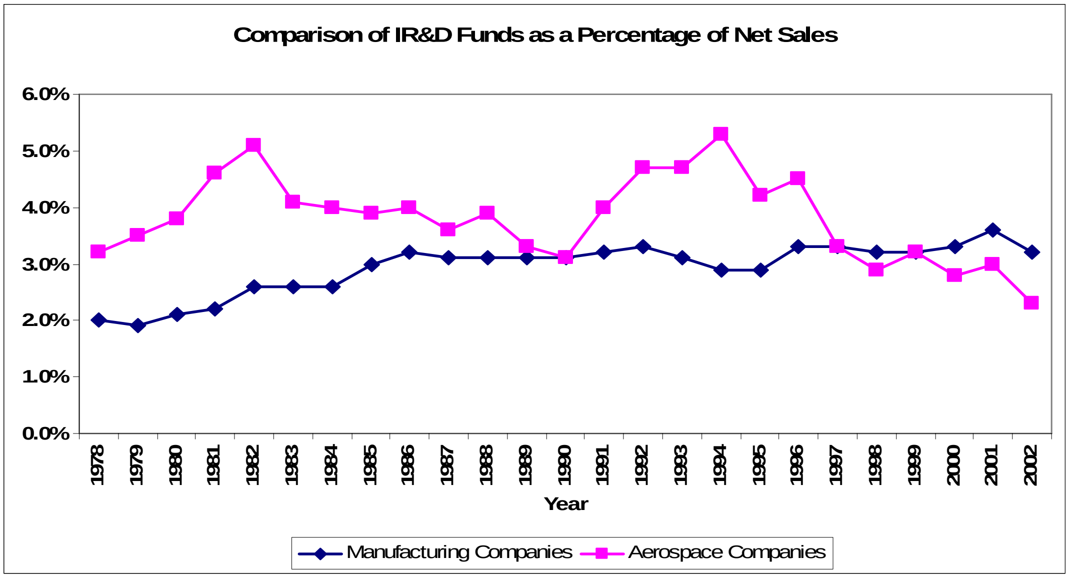
Overall, there is a decreasing trend in federal funds provided to the manufacturing industry for R&D. During the period of 1988-2002, the companies in the manufacturing industry, as a whole have provided the preponderance of the IR&D funding (see Table 8). Federal funds decreased at an average of 7.1% for manufacturing while the companies' funding increased at an average of 4.8%. However, when the aerospace industry is compared to the manufacturing industry, the trend is different. The majority of the funding for R&D spending came from federal agencies. With the exception of 2001 and 2002, aerospace companies received approximately two dollars of federal funds for every one dollar of IR&D spent. Similar to the manufacturing trend, federal funds for aerospace also decreased but, at a higher average of 10.3%. Dissimilar to the manufacturing trend, aerospace companies' IR&D also decreased at an average of 1.5%.

Table 8. Funding Source for R&D

	Manufacturing					Aerospace				
Year	Total Funds	Federal Funds	Company	% of Federal Funds	% of Company	Total Funds	Federal Funds	Company	% of Federal Funds	% of Company
1988	128,157	40,083	88,074	31.3%	68.7%	31,926	24,309	7,617	76.1%	23.9%
1989	129,676	36,282	93,394	28.0%	72.0%	28,375	21,382	6,992	75.4%	24.6%
1990	134,469	34,467	100,002	25.6%	74.4%	25,288	18,686	6,602	73.9%	26.1%
1991	138,569	31,246	107,322	22.5%	77.5%	19,703	13,147	6,556	66.7%	33.3%
1992	137,859	28,613	109,245	20.8%	79.2%	19,859	11,906	7,953	60.0%	40.0%
1993	132,805	25,802	107,003	19.4%	80.6%	17,032	10,602	6,430	62.2%	37.8%
1994	132,442	24,876	107,565	18.8%	81.2%	15,792	9,739	6,053	61.7%	38.3%
1995	143,434	25,463	117,972	17.8%	82.2%	18,405	12,445	5,960	67.6%	32.4%
1996	154,065	25,190	128,876	16.4%	83.7%	17,278	11,198	6,081	64.8%	35.2%
1997	165,135	25,082	140,053	15.2%	84.8%	18,726	11,430	7,297	61.0%	39.0%
1998	175,316	25,040	150,276	14.3%	85.7%	16,952	10,195	6,758	60.1%	39.9%
1999	186,630	23,018	163,612	12.3%	87.7%	14,734	9,313	5,423	63.2%	36.8%
2000	199,539	19,118	180,421	9.6%	90.4%	10,319	6,424	3,895	62.3%	37.7%
2001	193,853	16,503	177,350	8.5%	91.5%	7,684	3,696	3,987	48.1%	51.9%
2002	183,647	15,785	167,861	8.6%	91.4%	9,292	4,144	5,148	44.6%	55.4%

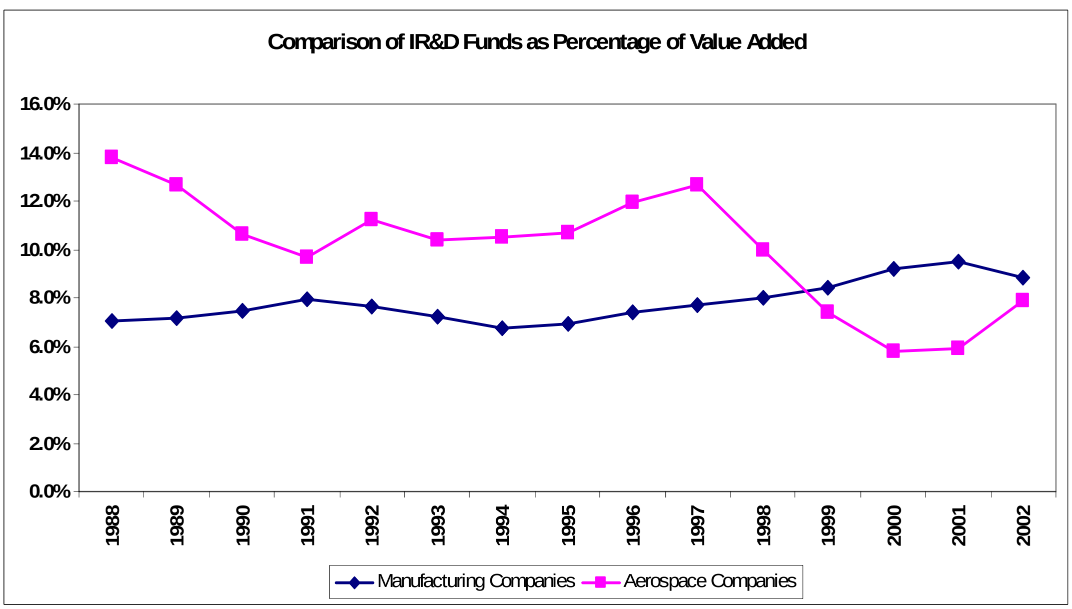
Source: Aerospace Facts and Figures 2004/2005, p.104

R&D intensity measures the relative importance of R&D across industry and among firms in the same industry (National Science Foundation, 2003: 33). R&D intensity is measured by the ratios of company-funded IR&D to net sales and to value added. Value added focuses on productivity and is defined as value of shipments less cost of materials. By subtracting the cost of materials, value added is attributed to the aerospace industry and not to materials produced in other sectors of the manufacturing industry. Overall, the IR&D intensity for aerospace companies averaged 3.8% of net sales which is higher than the total manufacturing companies average of 2.9% (see Figure 17). A similar increasing trend was also found in the ratio of IR&D funds to value added. The percentage of IR&D intensity for aerospace companies averaged 10.1% of value added which is higher than the total manufacturing companies' average of 7.8% (see Figure 18). Operating at the high end of technology, aerospace companies have to invest in IR&D in order to develop and produce sophisticated weapon systems. A unique relationship is shared between DOD and industry; DOD relies on industry to provide the technical advantage that is the heart of security doctrine and in turn, industry depends on DOD as its primary customer (Flamm, 2005: 6).



Sources: Aerospace Industries Association, *Facts and Figures,* 2004/2005
Bureau of Census, Economic Census 1992-2002

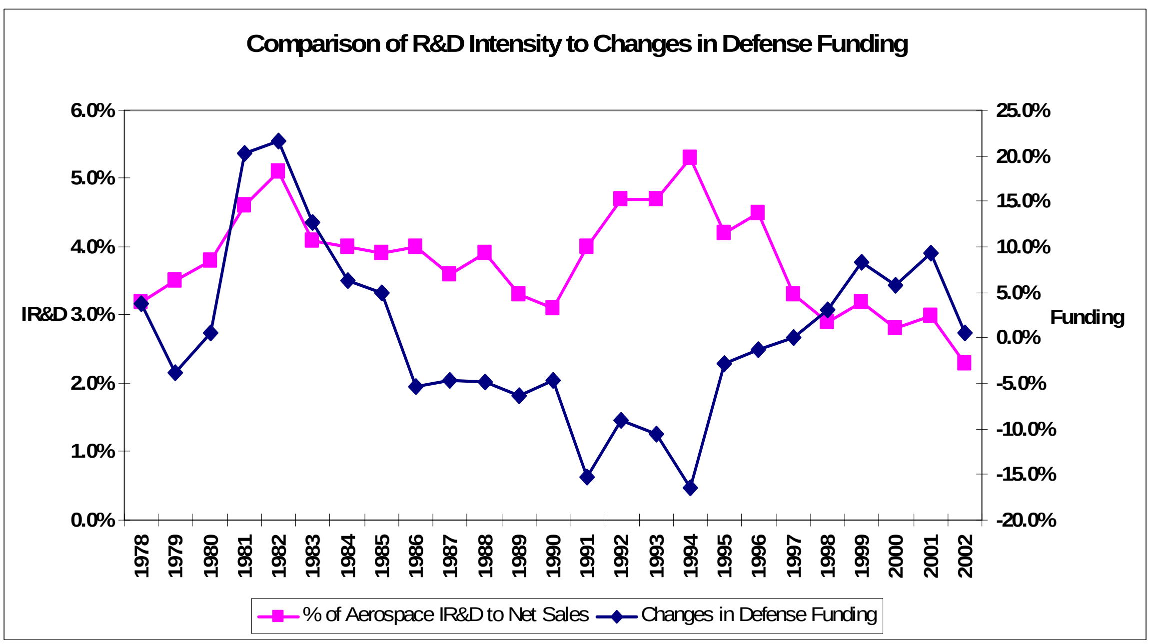
Figure 17. R&D Intensity in Aerospace Firm as Percentage of Net Sales



Sources: Aerospace Industries Association, *Facts and Figures*, 2004/2005
Bureau of Census, Economic Census 1992-2002

Figure 18. R&D Intensity in Aerospace Firm as Percentage of Value Added

Anecdotal evidence reflects mixed results in the measures of R&D importance during the defense consolidation period. The R&D intensity was above or at the same level as the total manufacturing companies before defense consolidation for both net sales and value added. During the consolidation period, IR&D funding as a percentage of net sales decreased an average of 6.6% and the trend appears to be falling below total manufacturing industry. However, defense consolidation may not have been the cause of this decrease. A possible correlation may exist between IR&D funding and changes in defense spending. It appears that as defense funding decreases, aerospace companies increase their IR&D funding (see Figure 19).



Sources: Aerospace Industries Association, *Facts and Figures*, 2004/2005
National Defense Budget Estimates for FY 2006, Office of the Undersecretary of Defense (Comptroller), April 2005

Figure 19. Aerospace R&D Intensity and Changes in Defense Funding

In summary, there are mixed results on the impact of the defense consolidation on the conduct of the aerospace industry. Anecdotal evidence reflects that the restructuring activities of the large downstream firm did cause labor to shift within and across industries. Average aerospace firms' capital expenditures were decreasing prior to the defense consolidation. Furthermore, the IR&D funding appears to be more related to changes in defense funding. The measure of IR&D as value added for productivity dropped after the defense consolidation period. This may be the result of efficiency lost from the shifting of high tech labor due to consolidation of facilities.

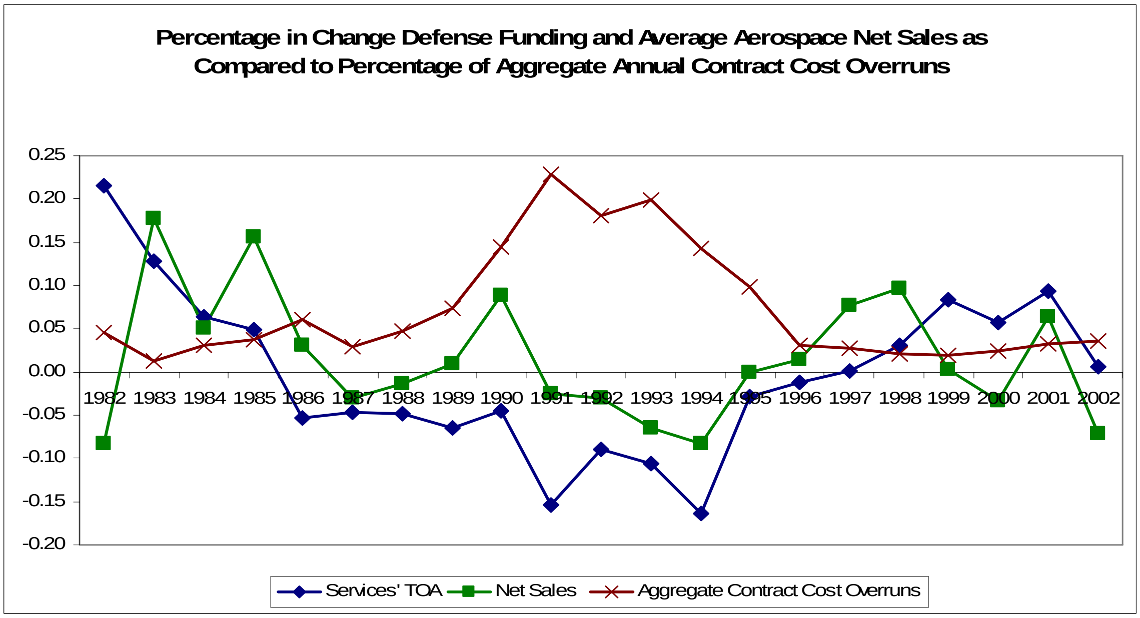
Performance

Profitability

Only a handful of U.S. industries are dominated by defense spending, the aerospace manufacturing industry is one of them (Flamm, 2005: 6). The sales of defense products from the aerospace industry are determined by the amount of monies Congress appropriates to the DOD to meet its requirements. Since the government regulates the level of competition, the estimated cost of the new weapons system acts as a proxy for price. In theory, as a firm approaches monopoly, profits should increase, although government contractual controls may mute this effect. The increasing concentration ratios from the defense consolidation should result in higher firm profits. This section focuses on the performance of the aerospace industry and the five surviving downstream firms (Boeing, General Dynamics, Lockheed Martin, Northrop Grumman, and Raytheon) before and after the defense consolidation period.

Performance was measured by using the following profitability ratios: return on sales (profit margin), return on assets, and return on equity (net worth). First, the profit margin ratio is calculated by dividing net income by net sales. This ratio measures the amount of profit earned per a dollar of sales. Profit margin provides a measure of efficiency of the firm's operations. It also indicates the firm's ability to withstand adverse economic conditions such as falling prices, rising costs, and declining sales. Second, the return on assets (ROA) ratio is calculated by dividing net income by total assets. This ratio matches profits with operating assets used to earn the return. It measures how efficiently a firm uses its assets. Finally, the return on equity (ROE) ratio is calculated by dividing net income by total stockholders' equity or net worth (total assets minus total liabilities). This ratio measures the ability of management to earn an adequate return on the capital invested by the owners of the firm.

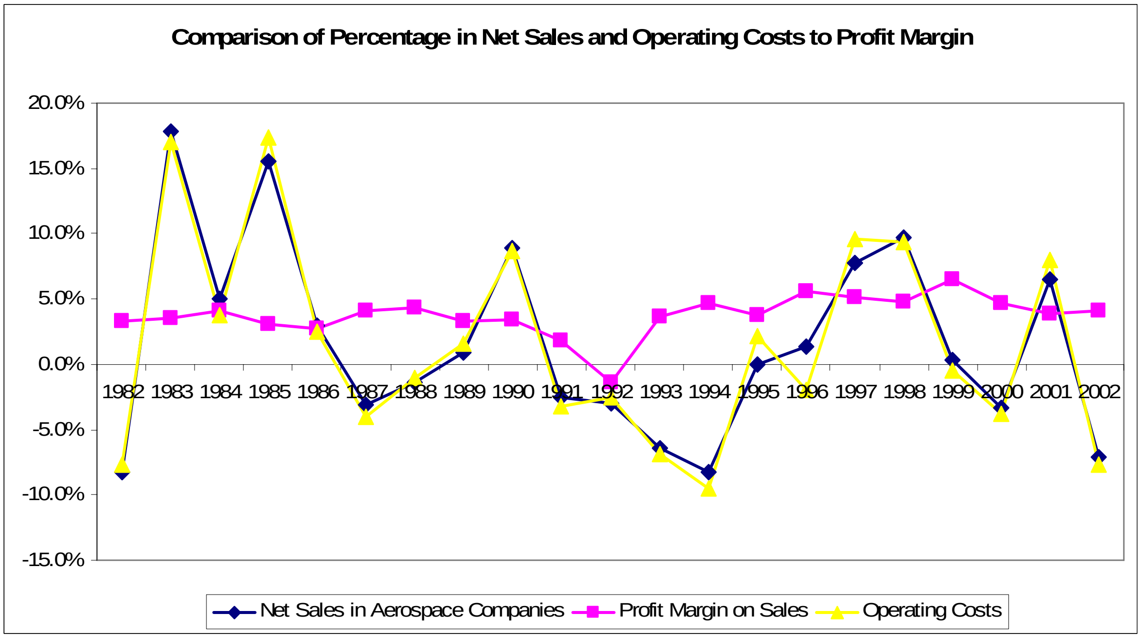
The data from the aerospace industry indicates a relationship between the changes in defense funding, higher percentage of cost overruns in weapons system costs, and lower net sales particularly during the period of 1991-1996 (see Figure 20). Generally,



Sources: Aerospace Industries Association, *Facts and Figures*
National Defense Budget Estimates for FY 2006, Office of the Undersecretary of Defense (Comptroller), April 2005

Figure 20. Aerospace Industry Performance

firms increase profits by reducing operating costs through efficiencies in operations. Operating costs increased and decreased at the same rate as nets sales (see Figure 21). One observation is that the trend is likely related to changes in defense funding which drives both the net sales and operating costs of the firms. Another observation may be the firms with government contracts may not be efficient due to the ability to claim "allocable, allowable, and reasonable" costs for cost plus contracts in accordance with the FAR, Section 31. The combination of negotiated profit rates on contracts and the ability to claim costs according to the FAR may not encourage firms to be efficient.



Sources: Aerospace Industries Association, *Facts and Figures*
National Defense Estimates for FY 2006

Figure 21. Comparison of Net Sales, Operating Costs, and Profit Margin

Another indication at the aerospace industry level that supports the possibility of an artificial condition controlling profitability is in the ROE ratio and its relationship to concentration. Based on the HHI, the ROE for selected industries with different concentration levels were used to compare the ROE of NAICS codes 336411, 336412, and 336413 from the aerospace industry. The average ROE was calculated for the time period of 1992-1997. NAICS 336411 and 336412 are highly concentrated; however, in comparison to other industries, their respective ROE is more comparable to the moderately concentrated industries than those of the highly concentrated ones (see Table 9).

Table 9. Comparison of Rate of Return to Selected Industries

Selected Industry (1992-1997)	NAIC	HHI	Return on Equity (%)
Unconcentrated			
Canned fruits and vegetables	311421	259.3	11.3
Musical instruments	339992	420.8	10.9
Moderately Concentrated			
Knit outerwear mills	315192	1325.0	12.9
Tire mfg	326211	1690.3	13.2
Highly Concentrated			
Malt beverages	312120	D	18.4
Flat glass	327211	1828.9	16.8
Aerospace Industry			
Aircraft	336411	D	12.4
Aircraft engines and engine parts	336412	2057.9	12.3
Aircraft parts and auxiliary equipment	336413	1038.3	12.0

Source: Dun & Bradstreet, Industry Norms & Key Business Ratios, 1992-1997

D Data withheld to avoid disclosing data of individual companies

To analyze the effects of the defense consolidation on the profitability ratios, a comparison was made between the manufacturing industry, the aerospace industry, and the five large surviving downstream firms. Aerospace industry and the five firms are compared to the manufacturing industry to determine for the changes from defense consolidation. A three-year moving average was used to smooth the past data and to identify a trend-component (see Table 10).

Table 10. Comparison of Profitability Ratios

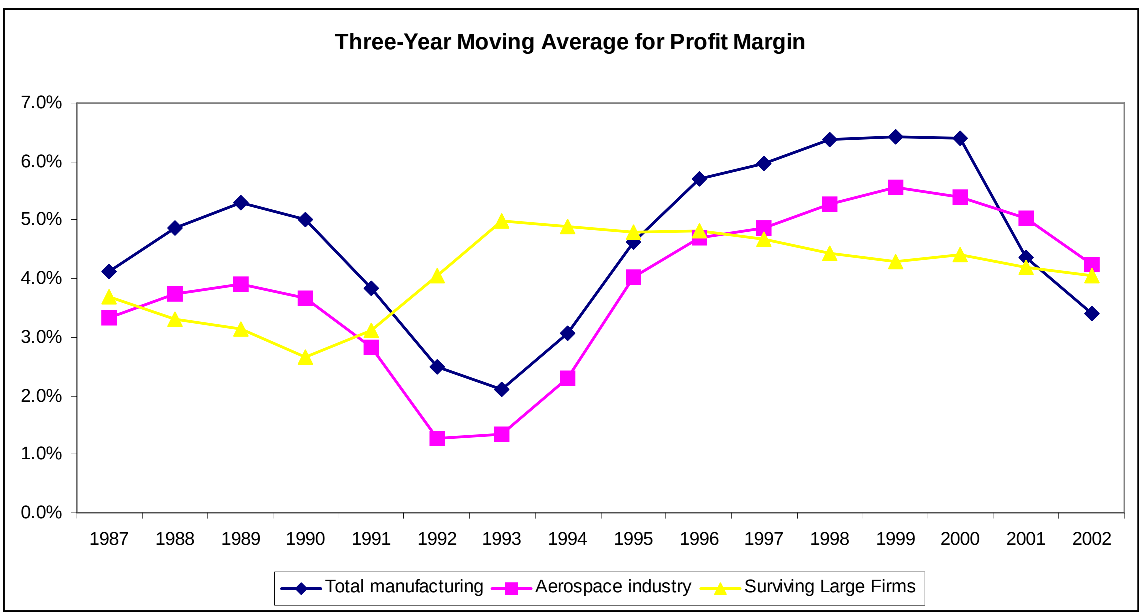
Year	Total Manufacturing Average Profit Margin	Aerospace Industry Average Profit Margin	Surviving Firms Average Profit Margin	Total Manufacturing Average ROA	Aerospace Industry Average ROA	Surviving Firms Average ROA	Total Manufacturing Average ROE	Aerospace Industry Average ROE	Surviving Firms Average ROE
1985									
1986									
1987	4.1%	3.3%	3.7%	4.8%	3.7%	6.8%	10.8%	11.7%	17.2%
1988	4.9%	3.7%	3.3%	5.6%	4.0%	5.6%	12.8%	13.0%	14.4%
1989	5.3%	3.9%	3.1%	6.0%	4.0%	5.2%	14.2%	13.4%	13.2%
1990	5.0%	3.7%	2.7%	5.6%	3.7%	4.3%	13.5%	12.4%	9.2%
1991	3.8%	2.8%	3.1%	4.2%	2.9%	5.1%	10.3%	9.4%	10.7%
1992	2.5%	1.3%	4.0%	2.6%	1.4%	6.2%	6.6%	4.1%	13.2%
1993	2.1%	1.3%	5.0%	2.2%	1.4%	7.1%	5.7%	4.7%	16.2%
1994	3.1%	2.3%	4.9%	3.2%	2.2%	6.3%	8.8%	7.6%	14.2%
1995	4.6%	4.0%	4.8%	5.0%	3.8%	5.8%	13.3%	13.0%	13.6%
1996	5.7%	4.7%	4.8%	6.2%	4.3%	5.3%	16.2%	14.3%	13.3%
1997	6.0%	4.9%	4.7%	6.4%	4.5%	4.7%	16.5%	15.2%	13.3%
1998	6.4%	5.3%	4.4%	6.7%	4.9%	4.2%	17.1%	17.3%	12.7%
1999	6.4%	5.6%	4.3%	6.5%	5.2%	4.3%	17.0%	18.9%	13.1%
2000	6.4%	5.4%	4.4%	6.3%	5.1%	4.7%	16.5%	17.8%	12.8%
2001	4.4%	5.0%	4.2%	4.3%	4.7%	4.5%	11.2%	15.9%	12.6%
2002	3.4%	4.2%	4.1%	3.2%	3.9%	4.0%	8.3%	12.5%	12.3%

Sources: Aerospace Industries Association, *Facts & Figures*
Standard & Poor's, Compu$tat

For the analysis of the profitability ratios, three major events should be noted. There were two recessions that occurred; one prior to and one after the defense industry consolidation period. According to the National Bureau of Economic Research, one recession occurred during the period of July 1990 to March 1991 and the other from March 2001 to November 2001. In addition, the September 11, 2001 terrorist attacks also had an impact on the economy. Noting these events, this study uses the data points for 1989 and 1999 for comparison of profitability ratios before and after the defense consolidation period.

As expected, the average profit margin for the aerospace industry increased. Prior to the defense consolidation period, in 1989, the average profit margin was 3.9%. After the consolidation period, in 1999, the average profit margin was 5.6% resulting in a net increase of 1.7% (see Table 10). Based on the observed trend, it appears that profit margin has leveled out (see Figure 21). This may be the result of an artificial condition created by the government based on negotiated profit rates in contracts for procuring defense products. Also, the defense firms may have specialized to focus on transactions with the government and not on any particular product (Dreissnack and King, 2004: 65). Therefore, it is unknown if this increase in profit margin is comparable to the 11% average increase in concentration ratio for the industry.

During the years of 1992 and 1993, average profits for the five defense firms increased while they dropped at the aerospace and manufacturing industry level (see Figure 22).

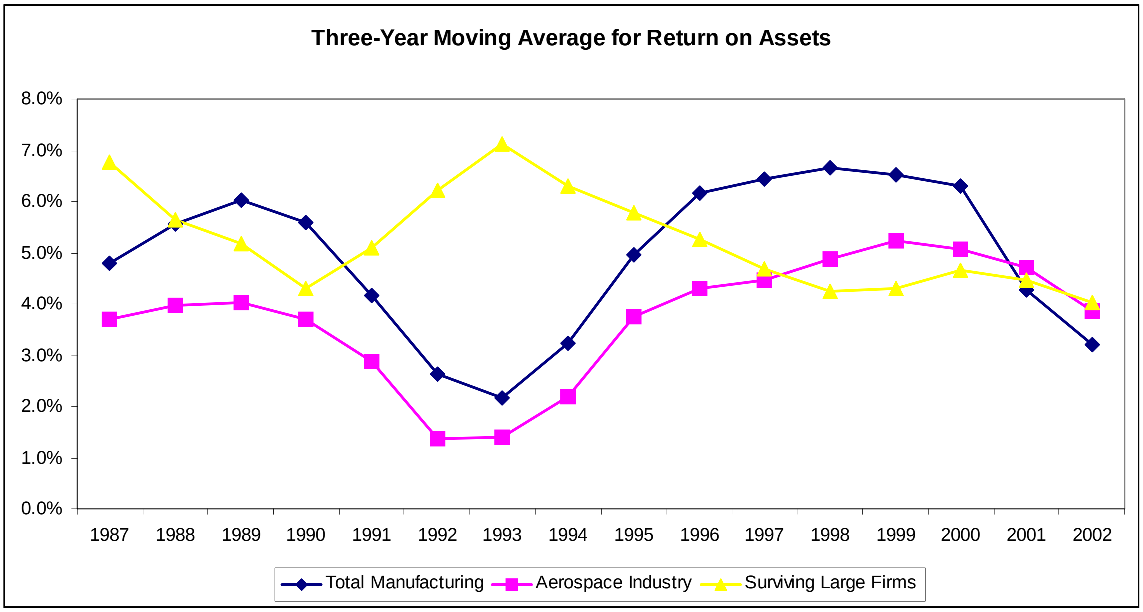


Sources: U.S. Bureau of Census
Aerospace Industries Association, *Facts and Figures*
Standard & Poor's Compu$tat

Figure 22. Comparison of Profit Margin

One possible observation may be that the increases in profit are due to prior knowledge that firms can recoup restructure costs from the government. A meeting was held in 1993 between the DOD and industry leaders to encourage consolidation (Deutch, 2001: 138). Another possibility may be that the large firms, in addition to shedding less profitable functions, acquired the smaller less profitable firms to achieve better economies of scale. The final possibility for the difference may be due to the mixture of commercial and government business in aerospace and total manufacturing firms.

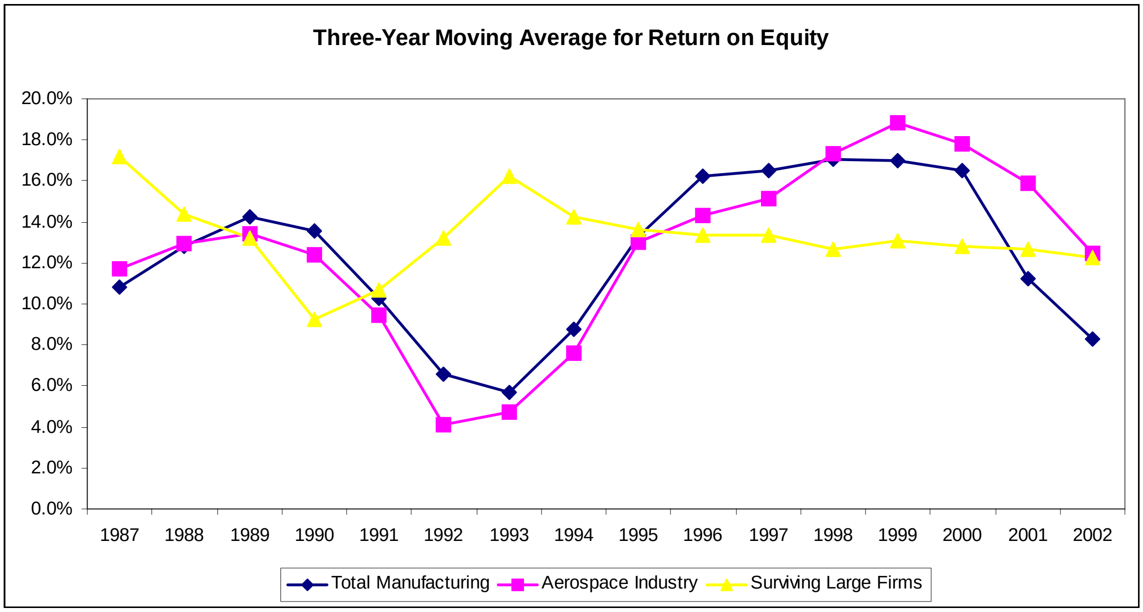
For ROA, both manufacturing and aerospace industries improved in performance after the consolidation period. The asset base for the top five contractors did decrease during the consolidation period since the fixed asset turnover ratio (ratio of net sales to operating assets) improved by 20% from 1.59 to 1.94 (Deutch, 2001: 142). However, the five surviving firms' ROA which is based on total assets did not perform as well after the consolidation period in 1999 as it did in 1989 (see Figure 23 and Table 10). As noted earlier in profit margin, the increase in performance during period of 1992-1994 is also reflected in the ROA.



Sources: U.S. Bureau of Census
Aerospace Industries Association, *Facts and Figures*
Standard & Poor's Compu$tat

Figure 23. Comparison of Return on Assets (ROA)

Finally, the ROE reflects a difference in trend between the total manufacturing and aerospace industries. The marked increase performance of the overall aerospace industry may be due to the defense consolidation. Returns to shareholders increased in the aerospace industry while it decreased for total manufacturing industry. This increase in performance trend is not reflected in the five firms (see Figure 24 and Table 10). Also, as noted earlier in the profit margin and ROA, the increase in performance during period of 1991-1993 is also reflected in the ROE.



Sources: U.S. Bureau of Census
Aerospace Industries Association, *Facts and Figures*
Standard & Poor's Compu$tat

Figure 24. Comparison of Return on Equity (ROE)

The ROE increased after the defense consolidation period for both the total manufacturing and aerospace industries (see Table 10). For the total manufacturing industry, the ROE was 14.2% in 1989 and 17.0% in 1999. The evidence indicates a 2.8% increase in performance after the defense consolidation period. In addition, the aerospace industry ROE reflected marked improvement after the consolidation period. In 1989, the ROE was 13.4% and 18.9% in 1999 which reflects a 5.5% increase after the consolidation period. However, the same improvement was not reflected in the five surviving firms. Prior to the consolidation period, in 1989, the ROE was 13.2% and after the consolidation period, it was 13.1% in 1999. Therefore, it is difficult to determine if the aerospace industry's performance was based on market conditions or the defense consolidation.

Returns to Scale

Economies of scale exist in a firm whenever the long run average cost curve (LRAC) declines as output increases (Baye, 2003: 183). For the context of this analysis, the LRAC is the aggregate of the firms' average cost curves in the aerospace industry. When the LRAC decreases as output increases, economies of scale exist. If the LRAC increases as output increases, diseconomies of scale exist. Constant returns to scale exist when the LRAC is constant when output increases. Economies of scale are determined by the inputs of capital, labor, and technology in the industry.

In addition to defense consolidation, there are other external factors from the DOD's acquisition process such as types of contracts, established profit rates, and changes in defense budgets that may impact the industry's returns to scale. The assumption is made that the government considered economies of scale especially with its need to preserve critical capability in the defense industrial base.

The Cobb-Douglas production function was used in this analysis because it assumes some degree of substitution between the inputs of capital and labor used in producing output. The production equation is as follows:

$$Y = F(K, L) = K^{a} L^{b} \qquad (3)$$

where Y is *output*, K is *capital*, L is *labor*, and a and b are *constants*.

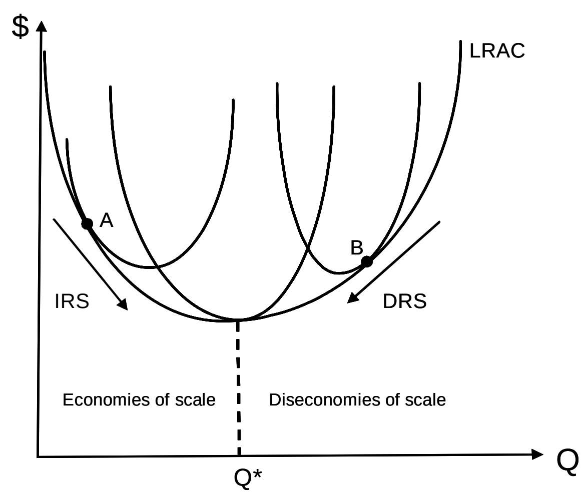
By taking the natural log of the inputs, the Cobb-Douglas function becomes a linear equation:

$$\ln Y = \alpha \ln(K) + \beta \ln(L) \quad (4)$$

This linear equation can be used in a regression to derive the alpha coefficient, the beta coefficient, and the intercept:

$$\ln Y = c + \alpha \ln(K) + \beta \ln(L) + \varepsilon \quad (5)$$

where α is the *coefficient for capital*, β is the *coefficient for labor*, and *c* is the *technical parameter*. To determine if there are constant, increasing, or decreasing returns to scale, the alpha and beta coefficients are summed. If the total is less than 1, there is decreasing returns to scale; the sum is greater than 1 then there is increasing returns to scale; and if the sum is equal to 1, there are constant returns to scale. Ideally, firms' in the aerospace industry would like to operate as close as possible within points A and B and towards the theoretical quantity (Q*) (see Figure 25).



Aerospace Industry				
Period	Technical Parameter	Capital (α)	Labor (β)	α + β
1972-1992	0.0251	0.0128	0.8530	0.8658
1972-1997	0.0215	0.0372	1.0224	1.0597
1972-2002	0.0205	0.0423	1.0367	1.0789

Sources: Bureau of Census, Economic Census, 1982-2002

Figure 25. Economies of Scale

The aerospace industry was experiencing increasing returns to scale prior to the defense industry consolidation. Even though the industry continues to experience more returns to scale, it appears that it may have improved as the result of restructuring in the aerospace firms (see Figure 25). The improvement in returns to scale was also reflected in the industry's overall increase in average profit margin (see Table 10). However, it is unknown if improvements in returns to scale were accelerated by the defense consolidation or if it will continue due to market forces.

Impact of Defense Consolidation on Contract Cost Growth

By allowing the contractors to claim restructuring costs for their business combinations, the government expected to achieve savings for its current and future contracts with defense firms. The restructuring costs were allocated to all the contractor's customers at the time of the business combination. Therefore, DOD's portion of the costs was dependent upon its share of the contractor's total business base (GAO-NSIAD-98-156, 1998: 4). Even though it is difficult to precisely identify the actual savings realized from restructuring activities, DOD estimated a realized net savings of $2.2 billion from the restructuring activities (see Table 11). GAO stated in its final report that it was unable to apply a standard methodology to account for the impact of the restructuring costs from other costs on contract prices (GAO/NSIAD-99-22, 1999: 5).

Table 11. DOD's Estimate of Restructuring Savings Realized and Costs Paid ($M)

Business Combination	Savings Realized	Costs Paid	Net Savings
Hughes - General Dynamics missile operations[a]	$505.8	$121.4	$384.4
United Defense Limited Partnership[a]	37.6	14.0	23.6
Martin Marrietta - General Electric Aerospace[a]	198.2	71.9	126.3
Northrop - Grumman - Vought[b]	163.7	26.4	137.3
Martin Marrietta - General Dynamics Space Systems Division[b]	113.0	17.5	95.5
Lockheed-Martin Marrietta[b]	1406.6	49.7	1356.9
Hughes - CAE Link[b]	37.3	13.8	23.5
Total	**$2,462.2**	**$314.7**	**$2,147.5**

[a]As of August 31, 1997
[b]As of December 31, 1997
Source: GAO analysis of DOD's most recent data, as reflected in *GAO/NSIAD-97-97* and *GAO/NSIAD-98-156* reports.

There is no data or empirical analysis available at the firm level to determine if the defense industry consolidation goal of passing the restructure savings to current and future contracts was achieved. Earn value is a management technique used to monitor the progress of performance on major weapon systems R&D and procurement contracts. The percentage of contract cost overruns is one of the measures used in the earn value management system to report progress of contracts. The percentage of average aggregate annual contract cost overruns will be used as a proxy for performance on government contracts.

Model

The purpose of this model is to determine the factors affected by the defense consolidation that may impact the firms' performance on government contracts. A first order general multiple regression model was used as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \varepsilon \qquad (6)$$

where y is *percentage of average aggregate annual contract cost overrun*, x_1 is *percentage change in total aerospace industry employees*, x_2 is *percentage change in defense funding*, x_3 is *profit margin on sales*, x_4 is *percentage change in operating costs*, x_5 is *percentage change in CR4*, x_6 is *capital investment as a percentage of fixed assets*, x_7 is *percentage change in average IR&D funded by aerospace companies*, x_8 is *percentage change in average firm size* and ε is the *error term*.

Preliminary Technique

A Dickey-Fuller test was performed to determine if the dependent variable had a stationary unit root. Since the data failed the Dickey-Fuller test, the first difference was taken and used in the regression. The transformed data passed the Dickey-Fuller test.

Regression Results

The independent variables were selected based on literature and the analysis of structure, conduct, and performance of the aerospace industry. Three of the eight variables were significant at $\alpha = .10$. The following includes assumptions and statistics for each of the independent variables (see Table 12).

Table 12. Defense Consolidation Research Variables

Variable	Anticipated Impact on Contract Cost Growth	Coefficient	t-Stat	Significance ($\alpha = 0.10$)
Labor	Increase in employees will decrease contract costs	-0.6173	-1.97	p<0.07
Defense Funding	Decreases in defense R&D and procurement budgets may cause schedule delay and changes in quantities will increase unit costs	-0.3548	-2.28	p<0.04
Profit Margin	Contract costs will increase if firms profit margins increase	0.3797	0.61	p<0.56
Operating Cost	Increases in operating costs will increase contract costs	0.2895	1.44	p<0.18
Concentration	Increase in industry concentration will increase costs	2.0638	1.81	p<0.10
Capital Investment	Increases in capital expenditures will increase contract costs	0.7899	1.32	p<0.21
IR&D	Increase IR&D will increase contract costs	0.0734	1.38	p<0.20
Average Firm Size	Increase in average firm size will decrease costs (transactions)	-0.2327	-1.25	p<0.24

Measures

Percentage change in number of aerospace employees is the first variable. The assumption is made that an increase in percentage change of labor will result in a decrease in the percentage of aggregate annual contract cost overrun. This may indicate that an appropriate mix of specialized labor is needed for development and production of complex weapon systems. This variable is significant at $p < 0.07$. The coefficient reflects that a 1% increase in this variable can result in a 0.62% decrease in the percentage of aggregate annual contract cost overrun.

Percentage change in defense R&D and procurement funding is the second variable. The assumption is made that a decrease in percentage change in funding will result in an increase in the percentage of aggregate annual contract cost overrun. This variable is significant at $p < 0.04$. The coefficient reflects that a 1% increase in this variable can result in a 0.35% decrease in the percentage of aggregate annual contract cost overrun.

Profit margin is the third variable. Because development and procurement of major weapons systems takes years and consists of technical, schedule, and cost risks, it is assumed that an increase in profit margin will increase the percentage of aggregate annual contract cost overrun. The variable is insignificant at $p < 0.56$.

Percentage change in operating costs is the fourth variable. Operating costs reflect the contractors' efficiency. The assumption is made that an increase in operating costs will increase the percentage of aggregate annual contract cost overrun. The variable is insignificant at $p < 0.18$.

Percentage change in CR4 for the aerospace industry is the fifth variable. The assumption is made that an increase in the CR4 will increase the percentage of aggregate annual contract cost overrun. The variable is significant at $p < 0.10$. The coefficient for this variable is the most significant of all the eight variables. A 1% increase in CR4 can result in approximately 2% increase in the percentage of aggregate annual contract cost overrun.

Capital investment as a percentage of fixed assets is the sixth variable. Since the goal of defense consolidation was to reduce total assets dedicated to defense, the assumption is made that an increase in capital expenditures will increase the percentage of aggregate annual contract cost overrun. The variable is insignificant at $p < 0.21$.

However, the coefficient reflects that a 1% increase in this variable can result in a 0.79% increase in the percentage of aggregate annual contract cost overrun.

The percentage change in IR&D funding is the seventh variable. The assumption is made that an increase in IR&D funding will increase the percentage of aggregate annual contract cost overrun. This may be due to diminishing returns where firms only perform enough R&D needed to be aware of external technology and to maintain the ability to absorb technological developments (King and Dreissnack, 2003: 266).

Percentage change in average firm size is the final variable. The number of employees is positively correlated with firm size (Kumar, et al, 2001: 4). The assumption was made that an increase in average firm size may indicate a decrease in the number of subcontractors which can result in a decrease in transaction costs for the prime contractor. This variable is insignificant at $p < 0.24$.

In summary, changes in labor, defense funding, and industry concentration were statistically significant variables. The coefficient for industry concentration had the largest impact on the dependent variable. Although, capital investment was not statistically significant, its coefficient had the second highest impact on the dependent variable. These results were expected based on the anecdotal evidence presented earlier in this chapter.

Post-Estimation Tests

Post-estimation tests were performed to ensure normality of residuals, to identify the presence of multicollinearity, and to check proper model specification. The regression model results passed all of the following tests. For normality of residuals, the data was plotted into a histogram and the Shapiro-Wilk normality test was performed. The mean variance inflation factor (VIF) score was calculated for the presence of multicollinearity. Finally, a model specification test was performed based on the variable of prediction and the variable of squared prediction.

In summary, the impact of the defense consolidation on the firms' performance is unknown based on the trended data. King and Driessnack (2003) analyzed the stock performance of acquiring firms and on average found no marked improvement.

Investigative Questions Answered

Primary Research Question

How did the defense industry consolidation affect the structure, conduct, and performance of the aerospace industry?

The defense industry consolidation affected the market structure of the aerospace industry. The industry concentration level increased after the defense consolidation. The most drastic changes occurred at the large downstream firm level where two of the six defense sectors in the aerospace industry have reached duopoly. The increase in concentration level has also affected the competition between the remaining firms. In 1994, a DSB Task Force recommended DOD adjust their practices and develop innovative processes to encourage competition and entry of new firms into the market.

From a conduct aspect, the defense consolidation allowed firms to claim restructuring costs for mergers and acquisitions as long as the criteria of savings to the government and maintaining critical capability in the defense industrial base were met.

Prior to the government sanctioned defense consolidation, firms acquired and merged without claiming business combination costs. The defense consolidation shifted labor between the downstream and upstream firms and industries supporting the aerospace industry. IR&D funding appears to be more correlated to changes in defense funding than the defense consolidation. Since capital expenditures were already decreasing prior to the defense consolidation, the impact is unknown.

Finally, the impact to the performance aspect is unknown. The profitability ratios depict the impact of the recession of the 1990's. Recovering from the recession, the profitability ratios for aerospace and total manufacturing industries showed increases after 1992. After the defense consolidation, the aerospace industry's profit margin increased a net average of 1.7%. It is unknown based on the anecdotal evidence, if the defense consolidation or market conditions improved the firms' performance.

Secondary Research Questions

Did industry concentration increase as a result of the defense consolidation?

Industry concentration for aerospace did increase as a result of the defense consolidation. Prior to the defense consolidation, the aerospace industry was already highly concentrated. After defense consolidation, both the average aggregate CR4 and HHI for aerospace increased to 75.4% and 1,958 points respectively.

Did subcontractor activity increase?

Anecdotal evidence indicates subcontractor activity may have increased during defense consolidation period. Even though there were drastic decreases in the large downstream aerospace firms, the total number of aerospace firms did not decrease at the same rate. Labor may have shifted from the large downstream firms to the smaller upstream firms or to other industries supporting defense firms.

Are the firms performing more efficiently?

Profitability ratios at the aggregate aerospace industry level reflect improved performance. Profit margin improved by 2.0%, return on assets by 1.5%, and return on equity by 5.9%. However, it is difficult to determine if these improvements are comparable to the increase in industry concentration.

How did it affect vertical integration or vertical disintegration?

Anecdotal evidence indicates that vertical disintegration occurred during the defense consolidation period. However, the data from the Economic Census of 2002 show three of the six NAICS code in the aerospace industry were more vertically integrated after the defense consolidation period than prior. Based on the mixed results, it is unknown if it was an impact from the defense consolidation or if it was due to market forces.

Did the average firm size change?

Average firm size decreased after the defense consolidation. At the aggregate level, the average firm size decreased by approximately 46%. The decreasing trend in average firm size also supports the indication of increased subcontractor activity.

What are the returns to scale for the industry?

Evidence indicates the aerospace industry was experiencing increasing returns to scale prior to the defense industry consolidation. Even though the industry continues to experience more returns to scale, it is unknown if improvements in returns to scale will continue due to market forces.

Summary

The structure, conduct, and performance paradigm was used to analyze the impact of the defense consolidation on the aerospace industry. For market structure, concentration, buyers and sellers, vertical integration, and product differentiation were examined. The evidence indicated an increase in industry concentration and subcontractor activity. For conduct, asset specificity, barriers to entry, capital investment, and R&D performance were reviewed. Asset specificity and barriers to entry remained high before and after defense consolidation. The decreasing trend in capital expenditures prior to consolidation appeared to have continued afterwards. The data reflected mixed results on the effects of defense consolidation on R&D intensity. For performance, profitability ratios, returns to scale, and impact on government contracts were examined. Profit margin, ROA, and ROE increased after the consolidation period. However, it was unknown if the increases were comparable to the increase in industry concentration. In addition, the industry experienced improvements in returns to scale prior to defense consolidation and continue to do so afterwards. Finally, a multiple regression model was used to determine the significance of the independent research variables to the dependent variable, the percentage of aggregate annual contract cost growth.

IV. Conclusions and Recommendations

Chapter Overview

This section summarizes the research performed to determine how the defense consolidation affected the structure, conduct, and performance of the aerospace industry. At the end of the Cold War, the government was faced with decreasing defense budgets and excess capacity in the defense industrial base. Demobilization did not occur as in previous conflicts. The Clinton Administration explicitly encouraged the acquisition and merger activity of defense firms. During this period, firms were allowed to claim restructuring costs for business combinations as long as they met the criteria of maintaining critical capability and long-term savings to the government. Six of the twelve defense sectors fall within the aerospace industry.

Conclusions of Research

Specifically, the analysis focused on the elements that defined the structure, performance, and conduct of the aerospace industry. The defense industry consolidation attempted to encourage market forces to accelerate the reduction of the excess capacity. The assumption is made that the effects of this effort should be reflected in the structure and behavior of the aerospace industry. Changes in the structure and behavior of the aerospace industry before and after the defense consolidation at the microeconomic level are summarized in Table 13.[2]

Table 13. Summary of Aerospace Industry Indicators

Period	HHI	CR4	Average Firm Size	Vertical Integration	Barriers to Entry	Asset Specificity	Capital Investment as % of Fixed Assets	R&D Intensity	Returns to Scale	Profit Margin	Return on Assets	Return on Equity
Prior to Defense Consolidation	1820	69.5%	2251	55.9%	High	High	15.8%	3.9%	0.87	3.9%	4.0%	13.4%
After the Defense Consolidation	1958	75.4%	1210	59.5%	High	High	10.0%	3.6%	1.08	5.6%	5.2%	18.9%
Structure	●	●	●	●								
Conduct					●	●	●	●				
Performance									●	●	●	●

Sources: U.S. Bureau of Census, Economic Census
Aerospace Industries Association, *Facts & Figures*
Standard & Poor's, Compu$tat

Structure

The industry concentration level increased after the defense consolidation. Both the average HHI and CR4 showed an increase at the aggregate aerospace industry level.

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[2] The analysis period ranged from 1972-2002 depending on the availability of industry data. The years before 1993 were considered to be prior to the defense consolidation. The time period after defense consolidation was from 1993 forward. However, for the analysis of profitability ratios, 1989 was the comparison point for prior to the consolidation and 1999 was considered the comparison point for after the consolidation period.

Although the HHI for guided missile and space vehicle was withheld by the U.S. Bureau of Census to prevent from disclosing data of individual companies, the average aggregate HHI increased by 138 points. The CR4 increased by approximately 6%. The most drastic changes occurred at the large downstream firm level where two of the six defense sectors in the aerospace industry reached duopoly.

The average firm size at aggregate aerospace industry level decreased dramatically from 2,251 to 1,210 employees per firm. The high specificity of human capital in the aerospace industry may indicate a redistribution of labor from downstream firms to upstream firms. More employees are available to support the smaller upstream firms and industries supporting defense firms; therefore, a larger subcontractor pool may be available to the large downstream firms. Furthermore, the data representing the number of companies supporting guided missile and space vehicle production reflect a cyclical trend that indicates the aerospace industry may have gained efficiencies through the market forces without DOD's encouragement of a defense consolidation.

Vertical disintegration appears to have occurred during the defense consolidation period. Vertical disintegration also supports the possible increase in subcontractor activity. However, the vertical disintegration appears to be temporary. As of the 2002 Economic Census, the vertical integration increased in three of six subsectors in the aerospace industry. The vertical integration for aerospace industry increased from 55.9% to 59.5%. This may indicate defense firms specializing to meet the needs of the government, as the primary customer and regulator, instead of a particular product.

Conduct

The purpose of the defense consolidation was to reduce the total assets dedicated to defense. The average capital investment as a percentage of fixed assets decreased from 15.9% to 10.0% after the defense consolidation period. Even with the decrease in capital expenditures, the defense consolidation increased the already high barriers of entry for new defense firms. Since large amounts of capital are needed to compete, design, develop, and produce major weapon systems, the likelihood that a new defense firm entering the market is low.

Anecdotal evidence reflects mixed results in R&D intensity before and after the defense consolidation period. IR&D funding increased during the defense consolidation period but, decreased afterwards. Because R&D is normally conducted by large firms, this may indicate a threshold level of diminishing returns in the performance of R&D for the surviving large downstream firms. They may be performing only enough R&D to be aware of external developments and to maintain current technological levels.

Performance

As expected, the profitability ratios for profit margin, ROA, and ROE showed increases after the defense consolidation. Average profit margin increased from by 1.7% and average return on assets increased by 1.2%. Generally, increases in profit margin result from efficiencies achieved in decreasing operating costs. No marked improvement was identified since changes in operating costs tracked with changes in net sales. Also, the government regulates the defense industry and may dampen the effects of industry concentration. It is unknown if these increases are comparable to the increase in industry concentration. No increase in ROE was reflected in the large five surviving defense firms. Therefore, it is difficult to determine if these increases are related to the increasing returns to scale in the industry or the defense consolidation.

In summary, defense consolidation affected the market structure by increasing the industry concentration in aerospace. Anecdotal evidence for average firm size indicates an increase in subcontractor activity. However, empirical evidence at the firm level is not available due to privy of contract between the prime contractor and its subcontractors. As for conduct, it is difficult to determine if capital investment and R&D intensity is more related to the changes in defense funding or to the defense consolidation. In the area of performance, it is unknown if the increases in the profitability are due to market forces or defense consolidation. The analysis of the structure, conduct, and performance of the aerospace industry does not reveal if restructured savings from the defense consolidation was achieved.

Significance of Research

This study helps us understand how the defense sectors in the aerospace industry work. The research examines the effects of the defense consolidation on the aerospace industry. Because empirical data are not available at the firm level, this study gathers data at the industry level to determine if the structure and behavior of the aerospace industry has been impacted by the defense consolidation. This study does not focus on the surviving large downstream firms. Instead, it attempts to identify trends by comparing the aerospace industry to the total manufacturing industry, and comparing the large surviving downstream firms to the aerospace industry and to the total manufacturing industry.

Recommendations for Future Research

During the defense consolidation, the government as a monopsonist may have transferred some degree of power to the oligopolist defense industry. An area of future research may be in examining the risk in performance of government contracts after the defense consolidation. Prior to the defense consolidation, fixed price contracts were a risk to contractors. After the consolidation, these contracts may now be a risk to the government because it dictates the competition level of the firms producing defense products and the size of the defense industrial base. Another area of future research may be in the examining overhead rates for programs in development and production phases. This analysis may determine if companies are making more profit in the production phase as compared to the development phase. Because the consolidation effort resulted in some defense sectors operating in a duopoly, a final recommended area of future research is analyzing the level of subcontractor activity in government contracts. Subcontractor activity may indicate the level of competition at the tiers below the prime contractors.

Appendix A: NAICS Codes, Titles, and Descriptions

This section provides a crosswalk from SIC to NAICS codes, NAICS code titles, and descriptions for the aerospace manufacturing industry. The descriptions are taken from the U.S Bureau of Census, 2002 Economic Census, *Manufacturing Subject Series, General Summary*, Appendix B, pages B-88 through B-90.

Crosswalk from SIC Code to NAICS

SIC Code	NAICS Code
3721	336411
3724	336412
3728	336413
3761	336414
3764	336415
3769	336419

3364/33641 Aerospace Product and Parts Manufacturing

This industry group comprises of establishments primarily engaged in one or more of the following: (1) manufacturing complete aircraft, missiles, or space vehicles; (2) manufacturing aerospace engines, propulsions units, auxiliary equipment or parts; (3) developing and making prototypes of aerospace products; (4) aircraft conversion (i.e., major modifications to systems); and (5) complete aircraft or propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft to original design specifications).

336411 Aircraft Manufacturing

This U.S. industry comprises of establishments primarily engaged in one or more of the following: (1) manufacturing or assembling complete aircraft; (2) developing and making aircraft prototypes; (3) aircraft conversion (i.e., major modifications to systems); and (4) complete aircraft overhaul and rebuilding (i.e., periodic restoration of aircraft to original design specifications).

336412 Aircraft Engine and Engine Parts Manufacturing

This U.S. industry comprises of establishments primarily engaged in one or more of the following: (1) manufacturing aircraft engines and engine parts; (2) developing and making prototypes of aircraft engines and engine parts; (3) aircraft propulsion system conversion (i.e., major modifications to systems); and (4) aircraft propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft propulsion system to original design specifications).

336413 Other Aircraft Parts and Auxiliary Equipment Manufacturing

This U.S. industry comprises of establishments primarily engaged in (1) manufacturing aircraft parts or auxiliary equipment (except engines and aircraft fluid power subassemblies) and/or (2) developing and making prototypes of aircraft parts and auxiliary equipment. Auxiliary equipment includes such items as crop dusting apparatus, armament racks, in-flight refueling equipment, and external fuel tanks.

336414 Guided Missile and Space Vehicle Manufacturing

This U.S. industry comprises of establishments primarily engaged in (1) manufacturing complete guided missiles and space vehicles and/or (2) developing and making prototypes of guided missiles or space vehicles.

336415 Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing

This U.S. industry comprises of establishments primarily engaged in (1) manufacturing guided missile and/or space vehicle propulsion units and propulsion unit parts and/or (2) developing and making prototypes of guided missile and space vehicle propulsion units and propulsion unit parts.

336419 Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing

This U.S. industry comprises of establishments primarily engaged in (1) manufacturing guided missile and space vehicle parts and auxiliary equipment (except guided missile and space vehicle propulsion units and propulsion unit parts) and/or (2) developing and making prototypes of guided missile and space vehicle parts and auxiliary equipment.

Appendix B: Data Table for Concentration Measures

The following table was used for concentration measure calculations and as the data source for *Figure 4. Concentration Measures for Aerospace Industry*. The data was collected from the U.S. Census Bureau, Economic Censuses, Manufacturing Subject Series, *Concentration Ratios in Manufacturing*.

Fields with "D" denotes data withheld to prevent from disclosing data of individual companies. The "difference" refers to change in CR4 or HHI from 1992 to 1997. The assumption is made that census year 1992 represents the industry concentration level prior to the defense consolidation period and 1997 represents the level after this period.

The aggregate industry averages for the CR4 and HHI represented in *Figure 4. Concentration Measures for Aerospace Industry* is a simple average of the six NAICS codes for each census year. The aggregate industry averages can be found under NAICS code 3364.

Table 14. Concentration Measures for Aerospace Industry

Concentration Ratio for Four Largest Firms (CR4)							
Year	NAICS 336411	NAICS 336412	NAICS 336413	NAICS 336414	NAICS 336415	NAICS 336419	NAICS 3364
1982	64.0%	72.0%	38.0%	71.0%	68.0%	95.0%	68.0%
1987	72.0%	77.0%	42.0%	58.0%	73.0%	62.0%	64.0%
1992	79.0%	77.0%	44.0%	71.0%	71.0%	75.0%	69.5%
1997	80.9%	74.2%	55.2%	91.6%	78.6%	71.6%	75.4%
Difference	1.9%	-2.8%	11.2%	20.6%	7.6%	-3.4%	5.9%

Hirschman-Herfindahl Index (HHI)							
Year	NAICS 336411	NAICS 336412	NAICS 336413	NAICS 336414	NAICS 336415	NAICS 336419	NAICS 3364
1982	1358	1778	598	1578	1402	D	1343
1987	1686	2201	652	1220	1570	1350	1447
1992	2717	2378	772	1570	1446	2034	1820
1997	2526	1754	1126	D	2056	2327	1958

Appendix C: Data Table and Calculations Total Aerospace Industry Labor

To determine downstream employees, the total number of employees data is collected from the U.S. Bureau of Census, Economic Censuses, Manufacturing Subject Series, *Census of Manufactures Report, Table 1. Historical Statistics for the Industry* for each of the NAICS codes or their SIC equivalents. For total downstream employees, sum up the number of employees from the six NAICS/SIC codes for each year.

Upstream employees is composed of employees from aerospace NAICS/SIC codes and non-aerospace NAICS/SIC codes. To calculate upstream employees the following steps apply.

1. From the U.S. Bureau of Census, Economic Census, Manufacturing Subject Series, *Census of Manufactures Reports* for aerospace, Table 7. Materials Consumed in Kind, collect the NAICS/SIC codes of the industry producing the materials or parts and the "Delivered Cost" amounts.
2. Using the U.S. Bureau of Census, Economic Census, Manufacturing Subject Series, *General Summary Report*, *Table 2. Industry Statistics for Industry Groups and Industries*, collect the "Number of Employees" and the "Total Value of Shipments" for each of the NAICS/SIC codes identified in Step 1.
3. The assumption is made that the "Delivered Cost" of the materials consumed to produce aerospace products is representative of the sales of the NAIC/SIC code that produce the materials. Therefore, a percentage of the "Number of Employees" of NAICS/SIC codes producing the materials are considered to be upstream labor in the aerospace industry. To calculate the ratio, divide the

“Delivered Cost” by the “Total Value of Shipments” for each of the NAICS/SIC codes identified in Step 1.

4. To calculate the number of upstream employee (labor), multiply the ratio calculated in Step 3 by the “Number of Employees” for each of the NAICS/SIC codes identified in Step 1.
5. Sum the number of upstream employees calculated by “Total Upstream Employees for Aerospace NAICS/SIC” and “Total Upstream Employees for Non-Aerospace NAICS/SIC.”

Total aerospace labor is calculated as the sum of the total number of downstream employees and the total number of upstream employees from non-aerospace NAICS/SIC.

Table 15 is the source data for *Figure 6. Labor in Aerospace Industry*. The data for this table was collected as stated in the above steps.

Table 15. Labor for Aerospace Industry

Labor for Aerospace Industry				
Year	Total employees (nbr) for Aerospace Industry	All employees (nbr) for Aerospace Industry Downstream	Total Upstream Employees (nbr) from Aerospace Industry NAICs/SICs	Total Upstream Employees (nbr) from Non-Aerospace Industry NAICs/SICs
1972	656814	598800	54439	58014
1973	684498	618800	55776	65698
1974	689782	616400	57113	73382
1975	666766	585700	58451	81066
1976	638450	549700	59788	88750
1977	645002	550600	61126	94402
1978	687573	585700	70985	101873
1979	791345	682000	80845	109345
1980	838117	721300	90704	116817
1981	856788	732500	100564	124288
1982	817721	684900	110423	132821
1983	786240	689700	109116	96540
1984	788871	692600	107809	96271
1985	842002	746000	106502	96002
1986	894032	798300	105195	95732
1987	905063	809600	103888	95463
1988	915494	820300	107759	95194
1989	918325	823400	111630	94925
1990	910755	816100	115502	94655
1991	839986	745600	119373	94386
1992	790617	696500	123244	94117
1993	710781	612600	111998	98181
1994	637245	535000	100751	102245
1995	589509	483200	89504	106309
1996	568173	457800	78258	110373
1997	601550	487114	67011	114436
1998	621660	517013	65922	104647
1999	579517	484659	64832	94858
2000	528844	443775	63743	85069
2001	508419	433139	62654	75280
2002	470569	405079	61564	65490

Appendix D: Average Firm Size Data Table

Table 16 represents the source data for Figure 7. *Average Firm Size in Aerospace Industry, Figure 8. Companies Supporting Aircraft Production, Figure 9. Number of Companies vs. Number of Employees in Aircraft Production, Figure 10. Number of Companies Supporting Guided Missile and Space Vehicle Production vs. Number of Employees*, and *Figure 11. Companies Supporting Guided Missiles and Space Vehicle Production*.

The data was collected from the U.S. Bureau of Census, Economic Censuses, Manufacturing Subject Series, *Census of Manufactures Report, Table 1. Historical Statistics for the Industry* for each of the NAICS codes or their SIC equivalents. For years that are not covered in the *Census of Manufactures Report*, the data can also be found in the *Annual Survey of Manufactures (ASM)* reports.

Table 16. Average Firm Size Data for Aerospace Industry

	Aircraft Production									Guided Missiles and Space Vehicles								
	Number of Companies				Number of Employees				Average Firm Size	Number of Companies				Number of Employees				Average Firm Size
Year	NAICS 336411	NAICS 336412	NAICS 336413	Total	NAICS 336411	NAICS 336412	NAICS 336413	Total		NAICS 336414	NAICS 336415	NAICS 336419	Total	NAICS 336414	NAICS 336415	NAICS 336419	Total	
1972	141	189	649	979	231800	104700	102200	438700	448	23	22	45	90	118400	20800	20900	160100	1779
1973	143	196	655	995	238500	114000	106300	458800	461	22	21	44	88	117300	22500	20200	160000	1822
1974	145	204	662	1011	238700	115900	107400	462000	457	22	20	43	86	116900	21000	16500	154400	1804
1975	147	211	668	1026	219900	108000	110200	438100	427	21	20	43	83	110800	20500	16300	147600	1770
1976	149	219	675	1042	208700	99300	100000	408000	391	21	19	42	81	106200	19000	16500	141700	1745
1977	151	226	681	1058	222700	106100	102000	430800	407	20	18	41	79	94000	18600	7200	119800	1516
1978	149	237	727	1113	237700	115700	110200	463600	417	19	18	42	79	93800	20100	8200	122100	1538
1979	146	248	773	1168	273400	134800	137500	545700	467	18	19	43	80	104600	22200	9500	136300	1708
1980	144	259	820	1222	281100	140600	158900	580600	475	18	19	43	80	106500	25500	8700	140700	1754
1981	141	270	866	1277	301100	140000	140300	581400	455	17	20	44	81	106500	26700	17900	151100	1875
1982	139	281	912	1332	275100	130700	132800	538600	404	16	20	45	81	99600	25300	21400	146300	1806
1983	139	299	915	1352	250900	122000	154100	527000	390	17	21	48	86	110700	27600	24400	162700	1887
1984	138	317	917	1373	232500	109100	175200	516800	376	17	23	51	91	120900	28200	26700	175800	1923
1985	138	336	920	1393	241800	118600	167800	528200	379	18	24	55	97	154300	29800	33700	217800	2255
1986	137	354	922	1414	256700	127500	186400	570600	404	18	26	58	102	174200	31400	22100	227700	2237
1987	137	372	925	1434	268200	139600	188200	596000	416	19	27	61	107	166700	31800	15100	213600	1996
1988	140	365	946	1451	274200	141400	181000	596600	411	20	28	60	107	169000	35300	19400	223700	2091
1989	143	358	967	1468	277500	132000	192900	602400	410	21	28	58	107	172600	30000	18400	221000	2065
1990	145	352	988	1485	289300	129000	197500	615800	415	21	29	57	107	156200	29700	14400	200300	1872
1991	148	345	1009	1502	258300	122300	187300	567900	378	22	29	55	107	135800	27700	14200	177700	1661
1992	151	338	1030	1519	264900	116700	165300	546900	360	23	30	54	107	100100	32300	17200	149600	1398
1993	155	327	1034	1516	241200	102600	139700	483500	319	21	28	53	102	87500	29200	12400	129100	1266
1994	159	315	1038	1512	217900	86900	119500	424300	281	20	26	52	97	76800	22800	11100	110700	1141
1995	164	304	1041	1509	201400	76300	116300	394000	261	18	23	50	92	60800	19600	8800	89200	970
1996	168	292	1045	1505	188300	75100	113400	376800	250	17	21	49	87	55700	17200	8100	81000	931
1997	172	281	1049	1502	202491	84373	124677	411541	274	15	19	48	82	51398	17738	6437	75573	922
1998	174	284	991	1450	213148	84617	140978	438743	303	14	19	49	82	53085	18430	6755	78270	959
1999	177	287	933	1397	194158	85111	132663	411932	295	14	18	49	81	48748	17911	6068	72727	896
2000	179	291	875	1345	183060	81961	119727	384748	286	13	18	50	81	38295	14688	6044	59027	731
2001	182	294	817	1292	178937	79914	116803	375654	291	13	17	50	80	36649	15324	5512	57485	715
2002	184	297	759	1240	174669	72284	99369	346322	279	12	17	51	80	37908	14617	6232	58757	734

Source: U.S. Bureau of Census, Economic Censuses 1972-2002, and ASMs 1994-1996

Appendix E: Data Tables and Calculations for Vertical Integration

The data was collected from the U.S. Bureau of Census, Economic Censuses, Manufacturing Subject Series, *Census of Manufactures Report, Table 1. Historical Statistics for the Industry* from the “Value Added” and “Total Value of Shipments” for each of the selected industries.

The “Value Added” by manufacturing represents the amount of work done in the establishment by transforming the materials to a more useful product going out. It is derived by subtracting the cost of materials, supplies, containers, fuel, purchased electricity, and contract work from the value of shipments (products manufactured plus receipts for services rendered). To calculate the percentage of vertical integration, divide the “Value Added” by the “Total Value of Shipments.”

The percentage of vertical integration represents the amount of work done within the establishments of the industry. The assumption is made that higher the percentage the more vertically integrated the industry. Thus, the industry may have control of key inputs for its products.

Table 17 represents the source data and calculations for *Table 5. Percentage of Vertical Integration in Selected Industries* and *Figure 13. Percentage of Vertical Integration within the Aerospace Industry*.

Table 17. Source Data for Vertical Integration

Year	Value Added	Total Value of Shipments	% of Vertical Integration	
2002	2,044,380,919	4,234,628,332	48.3%	***Total Manufacturing***
1997	2,150,755,610	4,517,477,462	47.6%	
1992	1,856,461,852	3,915,318,613	47.4%	
1987	1,795,569,300	3,813,643,852	47.1%	
1982	1,489,868,265	3,543,727,326	42.0%	
1977	1,556,709,148	3,614,071,767	43.1%	
2002	68,766,432	135,276,276	50.8%	***Aerospace***
1997	67,960,167	141,882,488	47.9%	
1992	84,171,349	171,817,946	49.0%	
1987	90,967,963	159,556,556	57.0%	
1982	70,973,406	120,085,033	59.1%	
1977	50,953,830	86,369,981	59.0%	
2002	8,449,010	12,814,574	65.9%	***Shipbuilding***
1997	6,202,797	10,542,961	58.8%	
1992	6,543	10,608	61.7%	
1987	5,213	8,504	61.3%	
1982	6,379	10,967	58.2%	
1977	3,825	6,495	58.9%	
2002	818,038	1,450,942	56.4%	***Tanks and tank components***
1997	543,119	1,063,668	51.1%	
1992	1,158	2,035	56.9%	
1987	969	2,522	38.4%	
1982	1,158	2,351	49.2%	
1977	438	934	46.8%	
2002	30,444,591	34,562,900	88.1%	***Cigarettes***
1997	23,338,692	29,252,787	79.8%	
1992	24,802	29,746	83.4%	
1987	12,971	17,372	74.7%	
1982	8,098	12,127	66.8%	
1977	3,803	6,377	59.6%	
2002	83,557,842	113,991,849	73.3%	***Pharmaceutical Preparations***
1997	47,864,824	66,734,737	71.7%	
1992	37,229	50,418	73.8%	
1987	23,884	32,094	74.4%	
1982	13,484	18,998	71.0%	
1977	8,214	11,459	71.7%	
2002	9,482,397	18,961,004	50.0%	***Canned fruits and vegetables***
1997	6,940,605	15,801,279	43.9%	
1992	6,959	15,066	46.2%	
1987	5,440	11,890	45.8%	
1982	3,553	9,283	38.3%	
1977	2,546	6,667	38.2%	
2002	10,957,221	29,514,919	37.1%	***Corrugated and solid fiber boxes***
1997	9,627,993	25,555,136	37.7%	
1992	6,738	19,790	34.0%	
1987	5,476	16,104	34.0%	
1982	3,659	10,558	34.7%	
1977	2,704	7,351	36.8%	

Appendix F: Data Tables for Analysis of "Conduct" in the SCP Paradigm

This appendix covers the sources of data for tables and figures discussed under "Conduct" in Chapter III. Table 18 represents the source data used in *Figure 15. Comparison of Cost to Change in Labor and Defense Funding* and part of *Figure 19. Aerospace R&D Intensity and Changes in Defense Funding*.

Table 19 is the source data used to calculate the average capital investment as a percentage of fixed assets before and after the defense consolidation. The source of the data is the AIA, *Facts and Figures*.

Table 20 represents the source data used in *Figure 16. Comparison of Capital Expenditures as a Percentage of Fixed Assets*. The total manufacturing and aerospace industry data was collected from the U.S. Bureau of Census and AIA *Facts and Figures*. Firm level financial statement data is collected from the *S&P Compu$tat* database.

Tables 21, 22, and 23 represent source data for *Figure 17. R&D Intensity in Aerospace Firms as Percentage of Net Sales*, *Figure 18. R&D Intensity in Aerospace Firms as Percentage of Value Added*, and part of *Figure 19. Aerospace R&D Intensity and Changes in Defense Funding*. The source data is the U.S. Bureau of Census and the AIA *Facts and Figures*. The percentages represent funding as a percentage of net sales.

Table 18. Source Data for Figures 15 and 19

Year	Total employees (number) for Aerospace Industry	% Change in Total employees (number) for Aerospace Industry	Total Services' TOA ($K) (CY06$)	% Change in Total Services' TOA ($K) (CY06$)	% Aggregate Contract Cost Overrun
1972	656814	-7.6%	104002000	1.5%	1.5%
1973	684498	4.2%	97446000	-6.3%	3.0%
1974	689782	0.8%	87549000	-10.2%	2.2%
1975	666766	-3.3%	80362000	-8.2%	1.9%
1976	638450	-4.2%	87477544	8.9%	2.4%
1977	645002	1.0%	98349459	12.4%	6.6%
1978	687573	6.6%	102123000	3.8%	1.6%
1979	791345	15.1%	98189000	-3.9%	2.1%
1980	838117	5.9%	98737000	0.6%	5.2%
1981	856788	2.2%	118717000	20.2%	5.8%
1982	817721	-4.6%	144357000	21.6%	4.5%
1983	786240	-3.8%	162727000	12.7%	1.3%
1984	788871	0.3%	173103000	6.4%	3.0%
1985	842002	6.7%	181523000	4.9%	3.7%
1986	894032	6.2%	171784000	-5.4%	6.0%
1987	905063	1.2%	163831000	-4.6%	2.9%
1988	915494	1.2%	155945000	-4.8%	4.7%
1989	918325	0.3%	145947000	-6.4%	7.3%
1990	910755	-0.8%	139259000	-4.6%	14.4%
1991	839986	-7.8%	117902000	-15.3%	22.9%
1992	790617	-5.9%	107272000	-9.0%	18.1%
1993	710781	-10.1%	95943000	-10.6%	19.9%
1994	637245	-10.3%	80219000	-16.4%	14.4%
1995	589509	-7.5%	77987000	-2.8%	9.8%
1996	568173	-3.6%	77042000	-1.2%	3.0%
1997	601550	5.9%	77084000	0.1%	2.7%
1998	621660	3.3%	79477000	3.1%	2.1%
1999	579517	-6.8%	86050000	8.3%	1.9%
2000	528844	-8.7%	91031000	5.8%	2.5%
2001	508419	-3.9%	99549000	9.4%	3.2%
2002	470569	-7.4%	100170000	0.6%	3.6%

Table 19. Source Data for Average Capital Investment as Percentage of Fixed Assets

Year	Net PP&E ($K) (CY06$)	New Capital Expenditures ($K) for Aerospace Industry Downstream (CY06$)	Capital Investment as a % of Fixed Assets
1985	31462228	6120045	19.5%
1986	34933598	6550346	18.8%
1987	33912384	5562728	16.4%
1988	33167759	5059162	15.3%
1989	35226202	5636394	16.0%
1990	36258341	4836894	13.3%
1991	35475490	4550486	12.8%
1992	35811856	5029140	14.0%
1993	35291602	3472588	9.8%
1994	44313058	2995865	6.8%
1995	32110586	2633593	8.2%
1996	29092814	3012243	10.4%
1997	29238075	3689724	12.6%
1998	31101311	4046992	13.0%
1999	32871964	3930918	12.0%
2000	31839351	2619608	8.2%
2001	31598128	2693833	8.5%
2002	29774793	3021649	10.1%

Average capital investment as % of fixed assets 1985-1992	***15.8%***
Average capital investment as % of fixed assets 1993-2002	***10.0%***

Table 20. Source Data for Figure 16

Year	Net Sales from Aerospace Companies ($K) (CY06$)	New Capital Expenditures ($K) for Aerospace Industry Downstream (CY06$)	Capital Exp as % of Sales for Aerospace Companies	Boeing Sales ($M)	Boeing Capital Expenditures ($M)	Boeing Capital Exp as % of Sales	General Dynamics Sales ($M)	General Dynamics Capital Expenditures ($M)	General Dynamics Capital Exp as % of Sales	Lockheed Martin Sales ($M)	Lockheed Martin Capital Expenditures ($M)	Lockheed Martin Capital Exp as % of Sales	Northrop Grumman Sales ($M)	Northrop Grumman Capital Expenditures ($M)
1985	171192106	6120045	3.6%	13,636.00	551.00	4.0%	8,163.77	413.50	5.1%	9,535.00	452.00	4.7%	5,056.56	384.00
1986	176351211	6550346	3.7%	16,341.00	795.00	4.9%	8,892.00	421.30	4.7%	10,273.00	493.00	4.8%	5,608.40	364.20
1987	170958954	5562728	3.3%	15,355.00	738.00	4.8%	9,344.00	349.60	3.7%	11,321.00	419.00	3.7%	6,052.50	294.40
1988	168513301	5059162	3.0%	16,962.00	690.00	4.1%	9,551.00	515.90	5.4%	10,590.00	380.00	3.6%	5,797.10	254.20
1989	170046275	5636394	3.3%	20,276.00	1362.00	6.7%	10,042.90	418.80	4.2%	9,891.00	399.00	4.0%	5,248.40	186.80
1990	185190437	4836894	2.6%	27,595.00	1586.00	5.7%	10,173.00	321.00	3.2%	9,958.00	340.00	3.4%	5,489.80	121.20
1991	180570068	4550486	2.5%	29,314.00	1850.00	6.3%	8,751.00	82.00	0.9%	9,809.00	312.00	3.2%	5,694.20	117.40
1992	175156633	5029140	2.9%	30,184.00	2160.00	7.2%	3,472.00	18.00	0.5%	10,100.00	327.00	3.2%	5,550.00	123.00
1993	163921579	3472588	2.1%	25,438.00	1317.00	5.2%	3,187.00	14.00	0.4%	13,071.00	321.00	2.5%	5,063.00	134.00
1994	150330857	2995865	2.0%	21,924.00	795.00	3.6%	3,058.00	23.00	0.8%	22,906.00	509.00	2.2%	6,711.00	134.00
1995	150252134	2633593	1.8%	19,515.00	629.00	3.2%	3,067.00	32.00	1.0%	22,853.00	531.00	2.3%	6,818.00	133.00
1996	152285398	3012243	2.0%	22,681.00	762.00	3.4%	3,581.00	75.00	2.1%	26,875.00	737.00	2.7%	8,071.00	194.00
1997	164087343	3689724	2.2%	45,800.00	1391.00	3.0%	4,062.00	83.00	2.0%	28,069.00	750.00	2.7%	9,153.00	238.00
1998	179950198	4046992	2.2%	56,154.00	1584.00	2.8%	4,970.00	158.00	3.2%	26,266.00	697.00	2.7%	8,902.00	211.00
1999	180468956	3930918	2.2%	57,993.00	1236.00	2.1%	8,959.00	197.00	2.2%	25,530.00	669.00	2.6%	8,995.00	201.00
2000	174406990	2619608	1.5%	51,321.00	932.00	1.8%	10,356.00	288.00	2.8%	25,329.00	500.00	2.0%	7,618.00	274.00
2001	185654681	2693833	1.5%	58,198.00	1068.00	1.8%	12,163.00	356.00	2.9%	23,990.00	619.00	2.6%	13,558.00	393.00
2002	172361562	3021649	1.8%	54,069.00	1001.00	1.9%	13,829.00	264.00	1.9%	26,578.00	662.00	2.5%	17,206.00	538.00

Table 21. Source Data for Figures 17 and 19

Year	Manufacturing		Aerospace		
	Total Funds	Company Funds	Total Funds	Company Funds	% Change in R&D Intensity
1978	2.9%	2.0%	13.3%	3.2%	
1979	2.6%	1.9%	12.9%	3.5%	9.4%
1980	3.0%	2.1%	13.7%	3.8%	8.6%
1981	3.1%	2.2%	16.0%	4.6%	21.1%
1982	3.8%	2.6%	17.1%	5.1%	10.9%
1983	3.9%	2.6%	15.2%	4.1%	-19.6%
1984	3.9%	2.6%	15.4%	4.0%	-2.4%
1985	4.4%	3.0%	14.9%	3.9%	-2.5%
1986	4.7%	3.2%	13.4%	4.0%	2.6%
1987	4.6%	3.1%	14.7%	3.6%	-10.0%
1988	4.5%	3.1%	16.3%	3.9%	8.3%
1989	4.3%	3.1%	13.5%	3.3%	-15.4%
1990	4.2%	3.1%	11.8%	3.1%	-6.1%
1991	4.2%	3.2%	12.1%	4.0%	29.0%
1992	4.2%	3.3%	11.8%	4.7%	17.5%
1993	3.8%	3.1%	12.5%	4.7%	0.0%
1994	3.6%	2.9%	13.8%	5.3%	12.8%
1995	3.6%	2.9%	12.9%	4.2%	-20.8%
1996	4.0%	3.3%	12.9%	4.5%	7.1%
1997	3.9%	3.3%	8.4%	3.3%	-26.7%
1998	3.7%	3.2%	7.2%	2.9%	-12.1%
1999	3.7%	3.2%	8.8%	3.2%	10.3%
2000	3.6%	3.3%	7.3%	2.8%	-12.5%
2001	4.0%	3.6%	5.7%	3.0%	7.1%
2002	3.6%	3.2%	4.1%	2.3%	-23.3%

Table 22. Source Data for Figure 18 for Total Manufacturing Industry

Total Manufacturing Companies													
Year	Value of industry shipments ($K) for all manufacturing industries (CY06$)	Cost of materials for all manufacturing industries ($K) (CY06$)	Value Added for Manufacturing (B - C)	Total Mfg R&D Funding	Federal Funds for R&D	Company R&D Funding	GDP Deflator	Total Mfg R&D Funding (CY06$)	Federal Funds for R&D (CY06$)	Company R&D Funding (CY06$)	Total Mfg R&D Funding as % of Value Added	Federal Funds for R&D as % of Value Added	Company R&D Funding as % of Value Added
1988	4025097882	2157077925	1868019957	128157000	40083000	88074000	0.669656	191377268	59856075	131521193	10.2%	3.2%	7.0%
1989	4082904536	2202651025	1880253511	129676000	36282000	93394000	0.695675	186403043	52153638	134249404	9.9%	2.8%	7.1%
1990	4036259094	2182371128	1853887966	134469000	34467000	100002000	0.721517	186369896	47770201	138599695	10.1%	2.6%	7.5%
1991	3844722872	2045442830	1799280042	138569000	31246000	107322000	0.748601	185103856	41739170	143363350	10.3%	2.3%	8.0%
1992	3915318613	2048107080	1867211533	137859000	28613000	109245000	0.767427	179637838	37284308	142352227	9.6%	2.0%	7.6%
1993	3985079580	2099164310	1885915270	132805000	25802000	107003000	0.784833	169214427	32875800	136338627	9.0%	1.7%	7.2%
1994	4176123639	2186259411	1989864228	132442000	24876000	107565000	0.801705	165200417	31028870	134170300	8.3%	1.6%	6.7%
1995	4390983234	2318132312	2072850922	143434000	25463000	117972000	0.818577	175223506	31106405	144118322	8.5%	1.5%	7.0%
1996	4453372747	2367701182	2085671565	154065000	25190000	128876000	0.834295	184664818	30193144	154472872	8.9%	1.4%	7.4%
1997	4517477462	2374275126	2143202337	165135000	25082000	140053000	0.848859	194537633	29547903	164989730	9.1%	1.4%	7.7%
1998	4539096398	2348869453	2190226945	175316000	25040000	150276000	0.85916	204055140	29144748	174910391	9.3%	1.3%	8.0%
1999	4632019217	2394561004	2237458214	186630000	23018000	163612000	0.870438	214409348	26444164	187965184	9.6%	1.2%	8.4%
2000	4739284243	2529039628	2210244615	199539000	19118000	180421000	0.888021	224700868	21528780	203172088	10.2%	1.0%	9.2%
2001	4367768474	2317834097	2049934377	193853000	16503000	177350000	0.908978	213264814	18155557	195109257	10.4%	0.9%	9.5%
2002	4234628332	2186717834	2047910499	183647000	15785000	167861000	0.92585	198354965	17049193	181304692	9.7%	0.8%	8.9%

Average IR&D intensity for total manufacturing companies *7.8%*

Table 23. Source Data for Figure 18 for Aerospace Industry

	Aerospace Companies													
Year	Total Value of Shipments ($K) for Aerospace Industry Downstream (CY06$)	Total Cost of Materials ($K) for Aerospace Industry Downstream (CY06$)	Value Added for Aerospace Downstream (R - S)	Total Mfg R&D Funding	Federal Funds for R&D	Company R&D Funding	GDP Deflator	Total Mfg R&D Funding (CY06$)	Federal Funds for R&D (CY06$)	Company R&D Funding (CY06$)	Total Mfg R&D Funding as % of Value Added	Federal Funds for R&D as % of Value Added	Company R&D Funding as % of Value Added
1988	160897604	78274030	82623574	31926000	24309000	7617000	0.669656	47675200	36300709	11374491	57.7%	43.9%	13.8%
1989	163118187	83594597	79523589	28375000	21382000	6992000	0.695675	40787704	30735601	10050665	51.3%	38.6%	12.6%
1990	173515448	87471706	86043742	25288000	18686000	6602000	0.721517	35048390	25898221	9150169	40.7%	30.1%	10.6%
1991	175454261	85030435	90423826	19703000	13147000	6556000	0.748601	26319749	17562084	8757665	29.1%	19.4%	9.7%
1992	171817946	79323334	92494612	19859000	11906000	7953000	0.767427	25877366	15514171	10363195	28.0%	16.8%	11.2%
1993	148395465	69673074	78722392	17032000	10602000	6430000	0.784833	21701443	13508613	8192830	27.6%	17.2%	10.4%
1994	130973363	59234132	71739231	15792000	9739000	6053000	0.801705	19698019	12147860	7550159	27.5%	16.9%	10.5%
1995	125255719	57106879	68148840	18405000	12445000	5960000	0.818577	22484129	15203205	7280924	33.0%	22.3%	10.7%
1996	121445960	60513462	60932498	17278000	11198000	6081000	0.834295	20709692	13422105	7288786	34.0%	22.0%	12.0%
1997	141882488	74004079	67878409	18726000	11430000	7297000	0.848859	22060204	13465135	8596246	32.5%	19.8%	12.7%
1998	159927978	80961001	78966977	16952000	10195000	6758000	0.85916	19730901	11866242	7865823	25.0%	15.0%	10.0%
1999	159676178	75253981	84422197	14734000	9313000	5423000	0.870438	16927114	10699214	6230198	20.1%	12.7%	7.4%
2000	143676995	68036010	75640985	10319000	6424000	3895000	0.888021	11620226	7234066	4386160	15.4%	9.6%	5.8%
2001	147136202	72977911	74158291	7684000	3696000	3987000	0.908978	8453451	4066106	4386245	11.4%	5.5%	5.9%
2002	135276276	64982590	70293686	9292000	4144000	5148000	0.92585	10036180	4475886	5560294	14.3%	6.4%	7.9%

Average IR&D intensity for aerospace companies 10.1%

Appendix G: Data Tables for Profitability Ratios

This appendix contains the source data for the calculations of the moving averages of the profitability ratios for *Figure 22. Comparison of Profit Margin*, *Figure 23. Comparison of Return on Assets (ROA)*, and *Figure 24. Comparison of Return on Equity (ROE).*

Table 24. Source Data for Three-Year Moving Average Calculation of Profitability Ratios

Year	Manufacturing Industry			Aerospace Industry			Raytheon			Lockheed Martin			Boeing		
	Total Manufacturing Profit Margin	Total Manufacturing Return on Assets	Total Manufacturing Return on Equity	Aerospace Profit Margin	Aerospace Return on Assets	Aerospace Return on Equity	Raytheon Profit Margin	Raytheon Return on Assets	Raytheon Return on Equity	Lockheed Martin Profit Margin	Lockheed Martin Return on Assets	Lockheed Martin Return on Equity	Boeing Profit Margin	Boeing Return on Assets	Boeing Return on Equity
1985	3.8%	4.6%	10.1%	3.1%	3.6%	11.1%	5.9%	10.9%	19.5%	4.2%	9.6%	26.5%	4.2%	6.1%	13.0%
1986	3.7%	4.2%	9.5%	2.8%	3.1%	9.4%	5.4%	11.1%	20.1%	4.0%	6.9%	21.9%	4.1%	6.0%	13.8%
1987	4.9%	5.6%	12.8%	4.1%	4.4%	14.6%	5.8%	11.0%	24.1%	3.9%	6.9%	20.9%	3.1%	3.8%	9.6%
1988	6.0%	6.9%	16.2%	4.3%	4.4%	14.9%	6.0%	10.3%	23.1%	4.2%	6.7%	17.9%	3.6%	4.9%	11.4%
1989	5.0%	5.6%	13.7%	3.3%	3.3%	10.7%	6.0%	9.9%	21.8%	0.1%	0.1%	0.3%	3.3%	5.1%	11.0%
1990	4.0%	4.3%	10.7%	3.4%	3.4%	11.5%	6.0%	9.1%	19.6%	3.4%	4.9%	14.5%	5.0%	9.5%	19.9%
1991	2.5%	2.6%	6.4%	1.8%	1.9%	6.1%	6.4%	9.7%	17.8%	3.1%	4.7%	12.3%	5.3%	9.9%	19.4%
1992	1.0%	1.0%	2.6%	-1.4%	-1.2%	-5.2%	7.0%	10.6%	16.5%	3.4%	5.2%	17.0%	5.1%	8.6%	18.9%
1993	2.8%	2.9%	8.1%	3.6%	3.5%	13.2%	7.5%	9.5%	16.1%	3.2%	4.7%	17.3%	4.9%	6.1%	13.6%
1994	5.4%	5.8%	15.6%	4.7%	4.3%	14.8%	6.0%	8.1%	15.2%	4.6%	5.8%	17.3%	3.9%	4.0%	8.8%
1995	5.7%	6.2%	16.2%	3.8%	3.5%	11.1%	6.8%	8.1%	18.5%	3.0%	3.9%	10.6%	2.0%	1.8%	4.0%
1996	6.0%	6.5%	16.8%	5.6%	5.1%	17.1%	6.2%	6.8%	16.6%	5.0%	4.6%	19.6%	4.8%	4.0%	10.0%
1997	6.2%	6.6%	16.6%	5.2%	4.8%	17.3%	3.9%	1.8%	5.1%	4.6%	4.6%	25.1%	-0.4%	-0.5%	-1.4%
1998	6.9%	6.9%	17.8%	5.0%	4.7%	17.5%	4.4%	3.1%	8.0%	3.8%	3.5%	16.3%	2.0%	3.1%	9.1%
1999	6.2%	6.1%	16.5%	6.5%	6.2%	21.8%	2.3%	1.6%	4.2%	2.9%	2.5%	11.6%	4.0%	6.4%	20.1%
2000	6.1%	5.9%	15.2%	4.7%	4.3%	14.2%	2.9%	1.9%	4.6%	-1.7%	-1.4%	-5.9%	4.1%	5.1%	19.3%
2001	0.8%	0.8%	1.9%	3.9%	3.6%	11.6%	0.0%	0.0%	0.0%	0.3%	0.3%	1.2%	4.9%	5.8%	26.1%
2002	3.3%	2.9%	7.7%	4.1%	3.7%	11.7%	4.5%	3.2%	8.5%	2.0%	2.1%	9.1%	4.3%	4.4%	30.1%

Table 25. Three-Year Moving Average Calculation for Profitability Ratios

	Manufacturing Industry			Aerospace Industry			Raytheon			Lockheed Martin			Boeing		
Year	Total Manufacturing Profit Margin	Total Manufacturing Return on Assets	Total Manufacturing Return on Equity	Aerospace Profit Margin	Aerospace Return on Assets	Aerospace Return on Equity	Raytheon Profit Margin	Raytheon Return on Assets	Raytheon Return on Equity	Lockheed Martin Profit Margin	Lockheed Martin Return on Assets	Lockheed Martin Return on Equity	Boeing Profit Margin	Boeing Return on Assets	Boeing Return on Equity
1985															
1986															
1987	4.1%	4.8%	10.8%	3.3%	3.7%	11.7%	5.7%	11.0%	21.2%	4.0%	7.8%	23.1%	3.8%	5.3%	12.1%
1988	4.9%	5.6%	12.8%	3.7%	4.0%	13.0%	5.7%	10.8%	22.4%	4.0%	6.8%	20.2%	3.6%	4.9%	11.6%
1989	5.3%	6.0%	14.2%	3.9%	4.0%	13.4%	5.9%	10.4%	23.0%	2.7%	4.6%	13.0%	3.4%	4.6%	10.7%
1990	5.0%	5.6%	13.5%	3.7%	3.7%	12.4%	6.0%	9.8%	21.5%	2.5%	3.9%	10.9%	4.0%	6.5%	14.1%
1991	3.8%	4.2%	10.3%	2.8%	2.9%	9.4%	6.1%	9.6%	19.7%	2.2%	3.2%	9.0%	4.6%	8.2%	16.7%
1992	2.5%	2.6%	6.6%	1.3%	1.4%	4.1%	6.5%	9.8%	18.0%	3.3%	4.9%	14.6%	5.2%	9.3%	19.4%
1993	2.1%	2.2%	5.7%	1.3%	1.4%	4.7%	7.0%	9.9%	16.8%	3.3%	4.8%	15.5%	5.1%	8.2%	17.3%
1994	3.1%	3.2%	8.8%	2.3%	2.2%	7.6%	6.8%	9.4%	15.9%	3.8%	5.2%	17.2%	4.6%	6.2%	13.8%
1995	4.6%	5.0%	13.3%	4.0%	3.8%	13.0%	6.8%	8.6%	16.6%	3.6%	4.8%	15.1%	3.6%	3.9%	8.8%
1996	5.7%	6.2%	16.2%	4.7%	4.3%	14.3%	6.3%	7.7%	16.7%	4.2%	4.8%	15.9%	3.6%	3.3%	7.6%
1997	6.0%	6.4%	16.5%	4.9%	4.5%	15.2%	5.6%	5.6%	13.4%	4.2%	4.4%	18.5%	2.2%	1.8%	4.2%
1998	6.4%	6.7%	17.1%	5.3%	4.9%	17.3%	4.8%	3.9%	9.9%	4.5%	4.2%	20.4%	2.1%	2.2%	5.9%
1999	6.4%	6.5%	17.0%	5.6%	5.2%	18.9%	3.5%	2.2%	5.7%	3.8%	3.5%	17.7%	1.9%	3.0%	9.3%
2000	6.4%	6.3%	16.5%	5.4%	5.1%	17.8%	3.2%	2.2%	5.6%	1.7%	1.5%	7.3%	3.4%	4.8%	16.2%
2001	4.4%	4.3%	11.2%	5.0%	4.7%	15.9%	1.8%	1.2%	2.9%	0.5%	0.4%	2.3%	4.3%	5.8%	21.9%
2002	3.4%	3.2%	8.3%	4.2%	3.9%	12.5%	2.5%	1.7%	4.4%	0.2%	0.3%	1.5%	4.4%	5.1%	25.2%

Appendix H: Returns to Scale Using Cobb-Douglas Production Function

This appendix addresses the data and calculations for determining the returns to scale for the total manufacturing, total aerospace industry (includes non-aerospace NAICS/SIC codes), and aerospace NAICS/SIC codes only. This section provides a summary table of the regressions performed, data table for the three respective categories, preliminary data tests for unit root, regression results, and plots of residuals against actuals and actuals against predicted *Y*. The source data was collected from the U.S. Bureau of Census. The dependent variable is the value of shipments. The independent variables are capital expenditures and employee payroll. The natural log is taken for data prior to running the linear regression model.

Table 26. Summary of Returns to Scale Calculations

Total Manufacturing Industry				
Period	Technical Parameter	Capital (α)	Labor (β)	α + β
1972-1992	0.0129	0.1663	0.9493	1.1156
1972-1997	0.0122	0.1659	0.9349	1.1008
1972-2002	0.0128	0.1542	0.9531	1.1073
Total Aerospace Industry (Includes Non-Aerospace NAICS/SICS)				
Period	Technical Parameter	Capital (α)	Labor (β)	α + β
1972-1992	0.0236	0.0293	0.8181	0.8474
1972-1997	0.0200	0.0471	0.9795	1.0266
1972-2002	0.0192	0.0500	1.0006	1.0506
Aerospace NAICS/SIC Only				
Period	Technical Parameter	Capital (α)	Labor (β)	α + β
1972-1992	0.0251	0.0128	0.8530	0.8658
1972-1997	0.0215	0.0372	1.0224	1.0597
1972-2002	0.0205	0.0423	1.0367	1.0789

Total Manufacturing Industry

Dependent variable before taking the first difference shows no stationary unit root at 95% CI.

Table 27. Unit Root Test for Total Manufacturing Industry Data

Dickey-Fuller test for unit root
Number of obs = 30
Interpolated Dickey-Fuller

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.75	-3.716	-2.986	-2.624

MacKinnon approximate p-value for Z(t) = 0.0658

Dependent variable after taking the first difference reflects data is stationary.

Table 28. Unit Root Test After Taking First Difference for Total Manufacturing Data

Dickey-Fuller test for unit root
Number of obs = 29
Interpolated Dickey-Fuller

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-4.738	-3.723	-2.989	-2.625

MacKinnon approximate p-value for Z(t) = 0.0001

Table 29. Regression Results for Total Manufacturing for 1972-2002

Regression with robust standard errors (1972-2002)

Number of obs =	30
F(2, 27) =	61.4
Prob > F =	0
R-squared =	0.7867
Root MSE =	0.02341

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.154207	0.075453	2.04	0.051	-0.0006097	0.309024
fmfgpay	0.953138	0.173439	5.5	0	0.5972708	1.309005
_cons	0.012816	0.003923	3.27	0.003	0.0047663	0.020866

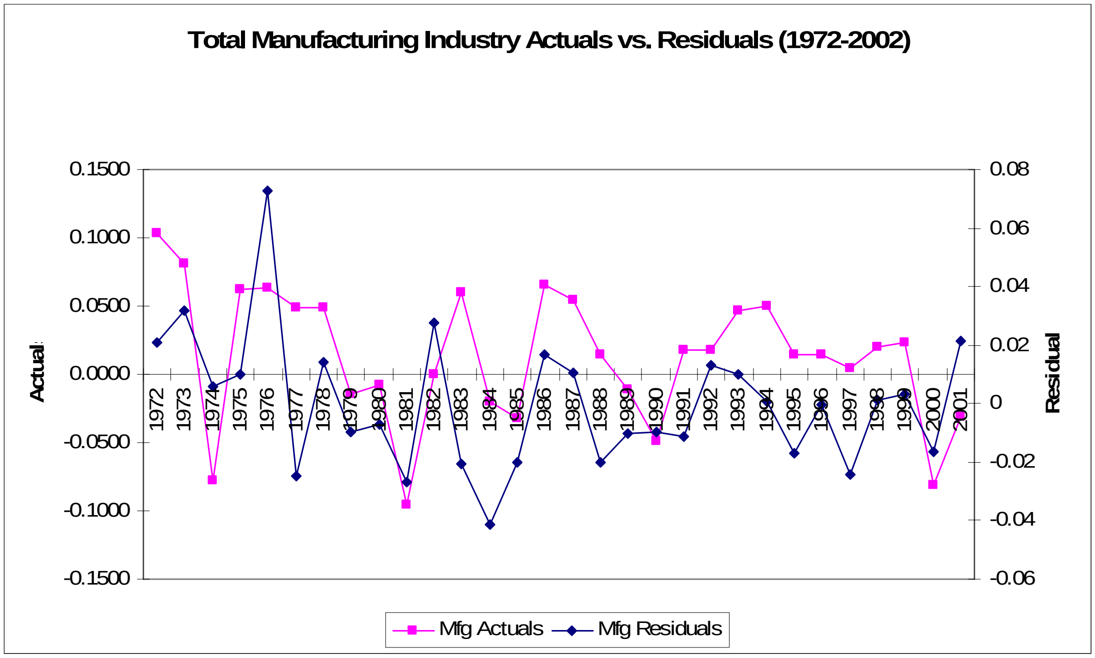

Figure 26. Actuals vs. Residuals for Total Manufacturing 1972-2002

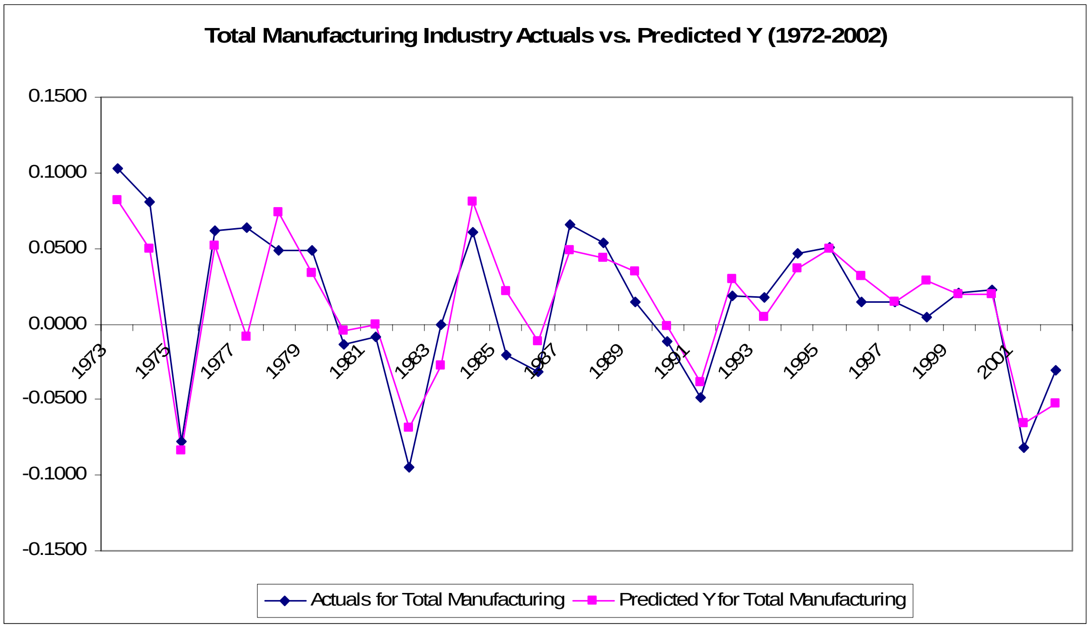

Figure 27. Actuals vs. Predicted Y for Total Manufacturing 1972-2002

Table 30. Regression Results for Total Manufacturing for 1972-1998

Regression with robust standard errors (1972-1998)

Number of obs =	26
F(2, 23) =	44.61
Prob > F =	0
R-squared =	0.7568
Root MSE =	0.02471

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.165902	0.080753	2.05	0.051	-0.0011478	0.332953
fmfgpay	0.934868	0.185752	5.03	0	0.5506095	1.319126
_cons	0.012175	0.00467	2.61	0.016	0.0025148	0.021834

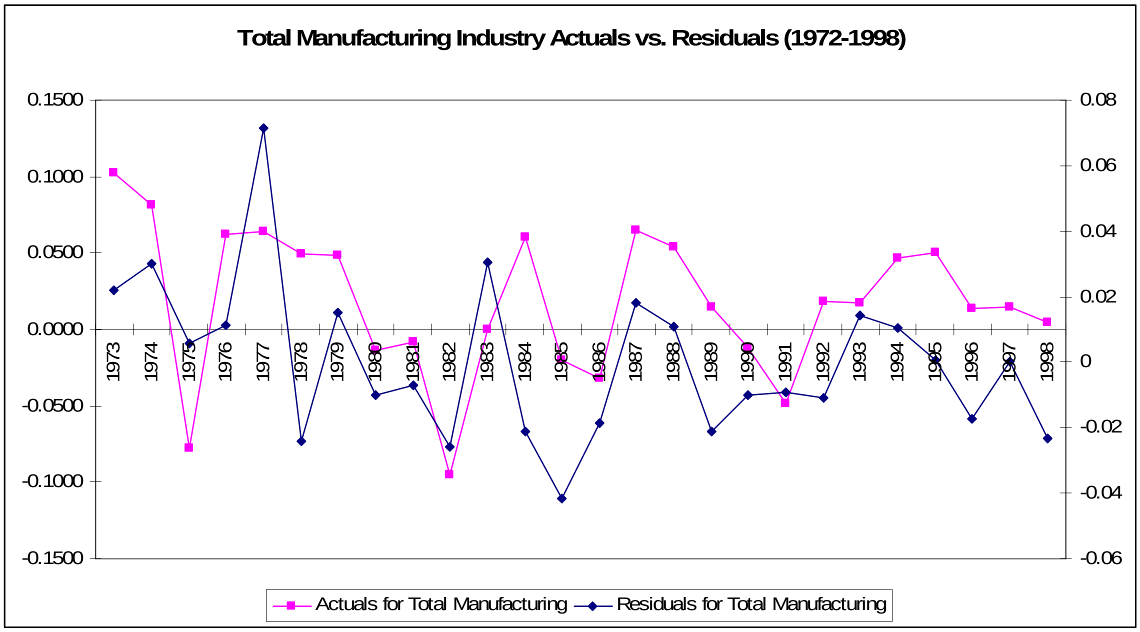

Figure 28. Actuals vs. Residuals Y for Total Manufacturing 1972-1998

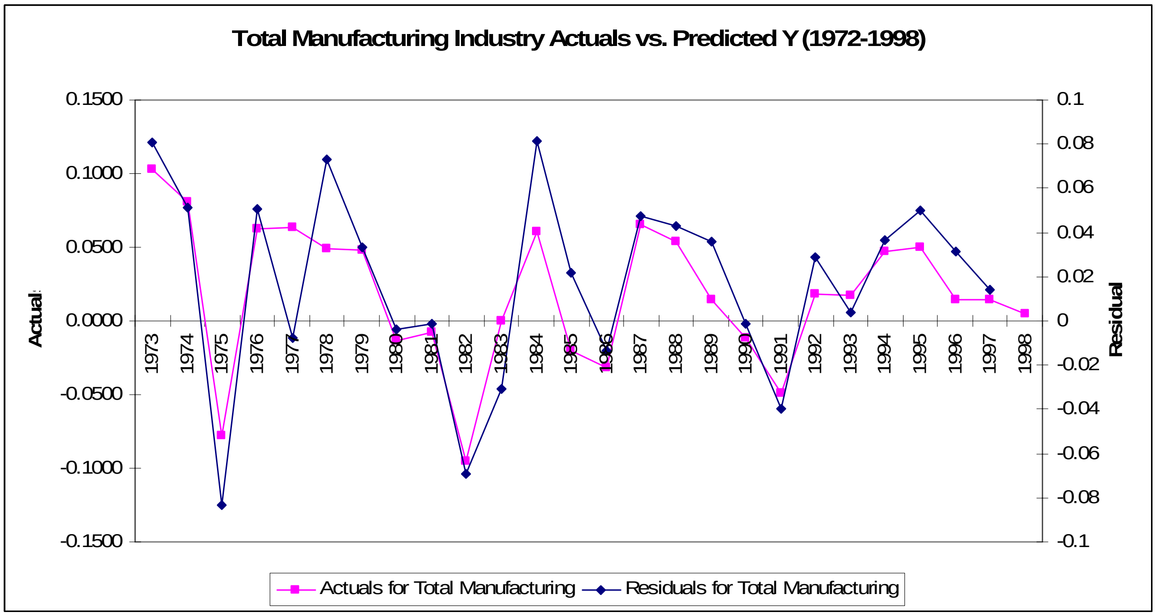

Figure 29. Actuals vs. Predicted Y for Total Manufacturing 1972-1998

Table 31. Regression Results for Total Manufacturing for 1972-1992

Regression with robust standard errors (1972-1992)

Number of obs = 20
F(2, 17) = 41.3
Prob > F = 0
R-squared = 0.7679
Root MSE = 0.02755

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.166262	0.086425	1.92	0.071	-0.0160779	0.348602
fmfgpay	0.949297	0.187927	5.05	0	0.5528066	1.345787
_cons	0.012949	0.005724	2.26	0.037	0.0008732	0.025026

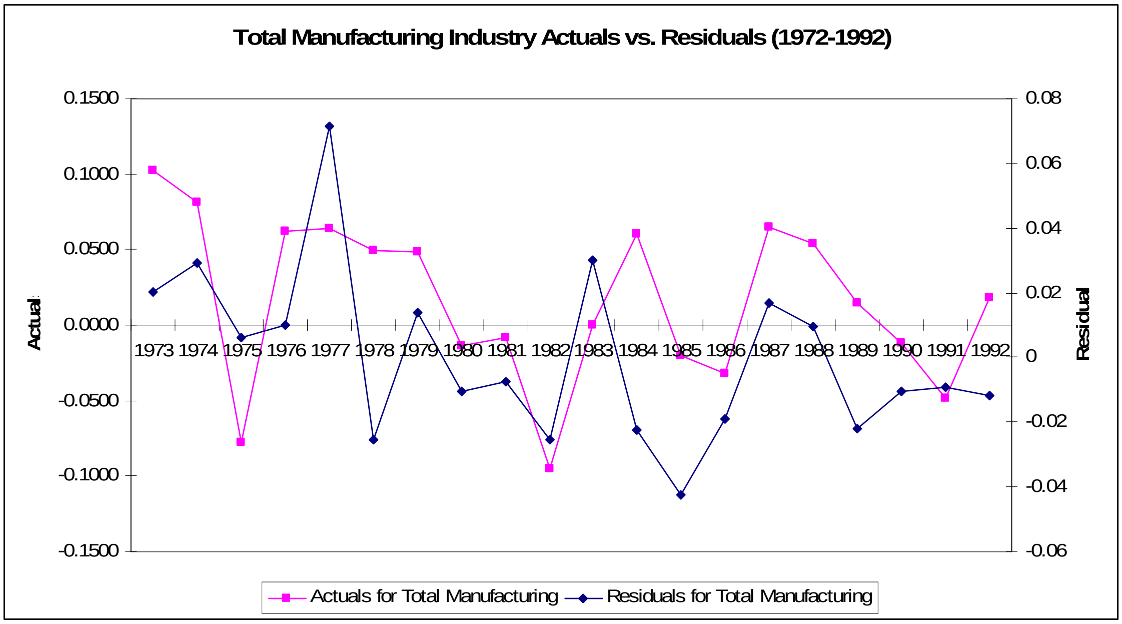

Figure 30. Actuals vs. Residuals for Total Manufacturing 1972-1992

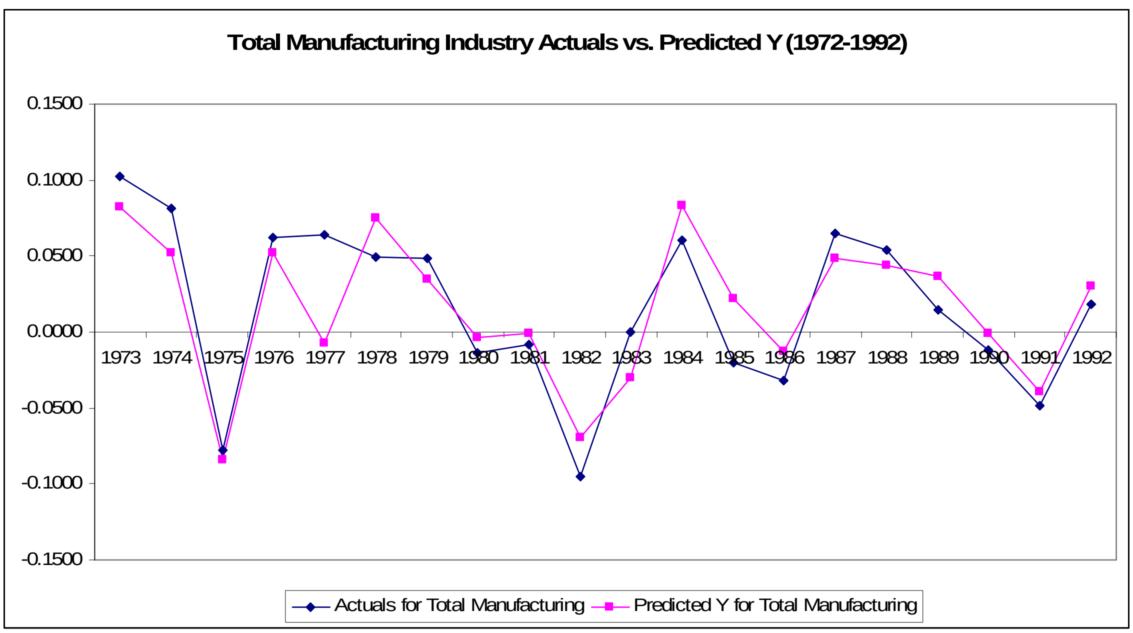

Figure 31. Actuals vs. Predicted Y for Total Manufacturing 1972-1992

Table 32. Data for Total Manufacturing Returns to Scale Regression

Total Manufacturing Industry												
year	mafgexp	mfgpay	mfgvalshp	fmfgcapexp	fmfgpay	mfgvalsh	residmfg	yhatmfg	residmfg7	yhatmfg72	residmfg7	yhatmfg72
1972	18.3289	20.3079	21.7764									
1973	18.3993	20.3689	21.8792	0.0704	0.0610	0.1028	0.0209864	0.0818136	0.0219191	0.0808809	0.0202386	0.0825614
1974	18.6056	20.3738	21.9603	0.2063	0.0050	0.0810	0.0316	0.0494	0.0299	0.0511	0.0290	0.0520
1975	18.5538	20.2807	21.8822	-0.0518	-0.0932	-0.0780	0.0060	-0.0840	0.0055	-0.0835	0.0061	-0.0841
1976	18.5717	20.3189	21.9443	0.0178	0.0382	0.0620	0.0100	0.0520	0.0112	0.0508	0.0098	0.0522
1977	18.6538	20.2830	22.0081	0.0821	-0.0359	0.0638	0.0725	-0.0087	0.0716	-0.0078	0.0713	-0.0075
1978	18.7399	20.3329	22.0572	0.0861	0.0499	0.0491	-0.0246	0.0737	-0.0240	0.0731	-0.0255	0.0746
1979	18.7709	20.3502	22.1056	0.0310	0.0173	0.0484	0.0143	0.0341	0.0149	0.0335	0.0139	0.0345
1980	18.8174	20.3246	22.0916	0.0465	-0.0256	-0.0139	-0.0095	-0.0044	-0.0099	-0.0040	-0.0103	-0.0036
1981	18.8386	20.3067	22.0835	0.0213	-0.0179	-0.0082	-0.0072	-0.0010	-0.0072	-0.0010	-0.0077	-0.0005
1982	18.7193	20.2407	21.9884	-0.1194	-0.0659	-0.0950	-0.0266	-0.0684	-0.0258	-0.0692	-0.0255	-0.0695
1983	18.4949	20.2344	21.9880	-0.2244	-0.0063	-0.0004	0.0274	-0.0278	0.0305	-0.0309	0.0299	-0.0303
1984	18.6482	20.2812	22.0484	0.1533	0.0469	0.0604	-0.0208	0.0812	-0.0211	0.0815	-0.0226	0.0830
1985	18.7158	20.2792	22.0283	0.0676	-0.0020	-0.0202	-0.0415	0.0213	-0.0417	0.0215	-0.0425	0.0223
1986	18.6086	20.2709	21.9965	-0.1072	-0.0083	-0.0318	-0.0202	-0.0116	-0.0184	-0.0134	-0.0190	-0.0128
1987	18.6125	20.3077	22.0619	0.0038	0.0369	0.0653	0.0167	0.0486	0.0180	0.0473	0.0167	0.0486
1988	18.6557	20.3331	22.1158	0.0432	0.0254	0.0540	0.0103	0.0437	0.0109	0.0431	0.0098	0.0442
1989	18.8023	20.3321	22.1301	0.1466	-0.0009	0.0143	-0.0203	0.0346	-0.0214	0.0357	-0.0222	0.0365
1990	18.8097	20.3162	22.1186	0.0074	-0.0160	-0.0115	-0.0102	-0.0013	-0.0099	-0.0016	-0.0105	-0.0010
1991	18.7413	20.2729	22.0700	-0.0684	-0.0432	-0.0486	-0.0097	-0.0389	-0.0090	-0.0396	-0.0092	-0.0394
1992	18.7865	20.2830	22.0882	0.0453	0.0100	0.0182	-0.0111	0.0293	-0.0108	0.0290	-0.0118	0.0300
1993	18.7457	20.2811	22.1058	-0.0408	-0.0019	0.0177	0.0130	0.0047	0.0141	0.0036		
1994	18.8128	20.2953	22.1526	0.0671	0.0142	0.0468	0.0101	0.0367	0.0102	0.0366		
1995	18.9159	20.3171	22.2028	0.1031	0.0219	0.0502	0.0006	0.0496	0.0004	0.0498		
1996	18.9835	20.3255	22.2169	0.0676	0.0084	0.0141	-0.0171	0.0312	-0.0171	0.0312		
1997	19.0000	20.3247	22.2312	0.0165	-0.0009	0.0143	-0.0002	0.0145	0.0002	0.0141		
1998	18.9958	20.3423	22.2360	-0.0042	0.0176	0.0048	-0.0241	0.0289	-0.0231	0.0279		
1999	18.9671	20.3537	22.2563	-0.0288	0.0114	0.0203	0.0011	0.0192				
2000	18.9743	20.3595	22.2792	0.0073	0.0058	0.0229	0.0034	0.0195				
2001	18.8737	20.2937	22.1975	-0.1006	-0.0658	-0.0816	-0.0162	-0.0654				
2002	18.7251	20.2495	22.1666	-0.1485	-0.0442	-0.0310	0.0212	-0.0522				

Total Aerospace (Includes Non-Aerospace NAICS/SIC for Upstream) Industry

Dependent variable before taking the first difference shows no stationary unit root at 95% CI.

Table 33. Unit Root Test for Total Aerospace Data

Dickey-Fuller test for unit root

Number of obs = 30

Interpolated Dickey-Fuller

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.499	-3.716	-2.986	-2.624

MacKinnon approximate p-value for Z(t) = 0.1156

Dependent variable after taking the first difference reflects data is stationary.

Table 34. Unit Root Test After Taking First Difference for Total Aerospace Data

Dickey-Fuller test for unit root

Number of obs = 29

Interpolated Dickey-Fuller

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.421	-3.723	-2.989	-2.625

MacKinnon approximate p-value for Z(t) = 0.0103

Table 35. Regression Results for Total Aerospace for 1972-2002

Regression with robust standard errors (1972-2002)

Number of obs =	30
F(2, 27) =	40.37
Prob > F =	0
R-squared =	0.7602
Root MSE =	0.03694

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.050044	0.064794	0.77	0.447	-0.0829037	0.182991
fmfgpay	1.000572	0.177591	5.63	0	0.6361858	1.364958
_cons	0.019173	0.006472	2.96	0.006	0.005893	0.032453

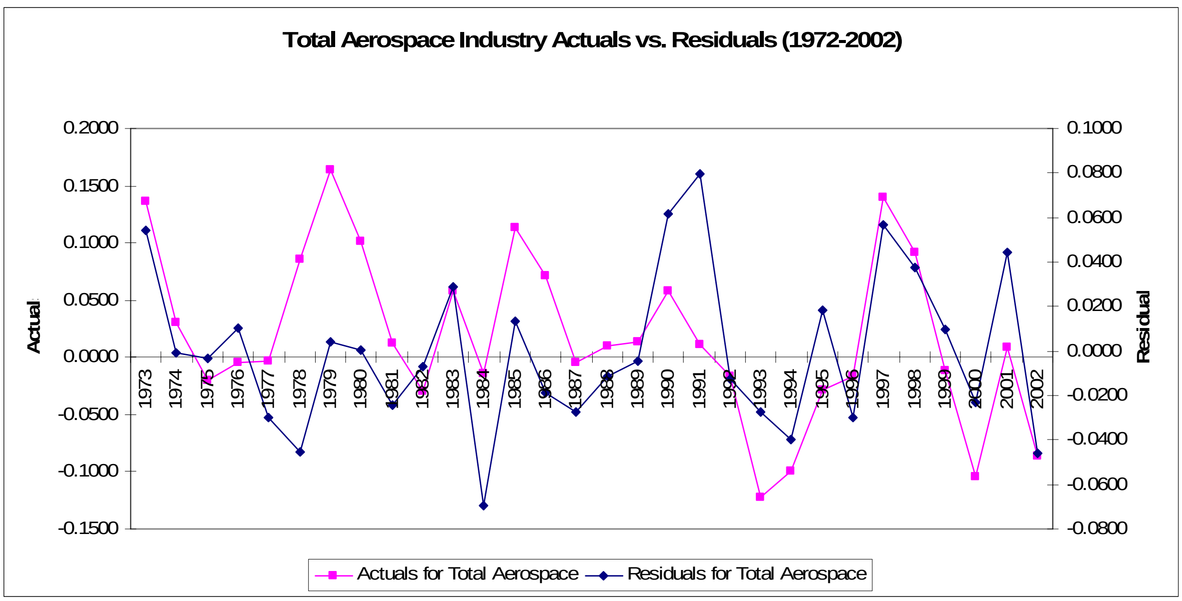

Figure 32. Actuals vs. Residuals for Total Aerospace 1972-2002

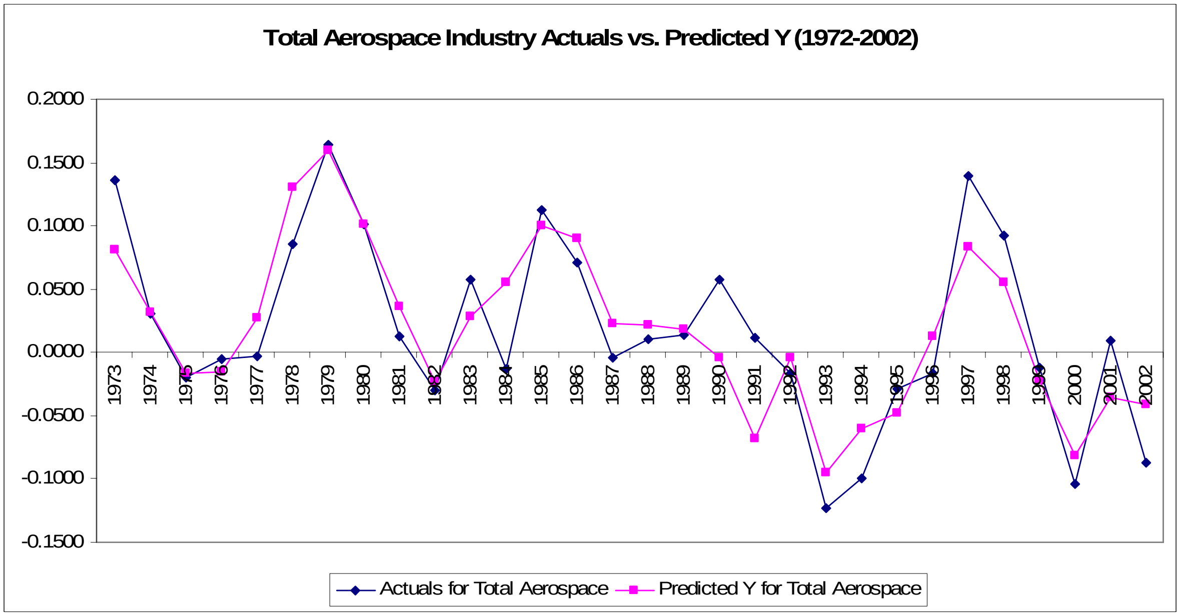

Figure 33. Actuals vs. Predicted Y for Total Aerospace 1972-2002

Table 36. Regression Results for Total Aerospace for 1972-1998

Regression with robust standard errors (1972-1998)

Number of obs =	26
F(2, 23) =	29.4
Prob > F =	0
R-squared =	0.741
Root MSE =	0.03737

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.047133	0.076973	0.61	0.546	-0.1120986	0.206364
fmfgpay	0.979463	0.190746	5.13	0	0.5848748	1.374051
_cons	0.020009	0.007528	2.66	0.014	0.0044354	0.035583

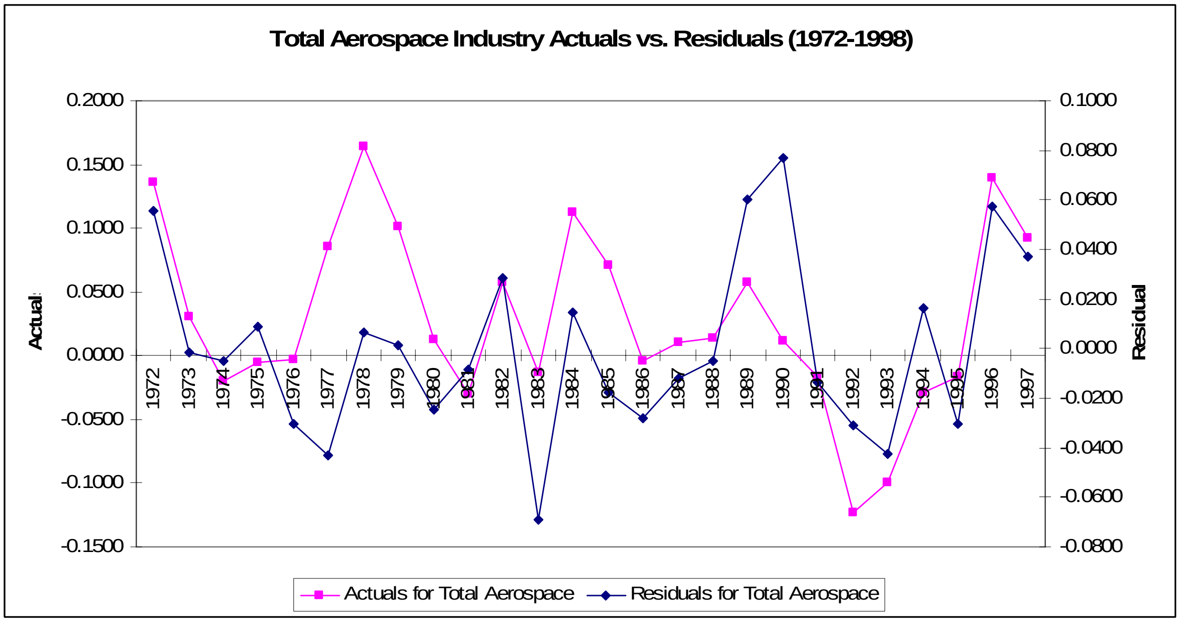

Figure 34. Actuals vs. Residuals for Total Aerospace 1972-1998

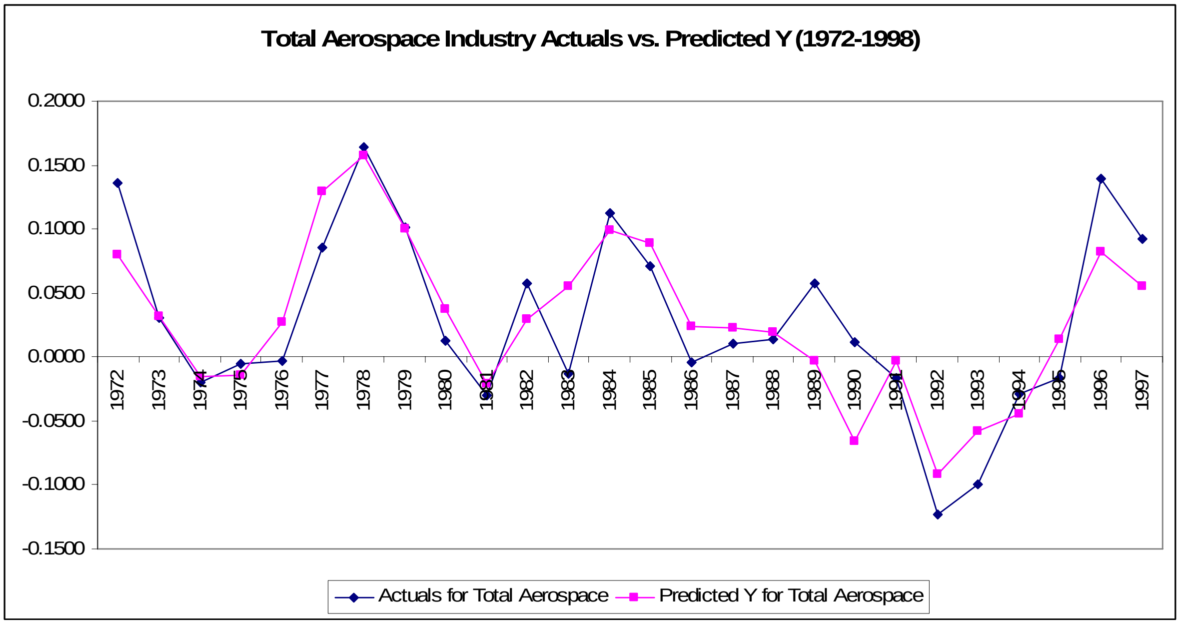

Figure 35. Actuals vs. Predicted Y for Total Aerospace 1972-1998

Table 37. Regression Results for Total Aerospace for 1972-1992

Regression with robust standard errors (1972-1992)

Number of obs =	20
F(2, 17) =	14.47
Prob > F =	0.0002
R-squared =	0.6465
Root MSE =	0.03554

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.029346	0.089232	0.33	0.746	-0.1589173	0.217609
fmfgpay	0.818103	0.189694	4.31	0	0.4178841	1.218322
_cons	0.023551	0.008997	2.62	0.018	0.0045699	0.042532

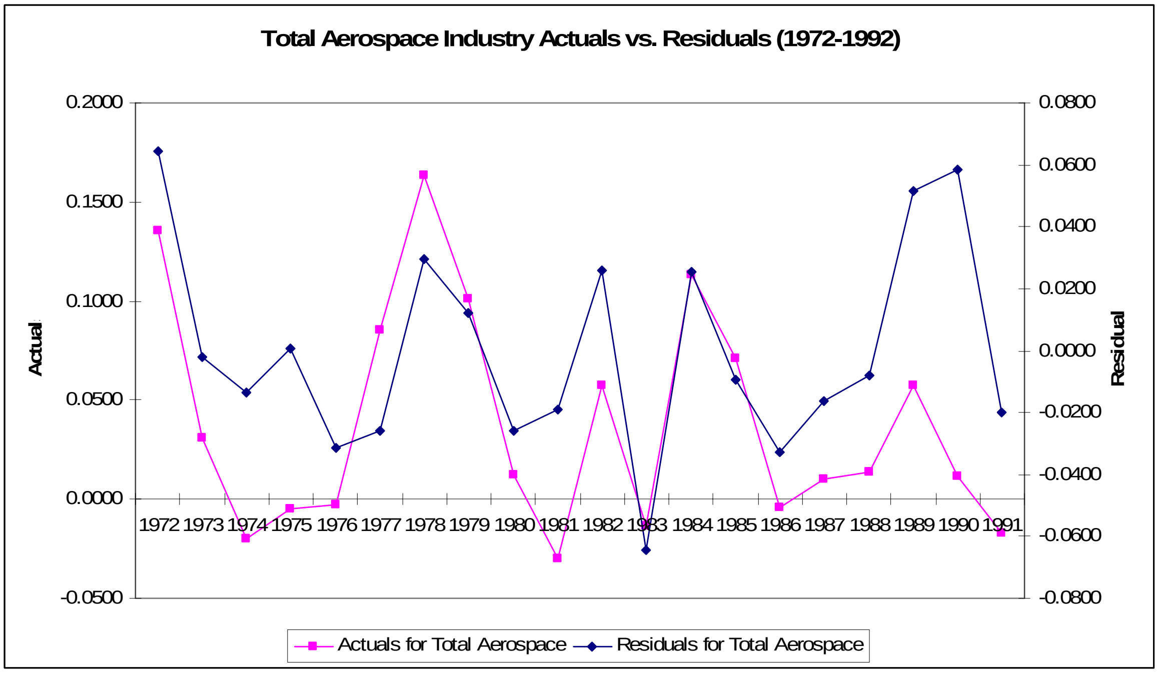

Figure 36. Actuals vs. Residuals for Total Aerospace 1972-1992

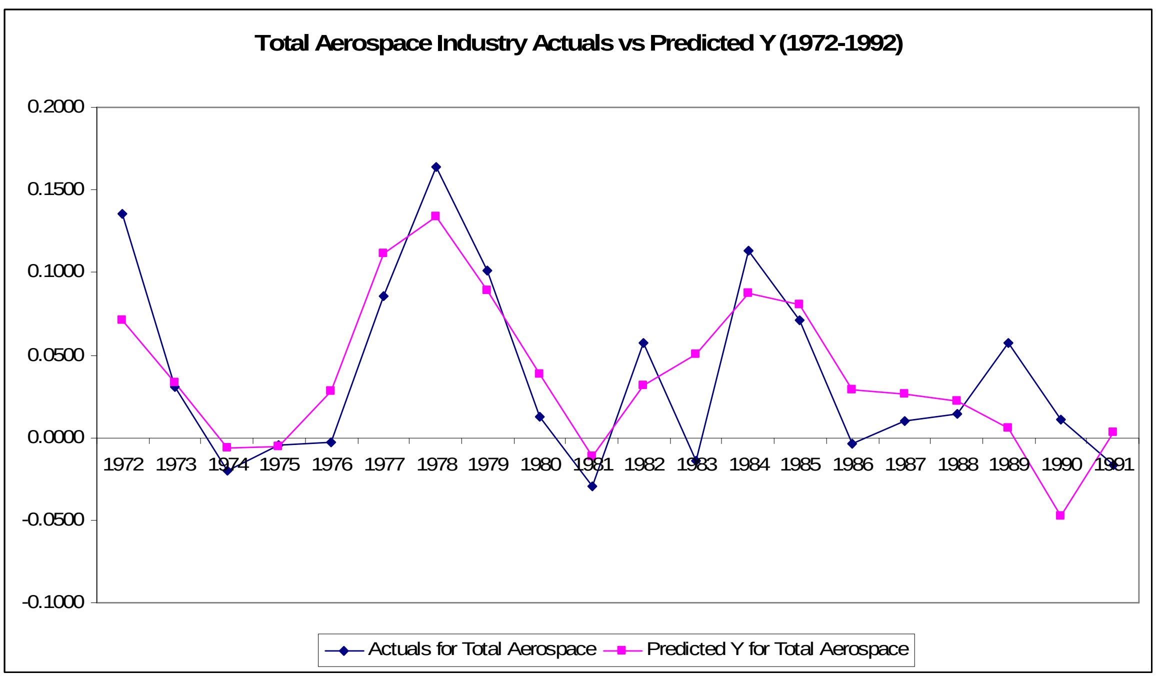

Figure 37. Actuals vs. Predicted Y for Total Aerospace 1972-1992

Table 38. Data for Total Aerospace Returns to Scale Regression

	Total Aerospace Industry - Aerospace NAICS/SIC Plus Non-Aerospace Upstream NAICS/SIC											
year	taerocapexp	taeropay	taerovalshp	ftaerocapexp	ftaeropay	ftaerovalshp	residtaero	yhattaero	resid7298	yhat7298	resid7292	yhat7292
1972	14.0281	17.2503	18.2901									
1973	14.3156	17.2983	18.4258	0.2875	0.0479	0.1358	0.0543	0.0815	0.0553	0.0805	0.0646	0.0712
1974	14.3920	17.3069	18.4566	0.0764	0.0087	0.0308	-0.0009	0.0317	-0.0013	0.0321	-0.0021	0.0329
1975	14.4645	17.2677	18.4369	0.0724	-0.0392	-0.0197	-0.0033	-0.0164	-0.0047	-0.0150	-0.0133	-0.0064
1976	14.5518	17.2290	18.4321	0.0873	-0.0388	-0.0048	0.0105	-0.0153	0.0091	-0.0139	0.0008	-0.0056
1977	14.6582	17.2312	18.4290	0.1064	0.0022	-0.0031	-0.0298	0.0267	-0.0303	0.0272	-0.0316	0.0285
1978	14.9264	17.3294	18.5147	0.2682	0.0982	0.0857	-0.0452	0.1309	-0.0431	0.1288	-0.0261	0.1118
1979	15.2884	17.4517	18.6783	0.3620	0.1223	0.1636	0.0039	0.1597	0.0067	0.1569	0.0294	0.1342
1980	15.4147	17.5268	18.7792	0.1263	0.0752	0.1009	0.0002	0.1007	0.0013	0.0996	0.0121	0.0888
1981	15.3846	17.5459	18.7917	-0.0301	0.0190	0.0125	-0.0242	0.0367	-0.0247	0.0372	-0.0257	0.0382
1982	15.3982	17.5030	18.7618	0.0136	-0.0428	-0.0299	-0.0069	-0.0230	-0.0086	-0.0213	-0.0188	-0.0111
1983	15.3517	17.5149	18.8195	-0.0465	0.0119	0.0577	0.0289	0.0288	0.0282	0.0295	0.0258	0.0319
1984	15.5950	17.5393	18.8058	0.2434	0.0244	-0.0137	-0.0695	0.0558	-0.0691	0.0554	-0.0644	0.0507
1985	15.7450	17.6124	18.9187	0.1500	0.0730	0.1130	0.0133	0.0997	0.0144	0.0986	0.0253	0.0877
1986	15.7977	17.6805	18.9901	0.0526	0.0681	0.0713	-0.0186	0.0899	-0.0179	0.0892	-0.0095	0.0808
1987	15.6422	17.6922	18.9859	-0.1555	0.0117	-0.0041	-0.0272	0.0231	-0.0282	0.0241	-0.0327	0.0286
1988	15.5582	17.6986	18.9962	-0.0840	0.0064	0.0102	-0.0112	0.0214	-0.0121	0.0223	-0.0161	0.0263
1989	15.6540	17.6933	19.0102	0.0959	-0.0053	0.0141	-0.0046	0.0187	-0.0052	0.0193	-0.0079	0.0220
1990	15.5176	17.6768	19.0678	-0.1364	-0.0165	0.0575	0.0617	-0.0042	0.0601	-0.0026	0.0515	0.0060
1991	15.4634	17.5920	19.0791	-0.0542	-0.0847	0.0113	0.0796	-0.0683	0.0768	-0.0655	0.0586	-0.0473
1992	15.5522	17.5639	19.0622	0.0888	-0.0281	-0.0168	-0.0123	-0.0045	-0.0135	-0.0033	-0.0200	0.0032
1993	15.2488	17.4645	18.9395	-0.3034	-0.0994	-0.1228	-0.0273	-0.0955	-0.0312	-0.0916		
1994	15.1463	17.3904	18.8394	-0.1026	-0.0742	-0.1000	-0.0398	-0.0602	-0.0425	-0.0575		
1995	15.0645	17.3279	18.8104	-0.0818	-0.0625	-0.0290	0.0185	-0.0475	0.0161	-0.0451		
1996	15.1840	17.3157	18.7936	0.1195	-0.0122	-0.0168	-0.0297	0.0129	-0.0305	0.0137		
1997	15.3566	17.3708	18.9333	0.1726	0.0551	0.1397	0.0568	0.0829	0.0576	0.0821		
1998	15.4119	17.4038	19.0256	0.0553	0.0330	0.0923	0.0373	0.0550	0.0374	0.0549		
1999	15.3692	17.3652	19.0140	-0.0427	-0.0386	-0.0117	0.0099	-0.0216				
2000	15.0169	17.2819	18.9094	-0.3523	-0.0832	-0.1045	-0.0228	-0.0817				
2001	15.0116	17.2280	18.9186	-0.0053	-0.0539	0.0092	0.0442	-0.0350				
2002	15.0824	17.1644	18.8320	0.0708	-0.0636	-0.0867	-0.0458	-0.0409				

Aerospace (Aerospace NAICS/SIC Only) Industry:

Dependent variable before taking the first difference shows no stationary unit root at 95% CI.

Table 39. Unit Root Test for Aerospace Data

Dickey-Fuller test for unit root

Number of obs = 30

Interpolated Dickey-Fuller

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.114	-3.716	-2.986	-2.624

MacKinnon approximate p-value for Z(t) = 0.2388

Dependent variable after taking the first difference reflects data is stationary.

Table 40. Unit Root Test After Taking First Difference for Aerospace Data

Dickey-Fuller test for unit root

Number of obs = 29

Interpolated Dickey-Fuller

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.438	-3.723	-2.989	-2.625

MacKinnon approximate p-value for Z(t) = 0.0097

Table 41. Regression Results for Aerospace for 1972-2002

Regression with robust standard errors (1972-2002)

Number of obs =	30
F(2, 27) =	41.85
Prob > F =	0
R-squared =	0.7589
Root MSE =	0.04136

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.042252	0.060891	0.69	0.494	-0.0826862	0.16719
fmfgpay	1.036692	0.17225	6.02	0	0.6832638	1.390121
_cons	0.020491	0.007194	2.85	0.008	0.0057304	0.035252

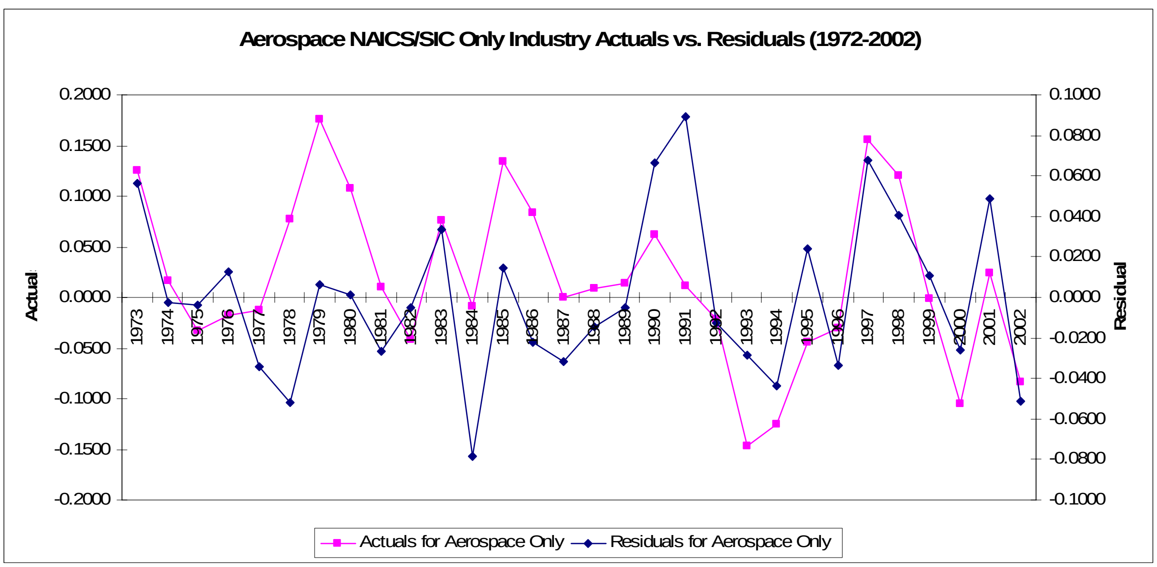

Figure 38. Actuals vs. Residuals for Aerospace 1972-2002

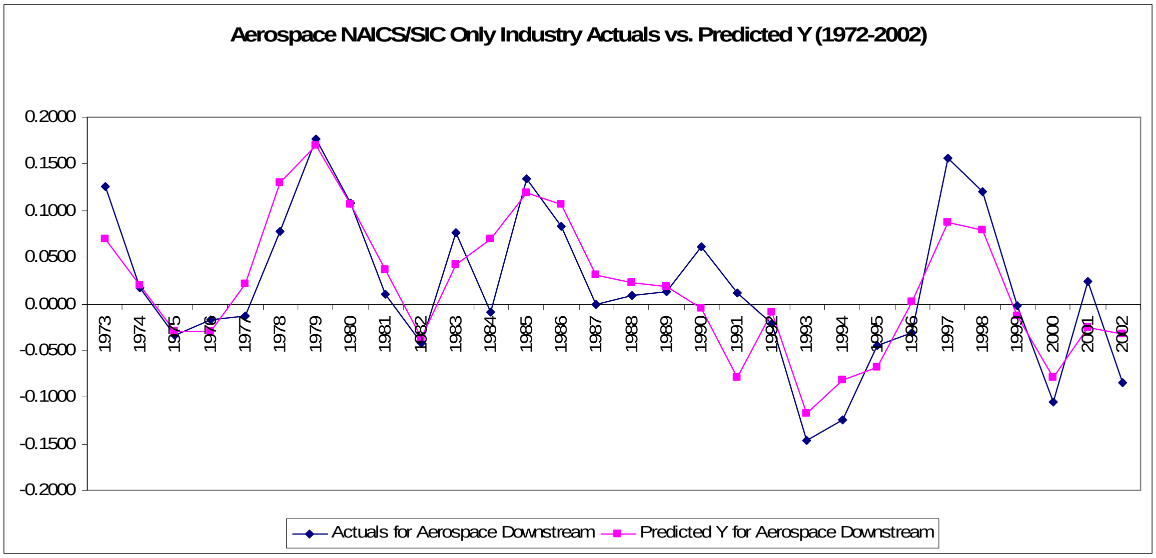

Figure 39. Actuals vs. Predicted Y for Aerospace 1972-2002

Table 42. Regression Results for Aerospace for 1972-1998

Regression with robust standard errors (1972-1998)

Number of obs =	26
F(2, 23) =	33.54
Prob > F =	0
R-squared =	0.7536
Root MSE =	0.04186

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.037237	0.07382	0.5	0.619	-0.1154713	0.189945
fmfgpay	1.022433	0.183407	5.57	0	0.6430264	1.40184
_cons	0.021474	0.008235	2.61	0.016	0.0044398	0.038509

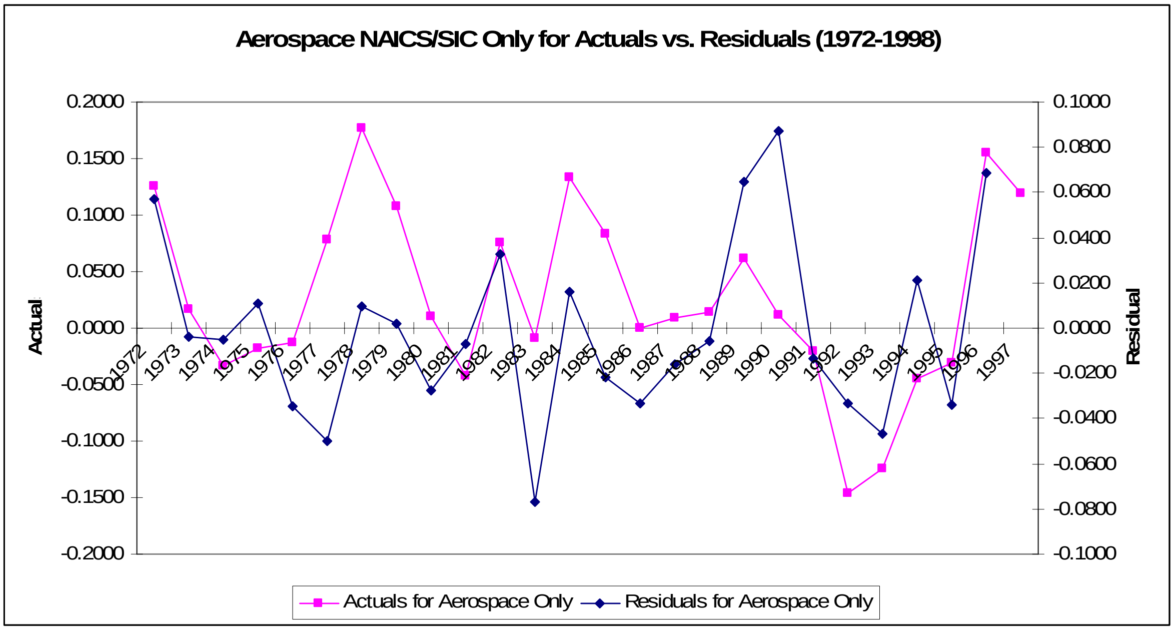

Figure 40. Actuals vs. Residuals for Aerospace 1972-1998

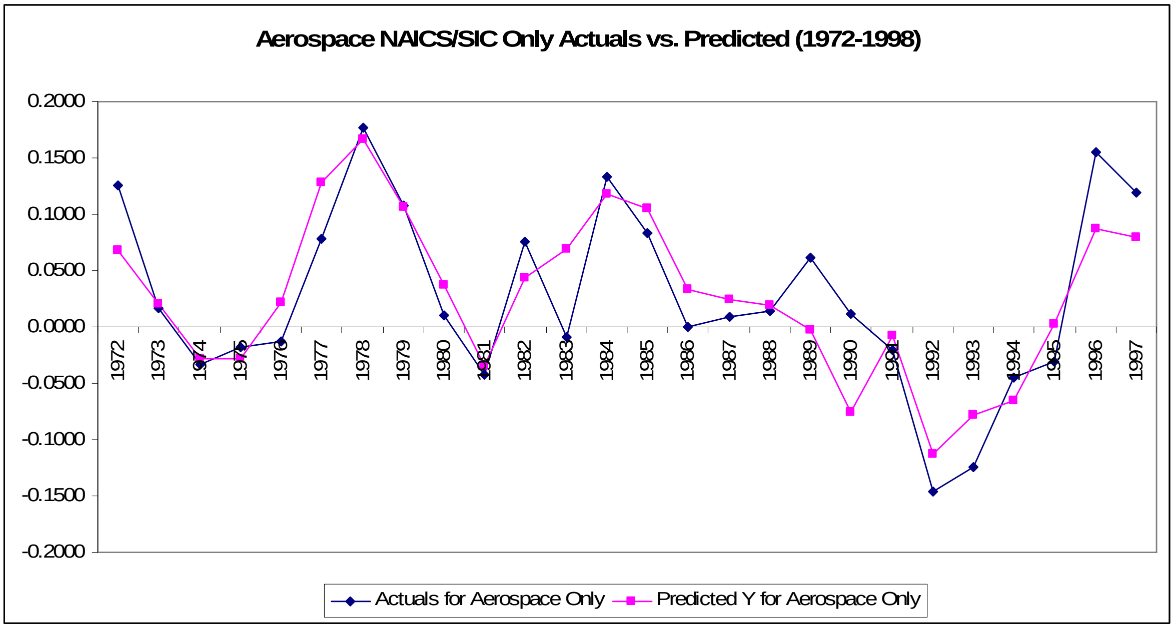

Figure 41. Actuals vs. Predicted Y for Aerospace 1972-1998

Table 43. Regression Results for Aerospace for 1972-1992

Regression with robust standard errors (1972-1992)

Number of obs =	20
F(2, 17) =	14.67
Prob > F =	0.0002
R-squared =	0.6475
Root MSE =	0.03923

fmfgvalshp	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
fmafgexp	0.012773	0.085841	0.15	0.883	-0.1683354	0.193882
fmfgpay	0.853001	0.185642	4.59	0	0.4613306	1.244671
_cons	0.025061	0.009807	2.56	0.02	0.0043694	0.045753

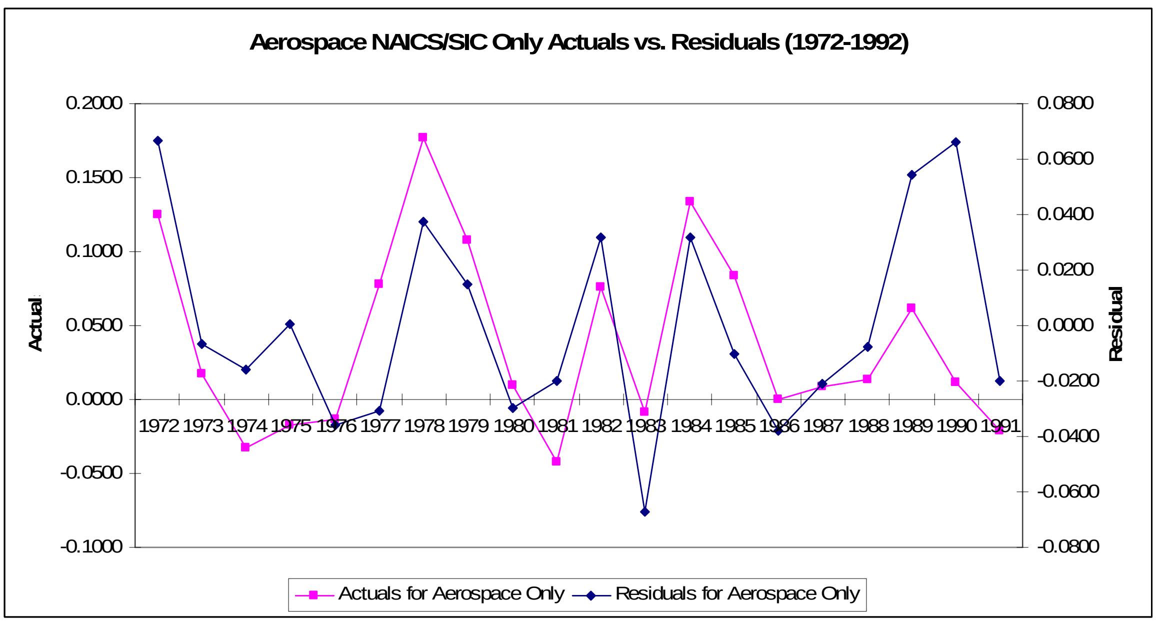

Figure 42. Actuals vs. Residuals for Aerospace 1972-1992

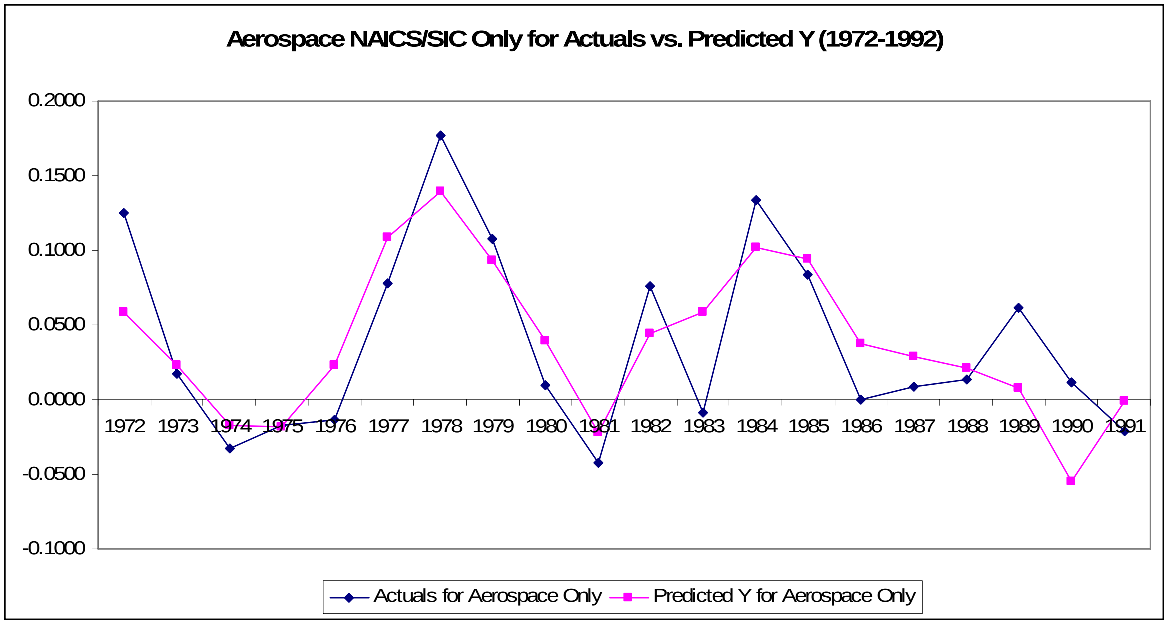

Figure 43. Actuals vs. Predicted Y for Aerospace 1972-1992

Table 44. Data for Aerospace Returns to Scale Regression

	Aerospace Downstream - Aerospace NAICS/SIC Only											
year	dncapexp	dnpay	dnvalshp	fdncapexp	fdnpay	fdnvalshp	residdn	yhatdn	residdn7298	yhatdn7298	residdn7292	yhatdn7292
1972	13.8055	17.1756	18.1959									
1973	14.0889	17.2109	18.3212	0.2834	0.0353	0.1253	0.0562	0.0691	0.0572	0.0681	0.0665	0.0588
1974	14.1351	17.2083	18.3381	0.0462	-0.0026	0.0169	-0.0028	0.0197	-0.0036	0.0205	-0.0065	0.0234
1975	14.1977	17.1578	18.3050	0.0626	-0.0505	-0.0331	-0.0039	-0.0292	-0.0053	-0.0278	-0.0159	-0.0172
1976	14.2812	17.1056	18.2873	0.0835	-0.0522	-0.0177	0.0124	-0.0301	0.0111	-0.0288	0.0007	-0.0184
1977	14.3978	17.1013	18.2742	0.1166	-0.0043	-0.0132	-0.0342	0.0210	-0.0346	0.0214	-0.0361	0.0229
1978	14.6756	17.1950	18.3518	0.2778	0.0937	0.0777	-0.0517	0.1294	-0.0499	0.1276	-0.0308	0.1085
1979	15.0899	17.3224	18.5283	0.4143	0.1274	0.1765	0.0064	0.1701	0.0093	0.1672	0.0375	0.1390
1980	15.2212	17.4001	18.6360	0.1313	0.0777	0.1077	0.0011	0.1066	0.0019	0.1058	0.0147	0.0930
1981	15.1697	17.4177	18.6457	-0.0514	0.0176	0.0097	-0.0269	0.0366	-0.0279	0.0376	-0.0297	0.0394
1982	15.1693	17.3625	18.6037	-0.0004	-0.0552	-0.0420	-0.0052	-0.0368	-0.0070	-0.0350	-0.0200	-0.0220
1983	15.1339	17.3851	18.6796	-0.0354	0.0226	0.0759	0.0335	0.0424	0.0326	0.0433	0.0320	0.0439
1984	15.4434	17.4200	18.6711	0.3095	0.0349	-0.0085	-0.0782	0.0697	-0.0772	0.0687	-0.0673	0.0588
1985	15.6271	17.5077	18.8048	0.1837	0.0877	0.1338	0.0146	0.1192	0.0158	0.1180	0.0316	0.1022
1986	15.6950	17.5874	18.8884	0.0679	0.0796	0.0835	-0.0224	0.1059	-0.0219	0.1054	-0.0103	0.0938
1987	15.5316	17.6045	18.8879	-0.1634	0.0171	-0.0004	-0.0317	0.0313	-0.0333	0.0329	-0.0380	0.0376
1988	15.4367	17.6108	18.8963	-0.0949	0.0063	0.0084	-0.0146	0.0230	-0.0160	0.0244	-0.0208	0.0292
1989	15.5448	17.6050	18.9100	0.1080	-0.0058	0.0137	-0.0053	0.0190	-0.0059	0.0196	-0.0078	0.0215
1990	15.3918	17.5869	18.9718	-0.1530	-0.0181	0.0618	0.0665	-0.0047	0.0645	-0.0027	0.0541	0.0077
1991	15.3307	17.4941	18.9829	-0.0610	-0.0929	0.0111	0.0895	-0.0784	0.0869	-0.0758	0.0661	-0.0550
1992	15.4308	17.4621	18.9619	0.1000	-0.0320	-0.0209	-0.0124	-0.0085	-0.0134	-0.0075	-0.0199	-0.0010
1993	15.0604	17.3437	18.8154	-0.3703	-0.1184	-0.1466	-0.0287	-0.1179	-0.0332	-0.1134		
1994	14.9127	17.2514	18.6905	-0.1477	-0.0923	-0.1249	-0.0435	-0.0814	-0.0465	-0.0784		
1995	14.7839	17.1707	18.6459	-0.1289	-0.0806	-0.0446	0.0239	-0.0685	0.0211	-0.0657		
1996	14.9182	17.1479	18.6150	0.1343	-0.0228	-0.0309	-0.0334	0.0025	-0.0341	0.0032		
1997	15.1211	17.2046	18.7705	0.2029	0.0567	0.1555	0.0677	0.0878	0.0685	0.0870		
1998	15.2135	17.2575	18.8902	0.0924	0.0529	0.1197	0.0405	0.0792	0.0407	0.0790		
1999	15.1844	17.2269	18.8887	-0.0291	-0.0306	-0.0016	0.0109	-0.0125				
2000	14.7785	17.1469	18.7831	-0.4058	-0.0800	-0.1056	-0.0260	-0.0796				
2001	14.8065	17.1016	18.8069	0.0279	-0.0452	0.0238	0.0490	-0.0252				
2002	14.9213	17.0456	18.7228	0.1148	-0.0561	-0.0840	-0.0512	-0.0328				

Appendix I: Regression Results for Impact on Government Contracts

This appendix contains the source data for the regression model and the results of the regression performed for this study.

A Dickey-Fuller test was performed to determine if the dependent variable had a stationary unit root. Since the data failed the Dickey-Fuller test, the first difference was taken. The transformed data passed the Dickey-Fuller test (Table 45) with a significant p-value of 0.0147 for Z(t).

Table 45. Dickey-Fuller Test for Unit Root

Number of obs = 19

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.303	-3.75	-3	-2.63

MacKinnon approximate p-value for Z(t) = 0.0147

Post-estimation tests were performed to ensure normality of residuals, to identify the presence of multicollinearity, and to check proper model specification. For normality of residuals, the data was plotted into a histogram and the Shapiro-Wilk normality test was performed. The residuals are normal through both visual inspection (see Figure 44) and Shapiro-Wilk test with a Prob>z of .99616 (see Table 46).

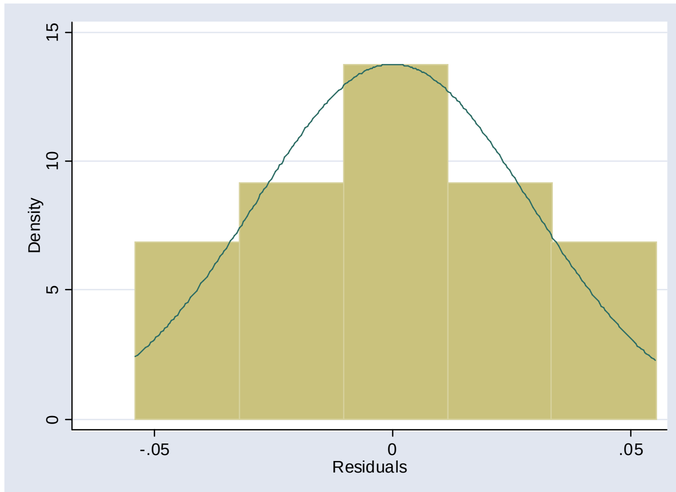

Figure 44. Histogram of Residuals

Table 46. Shapiro-Wilk Normality Test

Variable	Obs	W	V	z	Prob>z
residuals	20	0.989	0.266	-2.666	0.99616

The mean variance inflation factor (VIF) score is 2.91 which is well below 10 (see Table 47).

Table 47. Variance Inflation Factor

Variable	VIF	1/VIF
fdchgopcost	6.09	0.16411
fdchgtotemp	3.64	0.275041
fdcapinvfa	3.26	0.306528
fdchgavgfs~e	3.25	0.307518
fdprofitma~n	2.03	0.493547
fdchgcr4	1.88	0.531853
fdchgdfundg	1.71	0.585952
fdchgird	1.45	0.689367
Mean VIF	**2.91**	

Thus, multicollinearity is not detected between two or more variables. Finally, a model specification test was performed based on the variable of prediction and the variable of squared prediction. For the model to be correctly specified, the p-value of the variable of squared should be insignificant. The p-value of 0.526 for *_hatsq* is insignificant (see Table 48).

Table 48. Model Specification Test

Source	SS	df	MS
Model	0.0131	2	0.0066
Residual	0.0155	17	0.0009
Total	0.0287	19	0.0015

Nbr of obs	20
F(2, 17)	7.18
Prob > F	0.0055
R-squared	0.458
Adj R-squared	0.3942
Root MSE	0.03022

fdaggregat~o	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
_hat	0.8967	0.3117	2.8800	0.01	0.2390	1.5544
_hatsq	6.2960	9.7238	0.6500	0.526	-14.2193	26.8114
_cons	-0.0041	0.0092	-0.4400	0.665	-0.0235	0.0154

Table 49. Source Data Before Taking the First Difference for Regression

Year	%ChgTotEmp	%ChgDFundg	ProfitMargin	%ChgOpCost	%ChgCR4	CapInv%FA	%ChgIR&D	%ChgAvgFSize	%AggregateCO
1982	-0.0456	0.2160	0.0331	-0.0772	0.0104	0.1751	0.0078	-0.0512	0.0452
1983	-0.0385	0.1273	0.0347	0.1701	-0.0118	0.1477	-0.1014	0.0301	0.0132
1984	0.0033	0.0638	0.0410	0.0370	-0.0119	0.1934	-0.0294	0.0100	0.0301
1985	0.0674	0.0486	0.0309	0.1733	-0.0120	0.1945	0.0059	0.1452	0.0371
1986	0.0618	-0.0537	0.0277	0.0254	-0.0122	0.1875	0.1341	0.0025	0.0600
1987	0.0123	-0.0463	0.0413	-0.0398	-0.0123	0.1640	-0.1574	-0.0865	0.0286
1988	0.0115	-0.0481	0.0433	-0.0109	0.0172	0.1525	-0.0175	0.0373	0.0469
1989	0.0031	-0.0641	0.0327	0.0161	0.0169	0.1600	0.0328	-0.0104	0.0733
1990	-0.0082	-0.0458	0.0336	0.0869	0.0166	0.1334	0.0595	-0.0764	0.1443
1991	-0.0777	-0.1534	0.0184	-0.0320	0.0163	0.1283	0.2745	-0.1084	0.2293
1992	-0.0588	-0.0902	-0.0137	-0.0256	0.0161	0.1404	0.2036	-0.1377	0.1806
1993	-0.1010	-0.1056	0.0359	-0.0692	0.0168	0.0984	-0.0573	-0.0987	0.1986
1994	-0.1035	-0.1639	0.0469	-0.0950	0.0166	0.0676	0.0153	-0.1028	0.1436
1995	-0.0749	-0.0278	0.0377	0.0212	0.0163	0.0820	-0.1552	-0.1344	0.0976
1996	-0.0362	-0.0121	0.0563	-0.0200	0.0160	0.1035	0.0869	-0.0401	0.0304
1997	0.0587	0.0005	0.0518	0.0954	0.0158	0.1262	0.1072	0.0121	0.0270
1998	0.0334	0.0310	0.0481	0.0934	0.0223	0.1301	0.0231	0.0554	0.0214
1999	-0.0678	0.0827	0.0650	-0.0051	0.0041	0.1196	-0.0767	-0.0566	0.0194
2000	-0.0874	0.0579	0.0469	-0.0374	0.0041	0.0823	0.0255	-0.1460	0.0247
2001	-0.0386	0.0936	0.0389	0.0796	0.0041	0.0853	0.3746	-0.0108	0.0322
2002	-0.0744	0.0062	0.0410	-0.0770	0.0040	0.1015	0.0678	0.0081	0.0359

Table 50. First Difference Data for Regression and Resulting Residuals

Year	fdChgTotEmp	fdChgDFundg	fdProfitMargin	fdChgOpCost	fdChgCR4	fdCapInv%FA	fd%ChgIR&D	fd%ChgAvgFSize	fd%AggregateCO	residuals
1982										
1983	0.0071	-0.0887	0.0016	0.2474	-0.0222	-0.0274	-0.1092	0.0814	-0.0320	-0.0357
1984	0.0418	-0.0635	0.0063	-0.1331	-0.0001	0.0457	0.0720	-0.0202	0.0169	0.0116
1985	0.0640	-0.0151	-0.0101	0.1362	-0.0001	0.0011	0.0353	0.1352	0.0070	0.0350
1986	-0.0056	-0.1023	-0.0032	-0.1479	-0.0001	-0.0070	0.1282	-0.1427	0.0229	-0.0085
1987	-0.0495	0.0074	0.0136	-0.0652	-0.0002	-0.0235	-0.2914	-0.0890	-0.0314	-0.0248
1988	-0.0008	-0.0018	0.0020	0.0290	0.0295	-0.0115	0.1399	0.1238	0.0183	-0.0240
1989	-0.0084	-0.0160	-0.0106	0.0269	-0.0003	0.0075	0.0503	-0.0477	0.0264	-0.0071
1990	-0.0113	0.0183	0.0009	0.0709	-0.0003	-0.0266	0.0267	-0.0660	0.0709	0.0551
1991	-0.0695	-0.1075	-0.0152	-0.1189	-0.0003	-0.0051	0.2150	-0.0320	0.0851	0.0269
1992	0.0189	0.0632	-0.0320	0.0064	-0.0003	0.0122	-0.0710	-0.0293	-0.0487	-0.0137
1993	-0.0422	-0.0155	0.0496	-0.0436	0.0008	-0.0420	-0.2609	0.0390	0.0179	0.0411
1994	-0.0025	-0.0583	0.0110	-0.0259	-0.0003	-0.0308	0.0726	-0.0041	-0.0550	-0.0541
1995	0.0285	0.1361	-0.0093	0.1162	-0.0003	0.0144	-0.1704	-0.0316	-0.0459	-0.0145
1996	0.0387	0.0157	0.0186	-0.0412	-0.0003	0.0215	0.2420	0.0943	-0.0672	-0.0439
1997	0.0949	0.0127	-0.0044	0.1155	-0.0003	0.0227	0.0203	0.0522	-0.0034	0.0225
1998	-0.0253	0.0305	-0.0037	-0.0021	0.0065	0.0039	-0.0841	0.0433	-0.0056	-0.0074
1999	-0.1012	0.0517	0.0169	-0.0985	-0.0182	-0.0105	-0.0998	-0.1120	-0.0020	0.0043
2000	-0.0196	-0.0248	-0.0181	-0.0323	0.0000	-0.0373	0.1023	-0.0895	0.0053	0.0029
2001	0.0488	0.0357	-0.0080	0.1170	0.0000	0.0030	0.3491	0.1352	0.0075	0.0241
2002	-0.0358	-0.0873	0.0021	-0.1566	0.0000	0.0162	-0.3069	0.0189	0.0037	0.0105

Bibliography

1. Acemoglu, Daron. “Technical Change, Inequality, and the Labor Market,” Journal *of Economic Literature,* 40: 7-72 (March 2002).

2. Aerospace Commission. *Commission on the Future of the U.S Aerospace Industry*. Washington: Department of Commerce, November 2002.

3. Baye, Michael R., *Managerial Economics and Business Strategy* (4th Edition). New York: McGraw-Hill, 2003.

4. Blair, Roger D. and Jeffrey L. Harrison. Monopsony: Antitrust Law and Economics. New Jersey: Princeton University Press, 1993.

5. Boettcher, Jennifer C. and Leonard M. Gaines. *Industry Research Using the Economic Census*. Connecticut: Greenwood Press, 2004.

6. Boezer, Gordon, Ivars Gutmanis, and Joseph E. Muckerman II. “The Defense Technology and Industrial Base: Key Component of National Power,” *Parameters,* ##: 26-51 (Summer 1997).

7. Christensen, Clayton M., Matt Verlinden, and George Westerman. “Disruption, Disintegration and the Dissipation of Differentiability,” *Industrial and Corporate Change*, 11: 955-993 (2002).

8. Conyon, Martin, Steve Thompson and Peter Wright. *The Impact of Mergers and Acquisitions on Company Employment in the United Kingdom*. Centre for Research on Globalisation and Labour Markets, School of Economics, University of Nottingham, May 2000.

9. Demski, Joel S. and Robert P. Magee. “A Perspective on Accounting for Defense Contracts,” *The Accounting Review*, 67: 732-740 (1992).

10. Department of Defense. *The Defense Acquisition System*. DoD Directive 5000.1. Washington: GPO, 12 May 2003.

11. Department of Defense. *Operation of the Defense Acquisition System*. DoD Directive 5000.2. Washington: GPO, 12 May 2003.

12. Department of Defense. *Defense Science Board (DSB) Task Force on Vertical Integration and Supplier Decision*. Washington: Office of the Secretary of Defense, May 1997.

13. Department of Defense. *Defense Science Board (DSB) Task Force on Antitrust Aspects of Defense Consolidation*. Washington: Office of the Under Secretary of Defense for Acquisition & Technology, April 1994.

14. Department of Defense. *National Defense Budget Estimates for FY 2006*. Washington: Office of the Under Secretary of Defense (Comptroller), April 2005.

15. Department of Justice and Federal Trade Commission. *1992 Horizontal Merger Guidelines.* Washington: Federal Trade Commission, April 1997 http://www.ftc.gov/bc/docs/horizmer.htm.

16. Deutch, John. "Consolidation of the U.S. Defense Industrial Base," *Acquisition Review Quarterly*, 8: 137-150 (Fall 2001).

17. Driessnack, John D. and David R. King. "An Initial Look at Technology and Institutions on Defense Industry Consolidation," *Defense Acquisition Review Journal*, 11: 62-77 (January-April 2004).

18. Eland, Ivan. "Reforming a Defense Industry Rife with Socialism, Industrial Policy, and Excessive Regulation," *Policy Analysis*, 421: 1-18 (December 2001).

19. Environmental Protection Agency. *EPA Office of Compliance Sector Notebook Project: Profile of Aerospace Industry.* Washington: Office of Enforcement and Compliance Assurance, November 1998.

20. Flamm, Kenneth. "Post-Cold War Policy and the U.S. Defense Industrial Base," *The Bridge*, 35: 5-12 (Spring 2005).

21. Gholz, Eugene and Harvey M. Sapolsky. "Restructuring the U.S. Defense Industry," *International Security*, 24: 5-31 (Winter 1999/2000).

22. Gowrisankaran, Gautam and Thomas J. Holmes. "Mergers and the Evolution of Industry Concentration: Results From the Dominant Firm Model," *Rand Journal of Economics*.

23. Harper, John K. "Corporate Governance and Performance During Consolidation of the United States and European Defense Industries," *Journal of Management and Governance*, 2: 333-353 (1999).

24. Hetrick, Ron L. "Employment in High-Tech Defense Industries in a Post Cold War Era," *Monthly Labor Review*, 119: 57-63 (August 1996).

25. Kawamoto, Takuji. "What Do the Purified Solow Residuals Tell Us about Japan's Lost Decade?" *Monetary and Economic Studies*: 113-148 (February 2005).

26. Kim, Jongwoo. "Concentrated?: High-Tech Defense Industries in the Post-Cold War Era," *LBJ Journal of Public Affairs*, 12: 54-64 (Spring 2000).

27. King, David R. and John D. Driessnack. "Investigating the Integration of Acquired Firms in High-Technology Industries: Implications for Industrial Policy," *Acquisition Review Quarterly*, 10: 261-283 (Summer 2003).

28. Kovacic, William E. "Competition Policy in the Postconsolidation Defense Industry," *Antitrust Bulletin*, 44, 2: 421-487 (Summer 1999).

29. Kumar, Krishna B., Raghuram G. Rajan, and Luigi Zingales. "What Determines Firm Size?" Marshall School of Business, University of Southern California. Graduate School of Business, University of Chicago, *NBER & CPER*. March 2001.

30. Leitzel, Jim. "Competition in Procurement," *Policy Sciences*, 25: 43-56 (February 1992).

31. Linster, Bruce G., LtCol Stephen Slate, and Robert E. Waller. "Consolidation of the U.S. Defense Industrial Base: Impact on Research Expenditures," *Acquisition Review Quarterly*, 9: 143-150 (Spring 2002).

32. Luker, Jr., William and Donald Lyons. "Employment Shifts in High Technology Industries, 1988-96," *Monthly Labor Review*, 120: 12-24 (June 1997).

33. McNutt, Ross T. *Reducing DoD Product Development Time: The Role of the Schedule Development Process*. PhD dissertation. Massachusetts Institute of Technology, Boston MA, 1998.

34. National Science Foundation, Division of Science Resources Statistics. *National Patterns of Research and Development:* 2003, NSF 05-308, Brandon Shackelford, Arlington VA, 2005.

35. Perloff, Jeffrey M. and Klaas T. van 't Veld. *Modern Industrial Organization* (2nd Edition). New York: Harper Collins College Publishers, 1994.

36. Perry, Martin K. "Vertical Integration: Determinants and Effects," *Handbook of Industrial Organization*, 1: 183-250 (1989).

37. Redman, Kevin D. *Analysis of Pricing Techniques in Determining a Fair and Reasonable Price.* MS thesis, Naval Post Graduate School, Monterey CA, December 1998 (ADA205036).

38. Reichelstein, Stefan,. "Constructing Incentive Schemes for Government Contracts: An Application of Agency Theory," *The Accounting Review*, 67: 712-731 (October 1992).

39. Rogerson, William P. "Overhead Allocation and Incentives for Cost Minimization in Defense Procurement," *The Accounting Review*, 67: 671-690 (October 1992).

40. Stigler, George J. *The Organization of Industry*. Illinois: Richard D. Irwin, Inc., 1968.

41. Thomson, Allison. "Defense-Related Employment and Spending, 1996-2006," Monthly Labor Review, 121: 14-33 (July 1998).

42. United States General Accounting Office: Testimony Before the Subcommittee on Oversight and Investigations, Committee on Armed Services, House of Representatives. *Defense Industry Consolidation: Issues Related to Acquisition and Merger Restructuring Costs.* GAO/T-NSIAD-94-247. Washington: Government Printing Office, July 1994.

43. United States General Accounting Office: Report to Congressional Committees. *Defense Restructuring Costs: Payment Regulations Are Inconsistent With Legislation.* GAO/NSIAD-95-106. Washington: Government Printing Office, August 1995.

44. United States General Accounting Office: Report to Congressional Requesters. *Overhead Costs: Defense Industry Initiatives to Control Overhead Rates.* GAO/NSIAD-95-115. Washington: Government Printing Office, May 1995.

45. United States General Accounting Office: Briefing Report to Congressional Requesters. *Defense Contractors: Pay, Benefits, and Restructuring During Defense Downsizing.* GAO/NSIAD-96-19BR. Washington: Government Printing Office, October 1995.

46. United States General Accounting Office: Report to Congressional Committees. *Defense Contractor Restructuring: First Application of Cost and Savings Regulations.* GAO/NSIAD-96-80. Washington: Government Printing Office, April 1996.

47. United States General Accounting Office: Report to Congressional Committees. *Defense Restructuring Costs: Projected and Actual Savings From Martin-*

Marietta Acquisition of GE Aerospace. GAO/NSIAD-96-191. Washington: Government Printing Office, September 1996.

48. United States General Accounting Office: Report to the Secretary of Defense. *Weapons Acquisition: Better Use of Limited DOD Acquisition Funding Would Reduce Costs.* GAO/NSIAD-97-23. Washington: Government Printing Office, February 1997.

49. United States General Accounting Office: Report to Congressional Committees. *Defense Restructuring Costs: Information Pertaining to Five Business Combinations.* GAO/NSIAD-97-97. Washington: Government Printing Office, April 1997.

50. United States General Accounting Office: Testimony Before the Subcommittee on Acquisition and Technology, Committee on Armed Services, United States Senate. *Defense Industry Restructuring: Cost and Savings Issues.* GAO/T-NSIAD-97-141. Washington: Government Printing Office, April 1997.

51. United States General Accounting Office: Report to Congressional Requesters. *Defense Industry: Trends in DOD Spending, Industrial Productivity, and Competition.* GAO/PEMD-97-3. Washington: Government Printing Office, January 1997.

52. United States General Accounting Office: Testimony Before the Subcommittee on Acquisition and Technology, Committee on Armed Services, U.S. Senate. *Defense Industry Consolidation: Competitive Effects of Mergers and Acquisitions.* GAO/T-NSIAD-98-112. Washington: Government Printing Office, March 1998.

53. United States General Accounting Office: Report to Congressional Committees. *Defense Industry: Consolidation and Options for Preserving Competition.* GAO/NSIAD-98-141. Washington: Government Printing Office, April 1998.

54. United States General Accounting Office: Report to Congressional Committees. *Defense Industry Restructuring: Updating Cost and Savings Information.* GAO/NSIAD-98-156. Washington: Government Printing Office, April 1998.

55. United States General Accounting Office: Report to Congressional Committees. *Defense Contractor Restructuring: DOD Risks Forfeiting Savings on Fixed-Price Contract.* GAO/NSIAD-98-162. Washington: Government Printing Office, July 1998.

56. United States General Accounting Office: Report to Congressional Requesters. *Defense Contractor Restructuring: Benefits to DOD and Contractors.*

GAO/NSIAD-98-225. Washington: Government Printing Office, September 1998.

57. United States General Accounting Office: Report to Congressional Committees. *Defense Industry: Restructuring Costs Paid, Savings Realized, and Means to Ensure Benefits.* GAO/NSIAD-99-22. Washington: Government Printing Office, December 1998.

58. Williamson, Oliver E. "Transaction Cost Economics," *Handbook of Industrial Organization*, 1: 135-182 (1989).

Vita

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14. ABSTRACT

The purpose of this research was to investigate the impact of the defense industry consolidation on the aerospace industry. The defense industry is comprised of twelve sectors that impact different industries. This research focused on the formal aspects of the aerospace industry which supports six of the twelve defense sectors. The aerospace industry is identified by six North American Industry Classification System (NAICS) or Standard Industrial Classification (SIC) codes. Using the structure-conduct-performance paradigm, a method in industrial organization, this thesis focused on how the defense consolidation affected the structure and behavior of the aerospace industry. For structure, this study examined the industry concentration, buyers and sellers, vertical integration, and product differentiation. Barriers to entry, asset specificity, capital investment, and research and development intensity were analyzed for conduct. Profitability ratios, returns to scale, and impact on cost overruns of government contracts were analyzed for the area of performance. Finally, this study identified trends by comparing the aerospace industry to total manufacturing industry, and comparing the surviving large downstream firms to the aerospace industry and total manufacturing industry.

15. SUBJECT TERMS

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