May 2007

Defense Procurement Funding to Business Enterprises in the Development of U.S. Electronics Sector

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Abstract
The United States was an early leader in the history of the global electronics sector. Success in technology had strong implications for national security, political influence, and economic growth. Thus, there is much value to be gained in understanding the conditions of the early U.S. electronics sector development.

It is suggested from background materials that government support was an important, possibly essential, force in the evolution of the electronics sector. The influence of the federal government on the development of the industry has been attributed to a variety of mechanisms from antitrust to intellectual property policies but prominence is usually assigned to the funds that the US government provided to the business sector in the form of R&D funding and procurement contracts. As Mowery and Nelson (1999) put it: "[v]irtually all accounts of the rise to dominance of the American semiconductor and computer industries … emphasize the procurement and R&D policies of the U.S. Department of Defense." Of the two policies, procurement arises as the more influential factor.

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INTRODUCTION

The United States was an early leader in the history of the global electronics sector. Success in technology had strong implications for national security, political influence, and economic growth. Thus, there is much value to be gained in understanding the conditions of the early U.S. electronics sector development.

It is suggested from background materials that government support was an important, possibly essential, force in the evolution of the electronics sector. The influence of the federal government on the development of the industry has been attributed to a variety of mechanisms from antitrust to intellectual property policies but prominence is usually assigned to the funds that the US government provided to the business sector in the form of R&D funding and procurement contracts. As Mowery and Nelson (1999) put it: "[v]irtually all accounts of the rise to dominance of the American semiconductor and computer industries … emphasize the procurement and R&D policies of the U.S. Department of Defense." Of the two policies, procurement arises as the more influential factor.

With these accounts in mind, I further research the extent, nature, and impact of defense procurement on the electronics sector and companies during the 1950-1970s time period. Analysis of historical primary texts and secondary sources reveal that defense procurement consistently constituted a large percentage of GNP over this time period. Examination of the nature of defense including the types of contracts available and the goals that policymakers were concerned with, show us some of the reasons how and why procurement was able to play such important roles. We learned that electronic content was procured as part of several procurement programs and made up a significant portion of total awarded contracts. From the electronic

industries' perspective, sales to the government were discovered to make up half or more of total electronics sales. These sales were highly concentrated to the top companies but procurement policies often made a deliberate effort to support small businesses.

On an industry-level, the government's influence was large and important, but was an individual company that participated in defense procurement better off or more successful in the future than a comparable firm that didn't? Although defense sales clearly provided often much-needed revenue to firms along with other benefits, not all remarks about the role of defense procurement in previous scholarly discussion have been positive. I reviewed some of the arguments from both sides and next proceeded to search for quantitative evidence to back up these qualitative observations. Finally, finding unsatisfactory to non-existent quantitative evidence, I identified approaches to gather the necessarily procurement and financial firm-level data from various primary sources in order to model and test relationships between participation in defense contracting and later company success.

BACKGROUND

Definition

Electronics is defined as "the science dealing with the development and application of devices and systems involving the flow of electrons in a vacuum, in gaseous media, and in semiconductors." Electronic devices allow for conversion and distribution of power as well as control and processing of data. It includes both components and end products. A classification of electronics is provided below. Outlined in the 1970s, it is appropriate for our historical study and still quite relevant today (Tilton 1971).

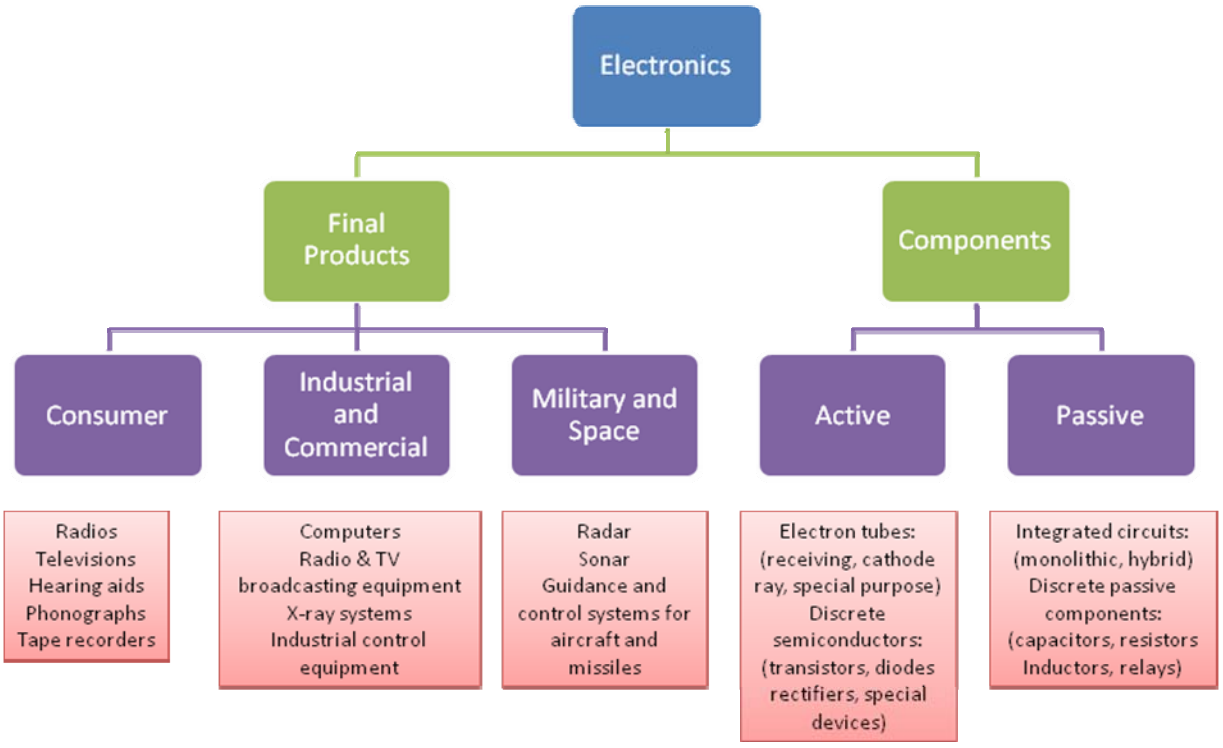


Figure 1: Classification of Electronics Products
Source: Tilton (1971)

Importance

Today's information technology industries include electronics and, industries such as software and the Internet, those directly made possible by electronics. According to the 2002 US Economic Census, 4.5 million people in the United States were employed in IT manufacturing and IT services. It is still the fastest growing sector of the economy today, contributing more than $1 trillion in revenue every year to GDP.

In addition to the direct economic benefits that electronics have brought to the nation's economy, they are an input into almost every other facet of American industries and businesses. The productivity impact of this is vast, but difficult to measure. One conservative estimate attributes 64% of total factor productivity growth in as recent as 1995-2000 to information technology advances which have been made possible by semiconductors and computers (Jorgenson *et al.* 2002). As consumers, we have come to rely on common personal consumer electronics products such as laptops, cell phones, mp3 music players, etc. for convenient communication and gathering and processing of information.

In another crucial application, the contributions of electronics firms were vital to the strength of the country's national defense. With the increasing role of sophisticated weapons, planes, ships, and other military implements through the 20th century, it was acknowledged with the creation of ARPA (Advanced Research Projects Agency), now DARPA, that maintaining a lead in applying state-of-the-art technology for military capabilities was a high priority and a centerpiece of military strategy. In turn, due to this dependent relationship, as we will see, the military played an important part shaping the development of the electronics sector.

Researching the conditions and reasons for the success of the U.S. electronics sector is important for intellectual and scholarly purposes because it adds to a greater understanding in economics about technology industries, role of governments, and innovation. It should also be of interest to historians as the story of the historical development of the electronics industry is an integral part of the story of the United States as a whole.

Finally, and possibly most importantly, for the same reasons that we study economics and history in general, it is recognized that as the United States seeks to maintain leadership and success in technology, "business leaders, policymakers, and university researchers will need to understand the sources of their past success." (*Funding a Revolution* 1999) The lessons of the past including any generalizations of phenomenon or assessments on the efficacy of past policies can provide valuable insights to be used when developing future policies and strategies so that the same success can be replicated.

Historical Context

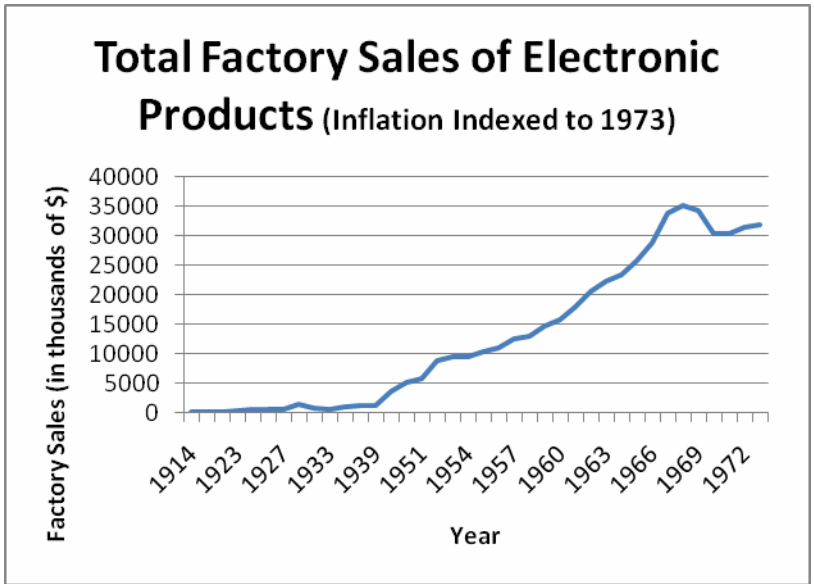


Figure 2: Total Sales of Electronics Products (1914-1972)
Source: Data collected from *Electronic Industries Yearbook* (1962-1972)

It can be said that the origin of the electronics sector began with the invention of the radio in the late 19th century. Vacuum tubes were developed in 1915 and were used in early electronic devices such as radios, televisions, and early computers. ENIAC, the first general purpose electronic digital computer, was finished in 1946 at University of Pennsylvania. Although the ENIAC still used vacuum tube technology, at around the same time, transistors, a type of semiconductor device, were invented and would replace vacuum tubes in electronic devices as they were smaller, cheaper, more reliable, and had a longer life.

As seen from the chart, based on data collected from the 1962 through 1972 issues of *Electronics Industries Yearbook*, sales in the electronics sector only truly began taking off during World War II in the 1940s. The industries continued their exponential growth into the Cold War era. In 1959, integrated circuits were invented which allowed for the integration of transistors

into a small chip and could be reliably mass produced. Thus it makes sense to focus on the time period of 1950-1970 as they prove to be the important formative years of the electronics sector.

LITERATURE REVIEW

The existing body of knowledge about the historical development of electronics include histories of individual technologies or industries such as the computer or the radio as well as of prominent companies such as IBM. Scholars have also done comparison work on individual industries, contrasting them with the development of the same sectors in other countries. It has been found that industries evolved differently in accordance with the situations, resources, and opportunities available as well as deliberate choices that governments and firms have made. I will attempt to review some of the specific factors deemed important to the success and evolution of the U.S. electronics sector that have been explored or remarked upon by scholars.

Mowery and Nelson (1999) contend that in some cases, American companies allowed liberal licensing policies that helped diffuse technology among companies. To illustrate, the transistor was invented at AT&T's Bell Laboratories and Western Electric, an affiliate of Bell Laboratories, began commercial production soon thereafter. However, AT&T was generous with allowing cross-licensing agreements and this action is recognized for enabling an early widespread diffusion that was key to the success of the U.S. semiconductor industry. AT&T's vice president said at the time, "We realized that if this thing [the transistor] was as big as we thought, we couldn't keep it to ourselves and we couldn't make all the technical contributions. It was to our interest to spread it around." New entrants soon undertook production of transistors as well and continued researching improvements and ways to commercialize the new technology. Indeed when Jack Kilby at Texas Instruments and Robert Noyce at Fairchild concurrently invented the integrated circuit, their two companies, continuing in the tradition of AT&T, forged

a cross-licensing agreement that gave them joint claim on the invention and diffused the innovation to the rest of the industry.

In historical works such as Campbell-Kelly and Aspray (2004) and Flamm (1988), the authors remind us that early computer models such as Harvard's Mark I and University of Pennsylvania's ENIAC were the result of university research. Lessons learned from both of these computers would be incorporated into later successful commercial computers produced by IBM and UNIVAC (soon acquired by giant Sperry Rand).

In addition to inventing new technologies, universities were also responsible for educating the next generation of scientists and engineers to provide talent and training for the burgeoning technology industries. In software especially, Mowery and Langlois (1996) argue that the university system and the creation of the academic discipline of computer science was extremely important. Universities were also the site of large projects that provided ample opportunities for people to gain experience. In the software industry, Project Whirlwind at MIT was responsible for the SAGE air defense system and this project was so large that it was noted that, "the chances are reasonably high that on a large data processing job in the 1970s you would find at least one person who had worked with the SAGE system."

Universities also helped diffuse knowledge by formally publishing research and informally sharing ideas. Again in the example of the computer industry, the famous Moore School lectures were held from July 8, 1946 – August 31, 1946 soon after ENIAC was finished and invited scientists from around the world to learn about the groundbreaking work that had just been completed. Attendees such as Maurice Wilkes of Cambridge University then went back to their respective institutions to continue work in the field. Cambridge University's EDSAC

computer was completed in 1949. Indeed, John Mauchly, one of the creators of ENIAC, had himself spent several days with Professor John Atanasoff at Iowa State University learning about their earlier Atanasoff-Berry Computer. (Campbell-Kelly and Aspray, 2004)

It is impossible to overlook the government's influence underlying both the actions of enterprises and universities. Mowery and Nelson praised AT&T's supposedly benevolent and prudent decision to cross-license the transistor. However, as another side to the story, Tilton (1971) argues that fears of inciting the U.S. government's antitrust scrutiny were another motivation for AT&T and other companies to adopt liberal licensing policies. Flamm (1987) concurs that "antitrust pressure on IBM continued to affect IBM's actions vis-à-vis its competitors in the 1960s and 1970s." Flamm (1987) also brings up fiscal assistance, government-supported joint ventures, government standards, and intellectual property protection as mechanisms that the government influenced electronics industries, but even in his view, they are minor compared to R&D support and procurement, two of the most widely recognized influential government mechanisms on electronics.

Mowery and Langlois (1996) recognize the importance of federal funding of university research from agencies such as Department of Defense and ARPA (Advanced Research Projects Agency) in software. Tilton (1971) discovers that government-sponsored R&D constituted almost a quarter of all semiconductor industry R&D in the late 1950s. In an industry with such high R&D requirements and difficult recovering those costs, Flamm (1987) says, "There is a general tendency to underinvest in research. Economists of all stripes generally support some degree of government involvement in encouraging research, particularly basic research (arguably the most difficult to appropriate for private use)." In another work, Flamm (1988) notes that

another feature is that “the military budget is largely immune from the philosophical and ideological passions raised by arguments about the role of government in the economy. One recurring phenomenon has been the sheltering of research programs under the protective wings of the military service.”

However, most also agree that one of the major limitations of direct R&D funding was that it tended to only go to large companies. Mowery and Nelson (1999) wrote that, “In 1959, for example, Western Electric and eight established vacuum-tube firms received 78% of the government’s R&D funding despite accounting for only half of private R&D activity in the industry and only 37% of semiconductor sales. By contrast, the military was far less biased toward established firms in its role as a buyer: in the same year, new firms accounted for 63% of all semiconductor sales, but 69% of sales to the military.”

It is also not even true that government-sponsored R&D were successful in churning out the great, industry-moving inventions. As a different argument against the efficacy of government R&D funding, Mowery and Nelson (1999) claim that, “These R&D and production-development activities were not as effective in pushing the industry along as were the fact and extent of government demand itself. All the major breakthroughs in transistors were developed privately with the military market (among others) in mind.” In fact, wasting companies’ time with non-commercially viable R&D projects diverted the firms from other potentially profitable ventures. Government-sponsored R&D programs regarding miniaturization implemented at Westinghouse by the Air Force and RCA by the Army were ultimately failures and “may have contributed to their falling behind in the IC era.”

It is government procurement that rises to the top as most influential. Mowery and Nelson (1999) consider "procurement demand [to be] arguably the most important – and the most salutary – aspect of government policy." Tilton (1971) agrees that it was "particularly important [especially for] new firms." While the high technology Silicon Valley industries are proud of their entrepreneurial roots supposedly unfettered by government interference, Thomas Heinrich (2002) sets the record straight by reminding us that the government purchased a wide variety of Silicon Valley products and, through this, influenced company strategies and organizations. His study included microwave electronics, missiles, satellites, space electronics, and semiconductor industries.

Flamm (1987) focused on the advancement of particular technologies in his analysis of the computer industry and is able to point out that 19 out of 25 principle innovations in the computing industry had first sales to the government.

This review of some of the relevant past literature suggests that studying procurement is one worthwhile avenue to explore when seeking answers about the success of the U.S. electronics sector. We would want to know what the entire extent of the government procurement spending on electronics firms was, first from on aggregate-level and then on firm-specific level if possible, especially for those small firms we know are so important and what makes procurement funding more influential than R&D. This information is difficult to obtain, which is why most prior work taken a qualitative case-based approach or by examining data on only the largest companies. We begin our exploration by searching out historical primary sources as well as helpful secondary sources in order to paint the fullest picture of what government procurement looked like in the 1950-70s. The results are what follow in the next section.

GOVERNMENT PROCUREMENT

Magnitude

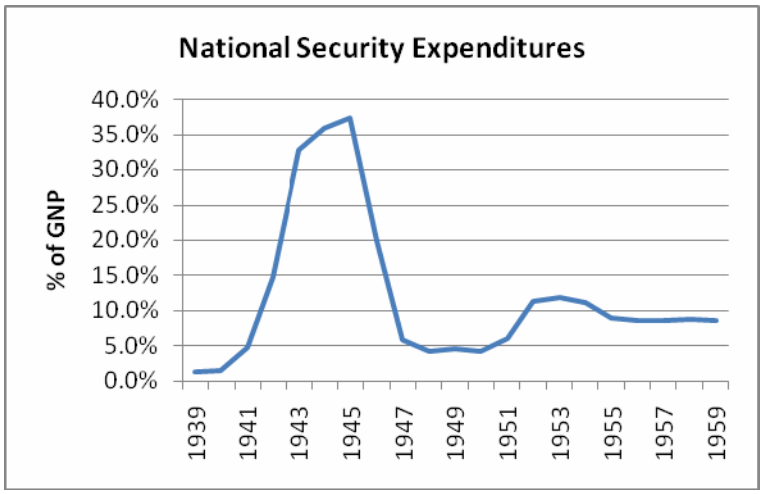


Figure 3: National Security Expenditures (1939-1959)
Source: Novick & Springer (1959)

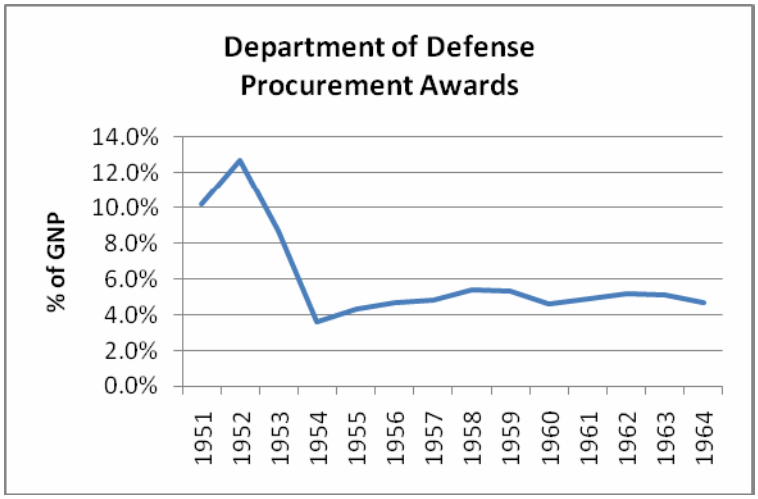


Figure 4: DoD Procurement Awards (1951-1964)
Source: Baldwin (1967)

As can be expected, national security expenditures rose to almost 40% of GNP during the World War II years, but, strikingly, they remained high afterwards, especially compared to their pre-World War II levels. Procurement awards, a component of national security expenditures,

also consistently made up a significant percentage of GNP. Even after dropping off in 1954, defense procurement still made up around 5% of GNP every year which amounted to $20-30 billion, which clearly made it a sizeable economic force to be reckoned with in its own right. This was due to military preparedness build up in light of the Cold War situation. Electronics expenditures were especially thrust into the spotlight after the Soviet Union scored a victory in launching Sputnik in 1957. The Korean and Vietnam Wars from 1950-1953 and 1959-1975 respectively also kept defense contractors busy with the military's demand for products.

Goals

The institution of government procurement is unique in its goals and practices, so it is worthwhile to take a closer look at the "nature of the beast." Unlike profit-seeking entities, the goals that a government procurement office pursues are more complex. Five main goals of the government in procurement can be described by the following:

1. Fulfillment of requirements: To insure that resources are allocated to satisfy the legitimate requirements of the military establishment; and that it receives goods and services of the volume and quality and at the time and place needed.

2. Efficient production: To insure that resources including labor, materials and facilities are used efficiently in the production of both military and civilian goods.

3. Budgetary economy: To insure that military requirements are supplied at a minimum budgetary cost to the government.

4. Economic stabilization: To support so far as possible the objectives of the economic stabilization.

5. Sociopolitical objectives: To promote unity of purpose within the nation and with our allies, and to preserve and strengthen our democratic institutions.

(Miller 1952)

In order for a product to be requisitioned, it had to go through an extensive approval process. After being justifying a purchase as necessary to national defense, the procurement officer was not likely to come back empty-handed because of cost considerations. Although efficient production and budgetary economy were goals as well, they were secondary. It was a very unsettling and politically disastrous idea that the lives of American soldiers and citizens depended on weapons and equipment manufactured by the lowest bidder.

To explain the goal of economic stabilization further, given that the magnitude of procurement was such that it made procurement a significant economic force, the government tried not to disrupt the normal operations of the economy too much in diverting consumer or industrial production towards military needs. Sociopolitical objectives were those such as preference to small businesses and disadvantaged areas and were even more of a unique characteristic which will have important ramifications later.

Prime Contracts vs. Subcontracts

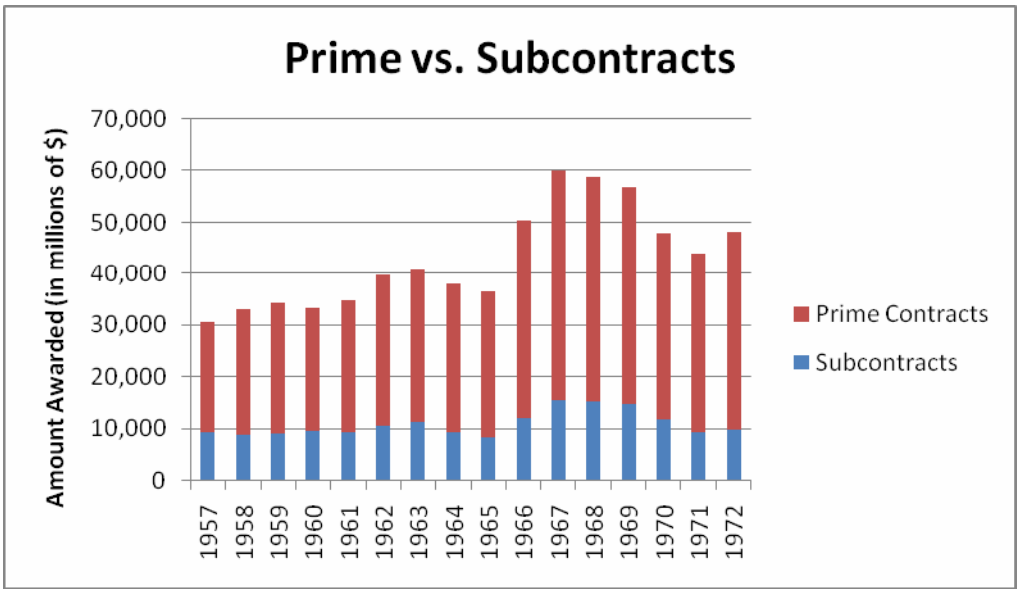


Figure 5: DoD Prime and Subcontracts
Source: Data collected from *Military Prime Contract Awards and Subcontract Payments* (1961)

It is important to distinguish between prime contracts versus subcontracts. Firms that sell their goods and services directly to the government receive prime contracts. There were also subcontractors that sell to prime contractors. The prime contractors, in a sense, could outsource parts of the project out to smaller or more specialized firms. However, large companies could be and often were simultaneously prime contractors as well as subcontractors on other projects. The total amount of subcontracts awarded tended to equal around 35% of the total amount of prime contracts awarded for our time period for a total value of around $10-15 billion.

Other Contract Types

Competitive vs. Non-competitive

Contracts were competitive or non-competitive. Of the competitive contracts, these could be formally advertised or the result of a price or technical design competition. However, 60-70% were non-competitive. These were negotiated and resulted from situations such as if a firm had previously conducted R&D on the desired product or was the only one with the expertise to produce it efficiently.

Pricing Provisions

60-80% of all contracts were fixed price type contracts. The rest were cost reimbursement and other types. Cost-plus contracts were useful in mitigating the risk associated with undertaking more innovative production. Under cost-plus contracts, the client pays for all of the associated costs plus some margin for compensation. This pushes the risk of cost and time overruns (which are particularly common and concerning in the development of technology products) onto the government, making a firm more likely to accept such an undertaking.

EDT&R Contracts

15-20% of total contracts or around $5-6 billion were Research, Development, Testing, & Evaluation Work (RDT&E) contracts with the vast majority classified as “Development” work as opposed to “Research” or “Management and Support”. Unsurprisingly, more than half of these awards went towards missile systems, ~20% to electronics and communications, and also ships and ammunition whereas very little went towards less cutting-edge items such as clothing.

Small Business

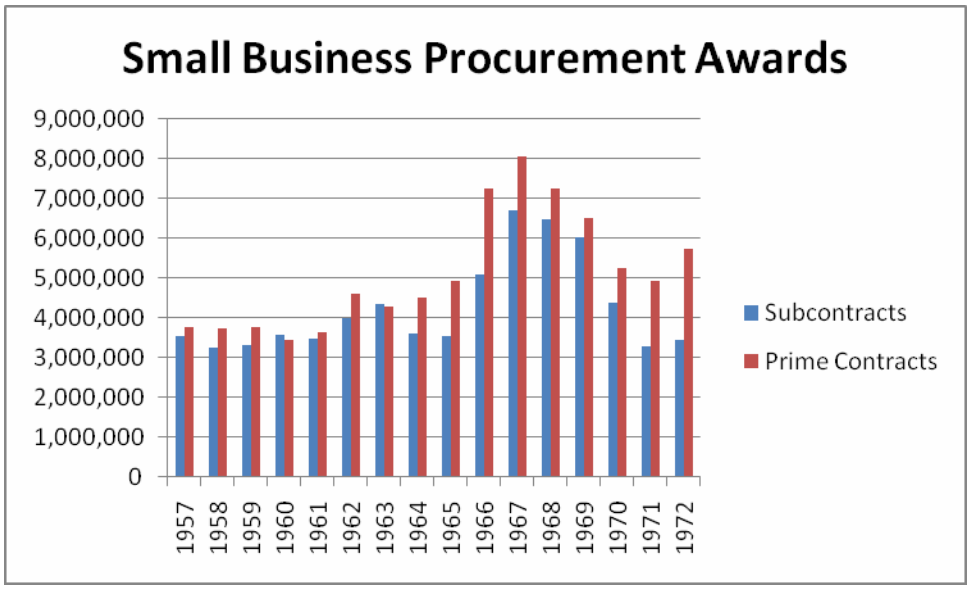


Figure 6: Small Business Procurement Awards
Source: Data collected from *Military Prime Contract Awards and Subcontract Payments* (1961)

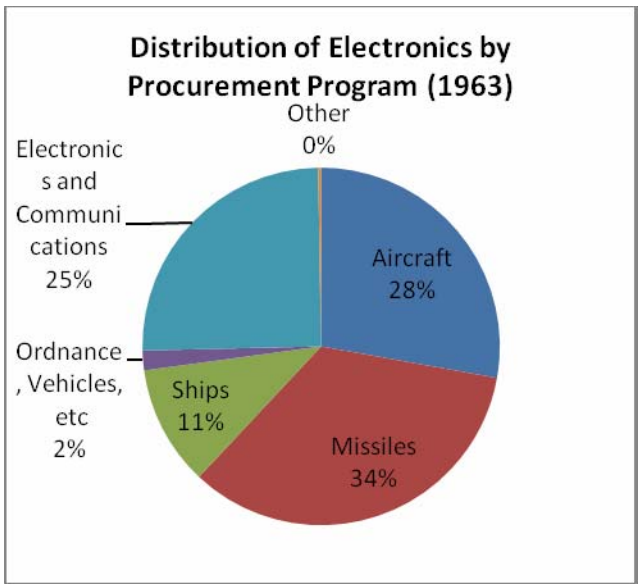
Encouraging small business participation was extremely important politically and was the subject of countless Congressional studies and hearings. The Small Business Act of 1953 read, "It is the declared policy of the Congress that the Government should aid, counsel, assist, and protect insofar as is possible the interests of small-business concerns in order to preserve free competitive enterprises, to insure that a fair proportion of total purchases and contracts for supplies and services for the Government be placed with small-business enterprises, and to maintain and strengthen the overall economy of the Nation."

As economists looking at the development of industries, inclusion of small businesses is important because small businesses serve as a vehicle for new inventions and diffusion of knowledge, they keep competition healthy and force existing companies to keep innovating, and successful ones become tomorrow's big companies.

Small businesses generally received around $4-8 billion in prime contracts. They also received only a little less in subcontracts, around $3.5-6.5 billion. As a percentage of total awards, 17-18% of prime contracts were awarded to small businesses while, as a drastic improvement, around 40% of subcontracts were awarded to small businesses. In accordance with previous criticisms about the restrictiveness of R&D funding to small firms, small businesses only received 3-5% of RDT&E contracts. For a while, it was thought that small businesses benefited from advertised contracts and Congress sought to make those more available in order to encourage small business participation. Instead, it was found that it was difficult for small businesses to compete on advertised contracts and small business owners themselves preferred negotiated contracts. (Baldwin 1967)

PROCUREMENT OF ELECTRONICS

DoD Procurement Programs



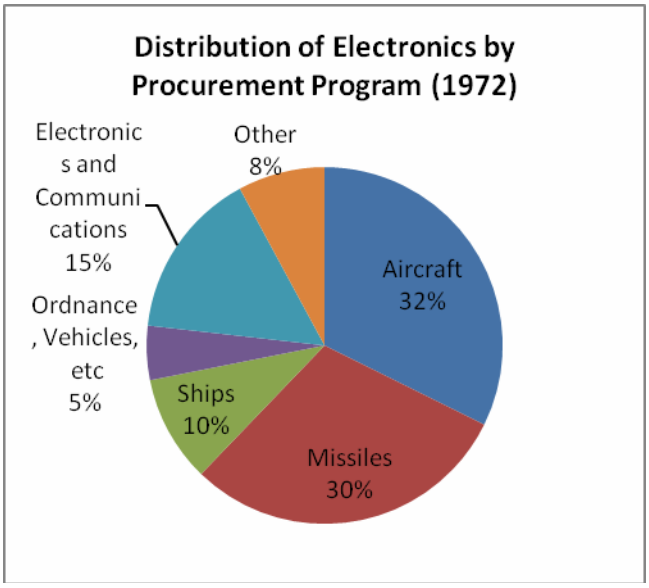


Figure 7: Distribution of Electronics by Procurement Program (1963, 1972)
Source: Data collected from *Electronics Industries Yearbook* (1962-1972)

Government procurement was divided into 13 different procurement programs, each responsible for a different category of products. Electronics were procured through not only the Electronics and Communications procurement program, but significant portions of electronic content were procured from the Missile Systems, Aircraft, and Ships procurement programs as well as, to a lesser extent. the Ordnance, Vehicles, etc. and Other programs. The two snapshots above taken from 1963 and 1972 show that these portions remained relatively constant.

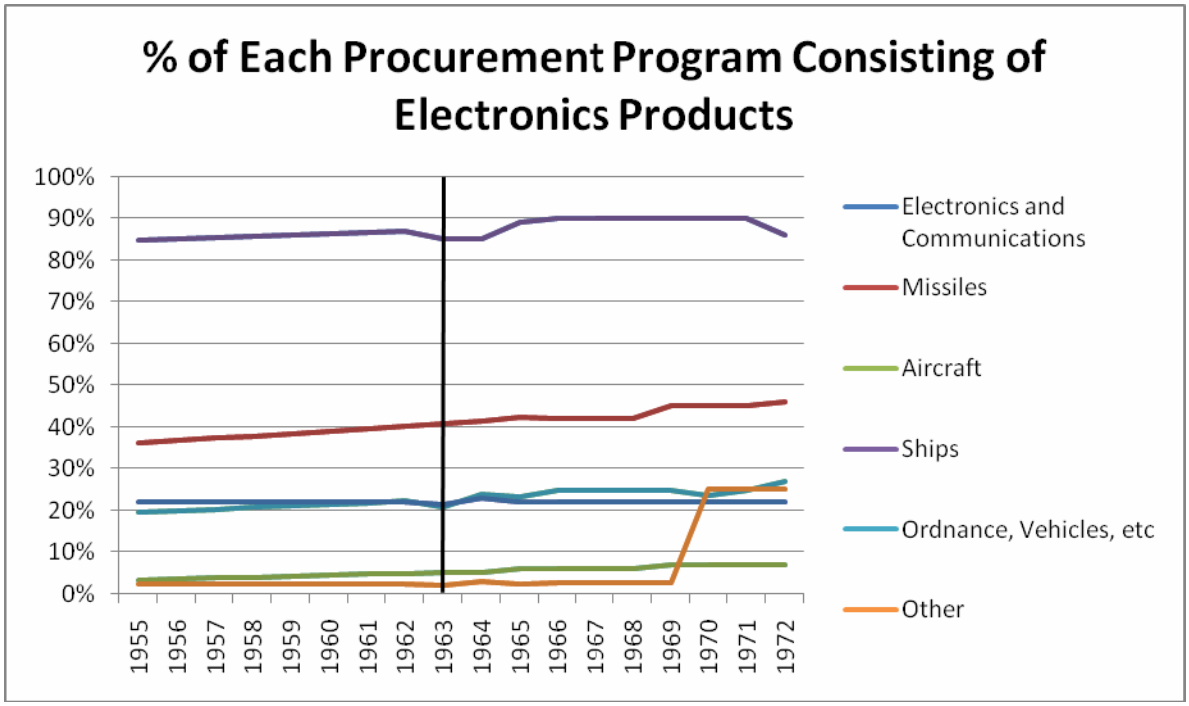


Figure 8: % of Procurement Program Consisting of Electronic Content
Source: Data collected from *Electronics Industries Yearbook* (1962-1972)

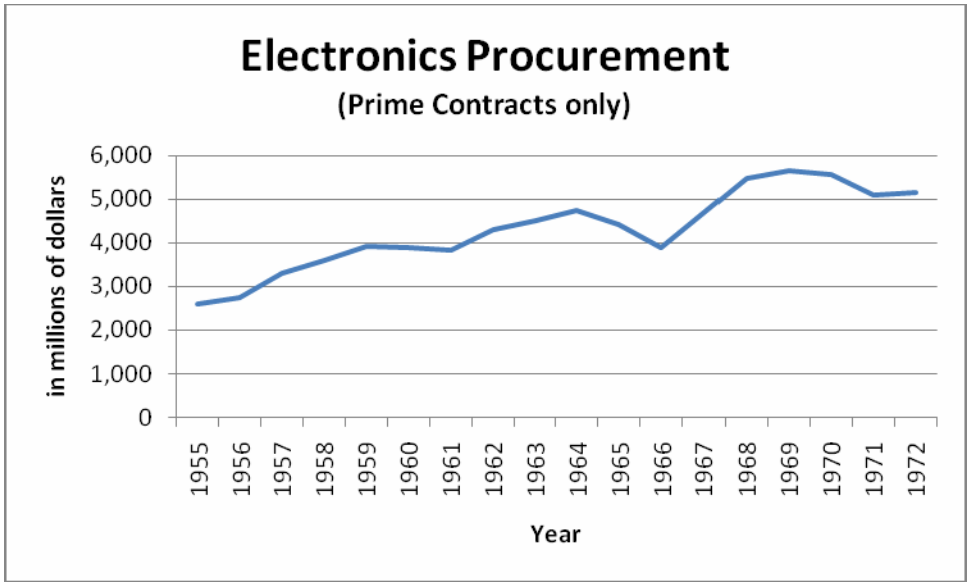


Figure 9: Total Electronics Procurement from DoD Prime Contracts
Source: Data collected from *Electronics Industries Yearbook* (1962-1972) and *Military Prime Contracts and Subcontract Payments* (1961)

The fact that electronics procurement is spread out among procurement programs makes determining the total size of electronics procurement more complicated. The EIA reported electronics procurement in total and also broken down by procurement program for 1963-1972, but I had to estimate the earlier years when only the total was available. Since the % contribution of each procurement program maintains fairly stable trends over the known time period, I conducted a linear regression on the known points and extrapolated back to determine the % electronic content of each procurement program in 1955-1962. The total amount of prime contracts awarded through each procurement program is available for those years, so I multiplied that number by my calculated % of electronic content to obtain an overall figure for prime contract awards for electronics products.

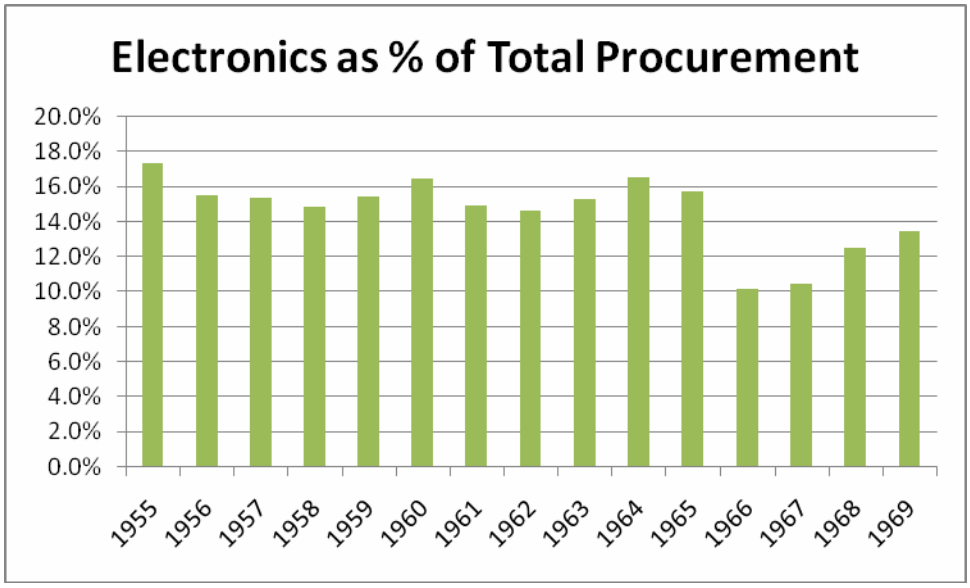


Figure 10: Electronics as % of Total Procurement
Source: Data collected from *Electronics Industries Yearbook* (1962-1972) and *Military Prime Contracts and Subcontract Payments* (1961)

As a percentage of total defense procurement, electronics made up on average 15% of total procurement.

Importance to Electronics Sector

To examine the situation from the other, more telling perspective of the electronics industries and companies themselves, I needed to determine how important government sales were to the electronics sector.

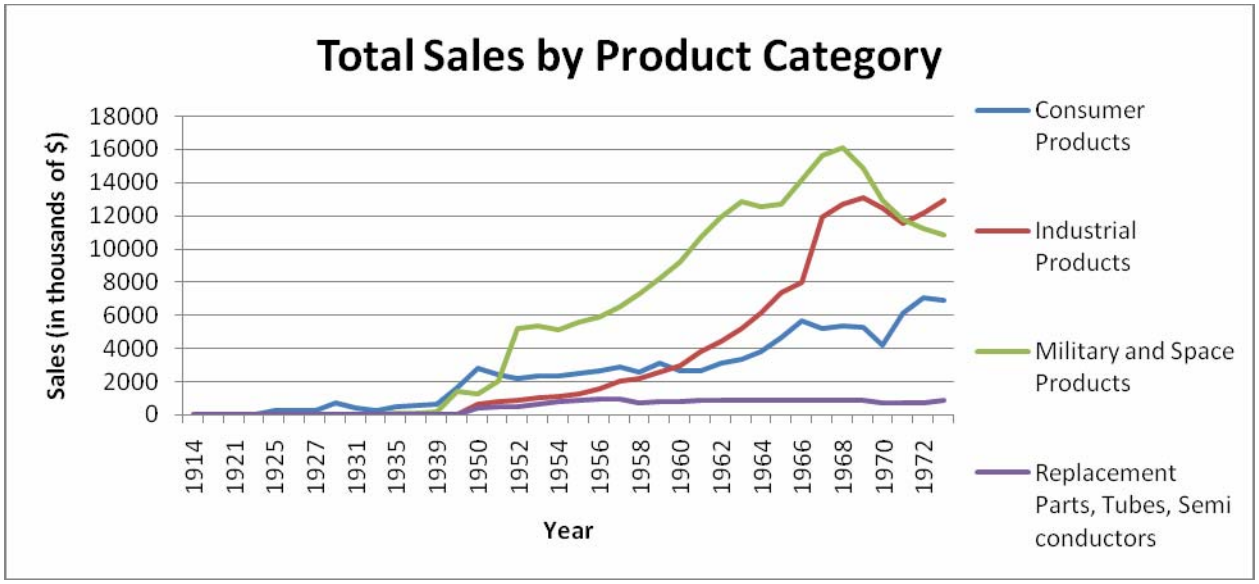


Figure 11: Total Sales of Electronics by Category
Source: Data collected from *Electronics Industries Yearbook* (1962-1972)

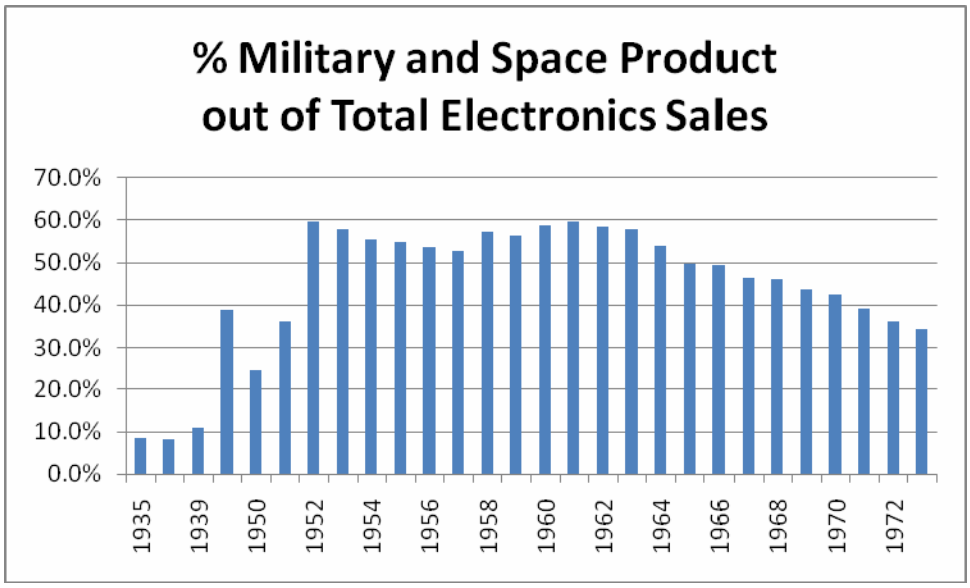


Figure 12: Military and Space Product Sales as % of Total Electronics Sales
Source: Data collected from *Electronics Industries Yearbook* (1962-1972)

In general, military and space products sold to the government made up a significant portion of total electronics sales. Military and space product sales made up of as much as 60% of total industry sales in this time period. Sales of military and space products were higher than that of both consumer and industrial products for the entire two decades of the 1950s and 1960s before industrial products finally overtook military and space products in 1970.

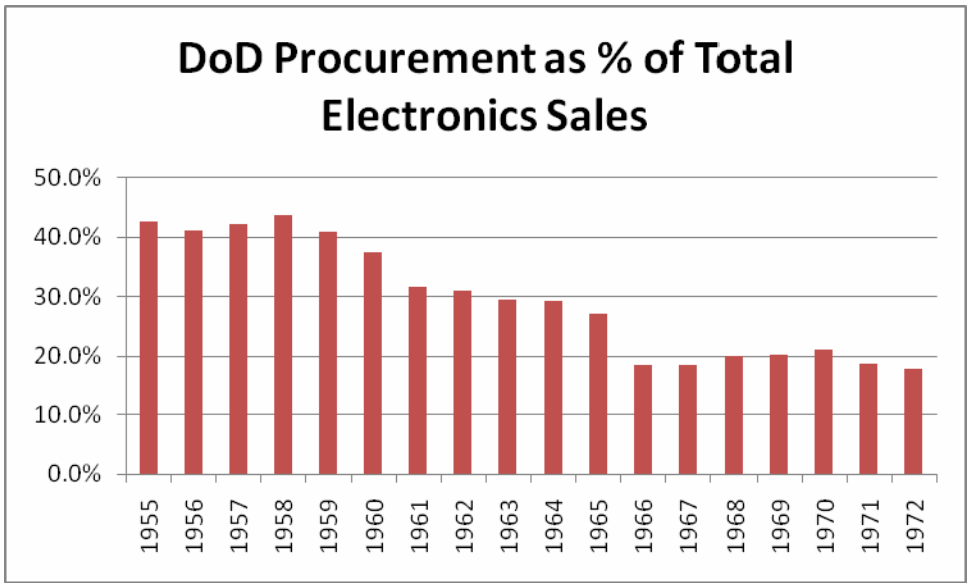


Figure 13: DoD Procurement as % of Total Electronics Sales
Source: Data collected from *Electronics Industries Yearbook* (1962-1972) and *Military Prime Contracts and Subcontract Payments* (1961)

Excluding NASA, R&D contracts, etc, strictly defense procurement made up as much as 40% of total electronics sales in the early years, but still as much as 20% into the late 1960s.

Concentration of Firms Receiving Procurement Funds

Prime contracts were generally highly concentrated to the largest firms and it was no different in electronics. There were usually 17-18 electronics companies among the 50 largest prime contractors and they made up around 20% of total prime contracts. A cursory examination of the top hundred or so electronics companies in 1966 revealed that they had all received prime procurement contracts in that year.

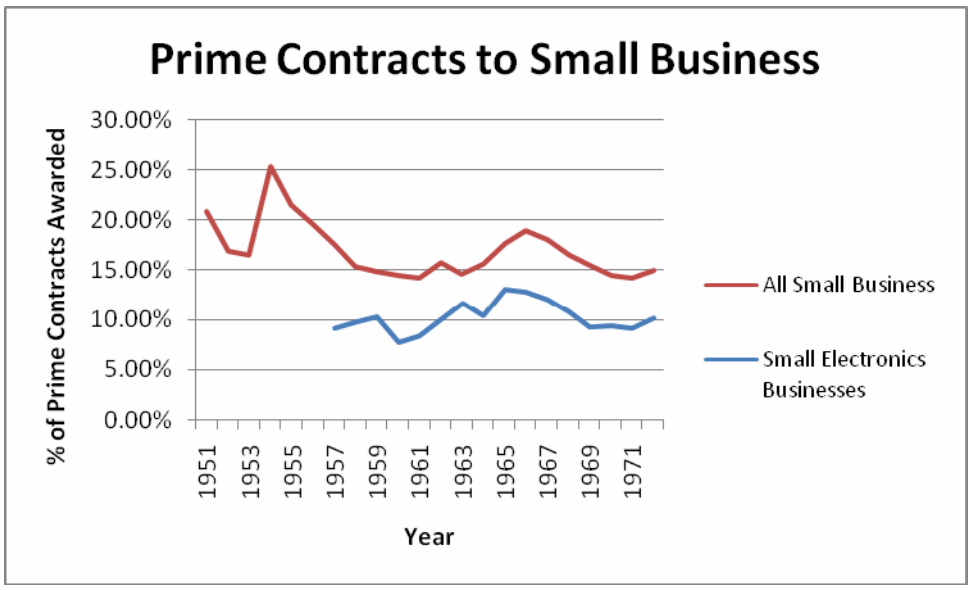


Figure 14: Prime Contracts to Small Business
Source: Data collected from *Military Prime Contracts and Subcontract Payments* (1961)

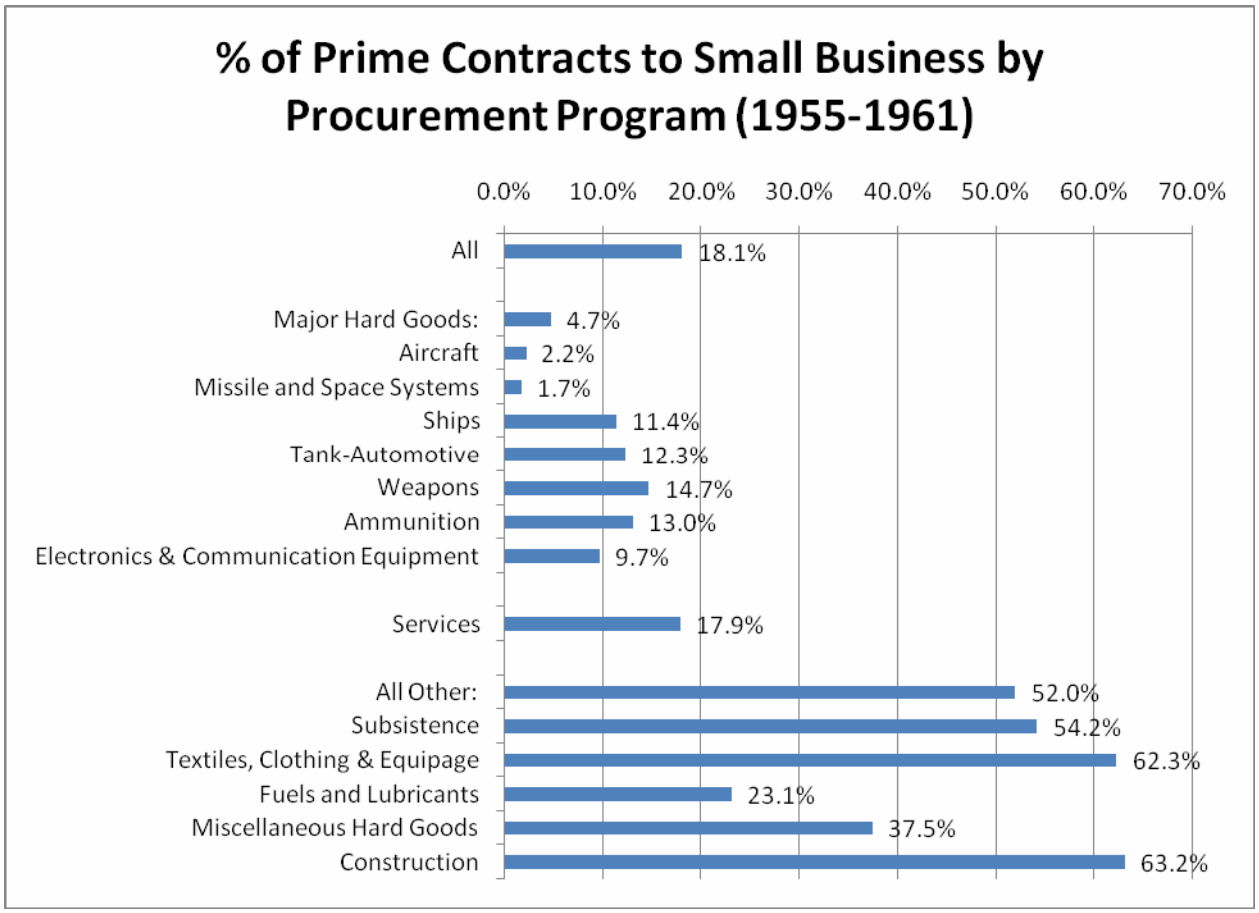


Figure 15: % of Prime Contracts to Small Business by Procurement Program
Source: Data collected from *Military Prime Contracts and Subcontract Payments* (1961)

Small businesses received 10% of Electronics & Communication Equipment category prime contracts. This seems disappointingly small when compared to all small businesses which received an average of 18% of prime contracts during the same time period, but we must remember that this overall number is increased by categories such as subsistence, textiles, clothing, and construction which are naturally more amenable to small business participation.

Subcontracts could not be broken down by procurement program, so all we know is that the small business share of subcontracts was generally twice as much as their share of prime contracts.

FIRM-LEVEL CONSEQUENCES OF PARTICIPATION IN PROCUREMENT

While it is clear now that government procurement demand played an enormous role in the early electronics market, we now want to ask about specific firm-level consequences. Was a company better off by having participated in the defense contracting program? Past research has touched upon the question of consequences of procurement in the form of case studies on companies and industries. I review some of these comments below.

Positive Consequences

As is clear from the previous section, procurement demand constituted a large and growing market that sustained electronics industries and firms through the decades when commercial and industrial markets were still small. Tilton (1971) wrote that "most new semiconductor devices first find a home in military products… within a few years, the price is low enough to penetrate the industrial market, and eventually the consumer market." Profits from defense contracts financed company operations as well as funded a company's internal R&D projects. Compounded by this indirect effect, the impact of defense procurement was even larger.

The government was uniquely positioned to play this early adopter role because, thinking back to the stated goals of defense procurement, cost was less of a concern. An Assistant Secretary of Defense said, "Cost, even though given active and sympathetic recognition, tends to assume a secondary role." Cost was especially forced to be subordinate to other considerations when the Department of Defense placed such priority on acquiring highly innovative products. Baldwin (1967) in his analysis of the defense market explains this fixation with cutting-edge technology in that, to the military, "technological advance is frequently viewed as more of an

end in itself." Demonstrated technological ability might discourage potential enemies, especially in the Cold War political atmosphere. Technical superiority in weapons could literally mean the difference between life and death, thus the military was willing to pay a lot for even small improvements. This is in contrast to civilian markets where commercial R&D pays off only after new products are accepted by consumers and profitably sold and/or cost reductions from more efficient production processes are realized. In this sense, the government was a crucial early customer to have.

Government emphasis on quality and reliability also forced firms to turn out quality products and to improve manufacturing processes in order to do so. When Fairchild booked a $1.5 million contract for work on the Minuteman intercontinetal ballistic missile, "the firm vastly improved its manufacturing processes to mee the stringent quality requirements of the Minuteman reliability improvement program" and this "commitment to reliability became a major asset when the copany entered civilian markets in the 1960s." (Lecuyer, 2000)

Finally, to the small business owner, the defense market was more open to small business than consumer or industrial markets given political pressures to favor small business when possible although there was a prohibition against paying premium prices. Baldwin (1967) also reviewed small business policies. Each department had an Office of Small Business with small business specialists to suggest contracts suitable for small business as well as specific contractors. Prime contractors were also forced to provide opportunities for small business subcontracting when appropriate.

Negative Consequences

Some firms, especially specialized defense contractors, experienced an enormous amount of dependence on one customer: the government. This was unhealthy in two ways. Due to highly politicized decision-making, the defense budget experienced fluctuations. Heinrich (2002) tells the sad tale of Varian Associates, a klystron and microwave tube manufacturer, whose sales to the government accounted for 65% of business volume. When the Pentagon temporarily reduced its purchases of those products in 1963, the company reported a $1 million loss in 1964, throwing the company's financial situation into agitation. Unable to successfully diversify afterwards, industry analysts deemed Varian's earnings a "never-ending horror story." However, this is only one example and it is difficult to disaggregate the effects of the defense budget cuts with other factors such as poor company management.

The negative side of the government's demand for cutting-edge products and unconcern for costs was that by emphasizing technical prowess instead of cost efficiency and having very specific demands, the companies found it difficult to compete later on in commercial markets. Heinrich (2002) notes that military satellite builders rarely succeeded in civilian markets. Indeed, as military needs and consumer needs diverged, increasingly fewer externalities could be gained from past military contract work. Limited incentive and scope to develop capabilities in areas like marketing and production also inhibited transfer of success to other markets.

Contracting with the government demands so much paperwork that the bookkeeping costs are nontrivial. Baldwin (1967) says that "a contractor must have substantial manpower and capital tied up in keeping special records, gathing information, and preparing reports." For all of the conscious efforts to encourage small business, it is possible that they could not overcome

these and other barriers of entry to small firms. Bureaucratic “red tape” is also annoying and costly to deal with.

However, Baldwin actually believes that “the single most important aspect of the Relationship [between the contractor and the government]… is embodied in the Department of Defense policies regarding rights to data.” Companies faced the loss of patent rights, trade secrets, and proprietary data. Subcontractors especially complained about prime contractors infringing on their patents. Companies did not mind so much furnishing information to the government, but were more concerned by having to provide information to other firms either in the bidding process or as their subcontractor because they would have to turn around and compete against them at a later time.

FURTHER ANALYSIS

As seen from the previous section, accounts of the consequences of defense participation are mixed. It is unclear whether the positive consequences outweigh the negative and difficult to gauge the relative importance of the many factors. I would like to see some comprehensive quantitative firm-level evidence on the consequences of procurement, but unfortunately the existing evidence is extremely limited. Existing studies focus only on the largest electronics companies for which data is more readily available.

For example, although he does not focus on electronics companies, Baldwin (1967) analyzes the largest 50 companies that received prime contract awards which includes 18 companies that primarily sold electronics products. He conducts a financial analysis of ROA, ROE, and net sales and, among his findings, learns that companies that participated in the defense market received comparable returns to the average American manufacturing firm. He also conducts an interesting study comparing returns based on degree of firm specialization in defense sales. The sample of companies in Baldwin's study was too limited to draw any broad conclusions for our purposes, but these and more rigorous types of analyses can shed more light on the question in order to reach a more definitive answer.

Except for some claims from industry studies (e.g. semiconductors) I have been able to find no systematic evidence on the effects of government procurement on electronics companies that includes smaller companies outside the top 100. An ideal analysis would require firm-level data on procurement awards be broken down into prime and subcontracts by firm as well as financial data on the characteristics and performance of these firms in order to find relationships

between the two. Since no such analysis has ever been done, I must identify and compile new data and have come up with two different strategies for doing so.

Compiling Firm-Level Data

Procurement Data

Procurement data needs to be compiled in order to systematically identify every company that received procurement funding including electronics companies. Procurement data by firm is available from Department of Defense. It includes all prime contracts issued and includes useful information such as dates, contractor name, place of performance, dollar value of contract, type of service rendered, type of contract signed, and whether or not the business was small or disadvantaged. However, it is only readily available for 1966 on. Attempts to locate pre-1966 data through inquiry to the Department of Defense and National Archives have been thus far unsuccessful. This data set also omits subcontracts. Trade journals, notably *Electronic News*, are another source. *Electronic News* published major and other contract awards in its weekly section on Defense. It includes basic information on name of company, dollar value of contract, service to be rendered, and branch of the military that requisitioned it. However, they do not purport to offer complete coverage and this is also seemingly limited to subcontracts.

ment procurement.)

Major Contract Awards

The following major contracts have been awarded by Government agencies and prime contractors. Inquiries regarding subcontracts should be directed to the location indicated for each firm:

Lear Siegler, Inc., $6 million from Air Force for flight navigation and reference systems for RF-4C reconnaissance aircraft and for F-4D and F-4J fighters.

Northrop Corp. Nortronics division, $2.4 million from North American, Inc. Autonetics division for follow-on production of auxiliary gyroscopes for Minuteman II inertial guidance program.

Western Electric Co., New York, $1.5 million from AF Systems Command for engineer services for the 490L communications system.

F&M Systems Co., Dallas, $1.2 million from AF Logistics Command for engineering, furnishing and installing TV facilities in mobile recorder vans.

Union Carbide Corp., Consumer Products division, New York, $1 million from Army Electronics Command for dry cell batteries and tactical radio sets.

Lear Siegler, Inc., Data & Controls division, Long Island City, N. Y., $1.5 million from AF Systems Command for radar equipment.

General Electric Co., Reentry Systems department, Philadelphia, $4.1 million from AF Systems Command for research and development on Mark 12 reentry system.

Tumpane Co., Los Angeles, $2 million from AF Systems Command for photographic processing and interpretation equipment.

Chicago Aerial Industries, Inc., Barrington, Ill., more than $1 million from General Electric Co. for production of radar recording cameras for use in AF F-111A.

University of Michigan, Ann Arbor, Mich., $1.3 million from DOD to develop a computer language.

Ampex Corp., Redwood City, Calif., $1.4 million from Columbia Broadcasting System for 16 VR-2000 high band color videotape recorders.

Other Awards

LFE Electronics division, Laboratory for Electronics, Inc., Boston, $600,000 from Navy for continued production of AN/APN-141(V) radar altimeters.

Rixon Electronics, Inc., Silver Spring, Md., $600,000 from Air Force for data transmission equipment to be used at Cape Kennedy.

University of Michigan, Ann Arbor, Mich., $100,000 from NASA for feasibility study for development of web-like six-mile-wide radio antenna.

Figure 16: Sample of *Electronic News* data
Source: *Electronic News* January 1966

Financial Data

The second necessity is financial data in order to relate procurement contracts with financial performance. Financial performance data and importance of government as a customer can be compiled from prospectuses issued to the SEC. These are available for all electronics companies that have completed public issues of securities. Close to a thousand companies issued securities and data on these companies including names, size, year of establishment have already compiled by Prof. O'Sullivan from Investment Dealers' Digest. Historical prospectuses and other filings submitted to the SEC are now stored in the National Archives in Maryland and it has been determined that there are 11,000 boxes of them, organized based on obscure SEC-designated codes which are needed to access them. We have established that an "accession log" exists which should allow us to match company name to SEC code but would have to persuade the SEC to provide matches for all of the companies needed. The limitation to this approach is that it is confined only to publicly traded companies. Although the financial data they contain are not as complete, industry directories like *Electronics' Buyers Guide* can provide some cursory data on private companies.

Modeling the Relationship between Procurement and Performance

Having these supplementary data would allow me to test and reveal positive or negative relationships with the later success of the firm. Success is difficult to measure, but can be defined by:

- Revenue during the year measured, 5 years later, 10 years later, etc.
- Net income, operating margin

- Return on assets, return on equity
- Share price for publicly traded companies
- Number of patents
- Longevity of the company before it becomes bankrupt or acquired.

I would set each of these as a dependent variable against a measure of dependence on government sales (% of government sales to total sales). Confounding factors such as size, age, or previous success of companies would need to be held constant.

Since it was suggested that the fluctuations in defense budgets adversely impacted companies, if this ends up being true and significant, we would expect to see poorer returns or stock performance for more government-dependent companies than average in lean budget years. The magnitude of disparity between the two would also give an indication of how important this phenomenon was.

For those interested in specific companies, I could also track the amount of procurement awards received by a given company over the years and perhaps map any successful transitions to the consumer market (by increases in advertising expenses and decreases in dependency on government sales).

Although we already have a pretty good idea about the importance of government funding to the entire industry, a comprehensive firm-level dataset would also allow me to go back and answer other questions about extent of participation in procurement in the electronics sector more satisfactorily than with the previous aggregate data. For example, out of X electronics companies total, exactly Y participated in defense contracting this year.

CONCLUSION

The remarkable success of the early U.S. electronics sector has understandably prompted academics and policymakers alike to research the causes of this success. After examination of past literature, many sources were discussed but government procurement stood out as quite possibly the most important factor. This prompted my study where I went back to the 1950-1970s time period and examined primary government and electronics industry sources in order to confirm and shed more light on the role of government procurement in the early electronics sector.

We learned that the nature and goals of defense procurement were well-suited to play a pivotal role in the growth of the electronics sector as the government emerged as a buyer willing and able to take chances on many expensive electronics products and untried small businesses. At a time fraught with political and military turbulence, around 5% of GNP was consistently and solely spent on defense procurement awards. Armed with this enormous amount of funding available, we estimated that sales from defense procurement prime contracts made up 20-40% of total sales in the electronics sector which is a significant figure.

There is certainly room for further investigation on the topic especially in sifting through the various firm-level consequences for participating in defense procurement programs. Analyses in this direction require a comprehensive firm-level dataset that does not currently exist and must be compiled from scratch. I have generally outlined an approach to do it. It is a challenging and still imperfect task, but promises even more answers as the next step to this study.

BIBLIOGRAPHY

Baldwin, William L. (1967). *The Structure of the Defense Market 1955-1964*. Durham, NC: Duke University Press.

Campbell-Kelly, Martin & Aspray, William. (2004). *Computer: A History of the Information Machine*. Boulder, CO: Westview Press.

Economic Aspects of Military Procurement and Supply, Report of the Subcommittee on Defense Procurement to the Joint Economic Committee, Congress of the United States. (1960). Washington, DC: U.S. Government Printing Office.

Electronic Industries Yearbook. (1962-1972). Washington, DC: Electronic Industries Association, Marketing Services Department.

Flamm, Kenneth. (1988). *Creating the Computer: Government, Industry, and High Technology*. Washington, DC: The Brookings Institution.

Flamm, Kenneth. (1987). *Targeting the Computer: Government Support and International Competition*. Washington, DC: The Brookings Institution.

Funding a Revolution: Government Support for Computing Research. (1999) Washington, DC: National Academy Press

Heinrich, Thomas. (2002) "Cold War Armory: Military Contracting in Silicon Valley." *Enterprise & Society*, vol. 3, pp. 247-283.

Jorgenson, Dale W. *et al*. (2002). "Projecting Productivity Growth: Lessons from the U.S. Growth Resurgence." *Resources for the Future*.

Military Prime Contract Awards and Subcontract Payments. (1961). Directorate for Statistical Services. Washington, DC: Office of the Secretary of Defense.

Miller, John Perry. (1952). "Military Procurement Policies: World War II and Today." *The American Economic Review*, vol. 42, no. 2, pp. 453-475.

Mowery, David C. & Langlois, Richard N. (1996). "Spinning off and spinning on (?): the federal government role in the development of the US computer software industry," *Research Policy*, vol. 25, pp. 947-966.

Mowery, David C. & Nelson, Richard R. (eds) (1999). *Sources of Leadership: Studies of Seven Industries*. Cambridge, UK: Cambridge University Press.

Mowery, David C. & Simcoe, Timothy. (2002). "Is the Internet a US invention? – an economic and technological history of computer networking," *Research Policy*, vol. 31, pp. 1369-1387.

Novick, David & Springer, J. Y. (1959). "Economics of Defense Procurement and Small Business." *Law and Contemporary Problems*, vol. 24, no. 1, Small Business, pp. 118-131.

Statistical Abstract of the United States. (1937-1975). Washington, DC: U.S. Department of Commerce, Bureau of the Census.

Tilton, John. (1971). *International Diffusion of Technology: The Case of the Semiconductors*. Washington, DC: The Brookings Institution.