ANALYSIS OF COST GROWTH IN U.S. AIR FORCE BASE SUPPORT FUNCTION CONTRACTS

THESIS

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AFIT/GEE/ENV/99M-14

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James S. Romasz

Table of Contents

Page

List of Figures

Table Page

List of Tables

Abstract

The United States Air Force (USAF) has outsourced a significant portion of their activities defined as commercial activities and plans to aggressively outsource more in the future. The USAF outsources its commercial activities in the form of multi-year contracts to the private sector. Cost growth (either negative or positive) has been experienced by most of these contracts.

This research effort performed a review of current literature and used statistical analysis to clarify the issue: what are the causes, and extent of cost growth in USAF base-support-function contracts?

To clarify the causes of cost growth the following were employed: (1) A review of the Federal Acquisition Regulations (FAR) in order to understand how cost growth can occur within the context of USAF contracts. (2) A review of current literature and government publications concerning cost growth in USAF as well as other government contracts. (3) A review of cost growth in the construction industry was accomplished in order that possible further insights could be gained.

To clarify the extent and explore the various factors (MAJCOM, contract function, contract type, and award year) the following statistical analysis on 124 USAF base

support function contracts was employed: (1) descriptive statistics, (2) Kruskal-Wallis and Mann-Whitney tests for statistical differences, and (3) regression analysis.

From the literature, it can be concluded that changes to the statement of work or performance work statements and Department of Labor (DOL) mandated wage rates are the primary causes of cost growth in USAF as well as other government service-type contracts. It can also be concluded that cost growth in the construction industry is similar to cost growth in USAF base-support function contracts.

With respect to the statistical analysis of extent and factors (MAJCOM, contract function, contract type, and award year of contract), the following can be reasonably concluded. Cost growth in USAF contracts is widely variable. The median value of cost growth for all contracts was 4.56 percent, and the inner-quartile range value of percent cost growth was 13.63 percent. Although relative differences do exist between variables within factors, none of the variables within factors were statistically different at the .05 significance level. At the .10 significance level, the variables within the factor contract type were shown to be significantly different. However, this cannot be stated concerning the other factors (MAJCOM, contract function, or award year of contract).

ANALYSIS OF COST GROWTH IN U.S. AIR FORCE BASE SUPPORT FUNCTION CONTRACTS

I. Introduction

The United States Air Force (USAF) undertakes a great number of activities in order to accomplish its stated mission. The USAF defines these activities into two broad categories: Governmental Function and Commercial Activity.

According to Air Force Pamphlet (AFP) 26-12, "A governmental function is one that is so intimately related to the public interest as to mandate performance by Department of Defense employees. These functions include those activities requiring either the exercise of discretion in applying governmental authority or the use of value judgment in making decisions for the government".

"A commercial activity is an activity that provides a product or service obtainable (or obtained) from a commercial source. A commercial activity is not a governmental function."

Outsourcing in the USAF

Since 1955, all federal agencies have been encouraged to obtain the performance of their commercial activities from the private sector, through either privatization or outsourcing. Privatization involves the change in ownership as well as responsibility for operating and maintaining a commercial activity. Privatization is relatively new to the USAF; however, is becoming more utilized. Outsourcing, the more common of the two, is contracting out to the private sector to operate and/or maintain a commercial activity. The government still maintains ownership of the facilities, systems and equipment associated with the commercial activity (GAO, 1997: 2).

There are many reasons for outsourcing commercial activities. Outsourcing can "enhance military readiness and/or quality of life." (Keating, 1997: 6), or "achieve cost savings, management efficiencies, and operating flexibility" (GAO, 1997: 1). One might conclude that outsourcing by the USAF is a potential way to save money in one area, particularly base support or personnel costs, in order to reallocate the saved money from outsourcing to other areas, such as aircraft procurement or construction of new facilities.

In 1996, the USAF "estimated that it had outsourced 64 percent of its workforce performing commercial activities" (GAO/ 1997:5). This percentage equates to 94,714 contractor manpower equivalents (CME) working for the USAF. A CME is an estimate of the number of government employees who would be required to perform the function that is currently being performed by contract (Keating, 1997:12).

From 1996 to 2003 the USAF planned or plans on studying up to 60,000 positions for potential outsourcing. The majority of these positions are planned to be within base support service billets. In order to facilitate and manage this push, the USAF created an Outsourcing and Privatization division with the Air Staff (GAO 1997:6).

It is reasonable to conclude from the following information that the USAF has not only outsourced a significant portion of their present workforce but plans to aggressively pursue outsourcing in the future. Outsourcing of a commercial activity occurs through the A-76 process.

The A-76 Process

In 1966, the Office of Management and Budget (OMB) issued Circular A-76. This document established the federal policy for the performance of commercial services by the private sector. In 1983, a supplement was issued which provided procedures for determining whether a commercial activity should be outsourced or remain in-house. In 1996, the supplement was revised to streamline and improve the outsourcing process (GAO, 1997: 2-3).

The OMB's Circular A-76 defines 29 types of services (types of commercial activities) as inherently base support. The following list, from the 1996-Revised Supplemental

Handbook to Circular A-76, is provided so that the reader may gain an understanding into types of services which the USAF outsources and which this research is focused upon:

1. Natural resource services
2. Advertising and public relations
3. Financial and payroll services
4. Debt collection
5. Bus services
6. Laundry and dry cleaning
7. Custodial services
8. Pest management
9. Refuse collection and disposal services
10. Food services
11. Furniture Repair
12. Office equipment maintenance and repair
13. Motor vehicle operation
14. Motor vehicle maintenance
15. Fire prevention and protection
16. Military clothing
17. Guard service
18. Electric plants and systems operation and maintenance
19. Heating plants and systems operation and maintenance
20. Water plants and systems operation and maintenance
21. Sewage and waste plants operation and maintenance
22. Air conditioning and refrigeration plants
23. Other utilities operation and maintenance
24. Supply operations
25. Warehousing and distribution of publications
26. Transportation management services
27. Museum operations
28. Contractor-operated parts stores and civil engineering supply
29. Other installation services (OMB, 1996)

Unfortunately, the USAF does not have a clear definition of commercial activities that fall into the OMB's defined base support function categories (GAO, 1997:23-24). However, upon review of USAF base support contracts, all of them might reasonably be categorized under one or more of the OMB's defined activities for base support functions.

The decision to outsource a base support function or keep the function in-house is normally determined by the A-76 process. This is more commonly referred to as an A-76 Study. A-76 studies are normally initiated at the Air Staff and MAJCOM levels of the USAF. Local base commanders can also initiate A-76 studies; however, this rarely occurs. The reasons for initiating an A-76 study vary; however, as mentioned in the previous section, a potential to achieve cost savings, management efficiencies, and operating flexibility are most commonly cited. The A-76 process consists of six steps, which are generally accomplished in the following order; however, there is considerable overlap among several of the steps:

1. Develop a performance work statement (PWS) and quality assurance plan
2. Conduct a management study to determine the government's most efficient organization (MEO)
3. Develop an in-house government cost estimate for the MEO
4. Issue requests for proposals or invitation for bids
5. Evaluate the proposals or bids and comparing the in-house estimate under the MEO and selecting the best proposal
6. Addressing any appeals submitted

The function is outsourced when, through the A-76 process, a contractor underbids the USAF's MEO estimate by at least 10%, otherwise the function remains in-house and is accomplished by using the government's MEO (GAO 1998: 22).

Base support functions are usually outsourced in the form of multi-year contracts (base year(s) plus option years). Typically these contracts last from three to seven years. The contracts can be in many forms such as firm-fixed price, firm-fixed price with incentive,

indefinite delivery indefinite quantity, cost, and cost-plus incentive. However, firm-fixed price (FFP) appears the most prevalent contract-type form.

Cost Growth in Contracts

It is well accepted that most contracts experience cost growth during their contract life. Cost growth is when the final amount paid on a contract does not match the initial amount when the contract was awarded. The extent of cost growth can be negative or positive, and is the result of various causes and factors.

Research Question

The USAF has outsourced a significant portion of their commercial activities and plans to outsource a great number more in the future. It is therefore useful to attempt to more clearly understand the extent, causes, and factors of cost growth in outsourced commercial activities. This research effort focuses on the following question: what are the extent and causes of cost growth in outsourced base support functions at USAF bases?

In order to clarify the causes of cost growth, the following were employed:

(1) A review of the Federal Acquisition Regulations (FAR) was conducted in order to understand how cost growth can occur within the context of USAF contracts.

(2) A review of current literature and government publications concerning cost growth in USAF as well as other government contracts was conducted.

(3) A review of cost growth in the construction industry was conducted in order that possible further insights could be gained, since little information exists concerning cost growth in service-type contracts and much research has been conducted in the construction industry.

To clarify the extent and explore the various factors: MAJCOM, contract function, contract type, and award year, the following statistical analysis on 124 USAF base support function contracts was employed.

(1) Descriptive statistics were used to present an overall understanding of the extent of cost growth within the aforementioned factors.

(2) Kruskal-Wallis and Mann-Whitney tests for statistical differences between variables within factors were conducted.

(3) Regression analysis was conducted in order to determine whether cost growth is increasing, decreasing, or remaining constant over time for the factor award year of contract.

II. Literature Review

Overview

The literature review chapter of this research focuses on five areas: (1) a discussion of potential causes for cost growth in USAF contracts as listed in the Federal Acquisition Regulation (FAR), (2) a discussion of the USAF's experiences with cost growth in outsourced commercial activities is presented (3) a discussion of cost growth with respect to the construction industry, (4) a discussion of the comparisons between cost growth in the USAF and the construction industry, and (5) summary of the literature reviewed.

Causes of Potential Cost Growth in USAF Contracts

The purpose of this section of the research is to provide the reader with an understanding of the primary causes of cost growth, which are allowed by the government in their contracts. The three primary causes of cost growth, which are allowed by the government under the Federal Acquisition Regulation (FAR), are changes, delays, and adjustments to Department of Labor wage rate. Arnavas and Ruberry, in their book, Government Contract Handbook, provide an excellent understanding of these three causes.

A change is an alteration of the contract documents within the general scope of the contract. Changes in the following are allowed under the FAR:

1.) Drawings, designs, or specifications
2.) Method of shipment or delivery
3.) Place of delivery (Arnavas and Ruberry, 1994: 11-1-11-23)

Changes may result, according to the FAR, from the following:

1.) Value Engineering - a change originated by the contractor which results in savings due to a change in method of operation or installation. The contractor shares in the generated savings.

2.) Formal Change - a change originated by either the government or the contractor with the purpose of changing the requirements of the contract. A formal change order can be either unilateral or bilateral.

3.) Constructive Change - is any action or inaction by the government which is not a formal change order but nonetheless has the effect of requiring the contractor to perform additional work beyond the contract's requirements. Constructive changes are further divided into five subtypes:

a.) Contract interpretation - occurs when the government interprets the contract to require work that is more costly than the work contemplated by the contractor.

b.) Interference and failure to cooperate - occurs when the government increases the contractor's cost of performance by actively interfering with the progress of the work or failing to cooperate with the contractor.

c.) Defective specifications - occur when the contractor incurs additional costs attempting to comply with specifications due to improperly prepared specifications or specifications that call for performance which cannot be attained.

d.) Nondisclosure of vital information - occurs when the government withholds information that is necessary for the contractor to achieve satisfactory performance.

e.) Acceleration - occurs when the contractor is ordered or induced to incur additional costs to accelerate the work to complete performance prior to the time the contract requires (Arnavas and Ruberry, 1994: 11-1-11-23).

A delay is an interference of the contractor's performance for various reasons that do not allow for the completion of the requirements within the time allowed under the contract requirements. Delays can be the fault of the government, the contractor or neither. Delays are broadly categorized as constructive suspension, constructive delay, or excusable delay (Arnavas, and Ruberry, 1994: 12-1-12-11).

A constructive suspension normally occurs through a "Stop Work Order" issued by the contracting officer. The "Stop Work Order" requires the contractor to stop all or partial work on a contract. A constructive suspension can occur without a "Stop Work Order" (Arnavas and Ruberry, 1994: 12-1-12-11).

A constructive delay is divided into the following sub-categories of delays (Arnavas and Ruberry, 1994: 12-1-12-11):

1.) Delays involving changes - result from a change that is ordered by the contracting officer.

2.) Delays involving faulty specifications - result from inadequate or faulty specifications or plans governing the performance of work.

3.) Delays in furnishing property - result from the failure of the government to timely provide materials or equipment for the contractor's use in the performance of the contract.

4.) Delays in approval or inspection of work - result from the government's failure to inspect or approve a contractor's submitted documentation or completed work in a timely manner.

An excusable delay is a delay that results in the contractor's nonperformance of work that is out of the contractor's control and occurs without fault or negligence by the contractor. The following list is generally accepted as reasons for possible excusable delays:

1.) Acts of God
2.) Acts of the government in either its sovereign or contractual capacity
3.) Fires
4.) Floods
5.) Epidemics
6.) Quarantine restrictions
7.) Strikes
8.) Freight Embargoes
9.) Unusually severe weather
10.) Subcontractor or supplier delays arising from unforeseeable causes beyond the control and without the fault or negligence of either the contractor and subcontractor or supplier (Arnavas and Ruberry, 1994: 12-1-12-11).

The Department of Labor (DOL) through The Service Contract Act requires contractors engaged in federal contracts to pay their employees not less than the prevailing wage as determined by the Department of Labor, based on the type of work and location. When

the prevailing wage increases, contracts must be modified to reimburse contractors for the increased cost of paying their employees (Arnavas and Ruberry, 1994: 6-16).

It would be reasonable to conclude from the previous information that changes and delays, which often result in cost growth, can occur for a variety of reasons. In addition, it can be stated that these changes and delays result in changes to the statement of work or performance work statement.

USAF Experience With Cost Growth

The purpose of this portion of the research is to determine through a review of available literature the causes of cost growth in USAF base support function contracts.

The General Accounting Office (GAO) found that "inadequately crafted statements of work have necessitated changes to contracts, which have often resulted in cost increases" and also found that "increases in federally established wage rates . . . as a source of increased contract costs" (GAO, 1997: 5).

The Air Force Audit Agency (AFAA, 1998) similarly concluded that changes in performance work statements and increases in labor wage rates resulted in increases in cost growth of commercial activity contracts.

Additionally, in an audit of 20 commercial activity contracts, the Department of Defense Inspector General (DOD IG, 1996: 2) found cost growth had occurred in 18 of the contracts due to changes to the performance work statement or DOL mandated wage increases.

The three aforementioned reports both cited changes in performance work statements as one of the primary reasons for cost growth in USAF commercial activity contracts. However, they do not state what types of changes have caused the most or least increase in cost (i.e., particular areas in the FAR to which the changes fall under).

The other primary source, as mentioned in the three reports, was increases in labor wage rates. As previously mentioned, The Service Contract Act requires contractors engaged in federal contracts to pay their employees not less than the prevailing wage as determined by the Department of Labor, based on the type of work and location. When the prevailing wage increases, contracts must be modified to reimburse contractors for the increased cost of paying their employees (GAO 1997: 6).

It is reasonable to conclude from the previous information that the primary causes of cost growth are due to changes to the performance work statement (PWS) or statement of work (SOW) and changes to the wage rate as determined by the DOL. As stated before, none of the reports or audits offers exact causes associated with particular changes to the PWS or SOW. Unfortunately, the data used in this research does not support additional

insight either. This would be a good area for future research, due to the fact insight regarding particular changes could be would be incredibly useful information.

Construction Industry Cost Growth

The purpose of this section of the research is to determine if additional insight regarding cost growth in USAF base support contracts can be garnered from studies which occurred in the construction industry. This research focuses on construction industry cost growth for two reasons. First, little information exists regarding cost growth in service-type (i.e., commercial-activity type) contracts, either in the public or private sector. Second, numerous studies have been concluded regarding cost growth in the construction industry. Although construction contracts differ from service-type contracts, they still contain many similarities with service-type contracts. The similarities include the fact construction and service contracts are structured in basically the same way. In addition they both involve the providing of an overall service to a customer by an independent contractor. They differ in the fact that construction contracts are normally of a shorter duration thereby precluding the development of a long-term relationship between the customer and the contractor.

Baldwin & Manthei (1971) studied the severity (importance) of construction delays as determined through a survey of contractors, architects, and engineers. The following causes (in no particular order) were given to the survey respondents to rank:

- Weather
- Subcontractors
- Shop Drawings
- Material Shortages
- Sample Approvals
- Equipment Failure
- Construction Mistakes
- Finances
- Building Codes
- Labor Supply
- Design Changes
- Foundation Changes
- Manufactured Items
- Jurisdiction Disputes
- Contracts
- Inspections
- Permits

The three groups (architects, contractors, and engineers) ranked weather, labor, and subcontractors as the top three causes of delay (Baldwin and Manthei, 1971).

The purpose of an effort by Diekmann & Nelson (1985) was to ascertain the frequency, severity, and possible causal factors of various construction claims in federally administered construction projects. The authors used the following causes of claims in their research:

- Design Errors
- Changes (Mandatory)
- Weather
- Strike (including labor wage disputes)
- Changes (Discretionary)
- Differing Site Conditions
- Value Engineering
- Other

Diekmann & Nelson (1985) found that design errors accounted for 72 percent of claims.

Thurgood et al. (1990), through a combination of interviews with contractors and state employees and an analysis of 800 highway projects, attempted to determine the causes of

cost overruns on Utah Department of Transportation construction projects. They used the following categories for causes of cost overruns:

Quantity estimate error
Time estimate error
Archaeological
Field Design Changes
Labor violation/dispute
Traffic control problem
Weather
Utility relocation
Other
Traffic safety improvements
Surface water
Technical design error
Unclear Specification
Environmental problems
Groundwater
Subsoil
Traffic damage
Construction materials
Zoning change approval
Other
Design concept change

Thurgood et al. (1990) found that quantity estimate errors, technical design errors, time estimate errors, and field design changes had occurred in large percentages of the total projects analyzed.

Unlike most other researchers, Hinze et al. (1992) attempted to determine factors that have strong association with cost overruns in contracts. They used the following areas of analysis:

Project size
Project type
Number of Bidders
Range or spread of submitted bid amounts
Cost overruns attributable to specific contractors
Time overruns

They found that cost overruns tend to increase with the size of the project. In addition, they found that as the number of bidders increased so did the range or spread in the bid amounts, which is associated with increased overruns.

O'Conner et al. (1993) attempted to provide insight into both the classification and frequency of claims with respect to damage type, highway project element, and fundamental causes of claims on Texas Department of Transportation projects. They used the following causes in their analysis (in order of frequency):

Defective contract documents
Differing site conditions
Compensable delays
Excusable delays
Hindered productivity
Mal-administration
Implied warranty
Constructive changes
Directed changes
Economic impossibility of performance

They found that defective contract document, compensable delays and hindered productivity to be the most prevalent source of claim.

Semple et al. (1994) analyzed the causes of claims, delays, and cost overruns in 24 construction projects in Western Canada. Semple et al. hypothesized the following causes in their analysis:

Acceleration	Restricted access
Weather	Increase in Scope (design changes, extra work, errors)

They found increase in scope as the most prevalent cause of claim.

Kaming et al. (1997) attempted, through the survey of 31 project managers of high-rise construction projects in Indonesia, to identify and analyze factors (causes) which influence time and cost overruns. The following factors were identified and analyzed:

Delays
- Weather
- Inaccuracy of materials estimate
- Inaccurate prediction of craftsman production rate
- Inaccurate prediction of equipment production rate
- Materials shortage
- Equipment shortage
- Skilled labor shortage
- Locational restriction
- Inadequate planning
- Poor labor productivity
- Design changes

Cost Overruns
- Weather
- Material cost increase
- Inaccurate quantity take-off
- Increase labor cost
- Lack of expertise

They found that design changes accounted for delays and material cost increases for cost overruns to be the most prevalent causes as ranked by the survey respondents.

The purpose and research methodology between articles varied greatly; however, for purposes of research in this paper the categories or causes of cost growth were the focus. The causes or categories of cost growth (whether in the form of delays or claims) varied greatly. The disparity among researchers' findings regarding causes or categories of cost growth is due to several factors: (1) there is no industry accepted standard for categorizing causes of cost growth, (2) many of the papers focused on specific types of

construction situations or locations, and (3) causes in one paper may be called a different name in another paper.

Comparison between Cost Growth in the USAF and Construction Industry

In four of the reviewed articles, either one or a combination of the following were cited: design errors, quantity estimate errors, technical design errors, time estimate errors, defective contract documents, and increases in scope (design changes, extra work, errors) as primary causes of claims or cost overruns. These previously cited causes all relate to improperly prepared statements of work or performance work statements.

It is reasonable to conclude from the previous paragraph as well as from the section of this research dealing with USAF Experience With Cost Growth, that the USAF is not unique in their inability to consistently construct adequate statement of works or performance work statements. This conclusion is due to the fact the three reports or audits cited improperly prepared statements of work or performance work statements as one of the primary causes of cost growth.

Although none of the articles dealt with labor price increases as a form of cost growth, it is interesting to note that Kaming et al. (1997) found material cost increases were the primary cause of cost overruns. A parallel (if somewhat weak) can be drawn between the rise in material costs, due to local price increases, and the fact that the GAO, AFAA, and

DOD IG reports cite rises in the Department of Labor mandated wage rate as a primary cause cost growth in contracts.

Summary of Literature Reviewed

From the literature, several conclusions can be reasonably made. First, changes to the statement of work or performance work statements, whether in the form of changes or delays as outlined in the FAR, are a primary cause of cost growth in USAF commercial activity contracts. Second, changes to the DOL mandated wage rate is the other primary cause of cost growth. Third, while this research was hoping to gain possible additional insight into cost growth for USAF contracts from construction industry literature, it could be reasonably concluded that causes of cost growth in USAF contracts are not all that different from causes of cost growth in the construction industry.

Due to the fact the causes of cost growth, in USAF and DOD commercial activity contracts can be reasonably concluded as stated above, this research will now focus on the extent and factors (in particular MAJCOM, contract function, contract type, and award year of contract) associated with cost growth for USAF commercial activity contracts, particularly those in the base support function area.

III. Methodology

Overview

The purpose of this methodology is to attempt to determine the extent and explore various factors, in particular MAJCOM, contract function, contract type and award year of contract, associated with cost growth. The methodology section of this research effort focuses on three areas: (1) characterization of the data, (2) strengths and weaknesses of the data, and (3) statistical methods employed.

Characterization of Data

The Air Force Audit Agency gathered data in order to accomplish a Management Advisory Service request and provided the information for this research effort. Cost growth and descriptive information on 124 USAF commercial activity contracts were used in this research effort. All of the contracts were on active-duty bases (as opposed to Air National Guard or Air Force Reserve bases), were awarded between 1986 and 1994, and were completed contracts (meaning they were not active). In addition, all contracts were at locations within the Continental United States (CONUS). The sample of 124 contracts is believed to be as random as could possibly be obtained.

The information regarding each contract consisted of the following:

(1) Location (i.e., USAF installation name at which the contract was undertaken)

(2) Major Command (MAJCOM)

(3) Description of Contract Function (i.e., Postal Service, Furnishings Management, Grounds Maintenance, etc)

(4) Type of Contract (Firm Fixed Price, Cost-Plus, etc)

(5) Award Date

(6) Original Contract Cost

(7) Final Contract Cost

(8) Total Cost Growth

[Final Contract Cost] - [Original Contract Cost] (1)

(9) Adjusted Final Contract Cost

Due to the fact some contracts had extensions of performance because of the USAF's inability to award a successive contract before existing contract expired. This "growth" cannot be counted with the cost growth of the contract due to the performance of the service provided was needed.

(10) Adjusted Cost Growth

[Adjusted Final Contract Cost] – [Original Contract Cost] (2)

(11) Percent Cost Growth

To equally compare contracts of different award amounts, percent cost growth is used. Percent cost growth is calculated by

[Adjusted Cost Growth] / [Original Contract Cost]*100 (3)

Organizing the data into 1 independent (All Contracts) and 4 dependent factors (MAJCOM, contract function, contract type, and award year of contract) is intended to provide an understanding of the contracts which were used for this research effort, as well as to provide a basis for defining the strengths and weakness of the data:

Figure 1 reflects the distribution of all the contracts according to their MAJCOM. The five MAJCOMs (ACC, AETC, AFMC, AFSPC, and AMC} represent five out of the six MAJCOMs located in the Continental United States (CONUS). Data for Air Force Special Operations Command (AFSOC) was not available; however, AFSOC only has one USAF installation located in the CONUS (Airman: 19).

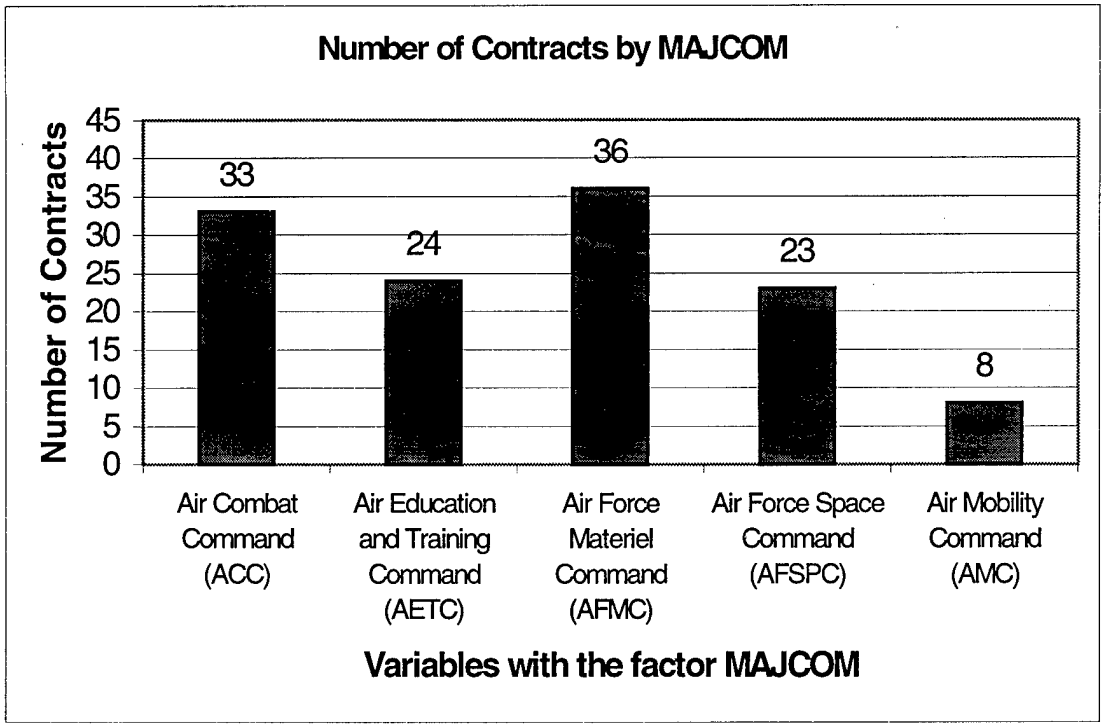

Figure 1 - Number of Contracts by MAJCOM

Figure 2 reflects the distribution of all the contracts according to their contract function. In order to maintain adequate variable sample sizes for statistical analysis, all variables with three or less cases were grouped into the variable Other-Contract Functions.

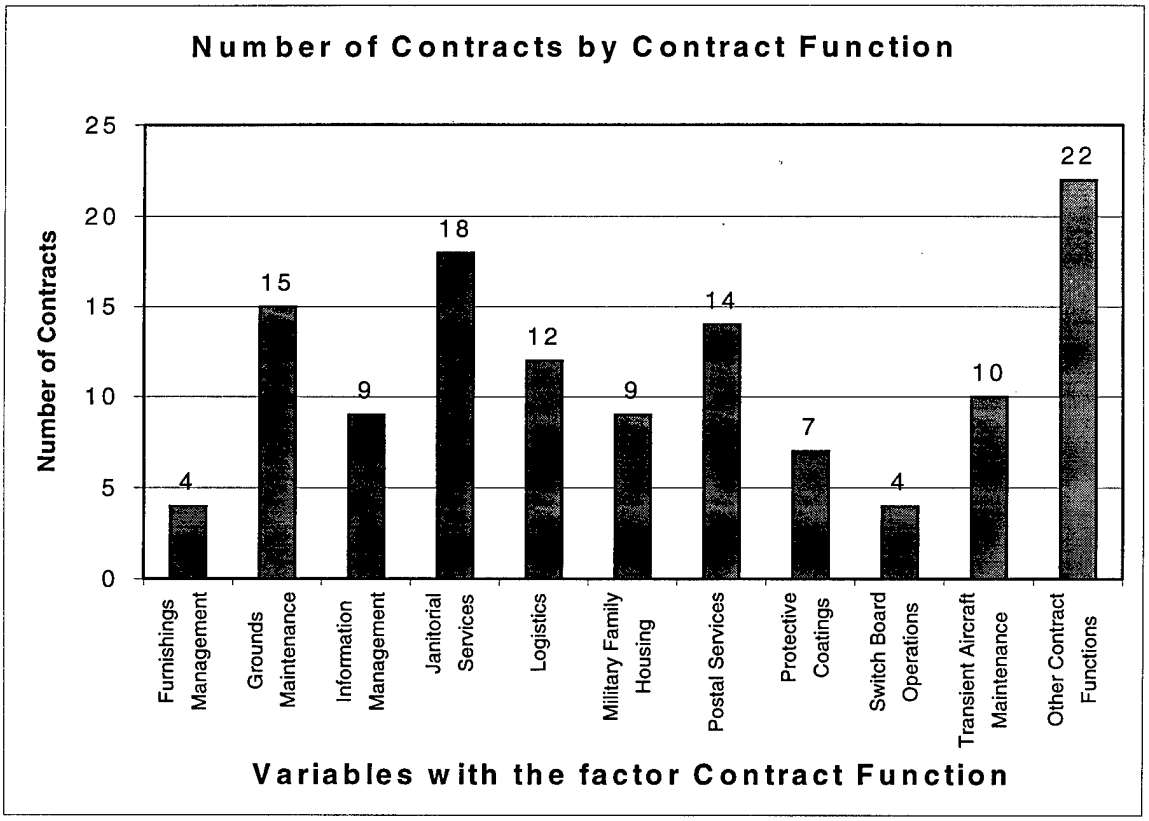

Figure 2 – Number of Contracts by Contract Function

Figure 3 reflects the distribution of all the contracts according to their contract type. In order to maintain adequate variable sample size for statistical analysis considering the large sample size of Firm-Fixed-Price, all other contract types were grouped into the variable Other-than-Firm-Fixed Price.

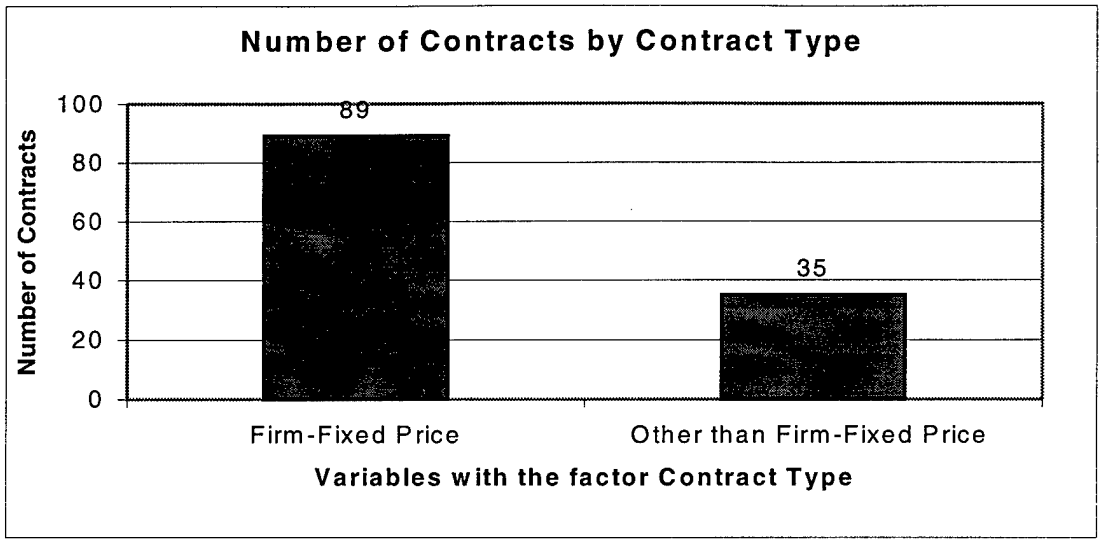

Figure 3 - Number of Contracts by Contract Type

Figure 4 reflects the distribution of all the contracts according to the year that they were awarded. It is noteworthy from the figure that the majority of contracts, 99 out of 124 contracts, were awarded between the years 1990 – 1994.

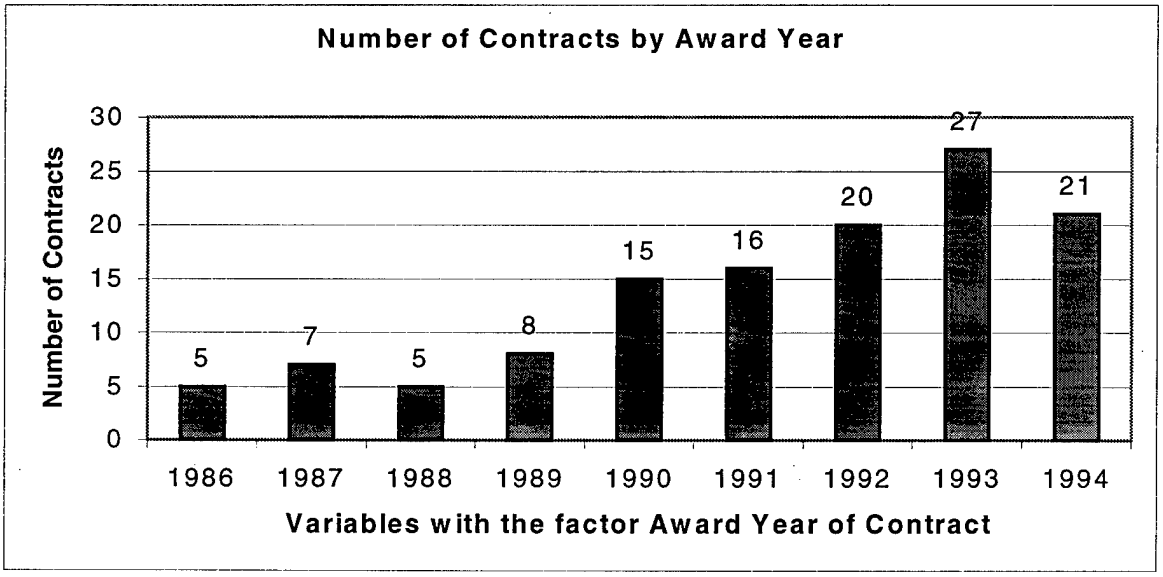

Figure 4 – Number of Contracts by Award Year

The contracts analyzed in this research range in initial award cost of $44,096 to $44,018,657; however, from the following figure it is apparent that the great majority, 115 out of 124 contracts, was awarded for less than a total of $10,000,000. Figure 5 shows the distribution of initial award amount from lowest to highest.

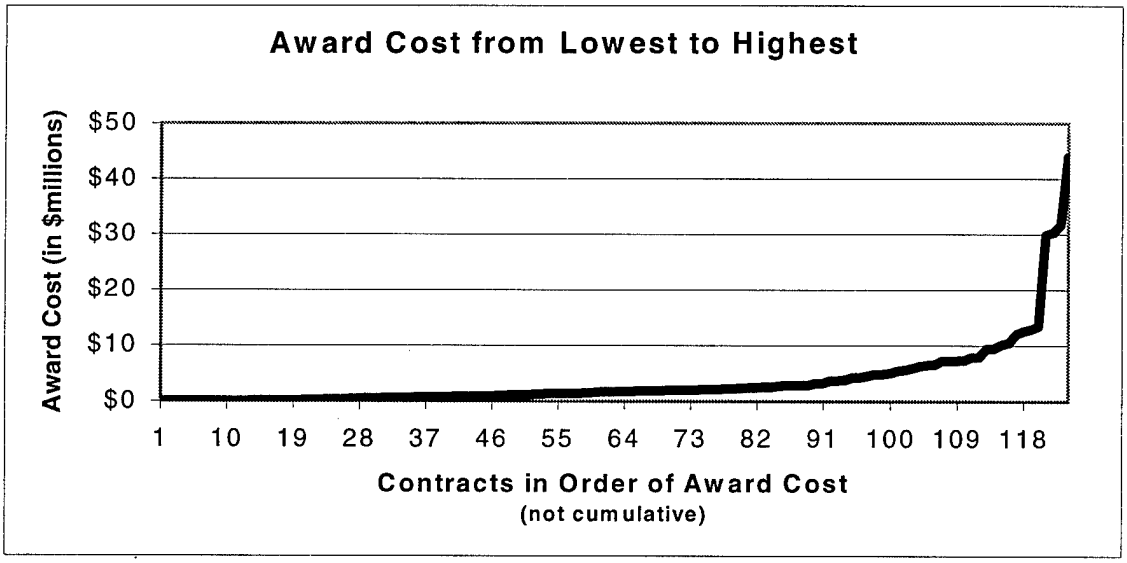

Figure 5 – Award Cost of All Contracts from Lowest to Highest

Strengths and Weaknesses of the Data

The strength of the data is based upon the fact that the data was randomly collected almost simultaneously by a homogeneous group of auditors. In addition, the data is perhaps the only type of its kind in existence.

The limitations of the data stem from the fact that when percent cost growth is calculated for each of the variables within the factors, as described in the proceeding paragraphs, they do not fall under one or a consistent set of distributions. For this reason, only non-

parametric tests can be used to determine statistical differences between variables within factors. Finally, it is not known whether the data is a good representative sample of USAF base support function contracts awarded between 1986 –1984. For this reason, tests for statistical differences will only be employed at the 0.05 and 0.10 significance level.

Statistical Methods Employed

In order to determine the extent and factors (MAJCOM, contract function, contract type, and award year of contract) this research effort focuses on three statistical methods: (1) descriptive statistics, (2) non-parametric statistics, and (3) linear regression. The purpose of each is explained in the following paragraphs:

Descriptive Statistics is used to present an overview of the extent of cost growth for all contracts collectively and the four factors (MAJCOM, contract function, contract type, and award year of contract). The mean, standard deviation, minimum, median, maximum, and inner-quartile range values of percentage of cost growth are presented for all contracts collectively as well as for all variables with the four factors. All values are computed using the STATISTIX software package. In addition, median and inner-quartile range ranks tables, as well as median with inner-quartile range charts, are used to present relative (not statistical) differences between variables within the four factors analyzed in this research. Finally, for all contracts collectively ExpertFit® is used to determine the distribution for percent cost growth. This will provide a basis for

computing probabilities falling below, exceeding, or falling in an interval of percent cost growth. ExpertFit® attempts to fit data sets within 17 known continuous distributions. It then ranks the distributions from highest to lowest according to the distribution the data most likely fits. ExpertFit® then provides one of three possible characterizations, based upon a heuristic evaluation, of how good the data fits the particular ranked distributions. The three possible characterizations are "good representation", "borderline representation", and bad representation". A "good representation" characterization by ExpertFit® means the particular distribution represents the data well, while a "borderline representation" recommends caution before accepting the distribution as representative of the data, and finally a "bad representation" does not recommend using the distribution for representing the data.

Non-parametric statistics, in particular, the Kruskal-Wallis One-Way Analysis of Variance by Ranks, is used in order to determine if any statistical differences occur between variables within the four aforementioned factors (MAJCOM, contract function, contract type, and award year of contract). The Kruskal-Wallis test is calculated using the STATISTIX® software package. The reason for using the Kruskal-Wallis lies in two reasons: (1) the data for all variables within factors do not have normal distributions, therefore use of a single factor between subjects analysis of variance is saliently violated, and (2) the variables within the factors are independent from another. Although, the variables do not have homogeneity of distributions as required by the rigorous employment of the Kruskal-Wallis, it has nevertheless been proved with empirical

evidence that this condition need not be met (Sheskin, 1997). Tests will be conducted at the 0.05 and 0.10 level of significance.

These two levels of significance are chosen for two reasons. One, it is not known whether the sample of data in this analysis is a truly representative sample. If this data were truly representative of the population, a level of significance less than or equal to 0.01 would be used. On the other hand, this research is not exploratory research for which a level of significance greater than or equal to 0.15 would be used (Roscoe, 1969). Therefore, the 0.05 and 0.10 levels of significance used in this research can be viewed as a compromise between the two extremes of equal or less than 0.01 and greater than or equal to 0.15.

Due to the fact the factor contract type only has two variables (firm-fixed price, and other-than-firm-fixed price), the Mann-Whitney test is used to test for statistical differences between the two variables. The Mann-Whitney test is computed using the STATISTIX® software package. This test was developed before the Kruskal-Wallis test and in fact was the basis for the development of the Kruskal-Wallis test (where the number of variables are greater than two) (Roscoe, 1969). Again, tests will be conducted at the 0.05 and 0.10 level of significance.

Finally, linear regression is used to determine if a statistical inference (trend) can be determined concerning the factor Award Year of Contract. Since this is the only factor in

time-series, it is appropriate to determine if cost growth is increasing, decreasing, or constant with time (Devore, 1995). The unweighted linear regression is computed using the STATISTIX® software package.

IV. Results

Overview

The results section of this research effort focuses on the presentation of results from the use of descriptive statistics, non-parametric statistics, and linear regression, as described in the methodology section. Throughout this research values for the median, minimum, maximum, inner-quartile range, mean, and standard deviation, as well as all values presented unless otherwise indicated are presented using the unit percent cost growth as calculated in equation (3) of the methodology section. First, results for all contracts taken collectively are presented. Next, results for the four factors (MAJCOM, contract function, contract type, and award year of contract) are presented.

All Contracts

Table 1 represents the results of descriptive statistics as described in the methodology section of this research. There is a great variation of results with respect to percent cost growth. This is apparent from the standard deviation value of 37.16. In addition, the great difference between the minimum (-29.5) and maximum (310.69) values of percent cost growth reiterate the substantial variation that exists with respect to percent cost growth. Noteworthy, is the difference between the mean value of 14.02 and the median value of 4.57, which would indicate a non-normal distribution of the data.

Table 1 – Descriptive Statistics for All Contracts

	All Contracts
Number of Observations	124
Mean	14.02
Standard Deviation	37.16
Standard Error of the Mean	3.34
Minimum	-29.51
Median	4.57
Maximum	310.69
Inner-Quartile Range	14.26

The histogram in Figure 6 below shows the distribution of percent cost growth. It is apparent that the great majority of values fall between (-30) and 50 percent cost growth. The four percent cost growth bins with the highest frequencies, [0-5], [5-10], [10-15], and [15-20], account for 82 of the 124 contracts, or just over 2/3^{rds} of the contracts analyzed. Noteworthy is the fact two "spikes" occur in the [0,5], and [5,10] bins. These two "spikes" would initially indicate a non-normal distribution; however, due to the fact the bins are in 5 percent cost growth increments it cannot be concluded that this is a non-normal distribution. In addition, the values located in the [165,170] and [310,315] bins would appear to be well outside grouping of the remaining data. This indicates that these two values could possibly be considered outliers; however, this cannot be confirmed from this histogram alone.

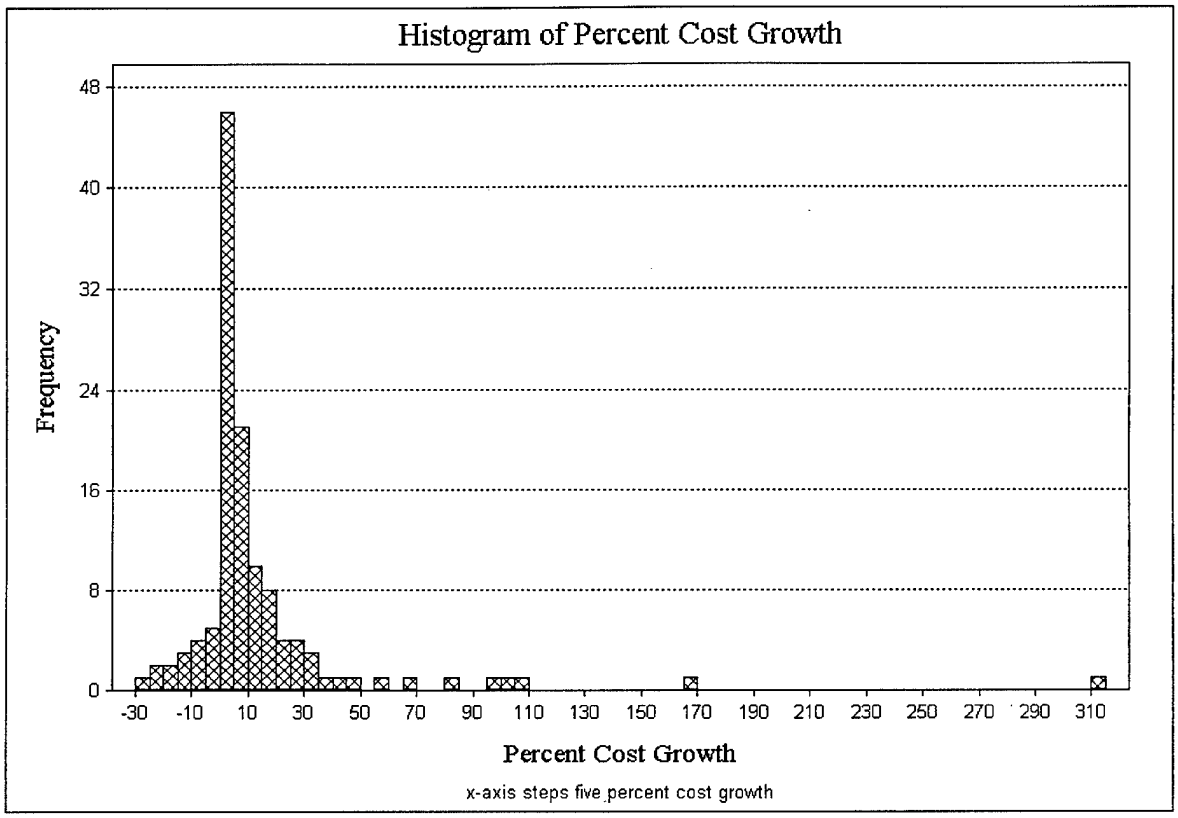

Figure 6 – Histogram of Percent Cost Growth for All Contracts

Figure 7 is a box and whisker plot of percent cost growth for all contracts. Extreme values are displayed as "*" for possible outliers and "O" for probable outliers. Possible outliers are values that are outside the box boundaries by more than 1½ times the size of the box. Probable outliers are values that are outside the box boundaries by more than 3 times the size of the box. Although, eight values appear to be probable outliers, only the two values greater than 110 percent cost growth appear to be distinct extreme probable outliers. For this reason, they shall be removed from the analysis. Although the other six probable outliers can be removed from the analysis, the fact that there are six and the fact they are basically evenly spread from the possible outliers validates their inclusion in further analysis. This is the judgement of the author. (Note: The entire analysis in this

research was run with their inclusion, and produced no different results with respect to the statistical differences between variables within the four factors. It is the author's judgment that these two cases were extreme examples of cost growth that would not be the result of typical causes of cost growth considering the rest of the data.).

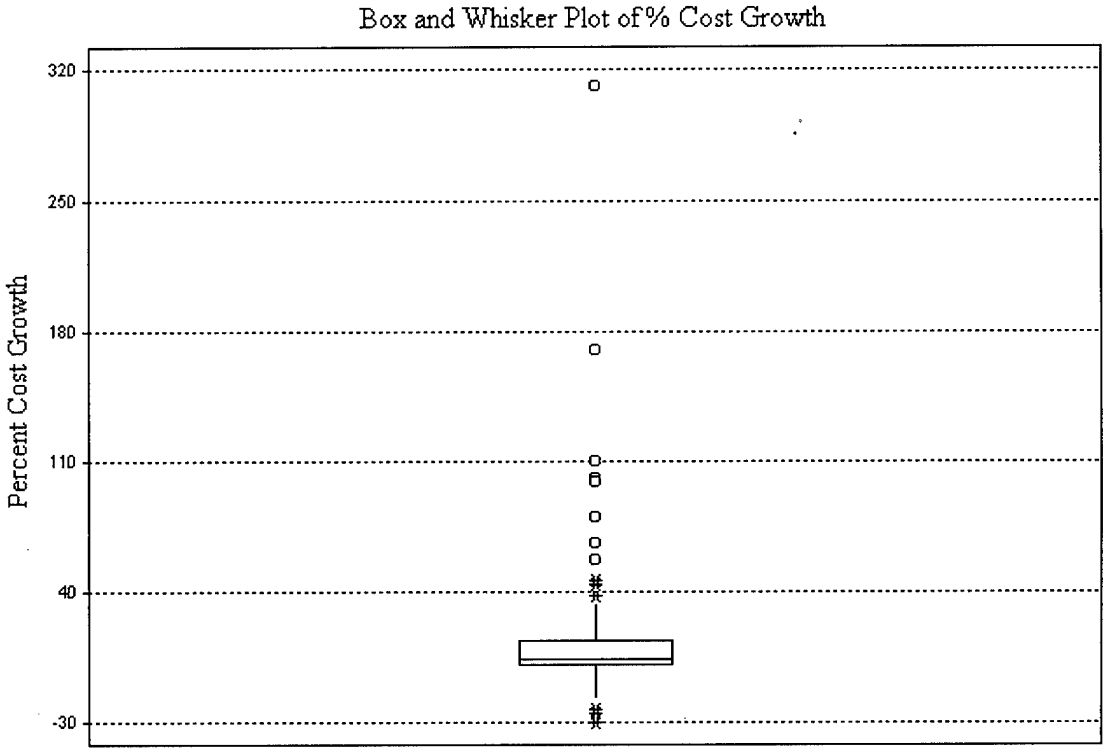

Figure 7 – Box and Whisker Plot of Percent Cost Growth

Table 2 represents a revised analysis without the two extreme probable outliers. The mean and standard deviation are effected greatly. The mean decreases from 14.02 to 10.31 and the standard deviation decreases from 37.16 to 21.51. In addition, the standard error of the mean falls from 3.34 to 1.95. It is apparent the two extreme probable outliers had profound effect due to the relatively small sample size of this data. The median value

remains changes little to 4.56. The difference between the mean and median values still indicates a non-normal distribution.

Table 2 – Revised Descriptive Statistics without Extreme Probable Outliers

	All Contracts
Number of Observations	122
Mean	10.31
Standard Deviation	21.51
Standard Error of the Mean	1.95
Minimum	-29.51
Median	4.56
Maximum	109.97
Inner-Quartile Range	13.625

ExpertFit® is used to determine the distribution for which the data is representative. Initially, the 122 cases were entered and produced "borderline representations" and "bad representations" regarding the particular distributions ExpertFit® characterized as most representative of the data (see methodology section for explanation of ExpertFit® representations). This was confirmed using frequency-comparison-overlay plots of the data compared to the actual distributions as recommended by ExpertFit®. It was noted during evaluation of the frequency-comparison-overlay plots that a "spike" occurred at the 0.00 value of percent cost growth. This "spike" was caused by the fact 11(or 9.02%) of the 122 cases are exactly 0.00. Since it is likely many contracts will have 0.00 percent cost growth, there is a point mass of probability at 0.00 percent cost growth to go with the rest of the probability density distributed on the real line. This means we really have a mixture distribution of a discrete part and a continuous part of the distribution. If we

exclude the point mass discrete part from the data we can try to fit a distribution to the remaining continuous part.

In order to attempt to fit the data within a continuous distribution, ExpertFit® was run without the eleven 0.00 values. ExpertFit ® produced one "good representation" with respect to the $Johnson_{SU}$ distribution. The $Johnson_{SU}$ distribution can be most compared to a Normal distribution; however, it has a much narrower peak and accounts for greater variation at or near the tails (Miller, 1995: 481).

Figure 8 represents a probability density function for the $Johnson_{SU}$ distribution of the data for percent cost growth taking into account that the 0.00 values (which compose 9.02% of the data) are removed. Noteworthy is the fact the distribution appears to be a "normal-like" distribution with a steep peak and centered at approximately10 percent cost growth. In addition, examination of the curve reveals non-symmetry. This is confirmed by comparing the values –10 and 30 percent cost growth (both values are equal units on the chart from the apparent center of the distribution). The probability for –10 percent cost growth is approximately 0.04 while for 30 percent cost growth the value is 0.07. This is true for all corresponding values near the ends of the distribution. This confirms the non-symmetry of the distribution as well as indicating the larger probability of positive cost growth values.

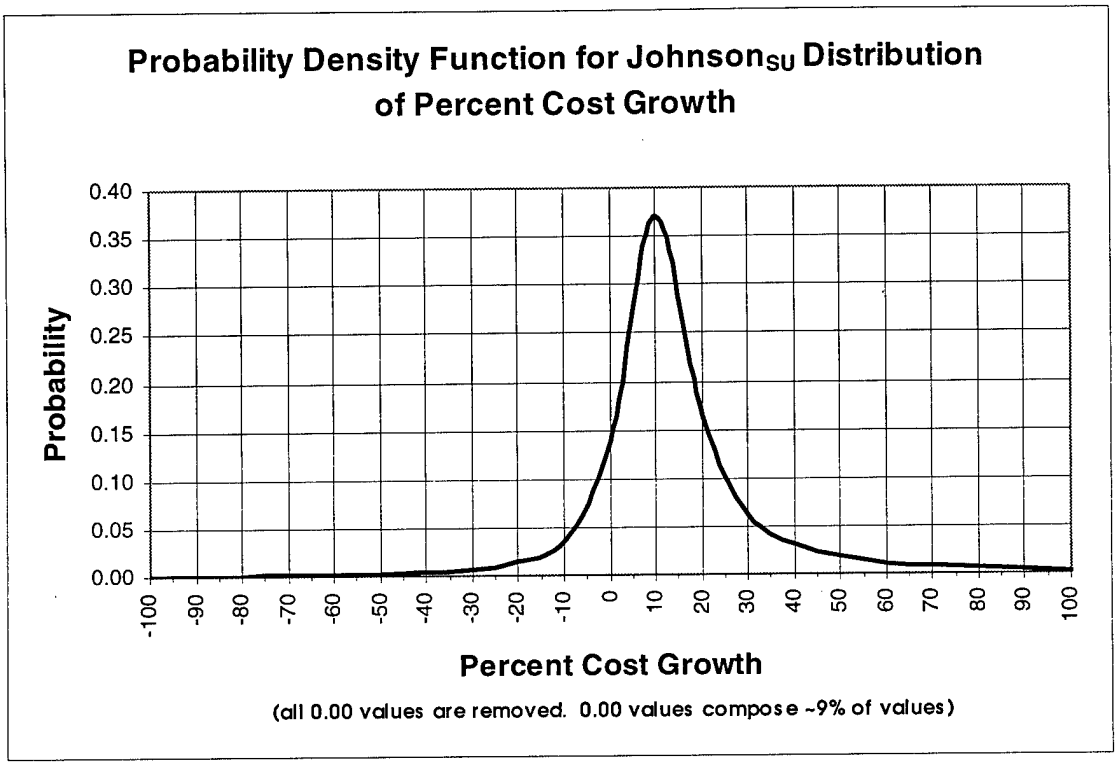

Figure 8 – Probability Density Function

Figure 9 is a cumulative density function (CDF) for the Johnson$_{SU}$ distribution of percent cost growth also without the eleven 0.00 values (apparent from the fact the CDF line only approaches 0.90. From this figure it is clear that the vast majority of percent cost growth values are greater than zero. In fact from the figure it is easy to approximate that 7% of the values are negative. From this it can be concluded that 84% of all values are positive (100% minus 7% for negative cost growth minus 9% for no cost growth). It can be concluded from this that the great majority of USAF base support function contracts awarded between 1986 – 1994 have experienced cost growth (84% positive and 7% negative). It could be stated that this confirms, among other possibilities, the inability of the USAF to consistently construct adequate statements of work considering the findings of the GAO, AFAA, and DOD IG audits/reports.

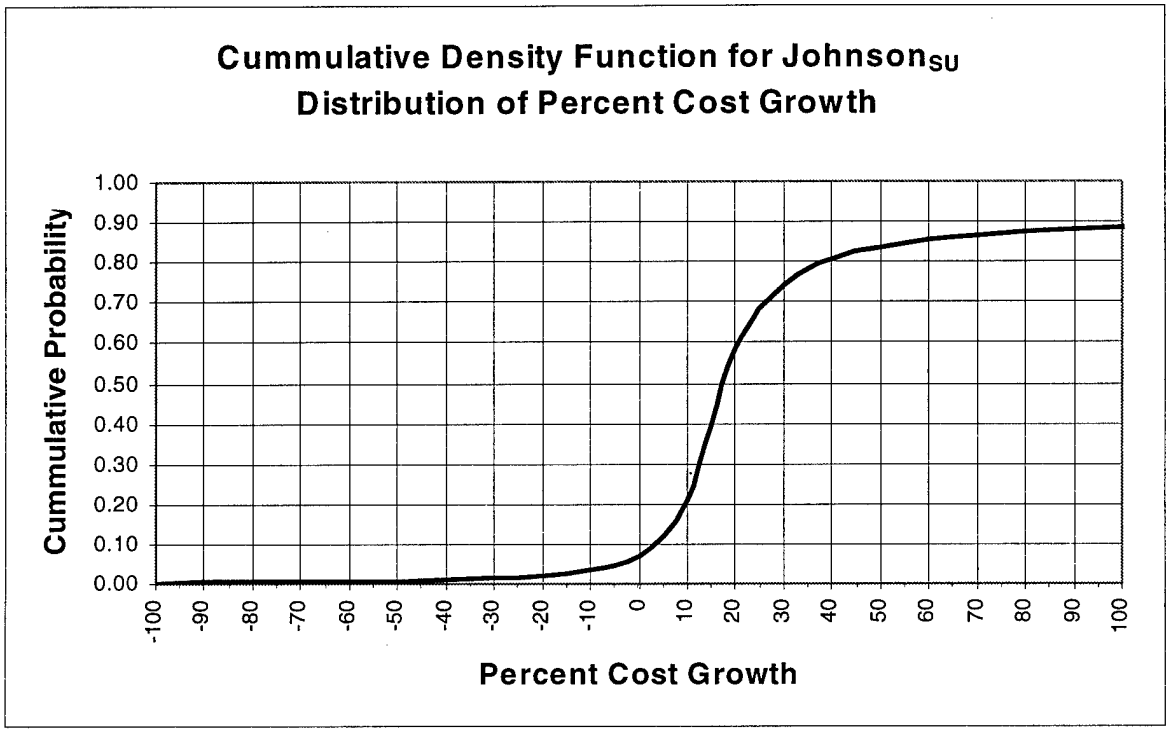

Figure 9 – Cumulative Density Function

Factors

The results for the four factors (MAJCOM, contract function, contract type, and award year of contract) are presented in the following format:

1.) Results of descriptive statistics and discussion
2.) Presentation of mean and standard deviation rank table and discussion
3.) Results of the Kruskal-Wallis test and discussion
4.) Results of linear regression (for the factor – award year of contract only)

FACTOR 1 - MAJCOM

Table 3 represents the results of descriptive statistics as described in the methodology section of this research for the factor MAJCOM. All variables within the factor MAJCOM have non-normal distributions; therefore, the median and inner-quartile range

values will be used to compare variables. The median value of percent cost growth varies from a low of 3.72 for AFMC to a high of 10.98 for AFSPC. This compares to a median value of percent cost growth for all contracts collectively of 4.56. The inner-quartile range varies from a low of 7.71 for AFMC to a high of 28.88 for AMC. This compares to an inner-quartile range value of 13.625 for all contracts taken collectively. There appears to be a disparity between the MAJCOMs. This research will first address the relative differences (using a median and inner-quartile range rank table and a median with inner-quartile range figure) and then the statistical differences (using the Kruskal-Wallis test) between the MAJCOMs.

Table 3 – Descriptive Statistics for Contracts by MAJCOM

MAJCOM	Number of Observations	Median	Min	Max	Inner-Quartile Range	Mean	Standard Deviation
ACC	33	4.58	-22.68	109.97	17.48	12.73	24.79
AETC	24	4.48	-11.05	99.30	9.79	10.33	21.57
AFMC	36	3.72	-29.51	101.32	7.71	8.21	23.14
AFSPC	21	10.98	-24.56	33.62	12.62	8.64	14.55
AMC	8	7.68	0.00	45.82	28.88	14.15	17.46

To further explore the relative differences between variables within the factor MAJCOM, Table 4 represents the median and inner-quartile range ranks for the variables within the factor MAJCOM. AFMC appears dominant (i.e., having the lowest median and inner-quartile range ranks) followed by AETC. This indicates that AFMC and AETC when compared to the other MAJCOMs not only has a relatively lower percent cost growth, but also that their percent cost growth values are not as widely distributed. AFSPC and AMC

appear to have relatively high median and inner-quartile range ranks when compared to the other MAJCOMs. Meaning, their percent cost growth values are not only higher but also more widely distributed.

Table 4 – Median and Inner-Quartile Range Rank Table for Contracts

MAJCOM	Median Rank	Inner-Quartile Range Rank
ACC	3	4
AETC	2	2
AFMC	1	1
AFSPC	5	4
AMC	4	5

Figure 10 reflects the median with inner-quartile range for all contracts by MAJCOM. Noteworthy from the figure is the fact the inner-quartile ranges overlap for all of the variables, initially indicating that there is no statistical difference between the variables within the factor MAJCOM. Thus the level of cost growth that occurs in one MAJCOM may not be statistically different from the level of cost growth in the other MAJCOMs. However, this statistical difference can only be shown with a statistical test conducted over a level of significance. This research will test for statistical differences between the variables within the factor MAJCOM with the Kruskal-Wallis test. Of note is the fact the mean values appearing higher than the median values in all but AFSPC. This would indicate the presence of high-value outliers, which significantly affect the mean value. The large inner-quartile range in AMC is likely due to the relatively small sample size and the presence of high-value outliers. AFSPC, due to the fact the mean value is lower

than the median value, would appear to have a number of relatively lower percent cost growth values.

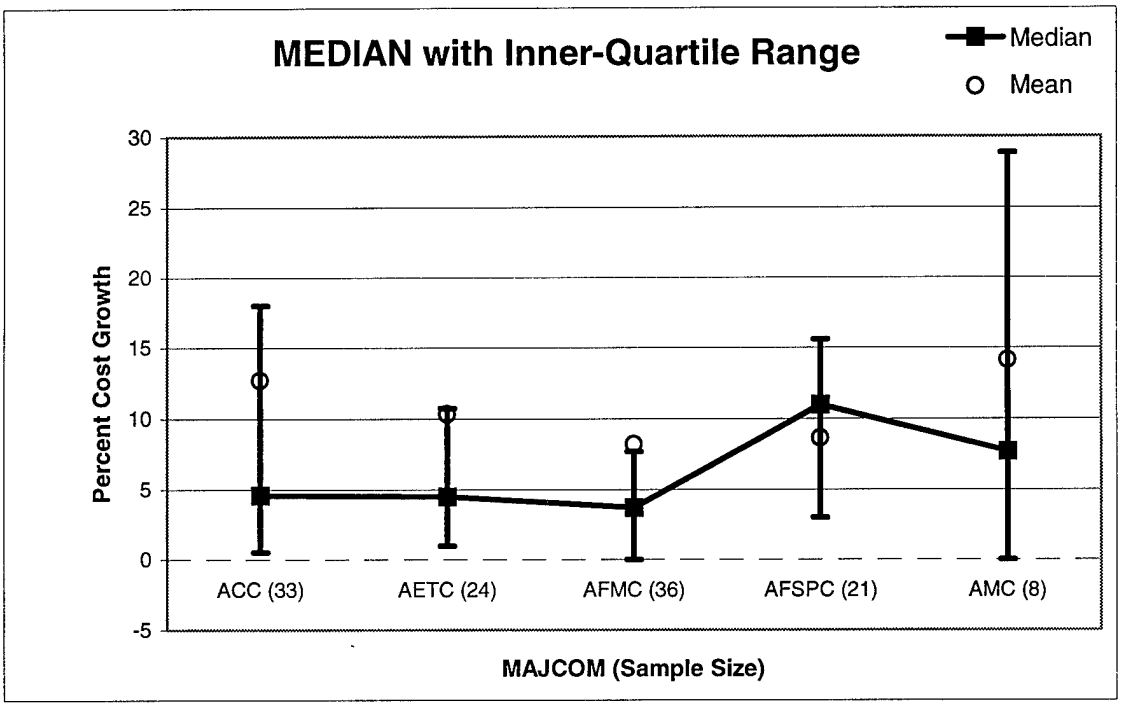

Figure 10 – Percent Cost Growth of Contracts by MAJCOM

Table 5 represents the results for the Kruskal-Wallis test for statistical differences between the variables within the factor MAJCOM. The results of the Kruskal-Wallis test, at 0.05 significance level, indicate that no significant pairwise statistical difference among the means exist. An additional test at significance level = 0.10 was run with the same results. This confirms, from Figure 10 and previous results, that the variables within the factor MAJCOM, while relatively different from one another, are not statistically different, at the 0.05 or 0.10 level, from one another.

Table 5 – Results for Kruskal-Wallis Test for Contracts by MAJCOM

Kruskal-Wallis Test for MAJCOM

Variable	Mean Rank	Sample Size	Homogeneous Groups
AFSPC	72.048	21	I
AMC	65.875	23	I
ACC	62.424	33	I
AETC	61.604	24	I
AFMC	53.458	36	I
TOTAL	**61.5**	**122**	

Rejection Level = .05
Total Number of Values that were Tied = 17
Maximum Difference Allowed Between Ties = .00001

In summary regarding the factor MAJCOM, the following can be concluded. Relative differences between MAJCOMs with respect to the amount of cost growth that occurred in USAF base support function contracts awarded between 1986 – 1994 do exist. This is clear from Figure 10. However, due to the overlap of the inner-quartile ranges for each variable's percent cost growth, no statistical differences can be found (at the .05 or .10 level of significance) between the MAJCOMs with respect to the amount of cost growth. In other words, no MAJCOM is meaningfully any different from any other with respect to the amount of cost growth of their respective contracts.

FACTOR 2 – CONTRACT FUNCTION

Table 6 represents the results of descriptive statistics as described in the methodology section of this research for the factor contract function. All variables within the factor MAJCOM have non-normal distributions; therefore, the median and inner-quartile range values will be used to compare variables. The median value of percent cost growth varies from a low of 0.75 for Other Contract Functions to a high of 19.05 for Military Family

Housing. This compares to a median value of percent cost growth for all contracts taken collectively of 4.56. The inner-quartile range varies from a low of 6.60 for Other Contract Functions to a high of 80.04 for Protective Coatings, compared to an inner-quartile range value of 13.625 for all contracts taken collectively. There appears a great disparity between the contract functions. This research will first address the relative differences (using a median and inner-quartile rank table and a median and inner-quartile range figure) and then the statistical differences (using the Kruskal-Wallis test) between the contract functions.

Table 6 – Descriptive Statistics for Contracts by Contract Function

Contract Function	Number of Observations	Median	Min	Max	Inner-Quartile Range	Mean	Standard Deviation
Furnishings Management (FM)	4	16.35	1.94	99.30	73.81	33.48	44.42
Military Family Housing (MFH)	9	19.05	0.59	66.10	34.70	20.88	22.04
Postal Service (PS)	14	5.67	-6.07	44.58	24.30	11.69	15.66
Transient Aircraft Maintenance (TAM)	10	4.99	0.65	101.32	6.90	14.07	30.80
Grounds Maintenance (GM)	15	4.56	-15.99	29.61	13.82	6.26	13.30
Protective Coatings (PC)	7	6.28	0.00	109.97	80.04	34.87	44.96
Janitorial Services (JAN)	18	7.28	-29.51	57.64	12.49	7.67	18.51
Information Management (INFO)	9	2.24	-24.56	17.82	11.70	0.30	12.00
Logistics (LOG)	12	9.87	0.00	26.27	11.99	10.28	7.41
Switchboard Operations (SWITCH)	4	2.68	-15.21	4.56	15.70	-1.33	9.41
Other Contract Functions (OTHER)	20	0.75	-13.97	19.69	6.60	1.75	7.94

To further explore the relative differences between variables within the factor contract function, Table 7 represents the median and inner-quartile range ranks for the variables within the factor contract function. Other Contract Functions [1,1] appears dominant (i.e. having the lowest median and inner-quartile range ranks). This indicates that Other Contract Functions when compared to the other contract functions has a relatively lower percent cost growth value, and its percent cost growth values are not as widely distributed. Information Management [2,3] appears to be the only other contract function with relatively lower median and inner-quartile range values. Clearly, Military Family Housing [11,9] and Furnishings Management [10,10] have relatively higher median and inner-quartile range ranks among the contract functions. This indicates that Military

Family Housing and Furnishings Management when compared to the other contract functions have a relatively higher percent cost growth value, and that their percent cost growth values are more widely distributed.

Table 7 – Median and Inner-Quartile Range Rank

Contract Function	Median Rank	Inner-Quartile Range Rank
Furnishing Management	10	10
Military Family Housing	11	9
Postal Service	6	8
Transient Aircraft Maintenance	5	2
Grounds Maintenance	4	6
Protective Coatings	7	11
Janitorial Services	8	5
Information Management	2	3
Logistics	9	4
Switchboard Operations	3	7
Other Contract Functions	1	1

Figure 11 reflects the median and inner-quartile for all contracts by contract function. Noteworthy from the figure is the fact that the inner-quartile ranges have considerable overlap, initially indicating that there is no statistical difference between the variables within the factor contract function. Thus the level of cost growth that occurs in one or more contract functions may not be statistically different from the level of cost growth in the other contract functions. However, this statistical difference can only be proven with a statistical test conducted over a level of significance. This research will test for statistical differences between the variables within the factor contract function with the Kruskal-Wallis test. The large inner-quartile range in Furnishing Management and Protective Coatings is likely a result of small sample sizes with the presence of high

percent cost growth values. As with the variables with the factor MAJCOM the presence of mean values larger than median values in a number of variables indicates not only a non-normal distribution, but also the presence of higher-valued outliers within the variables' distribution.

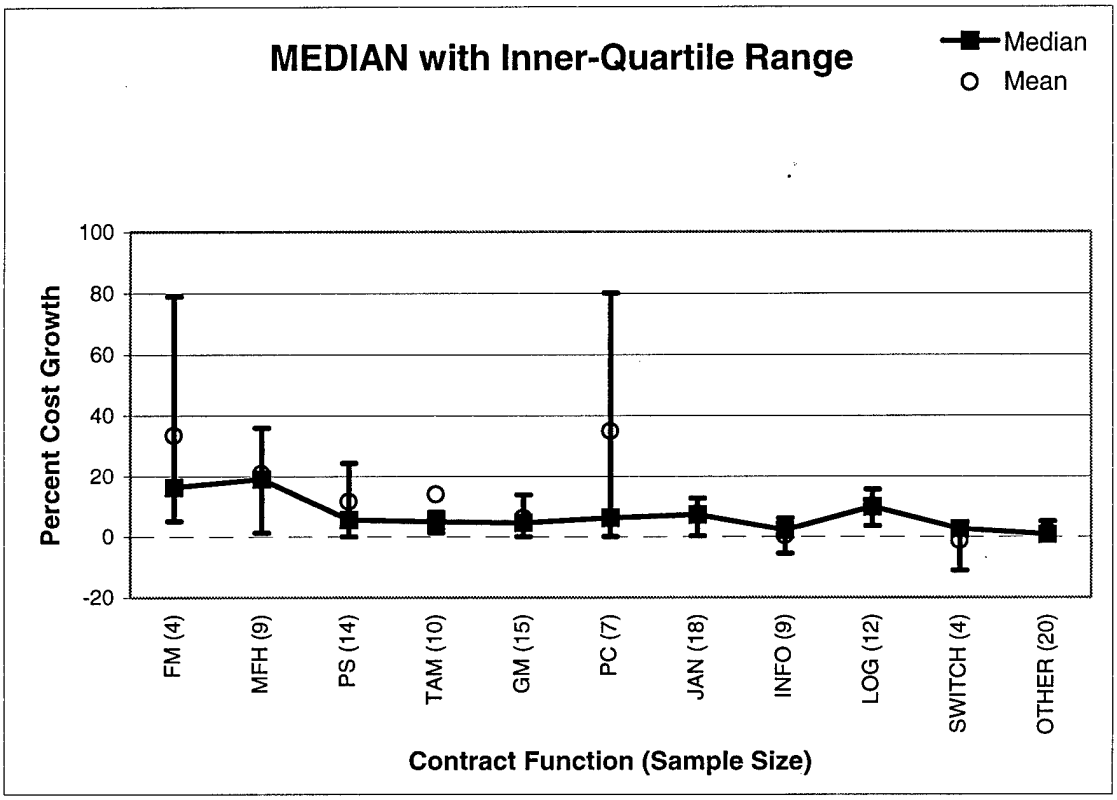

Figure 11 – Percent Cost Growth of Contracts by Contract Function

Table 8 represents the results for the Kruskal-Wallis test for statistical differences between the variables within the factor contract function. The results of the Kruskal-Wallis test, at 0.05 significance level, indicate that no significant pairwise difference among the means exist. An additional test at significance level = 0.10 was run with the same results. This confirms from Figure 11 and previous results, that the variables within

the factor contract function, while relatively different from one another, are not statistically different, at the 0.05 or 0.10 level, from one another. Therefore, it can be concluded that there is no difference between contract functions with respect to amount of percent cost that occurred in USAF base support function contracts awarded between 1986 –1994.

Table 8 – Results for Kruskal-Wallis Test for Contracts for Contract Function

Kruskal-Wallis Test for Contract Function

Variable	Mean Rank	Sample Size	Homogeneous Groups
Furnishing Management (FM)	89.8	4	I
Grounds Maintenance (GM)	59.1	15	I
Information Management (INFO)	46.6	9	I
Janitorial Services (JAN)	63.7	18	I
Logistics (LOG)	76.2	12	I
Military Family Housing (MFH)	81.9	9	I
Other Contract Functions (OTHER)	41.5	20	I
Protective Coatings (PC)	74.4	7	I
Postal Service (PS)	63.4	14	I
Switchboard Operations (SWITCH)	40.4	4	I
Transient Aircraft Maintenance (TAM)	64.2	10	I
TOTAL	**61.5**	**122**	

Rejection Level = .05
Total Number of Values that were Tied = 17
Maximum Difference Allowed Between Ties = .00001

In summary regarding the factor contract function, the following can be concluded. Relative differences between variables with respect to the amount of cost growth that occurred in USAF base support function contracts awarded between 1986 – 1994 does exist. However, due to the extensive overlap of inner-quartile ranges between variables, no statistical differences can be found (at the 0.05 or 0.10 level of significance) between

the variables with respect to the amount of cost growth. In other words, no contract function (variable) is meaningfully different from any other contract function with respect to the amount of cost growth of their respective contracts.

FACTOR 3 – CONTRACT TYPE

Table 9 represents the results of descriptive statistics as described in the methodology section of this research for the factor contract type. All variables within the factor Contract Type have non-normal distributions; therefore, the median and inner-quartile range values will be used to compare variables. There appears a noticeable difference between the two contract types. Other-than- FFP's median value of percent cost growth is close to double Firm Fixed Price's. The difference between their inner-quartile ranges is even more pronounced considering Firm Fixed Price's inner-quartile range is 11.15 and Other than Firm-Fixed Price's inner-quartile range is 21.16, a difference of greater than 10.0 percentage points.

Table 9 – Descriptive Statistics for Contracts by Contract Type

Contract Type	Number of Observations	Median	Min	Max	Inner-Quartile Range	Mean	Standard Deviation
Firm-Fixed Price	89	4.29	-29.51	101.32	11.15	7.92	18.86
Other-than-Firm-Fixed Price	33	7.34	-15.99	109.97	21.16	16.76	16.70

Figure 12 reflects the median with inner-quartile range for all contracts by contract type. Again, there is considerable overlap between the inner-quartile ranges for each of the contract types. This overlap of standard deviations initially would indicate that there is

no statistical difference between the two contract types. However, this statistical difference can only be shown with a statistical test conducted over a level of significance. This research will test for statistical differences between the variables within the factor contract type with the Mann-Whitney test. Even more significant is Other-than-Firm-Fixed Price's difference between median and mean value. This difference indicates the presence of a considerable number of high-percent, cost-growth values. The difference between Firm-Fixed Price's median and mean values is not as pronounced; however, it as well indicates the presence of high-percent, cost-growth values.

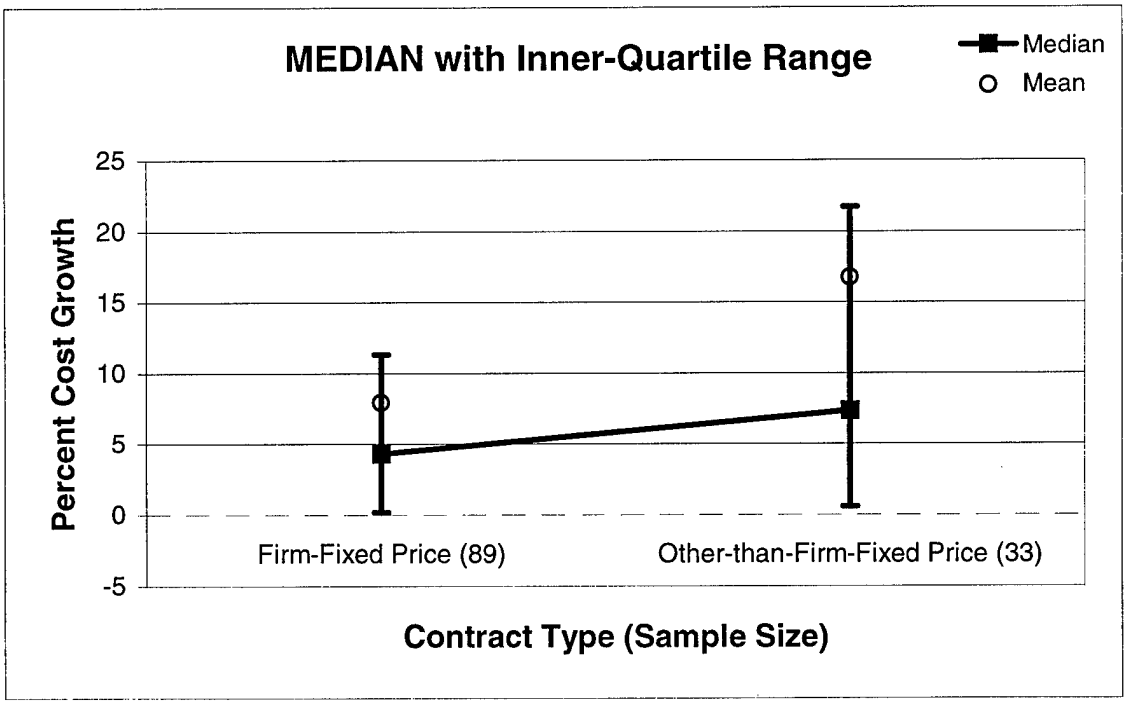

Figure 12 – Percent Cost Growth of Contracts by Contract Type

The factor contract type only has two variables, due to this and as described in the methodology section of this research the Mann-Whitney test will be conducted. Table 10

represents the results for the Mann-Whitney test for statistical differences between the variables with the factor contract type. The U-Stat for this particular test is 1156. No U-charts could be obtained for the particular sample sizes; therefore, the z-value must be used using the normal approximation. The z-value for this particular test is $z = -1.801$. (See Appendix B for calculation of z-value) The critical value is $-1.96 < z^{(crit)} < 1.96$. Since $z = -1.801$ falls between $-1.96 < z^{(crit)} < 1.96$, for a two-tailed test at the .05 significance level, this indicates that the two variables are not significantly different from one another (Roscoe, 1969). However, the Mann-Whitney test conducted at a significance level = 0.10 showed the variables to be statistically different from one another. In other words, when the rejection level was increased from 0.05 to 0.10 there is now a 10% probability that the null hypothesis (there is no statistical difference between the variables) has been falsely rejected when in fact it is true. This is significant, due to the fact that depending upon the validity (how representative of a sample) of the data, cost growth may or may not be the result of the type of contract.

Table 10 – Results for Mann-Whitney Test for Contracts for Contract Type

Mann-Whitney Test for Contract Type

Variable	Rank Sum	Sample Size	U Stat
Firm Fixed Price (FFP)	5161.00	89	1156
Other than Firm Fixed Price (OTHERTYPE)	2342.0	33	1781
TOTAL	**7503**	**122**	

Total Number of Values that were Tied = 17
Maximum Difference Allowed Between Ties = .00001

FACTOR 4 – AWARD YEAR OF CONTRACT

Table 11 represents the results of descriptive statistics as described in the methodology section of this research for the factor award year of contract. All variables within the factor Award Year of Contract have non-normal distributions; therefore, the median and inner-quartile range values will be used to compare variables. The median value of percent cost growth varies from a low of 1.37 for 1990 to a high of 7.04 for 1992. This compares to a median value of percent cost growth for all contracts taken collectively of 4.56. The inner-quartile range varies from a low of 7.20 for 1986 to a high of 40.65 for 1988, compared to a inner-quartile range of 13.63 for all contracts taken collectively. There appears to be a disparity between the award years of contracts. This research will first address the relative differences (using a median and inner-quartile range rank table and a median and inner-quartile range figure), then the statistical differences (using the Kruskal-Wallis test) between the award years of contracts, and linear regression to assess correlation between year and percent cost growth.

Table 11 – Descriptive Statistics for Contracts by Award Year of Contract

Award Year of Contract	Number of Observations	Median	Min	Max	Inner-Quartile Range	Mean	Standard Deviation
1986	5	3.88	0.00	11.58	7.20	4.72	4.33
1987	7	4.50	-15.21	14.64	11.89	3.04	9.67
1988	5	4.29	-13.97	45.82	40.65	11.91	22.96
1989	8	4.27	-15.99	109.97	15.12	13.57	39.88
1990	14	1.37	-1.62	31.76	8.06	5.88	9.35
1991	16	2.72	-22.68	44.58	16.65	8.00	16.73
1992	20	7.04	-29.51	101.32	14.85	11.17	24.25
1993	27	6.28	-8.69	99.30	18.55	14.25	22.77
1994	20	4.49	-24.56	80.04	19.88	11.33	23.73

To further explore the relative differences between variables within the factor award year of contract, Table 12 represents the median and inner-quartile range ranks for the variables within the factor award year of contract. No award year of contract dominates; however, 1986 [3,1], and 1990 [1,2], appear to have relatively lower median and inner-quartile range ranks among award years of contract. This indicates contracts awarded in 1986, and 1990 when compared to contracts awarded in other years have a relatively lower percent cost growth value, and their percent cost growth values are not as widely distributed. Only, 1993 [8,7] stands out from the other contracts as having both a high median and inner-quartile range rank among the award years of contract. This indicates that contracts awarded in 1993 when compared to other contracts awarded in other years has a relatively higher percent cost growth value, and its percent cost growth value is more widely distributed

Table 12 – Median and Inner-Quartile Range Rank Table

Award Year of Contract	Median Rank	Inner-Quartile Range Rank
1986	3	1
1987	7	3
1988	5	9
1989	4	5
1990	1	2
1991	2	6
1992	9	4
1993	8	7
1994	6	8

Figure 13 reflects the median with inner-quartile range for all contracts by award year of contract. Noteworthy from the figure is the fact that the considerable overlap of the inner-quartile ranges for all of the variables, initially indicating that there is no statistical difference between the variables within the factor award year of contract. Meaning the level of cost growth that occurs in one or more award years of contacts may not be statistically different from the level of cost growth in the other award years of contacts. However, this statistical difference can only be shown with a statistical test conducted over a level of significance. This research will test for statistical differences between the variables within the factor award year of contract using the Kruskal-Wallis test. The year 1988 has an unusually large inner-quartile range. This is likely the result of a small sample size coupled with the presence of one or two high values of percent cost growth. In addition, the repetitive pattern from 1991 to 1994 is significant. This would initially indicate almost a stabilization of the inner-quartile range coupled with the presence of high values in each of the years that cause the mean to be higher than the median values in all of those variables.

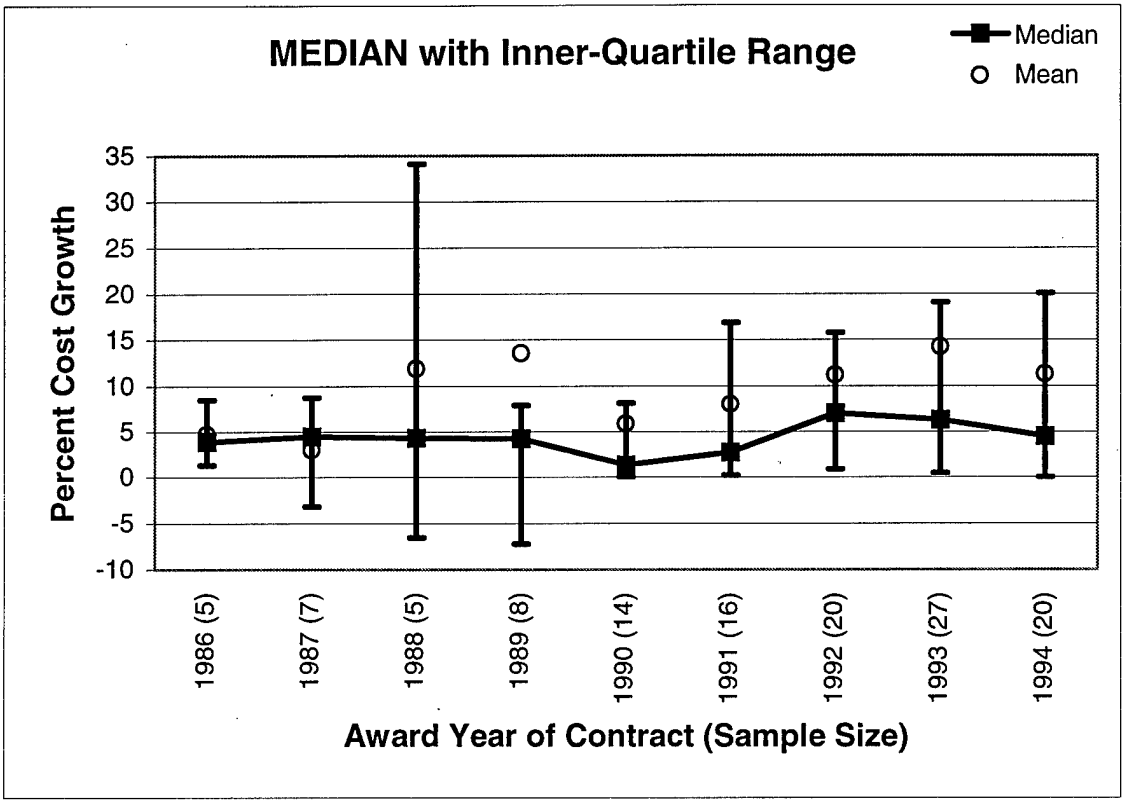

Figure 13 – Percent Cost Growth of Contracts by Award Year of Contract

Table 13 represents the results for the Kruskal-Wallis test for statistical differences between the variables, at 0.05 significance level, within the factor award year of contract. The results of the Kruskal-Wallis test indicate that no significant pairwise statistical differences among the means exist (i.e., no two variable means are statistically different). An additional test at significance level = 0.10 was run with the same results. This confirms, from Figure 13 and previous results, that the variables within the factor award year of contract, while relatively different from one another, are not statistically different, at the 0.05 or 0.10 significance level, from one another. Therefore, it can be concluded that there is no meaningful difference between the variables with the factor award year of

contract with respect to amount of percent cost that occurred in USAF base support function contracts in the years 1986 -1994.

Table 13 – Results for Kruskal-Wallis Test for Contracts by Award Year of Contract

Kruskal-Wallis Test for Award Year of Contract

Variable	Mean Rank	Sample Size	Homogeneous Groups
1986	56.3	5	I
1987	54.6	7	I
1988	64.0	5	I
1989	54.6	8	I
1990	53.2	14	I
1991	59.6	16	I
1992	66.3	20	I
1993	67.9	27	I
1994	61.3	20	I
TOTAL	**61.5**	**122**	

Rejection Level = .05
Total Number of Values that were Tied = 17
Maximum Difference Allowed Between Ties = .00001

Due to the fact the factor award year of contract is the only time-series type data, this portion of the results focuses on the use of linear regression on the factor of Award Year of Contract. All contracts were awarded between the years of 1986-1994. Linear regression will determine if cost growth is increasing, decreasing, or remaining constant during the time period in question. The results of an unweighted linear regression for all the values of percent cost growth follow in Figure 14 and Table 14. As one can see from the plot, it appears cost growth is increasing over time. However, the P-value of 0.2506 indicates little regression effect. In this case, the value of 0.2506, indicates that the regression line is not significantly different than zero. In other words, although the

regression line in the plot appears to be increasing over time, in reality its slope is not meaningfully different than a line with a slope of zero.

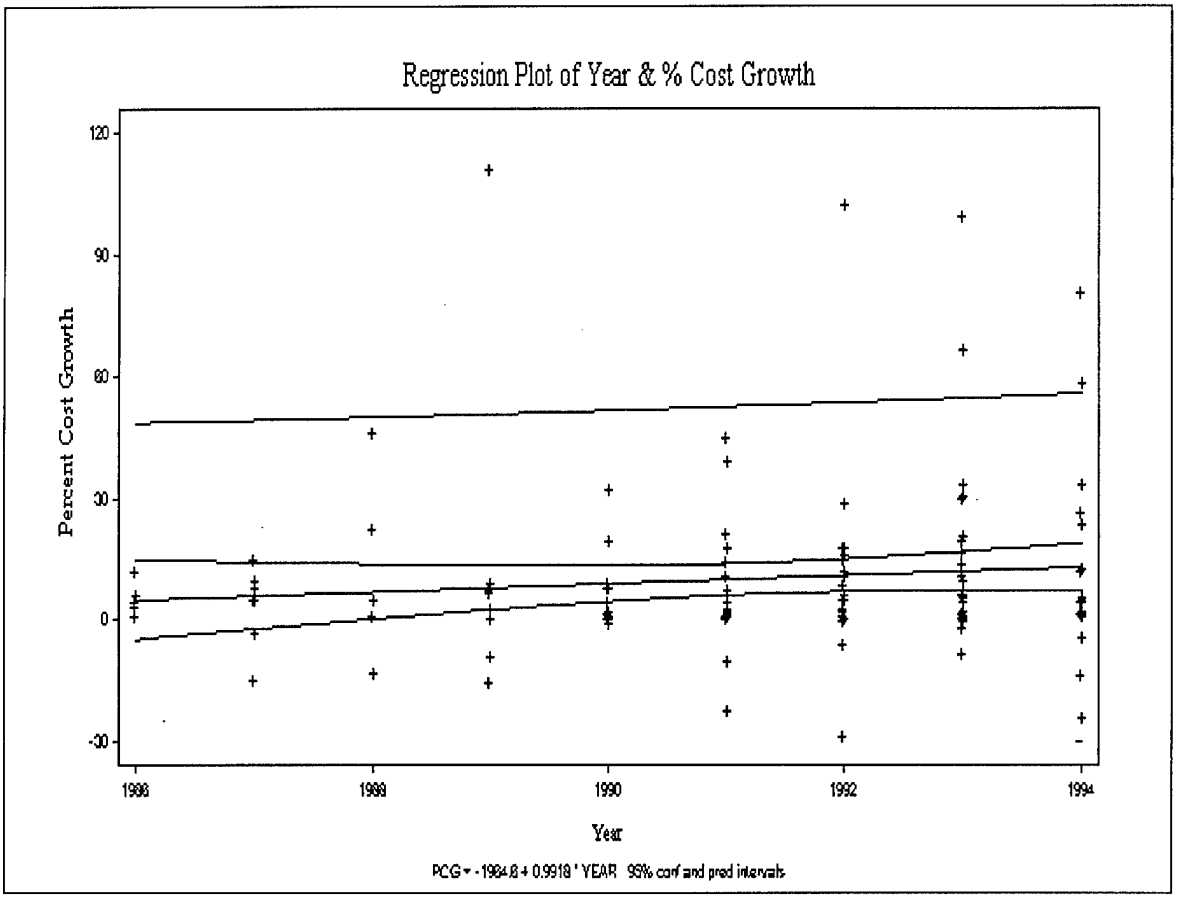

Figure 14 – Linear Regression Plot of Percent Cost Growth (All Values)

Table 14 – Results of Linear Regression (All Values)

LEAST SQUARES LINEAR REGRESSION OF ALL VALUES OF PERCENT COST GROWTH

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1964.62	1710.75	-1.15	0.2531
YEAR	0.99178	0.85911	1.15	0.2506

R-SQUARED	0.0110	RESID. MEAN SQUARE (MSE)	461.576
ADJUSTED R-SQUARED	0.0027	STANDARD DEVIATION	21.4843

SOURCE	DF	SS	MS	F	P
REGRESSION	1	615.143	615.143	1.33	0.2506
RESIDUAL	120	55389.2	461.576		
TOTAL	121	56004.3			

To further emphasis the previous results, Figure 15 and Table 15 reflect the results of a linear regression of the median values of percent cost growth over the years 1986-1994. As one can see from the plot, it appears cost growth is also increasing over time. However, the P-value of 0.4110 indicates little regression effect. In this case, the value of 0.4110, indicates that the regression line is not significantly different than zero. In other words, although the regression line in the plot appears to be increasing over time, in reality its slope is not meaningfully different than a line with a slope of zero. This further confirms the fact that it cannot be determined whether cost growth is increasing or decreasing over time.

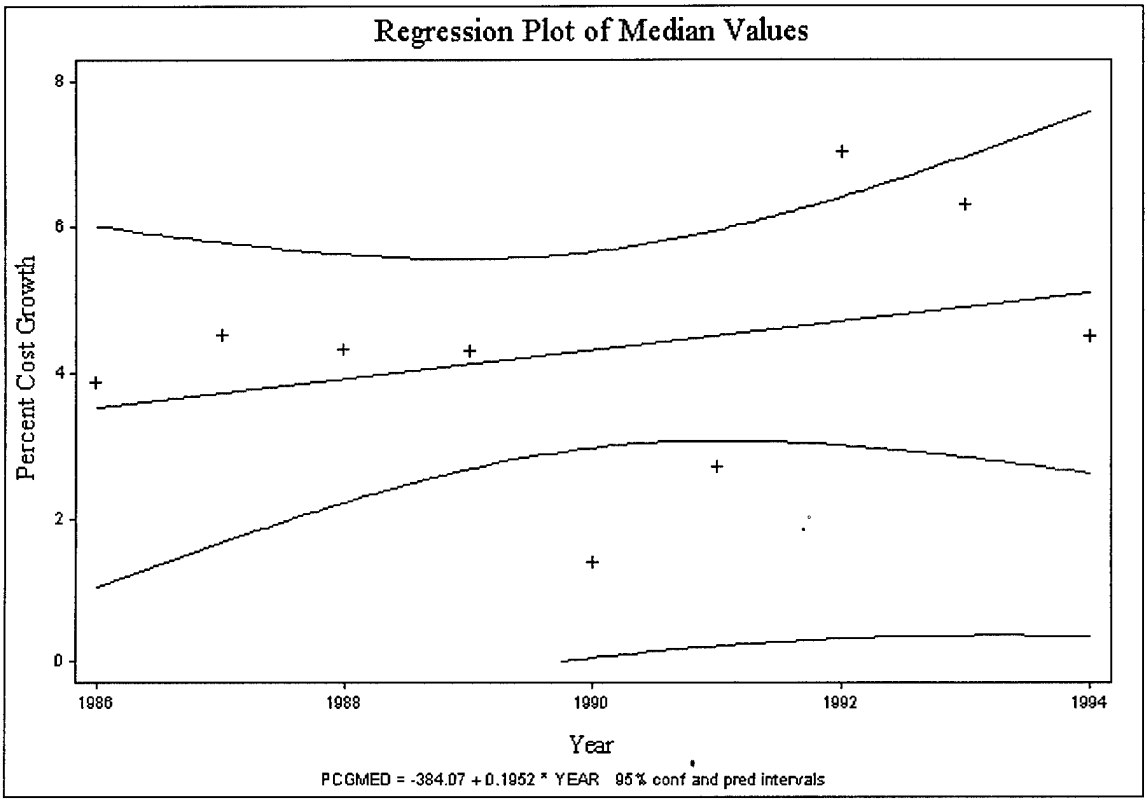

Figure 15 – Linear Regression Plot of Percent Cost Growth (Median Values)

Table 15 – Results of Linear Regression (Median Values)

LEAST SQUARES LINEAR REGRESSION OF MEDIAN VALUES OF PERCENT COST GROWTH

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-384.067	439.364	-0.87	0.4110
YEAR	0.19517	0.22079	0.88	0.4061

R-SQUARED	0.1004	RESID. MEAN SQUARE (MSE)	2.92479
ADJUSTED R-SQUARED	-0.0281	STANDARD DEVIATION	1.71020

SOURCE	DF	SS	MS	F	P
REGRESSION	1	2.28540	2.28540	0.78	0.4061
RESIDUAL	7	20.4735	2.92479		
TOTAL	8	22.7589			

In summary regarding the factor award year of contract, the following can be concluded. Relative differences between variables with respect to the amount of cost growth that occurred in USAF base support function contracts awarded between 1986 – 1994 does exist. However, due to the variation that exists for each variable's percent cost growth, no statistical differences exist between the variables with respect to the amount of cost growth that occurred. In other words, no award year (variable) was meaningfully different than the other award years with respect to the amount of cost growth that occurred. Finally, due to the high P-value of regression, found in both the regression of all values and the median values of percent cost growth, it can not be concluded that cost growth increased, or decreased for contracts awarded between the years 1986 – 1994.

V. Conclusions

Overview

The conclusions section of this research focus on three areas: (1) a reiteration of the research question, (2) a summary of the literature and results that apply to answering the research question and their implications, (3) recommendations and possible future areas for research and (4) lessons learned.

Research Question

This research effort focused on the following question: what are the extent and causes of cost growth in outsourced base support functions at USAF bases?

To clarify the causes of cost growth the following were employed:

(1) A review of the Federal Acquisition Regulations (FAR) in order to understand how cost growth can occur within the context of USAF contracts.

(2) A review of current literature and government publications concerning cost growth in USAF as well as other government contracts.

(3) A review of cost growth in the construction industry in order that possible further insights could be gained, since little information exists concerning cost growth in service-type contracts and much research has been conducted in the construction industry.

To clarify the extent and explore the various factors (MAJCOM, contract function, contract type, and award year) the following statistical analysis on 124 USAF base support function contracts was employed:

(1) Descriptive statistics in order to present an overall understanding of the extent of cost growth within the aforementioned factors.

(2) Kruskal-Wallis and Mann-Whitney tests for statistical differences between variables within factors were used because parametric tests were not appropriate due to non-normality.

(3) Regression analysis in order to determine whether cost growth is increasing, decreasing, or remaining constant over time for the factor award year of contract.

Summary of Literature and Results and Implications

From the literature reviewed in this research, the following can be concluded. First, changes to the statement of work (SOW) or performance work statement (PWS), and changes to the Department of Labor (DOL) mandated wage rate, due to the Service-Contract Act, are the primary causes of cost growth in USAF base support function contracts. Second, the causes of cost growth in the construction industry are similar to causes of cost growth in USAF base support function contracts. The implications of these two conclusions are discussed next.

According to the FAR, excluding the Service-Contract Act, changes to the SOW or PWS can be the result of two causes: (1) error on the part of the person who wrote the SOW or

PWS for failing to include or underestimating a requirement, or (2) an unforeseen requirement occurs and needs to be addressed after the SOW or PWS is written.

With respect to the latter, there is really nothing that can be done when writing the original PWS or SOW, except to make the document as flexible (easily adapted) as possible to accommodate the unforeseen change. Even so, such changes are likely to come at a price.

With respect to error on the part of the person who wrote the SOW or PWS and failed to include or underestimated a requirement, this research suggests the USAF look toward solutions that have worked in the construction industry. This is due to the following two reasons: (1) numerous research efforts have been conducted in the construction industry for controlling cost growth, and (2) this research has shown the causes of cost growth in the construction industry are similar to causes of cost growth in USAF base support function contracts.

The other cause cited in this research as a primary cause of cost growth was DOL mandated wage rate changes in accordance with the Service-Contract Act. Although, this type of change is beyond the control of the USAF, it nevertheless should be able to be predicted in the form of an economic model. The requirements of such a model would include but not be limited to predictors of local price indexes, and predictors of specific

trades/professions. Incorporation of such a model would allow these wage rate increases to not only be predicted but also budgeted for future contract years.

Overall with respect to the causes of cost growth, this research provides a valuable summary of causes from various sources, but was unable to provide much insight as to the specific (i.e., was the change caused by defective specifications, formal change, constructive change, delays, etc.) causes of cost growth in USAF base support functions.

From the statistical analysis of 124 USAF base support function contracts the several things can be concluded. First, cost growth does occur in the great majority of USAF base support function contracts. The distribution of the percent of cost growth for all of the contracts analyzed can be most closely associated with the Johnson_{SU} distribution; however, the distribution is non-symmetrical with a skew towards positive cost growth (76% of all contracts experienced positive cost growth). With respect to the four factors analyzed in this research (MAJCOM, contract function, contract type, and award year of contract), the following could be concluded. One, relative differences in percent cost growth between the variables within the factors MAJCOM, contract function, and award year of contract do exist; however, no statistical differences existed. In other words, no MAJCOM was actually significantly different from the other MAJCOMs, no contract function was actually significantly different than the other contract functions, and no award year of contract was actually significantly different from the other award year of contracts.

The lack of light shed with respect to the previous paragraph is unfortunate. Without any actual differences between MAJCOMs, or contract functions, the USAF cannot look at one MAJCOM or contract function that is experiencing less cost growth and apply that MAJCOMs or contract functions techniques, procedures, or polices to other MAJCOMs or contract functions. In other words, with respect to available information used in this research, the USAF cannot learn from itself how to limit cost growth.

Cost growth of firm-fixed-price contracts was shown to be statistically less than other-than-firm-fixed price contracts at the 0.10 level of significance, indicating a probability of lesser cost growth. However, this is not all that surprising of a revelation. Normally, a firm-fixed price-contract is written in a situation where a firm grasp upon the requirements is present. Other contract types are written in a situation the requirements of the contract may not be firmly understood. Simply, other contract types are used in order to allow a contract to "grow" to meet the requirements. Perhaps more surprising is that the difference was not found to be significant at the 0.05 level of significance.

Linear regression could not identify whether cost growth was increasing, or decreasing from 1986 through 1994. This in-determinability is unfortunate because the USAF cannot determine on the basis of the available data whether it is doing any "better" with respect to cost growth or learning over time how to "control" cost growth.

Overall, with respect to the extent and factors associated with cost growth, this research presented the extent of cost growth for not only all contracts collectively, but also for the four factors analyzed. This research also was able to conclude that the variables within the factors MAJCOM, contract function, and award year are no different from one another, thus indicating that cost growth is not isolated to a particular MAJCOM, contract function, or year.

Recommendations

During the course of this research several items for recommendation stood out. First, the USAF, an organization which has outsourced a significant portion of their commercial activities already and plans to outsource more in the future, does not have a central database to track the costs of these contracts. A database called the Commercial Activities Management Information System (CAMIS) does exist; however, CAMIS tracks only the commercial activity and its costs for three years once it is outsourced. After the three years the commercial activity, under succeeding contracts, is virtually forgotten. The CAMIS database could be modified in order to track outsourced activities throughout their life.

Second an economic model could and should be developed that would allow cost estimators of contracts to account for future changes to the DOL mandated wage rate. Such a model would allow for future wage-rate increases to be accounted, planned, and budgeted for in future contract years.

Finally, further analysis, similar to this research should be accomplished using the changes, as defined in the Federal Acquisition Regulations, as variables for defining, modeling, or predicting the causes of cost growth. In reality such an effort would be quite an intensive effort. This is due to the fact every contract included for analysis would have to be viewed at the location of the contract and in a similar manner to ensure contract extensions were not included in the calculation of percent cost growth of the contract. This type of research would provide vast amounts of insight into the causes as well as possible solutions for "controlling" cost growth.

Lessons Learned

During the course of this research, several unsuccessful analyses were attempted. Those analyses included (1) use of the General Linear Model, (2) attempting to correlate initial award cost with percent of cost growth, and (3) introducing additional various factors into the analysis.

The General Linear Model (GLM) was attempted both by the least squares and stepwise regression; however, the lack of data resulted in lost degrees of freedom. Reducing the variables within factors could have resulted in the successful implementation of the GLM; however, considerable resolution with respect to reality would be lost (i.e., how the Air Force is organized and operating).

The relationship between cost growth and initial award amount of contract was explored; however, no relationship could be determined. The amount of cost growth that occurred in the data represented a random stochastic process. For this reason, this was not included in the analysis.

Creation of more factors and associated variables beyond what was in the existing data was also explored. Categorizing the data into regions (i.e., Eastern, Southeastern, Northern, etc.) of the United States was attempted, but not included in this research for two reasons. One, it produced no results, and two the USAF does not operate on a geographic basis. The factor MAJCOM best represented how the USAF operates. Categorizing the data into high or low cost standard-of-living areas was also attempted, but like the geographic idea it produced no results and was not included in the analysis. In fact, many possibilities existed for additional categorizing of the data; however, all were dismissed because of their failure to represent realistically the organization or processes the USAF actually undertakes.

Appendix A: Summary of Data

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
1	Andrews	AMC	Furnishings Mgmt	FFP	20-Jul-92	$259,182	$297,430	$38,248	$297,430	$38,248	14.76
2	Andrews	AMC	Laundry/Dry Clean	IDIQ	26-Jul-90	$761,618	$861,751	$100,133	$761,619	$1	0.00
3	Andrews	AMC	Med Linen Contr	IDIQ	17-Nov-94	$595,116	$595,116	$0	$595,116	$0	0.00
4	Barksdale	ACC	Grounds Maint	FFP	01-Feb-87	$1,173,796	$1,534,856	$361,060	$1,225,329	$51,533	4.39
5	Barksdale	ACC	Grounds Maint	FFP	01-Oct-89	$4,515,933	$5,556,187	$1,040,254	$4,536,507	$20,574	0.46
6	Barksdale	ACC	Military Fam Hous	FFP	01-Oct-90	$3,670,145	$4,266,538	$596,393	$3,713,565	$43,420	1.18
7	Barksdale	ACC	Postal Service	FFP	24-Sep-91	$67,332	$67,332	$0	$67,332	$0	0.00
8	Barksdale	ACC	Postal Service	FFP	01-Oct-90	$64,476	$64,476	$0	$64,476	$0	0.00
9	Barksdale	ACC	Postal Service	FFP	09-Jan-86	$44,096	$44,096	$0	$44,096	$0	0.00
10	Barksdale	ACC	Refuse Collection	FFP	14-Jun-89	$1,578,389	$2,237,957	$659,568	$1,707,551	$129,162	8.18
11	Barksdale	ACC	Transient AC Maint	FFP	01-Jul-90	$1,310,308	$1,409,564	$99,256	$1,409,564	$99,256	7.58
12	Barksdale	ACC	Transient AC Maint	FFP	01-Jan-94	$1,384,578	$1,447,937	$63,359	$1,447,937	$63,359	4.58
13	Beale	ACC	Grounds Maint	FFP	01-Feb-92	$2,865,327	$4,327,985	$1,462,658	$3,672,361	$807,034	28.17
14	Beale	ACC	Military Fam Hous	RFP	01-Apr-89	$10,076,158	$11,256,723	$1,180,565	$10,794,198	$718,040	7.13
15	Beale	ACC	Postal Service	IFB	01-May-89	$105,682	$119,222	$13,540	$112,168	$6,486	6.14
16	Beale	ACC	Postal Service	IFB	01-Oct-93	$144,897	$188,167	$43,270	$188,167	$43,270	29.86

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
17	Beale	ACC	Prec Measure Equip	RFP	16-Aug-93	$1,951,751	$1,961,495	$9,744	$1,961,495	$9,744	0.50
18	Beale	ACC	Transient AC Maint	RFP	01-Feb-93	$685,713	$722,705	$36,992	$722,705	$36,992	5.39
19	Charleston	AMC	Postal Service	FFP	01-Oct-93	$108,367	$130,277	$21,910	$130,277	$21,910	20.22
20	Charleston	AMC	Protective Coating	FFP	05-Oct-88	$1,049,224	$1,529,957	$480,733	$1,529,957	$480,733	45.82
21	Charleston	AMC	Protective Coating	FFP	07-Jan-94	$1,437,002	$1,437,002	$0	$1,437,002	$0	0.00
22	Edwards	AFMC	BITS/Pubs Distr Ofc	FFP	01-Oct-93	$1,887,216	$1,887,216	$0	$1,887,216	$0	0.00
23	Edwards	AFMC	Food Service	FP/CPAF	01-May-93	$7,269,651	$8,088,106	$818,455	$7,249,096	-$20,555	-0.28
24	Edwards	AFMC	Grounds Maint	CPFF	01-Oct-94	$6,602,447	$5,691,096	-$911,351	$5,691,096	-$911,351	-13.80
25	Edwards	AFMC	Janitorial Services	FP/CPAF	01-Jul-93	$7,852,775	$8,142,282	$289,507	$8,142,282	$289,507	3.69
26	Edwards	AFMC	Military Fam Hous	FP/CPAF	01-Jul-93	$12,825,526	$24,272,815	$11,447,289	$21,303,490	$8,477,964	66.10
27	Edwards	AFMC	Photo/Video Service	FP/CPAF	01-Jan-93	$10,474,539	$11,044,706	$570,167	$11,044,706	$570,167	5.44
28	Edwards	AFMC	Visual Info Service	FFP	16-Nov-88	$5,053,921	$5,630,496	$576,575	$5,270,494	$216,573	4.29
29	Eglin	AFMC	Janitorial Services	FPAF	01-Jul-94	$2,170,496	$3,421,480	$1,250,984	$3,421,480	$1,250,984	57.64
30	Eglin	AFMC	Janitorial Services	FFP	01-Oct-92	$146,110	$102,992	-$43,118	$102,992	-$43,118	-29.51
31	Eglin	AFMC	Log Material Spt	FFP	09-Dec-91	$1,676,186	$1,782,579	$106,393	$1,782,579	$106,393	6.35
32	Eglin	AFMC	Material Control	FFP ID/IQ	08-Nov-89	$683,957	$745,369	$61,412	$700,369	$16,412	2.40

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
33	Eglin	AFMC	Material Control	FFP	20-May-94	$734,292	$927,217	$192,925	$927,217	$192,925	26.27
34	Eglin	AFMC	Protective Coating	FFP DO	30-Sep-93	$2,228,109	$2,228,109	$0	$2,228,109	$0	0.00
35	Eglin	AFMC	Transient AC Maint	FFP	01-Oct-92	$141,157	$284,180	$143,023	$284,180	$143,023	101.32
36	Eglin	AFMC	Transient AC Maint	FFP	01-Apr-93	$2,611,003	$2,628,313	$17,310	$2,628,313	$17,310	0.66
37	Eglin	AFMC	Transient AC Maint	FFP	30-Aug-90	$1,455,016	$1,509,434	$54,418	$1,509,434	$54,418	3.74
38	Ellsworth	ACC	Grounds Maint	IDIQ	13-Oct-93	$2,075,151	$2,689,631	$614,480	$2,689,631	$614,480	29.61
39	Ellsworth	ACC	Janitorial Services	FFP	01-Oct-92	$2,247,837	$2,629,820	$381,983	$2,629,820	$381,983	16.99
40	Ellsworth	ACC	Military Fam Hous	IDIQ	10-Oct-91	$5,858,831	$7,136,556	$1,277,725	$7,074,635	$1,215,804	20.75
41	Ellsworth	ACC	Protective Coating	IDIQ	11-Jun-89	$1,046,705	$2,197,737	$1,151,032	$2,197,737	$1,151,032	109.97
42	Ellsworth	ACC	Protective Coating	IDIQ	01-Nov-94	$885,774	$1,594,774	$709,000	$1,594,774	$709,000	80.04
43	Ellsworth	ACC	Transient AC Maint	IDIQ	01-Oct-92	$894,770	$900,563	$5,793	$900,563	$5,793	0.65
44	Falcon	AFSPC	Janitorial Services	FFP	01-Jun-90	$1,458,265	$1,811,562	$353,297	$1,590,760	$132,495	9.09
45	Goodfellow	AETC	BITC	FFP	22-Mar-94	$133,648	$136,645	$2,997	$136,645	$2,997	2.24
46	Goodfellow	AETC	BITC	FFP	22-Mar-91	$56,529	$50,284	-$6,245	$50,284	-$6,245	-11.05
47	Goodfellow	AETC	Furnishings Mgmt	FFP	01-Oct-93	$140,340	$279,700	$139,360	$279,700	$139,360	99.30
48	Goodfellow	AETC	Furnishings Mgmt	FFP	02-Apr-91	$148,945	$175,646	$26,701	$175,646	$26,701	17.93

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
49	Goodfellow	AETC	Grounds Maint	FFP	01-Sep-87	$733,829	$798,058	$64,229	$798,058	$64,229	8.75
50	Goodfellow	AETC	Grounds Maint	FFP	15-Sep-92	$1,796,239	$1,796,239	$0	$1,796,239	$0	0.00
51	Grandforks	ACC	Grounds Maint	FFP	01-Jun-94	$931,432	$983,282	$51,850	$983,282	$51,850	5.57
52	GrandForks	ACC	Grounds Maint	FFP	01-Oct-91	$1,833,518	$1,897,763	$64,245	$1,897,763	$64,245	3.50
53	GrandForks	ACC	Military Fam Hous	FFP	01-Oct-90	$7,306,638	$7,400,969	$94,331	$7,400,969	$94,331	1.29
54	GrandForks	ACC	Military Fam Hous	FFP	01-Dec-94	$6,421,935	$6,459,930	$37,995	$6,459,930	$37,995	0.59
55	GrandForks	ACC	Postal Service	FFP	01-Oct-91	$239,720	$346,598	$106,878	$346,598	$106,878	44.58
56	GrandForks	ACC	Refuse Collection	FFP	01-Jun-92	$2,820,205	$2,866,354	$46,149	$2,866,354	$46,149	1.64
57	GrandForks	ACC	School Bus Ops	FFP	01-Aug-91	$489,201	$489,201	$0	$489,201	$0	0.00
58	GrandForks	ACC	Transient AC Maint	FFP	01-Oct-91	$653,224	$662,623	$9,399	$662,623	$9,399	1.44
59	Keesler	AETC	Janitorial Services	FFP	01-Apr-93	$1,955,440	$2,149,463	$194,023	$2,149,463	$194,023	9.92
60	Keesler	AETC	Protective Coating	FFP	01-May-93	$1,861,155	$1,978,000	$116,845	$1,978,000	$116,845	6.28
61	Lackland	AETC	Medical Transcript	FFP	03-Apr-90	$1,936,842	$2,694,566	$757,724	$2,318,131	$381,289	19.69
62	Langley	ACC	Janitorial Services	FFP	01-Jul-91	$3,271,541	$2,529,702	-$741,839	$2,529,702	-$741,839	-22.68
63	Langley	ACC	Military Fam Hous	FFP	30-Apr-93	$5,404,735	$6,434,143	$1,029,408	$6,434,143	$1,029,408	19.05
64	Langley	ACC	PMEL	FFP	01-Jun-93	$30,293,532	$29,739,085	-$554,447	$29,739,085	-$554,447	-1.83

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
65	Langley	ACC	Postal Service	FFP	01-Oct-93	$209,490	$220,390	$10,900	$220,390	$10,900	5.20
66	Little Rock	AETC	Furnishings Mgmt	FFP	01-Oct-91	$347,242	$393,360	$46,118	$353,995	$6,753	1.94
67	Little Rock	AETC	Med Linen Contr	FFP	01-Jun-91	$82,089	$82,964	$875	$82,964	$875	1.07
68	Little Rock	AETC	Med Linen Contr	FFP	01-Oct-93	$112,236	$112,236	$0	$112,236	$0	0.00
69	Little Rock	AETC	Military Fam Hous	FFP	01-Apr-91	$1,458,492	$2,383,268	$924,776	$2,018,955	$560,463	38.43
70	Little Rock	AETC	Postal Service	FFP	01-Oct-92	$158,357	$171,990	$13,633	$171,990	$13,633	8.61
71	Little Rock	AETC	Postal Service	FFP	01-May-90	$85,229	$83,847	-$1,382	$83,847	-$1,382	-1.62
72	Little Rock	AETC	Postal Service	FFP	01-Oct-88	$1,364,312	$1,670,600	$306,288	$1,670,600	$306,288	22.45
73	Little Rock	AETC	Protective Coating	FFP	01-Oct-93	$779,397	$794,997	$15,600	$794,997	$15,600	2.00
74	Los Angeles	AFSPC	BITS & Pubs Distb	FFP	01-Oct-94	$2,372,832	$1,790,048	-$582,784	$1,790,048	-$582,784	-24.56
75	Los Angeles	AFSPC	CE Support Services	CRC	01-Jun-93	$44,018,657	$51,380,530	$7,361,873	$49,630,651	$5,611,994	12.75
76	LosAngeles	AFSPC	BITC & Pubs Dist	FFP	01-Jul-90	$2,303,812	$2,337,122	$33,310	$2,337,122	$33,310	1.45
77	LosAngeles	AFSPC	Switchboard	FFP	16-Sep-87	$982,161	$832,814	-$149,347	$832,814	-$149,347	-15.21
78	Maxwell	AETC	ECI	FFP	27-Jan-94	$2,545,669	$2,654,035	$108,366	$2,654,035	$108,366	4.26
79	Maxwell	AETC	Janitorial Services	FFP	01-Oct-94	$4,820,556	$5,352,965	$532,409	$5,352,965	$532,409	11.04
80	Maxwell	AETC	PMEL	FFP	01-Dec-93	$2,132,627	$1,947,268	-$185,359	$1,947,268	-$185,359	-8.69

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
81	Maxwell	AETC	Switchboard	FFP	01-Oct-94	$126,960	$132,554	$5,594	$132,554	$5,594	4.41
82	Maxwell	AETC	Switchboard	FFP	01-Nov-92	$454,850	$475,588	$20,738	$475,588	$20,738	4.56
83	Maxwell	AETC	Switchboard	FFP	17-Jun-88	$613,765	$631,466	$17,701	$619,541	$5,776	0.94
84	Maxwell	AETC	Transient AC Maint	FFP	01-Nov-92	$315,928	$333,199	$17,271	$333,199	$17,271	5.47
85	McGuire	AMC	Postal Service	FFP	01-May-94	$370,986	$373,200	$2,214	$373,200	$2,214	0.60
86	Patrick	AFSPC	Base Supply	FPAF	01-Oct-91	$31,675,563	$38,915,272	$7,239,709	$35,152,605	$3,477,042	10.98
87	Patrick	AFSPC	Janitorial Services	FPAF	01-Jan-92	$5,580,290	$8,451,302	$2,871,012	$6,437,810	$857,520	15.37
88	Patrick	AFSPC	Vehicle O&M	FFP	17-Mar-94	$11,989,168	$13,423,278	$1,434,110	$13,423,278	$1,434,110	11.96
89	Peterson	AFSPC	Computer Ops	FFP/CRC	02-Jan-90	$1,494,005	$6,011,013	$4,517,008	$6,135,769	$4,641,764	310.69
90	Peterson	AFSPC	Computer Ops	CPAF/CRC	01-Jun-94	$7,218,441	$19,452,336	$12,233,895	$19,452,336	$12,233,895	169.48
91	Peterson	AFSPC	Grounds Maint	FFP/CRC	01-Apr-94	$2,891,740	$3,548,776	$657,036	$3,548,776	$657,036	22.72
92	Peterson	AFSPC	Info Mgmt/Postal	FFP	15-Jan-91	$3,785,528	$4,401,847	$616,319	$4,308,282	$522,754	13.81
93	Peterson	AFSPC	Military Fam Hous	FFP/CRC	01-Apr-93	$2,458,855	$3,320,346	$861,491	$3,280,941	$822,086	33.43
94	Peterson	AFSPC	Supply Mgmt	FFP/CRC	01-Nov-92	$12,513,676	$14,499,541	$1,985,865	$14,499,541	$1,985,865	15.87
95	Peterson	AFSPC	Vehicle O&M	FFP/CRC	13-Apr-93	$6,242,726	$6,788,867	$546,141	$6,788,867	$546,141	8.75
96	Robins	AFMC	Grounds Maint	FFP	01-Feb-93	$9,440,553	$10,745,605	$1,305,052	$10,745,605	$1,305,052	13.82

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
97	Robins	AFMC	Grounds Maint	FFP/IDIQ	30-Jun-87	$7,191,115	$7,718,701	$527,586	$7,718,701	$527,586	7.34
98	Scott	AMC	Janitorial Services	FFP	01-Jan-90	$2,221,068	$2,926,547	$705,479	$2,926,547	$705,479	31.76
99	Vandenberg	AFSPC	Fuels & SBSS	FPAF	01-Mar-93	$13,361,818	$15,578,793	$2,216,975	$15,574,793	$2,212,975	16.56
100	Vandenberg	AFSPC	Fuels & SBSS	FPAF	01-Dec-87	$7,844,520	$9,455,432	$1,610,912	$8,993,318	$1,148,798	14.64
101	Vandenberg	AFSPC	Grounds Maint	FFP/IDIQ	01-Jun-89	$4,842,653	$5,839,233	$996,580	$4,068,551	-$774,102	-15.99
102	Vandenberg	AFSPC	Grounds Maint	FFP/IQ	01-Nov-94	$1,877,759	$1,779,311	-$98,448	$1,779,311	-$98,448	-5.24
103	Vandenberg	AFSPC	Grounds Maint	FFP/IQ	01-Oct-94	$4,269,906	$4,464,555	$194,649	$4,464,555	$194,649	4.56
104	Vandenberg	AFSPC	Transient AC Maint	FFP	01-Apr-92	$1,157,262	$1,409,330	$252,068	$1,271,065	$113,803	9.83
105	Vandenberg	AFSPC	School Bus Ops	FFP	31-Aug-93	$593,905	$635,353	$41,448	$635,353	$41,448	6.98
106	Vandenberg	AFSPC	Postal Service	FFP	01-May-94	$183,584	$229,808	$46,224	$245,310	$61,726	33.62
107	Wright-Pat	AFMC	Airfield 87	FFP	01-Jan-87	$747,865	$724,417	-$23,448	$724,417	-$23,448	-3.14
108	Wright-Pat	AFMC	Airfield 88	FFP	01-Jan-88	$632,240	$543,936	-$88,304	$543,936	-$88,304	-13.97
109	Wright-Pat	AFMC	Airfield 89	FFP	01-Jan-89	$949,006	$856,343	-$92,663	$856,343	-$92,663	-9.76
110	Wright-Pat	AFMC	Animal Caretaking	FFP	15-Jan-91	$2,026,608	$2,104,305	$77,697	$2,046,830	$20,222	1.00
111	Wright-Pat	AFMC	BITC 90-91	FFP	01-Jan-90	$1,121,781	$1,209,660	$87,879	$1,209,660	$87,879	7.83
112	Wright-Pat	AFMC	BITC 92-97	FFP	01-Jan-92	$3,201,389	$3,718,868	$517,479	$3,345,880	$144,491	4.51

Rec #	Location	MAJ COM	Description	Type	Award Date	Original Contract Cost	Final Contract Cost	Total Cost Growth	Adjusted Final Contract Cost	Adjusted Cost Growth	Percent Cost Growth
113	Wright-Pat	AFMC	Janitorial Services	FFP	01-Mar-92	$411,836	$410,623	-$1,213	$410,623	-$1,213	-0.29
114	Wright-Pat	AFMC	Janitorial Services	FFP	01-Oct-90	$9,423,060	$10,338,234	$915,174	$9,433,120	$10,060	0.11
115	Wright-Pat	AFMC	Janitorial Services	FFP	01-Mar-92	$862,172	$1,304,391	$101,637	$1,304,391	$101,637	11.79
116	Wright-Pat	AFMC	Janitorial Services	FFP	01-Jan-86	$1,681,062	$1,746,269	$65,207	$1,746,269	$65,207	3.88
117	Wright-Pat	AFMC	Janitorial Services	FFP	01-Jan-86	$2,926,541	$2,545,083	$160,221	$2,545,083	$160,221	5.47
118	Wright-Pat	AFMC	Janitorial Services	FFP	01-Mar-86	$4,305,693	$4,804,506	$498,813	$4,804,506	$498,813	11.58
119	Wright-Pat	AFMC	Janitorial Services	FFP	01-Feb-92	$3,699,638	$4,514,919	$815,281	$3,772,792	$73,154	1.98
120	Wright-Pat	AFMC	Janitorial Services	FFP	01-Apr-90	$2,764,506	$2,770,520	$6,014	$2,770,520	$6,014	0.22
121	Wright-Pat	AFMC	Postal Service	FFP	01-Mar-92	$231,256	$236,267	$5,011	$217,227	-$14,029	-6.07
122	Wright-Pat	AFMC	Pubs Distr Ofc	FFP	01-Jan-87	$1,733,160	$1,978,614	$245,454	$1,811,093	$77,933	4.50
123	Wright-Pat	AFMC	Pubs Distr Ofc	FFP	01-Mar-92	$2,474,492	$3,255,316	$780,824	$2,915,495	$441,003	17.82
124	Wright-Pat	AFMC	Vehicle O&M	FFP	01-Dec-86	$29,830,210	$33,557,903	$3,727,693	$30,622,108	$791,898	2.65

Appendix B: Calculation of Z-Value used in Mann-Whitney Test

$UStat_{FFP} := 1156$

$SampleSize_{FFP} := 89$

$SampleSize_{OTHERTYPE} := 33$

$$z := \frac{\left[UStat_{FFP} - \frac{\left(SampleSize_{FFP} \cdot SampleSize_{OTHERTYPE}\right)}{2}\right]}{\left[\frac{\left[\left(SampleSize_{FFP} \cdot SampleSize_{OTHERTYPE}\right) \cdot \left(SampleSize_{FFP} + SampleSize_{OTHERTYPE} + 1\right)\right]}{12}\right]^{\frac{1}{2}}}$$

$z = -1.801$

Performed with MathCad 7.0

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Vita

Capt James S. Romasz was born on 15 June 1971 in Basking Ridge, NJ. He graduated from Bridgewater-Raritan High School East in 1989 and entered undergraduate studies at the Virginia Military Institute. He graduated with a Bachelor of Science degree in Civil Engineering and was commissioned a second Lieutenant through the Reserve Officer Training Corps, Detachment 880, where he was a Distinguished Air Force Graduate, on 21 May 1993. His first assignment, from February 1994 to May 1996, was to Keesler AFB, Mississippi. While there, he served as a design civil engineer and Military Construction (MILCON) program manager in the 81st Civil Engineer Squadron. From October 1995 through January 1996, he deployed to Riyadh AB, Saudi Arabia as Chief of Resources for the 4409th Support Squadron in support of OPERATION DESERT STORM/SOUTHERN WATCH. His second assignment, from June 1996 to July 1997, was to Thule AB, Greenland. While there, he served as Chief of Engineering and Programs in the 12th Space Warning Squadron. In August 1997, he entered the Engineering and Environmental Management Program, Graduate School of Engineering, Air Force Institute of Technology. Following graduation, Capt Romasz will accept an assignment to the 89th Civil Engineer Squadron, Andrews AFB, Maryland.

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13. ABSTRACT *(Maximum 200 words)*

The United States Air Force (USAF) has outsourced a significant portion of their activities defined as commercial activities and plans to aggressively outsource more in the future. The USAF outsources its commercial activities in the form of multi-year contracts to the private sector. Cost growth (either negative or positive) has been experienced by most of these contracts. This research effort performed a review of current literature and used statistical analysis to clarify the issue: what are the causes, and extent of cost growth in USAF base-support-function contracts?. From the literature, it can be concluded that changes to the statement of work or performance work statements and Department of Labor (DOL) mandated wage rates are the primary causes of cost growth in USAF as well as other government service-type contracts. It can also be concluded that cost growth in the construction industry is similar to cost growth in USAF base-support function contracts. With respect to the statistical analysis of extent and various factors (MAJCOM, contract function, contract type, and award year of contract), the following can be reasonably concluded. Cost growth in USAF contracts is widely variable. The median value of cost growth for all contracts was 4.56 percent, and the inner-quartile range value of percent cost growth was 13.63 percent. None of the variables within factors were statistically different at the 0.05 or 0.10 significance level except for the factor contract type.

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