

AD-A135 562

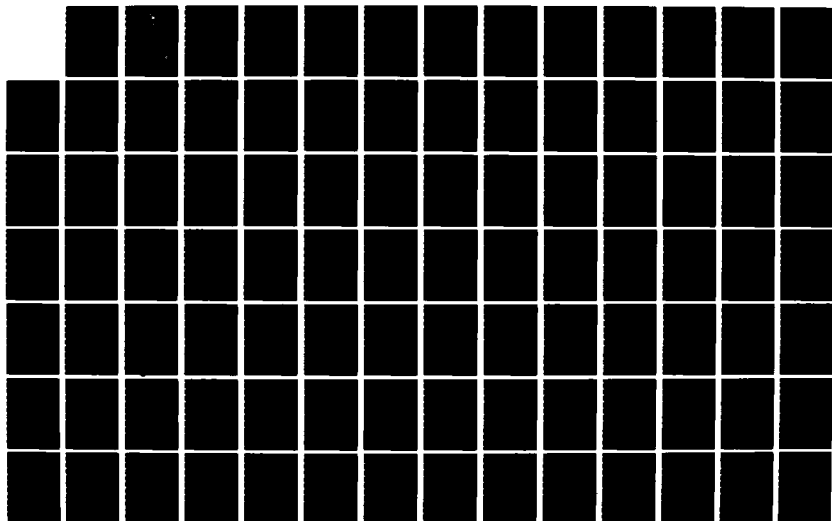
COMPETITION IN THE ACQUISITION OF REPLENISHMENT SPARE  
PARTS(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH  
SCHOOL OF SYSTEMS AND LOGISTICS S J ZAMPARELLI SEP 83  
AFIT-LSSR-102-83

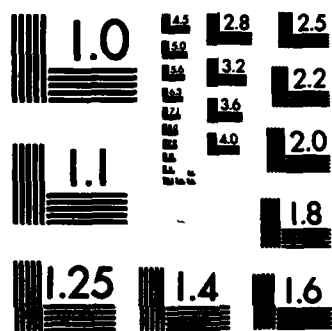
1/2

UNCLASSIFIED

F/G 5/1

NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

A135562



COMPETITION IN THE ACQUISITION  
OF REPLENISHMENT SPARE PARTS

Steven J. Zamparelli, Captain, USAF

LSSR 102-83

DTIC  
ELECTE  
DEC 09 1983  
S E

DEPARTMENT OF THE AIR FORCE  
AIR UNIVERSITY

**AIR FORCE INSTITUTE OF TECHNOLOGY**

Wright-Patterson Air Force Base, Ohio

This document has been approved  
for public release and sale; its  
distribution is unlimited.

83 12 09 136

FILE COPY

COMPETITION IN THE ACQUISITION  
OF REPLENISHMENT SPARE PARTS

Steven J. Zamparelli, Captain, USAF

LSSR 102-83

DTIC  
ELECTE  
DEC 09 1983  
S D  
E

This document has been approved  
for public release and sale; its  
distribution is unlimited.

The contents of the document are technically accurate, and no sensitive items, detrimental ideas, or deliterious information are contained therein. Furthermore, the views expressed in the document are those of the author and do not necessarily reflect the views of the School of Systems and Logistics, the Air University, the Air Training Command, the United States Air Force, or the Department of Defense.

|                    |                                     |
|--------------------|-------------------------------------|
| Accession For      |                                     |
| NTIS GRA&I         | <input checked="" type="checkbox"/> |
| DTIC TAB           | <input type="checkbox"/>            |
| Unannounced        | <input type="checkbox"/>            |
| Justification      |                                     |
| By                 |                                     |
| Distribution/      |                                     |
| Availability Codes |                                     |
| Dist               | Avail and/or<br>Special             |
| A-1                |                                     |



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                             |                                         | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------------------------------|
| 1. REPORT NUMBER<br>LSSR 102-83                                                                                                                                                                                                                                       | 2. GOVT ACCESSION NO.<br><b>A135562</b> | 3. RECIPIENT'S CATALOG NUMBER                                   |
| 4. TITLE (and Subtitle)<br>COMPETITION IN THE ACQUISITION OF<br>REPLENISHMENT SPARE PARTS                                                                                                                                                                             |                                         | 5. TYPE OF REPORT & PERIOD COVERED<br>Master's Thesis           |
|                                                                                                                                                                                                                                                                       |                                         | 6. PERFORMING ORG. REPORT NUMBER                                |
| 7. AUTHOR(s)<br>Steven J. Zamparelli, Captain, USAF                                                                                                                                                                                                                   |                                         | 8. CONTRACT OR GRANT NUMBER(s)                                  |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>School of Systems and Logistics<br>Air Force Institute of Technology, WPAFB OH                                                                                                                                         |                                         | 10. PROGRAM ELEMENT, PROJECT, TASK,<br>AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Department of Communications<br>AFIT/LSH, WPAFB OH 45433                                                                                                                                                                   |                                         | 12. REPORT DATE<br>September 1983                               |
|                                                                                                                                                                                                                                                                       |                                         | 13. NUMBER OF PAGES<br>158                                      |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                           |                                         | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED            |
|                                                                                                                                                                                                                                                                       |                                         | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                   |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited                                                                                                                                                                |                                         |                                                                 |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                            |                                         |                                                                 |
| 18. SUPPLEMENTARY NOTES<br><br>Approved for public release: LAW AFB 100-17.<br><i>[Signature]</i><br>LYNN E. WOLAYER<br>Dir. for Research and Professional Development<br>Air Force Institute of Technology (ATC)<br>Wright-Patterson AFB OH 45433<br><br>15 SEP 1983 |                                         |                                                                 |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br><br>Spare Parts                      Contracting<br>Competition                      Acquisition<br>Sole Source                      Procurement                                |                                         |                                                                 |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>Thesis Chairman: Donald L. Brechtel, Captain, USAF                                                                                                                           |                                         |                                                                 |

DD FORM 1473  
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED  
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

↙

The use of competition is required for Government procurement, because it is believed to lead to lower prices. This research project was undertaken as a result of a recent empirical study that reported that prices do not always decrease when competition is introduced into the acquisition of replenishment spare parts. The research objectives were: (1) to provide evidence to support or refute the expectation of price reductions stemming from competition, and (2) to identify unique characteristics of the spare parts that might influence the magnitude of competitive savings or losses. Four years of procurement data histories for replenishment spare parts, obtained from the Air Force Logistics Command's Air Logistics Centers, provided the data utilized in the research project. Three major conclusions resulted from this study: (A) competition leads to lower prices, (B) prices increase when a spare part transitions from competitive to sole source acquisitions, and (C) the prices of aircraft engine spare parts increase when competition is introduced into the marketplace. Several recommended changes and improvements to the replenishment spare parts acquisition process along with the identification of areas in need of additional research were made based upon the research findings.

↑

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

LSSR 102-83

COMPETITION IN THE ACQUISITION OF  
REPLENISHMENT SPARE PARTS

A Thesis

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the  
Degree of Master of Science in Logistics Management

By

Steven J. Zamparelli, BS  
Captain, USAF

September 1983

Approved for public release;  
distribution unlimited



This thesis, written by

Captain Steven J. Zamparelli

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 28 September 1983

*Donald L. Brechtel*

---

COMMITTEE CHAIRMAN

## ACKNOWLEDGEMENTS

To see one name on this project is like seeing one player credited with winning a football game. This thesis is the culmination of the efforts and support provided by a number of individuals, many of whom I'd like to mention.

Many thanks to:

Mr. Ed Brost for willingly sharing his knowledge, data, and time to help get this project off the ground.

Mr. Bob Begley of AFLC, who, on the basis of a phone call from an AFIT student, acquired, modified and reacquired the raw data upon which the research was based.

Mrs. Pat Norton and family for their encouragement, for suffering through reams of tiny, often misspelled words, numerous retypings, short suspenses, while still creating a professional finished manuscript.

Captain Don Brechtel whose words and advice are the essence of the author's thesis. Thanks for the much needed support, guidance, time, and billions of red corrections.

My wife Laurelle who read these pages as often as I, editing, advising, and encouraging, who held off a herd of two year old after a full day's work to allow me to scribble in peace.

My son Randy, for being my son and providing me with another reason, along with his mom, for wanting to succeed.

I hope you can share my feeling of accomplishment.

Steven J. Zamparelli

## TABLE OF CONTENTS

|                                                  | Page |
|--------------------------------------------------|------|
| ACKNOWLEDGEMENTS . . . . .                       | iii  |
| LIST OF TABLES . . . . .                         | ix   |
| LIST OF FIGURES . . . . .                        | x    |
| <br>CHAPTER                                      |      |
| I. THE RESEARCH PROBLEM . . . . .                | 1    |
| Introduction . . . . .                           | 1    |
| Problem Statement . . . . .                      | 2    |
| Background . . . . .                             | 3    |
| Justification for Research . . . . .             | 7    |
| Research Objectives . . . . .                    | 9    |
| Research Hypotheses . . . . .                    | 10   |
| Research Questions . . . . .                     | 10   |
| Scope of Research . . . . .                      | 11   |
| Summary List of Assumptions . . . . .            | 13   |
| Summary List of Limitations . . . . .            | 14   |
| Summary . . . . .                                | 15   |
| II. LITERATURE REVIEW . . . . .                  | 17   |
| Introduction . . . . .                           | 17   |
| Definition of Competition . . . . .              | 18   |
| Facilitating Factors . . . . .                   | 22   |
| Benefits and Objectives of Competition . . . . . | 24   |
| Cost Reduction . . . . .                         | 24   |

| CHAPTER                                       | Page |
|-----------------------------------------------|------|
| Motivation of Prime Contractor . . . . .      | 25   |
| Broadening Production Base . . . . .          | 26   |
| Mobilization . . . . .                        | 27   |
| Other Benefits . . . . .                      | 27   |
| Disadvantages and Barriers to Competition . . | 28   |
| Item Complexity . . . . .                     | 28   |
| Reliability . . . . .                         | 29   |
| Lost Learning . . . . .                       | 30   |
| Capital Investment . . . . .                  | 31   |
| Risk and Loss of Program Control . . . . .    | 31   |
| Empirical Research . . . . .                  | 32   |
| Research Study 1 . . . . .                    | 33   |
| Research Study 2 . . . . .                    | 33   |
| Research Study 3 . . . . .                    | 35   |
| Research Study 4 . . . . .                    | 36   |
| Research Study 5 . . . . .                    | 37   |
| Research Study 6 . . . . .                    | 38   |
| Summary . . . . .                             | 40   |
| III. RESEARCH METHODOLOGY . . . . .           | 42   |
| Introduction . . . . .                        | 42   |
| Research Plan . . . . .                       | 43   |
| Universe and Target Population . . . . .      | 43   |
| Data Collection . . . . .                     | 46   |
| Data Preparation . . . . .                    | 46   |
| Sample Selection . . . . .                    | 47   |

| CHAPTER                                  | Page |
|------------------------------------------|------|
| Data Analysis . . . . .                  | 49   |
| Data Adjustment . . . . .                | 49   |
| Statistical Techniques . . . . .         | 52   |
| Evaluation Plan for Research             |      |
| Hypotheses and Questions . . . . .       | 58   |
| Research Hypothesis 1 . . . . .          | 58   |
| Research Question 1 . . . . .            | 62   |
| Research Question 2 . . . . .            | 64   |
| Research Question 3 . . . . .            | 64   |
| Research Question 4 . . . . .            | 65   |
| Research Hypothesis 2 . . . . .          | 65   |
| Summary . . . . .                        | 66   |
| IV. DATA ANALYSIS AND FINDINGS . . . . . | 68   |
| Introduction . . . . .                   | 68   |
| Sample Selection Results . . . . .       | 68   |
| Research Hypothesis 1 Analysis . . . . . | 73   |
| Research Hypothesis 1 . . . . .          | 73   |
| Test 1 . . . . .                         | 73   |
| Test 2 . . . . .                         | 75   |
| Test 3 . . . . .                         | 76   |
| Test 4 . . . . .                         | 79   |
| Research Questions Analysis . . . . .    | 81   |
| Research Question 1 . . . . .            | 81   |
| Research Question 2 . . . . .            | 84   |
| Research Question 3 . . . . .            | 86   |

| CHAPTER                                                               | Page |
|-----------------------------------------------------------------------|------|
| Research Question 4 . . . . .                                         | 87   |
| Research Hypothesis 2 Analysis . . . . .                              | 88   |
| Research Hypothesis 2 . . . . .                                       | 88   |
| Test 1 . . . . .                                                      | 89   |
| Test 2 . . . . .                                                      | 91   |
| Test 3 . . . . .                                                      | 91   |
| Test 4 . . . . .                                                      | 91   |
| Other Observations . . . . .                                          | 94   |
| Summary . . . . .                                                     | 98   |
| V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS . . . .                   | 101  |
| Introduction . . . . .                                                | 101  |
| Summary of Purpose, Objectives, and<br>Research Methodology . . . . . | 101  |
| Conclusions . . . . .                                                 | 104  |
| Primary Conclusions . . . . .                                         | 104  |
| Conclusion 1 . . . . .                                                | 104  |
| Conclusion 2 . . . . .                                                | 105  |
| Conclusion 3 . . . . .                                                | 106  |
| Conclusion 4 . . . . .                                                | 107  |
| Corollary Conclusions . . . . .                                       | 107  |
| Conclusion 5 . . . . .                                                | 107  |
| Conclusion 6 . . . . .                                                | 108  |
| Implications of the Study . . . . .                                   | 109  |
| Recommendations for Implementation . . . . .                          | 109  |
| Contractor Awareness of Competition . . . .                           | 110  |

| CHAPTER                                                                                                                                                       | Page |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Require Competition for Items<br>With Competitive Histories . . . . .                                                                                         | 110  |
| Utilization of the Competition<br>Advocate Team . . . . .                                                                                                     | 111  |
| Improve Information Provided to Buyers . . .                                                                                                                  | 111  |
| Identification of the Item Manufacturer . .                                                                                                                   | 112  |
| Aircraft Engine Spare Parts Acquisition . .                                                                                                                   | 112  |
| Recommendations for Future Research . . . . .                                                                                                                 | 113  |
| "Competitive Forces" Versus<br>"Competition" . . . . .                                                                                                        | 114  |
| Compete Parts Previously Acquired<br>Sole Source . . . . .                                                                                                    | 115  |
| Administrative Costs of Competition . . . .                                                                                                                   | 115  |
| Analysis of Spare Parts Procurements . . . .                                                                                                                  | 116  |
| Identification of Characteristics That<br>Enhance Competitive Savings . . . . .                                                                               | 116  |
| Replication of Research Hypothesis 2 . . . .                                                                                                                  | 117  |
| Concluding Observations . . . . .                                                                                                                             | 117  |
| APPENDICES . . . . .                                                                                                                                          | 119  |
| A. 17 EXCEPTIONS TO FORMAL ADVERTISING . . . . .                                                                                                              | 120  |
| B. PARTIAL LISTING OF WEAPON SYSTEMS AND<br>COMMODITIES BY RESPONSIBLE AIR<br>LOGISTICS CENTER (ALC) . . . . .                                                | 122  |
| C. SUMMARY OF PROCUREMENT ACTIONS EXHIBITING<br>PRICE INCREASES, PRICE DECREASES, AND<br>NO CHANGE IN PRICES BY ALC FOR<br>BOTH RESEARCH HYPOTHESES . . . . . | 128  |
| D. RESEARCH QUESTIONS, KRUSKAL-WALLIS<br>H TEST RESULTS . . . . .                                                                                             | 133  |
| SELECTED BIBLIOGRAPHY . . . . .                                                                                                                               | 138  |
| REFERENCES CITED . . . . .                                                                                                                                    | 139  |

## LIST OF TABLES

| Table                                                                                                                  | Page |
|------------------------------------------------------------------------------------------------------------------------|------|
| 1. Example of Producer Price Indices Used<br>For Constant Year Dollar Adjustment of<br>Unit Price . . . . .            | 51   |
| 2. Summary Analysis of ALC Procurement<br>History Tapes for the Period From<br>March 1979 Through March 1983 . . . . . | 69   |
| 3. Research Hypothesis 1 Sample Data Summary . . .                                                                     | 71   |
| 4. Research Hypothesis 2 Sample Data Summary . . .                                                                     | 72   |
| 5. Z-Test of Means for Research Hypothesis 1,<br>Test 1 . . . . .                                                      | 74   |
| 6. Z-Test of Means for Research Hypothesis 1,<br>Test 2 . . . . .                                                      | 77   |
| 7. Z-Test of Means for Research Hypothesis 1,<br>Test 3 . . . . .                                                      | 78   |
| 8. Z-Test of Means for Research Hypothesis 1,<br>Test 4 . . . . .                                                      | 80   |
| 9. *ONEWAY Analysis of Variance, Summary of<br>Test 2 . . . . .                                                        | 83   |
| 10. Z-Test of Means for Research Hypothesis 2,<br>Test 1 . . . . .                                                     | 90   |
| 11. Z-Test of Means for Research Hypothesis 2,<br>Test 2 . . . . .                                                     | 92   |
| 12. Z-Test of Means for Research Hypothesis 2,<br>Test 3 . . . . .                                                     | 93   |
| 13. Z-Test of Means for Research Hypothesis 2,<br>Test 4 . . . . .                                                     | 95   |



## LIST OF FIGURES

| Figure                                                                                        | Page |
|-----------------------------------------------------------------------------------------------|------|
| 1. Competitive Trends in Department<br>of Defense Contracts . . . . .                         | 6    |
| 2. Market Structure, Item Complexity, Design<br>Stability, and Competition Spectrum . . . . . | 20   |
| 3. Flowchart of Research Methodology . . . . .                                                | 44   |
| 4. Commodity Groups . . . . .                                                                 | 63   |

CHAPTER I  
THE RESEARCH PROBLEM

Introduction

Throughout the history of economic policy in this country, a continuing effort to encourage and preserve market competition and limit monopoly is reflected in anti-trust laws, procurement statistics and regulations, and a variety of other public laws [14:1].

The maximum use of competition is universally stressed by decision makers, and the emphasis on competition is strongly supported by the American public. Legislators perceive that regulations should insure "fairness" in acquisition practices (11:2). This perception, coupled with a "widely held belief that competition leads to better products at lower prices [28:27]," led to mandates by the Department of Defense (DOD) to require the use of competition to the maximum extent possible.

For more than twenty years, the DOD has attempted to increase competitive procurements in the weapons acquisition process (3:2). Because of pressures to spend funds wisely, the Government has tended to overstress and overuse competitive bidding (16:98). Competition is not always the best method of procurement for obtaining the best price and/or quality (27:2). The introduction of competition has, on occasion, led to nonusable parts, delays in delivery, increased administration, and higher total cost. Major

empirical studies on the effect of competition have usually found that some measure of savings resulted from the use of competition. However, the empirical studies have also revealed cases in which losses occurred for competitive procurements. Strict adherence to the requirement for maximum competition may be inappropriate in some cases (5:93).

#### Problem Statement

The decision to introduce competition into the acquisition of an item is often made on the basis of meeting competitive goals or following Government regulations and policies. Several empirical studies have indicated that savings stemming from the introduction of competition were actually much lower than originally perceived and reported (5; 24:82). Brost found that there could just as likely be losses as savings from the use of competition in the procurement of weapon systems replenishment spares (5:100). The potential contracting pitfalls indicate the need for specific guidance for DOD buyers and contracting personnel on when or if competition is practical. Additional evidence to support or refute the generally accepted principle that lower prices result from the use of competition may provide impetus for policy makers to re-evaluate current guidance. Further investigation through expansion of Brost's data base and the additional evaluation of the effects of certain item

descriptive variables (e.g., cost makeup or availability of reprocurement data) on the savings (or losses) projected could serve as a starting point for a "competitive procurement" decision model for weapon systems replenishment spare parts.

### Background

The concept of insuring fairness through free and open competition is not new. Legislative requirements to procure supplies and services through competitive formal advertising began in 1809 and were reemphasized in the Armed Services Procurement Act of 1947. Competitive bidding was and is believed to be an assured technique for wise expenditure of public funds (16:97). Competition is thought to cause lower prices, strengthen the defense industrial base, and increase public confidence in the integrity and fairness of our system of Government procurement (24:12).

Today, there are two methods by which DOD buyers may acquire supplies or services--formal advertising and negotiation. Negotiation came into being in response to rapid technological changes and national emergencies which necessitated a more flexible method of acquisition (36:72-75). Negotiation is the acquisition process employed under certain permissible circumstances that are prescribed by law, when formal advertising is determined to be

infeasible or impractical (42:A1,B12). These permissible circumstances take the form of 17 exceptions to formal advertising (See Appendix A). The Contracting Officer, after determining the need to negotiate based on one of the 17 exceptions, is allowed to enter into discussions with any or all potential contractors after offers have been made to the Government. Negotiation allows bargaining on price, terms, and conditions up to the point of agreement (43:2-103). Negotiation, although the most used method of acquisition, is still the exception method, for formal advertising is the "law of the land [11:2]."

Formal advertising is contracting through the use of sealed bids, from which award is made to that responsive, responsible bidder whose price is lowest. Responsive means that the bidder has met the user's written requirements. To be responsible, the bidder must have adequate resources, a satisfactory record of performance and integrity, and otherwise be legally eligible to accept the contract (43:1-903 .1i-iv). Formal advertising is the economist's strict definition of competition where contract award is based on price competition. The Defense Acquisition Regulation (DAR) requires that:

. . . procurement shall be made by formal advertising . . . whenever such method is feasible and practicable . . . procurement shall generally be made by soliciting bids from all qualified sources of supply and services deemed necessary to assure full and free competition consistent with procurement of required supplies and services [43:2-102.1A].

Procurement through negotiation must be made on the basis of one of the 17 exceptions to formal advertising (See Appendix A). In practice, there are two types of negotiation, competitive and sole source. The DAR states that the use of negotiated procurement shall be on a competitive basis to the maximum practical extent. The DAR also requires that the Contracting Officer must not only verify the need for any sole source negotiation but also take steps to avoid subsequent non-competitive procurement (43:3-103.1D).

Competition is thus required on all DOD procurements, whether by formal advertising or by negotiation. The use of negotiation does not preclude the use of and benefits from competition. Firms involved in a competitive negotiation often compete in terms of technology and design as well as price. Although Congress strives for competition in military procurement by establishing public policy strictly limiting sole source procurements, sole source negotiated procurements amount to approximately 60 percent of the DOD procurement dollars spent (24:12; 11:73). Only eight percent of the DOD dollars are spent using the preferred method of procurement--formal advertising (11:2). Figure 1 provides DOD spending profiles in terms of percentage of dollars through formal advertising, competitive negotiation, follow-on non-competitive negotiation, and sole source negotiation.

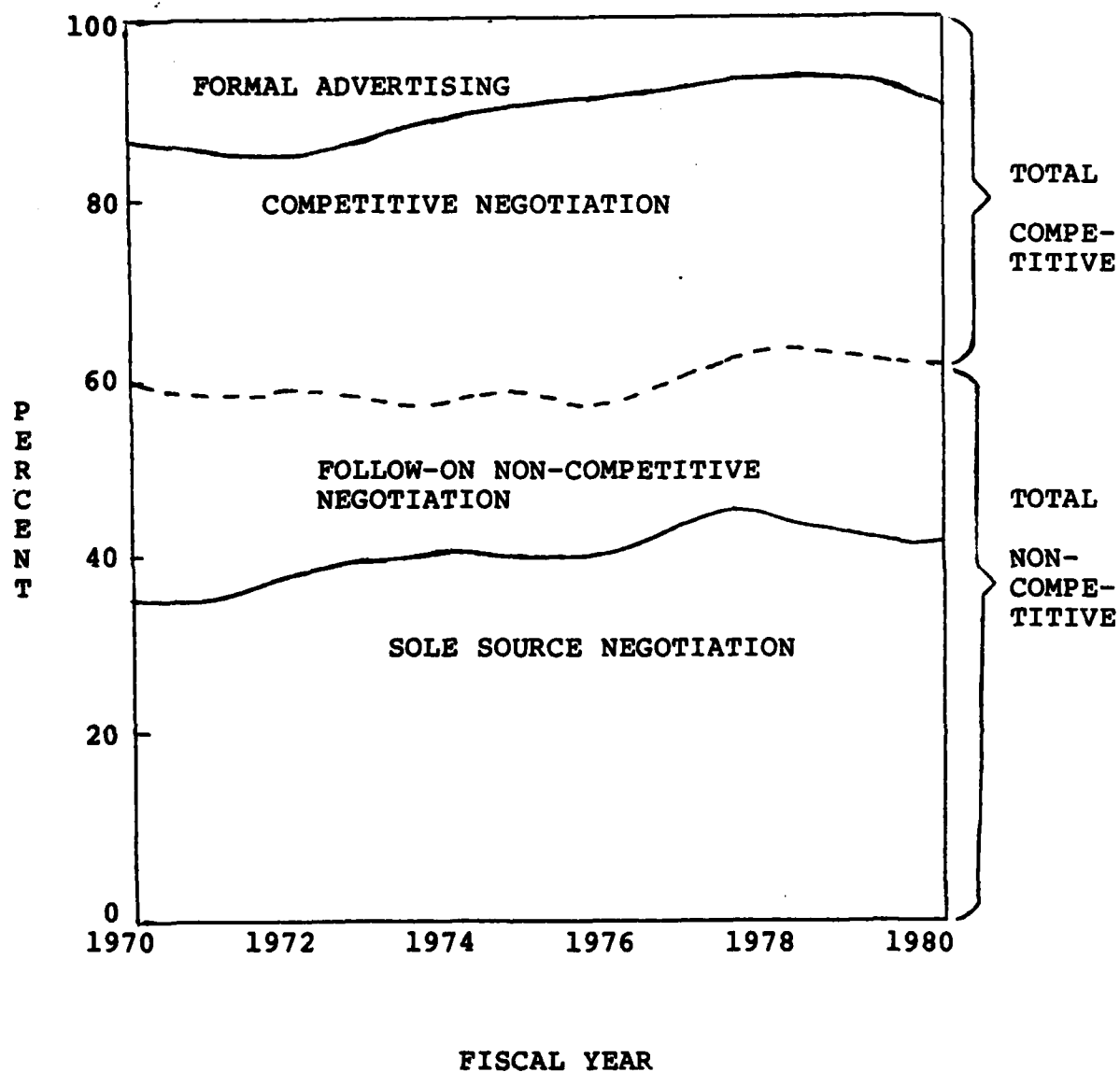


Fig. 1. Competitive Trends in Department of Defense Contracts

Source: Adopted from Gansler (11:76) and figures from DOD Prime Contract Awards FY 1978-1980 (44)

### Justification for Research

Competition is the cornerstone of the U.S. capitalist system. The preeminence of our nation's economic system can be attributable in large measure, to a commitment to competition [1:4].

The DOD's poor performance in the area of competition, in light of expected potential savings, has been the subject of considerable Congressional review and criticism. Citing the results of a study on defense procurement policy by Mr. Jacques Gansler, Congressman Kastenmeier stated that it "highlighted the grossly inefficient system that has developed as a result of the almost total lack of competition in the defense industry [8:1608]." Congressman Kastenmeier went on to say that the dollars wasted by the inefficient system result in the suffering of millions of people due to offsetting cuts in social programs (8:1609).

In 1965, Secretary of Defense Robert S. McNamara presented results of a study by the General Accounting Office (GAO) which indicated that the introduction of price competition into the procurement of studied items resulted in a price reduction of approximately 25 percent (36:1). The GAO study supported McNamara's belief that procurement competition should have been a key element of the defense management innovations introduced during the early 1960's. Armed with projected savings and in light of Congressional interest, the DOD has, for the past 20 years, attempted to increase the rate of competition in the weapon systems



acquisition process (3:2). Most recently, former Deputy Secretary of Defense Frank Carlucci made "increasing competition" one of the 32 initiatives for improving weapon systems acquisition (6). As a direct result of the defense policies with respect to competition, a number of programs have been developed to increase the use of competition. Such programs as component breakout, the High Dollar Spare Parts Breakout Program, and goals for the percentage of dollars spent competitively attempt to get DOD buyers to use competition (5:27-29). However, Figure 1 shows that there has been little change in the percentage of dollars competitively awarded over the past decade.

In 1982, Air Force Logistics Command (AFLC) spent 9.3 billion dollars for the acquisition of spare parts and related components, consuming approximately 39 percent of the Air Force budget (45:8-52). In recent months, the need for greater understanding and refinement of the spare parts acquisition process has become very evident. The development of numerous instances where spare parts have been bought at exorbitant prices has led Secretary of Defense Caspar Weinberger to state that the laxity by DOD has created an environment in which the contractor may "set his own price [34:11]." Congress and DOD have identified the lack of competition in spare parts acquisition as a major

contributor to the "pricing abuses," and Secretary Weinberger established new departmental procedures aimed at increased competition (19:22).

In 1982, approximately 25 percent of AFLC's portion of the Air Force budget was competitively awarded (32). There is apparently much room for improvement in the area of competition. Yet, in recent years competition has become more complex, and the assumption that competition yields a better, less expensive product has not always held true (28:4). Competition can be a successful strategy in one program and a failure in another program (31:2). Competition may even lead to paying a higher price for an item (5:100). Contracting policy makers and buyers need additional information on the competitive acquisition strategy. Policy makers and buyers need additional empirical evidence on whether tangible savings actually accrue for competitive procurements and guidance on the criteria to use in making decisions for competition.

[Competition] is found to be an acquisition strategy that can result in significant benefit to the Government. It is a strategy that must, however, be selectively applied. If attempted in a haphazard manner, the cost to the Government could be astronomical [20:7].

### Research Objectives

This research study had two primary research objectives. First, the research project obtained information on the effects of the introduction and use of competition in

the acquisition of weapon systems replenishment spare parts. Second, the study identified and evaluated the effects of certain common characteristics of the spare parts on the savings or losses projected due to the introduction of competition.

### Research Hypotheses

Two main research hypotheses were formulated to accomplish the first research objective.

1. A reduction in unit price is realized when competition is introduced in the acquisition of weapon systems replenishment spare parts previously procured on a sole source basis.

2. An increase in unit price is realized when weapon systems replenishment spare parts previously procured through competitive means are purchased on a sole source basis.

### Research Questions

Four research questions were developed to accomplish the second research objective concerning the influences of certain products and procurement characteristics on the competitive savings.

1. Does the type of item being procured, as identified by its Federal Stock Group or Federal Stock Class, affect the degree of competitive savings (or losses) resulting when competition is introduced into the acquisition process (5:12)?

2. Is there a significant difference for the competitive savings (or losses) identified among the five AFLC Air Logistics Centers?

3. Do the competitive savings (or losses) differ for weapon systems replenishment spare parts depending upon the magnitude of the average unit price?

4. Does the age of the item, as determined by the year in which the Federal Stock Number was assigned, affect the competitive savings (or losses) realized when transitioning from sole source to competitive acquisition?

#### Scope of Research

This research project was limited to the study of the effects of competition on repetitively purchased Air Force Logistics Command's weapon systems replenishment spare parts. The population of replenishment spares provided an ample data base of items that have been procured through relatively similar contracting procedures. The focus of this research project was on price competition; contract awards based on factors other than lowest price were not evaluated in the author's study.

In addition to weapon systems replenishment spare parts, there are two other categories of defense goods and services--new weapon systems and standard commercial off-the-shelf items (11:V). The other two categories of goods and services were not addressed in this research project. Standard commercial off-the-shelf items are items that have similar commercial counterparts for which multiple sources of supply are available (5:14). The standard commercial items are the primary emphasis of base level procurement. Historically, the DOD has used competition in the procurement of standard commercial off-the-shelf items.

New weapon system acquisitions include the design, development, and production of the system and initial provisioning of spare parts. Actual competitive opportunities vary with the complexity of the item and the stage of the acquisition process, i.e., design or production (4). Differing technologies, investment requirements, and the number of engineering changes make each procurement action significantly different from other procurements. Competition in major systems is usually characterized by design and technical competition as well as price competition. The various characteristics of new weapon system procurements make the study of those new weapon systems an extremely complex process.

The data base for this research project was constructed using four years of weapon systems replenishment spare parts procurement histories from March 1979 through March 1983, supplied from the five Air Force Logistics Command (AFLC) Air Logistics Centers (ALCs). Data were limited to those replenishment spare parts whose procurement histories included both sole source and competitive procurement actions.

#### Summary List of Assumptions

1. For the evaluation of the research hypotheses and research questions formulated for this study, price changes were assumed to be attributable to three factors: (a) inflation, (b) learning, and (c) procurement method.<sup>1</sup>

2. Coding of the procurement actions that served as the procurement history data for this study was accomplished accurately at each Air Force Logistics Command (AFLC) Air Logistics Center (ALC) in accordance with the Defense Acquisition Regulation (DAR).

3. The number of sources solicited was the basis for determining the presence of competition, thus it was assumed that potential offerors were aware of the change from sole source to competitive procedures.

---

<sup>1</sup>Similar assumptions were used in Brost's study (5:15) and in Olsen's study (18:26).

### Summary List of Limitations

1. The study of weapon systems replenishment spare parts involves approximately 16 percent of the annual Air Force budget. There was no support for the position that the findings would have general applicability to the other two categories of defense goods.

2. The procurement history of weapon systems replenishment spare parts provided a limited number of spare parts with a distinct change from one procurement method to another (i.e., from sole source to competition and vice versa). In order to obtain an acceptable sample size, some groupings of data were allowed that may have biased the competitive learning curve downward.

3. During the author's study, it was noted that the method of procurement for many items, as identified by the number of sources solicited, fluctuated back and forth between competition and sole source. Once an item has been successfully competed, the potential for more than one bidder always exists, and thus contractors may bid on future orders with the competitive influences in mind. The beneficial effects expected from the transition from sole source to competitive acquisition may only occur with the initial change in procurement method or may diminish with each change. Except for a small quantity of items, the number of times a transition occurred was impossible to identify.

4. There are numerous factors that may affect the success or application of competition. The factors include item type, complexity, use of scarce resources, place in the life cycle of the item, and the firm's financial situation. This study was limited to a review of certain factors which are addressed further in the conclusions chapter of this thesis.

#### Summary

Chapter I described this research project in terms of its overall purpose, justification for the research, the research hypotheses and research questions, and the assumptions and limitations of the research.

The basic objective of this study was to identify whether or not savings result when weapon systems replenishment spare parts under sole source procurement are subsequently acquired competitively. Two research hypotheses were designed to determine the impacts of transitioning from one procurement method to another (i.e., from sole source to competition and vice versa). Prices are affected by many factors including type of item, buyer, and economic conditions. Four research questions were developed to address some of the factors. The four research questions were used to evaluate the effects of unit price, buying



office, age of the item, and type of commodity on the competitive savings (or losses) identified for the first research hypothesis.

Competition is the preferred method of acquisition to satisfy Government requirements. The following chapter reviews many of the benefits and disadvantages of competition cited in relevant literature and also provides a review of six recent empirical studies that examined the savings associated with competitive acquisitions.

## CHAPTER II

### LITERATURE REVIEW

#### Introduction

Competition among firms in business with the Department of Defense (DOD), although having its base in economic theory, is unique due to the structure of the defense industry, types of products, and the regulatory controls placed on both contractors and the Government (4). Items procured by the DOD could be as commonplace as pens and pencils or as complex as communication satellites.

This literature review examines some of the unique features of competition theory within the Department of Defense (DOD) marketplace. First, the review of the literature provides a general definition of competition and the meaning of competition within defense acquisition. Next, an examination of the factors perceived to make the success of competitive procurements more probable is provided. The uniqueness of the defense marketplace leads to potential disadvantages as well as perceived benefits for the DOD by using competition. This literature review discusses a number of the disadvantages and benefits of competition. Finally, numerous studies have been undertaken in an attempt to verify and/or quantify the benefits of using competitive

procurements. A synopsis of six major empirical research studies provides insight into the overall effects of competition in weapon systems acquisition.

#### Definition of Competition

The basic definition of competition from the Armed Services Procurement Regulation Manual (ASPM No. 1) is:

an environment of varying dimensions relating to buy-sell relationships in which the buyer induces, stimulates or relies on conditions in the marketplace that causes independent sellers to contend confidently for the award of a contract [42:p.1A-3B].

There are actually two major types of competition found in defense procurement--design/technical competition and price competition--with each type having a different purpose.

Design or technical competition occurs when the basis of evaluation among competing firms is the design or technical merits of the contractor's proposal. Price is usually considered in the evaluation but is not weighted as highly as technical factors. Design or technical competition is often found in the design phase of the weapon systems acquisition process (4). In the design phase, the Government is buying the best technical design to meet mission requirements. "There is no evidence that design competition leads to a lower priced system in production [28:16]."

Price competition is defined in the Defense Acquisition Regulation (DAR) as existing:

if offerors are solicited and (i) at least two responsible offerors, (ii) who can satisfy the requirement, (iii) independently contend for a contract to be awarded to the responsive and responsible offeror submitting the lowest evaluated prices, (iv) by submitting price offers responsive to the expressed requirements of the solicitation [43:p.3-807.7].

Price competition offers the greatest potential for savings in defense acquisitions (1:2). This study concentrates in the area of price competition.

Competition theory within defense acquisition has its foundation in classical economic theory (4). A comparison of four continua, Figure 2, provides the basis for understanding competition within the defense industry.

The Department of Defense (DOD) does not deal exclusively in any one marketplace. DOD buys a variety of items; the characteristics of each item tend to define the specific marketplace for a particular procurement (11:3-4). When buying standard supply items, such as paint, wood or office supplies, DOD deals in a competitive marketplace. The seller's risk of cost overrun is low, design is stable, and risk to the buyer is also minimal. The purely competitive market is characterized by many buyers and sellers, homogeneous products, open information, freedom of entry and exit from the market, and sellers that are price takers (13:213). In the purely competitive marketplace, price

Market Structure

|                        |                     |                             |           |          |
|------------------------|---------------------|-----------------------------|-----------|----------|
| Perfect<br>Competition | Pure<br>Competition | Monopolistic<br>Competition | Oligopoly | Monopoly |
|------------------------|---------------------|-----------------------------|-----------|----------|

Item Complexity

|                             |             |                 |
|-----------------------------|-------------|-----------------|
| Standard<br>Item (low risk) | (high risk) | Complex<br>Item |
|-----------------------------|-------------|-----------------|

Design Stability

Fixed Design ————— Unstable Design

Competition Spectrum

Maximum Competition ————— No Competition

Fig. 2. Market Structure, Item Complexity, Design Stability, and Competition Spectrum

competition is often employed successfully (4). When an item is more complex and the design less stable, the procurement process moves to the right on the market structure spectrum away from competition in the direction of monopoly. In the monopolistic marketplace, defense acquisition for major weapon systems usually involves one buyer and one seller, each with market power to affect the quantity and price of the item (13:99). Competition is precluded in a monopoly.

Many of the dollars spent for defense are for the production of complex weapons. Due to the unique characteristics of the single buyer (monopsonist) and the single seller (monopolist), the DOD marketplace is often called a bilateral monopoly (9:10). The DOD is concerned with obtaining the technologically best weapon. Consequently, in the procurement of major weapon systems, the buyer (DOD) is often insensitive to price (11:32). Additionally, the buyer (DOD) does not control the funds with which to buy weapon systems. Congress controls the funds and has significant influence over the actual acquisition of weapon systems. The unique characteristics of the buyer, the Department of Defense, create barriers to both entry and exit within the defense industry (11:32-50). The uncertainty due to annual funding, the stress for high technology, and the associated costs to build such high technology create an industry where there are a few highly specialized sellers dependent on

defense business. The defense market factors limit "free market" competition and lead to monopolistic dealings (11:32-45).

### Facilitating Factors

The decision of whether or not to or how to introduce competition in defense acquisition is one that takes considerable planning, preparation, and knowledge about the specific item for purchase. There are several key elements that facilitate making a successful contracting decision.

First, the probability of success is dependent on several characteristics of the item being procured. As shown in Figure 2, the greater the complexity of an item, the greater the risk to both parties (buyers and sellers). Highly complex or "state of the art" items, due to the risk, do not facilitate the introduction of competition (31:10). Another important characteristic of an item is the existence of potential commercial spinoffs or Foreign Military Sales (FMS). The lure of additional profitable opportunities may interest more firms.

A major consideration in the purchase of required items from more than one source is the compatibility or standardization of the items. The availability of reprourement data (i.e., drawings, plans, specifications, and process designs) is a key element. The decision to buy reprourement data should be made early in the weapons acquisition

process, yet the decision must be made with costs in mind. It is estimated that only five percent of the reprourement data are actually used for the reprourement of weapon systems replenishment spare parts (15:2). Conversely, the existence of proprietary data or patents hinders attempts to use competition for spares (31:16).

The size of the procurement in terms of quantity of items and time is also important. Procurement of large quantities of items over a long period of time lessens some of the risk to the contractors (26:14).

Certain characteristics of potential contractors influence the ability to establish additional sources of supply. The availability of existing production capacity is necessary to preclude capital investment or extra work shifts. If potential sources need to expand production capacity, the sources may not be price competitive. Also, the existence of substantial subcontracting limits the margin from which potential competitive sources can reduce prices (31:18).

The combination of the aforementioned facilitating factors determines the relative success or failure of the use of competition in defense contracting. There is the potential for both benefits and disadvantages from the introduction of competitive acquisitions. Many of the potential



benefits and disadvantages cited in the literature on competition in Government contracting are discussed in the following sections.

### Benefits and Objectives of Competition

The most commonly discussed benefits and objectives from applying competition in defense contracting are discussed in the following sections of the chapter. This discussion of benefits from competition is not all inclusive, for each weapon system is unique and could derive unique benefits from competition.

### Cost Reduction

The most commonly identified benefit of competition is that the introduction of additional sources reduces production costs due to the existence of competitive forces within the marketplace (34:214; 3:13; 31:6). A 1965 Government study, reported by Secretary of Defense Robert S. McNamara, provided a figure of 25 percent for savings obtained through the introduction of competition. The savings projection from competition was later supported by a 1969 General Accounting Office (GAO) report on Government acquisition that also reported 25 percent savings. An Army Electronics Command report concluded that 59 percent of an item's cost serves as the potential for competitive savings with reasonable certainty that 40 percent savings should be used in planning for competitive procurements (29:29). Most

research studies have concluded that some degree of savings is realized with the introduction of competition. However, relatively little data are available on the effects of competition during the production phase of the weapons acquisition process, especially on large dollar systems (3:v).

In a Rand Study entitled "Factors Affecting the Use of Competition in Weapon Systems Acquisition," Archibald and Associates reviewed four Government studies on savings due to competition. The conclusion of each study was that competition saved money, but findings varied widely among the four studies. For example, estimated savings ranged from a plus 79 percent (i.e., decrease in prices) to a minus 14 percent (i.e., increase in prices) (3:47). Another study by Ed Lovett and Monte Norton evaluated 16 second sourced items. Lovett and Norton found a composite savings of 10.8 percent for the items, but Lovett and Norton also found that 5 of the 16 items actually had negative savings (17:18). Although competition theory indicates that the introduction of competition should lower prices for products (17:18; 31:3), Lovett and Norton's purpose for undertaking the study was based on the fact that little empirical data about competitive savings actually existed.

#### Motivation of Prime Contractor

Sometimes competition is introduced in the acquisition process for reasons that have nothing to do with price (3:26). The "threat" of developing a second source for a

sole source procurement can motivate the current supplier to improve performance and responsiveness. The potential use of competition has often been employed as leverage during negotiations with a sole source contractor. The U. S. Navy provided one example of contractor motivation due to the influence of competition when a sole source supplier of rocket motors cut prices by 50 percent upon finding that the Navy was attempting to develop a second source for the item (28:29).

#### Broadening Production Base

Broadening the production base of suppliers to strengthen the overall defense industrial base is another objective or benefit from maximum use of competition (31:6). Competition should not only increase the sources of supply for a system but also increase the number of subcontractors and suppliers within the defense industry. There has been a rapid drop in defense spending since the Vietnam conflict. The reduced defense spending has led to prime contractors doing more work in-house, and "large numbers of lower-level defense suppliers have either been going bankrupt or purposely leaving the defense business [11:5]." Little data were found to support the assertion that competition expands the defense base of subcontractors and suppliers. Mr. Webb Small, Financial Director of Ford Aeronutronics' Missile

System Organization, stated that, in the Sidewinder Program (of which Ford is a second source), Ford uses many of the same subcontractors as the leader company (32).

#### Mobilization

Related to broadening the production base are the benefits of increased war readiness, increased mobility, and shortened acquisition time for defense programs (29:215). Mobility factors include dispersing production geographically as well as developing multiple qualified sources. Having multiple qualified sources should improve delivery time and reduce program lengths (31:6). The mobilization objective is based on national security objectives rather than cost. "When mobilization is the prime reason for second sourcing, competition and price become only secondary [25:19]." With a tightly controlled budget and shrinking defense expenditures (in terms of percentage of GNP), enhanced mobilization capability might at times be too costly. For example, competition dollars used to qualify a second source are usually deleted in a budget reduction.

#### Other Benefits

There are other reasons to develop multiple sources for systems for which little data were found. The other benefits of competition include reducing the effects of

market fluctuations on defense contractors and pursuing socio-economic goals such as small and disadvantaged business contract awards (31:6; 25:50).

#### Disadvantages and Barriers to Competition

The potential problems and barriers of competitive procurements must be considered prior to making a decision to introduce competition. Several significant disadvantages and barriers to competition are presented below.

#### Item Complexity

A factor that affects almost all other concerns is the complexity of the item being purchased (28:10). An extremely complex item requires a stable, well defined, up-to-date technical data package that is legally available for Government use. The technical data package describes how the end item is built in terms of materials and processes (25:2). If the Government does not have the rights to design data from early procurement of data or Government development, the data must be bought or licensed from the contractor. Archibald and Associates point out in a Rand Study:

It is difficult and expensive to get a good technical data package to use in starting production and even more difficult to persuade the first producer to pass along to a competitor the benefits of his manufacturing experience [3:18].

Cost savings can accrue from early data preparation. In reality, the quality of a reprocurement data package is not known or verified until another source attempts to produce an item using the data package (25:24). Even when good reprocurement data are available, product quality cannot be assured by using the data package. In a 1975 interview, the Assistant Director of Procurement and Manufacturing for Aeronautical Equipment of the Aeronautical Systems Division of Air Force Systems Command Lt. Col. John D. Voss stated, "I have never seen reprocurement data be used successfully yet [15:19]." A complex item that requires technology transfer is very risky. An item's complexity is also the basis for other important concerns relative to competition.

### Reliability

The reliability of an item developed through some form of technology transfer is often suspect (2:15). The Army Materiel Systems Analysis Activity (AMSAA) studied nine cases of introducing competition for products, primarily reviewing reliability. The study concluded "that the reliability objective should be given little weight in the strategy selection decision . . . [2:33]." The study found, however, that initially all second sources had some problem producing the product (2:18). Also, AMSAA only studied programs in which the competitive source had successful

production, but there are cases where a new competitive source never produces a usable product (2:18). In a 1974 study of competition for weapon systems replenishment spare parts, the researchers concluded that spare parts bought competitively tended to be of poorer quality than the spare parts procured from sole source contractors (24:84).

### Lost Learning

Another barrier to competition is lost learning. That is, the development of a second source for production decreases the savings realized through the benefits of the learning curve (28:29). As a company continues to produce an item, process and labor improvements occur due to familiarity with the product. The introduction of competition reduces the quantity produced by the original contractor with experience, and additional sources of supply cause a quantity of the production requirement to return to the beginning of the learning curve. If the slope of the learning curve is shallow (i.e., little percentage improvement), as is usually found for less complex items or in firms with high turnover, the item is more adaptable to competitive procurement. Conversely, a steep learning curve (i.e., high percentage improvement) indicates that the overall costs for introducing competition could be prohibitive (26:12).

### Capital Investment

Technically complex or specialized items usually require unique production and test equipment, i.e., large initial capital investment. The large initial investment is required for major systems and is one reason why the major systems are not usually considered for competition. The large capital investment is a barrier to competition for both the Government and other potential sources (28:29). In addition, Government funds are often needed to obtain the technical data package and provide Government-furnished tooling, test equipment, and plant equipment to contractors. The number of potential sources may be limited, because of the capital investment required for the initial purchase of capital equipment.

### Risk and Loss of Program Control

When a program changes from sole source to competitive procurement, different contracting methods are utilized (e.g., request for proposals in negotiation versus invitation for bids in formal advertising). The competitive contracting methods decrease the Government program manager's influence during the source selection process. The Rand Study conducted by Archibald and Associates showed that program management experienced much risk related to competition, but most managers "placed little confidence in either the precision or relevance of estimated savings



[3:10]." Competition may result in an award to a prime contractor that the Government program manager considers not technically capable of performing the contract (3:20). Competition would then increase the Government buying office's workload. The benefits from competition are usually long term and often difficult to quantify and verify. On the other hand, program failures are immediate. The Government program manager has few real incentives to offset the high risks associated with competing a program (3:10).

#### Empirical Research

The potential benefit of cost savings from competition has been the emphasis of most of the research conducted in the area of competition. Since Secretary McNamara's reported competitive savings (3:22), numerous empirical studies have been undertaken. The empirical studies to date have dealt primarily with the production and acquisition of weapon systems replenishment spare parts. Six of the major studies highlight the present knowledge with respect to competition and point out the vastly different empirical results.

### Research Study 1

In a 1972 study, the Cost Analysis Division of the U.S. Army Electronics Command set out "to determine if a predictive model or methodology could be established to forecast unit price reduction from competitive procurement [3:29]."

The Army researchers found repetitive reprourement price data for 22 electronic items. Comparison of the last sole source unit price to the price of the first competitive purchase provided a mean unit price reduction of 53 percent. The prices were not adjusted for the effects of inflation or learning. All 22 items examined had lower prices after the introduction of competition (3:32).

As part of the study methodology, the researchers created multiple linear regression models based on three ratios: (1) competitive lead times to sole source lead times, (2) competitive quantity to sole source quantity, and (3) competitive delivery (per month) to sole source delivery (per month). The regression models were used to predict unit price reductions. The regression models failed to provide good predictions of potential savings (3:29-31).

### Research Study 2

In 1973, three graduate students at the Air Force Institute of Technology, Olsen, Cunningham, and Wilkens, completed a study of the costs and benefits of introducing

competition into the procurement of aircraft replenishment spare parts that had been previously purchased non-competitively (24). As in Research Study 1, Olsen, Cunningham, and Wilkens compared the last sole source unit price to the price of the first competitive buy. Prices were adjusted for inflation using wholesale price indices. An additional adjustment was made by computing an average item quantity to use in the regression equation (24:42).

Olsen, Cunningham, and Wilkens estimated that savings realized from the introduction of competition were between 10.85 and 17.5 percent depending upon the quantity. Estimated savings percentages were developed using regression analysis and fitting data into the following conceptual model:

$$\begin{aligned} \text{Net Savings (Loss)} &= \text{Gross Savings (Loss)} - \text{Procurement} \\ &\quad \text{Data Costs} \pm \text{Administrative Costs} - \text{Quality Costs} \\ &\quad \pm \text{Reliability Costs.} \end{aligned}$$

Evaluation of the model variables (excluding savings) was primarily subjectively based on interviews and report evaluations (24:74-79). The researchers concluded that administrative costs could be either positive or negative when changing to competitive procurement. Generally, for procurement actions over \$100,000, competitive procurement requires less administrative effort than sole source

procurement. Additionally, Olsen, et. al., concluded that competitively-procured spare parts were generally of poorer quality than the spare parts procured from sole source contractors (24:84).

### Research Study 3

Ed Lovett and Monte Norton of the U.S. Army Procurement Research Office conducted a study of competition in 1978 (18). The research objectives were to:

1. Develop a methodology to estimate net savings due to competition.
2. Further develop the methodology to forecast the net savings expected from the introduction of competition into the procurement of future major weapon systems.
3. Furnish an ongoing data base to support the net savings methodology [17:18].

The study was conducted using 16 production weapon systems as a sample of the population of interest. Lovett and Norton collected data on production costs, technical data, and other costs associated with the use of competition (18). A regression model based on a logarithmic transformation of price was used to predict unit prices for comparative purposes. The study found savings ranging from a plus 51 percent (i.e., decrease in prices) to a minus 13.2 percent (i.e., increase in prices) with a mean savings of plus 10.8 percent.

Lovett and Norton also developed a three-part forecasted savings methodology. The first part was a competition screen which involved the selection criteria used to

evaluate items as potential competitive candidates. The criteria included proprietary data, Congressional influences, and production quantities. The second part was a forecasting methodology that looked at prices and learning in order to estimate competitive savings. Finally, the forecasted savings methodology included a competition index summarizing the qualitative factors involved in an individual procurement.

#### Research Study 4

In 1979, Daly, Gates, and Schuttinga conducted an extensive study of competition for the Office of the Under Secretary of Defense for Research and Engineering (9). The study examined "the benefits and costs of utilizing price competition during the reprocurement phase of the weapon systems acquisition process [9:S-1]." Study objectives were to determine when competition should be considered, how long competition should be considered, and what policy changes would facilitate competitive procurement (9:S-1). The study reviewed the impact of competition on both price and non-price aspects of weapons acquisition. The researchers studied the effects of cost/quantity relationships and technology transfer on competitive savings for production contracts (9:S1-4).

Daly, Gates, and Schuttinga evaluated 31 items and found savings from a plus 64 percent (i.e., decrease in prices) to a minus 23 percent (i.e., increase in prices) with a mean savings of 35.1 percent (i.e., overall decrease in prices). Savings were calculated:

by subtracting the actual cost to the Government (contract price) of all post sole source production contracts from the price projected on the basis of the sole source progress curve and then expressing the difference as a percentage of the projected sole source price [9:62].

The results of the Daly, Gates, and Schuttinga study were:

1. Price competition is an investment decision.
2. Generally, price competition has proven to be cost effective.
3. The benefits of competitive reprocurment are usually long run in nature and should be balanced against the associated short run costs.
4. Several characteristics of a weapon system, such as duration of production and slope of the learning curve, indicate the probability of successful introduction of competition (9:S-4).

#### Research Study 5

Dr. Charles Smith and Charles Lowe conducted a 1981 study in the area of competition for the U.S. Army Procurement Research Office (34). The study was guided by two research questions:

1. Is the rate of decline in price (constant dollars) more rapid under competitive procurement than under sole source procurement?
2. What percentage savings is realized in the first competitive buy [34:51]?

Smith and Lowe selected a sample of 39 spare parts to analyze the impact of the introduction of competition. Although steeper competitive learning curves were found in 23 of the items, this finding was not statistically significant at the 95 percent confidence level. Thus, prices did not decline at a statistically more significant rate under competition.

In 29 of the 39 items, some savings were found when competition was introduced. The researchers concluded that a projected savings rate between 15 and 25 percent was most likely with the introduction of competition.

Smith and Lowe also evaluated the effects of small business purchasing procedures and purchase quantity on savings. The authors concluded that neither factor was statistically significant as related to competitive savings (28:54).

#### Research Study 6

In a 1982 thesis at the Air Force Institute of Technology, Brost studied the effects of competition on Air Force weapon systems replenishment spare parts that were previously procured non-competitively (5). Brost selected 36 items that had procurement histories showing at least

three sole source purchases followed by at least three competitive purchases. Estimated mean savings were analyzed using the following four tests:

1. The last sole source purchase was compared to the first competitive buy.

2. The average sole source purchase price was compared to the average competitive price.

3. The spare parts that experienced a price change greater than 50 percent were eliminated from the sample, and the remaining average sole source prices were compared with the corresponding average competitive prices.

4. Estimated sole source prices were compared with prices for the first competitive buy (5:61).

Brost's study provided mean savings of 16.9, 3.7, and 2.0 percent and a mean loss of 6.4 percent respectively for the aforementioned four tests. Brost found that the null hypothesis, the introduction of competition resulted in unit price increases, could not be rejected.

Brost also evaluated the effects of procurement method in conjunction with other variables to determine if the other factors influenced the changes in prices. Additionally, Brost analyzed the effect of the number of solicitations on price changes. Brost concluded that a portion of the observed change in price was attributable to the effects of competition, however, competition was just as



likely to raise prices as to lower prices. Eleven of the 36 items showed higher prices, while only 8 items experienced price decreases. Brost also found that the number of solicitations had no impact on spare parts' prices under competition (5:87).

The results of Brost's study contradict the results of several previous empirical studies (3; 18; 24; 33). Additional support for Brost's findings could provide significant impetus for changes in defense policy and guidance related to competition.

#### Summary

This chapter presented a review of the relevant literature related to competition. The chapter included: (1) a definition of competition, (2) background and a discussion of the uniqueness of the DOD marketplace, (3) a review of the benefits, objectives, and disadvantages of competition, and (4) an examination of six empirical studies related to competition.

The Department of Defense (DOD) operates in a unique contracting environment. The DOD buys high technology items through a regulated process in a marketplace often characterized by a single buyer and a single seller. Because of the unique environment, there exist both benefits and disadvantages related to the development of multiple sources for an

item (i.e., competition). The active search for competitive opportunities is a must, however, actual competition for a particular item should be conducted only after serious consideration of product characteristics, suppliers, risk, and potential savings.

Generally, competition has been found to reduce the unit prices for items. Five of the six empirical studies presented in this chapter reported mean savings due to competition ranging from 10.8 to 53 percent. Brost's study reported an actual loss (i.e., increase in prices) in some instances with the introduction of competition. Brost's unanticipated findings were the primary impetus for this research project. The author used Brost's research methodology with an increase in the sample size to validate or refute Brost's findings. The research methodology is presented in the following chapter.

### CHAPTER III.

#### RESEARCH METHODOLOGY

##### Introduction

The first chapter identified the research problem and outlined the research hypotheses and research questions used to accomplish the overall research objectives. The first research objective was to provide evidence to support or refute the belief that the introduction of competition into the procurement of Air Force weapon systems replenishment spare parts leads to savings. The second research objective was to evaluate the effects of certain characteristics of the spare parts on the projected savings or losses caused by competition.

Chapter II reviewed the relevant literature pertaining to the use of competition within defense acquisition. This chapter provides the research methodology that was developed to accomplish the research objectives. The first section of this chapter contains the research plan with a flowchart that provides an overview of the research methodology. The chapter then discusses the universe and target population, data collection and preparation, sample selection criteria, data analysis and adjustment, statistical techniques, and the basic methodology for each research hypothesis and research question.

### Research Plan

Figure 3 is a flowchart of the overall research methodology utilized to accomplish the author's research project. The research procedures or methods developed by or modified from earlier research projects are indicated by the bibliographic references. The elements of the flowchart are examined in detail in subsequent sections of this chapter.

### Universe and Target Population

The universe for this research project was all United States Air Force weapon systems replenishment spare parts procured under the authority of an Air Force buying office. The researcher considered enlarging the universe to include all Department of Defense (DOD) replenishment spare part purchases. However, the application of slightly different procurement techniques among the military services, combined with the difficulty of obtaining an adequate DOD sample, were considered significant enough to warrant limiting the universe to Air Force replenishment spare parts only.

Weapon systems replenishment spare parts are "spare parts procured for replenishment of items issued from the storage and distribution system [20:638]." The replenishment spares can be individual parts, subassemblies or components used for maintenance, repair, or overhaul of a system or an end item (20:638).

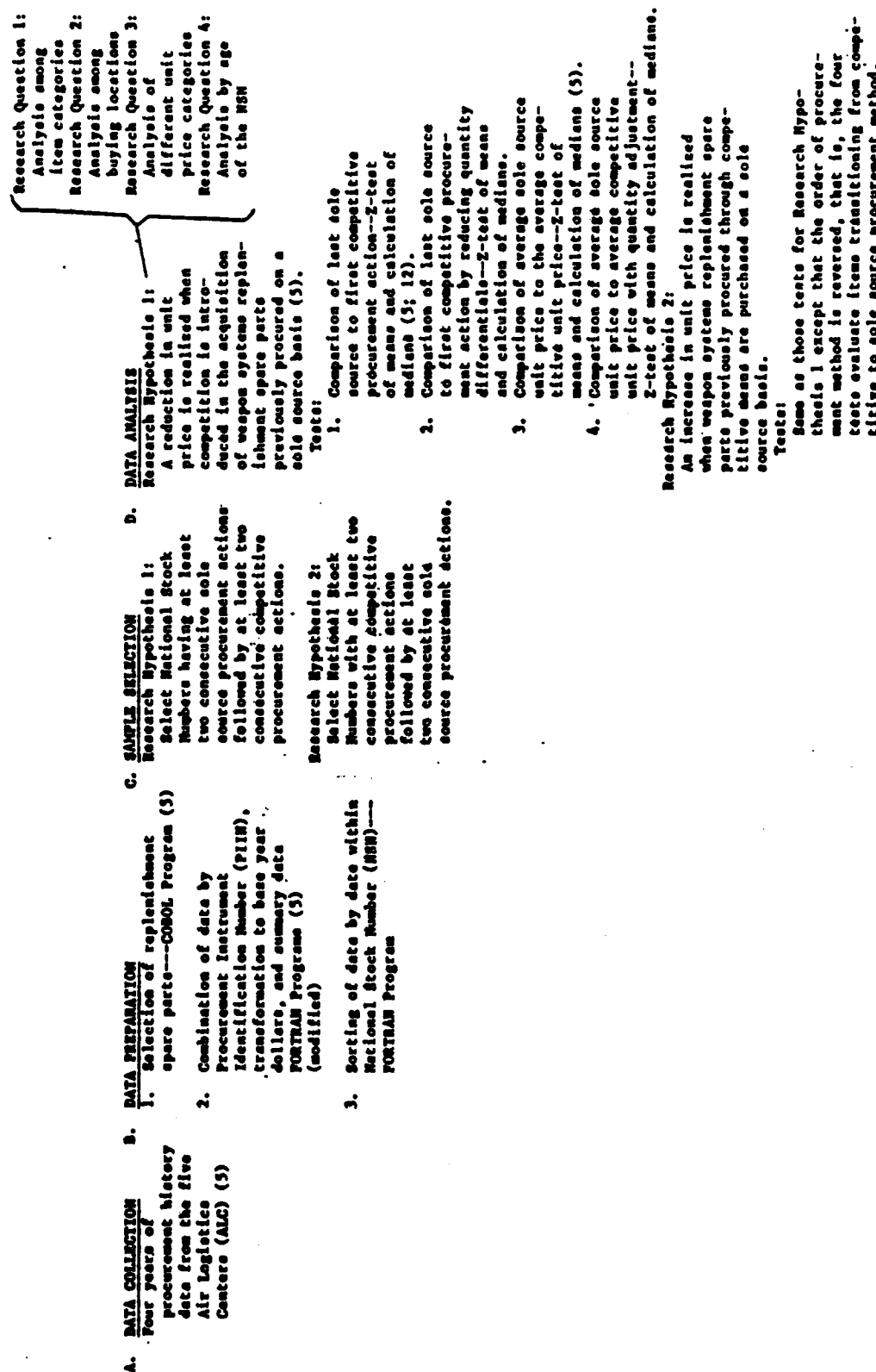


Fig. 3. Flowchart of Research Methodology

The United States Air Force Logistics Command (AFLC) has the primary responsibility for Air Force replenishment spare parts acquisition (40). AFLC uses five centralized acquisition field activities called Air Logistics Centers (ALCs) to carry out the Air Force spare parts procurement responsibility. Each ALC is assigned a unique set of weapon systems or end items for procurement of all related spare and repair parts (5:31). The ALCs and a partial list of the weapon systems or end items for the ALCs are provided in Appendix B.

When a replenishment spare part is acquired, the responsible ALC updates a procurement history file. The procurement history files contain information such as National Stock Number (NSN), purchasing office, quantity procured, price, procurement method, number of solicitations, and contract type.

The target population for the author's research project was replenishment spare parts purchased by AFLC Air Logistics Centers. Repair and spare parts procured by base contracting offices, AFLC maintenance organizations, or other Air Force buying activities were outside the target population but were included within the universe. In many cases, the same spare parts types are procured by all of the foregoing buying activities. The replenishment spare parts include aircraft repair parts, support equipment, support

equipment repair parts, and many other items. The DOD procurement process is governed by the Defense Acquisition Regulation (DAR) and, therefore, is common to all Air Force buying activities. The segregation of ALC procurement of weapon systems replenishment spare parts as a target population was primarily based on the availability of data.

#### Data Collection

AFLC Headquarters at Wright-Patterson AFB, Ohio, provided four years of procurement history files from the five ALCs as the data base for the author's research project. The raw data included all replenishment spare parts, initial provisioning spare parts, and new item procurement actions accomplished by the five ALCs during the period from March 1979 to March 1983.

#### Data Preparation

A COBOL computer program was developed to select the replenishment spare parts that experienced both sole source and competitive procurement actions. The computer program also provided summary data on the quantity of National Stock Numbers (NSN) included in the raw data and the number of procurement actions per NSN. At this point, the data were segregated by purchase request number which caused procurement actions on the same day under the same contract number, but for different requesting organizations, to be listed

separately. For the purpose of the comparisons made in this research project, a purchase order or contract, rather than a purchase request, was considered as one procurement action. Therefore, a FORTRAN program was written that combined purchase requests having the same Procurement Instrument Identification Number (contract or order number) and the same date. Finally, another FORTRAN program sorted the resultant data by date of purchase by National Stock Number to allow computerized selection of the sample data.

#### Sample Selection

Two different sets of sample selection criteria were used to obtain samples to evaluate each one of the two research hypotheses.

Research Hypothesis 1 was concerned with the effects, if any, on the prices of spare parts when changing from sole source to competitive acquisitions. Evaluation of Research Hypothesis 1 was the primary emphasis of the author's research project. The first criterion used in the sample selection for Research Hypothesis 1 identified the replenishment spare parts whose procurement histories showed both sole source and competitive procurement actions. A procurement action was classified as sole source when coded with a "1" in the source solicitation block and competitive when coded otherwise (5:39).



From the resulting group of replenishment spare parts, an additional sort of the data was made to identify the replenishment spare parts that experienced procurement histories of at least two consecutive sole source procurement actions followed by at least two consecutive competitive procurement actions. A visual inspection of the ALC procurement actions caused the researcher to reject a small number of items due to some obvious administrative errors or the use of unlike units of issue for different procurement actions.

Similar sample selection criteria were utilized in two previous studies in the area of competition (5:40; 3:51). The rationale for requiring two consecutive procurement actions for both sole source and competitive procurements was to utilize trend data as a firmer foundation upon which to make comparisons and generalizations about the ALC procurement action data. Consecutivity was utilized to reduce the potential bias that may occur when procurement actions transitioned back and forth between sole source and competitive acquisitions. The consecutivity requirement was conservative in that the requirement should have minimized "false savings" caused by buy-ins and procurement mistakes.

The criteria used for selecting a sample for Research Hypothesis 2 were the same as the sample selection criteria for Research Hypothesis 1 except that the sequence

of procurement methods was reversed. The second sample required at least two consecutive competitive procurement actions followed by at least two consecutive sole source procurement actions.

The research findings, based on an analysis of the foregoing samples, provided information about the degree of savings due to the introduction of competition for the target population. Because of the similarities between ALC spare parts procurement and the procurement of spares by other Air Force agencies, the research findings are applicable to the study's universe of all Air Force replenishment spare parts procurements.

#### Data Analysis

The primary data analysis in the author's study involved the evaluation of Research Hypotheses 1 and 2. The evaluation of Research Hypothesis 2 provided further support for the theory related to Research Hypothesis 1 by testing a reciprocal hypothesis. In addition, four research questions were utilized to further analyze the structure of the sample selected for Research Hypothesis 1.

#### Data Adjustment

To prepare the sample data for analysis, all prices of replenishment spare parts were adjusted to equivalent or constant year dollars in order to eliminate the influence of inflation and other economic perturbations on price changes

over time. Transformation was accomplished using the Producer Price Index (PPI) for special metals and metal products with a base year of 1980, as was used by Brost (5:41) and Olsen, et al., in previous research efforts (24:34).

The PPI uses a sample of approximately 3,400 items and 26,000 price quotations to identify the movement of prices for a variety of commodities produced in the United States. The indices are organized either by commodity or by stage of production. The special metals and metal products category includes products with similar end item uses or material makeup (41:72-76).

To obtain an adjusted unit price based on 1980 dollars, it was first necessary to establish a 1980 deflation factor (5:42). The PPI has a base year of 1967 with a PPI factor of 1.0 (see Table 1). Each year, the analysis of the price quotation leads to an estimate for that year's increase or decrease in price for a certain quantity of a commodity. The increase or decrease in price provides the basis for the development of that year's PPI factor. For example, the 1980 PPI factor for the general category of special metals and metal products is 2.585. This 1980 PPI factor indicates that the price of a given amount of a commodity is 2.585 times higher than the price in 1967. A 1980 deflation factor is obtained by dividing the PPI factor of a given year by 2.585 (the 1980

Table 1

Example of Producer Price Indices Used For Constant  
Year Dollar Adjustment of Unit Price

| Commodity Group |                                 | Special Metals and Metal Products |                        |       |                       |       |
|-----------------|---------------------------------|-----------------------------------|------------------------|-------|-----------------------|-------|
| Calendar Year   | 1967                            | 1979                              | 1980                   | 1981  | 1982                  | 1983  |
| PPI Index       | 1.00                            | 2.346                             | 2.585                  | 2.794 | 2.885                 | 2.947 |
| Award Date      | Unit Price in Then Year Dollars |                                   | 1980 Deflation Factor* |       | Adjusted Unit Price** |       |
| 1979            | \$20.00                         |                                   | .907                   |       | \$27.05               |       |
| 1980            | 20.00                           |                                   | 1.000                  |       | 20.00                 |       |
| 1981            | 20.00                           |                                   | 1.081                  |       | 18.50                 |       |
| 1982            | 20.00                           |                                   | 1.116                  |       | 17.92                 |       |
| 1983            | 20.00                           |                                   | 1.140                  |       | 17.54                 |       |

\* A sample calculation of a 1980 Deflation Factor:

$$\text{For Award Date of 1983} = \frac{\text{PPI for 1983}}{\text{PPI for 1980}} = \frac{2.947}{2.585} = 1.14$$

$$\text{** Adjusted Unit Price} = \frac{\text{Unit Price in Then Year Dollars}}{\text{1980 Deflation Factor}}$$

PPI factor). The new deflation factor is multiplied by the actual unit price in then year dollars to obtain an adjusted unit price in terms of constant 1980 dollars (see Table 1).

The PPI factors for special metals and metal products, used as the basis for transformation of unit prices to 1980 base year dollars, were developed by computing the combined averages for the twelve monthly PPI inflation factors for each of three categories of goods: (1) general metals, (2) automotive metal products, and (3) machinery and equipment. Data transformation was based on the date of the contract award. The contract award date provided a common point of reference for comparison purposes.

#### Statistical Techniques

The statistical techniques used in the author's study included computation of median scores, the large sample Z-test for means, the ONEWAY analysis of variance (ANOVA), and the Kruskal-Wallis H test.

The principal statistical technique employed in this research project was the Z-score or large sample mean hypothesis test. The Z-score measures the probability that a mean computed for a sample is from a certain hypothesized population (20:88). For example, suppose we expect that no savings occur when competition is introduced into the acquisition of replenishment spare parts. Thus, the expected population mean equals zero percent savings. A random

sample of 30 replenishment spares is drawn, and mean savings value of 5 percent is calculated. The mean savings value is calculated by summing the percentage of savings (or losses) found for each spare part and dividing by the total number of spare parts in the sample. The Z-test statistic provides evidence about whether, at a certain level of confidence (say 95 percent), a sample mean savings of 5 percent per spare part would have come from a population distribution that had a mean savings of zero percent.

For this example, the null hypothesis would be that the mean savings of the population is less than or equal to zero. A Z-test statistic would then be calculated using the sample mean and sample standard error as follows:

$$Z = \frac{\bar{x} - \mu}{\sigma_{\bar{x}}}$$

where:

$\bar{x}$  = the sample mean,

$\mu$  = the hypothesized population mean, and

$\sigma_{\bar{x}}$  = the standard error of the sample.

The calculated Z-test statistic would be compared to a critical Z-test value for a given confidence level to determine if the null hypothesis could be rejected. If the calculated Z-test statistic is greater than the critical value, then the null hypothesis would be rejected (21:257).

Median values were calculated to provide a basis for comparison with previous research that did not employ parametric statistics (i.e., means). The median is a measure of central tendency and is most often used with large data sets. The median is often a better measure of the central tendency of data than the mean, because the median is far less sensitive to large variations or abnormal values (21:61). The median for a data set is that number for which one-half of the data values fall above and one-half the values fall below the number (21:59). For the data set (-1, 0, 2, 3, 31) the median is 2, because two data points fall below and two data points are above 2. If the number of elements in the data set is an even number, e.g., -1, 0, 1, 2, 3, and 31, then the two center values, 1 and 2, are summed and divided by 2 to obtain the median (i.e.,  $\frac{2 + 1}{2} = 1.5$ ). To obtain a median value, the data must be sorted in ascending (or descending order). The author used the Statistical Packages for the Social Sciences (SPSS) sort program to obtain the median values.

The statistical technique used to analyze data for the four research questions was the ONEWAY analysis of variance (ANOVA). The analysis of variance is a parametric procedure that statistically tests whether the means of various subsamples or subgroups are significantly different (22:260). More explicitly, the ANOVA tested the null

hypothesis, ( $H_0$ ):  $M_1 = M_2 = \dots = M_N$ , where  $M_N$  was the mean of subgroup N (21:653). The following test statistic, an F-test value, was computed and compared to a table value to evaluate  $H_0$  (21:634):

$$F = \frac{MST}{MSE},$$

where:

MST = Mean Square for Treatment, which represents the unexplained variance among subgroups.

MSE = Mean Square for Error, which estimates the variation of the probability of the random error for a given set of values (21:462).

The rejection region for the null hypothesis was when F (computed) was greater than F (critical value).

An SPSS ONEWAY ANOVA procedure called the Scheffé option was employed when the F statistic analysis led to the rejection of the null hypothesis. The Scheffé option identified subgroups whose mean competitive savings or losses were statistically different (20:73). The Scheffé option provided multiple comparisons of the means of the subgroups by placing groups into subsets with those other groups from which there were no statistical differences among means (20:74). The ONEWAY analysis of variance is specifically limited to cases where there is only one independent variable with one or more dependent variables.



The following assumptions were required to use the ONEWAY ANOVA:

1. All subgroup population probability distributions were normal distributions.
2. All subgroup variances were equal.
3. Data were selected randomly and independently from the populations.

A 95 percent confidence level was used to establish the test criteria for the ONEWAY analysis of variance and the Z-test of means. The researcher accepted five percent risk of rejecting a true hypothesis. The larger the confidence level, the less the chance of rejecting a true hypothesis (22:283). A 95 percent confidence level value was considered to be an appropriate balance between the foregoing risks.

The Z-test of large sample means and the ONEWAY analysis of variance are parametric tests. Parametric analyses were conducted based upon the Central Limit Theorem, which states that if a random sample of observations is sufficiently large, the sampling distribution of means approximates a normal distribution (21:254). The Central Limit Theorem may be invoked regardless of the underlying distribution of the sample (46).

The last statistical technique used in this research project was the Kruskal-Wallis H test. The Kruskal-Wallis H test was used to compare the probability distributions or

median values for more than two samples (21:690, 693). The Kruskal-Wallis H test is a nonparametric procedure, similar to the ONEWAY ANOVA, in that the Kruskal-Wallis H test allows comparison among multiple samples or subgroups (21:690). The Kruskal-Wallis H test was used to evaluate the null hypothesis-- $H_0$ : The populations have identical probability distributions. Observations were ranked as though drawn from a single population. The observations were recategorized by sample groupings and sums of ranks,  $R_j$ , were obtained for all groupings. A test statistic, H, was calculated as follows:

$$H = \frac{12}{n(n+1)} \sum_{j=1}^K \frac{R_j^2}{n_j} - 3(n+1)$$

where:

$n$  = the total number of observations,

$K$  = the number of sample groupings,

$j$  = the sample number,

$R_j$  = ranked sum for sample  $j$ , and

$n_j$  = the number of measurements in sample  $j$ .

The calculated H value was then compared with a value obtained from a chi-square table, based on  $K-1$  degrees of freedom. The null hypothesis would be rejected if H was greater than the chi-square value. The assumptions made with the Kruskal-Wallis H test were:

1. The K samples were random and independent.
2. There were five or more measurements in each sample grouping.
3. The observations were ranked within the total sample (21:693).

The statistical technique utilized was dependent upon the specific research hypothesis or research question being analyzed.

#### Evaluation Plan for Research Hypotheses and Questions

In this section, the research hypotheses and research questions are discussed in terms of the evaluation methods and statistical techniques utilized. This section also examines the relative importance of certain research hypotheses and research questions in accomplishing the author's research objectives. Each research hypothesis or research question is restated prior to its discussion.

#### Research Hypothesis 1

A reduction in unit price is realized when competition is introduced in the acquisition of weapon systems replenishment spare parts previously procured on a sole source basis.

Research Hypothesis 1 was the basis for undertaking this study. The empirical results supporting the existence or nonexistence of savings were based on the four tests used to identify the savings (or losses) for each spare part. The author's four tests were either used in or modified from

previous studies (5:65-66; 24:40-45). The percentage of savings (or losses) was defined as the percent change in unit price for each line item. The percentage price change was calculated by subtracting the competitive unit price from the sole source unit price and dividing by the sole source unit price (5:50). This method of calculating percentage savings led to a few extremely skewed negative data points. The formula, 
$$\frac{\text{Sole Source Unit Price} - \text{Competitive Unit Price}}{\text{Sole Source Unit Price}},$$
 provided positive values that indicated the percent of savings up to a maximum of 1.00 or 100% if the competitive unit price was zero. Conversely, negative values (or losses) occurred when the competitive unit prices were larger than the sole source unit prices. Because of the extremes feasible, median values were also calculated for each test.

The first test compared the unit price (inflation adjusted) for the last sole source procurement action to the unit price for the first competitive buy for each replenishment spare part. A Statistical Package for the Social Sciences (SPSS) computer program was used to obtain an average (mean) savings for the sample of replenishment spare parts. The Z-test was then utilized to determine if the calculated sample mean was significantly greater than zero, therefore indicating the existence of savings.

Tests two, three, and four also utilized the Z-test to evaluate the significance of the calculated mean changes in prices. Since there was a possibility of extreme data observations caused by influences other than competition, the second test was developed to reduce the impact of the anticipated extreme values. The second test was the same as the first test, except that spare parts which exhibited the first three or the fourth of the following characteristics were eliminated from the sample:

1. The price change for a spare part was greater than plus or minus 50 percent.
2. The quantity of items in the last sole source procurement action was either 50 percent greater than or one-half as large as the first competitive procurement action.
3. The unit price of either the last sole source or the first competitive procurement action was greater than 50 percent above the average sole source or average competitive unit price respectively.
4. The unit price increases (i.e., the losses) were in excess of 500 percent.

The aforementioned criteria reduced the effects of different quantity buys for the last sole source and the first competitive procurement actions, while retaining the procurement actions for which quantity variations failed to have a significant effect on prices.

The third test compared the average unit prices for the sole source procurement actions to the average unit prices for the competitive procurement actions. In the fourth test, the average unit prices were again used, however, additional sample selection criteria were applied. Spare parts were eliminated from the sample if they met at least one of the following criteria:

1. The sole source savings (or losses) were greater than plus or minus 50 percent, and the average quantity of items procured sole source was 50 percent larger than the average competitive quantity procured.

2. The competitive savings (or losses) were greater than plus or minus 50 percent, and the average quantity of items procured competitively was 50 percent larger than the average sole source quantity.

3. The competitive losses (i.e., price increases) were over 500 percent for the spare parts.

The researcher utilized data from the fourth test for the evaluation of the four research questions, because the average price comparisons were based on a greater amount of information. The additional sample selection criteria for the fourth test further reduced the effects of quantity variations.

Research Hypothesis 1 was considered supported if three of the four tests reported statistically significant savings from competition. No individual test was without limitations, thus a simple majority of the tests was considered a valid degree of support for Research Hypothesis 1.

Research Question 1. Does the type of item being procured, as identified by its Federal Stock Group or Federal Stock Class, affect the degree of competitive savings (or losses) resulting when competition is introduced into the acquisition process (5:12)?

A National Stock Number (NSN) is assigned to an item based on a commodity classification that identifies the item's end use (5:59). The end use for the item, such as vehicle spares, is described by either the Federal Stock Group, which is the first two numbers of an NSN, or the Federal Stock Class, which comprises the first four numbers of the stock number (see Figure 4). Data were utilized from the following five categories to analyze Research Question 1: Group 1--Airframe structure components; Group 2--Aircraft engines (gas turbine and reciprocating related spares and parts); Group 3--Aircraft subsystems, accessories, components, and related spares and parts; Group 5--Mechanical miscellaneous; and Group 9--Electrical, electronic, and communication equipment, and related spares and parts. The ONEWAY analysis of variance was used to test whether observed differences in mean savings (or losses) for each

| <u>Group</u> | <u>Explanation</u>                                                                | <u>Stock Class</u>                                                                                             |
|--------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 1            | Airframe structure components                                                     | Group 15                                                                                                       |
| 2            | Aircraft engines (gas turbine and reciprocating related spares and parts)         | Class 2810, 2840, 2895, 2915, 2925, 2935, 2945, 2950, 2995                                                     |
| 3            | Aircraft subsystems, accessories, and components, related spares and parts        | Class 1270, 1280, 2620, 4920, 6340, 4940, 6605, 6610, 6615, 6680, 6685                                         |
| 4            | Guided missile components and related spares and parts                            | Group 14<br>Class 4935                                                                                         |
| 5            | Mechanical miscellaneous                                                          | Group 30, 39, 41, 43, 47, 48, 53                                                                               |
| 6            | Vehicle spares and parts                                                          | Group 24, 25<br>Class 2310, 2320, 2330, 2340, 2350, 2610, 2630, 2640, 2805, 2815, 2910, 2930, 2940, 2990, 6620 |
| 7            | Weapons components and related spares                                             | Group 10, 12 (except 1270, 1280)<br>Class 6920, 8140                                                           |
| 8            | Ammunition components and related spares and parts                                | Group 13                                                                                                       |
| 9            | Electrical, electronic, and communication equipment, and related spares and parts | Group 58, 59, 61<br>Class 6625                                                                                 |
| 10           | Other                                                                             |                                                                                                                |

Fig. 4. Commodity Groups

Source: AFLCR 70-11, Appendix 3, Attachment 1, page A1-7.



commodity group were statistically significant. Concurrently, a Kruskal-Wallis H test provided a nonparametric evaluation of each commodity group's median price in relation to the other commodity groups' median prices.

Research Question 2. Is there a significant difference for the competitive savings (or losses) identified among the five AFLC Air Logistics Centers?

The percentage savings (or losses) for all NSNs were categorized according to the AFLC Air Logistics Center responsible for the acquisitions. Comparisons of means and median values among the five Air Logistics Centers were made using the previously described ONEWAY ANOVA and Kruskal-Wallis H test procedures respectively.

Research Question 3. Do the competitive savings (or losses) differ for weapon systems replenishment spare parts depending upon the magnitude of the average unit price?

Five categories, based on the magnitude of average unit prices, were established and evaluated for Research Question 3. The sampled procurement actions included those in which the average unit prices appeared in the following five categories: (1) under \$10.01, (2) \$10.01 to \$100.00, (3) \$100.01 to \$500.00, (4) \$500.01 to \$1,000.00, and (5) over \$1,000.00. Research Question 3 was evaluated using the ONEWAY ANOVA and the Kruskal-Wallis H test procedures described in an earlier section.

Research Question 4. Does the age of the item, as determined by the year in which the National Stock Number was assigned, affect the competitive savings (or losses) realized when transitioning from sole source to competitive acquisition?

Air Force Logistics Command Headquarters provided data for the year in which each NSN was assigned. The three following NSN categories were developed for evaluation purposes: (1) NSNs assigned between 1978 and 1983, (2) NSNs assigned from 1968 through 1977, and (3) NSNs assigned in 1967 and earlier. Research Question 4 was also analyzed using the ONEWAY ANOVA and Kruskal-Wallis H test procedures.

#### Research Hypothesis 2

An increase in unit price is realized when weapon systems replenishment spare parts previously procured through competitive means are purchased on a sole source basis.

If data analysis supported Research Hypothesis 1, the researcher anticipated that Research Hypothesis 2 would also be supported. However, two factors tended to reduce the significance of any contradictory findings. First, as discussed earlier, previous competitive acquisitions create the potential for future competitive acquisitions. A firm interested in securing a contract award might bid as if in a competitive situation based on a knowledge of past procurement actions. Second, as related to Research Hypothesis 1, since a separate sample was analyzed for Research Hypothesis

2, the validity of comparisons would be limited. However, any research findings different from the anticipated results would provide impetus for future study.

Testing of Research Hypothesis 2 was accomplished by applying the same four tests used for Research Hypothesis 1, except the order of comparison for the category of procurement actions was reversed. Instead of comparing sole source to competitive procurement actions, the tests for Research Hypothesis 2 compared competitive to sole source procurement actions. For example, in the first test, the unit price for the last competitive procurement action was compared to the first subsequent sole source unit price. The percentage savings or losses were then calculated by subtracting the sole source unit prices from the competitive unit prices and dividing by the competitive unit prices.

#### Summary

The universe for the author's study included all Air Force purchases of replenishment spare parts. From the universe, the population of interest for this research study was identified as Air Force replenishment spare parts procured by the five ALCs. Sample data came from four years of procurement history records obtained from the five ALCs responsible for the acquisition of replenishment spare parts.

For Research Hypothesis 1, a sample was selected from the ALC procurement history files based on two criteria. The first criterion required an item to have a history of both sole source and competitive procurement actions. The second criterion required that each item have a procurement history with at least two consecutive sole source procurement actions followed by at least two consecutive competitive acquisitions. For the sample selection for Research Hypothesis 2, the second criterion was reversed to require at least two consecutive competitive procurement actions followed by at least two consecutive sole source procurement actions. The research samples were utilized to evaluate all research hypotheses and questions.

The evaluation of the research hypotheses and research questions was accomplished through the use of the following statistical techniques: (1) ONEWAY analysis of variance (ANOVA), (2) Z-test or large sample test of means, (3) computation of medians, and (4) Kruskal-Wallis H test. Nonparametric tests were employed to provide additional support for the parametric tests' results, because large negative values (losses) caused unequal variances for certain data analysis procedures.

## CHAPTER IV

### DATA ANALYSIS AND FINDINGS

#### Introduction

This chapter provides the findings that resulted from employment of the research methodology described in Chapter III. Findings are presented in five sections: (1) Sample Selection Results, (2) Research Hypothesis 1 Analysis, (3) Research Questions Analysis, (4) Research Hypothesis 2 Analysis, and (5) Other Observations. The Research Hypothesis 1 and Research Questions Analysis sections were sequenced in order to reemphasize that the data utilized for the research questions were developed for the evaluation of Research Hypothesis 1.

#### Sample Selection Results

The sample data for this research effort were obtained by applying the sample selection criteria described in Chapter III to approximately four years of procurement history data accumulated by the five AFLC Air Logistics Centers. In the four years, the ALCs procured 243,839 different spare parts having both competitive and non-competitive procurement histories accounting for a total of 427,127 procurement actions (see Table 2).

Table 2

Summary Analysis of ALC Procurement History Tapes  
for the Period From March 1979 Through March 1983

| Air Logistics Center<br>(ALC) | Number of Total NSNs Acquired | Total Procurement Actions* | Number of NSNs with Competitive and Sole Source Procurement Actions | Procurement Actions* for Competitive and Sole Source |
|-------------------------------|-------------------------------|----------------------------|---------------------------------------------------------------------|------------------------------------------------------|
| Warner Robins<br>ALC, GA      | 45,835                        | 75,715                     | 3,157                                                               | 10,673                                               |
| Sacramento<br>ALC, CA         | 46,447                        | 69,783                     | 2,686                                                               | 8,849                                                |
| Oklahoma City<br>ALC, OK      | 38,961                        | 68,352                     | 2,834                                                               | 10,799                                               |
| San Antonio<br>ALC, TX        | 73,582                        | 141,402                    | 6,832                                                               | 29,281                                               |
| Ogden<br>ALC, UT              | 39,014                        | 71,875                     | 3,242                                                               | 13,496                                               |
| TOTALS                        | 243,839                       | 427,127                    | 18,751                                                              | 73,098                                               |

\* The number of procurement actions was based on the number of purchase requests, not the number of purchase orders or contracts written for a particular item.

At this point in the research effort, procurement actions were defined based on purchase requests. After the initial identification of replenishment spares, purchase requests that were bought on the same day from the same contractor under the same contract (order) were combined. This approach insured comparison of total contractual instruments rather than parts of the same contract. Transformations of unit prices to 1980 base year dollars were also accomplished prior to the final sample selection.

Two samples were then selected from the transformed data. Four hundred and twenty-five spare parts met at least two consecutive sole source procurement actions followed by at least two consecutive competitive procurement actions for Research Hypothesis 1. Four hundred and seventy spare parts met at least two consecutive competitive procurement actions followed by at least two consecutive sole source purchases for Research Hypothesis 2. Several spare parts appeared in both sample sets due to the frequent transitioning of the spare parts back and forth between sole source and competitive acquisitions. A visual inspection of each sample led to the elimination of twenty-two spare parts from the samples. Fifteen of these spare parts had incorrect information in the procurement data histories, and the remaining seven spares were eliminated due to obvious coding errors. Tables 3 and 4 provide summaries of the sample selection results identified by ALC for each research hypothesis.

Table 3

Research Hypothesis 1  
Sample Data Summary

| Air Logistics Center        | NSNs/<br>Procurement<br>Actions<br>Meeting<br>Sample<br>Selection<br>Criteria* | NSNs/<br>Procurement<br>Actions<br>Eliminated<br>After Review<br>of Data | NSNs/<br>Procurement<br>Actions<br>in Final<br>Sample |
|-----------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------|
| Warner<br>Robins<br>ALC, GA | 42/184                                                                         | --                                                                       | 42/184                                                |
| Sacra-<br>mento<br>ALC, CA  | 46/218                                                                         | --                                                                       | 46/218                                                |
| Oklahoma<br>City<br>ALC, OK | 48/236                                                                         | --                                                                       | 48/236                                                |
| San<br>Antonio<br>ALC, TX   | 229/1168                                                                       | 5/38                                                                     | 224/1130                                              |
| Ogden<br>ALC, UT            | 60/285                                                                         | --                                                                       | 60/285                                                |
| TOTALS                      | 425/2091                                                                       | 5/38                                                                     | 420/2053                                              |

\* Research Hypothesis 1--Sample selection criteria required at least two consecutive sole source procurement actions followed by at least two consecutive competitive procurement actions for each NSN.



Table 4

Research Hypothesis 2  
Sample Data Summary

| Air Logistics Center     | NSNs/<br>Procurement<br>Actions<br>Meeting<br>Sample<br>Selection<br>Criteria** | NSNs/<br>Procurement<br>Actions<br>Eliminated<br>After Review<br>of Data | NSNs/<br>Procurement<br>Actions<br>in Final<br>Sample |
|--------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------|
| Warner Robins<br>ALC, GA | 42/232                                                                          | 5/34                                                                     | 37/198                                                |
| Sacramento<br>ALC, CA    | 40/218                                                                          | 2/10                                                                     | 38/208                                                |
| Oklahoma City<br>ALC, OK | 110/642                                                                         | 1/5                                                                      | 109/637                                               |
| San Antonio<br>ALC, TX   | 191/1158                                                                        | 8/74                                                                     | 183/1084                                              |
| Ogden<br>ALC, UT         | 87/515                                                                          | 1/4                                                                      | 86/511                                                |
| TOTALS                   | 470/2765                                                                        | 17/127                                                                   | 453/2638                                              |

\*\* Research Hypothesis 2--Sample selection criteria required at least two consecutive competitive procurement actions followed by at least two consecutive sole source procurement actions for each NSN.

### Research Hypothesis 1 Analysis

This section addresses the results of the four tests used to evaluate Research Hypothesis 1.

#### Research Hypothesis 1

A reduction in unit price is realized when competition is introduced in the acquisition of weapon systems replenishment spare parts previously procured on a sole source basis.

Test 1. The first test computed the percentage of savings or losses that were realized in transitioning from sole source to competitive acquisitions, through a comparison of the unit prices for the last sole source procurement actions to that of the first competitive acquisitions. Of the 420 parts remaining in the sample after elimination of inaccurate data, 168 reported losses (unit price increases), 236 parts had savings (unit price decreases), and 16 showed no differences in prices. A quantitative summary of the results by Air Logistics Centers is presented in Appendix C.

The mean calculated for Test 1 was a .2 percent savings (a unit price decrease) between the last sole source and the first competitive purchases. The mean and standard error were used to calculate a Z-test statistic, evaluating the null hypothesis:  $\mu \leq 0$ . The completed test is presented in Table 5.

The computed test statistic of .059 was less than the rejection range critical value of 1.645. Therefore, the null hypothesis, that the population mean was less than

Table 5

Z-Test of Means for  
Research Hypothesis 1, Test 1

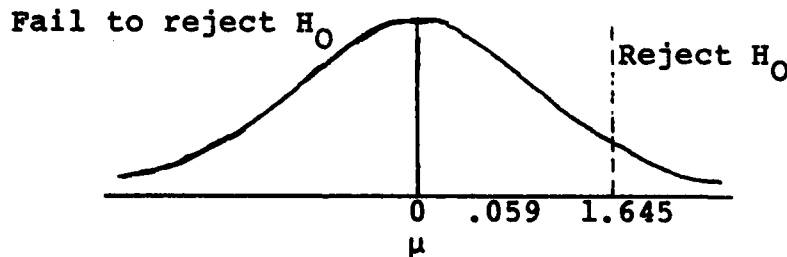
Null Hypothesis ( $H_0$ ):  $\mu \leq 0$  (There is either no change in unit price or there is a loss when transitioning from sole source to competition.)

Alternate Hypothesis ( $H_A$ ):  $\mu > 0$

Test Statistic:  $z = \frac{\bar{x} - 0}{\sigma_{\bar{x}}}$  where  $\bar{x}$  = the sample mean  
 $\sigma_{\bar{x}}$  = the sample standard error

Test 1:  $z = \frac{.002 - 0}{.034} = \frac{.002}{.034} = .059$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject  $H_0$  if Z-test statistic  $> 1.645$ .  
Since  $z = .059 < 1.645$ , fail to reject  $H_0$ .



\* Confidence Interval:  $\bar{x} \pm z_{\alpha/2} \sigma_{\bar{x}}$

For  $\alpha = .05$ , the confidence interval was

-.066 to .069 (i.e., 6.6 percent loss to 6.9 percent savings).

\* This technique provided a 95 percent confidence that the actual mean savings or losses were between a 6.6 percent loss and a 6.9 percent savings.

or equal to zero, was not rejected. The results of this first test agreed with Brost's findings that the "empirical evidence did not support a conclusion that prices decrease when competition is introduced [5:91]."

The median savings value was 3.1 percent, indicating that a few large negative values (losses) influenced the mean savings figure. An analysis of large losses is provided in the "Other Observations" section of this chapter. The median savings value, although larger than the mean savings, was not different enough to cause a reevaluation of the Z-test results.

Test 2. The second test was the same as Test 1 except that 25 replenishment spare parts that exhibited large quantity variations and large unit price variations between the last sole source and first competitive purchases were eliminated. Two other spare parts were eliminated because the two parts showed a loss of over 500 percent, (i.e., the first competitive unit price was at least six times larger than the last sole source unit price). These spare parts were significantly removed from the rest of the data, which spread over a continuous range.

A mean value of 5.9 percent savings was identified in Test 2. The elimination of data elements due to quantity variations and outliers significantly increased the mean savings and reduced the standard error of the data set.

This led to a Z-test statistic of 3.47, substantially larger than the critical value of 1.645. Based upon the Z-test results, summarized in Table 6, the null hypothesis that the population mean was zero savings or an actual loss was rejected. The median value of 3.1 percent savings was supportive of the occurrence of savings as reflected by the mean savings value. Therefore, Test 2 provided evidence to support Research Hypothesis 1, contrary to the results of Test 1.

Test 3. The third test compared the average sole source unit prices to the average competitive unit prices as the basis for calculation of savings or losses. Of the 420 spares analyzed in Test 3, 195 showed losses (price increases), 224 showed savings (price decreases), and 1 showed no change in unit price when competition was introduced. Appendix C presents a summary of the test results by Air Logistics Center.

The mean savings figure for the Test 3 data was 7.7 percent. As resulted in Test 2, the Z-test statistic was substantially larger than the critical value (see Table 7), and the null hypothesis was rejected. The median savings value, 7.1 percent, was extremely close to the mean savings value.

Table 6\*  
Z-Test of Means for  
Research Hypothesis 1, Test 2

---

Null Hypothesis ( $H_0$ ):  $\mu \leq 0$

Alternate Hypothesis ( $H_A$ ):  $\mu > 0$

Test Statistic:  $z = \frac{.059 - 0}{.017} = \frac{.059}{.017} = 3.47$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject

$H_0$  if Z-test statistic  $> 1.645$ .

Since  $z = 3.47 > 1.645$ , reject  $H_0$ .

Confidence Interval: For  $\alpha = .05$ , the confidence interval was  
.025 to .094 (i.e., 2.5 to 9.4 percent  
savings).

\* Additional information common to Research Hypothesis 1,  
Test 1 through Test 4 is provided on Table 5.

---

Table 7\*

Z-Test of Means for  
Research Hypothesis 1, Test 3

---

---

Null Hypothesis ( $H_0$ ):  $\mu \leq 0$

Alternate Hypothesis ( $H_0$ ):  $\mu > 0$

Test Statistic:  $z = \frac{.077 - 0}{.020} = \frac{.077}{.020} = 3.85$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject  
 $H_0$  if Z-test statistic  $> 1.645$ .

Since  $z = 3.85 > 1.645$ , reject  $H_0$ .

Confidence Interval: For  $\alpha = .05$ , the confidence interval was  
.037 to .097 (i.e., 3.7 to 9.7 percent  
savings).

\* Additional information common to Research Hypothesis 1,  
Test 1 through Test 4 is provided on Table 5.

---

Test 4. The fourth test was the final test used to evaluate Research Hypothesis 1. The criteria for Test 4 also required average unit prices. The test required the elimination from the sample of spare parts with substantial average purchase quantity differences between the sole source and competitive purchases and the omission of outliers that had over a 500 percent loss.

The mean savings of 7.7 percent produced a Z-test statistic of 4.27. The Z-test led to the rejection of the null hypothesis that the population mean reflected zero savings or a loss (see Table 8). The median savings value was 5.5 percent, a significant positive value.

Tests 2 through 4 provided statistically significant evidence to support Research Hypothesis 1. Reductions in unit prices were realized when competition was introduced into the acquisition of spare parts previously procured on a sole source basis. It should be noted that utilization of a more stringent 99 percent confidence level would not have changed the results of any of these four tests for Research Hypothesis 1.

The sample data set in Test 4 was utilized as the basis for evaluation of the four research questions. This data set provided the most valid estimate of competitive savings, because the Test 4 criteria reduced the effects of quantity variations, used a larger number of procurement



Table 8\*

Z-Test of Means for  
Research Hypothesis 1, Test 4

---

Null Hypothesis ( $H_0$ ):  $\mu \leq 0$

Alternate Hypothesis ( $H_A$ ):  $\mu > 0$

Test Statistic:  $z = \frac{.077 - 0}{.018} = \frac{.077}{.018} = 4.27$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject

$H_0$  if Z-test statistic  $> 1.645$ .

Since  $z = 4.27 > 1.645$ , reject  $H_0$ .

Confidence Interval: For  $\alpha = .05$ , the confidence interval was  
.041 to .112 (i.e., 4.1 to 11.2 percent  
savings).

\* Additional information common to Research Hypothesis 1,  
Test 1 through Test 4 is provided on Table 5.

---

actions to determine the unit prices for comparison purposes, and eliminated significant outliers. An analysis of the research questions is presented in the following section.

### Research Questions Analysis

In this section, the findings that resulted from the ONEWAY analysis of variance (ANOVA) are presented for each research question. The Kruskal-Wallis H test results, calculated for the research questions that reported significant differences in variance among subgroups of data, are provided in Appendix D. The Kruskal-Wallis H test results are discussed only when the ONEWAY ANOVA and Kruskal-Wallis H test findings differed.

#### Research Question 1

Does the type of item being procured, as identified by its Federal Stock Group or Federal Stock Class, affect the degree of competitive savings (or losses) resulting when competition is introduced into the acquisition process?

All of the replenishment spare parts were placed into the appropriate commodity groupings shown in Figure 4, Chapter III. Of the nine total subgroups, only five subgroups contained enough data (i.e., 30 or more percentages) to warrant inclusion into the ONEWAY analysis of variance. The commodity subgroups and calculated means are shown below:

AD-A135 562

COMPETITION IN THE ACQUISITION OF REPLENISHMENT SPARE  
PARTS(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH  
SCHOOL OF SYSTEMS AND LOGISTICS S J ZAMPARELLI SEP 83  
AFIT-LSSR-102-83

2/2

UNCLASSIFIED

F/G 5/1

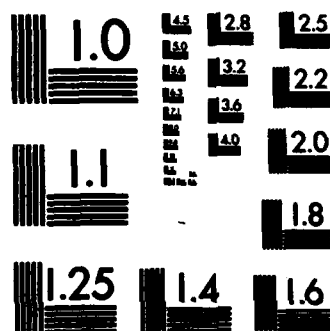
NL

END

FORMED

1.00

0110



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

| <u>Subgroup</u>                                                                   | <u>Mean Savings or (Losses)</u> |
|-----------------------------------------------------------------------------------|---------------------------------|
| Airframe structure components                                                     | .22 percent savings             |
| Aircraft engines (gas turbine and reciprocating related spares and parts)         | -9.40 percent (losses)          |
| Aircraft subsystems, accessories, and components, and related spares and parts    | 7.98 percent savings            |
| Mechanical miscellaneous                                                          | 8.05 percent savings            |
| Electrical, electronic and communications equipment, and related spares and parts | 14.05 percent savings           |

The F statistic, calculated to evaluate the null hypothesis that all means were equal, was 4.70 and had a significance of .011 (see Table 9). Therefore, at a 95 percent confidence level, at least two of the mean values differed from one another. The SPSS ANOVA program then used an option called the Scheffé procedure, which provided multiple comparisons of the means for each category (20:73). Subcategories were grouped together into homogeneous subsets, with those other categories from which there were no significant differences among means. For Research Question 1, the Scheffé procedure created two homogeneous subsets. The Aircraft engines commodity group was left out of the first subset, while the Airframe structure components group was left out of subset 2. The results indicated that the above

Table 9

\*ONEWAY Analysis of Variance  
Summary of Test 2

---

Null Hypothesis ( $H_0$ ):  $\mu_1 = \mu_2 = \mu_3 \dots = \mu_N$

Alternate Hypothesis ( $H_A$ ): At least two subgroups differ

Test Statistic:  $F = \frac{MST}{MSE} = 4.7$

\*Rejection Region: If the probability associated with F statistic value (F) was less than or equal to (1 - Confidence level), reject  $H_0$ . Since  $P(F) = .011 \leq .05$ , reject  $H_0$ .

\* This format was used for the evaluation of each research question.

---

two commodity groups were significantly different from each other but not significantly different from the other three commodity groups.

The 95 percent confidence interval around the mean for Aircraft engines spares of a -21 percent (price increases) to a 2.2 percent (price decreases) provided another perspective. There was a 93 percent probability that the mean savings value for the transition from sole source to competitive acquisition was zero savings. The confidence interval for the total ungrouped data conversely indicated a 93 percent probability that there were savings when competition was introduced.

#### Research Question 2

Is there a significant difference in the competitive savings (or losses) identified among the five AFLC Air Logistics Centers?

To evaluate Research Question 2, the spare parts percentage savings figures were grouped according to the ALC that purchased each spare part. The results of the ONEWAY ANOVA, which compared the mean savings for each category, provided an F statistic of 3.477, significant at the .008 confidence level (i.e., substantially larger than the critical value). Therefore, the null hypothesis was rejected. Through a review of the following mean savings values:

| <u>Air Logistics<br/>Center (ALC)</u> | <u>Mean Savings<br/>(percent)</u> |
|---------------------------------------|-----------------------------------|
| 1. Ogden ALC                          | 22.91                             |
| 2. Sacramento ALC                     | 5.96                              |
| 3. Oklahoma City ALC                  | 8.12                              |
| 4. Warner Robins ALC                  | 13.00                             |
| 5. San Antonio ALC                    | 3.46                              |

and of the Scheffé subsets, the two significantly different subgroups became evident. Ogden ALC's mean savings value (22.91 percent) was significantly different from San Antonio ALC's mean savings value (3.46 percent).

The findings for Research Question 2 were congruent with those of Research Question 1. San Antonio ALC, with the lowest mean competitive savings, was one of two ALCs that had Aircraft engines parts, the lowest mean savings' commodity group, in the sample data (95 percent of the Aircraft engines category were purchased by San Antonio ALC). One fourth of San Antonio ALC's data points were Aircraft engines replenishment spares. Conversely, Ogden ALC, while having no engine parts in the data base, had 28 percent of their procurement data from the highest mean savings' commodity group, Airframe structure components. Several possible explanations existed for these findings. For instance, each ALC is responsible for different types of items and major systems. The age of the major weapon



systems, whether or not major upgrades or modifications are being undertaken, and the procurement from different vendors could affect the acquisition cost of replenishment spare parts.

### Research Question 3

Do the competitive savings (or losses) differ for weapon systems replenishment spare parts depending upon the magnitude of the average unit price?

The average mean savings values calculated for the five groups of data are provided below:

| <u>Data Groups</u>        | <u>Mean Savings or<br/>Losses (percent)</u> |
|---------------------------|---------------------------------------------|
| 1. < \$10.01              | 5.65                                        |
| 2. \$10.01 to \$100.00    | 11.60                                       |
| 3. \$100.01 to \$500.00   | 7.80                                        |
| 4. \$500.01 to \$1,000.00 | 9.40                                        |
| 5. > \$1,000.00           | -4.24                                       |

The ONEWAY analysis of variance computed an F statistic significance of .08, which indicated that at the 95 percent confidence level, the null hypothesis could not be rejected. The statistical analysis indicated no significant differences among the mean savings for the five data groups. However, the SPSS program showed a significant difference among group variances.

The Kruskal-Wallis H test, conducted to validate the ONEWAY ANOVA findings, reported contradictory results. The Kruskal-Wallis H test indicated that, as a minimum, the over \$1,000.00 category mean savings differed significantly from the mean savings for the \$10.01 to \$100.00 category and quite possibly from the other three categories as well. For items with a unit price in excess of \$1,000.00, the statistical analysis showed that savings did not occur.

#### Research Question 4

Does the age of the item, as determined by the year in which the National Stock Number was assigned, affect the competitive savings (or losses) realized when transitioning from sole source to competitive acquisition?

The three categories involved spare parts whose NSNs were assigned during the following time periods:

| <u>Date NSN<br/>Assigned</u> | <u>Mean Savings<br/>(percent)</u> |
|------------------------------|-----------------------------------|
| 1. From 1978 Through 1983    | 11.20                             |
| 2. From 1968 Through 1977    | 6.90                              |
| 3. 1967 or Earlier           | 4.75                              |

The time period groups were developed to relate to the age of a weapon system. The items in the "From 1978 Through 1983" category were being procured from a second source for the first time. Whereas, in the middle category, the items probably had been bought more often, and sources of supply

were firmly established. The researcher hypothesized that parts with NSNs assigned in or before 1967 would have a stable design and be more apt to attract competitors into the marketplace. The ONEWAY ANOVA, however, calculated a F-test significance of .21, indicating that no significant differences existed among the mean savings values.

### Research Hypothesis 2 Analysis

Research Hypothesis 2 was developed as a corollary to Research Hypothesis 1. It was hypothesized that if the transition from sole source to competitive acquisitions led to lower unit prices, then the reverse transition from competition to sole source would cause unit price increases.

### Research Hypothesis 2

An increase in unit price is realized when weapon systems replenishment spare parts previously procured through competitive means are purchased on a sole source basis.

The same four tests were used to evaluate Research Hypothesis 2 except that the sequence of comparisons was reversed. The four tests were used to address spare parts that transitioned from competitive to sole source procurement actions. The percentage of unit price increases (or losses) were calculated by subtracting the sole source unit price from the competitive unit prices and dividing by the competitive unit prices. Negative values were expected and

provided support for Research Hypothesis 2. Thus, the rejection region for the Z-test was opposite (negative) the rejection region used for Research Hypothesis 1.

Test 1. The mean loss that resulted from the return to sole source acquisition was 10.6 percent, indicating that unit prices increased an average of 10.6 percent between the last competitive purchase and the first sole source acquisition. Table 10 shows the Z-test results for Test 1. The Z-test statistic of -3.92 was substantially less than the critical value of -1.645. Under the rejection range criteria for Research Hypothesis 2, the null hypothesis was rejected. Hence, actual price increases occurred when the procurement method changed from competition to sole source. The analysis of the 95 percent confidence interval and standard error of the mean demonstrated a 99.99 percent probability that the mean value was a price increase (loss).

The median value for the data set for Test 1 was 0 percent. This indicated that the number of spare parts that provided a savings and the number of spare parts that produced losses were very nearly equal. However, the average size of the losses (unit price increases) was substantially greater than the average amount of savings.

Table 10

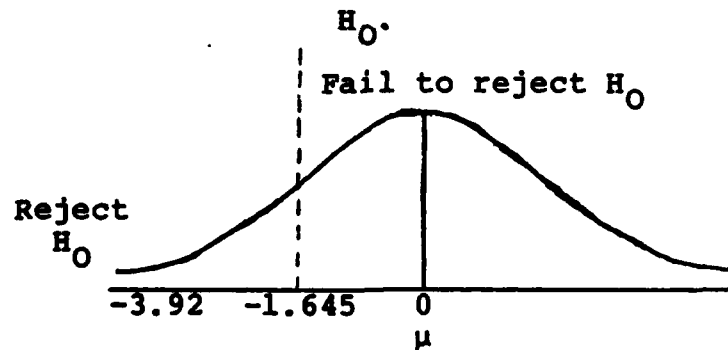
Z-Test of Means for  
Research Hypothesis 2, Test 1

Null Hypothesis ( $H_0$ ):  $\mu \geq 0$  (There is either no change in unit price or there is a savings when transitioning from competition to sole source.)

Alternate Hypothesis ( $H_A$ ):  $\mu < 0$

Test Statistic:  $z = \frac{\bar{x} - 0}{\sigma_{\bar{x}}} = \frac{-.106 - 0}{.027} = -3.92$

\*Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject  $H_0$  if Z-test statistic  $< -1.645$ . Since  $z = -3.92 < -1.645$ , reject



\*Confidence Interval:  $\bar{x} \pm z_{\alpha/2} \sigma_{\bar{x}}$   
For  $\alpha = .05$ , the confidence interval was  $-.052$  to  $-.16$  (i.e., 5.2 to 16 percent loss).

\* Note that to support the alternate hypothesis, a negative value (loss) was expected. Therefore, the rejection range was opposite that for Research Hypothesis 1.

Test 2. In Test 2, sixteen spare parts were eliminated from the sample in accordance with the sample selection criteria. Fifteen spare parts had significant quantity variations between the last competitive and first sole source purchase, and the other spare part was considered an extreme outlier. The results from Test 2 provided further support for Research Hypothesis 2. The mean loss computed by SPSS was 5.5 percent. The Z-test statistic, -2.75, was less than the critical value of -1.645, causing rejection of the null hypothesis (see Table 11). The median value remained at 0 percent.

Test 3. The third test compared the average competitive unit prices to the average sole source unit prices. The mean loss calculated was 9.4 percent. Once again, the Z-test statistic of -4.7 was less than the critical value of -1.645 (see Table 12), leading to the rejection of the null hypothesis. The median value for the comparisons of average unit prices was a 2.2 percent loss. This result provided more evidence that spare parts transitioning back from competitive to sole source acquisition were likely to cost more money.

Test 4. In the data set for Test 4, twelve items were eliminated due to quantity differences. There were no mean percentages that exceeded 500 percent, therefore, no items were eliminated from the sample as outliers. As in

Table 11\*

Z-Test of Means for  
Research Hypothesis 2, Test 2

---

---

Null Hypothesis ( $H_0$ ):  $\mu \geq 0$

Alternate Hypothesis ( $H_A$ ):  $\mu < 0$

Test Statistic:  $z = \frac{-.055 - 0}{.020} = \frac{-.055}{.020} = -2.75$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject  $H_0$  if Z-test statistic  $< -1.645$ .  
Since  $z = -2.75 < -1.645$ , reject  $H_0$ .

Confidence Interval: For  $\alpha = .05$ , the confidence interval was  $-.016$  to  $-.094$  (i.e., 1.6 to 9.4 percent loss).

\* Additional information common to Research Hypothesis 2, Test 1 through Test 4 is provided on Table 10.

---

Table 12\*

Z-Test of Means for  
Research Hypothesis 2, Test 3

---

Null Hypothesis ( $H_0$ ):  $\mu \geq 0$

Alternate Hypothesis ( $H_A$ ):  $\mu < 0$

Test Statistic:  $z = \frac{-.094 - 0}{.020} = \frac{-.094}{.020} = -4.70$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject  $H_0$  if Z-test statistic  $< -1.645$ .  
Since  $z = -4.70 < -1.645$ , reject  $H_0$ .

Confidence Interval: For  $\alpha = .05$ , the confidence interval was  $-.054$  to  $-.134$  (i.e., 5.4 to 13.4 percent loss).

---

\* Additional information common to Research Hypothesis 2, Test 1 through Test 4 is provided on Table 10.

---



all three previous tests for Research Hypothesis 2, Test 4 results led to the rejection of the null hypothesis (see Table 13). The mean was an 8.5 percent increase in unit prices.

A reduction in the number of sample data elements with quantity variations that may have affected the savings (or losses) provided a median loss value of 7.4 percent.

All four tests strongly supported Research Hypothesis 2. Even in the least supportive test, the 95 percent confidence interval provided a mean loss between 1.6 percent to 9.4 percent when replenishment spare parts transitioned from competitive to sole source acquisitions.

#### Other Observations

As usually occurs in many studies, a few unexpected or interesting observations were made, and while not directly examined by the research methodology, were of significance in the researcher's study. This section discusses two such observations made by the researcher. First, there was a large number of replenishment spare parts that reflected procurement actions returning to sole source acquisition after having been competitively purchased. Second, there were some cases where the competitive procurement action's unit price was three, four, and sometimes as much as eight times larger than the previous sole source unit price.

Table 13\*

Z-Test of Means for  
Research Hypothesis 2, Test 4

---

Null Hypothesis ( $H_0$ ):  $\mu \geq 0$

Alternate Hypothesis ( $H_A$ ):  $\mu < 0$

Test Statistic:  $Z = \frac{-.085 - 0}{.020} = \frac{-.085}{.020} = -4.25$

Rejection Range ( $\alpha = .05$ ): At 95% confidence level, reject  $H_0$  if Z-test statistic  $< -1.645$ .  
Since  $Z = -4.25 < -1.645$ , reject  $H_0$ .

Confidence Interval: For  $\alpha = .05$ , the confidence interval was  $-.046$  to  $-.124$  (i.e., 4.6 to 12.4 percent loss).

\* Additional information common to Research Hypothesis 2, Test 1 through Test 4 is provided on Table 10.

---

Brost's study identified the existence of cases in which procurement actions flip-flopped back and forth between competitive and sole source acquisitions (5:41). Brost's observation was the basis for the development of Research Hypothesis 2 in this study. Once an item has been successfully procured from multiple sources, the opportunity for continued competitive acquisition exists. With the existence of multiple capable sources and with the many regulations and guidance requiring competition, the author expected that a relatively small number of items would have purchase histories with at least two consecutive competitive procurement actions followed by at least two consecutive sole source procurement actions. However, as shown in Appendix C, the number of spare parts transitioning from competitive to sole source acquisitions (i.e., 453) actually exceeded the number of spare parts going from sole source to competitive acquisitions (i.e., 420). The researcher also observed that in both data sets for Research Hypotheses 1 and 2 there were numerous cases in which the spare parts were purchased sole source subsequent to competitive buys. Discussion with AFLC Headquarters personnel, personal observations, and recent newspaper articles provided the following possible explanations for returning to sole source procurement actions:

1. A small quantity purchase attempting to qualify other sources of supply,

2. A priority acquisition requiring immediate action,

3. Small dollar acquisitions in which the quoted unit price was substantially the same as the last competitive acquisition unit price and was cost ineffective to compete, and

4. The item became available under another contract (e.g., GSA schedule) or as a spare part under a new prime contract.

The general belief is that the introduction of competition leads to lower prices (17; 34). Brost's study provided some evidence that such competitive savings actually did not result from the introduction of competition, and in fact small losses occurred (5:19). This researcher found some items in which the first competitive unit price was up to eight times larger than the price for the last sole source purchase.

In Research Hypothesis 1, Tests 2 and 4, two items were eliminated from the sample as outliers, because the competitive loss percentages were far removed from the rest of the data set (i.e., over 500 percent). There were several other spare parts that exhibited losses of between 100 percent and 250 percent when transitioning from sole

source to competitive procurement actions. A request made to AFLC Headquarters personnel to research the two outliers provided the explanations for the extreme values. In both cases, the items were originally procured under a Basic Ordering Agreement. The two items were subsequently changed to a priced contract number with a new company. The low sole source prices in the procurement histories were actually small not-to-exceed prices used to allow the contractor to begin work in anticipation of obtaining negotiated prices at a later date. The subsequent negotiated unit prices were never entered into the procurement history files. In both cases, the actual negotiated unit prices for the sole source acquisitions were larger than the unit prices for the subsequent competitive acquisitions.

#### Summary

The application of the research methodology, outlined in Chapter III, led to the selection of a sample of 420 replenishment spare parts to evaluate Research Hypothesis 1 and 453 spare parts to test Research Hypothesis 2.

Research Hypothesis 1 stated that savings result from the introduction of competition into the replenishment spare parts acquisition process. Four tests were used to analyze Research Hypothesis 1. In three of the four tests, the Z-test of means provided statistically significant supporting results for Research Hypothesis 1.

The pricing data used to evaluate Research Hypothesis 1 were also used to analyze four research questions. The data analyses were accomplished using a ONEWAY analysis of variance and a Kruskal-Wallis H test when significant differences in subgroup variances existed. The findings for the research questions were as follows:

1. The mean competitive savings (or losses) for Aircraft engine parts were significantly less than the mean savings for Airframe structure components and were usually losses rather than savings.

2. The San Antonio ALC, with 25 percent of its sample being Aircraft engine spares, provided a substantially lower mean savings for replenishment spare parts than did Ogden ALC.

3. Spare parts with unit prices greater than \$1,000.00 had a significantly lower mean savings than did spare parts with unit prices ranging from \$10.01 to \$100.00.

4. No differences existed among the mean savings for replenishment spares of different ages.

Research Hypothesis 2, was analyzed with the same four tests used for Research Hypothesis 1, except that competitive procurement actions preceded sole source procurement actions in Research Hypothesis 2. Research Hypothesis 2 was strongly supported in all four tests.

The research findings, including some unusual observations on the size of competitive losses and the frequent return to sole source acquisitions, provided the basis for the researcher's conclusions, recommendations for implementation, and areas for future research that are presented in the following chapter.

## CHAPTER V

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### Introduction

The purpose of this research effort was to provide evidence to support or refute the contention that competition leads to lower prices. This chapter provides a summary of the research objectives and the researcher's conclusions. The chapter's first section is a summary of the research purpose, objectives, and research methodology. This summary is followed by a presentation of conclusions and recommendations developed from the findings, resulting from the application of the research methodology. Finally, the chapter concludes with the identification of several areas that are in need of future research.

#### Summary of Purpose, Objectives, and Research Methodology

Competition in Government contracting is the "law of the land [41:Para. 1-302.2]." In a recent spare parts buying scandal, inadequate competition was cited as the primary culprit leading to buyers paying exorbitant prices for inexpensive spare parts (35:3). From Secretary of Defense Robert McNamara in 1965 to Secretary of Defense Caspar Weinberger in 1983, competition has been the policy



for improving Department of Defense acquisitions (6; 35:1). The potential benefits to the Government resulting from the application of competitive acquisitions, however, are still a subject of controversy.

In 1982, Brost completed an empirical research project which reported evidence that the introduction of competition does not always lead to lower prices. Brost's findings were contrary to earlier research efforts (16; 24; 33). Validation of Brost's findings would raise some questions about a "blanket" DOD policy on the maximum use of competition and could lead to new procedures aimed at a selective approach to the use of competition.

The purpose of the author's research project was to support or refute Brost's findings by employing a similar research methodology but using a much larger data sample. Four years of procurement history data collected from five Air Force Logistics Command (AFLC) Air Logistics Centers (ALCs) provided the data base for selecting samples to evaluate the two research hypotheses. Four hundred and twenty Air Force replenishment spare parts, whose procurement purchase histories showed at least two consecutive sole source purchases followed by at least two consecutive competitive purchases, comprised the sample for Research Hypothesis 1 as follows:

A reduction in unit price is realized when competition is introduced in the acquisition of weapon systems replenishment spare parts previously procured on a sole source basis.

Four hundred and fifty-three Air Force replenishment spare parts, with at least two consecutive competitive purchases followed by at least two consecutive sole source purchases, comprised the sample for evaluating Research Hypothesis 2. Research Hypothesis 2 is restated as follows:

An increase in unit price is realized when weapon systems replenishment spare parts previously procured through competitive means are purchased on a sole source basis.

An additional objective of the author's research project was to evaluate certain subgroups of data in order to identify areas for which competition proved more or less beneficial. Four research questions were developed to evaluate the mean and median competitive savings among various subgroups (i.e., among the five ALCs, commodity categories, unit price magnitudes, and age of the spare parts).

Parametric statistical procedures were used to analyze the research hypotheses. Both research hypotheses were evaluated using four different tests. Z-tests of means were conducted, and medians were statistically evaluated using Statistical Package for the Social Sciences (SPSS) computer programs.

The research questions were evaluated using an SPSS ONEWAY analysis of variance (ANOVA) procedure. For several of the research questions, the ANOVA indicated that significant differences existed among the subgroups' variances. A

nonparametric test, the Kruskal-Wallis H test, was then conducted to provide additional statistical support for the research findings.

The research findings, stemming from the application of the aforementioned research methodology, provided the foundation for the conclusions discussed in the following section.

### Conclusions

Four primary conclusions were drawn from the researcher's analysis of the research findings. Concurrently, two corollary conclusions were drawn based upon other significant observations made during this research effort. Each conclusion is presented and discussed in light of the findings which provided the foundation for the conclusion and any limitations which might qualify the conclusion.

#### Primary Conclusions

Conclusion 1. The introduction of competition into the acquisition process generally led to a reduction in unit price.

Three of the four tests used to analyze Research Hypothesis 1 and all four of the calculated median values demonstrated that competitive savings were realized when a replenishment spare part transitioned from sole source to competitive acquisitions. The Z-test of means for the three

supporting tests were statistically significant at the 95 and 99 percent confidence levels. The researcher's findings support the policy that is documented in current Department of Defense (DOD) guidance. However, the confidence interval around the mean for the fourth test (selected as the most valid test by the researcher) indicated a probable savings of between 4.1 and 11.2 percent. The researcher's empirically-based competitive savings were much less than the savings identified in most earlier studies (16; 24; 33).

In the author's study, it was very difficult to determine if the reported sample results reflected the initial transition from sole source to competitive acquisitions or if an item had flip-flopped acquisition methods frequently. An assumption was made that the number of transitions was not significant.

Conclusion 2. Unit prices increased for items that transitioned from competitive back to sole source acquisitions.

Research Hypothesis 2 was designed as a corollary to Research Hypothesis 1. If competition theory is actually reflected in the marketplace, the empirical results should have supported both Research Hypotheses 1 and 2.

All four tests used to evaluate Research Hypothesis 2 provided statistically significant support. One explanation for the return of some procurement actions from competition to sole source acquisitions was the requirement for

priority requisitions. The data used in this research project demonstrated that unit prices generally increased when a transition was made from competitive to sole source acquisitions.

Conclusion 3. No reductions in unit prices were experienced when competition was introduced into the acquisition of aircraft engine spare parts.

A ONEWAY ANOVA demonstrated that a significant difference existed between the mean savings (or losses) for Aircraft engine spares and the mean savings (or losses) for Airframe structure components. The ANOVA also provided a confidence interval which showed a 93 percent probability that the sole source unit price was less than the competitive unit price for Aircraft engine spares.

This research project did not identify if the increase in unit prices for procurement actions going from sole source to competitive acquisitions was less than the unit prices for items that continued as sole source acquisitions. An evaluation of the foregoing point may indicate that Aircraft engine spares prices are increasing regardless of the method of acquisition. However, there are relatively few companies that can supply a particular engine spare part even if there were no proprietary data involved. A second source of supply may need to retool and change machine specifications in order to produce the engine spare parts. This situation would make it very difficult for a second source to produce a lower priced item.

Conclusion 4. Replenishment spare parts with unit prices over \$1,000 were less likely to show competitive savings when competition was introduced than spare parts with unit prices under \$1,000.

A mean loss of 4.24 percent was calculated for those spare parts whose unit prices exceeded \$1,000. A Kruskal-Wallis H test demonstrated that the mean for the over \$1,000 grouping was significantly different from the mean savings calculated for the other four groupings. The empirical evidence indicated that a loss will generally occur when a spare part with a unit price exceeding \$1,000 transitions to competitive acquisition from sole source.

#### Corollary Conclusions

Conclusion 5. In several situations, transitions from sole source to competitive acquisitions led to extreme price increases.

This fifth research conclusion could be extremely significant. Several spare parts' procurement histories demonstrated unit price increases of two to eight times the sole source unit price with the introduction of competition. Price increases of this magnitude are indicative of potentially serious problems and need further investigation. Perhaps the contractor is overcharging the Government. Extreme price increases, however, may stem from the part being no longer routinely manufactured, thus requiring extensive set-up and retooling. Another possible reason for large price increases is that the former supplier is no longer in business or refuses to sell the item.

No matter the cause, in cases with large price increases, consideration of alternative items, methods of procurement, or quantities of purchase should be considered. With what appears to be micro-management on the horizon for replenishment spares acquisition, unique or unusual observations must be thoroughly investigated.

Conclusion 6. All competitive opportunities were not fully utilized in the acquisition of replenishment spare parts.

Over 453 spare parts had procurement histories which showed a solicitation to a single source subsequent to at least two procurement actions in which multiple sources were solicited. Similar flip-flops were found in many of the sample elements for evaluating Research Hypothesis 1.

One assumption of this research project was that the solicitation to multiple sources meant competitive acquisitions. It is possible that some procurement histories that had two sources solicited were the initial attempts to find a second source. The buyer may have been unable to find a second source of supply capable of producing the item and subsequently returned to sole source acquisition in future procurements. However, the number of instances in which a spare part that had a history of multiple solicitations returned to sole source acquisition was substantial.

### Implications of the Study

The empirical evidence from the researcher's study provided strong support for the conclusion that the introduction of competition leads to lower prices. However, specific characteristics of the spare part (e.g., the magnitude of the unit price or the type of commodity) affect the amount of savings realized by the Government, caused by the solicitation to multiple sources. Thus, the researcher's findings, while supporting the continued emphasis by the Department of Defense on the use of competition, demonstrated that a selective approach to the use of competition needs to be developed.

Additionally, the large number of spare parts' procurement histories that transitioned from competitive back to sole source acquisition indicated that competitive opportunities are not being fully utilized. A number of recommendations developed in light of these implications are presented in the following two sections of this chapter.

### Recommendations for Implementation

Four recommendations for implementation were developed based upon the conclusions drawn from analysis of the research hypotheses and research questions.



### Contractor Awareness of Competition

A contractor supplying a part on a sole source basis has no impetus to reduce prices, unless the contractor knows additional sources of supply are being sought. A contractor is aware that potential competition exists in a formally advertised procurement. For negotiated procurements, buyers should inform contractors that a purchase may be competitive, unless proprietary requirements or some other factors prohibit such competitive procurement actions. Informing the contractor of potential competition may be done verbally or through a printed statement on Request for Proposals (RFPs) or Requests for Quotations (RFQs).

### Require Competition for Items With Competitive Histories

Government buyers should be required to solicit at least two sources for all spare parts having a history of competitive acquisition. Each Government buyer should be required to maintain a procurement action log of those purchases made on a sole source basis for which the procurement method code did not require sole source procurement. Fulfilling priority requisitions is insufficient justification for not contacting previous sources. The procurement action log should be a source of information for the Competition Advocate on potential competitive opportunities in the area of replenishment spare parts.

### Utilization of the Competition Advocate Team

Strengthening the role of the Competition Advocate at Government buying activities has been a recommendation to insure improved spare parts acquisitions (19). The Competition Advocate should be developed into a team concept. The team, led by the Competition Advocate, should include engineering, contracting, and manufacturing expertise dedicated to competition issues and opportunities. The Competition Advocate team should periodically analyze procurement histories of replenishment spare parts having both competitive and sole source acquisitions for the purpose of identifying price and procurement method trends, lost competitive opportunities, and unusual procurement actions. Observed trends or unusual procurement actions should be referred to the "competition team," who could take over the acquisition and/or provide alternate acquisition strategy and guidance to the buyers.

Lastly, the Competition Advocate team should be given the responsibility for reviewing purchase requirements that result in sole source procurements for future competition consideration.

### Improve Information Provided to Buyers

There is a need for a management information system that will provide Government buyers with sufficient procurement history information to reduce lost opportunities for

competition. At base-level contracting, upon receipt of a purchase request, buyers are provided an item's procurement history which includes: (1) last source of supply, (2) sources, dates, and prices from several previous purchases, and (3) other potential sources of supply. The procurement information, which is updated by the Government buyer at the time of award, also includes addresses, phone numbers, and points of contact within the firms. Provided with a cathode ray tube access to procurement history information, the Government buyer should be able to solicit multiple sources if the part has ever been competitively purchased.

#### Identification of the Item Manufacturer

In every purchase of spare parts or components, a request should be made for the identification of the item manufacturer. The request may be verbal or written as a certification required by the contractor. Often, replenishment spare parts are procured from the weapon system's prime contractor on a sole source basis. The identification of the actual manufacturer for a spare part could be input into the procurement history information discussed in the previous recommendation to provide additional sources of supply.

#### Aircraft Engine Spare Parts Acquisition

The researcher's analysis demonstrated that aircraft engine spare parts increased in unit price when competition was introduced. The research findings suggest that the

Government should attempt to obtain aircraft engine spare parts from the original source of supply. Alternative methods of acquiring aircraft engine spare parts should be developed. Initially, attempts should be made to obtain aircraft engine spare parts from the original source of supply using multi-year, priced, indefinite delivery contracts with guaranteed quantities. Also, the quantity of initial provisioning engine parts should be increased in order to take advantage of larger production runs and quantity purchases associated with production contracts. Additionally, extra complete engines could be procured as part of the production contracts as a source of spare parts to meet priority requirements.

The availability of spare parts to meet priority requests would allow the ALCs to consolidate requisitions, therefore buying larger quantities with reasonable delivery schedules. Consolidation should lead to lower prices.

#### Recommendations for Future Research

In addition to the recommendations for implementation, additional research in the area of competition within the spare parts acquisition process is necessary. Numerous opportunities for future research, as identified by the author during this research project, are provided in this section.

### "Competitive Forces" Versus "Competition"

Before any other research effort is undertaken on the subject of competition, it is necessary to better define what competition actually means to a contractor. The theoretical basis for the expectation of lower prices due to the introduction of competition is because the contractor knows that other suppliers are competing within the marketplace (24:2). There has not been any empirical evidence generated on whether a contractor actually knows whether competition exists in the award of a contract or purchase order. Research has not been undertaken to identify if the threat of competition, "competitive forces," motivate a contractor to price differently or if actual knowledge of other sources of supplies is required. It is entirely possible that competition does not lower prices within the structure of the defense acquisition process and the defense industry. The defense contracting environment may limit or eliminate a contractor's pricing flexibility. If competition is found to be a significant consideration, a follow-on research project should ascertain how often in the defense marketplace competition or the threat of competition must be exhibited in order to continue to affect contractors' bidding process.

A critical understanding of the definition of competition and the specific application of competition within the defense industry is needed. A survey of DOD contractors could provide provocative insight into the competitive forces within the defense marketplace. Additionally, physical experiments could be performed to assess the effects of actual competition as related to the threat of competition.

#### Compete Parts Previously Acquired Sole Source

Many of the unknowns and limitations of the author's study could have been removed if the researcher had controlled the actual purchasing process for the spare parts. An improvement upon the author's research study would be for a researcher to select a number of spare parts identified as sole source, attempt to find additional capable sources of supply, and actually compete the subsequent purchase of spare parts to determine the impact on prices. A research methodology similar to the one employed in this study could be used to provide additional evidence on the "true" effects of competition.

#### Administrative Costs of Competition

Several sources have argued that there are costs related to the introduction of competition into the acquisition process (24; 31). To date, little research has been

conducted to quantify the administrative costs or even to identify the costs associated with the introduction of competition. The administrative costs may vary for base contracting offices, ALCs, and System Program Offices.

#### Analysis of Spare Parts Procurements

Recently, a relatively small number of poor procurement actions for spare parts (e.g., spending over \$1100 for a one dollar item) made the news (19; 35). Are these procurement actions the exception or the rule in the area of replenishment spare parts buying? An indepth analysis of a random sample of AFLC replenishment spare parts to include an analysis of the available competition, the product itself, excessive specifications, and other factors, may provide evidence that the "poor procurement actions" are the exception rather than the rule.

#### Identification of Characteristics That Enhance Competitive Savings

This research project categorized savings by various subgroups to determine if factors such as the buying office or the type of commodity affected the amount of competitive savings realized. The commodity categorization deserves additional study to include a unit price trend analysis for the spare parts. Other comparisons could be made among

those items with and without reprourement data and for items procured from small business versus the items obtained from large business.

### Replication of Research Hypothesis 2

This research project reported that unit prices increase when spare parts transition from competitive back to sole source acquisitions. The effect of transitioning back to sole source from competition has received little empirical evaluation. Validation of the author's results and the identification of the reasons for the abundance of these reverse transitions (from competition to sole source) are necessary.

### Concluding Observations

The conclusions and implications of the author's research project indicate that the call for Department of Defense (DOD) buyers to seek competition will not diminish nor should it. Seeking competitive opportunities and utilizing existing competition are necessary parts of the Government buyer's job. Additional introduction of competition into the DOD marketplace should continually be planned and attempted.

The definitiveness of the researcher's support for competition does not diminish the need for continued study in the area of competition within the defense acquisition



process. More empirical research needs to be accomplished to examine how and if competitive acquisitions actually work within the defense marketplace. Additionally, empirical studies have indicated that there may be characteristics of the weapon system, spare part or component, yet unidentified, that will affect the magnitude of savings realized from the use of competition.

Competition is considered to be a key component within a competent, fair procurement system. An intimate knowledge of the subject, developed through continuing research, may lead to an operational competitive model that will guarantee that DOD buyers obtain the best possible item at the best possible price.

**APPENDICES**

**APPENDIX A**

**17 EXCEPTIONS TO FORMAL ADVERTISING**

1. National Emergencies
2. Public Exigency
3. Small Purchases (actions less than \$25,000)
4. Personal or Professional Services
5. Services of Educational Institutions
6. Purchases Outside the United States
7. Medicines or Medical Supplies
8. Supplies Purchased for Resale
9. Perishable or Nonperishable Subsistence Supplies
10. Supplies or Services For Which It Is Impractical to Secure Competition by Formal Advertising
11. Experimental Development or Research Work
12. Classified Purchases
13. Technical Equipment Requiring Standardization and Interchangeability of Parts
14. Technical Equipment Requiring Substantial Initial or Extended Periods of Preparation for Manufacture
15. Negotiation After Advertising
16. Purchases in the Interest of National Defense or Industrial Mobilization
17. Otherwise Authorized by Law

**APPENDIX B**

**PARTIAL LISTING OF WEAPON SYSTEMS AND COMMODITIES  
BY RESPONSIBLE AIR LOGISTICS CENTER (ALC)**

OGDEN AIR LOGISTICS CENTER (ALC)  
OGDEN, UTAH

MX (ICBMs)

UHF Emergency Radio

Aerojet Company Engines and  
Engine Components

AGM MAVERICK Missile

Ammunition and Explosives

F-101 VooDoo

F-4 Phantom

Titan II

Federal Supply Group 14 and  
Federal Supply Category  
4935 not listed elsewhere

OKLAHOMA CITY AIR LOGISTICS CENTER (ALC)  
OKLAHOMA CITY, OKLAHOMA

Ground Launched Cruise Missile

Air Launched Cruise Missile

Aircraft Maintenance Equipment

Engines:

J-33

J-35

J-71

B-52 StratoFortress

C-135 StratoLifter

C-97 StratoFreighter

C-137 StratoLiner

F-101 Engine

**SACRAMENTO AIR LOGISTICS CENTER (ALC)  
SACRAMENTO, CALIFORNIA**

**Continental Air Defense Control  
and Warning Systems**

**Sea Launched Ballistic Missile  
Phased Array Radar**

**Ballistic Missile Early  
Warning System**

**Air-to-Air Recovery Systems**

**F-104 StarFighter**

**F-105 ThunderChief**

**C-121 Constellation**

**Defense Meteorological Satellite  
Program**

**Federal Supply Group 18  
not elsewhere assigned**



**SAN ANTONIO AIR LOGISTICS CENTER (ALC)  
SAN ANTONIO, TEXAS**

**Aircraft Cargo Equipment**

**Aircraft Decontamination Equipment**

**Aircraft Engine Fuel and Electrical  
Systems**

**Chemical and Gas Cylinders**

**Electrical and Electronic Measuring  
Equipment**

**General Electric Jet Engines and  
Components**

**Nuclear Detection Equipment**

**Non-aircraft Engines**

**F-106 Delta Dart**

WARNER ROBINS AIR LOGISTICS CENTER (ALC)  
WARNER ROBINS, GEORGIA

Material Handling Equipment

Sparrow Missile

Sidewinder Missile

Airborne Electronic Warfare Equipment

Automatic Data Processing Equipment

C-140 JetStar

C-141 StarLifter

C-7A Caribou

Propeller Systems

NAVSTAR Global Positioning  
Satellite Equipment

**APPENDIX C**

**SUMMARY OF PROCUREMENT ACTIONS EXHIBITING  
PRICE INCREASES, PRICE DECREASES,  
AND NO CHANGE IN PRICES BY ALC  
FOR BOTH RESEARCH HYPOTHESES**

# RESEARCH HYPOTHESIS 1

## Transition From Sole Source to Competitive Procurement Actions

| TEST              | TEST 1   |            |           | TEST 2   |            |           |
|-------------------|----------|------------|-----------|----------|------------|-----------|
|                   | PRICE UP | PRICE DOWN | NO CHANGE | PRICE UP | PRICE DOWN | NO CHANGE |
| ALC               |          |            |           |          |            |           |
| OGDEN ALC         | 14       | 42         | 4         | 13       | 38         | 4         |
| SACRAMENTO ALC    | 16       | 28         | 2         | 15       | 25         | 2         |
| SAN ANTONIO ALC   | 107      | 112        | 6         | 102      | 106        | 6         |
| WARNER ROBINS ALC | 17       | 22         | 3         | 16       | 21         | 3         |
| OKLAHOMA CITY ALC | 14       | 32         | 1         | 11       | 30         | 1         |
| SUMMARY           | 168      | 236        | 16        | 157      | 220        | 16        |

# RESEARCH HYPOTHESIS 1

## Transition From Sole Source to Competitive Procurement Actions

| TEST<br>ALC             | TEST 3      |               |              | TEST 4      |               |              |
|-------------------------|-------------|---------------|--------------|-------------|---------------|--------------|
|                         | PRICE<br>UP | PRICE<br>DOWN | NO<br>CHANGE | PRICE<br>UP | PRICE<br>DOWN | NO<br>CHANGE |
| OGDEN<br>ALC            | 15          | 45            | 0            | 15          | 40            | 0            |
| SACRAMENTO<br>ALC       | 16          | 29            | 1            | 16          | 26            | 1            |
| SAN ANTONIO<br>ALC      | 131         | 93            | 0            | 127         | 85            | 0            |
| WARNER<br>ROBINS<br>ALC | 15          | 27            | 0            | 15          | 26            | 0            |
| OKLAHOMA<br>CITY<br>ALC | 18          | 30            | 0            | 18          | 26            | 0            |
| SUMMARY                 | 195         | 224           | 1            | 191         | 203           | 1            |

# RESEARCH HYPOTHESIS 2

## Transition From Competitive to Sole Source Procurement Actions

| TEST<br>ALC             | TEST 1      |               |              |
|-------------------------|-------------|---------------|--------------|
|                         | PRICE<br>UP | PRICE<br>DOWN | NO<br>CHANGE |
| OGDEN<br>ALC            | 39          | 38            | 9            |
| SACRAMENTO<br>ALC       | 16          | 18            | 4            |
| SAN ANTONIO<br>ALC      | 74          | 91            | 18           |
| WARNER<br>ROBINS<br>ALC | 13          | 17            | 7            |
| OKLAHOMA<br>CITY<br>ALC | 60          | 40            | 9            |
| SUMMARY                 | 202         | 204           | 47           |

| TEST 2      |               |              |
|-------------|---------------|--------------|
| PRICE<br>UP | PRICE<br>DOWN | NO<br>CHANGE |
| 35          | 38            | 9            |
| 16          | 18            | 4            |
| 70          | 88            | 18           |
| 13          | 16            | 7            |
| 56          | 40            | 9            |
| 190         | 200           | 47           |

## RESEARCH HYPOTHESIS 2

### Transition From Competitive to Sole Source Procurement Actions

| TEST<br>ALC             | TEST 3      |               |              | TEST 4      |               |              |
|-------------------------|-------------|---------------|--------------|-------------|---------------|--------------|
|                         | PRICE<br>UP | PRICE<br>DOWN | NO<br>CHANGE | PRICE<br>UP | PRICE<br>DOWN | NO<br>CHANGE |
| OGDEN<br>ALC            | 52          | 33            | 0            | 49          | 33            | 0            |
| SACRAMENTO<br>ALC       | 15          | 22            | 0            | 15          | 21            | 0            |
| SAN ANTONIO<br>ALC      | 82          | 101           | 0            | 79          | 99            | 0            |
| WARNER<br>ROBINS<br>ALC | 22          | 16            | 0            | 21          | 16            | 0            |
| OKLAHOMA<br>CITY<br>ALC | 78          | 32            | 0            | 76          | 32            | 0            |
| SUMMARY                 | 249         | 204           | 0            | 240         | 201           | 0            |

APPENDIX D

RESEARCH QUESTIONS,  
KRUSKAL-WALLIS H TEST RESULTS



# KRUSKAL-WALLIS H TEST RESULTS

## RESEARCH QUESTION 1

### FSC TEST

FILE NONAME (CREATION DATE = 08/06/83)

----- KRUSKAL-WALLIS ONEWAY ANOVA -----

### PERCENT BY CATEGORY

### PERCENTAGE OF SAVINGS CATEGORY OF SUPPLY

| CATEGORY   | 1      | 2     | 3      | 4      | 5      |
|------------|--------|-------|--------|--------|--------|
| NUMBER     | 46     | 53    | 25     | 93     | 45     |
| MEAN RANKS | 157.97 | 94.54 | 127.24 | 133.83 | 145.52 |

| CASES | CHI-SQUARE | SIGNIFICANCE | CHI-SQUARE | SIGNIFICANCE |
|-------|------------|--------------|------------|--------------|
| 262   | 19.930     | .001         | 19.930     | .001         |

### CORRECTED FOR TIES

- Category 1--Electrical, electronic, and communication equipment, and related spares and parts
- Category 2--Airframe structure components
- Category 3--Aircraft engines (gas turbine and reciprocating related spares and parts)
- Category 4--Aircraft subsystems, accessories, and components related spares and parts
- Category 5--Mechanical miscellaneous

# KRUSKAL-WALLIS H TEST RESULTS

## RESEARCH QUESTION 2

### DEPOT TEST

FILE NONAME (CREATION DATE = 08/06/83)

----- KRUSKAL-WALLIS ONEWAY ANOVA -----

PERCENT  
BY DEPOT

PERCENTAGE OF SAVINGS  
DEPOT OF PURCHASE

|            |        |        |        |        |        |
|------------|--------|--------|--------|--------|--------|
| DEPOT      | 1      | 2      | 3      | 4      | 5      |
| NUMBER     | 55     | 44     | 44     | 41     | 203    |
| MEAN RANKS | 236.13 | 187.20 | 201.31 | 204.50 | 180.35 |

| CASES | CHI-SQUARE | SIGNIFICANCE | CORRECTED FOR TIES |              |
|-------|------------|--------------|--------------------|--------------|
|       |            |              | CHI-SQUARE         | SIGNIFICANCE |
| 387   | 11.533     | .021         | 11.533             | .021         |

Depot 1--Ogden ALC

Depot 2--Sacramento ALC

Depot 3--Oklahoma City ALC

Depot 4--Warner Robins ALC

Depot 5--San Antonio ALC

# KRUSKAL-WALLIS H TEST RESULTS

## RESEARCH QUESTION 3

### UNIT PRICE TEST

FILE NONAME (CREATION DATE = 08/01/83)

----- KRUSKAL-WALLIS ONEWAY ANOVA -----

| PERCENT<br>BY UNIT PRICE |        | PERCENTAGE OF SAVINGS<br>UNIT PRICE GROUP |        |        |        |        |
|--------------------------|--------|-------------------------------------------|--------|--------|--------|--------|
| UNIT PRICE               |        | 1                                         | 2      | 3      | 4      | 5      |
| NUMBER                   | 85     |                                           | 45     | 37     | 166    | 52     |
| MEAN RANKS               | 193.05 |                                           | 212.14 | 196.12 | 200.32 | 150.76 |

| CASES | CHI-SQUARE | SIGNIFICANCE | CORRECTED FOR TIES |              |
|-------|------------|--------------|--------------------|--------------|
|       |            |              | CHI-SQUARE         | SIGNIFICANCE |
| 385   | 9.571      | .048         | 9.572              | .048         |

Unit Price Grouping 1-- < \$10.01  
 Unit Price Grouping 2--\$10.01 to \$100.00  
 Unit Price Grouping 3--\$100.01 to \$500.00  
 Unit Price Grouping 4--\$500.01 to \$1,000.00  
 Unit Price Grouping 5-- > \$1000.00

# KRUSKAL-WALLIS H TEST RESULTS

## RESEARCH QUESTION 4

### NATIONAL STOCK NUMBER (NSN) GROUP TEST

FILE NONAME (CREATION DATE = 08/01/83)

----- KRUSKAL-WALLIS ONEWAY ANOVA -----

PERCENT  
GROUP

PERCENTAGE OF SAVINGS  
DATE GROUP OF NSN

GROUP 1  
NUMBER 86  
MEAN RANKS 197.06

2  
178  
202.69

3  
122  
177.59

CASES  
386

CHI-SQUARE  
3.776

SIGNIFICANCE  
.151

CORRECTED FOR TIES  
CHI-SQUARE 3.776  
SIGNIFICANCE .151

Group 1--From 1978 Through 1983  
Group 2--From 1968 Through 1977  
Group 3--1967 or Earlier

**SELECTED BIBLIOGRAPHY**

# REFERENCES CITED

1. AMSAA, Army Procurement Research Office. Guidelines for the Application of Competition. APRO 82-04, Fort Lee VA, June 1982.
2. \_\_\_\_\_. Strategy Selection to the Production Phase of Weapon System Acquisition. APRO 81-05, Fort Lee VA, May 1982.
3. Archibald, K. A., et al. Factors Affecting the Use of Competition in Weapon System Acquisition. Rand Corporation R-2706, Santa Monica CA, February 1981.
4. Brechtel, Captain Donald L., USAF. Assistant Professor of Management, AFIT/LSP, Wright-Patterson AFB OH. Course CM5.45, "Cost and Price Theory," Class 1983S. Lecture. 18 January 1983.
5. Brost, Edward J. "A Comparative Analysis of Sole Source Versus Competitive Prices in the Acquisition of Weapon System Replenishment Spare Parts." Unpublished master's thesis. LSSR 51-82, AFIT/LS, Wright-Patterson AFB OH, September 1982.
6. Carlucci, The Honorable Frank C. The Deputy Secretary of Defense. Memorandum, subject: Increasing Competition in the Acquisition Process for Secretaries of the Military Departments and others, 27 July 1981.
7. Carter, Gregory A. Direct Licensing: An Evaluation of a Proposed Technique for Reducing the Procurement Cost of Aircraft. Rand Corporation R-1604, Santa Monica CA, December 1974.
8. Congress of the United States. Congressional Record-Extension of Remarks. Volume 13. Washington DC: Government Printing Office, 1981.
9. Daly, George G., Howard P. Gates, and James A. Schuttinga. "The Effect of Price Competition on Weapon System Acquisition Costs." Unpublished research paper No. P-1435, Institute for Defense Analysis, Arlington VA, September 1979. AD A078232.

10. Falconer, Captain Thomas E., USAF, and Captain David J. Murphy, Jr., USAF. "An Analysis of Factors Which Should Be Considered in Developing Procurement Data Requirements." Unpublished master's thesis. LSSR 11-80, AFIT/LS, Wright-Patterson AFB OH, June 1980. AD A08787494.
11. Gansler, Jacques S. The Defense Industry. Cambridge MA: The MIT Press, 1982.
12. Gibbons, Jean Dickson. Nonparametric Methods for Quantitative Analysis. Atlanta GA: Holt, Rinehart and Winston, 1976.
13. Gould, J. P. and C. E. Ferguson. Microeconomic Theory. Homewood IL: Richard D. Irwin, Inc., 1980.
14. Johnson, Robert E., and James W. McKie. Competition in the Reprocurement Process. Rand Memorandum RM-5657-PR, Santa Monica CA, May 1968. AD 670567.
15. Johnson, Captain Robert L., USAF, and Captain Mark A. Southwick, USAF. "An Assessment of Relevant Decision-Making Factors Used in the Purchase of Reprocurement Data." Unpublished master's thesis. LSSR 7-79A, AFIT/LS, Wright-Patterson AFB OH, June 1979. AD A072669.
16. Lee, Lamar, Jr., and Donald W. Dobler. Purchasing and Materials Management. 3d ed. New York NY: McGraw-Hill Book Company, 1977.
17. Lovett, Ed and Monte Norton. "Determining and Forecasting Savings Due to Competition," National Contract Management Journal. Volume 12 (Summer 1980), pp. 18-26.
18. \_\_\_\_\_. "Determining and Forecasting Savings From Competing Previously Sole Source/Noncompetitive Contracts." Unpublished research report No. 709-3, Army Procurement Research Office, Fort Lee VA, October 1978. AD A064168.
19. Marsh, Alton K. "Pricing of Spares Scrutiny by Department of Defense," Aviation Week and Space Technology, 1 August 1983, pp. 22-23.

20. McCann, John A., Ernest R. Keucher, and others, ed. Compendium of Authenticated Systems and Logistics Terms, Definitions, and Acronyms. Wright-Patterson AFB OH: School of Systems and Logistics, AFIT 1981.
21. McClave, James T., and P. George Benson. Statistics for Business and Economics. 2nd ed. San Francisco CA: Dellen Publishing Company, 1979.
22. Nie, Norman H., et al. Statistical Package for the Social Sciences. 2nd ed. New York NY: McGraw Hill Book Company, 1975.
23. Norusis, Marija J. SPSS Introducing Guide: Basic Statistics and Operations. New York NY: McGraw-Hill Book Company, 1982.
24. Olsen, Major Alan E., USAF, Captain James A. Cunningham, USAF, and Captain Donald J. Wilkins, USAF. "A Cost-Benefit Analysis of Competitive Versus Sole-Source Procurement of Aircraft Replenishment Spare Parts." Unpublished master's thesis. SLSR 21-74A, AFIT/LS, Wright-Patterson AFB OH, January 1974. AD 777247.
25. Perry, Dennis Scott. "Second Sourcing in the Acquisition of Major Weapon Systems." Unpublished master's thesis. Naval Postgraduate School, Monterey CA, June 1979. AD 01995.
26. Rich, Michael D. Competition in the Acquisition of Major Weapon Systems: Legislative Perspectives. Rand Corporation R-2058-PR, Santa Monica CA, November 1976.
27. Rutherford, F. E. et. al. The Impact of OMB Circular A-109 on Competition. Washington DC: National Defense University, June 1980.
28. Sellers, Benjamin R. "A Model for Enhancing Second Sourcing and Production Competition in Major Weapon Systems Acquisition," National Contract Management Journal. Volume 15 (Summer 1981), pp. 27-40.
29. Sherman, Stanley N. Government Procurement Management. Gaithersburg MD: Wordcrafters Publications, 1981.



30. Shields, Major Matthew D., USAF. Principles of Contract Pricing. 3rd ed. Maxwell AFB AL: ECI(AU), 1982.
31. Shipman, Major Robert H. Jr., USAF. "Establishing a Second Source in Production, A Guide for Acquisition Managers." Unpublished research report No. 2190-81, Air Command and Staff College, Maxwell AFB AL, 1981.
32. Small, Webb, Financial Director, Missile Systems Organization, Ford Aeronutronics Division, Ford Aerospace Corporation, Personal Interview, November 1981.
33. Smith, Charles H., and Charles M. Lowe, Jr. "Sole Source and Competitive Price Trends in Spare Parts Acquisition," National Contract Management Journal, Winter 1982, pp. 51-56.
34. \_\_\_\_\_. "Sole Source and Competitive Price Trends in Spare Parts Acquisition." Unpublished paper No. P-5, Army Procurement Research Office, Fort Lee VA, January 1981.
35. Smith, Paul. "Weinberger Hits Spare Parts Buying," The Air Force Times, 1 August 1983, p. 11.
36. Soderquist, Captain Larry L., USAF. "Leader-Follower: An Analysis of a Proposed Technique for Increasing Competition in Air Force Weapons System Procurement." Unpublished master's thesis. AFIT/GSM/SM/79S-13, Wright-Patterson AFB OH, September 1979. AD A076159.
37. Thybony, William W. "What's Happened to the Basics?" National Contract Management Journal, Spring 1975, pp. 71-84.
38. U.S. Air Force Logistics Command. Acquisition and Due-In System (ADIS) (JO41). AFLCR 70-11. Appendix 3: "Procurement Information Processing." Washington DC: Government Printing Office. 30 April 1981.
39. U.S. Air Force Logistics Command. Competitive Acquisition Program Summary for 1982. January 1982.

40. U.S. Air Force Logistics Command. Mission Assignment Policy. AFLCR 523.1. Attachment: "Work Load Balance Tech Groups." Washington DC: Government Printing Office. 10 August 1977.
41. U.S. Bureau of Labor Statistics. Producer Prices and Price Indexes. Washington DC: Government Printing Office, 1978-1982.
42. U.S. Department of Defense. Armed Services Procurement Regulation Manual for Contract Pricing. Washington DC: Government Printing Office, 1975.
43. \_\_\_\_\_. Defense Acquisition Regulation (DAR). Washington DC: Government Printing Office, 1976.
44. \_\_\_\_\_. Prime Contract Awards, Fiscal Years 1978 Through 1982. Washington DC: The Pentagon, October 1978, 1979, 1980, 1981, and 1982.
45. U.S. Office of Management and Budget. Budget of the United States Government, Fiscal Year 1983. Washington DC: Government Printing Office, 1982.
46. Weigand, Commander Rudolf, USN, Professor of Mathematics, AFIT/EN, Personal Interview, 27 July 1983.

**END**

**FILMED**

**1-84**

**DTIC**