
# USING MULTIPLE OBJECTIVE DECISION ANALYSIS TO POSITION FEDERAL PRODUCT AND SERVICE CODES WITHIN THE KRALJIC PORTFOLIO MATRIX

THESIS

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Robert T. Montgomery, Captain, USAF

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**DEPARTMENT OF THE AIR FORCE**
**AIR UNIVERSITY**

***AIR FORCE INSTITUTE OF TECHNOLOGY***

**Wright-Patterson Air Force Base, Ohio**

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# Abstract

Despite the best efforts of the Federal Government to implement strategic sourcing, recent Government Accountability Office (GAO) reports highlight major procurement deficiencies and encourage the use of commercial best practices to identify and reap substantial savings. The Kraljic Portfolio Matrix (KPM) is considered the premier tool for purchasing organizations to determine which commercial best practices to utilize for different categories of spend. However, critics of the KPM point to its lack of analytical rigor and the absence of a simplistic quantitative methodology for implementation. The Air Force Installation Contracting Agency (AFICA), the centralized procurement arm for 79 USAF installations worldwide, desires to exploit the KPM to determine if current contracting strategies are in line with commercial best practices. Therefore, this research seeks to fill both an operational and research gap. The operational gap is filled using multi-objective decision analysis (MODA) as a framework to position installation procured goods and services within the KPM in order to facilitate AFICAs strategic sourcing efforts. The application of MODA fills a research gap by providing a quantitative methodology not yet found in literature.

*To the Alpha and Omega, the beginning and the end, the first and the last, the author and finisher of my faith, without whom nothing is possible. I also dedicate this research to my wife, daughters, and parents for their unconditional love, support, patience, and encouragement throughout this process.*

## Acknowledgements

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Robert T. Montgomery

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USING MULTIPLE OBJECTIVE DECISION ANALYSIS TO POSITION FEDERAL PRODUCT AND SERVICE CODES WITHIN THE KRALJIC PORTFOLIO MATRIX

# I. Introduction

For the first time since its inception in 1947, the United States Air Force (USAF) was forced to stand down "flight operations for about one-third of...active duty combat units" (Pickup & Sullivan, 2013) in Fiscal Year 2013 (FY13). These actions were triggered by sequestration whereby immediate budget cuts across the entire department of approximately ten billion dollars were enforced. Then current Air Combat Command (ACC) Commander, General Mike Hostage, made the following remarks: "Historically, the Air Force has not operated under a tiered readiness construct because of the need to respond to any crisis within a matter of hours or days...The current situation means we're accepting risk that combat airpower may not be ready to respond immediately to new contingencies as they occur" (Air Force News Service, 2013 (accessed: 6 October 2015)). Dr. Jamie Morin, who served as the Assistant Secretary of the Air Force for Financial Management and Comptroller during this same period added that the USAF should play an integral part in getting the federal deficit under control (Air Force News Service, 2013 (accessed: 8 October 2015)).

Although sequestration during FY13 was an extreme budgetary event, budget threats have not been foreign to the USAF and the Department of Defense (DoD) at large in recent years. Continuing resolutions (CR), which fund the government using the previous year's budget, have been used every year since 2009. The most volatile period occurred in FY11 when Congress passed seven different CRs(Gould &

Mehta, 2015 [accessed: 6 October 2015]). Approaching the FY16 budget cycle, the now retired Chairman of the Joint Chiefs of Staff General Martin Dempsey remarked, "do I assess right now, as we go into the fall review for 2016 that we're going to have budget problems? Yes..." (Bordelon, 2014 [accessed: 6 October 2015]). General Dempsey was accurate in that a CR was passed only hours before the end of the last budgetary day of FY15 in order to avert a government shutdown. Although a new National Defense Authorization Act (NDAA) was signed in 2015, "funding gaps from the 2011 Budget Control Act are set to fully return in 2016 and Congress appears to...not support overturning the law's sequestration mechanism" (CSBA, 2015 [accessed: 9 October 2015]). This is concerning given that the USAF continues to fly contingency missions in austere locations such as Syria, Iraq, and Afghanistan. Moreover, approximately eleven percent of the USAF budget from FY10-14 was spent on installation support. Without identifying ways to curb spending, the USAF may soon be forced to face a trade-off between funding flying operations and supporting USAF installations across the globe.

### 1.1 Air Force Installation Contracting Agency

The Air Force Installation Contracting Agency (AFICA) is headquartered at Wright Patterson Air Force Base, Ohio and is the sponsor of this research. Their mission is to "provide responsive enterprise acquisition solutions to enable efficient and effective mission and installation operations" (AFICA, 2015 [accessed: 6 October 2015]). To do this, AFICA provides contracting support to 79 USAF bases across all nine Major Commands (MAJCOMs). From FY10-14, AFICA was responsible for over $43B of USAF expenditures. Figure 1 shows the relationship between AFICA and various levels of leadership and oversight up to the Federal level.[1]

[1] Figure may not reflect current organizational structure

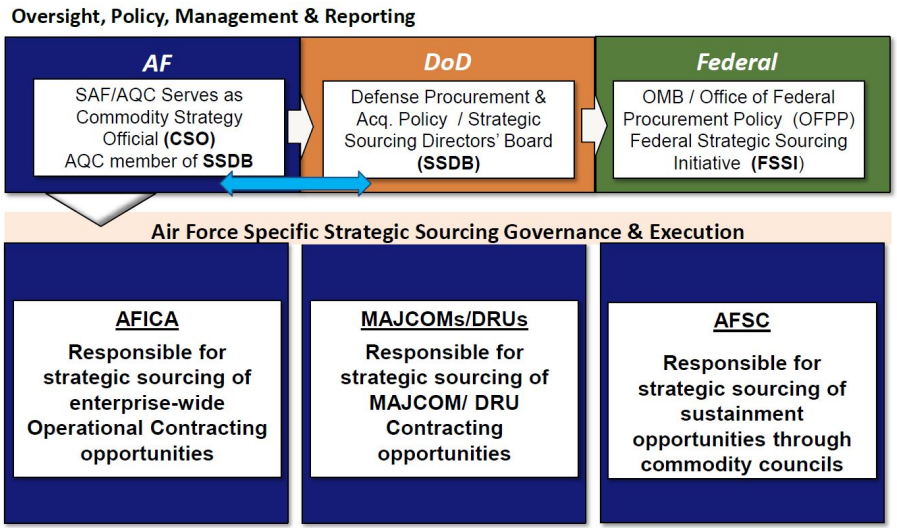


**Figure 1. U.S. Government Strategic Sourcing Framework(DPAP, Unknown [accessed: 6 October 2015])**[2]

AFICA also "conducts spend and market analysis; develops and executes responsive strategies and sourcing solutions that allow the Air Force to:

- Leverage Air Force-wide installation **strategic sourcing opportunities**;
- optimize productivity and limited specialized manpower;
- achieve better supplier relationship management;
- **generate substantial savings** to the Air Force;
- accelerate the acquisition process" (DPAP, 2015 [accessed: 15 October 2015])

## 1.2 Research Question, Purpose, and Scope

The fundamental research question is: *How does* AFICA *determine if current contracting strategies are in line with commercial best practices?* Answering this

[2] OMB – Office of Management and Budget; DPAP – Defense Procurement & Acquisition Policy; DRU – Direct Reporting Unit; AFSC – Air Force Sustainment Center

question is essential for AFICA to assess its current state of operations in relation to its mission and leadership directives from the Federal, DoD, and USAF level.

The purpose of this research is to aid AFICA in applying commercial best practices to USAF contracting operations that will:

1. facilitate Federally directed strategic sourcing efforts;
2. uncover cost reductions to generate savings;
3. ensure the USAF is properly leveraging its buying power;
4. maximize value to the American taxpayer.

Rather than investigate every Federal Product and Service Code (PSC) involved in installation contracts, this research will specifically investigate the prioritized subset of 138 PSCs provided by AFICA which represent roughly 80 percent of annual installation spend. We will also investigate eleven additional PSCs that are not part of the prioritized set. It is also understood that all practices are in accordance with the Federal Acquisition Regulations (FAR). This research also does not specifically investigate the impact of the FAR on implementing commercial best practices.

## 1.3 Terminology

### Strategic Sourcing.

The emergence of strategic sourcing within the DoD began with a 2005 Memorandum from the OMB directing its implementation. According to this memorandum, strategic sourcing is defined as "the *collaborative* and *structured* process of critically analyzing an organization's spending and using this information to make business decisions about acquiring commodities and services more effectively and efficiently" (Deputy Director for Management, Office of Management and Budget, 2005 [accessed

5 June 2015]). Its implementation, according to the memorandum, enables OMB to achieve its top priority: "Maximizing value for taxpayers." Finally, the two elements for implementing strategic sourcing that are identified and directed underpin the focus of this research:

1. Spend analysis;
2. Identification of commodities for implementation of strategic sourcing.

**Spend.**

Dollars obligated by USAF contracting organizations are collectively known as "spend." The use of the term "spend" as a noun may seem odd, but is fundamental to the contracting lexicon.

**Category Management.**

"Category Management is the strategic management of spend categories using an array of tools to improve costs and achieve best-in-class category performance; strategic sourcing is one such tool" (Muir *et al.*, 2014). Category management is "used extensively in industry" and shifts purchasing focus from simply managing "purchases and price individually across thousands of procurement units to managing entire categories of common spend and total cost" (Office of Federal Procurement Policy, Office of Management and Budget, 2014 [accessed 4 November 2015]).

**Federal Product and Service Code.**

The U.S. Government Services Administration (GSA) defines the PSC as "products, services, and research and development (R&D) purchased by the federal government" (GSA, 2011). For the purposes of this research, a PSC is equivalent to a *commodity* or *service* under consideration for implementing strategic sourcing.

Spend categories are comprised of various PSCs. In 2014, the Category Management Leadership Council (CMLC) and OMB mapped all PSCs (nearly 5,800) to 19 categories and developed the first Government-Wide Category Structure (see Appendix A). The goal of this structure is to better manage and analyze government spend (GSA, 2015 [accessed: 4 November 2015]). This research aids category managers in decision-making and strategic management of categories through the employment of commercial best practices and quantitative techniques at the PSC level.

### 1.4 Federal Acquisition Regulation

"The Federal Acquisition Regulation (FAR) is the primary regulation for use by all Federal Executive agencies in their acquisition of supplies and services with appropriated funds" (AFLCMC/HIBB-Hill, 2016 [accessed: 28 January 2016]). FAR Part 16 identifies the types of contracts available for acquisitions and outlines two major categories: fixed-price contracts (Subpart 16.2) and cost-reimbursement contracts (Subpart 16.3). Within these two broad categories (Subpart 16.4) lies an assorted number of incentive contracts. The possible contract types are the available options for contracting agencies to acquire PSCs. A complete listing of contract types is provided in Appendix B.

### 1.5 Current AFICA Analysis Efforts

From 2014-15, AFICA performed an Air Force-wide spend analysis that covers installation contracts comprising more than 2,900 PSCs. They also identified the 138 PSCs that account for roughly 80% of annual installation budgetary expenditures, or annual spend. In essence, a thorough spend analysis is ongoing and commodities and services (PSCs) befitting implementation of strategic sourcing continue to be

identified.

Prior to undertaking our research, AFICA also performed internal analysis of all PSCs associated with installation spend based on the following factors termed "*Key Performance Indicators* (KPI)":

1. Market structure – specifically the availability of alternatives and ease of purchasing;

2. Market risk – elements of volatility impacting a buyer's ability to make long-term deals;

3. Industry and Product life-cycle – a ratio of the growth in the number of establishments and the growth in the share of the economy;

4. Competition level – number of suppliers in the market;

5. Geography – a *services only* measure that considers eight possible regions (West, Great Lakes, Mid-Atlantic, New England, Plains, Rocky Mountains, Southeast, and Southwest).

These KPIs along with their respective annual spend levels were used to develop a prioritized set of 138 PSCs which AFICA will focus future strategic sourcing efforts on. For this reason, we use the same set of PSCs and include it in Appendix C for reference.

### 1.6 Research Method

The Kraljic Portfolio Matrix (KPM) is a $2 \times 2$, four-category matrix used extensively by purchasing and supply chain managers that exposes a trade-off between the supply market and the purchasing organization. Commodities or services are first positioned within one of the four categories of the matrix. The categories determine

the appropriate purchasing strategy and the strategy is underpinned by supply market and organizational trade-offs. The KPM, as we shall discuss, is a widely used and effectively employed commercial tool. Multi-objective decision analysis (MODA) is a decision-making tool especially suited for scenarios involving trade-offs. MODA techniques will be used as a framework to position PSCs within the KPM. Quantitatively positioning PSCs will remove subjectivity and enable AFICA to compare current contracting strategies with commercial best practices. Any disconnects will highlight PSCs ripe for cost reduction. MODA techniques will also provide additional insight into which PSCs AFICA should consider **first** for in-depth analysis. We also consider MODA as an analytical technique that can be more easily replicated by other governmental organizations. The following figure is meant to pictorially tie together Federal directives and the goal of this research.

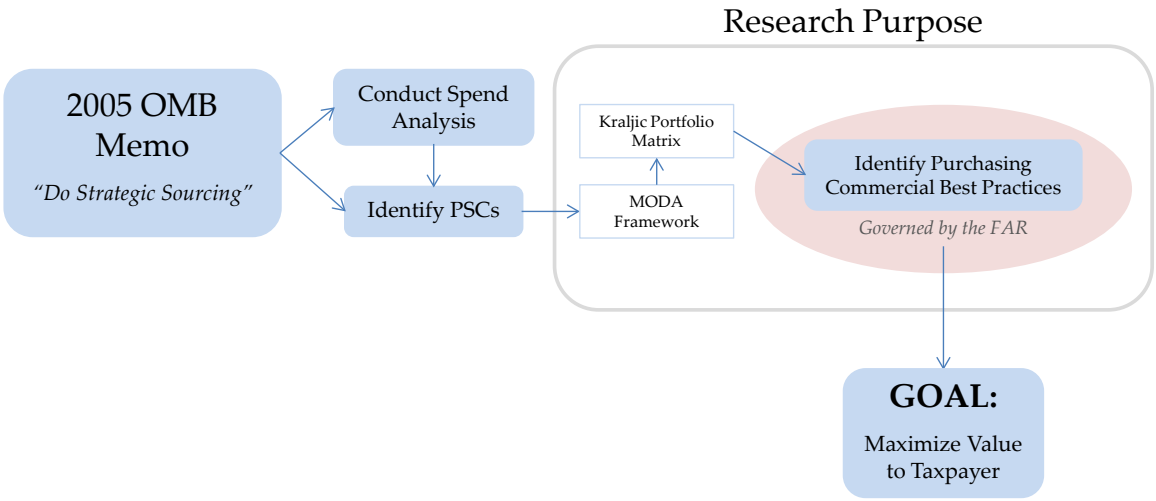


**Figure 2. Research Method and Purpose**

## 1.7 Organization of Research

In Chapter II, the use of the KPM for purchasing organizations is substantiated and advocated as a commercial best practice for AFICA. Moreover, the motivation

for using commercial best practices to implement strategic sourcing within the USAF and the DoD is presented. The literature review cannot be considered exhaustive, but seeks to unveil the appeal and practicality of the KPM since Kraljic's seminal work was released in 1983. Emphasis is placed on the lack of research regarding positioning items within the KPM through a quantitative approach rather than subjective reasoning. Finally, a short history of leadership guidance along with current regulations which create the governmental bounds of contracting operations for AFICA and even the Federal Government at large are briefly discussed. Chapter III outlines the use of MODA as a framework to quantitatively position PSCs within the KPM. Chapter IV presents results and augments graphical output with pertinent discussion. Chapter V is a summary of results as they pertain to the research question and purpose. Recommendations for AFICA are provided based on analysis results. Recommendations for further study are also introduced.

# II. Literature Review

## 2.1 Overview

The purpose of this review is to provide relevant background information on what has been deemed "the most widely used framework in industry today" (Wagner *et al.*, 2013), the Kraljic Portfolio Matrix (KPM). An examination of the usefulness of the KPM, its genesis, and the need for analytical rigor rather than applying a subjective approach follows. This review also provides a thorough summary of the drive for strategic sourcing within the Federal Government and hence, the USAF. Brief discussion is provided regarding leadership guidance for defense contracting and the regulations that impact sourcing functions. Terms are defined and a review of literature underpins the framework of current and future research.

## 2.2 The Kraljic Portfolio Matrix

The early 1980's saw a major shift in the economic policy of the United States of America. The recession that began "in the second half of the Carter administration, at the time of the second oil shock" (Alesina & Sachs, 1986) as well as a period of high inflation were two of the leading causes. Given the macroeconomic strain on many businesses, efforts were made to develop methods to overcome the damaging effects of the last decade. One voice that rose to shine light on a new way forward for businesses was Peter Kraljic via his seminal paper "Purchasing Must Become Supply Management" in the September-October 1983 issue of the Harvard Business Review. At the outset of this paper, he describes with clarity the pressure and difficulties that businesses, and especially purchasing departments, were facing as they clawed their way out of the 1970s and into the 1980s. Kraljic states, "The stable way of business life many corporate purchasing departments enjoy has been increasingly imperiled.

Threats of resource depletion and raw materials scarcity, political turbulence and government intervention in supply markets, intensified competition, and accelerating technological change have ended the days of no surprises. As dozens of companies have already learned, supply and demand patterns can be upset virtually overnight" (Kraljic, 1983). He goes on to ask two very important questions: "How can a company guard against disastrous supply interruptions and cope with the changing economics and new opportunities brought on by new technologies? What capabilities will a profitable international business need to sustain itself in the face of strong protectionist pressures" (Kraljic, 1983). It is based on this macroeconomic view of the business landscape that Kraljic identifies a purchasing portfolio strategy to deal with the supply chain complexities for purchasing managers. Gelderman & Van Weele (2003) state that "Kraljic (1983) introduced the first comprehensive portfolio approach for purchasing and supply management."

Kraljic highlighted the need for companies to assess their current purchasing strategy and situation according to two factors:

1. "the strategic importance of purchasing in terms of the value added by product line, the percentage of raw materials in total costs and their impact on profitability, and so on"

2. "the complexity of the supply market gauged by supply scarcity, pace of technology and/or materials substitution, entry barriers, logistics cost or complexity, and monopoly or oligopoly conditions" (Kraljic, 1983).

Kraljic used these two factors to underpin his $2 \times 2$, four category, purchasing matrix (the KPM) whereby the factors reveal the strength of the company and the strength of the market to purchasing and supply managers. As a result, the ability to segment a purchasing portfolio into one of four categories is achieved (Lee & Drake, 2010). The four categories are defined as:

1. *Leverage Items* - high profit impact, low supply risk
2. *Strategic Items* - high profit impact, high supply risk
3. *Bottleneck Items* - low profit impact, high supply risk
4. *Noncritical Items* - low profit impact, low supply risk (Kraljic, 1983)

Items placed within this matrix determine the overarching strategy to manage each item. Figure 3 is a modified version of the KPM that combines item classification, the trade-off between company strength and supply market strength, and the appropriate purchasing strategy based on matrix position.

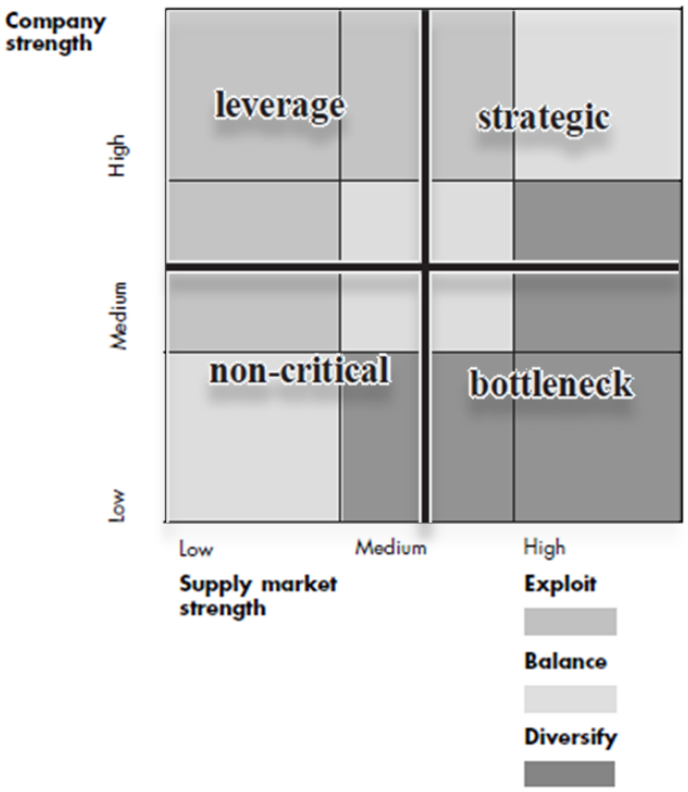


**Figure 3. The Kraljic Portfolio Matrix (modified from Kraljic, 1983)**

Cox (2001) noted that embedded within the KPM is the concept of a "Power Matrix" whereby purchasing strategies hinge on relative power differences between the buyer and supplier as shown in Figure 4.

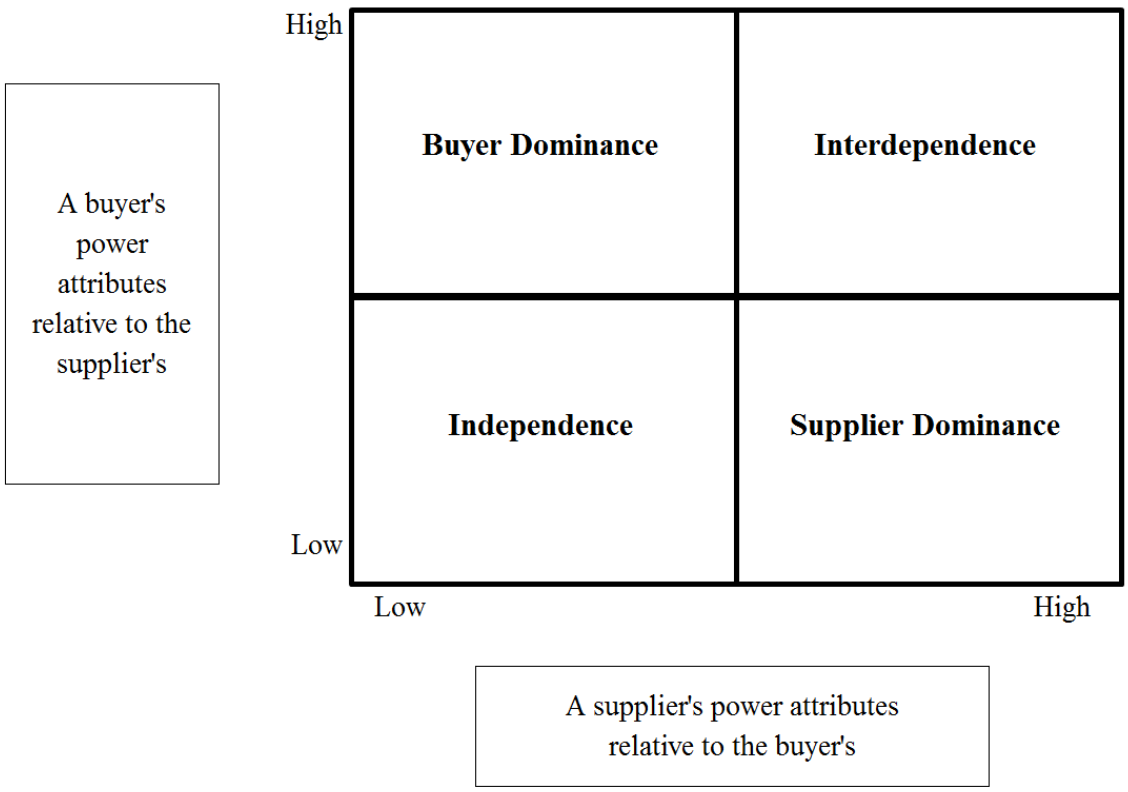


**Figure 4. The Power Matrix Between Buyers and Suppliers**

After items are positioned within the KPM, Kraljic's work calls for "three strategic thrusts" for purchasing that have "distinctive implications for the individual elements of the purchasing strategy, such as volume, price, supplier selection, material substitution, inventory policy, and so on." The three strategies are:

1. ***Exploit*** - leverage buying power; be aggressive
2. ***Balance*** - implement neither aggressive nor conservative purchasing approach
3. ***Diversify*** - search for new suppliers or substitutes

The goal of the supply strategy is to "minimize supply vulnerabilities and make the most of potential buying power" (Kraljic, 1983).

**Advantages.**

Research has "confirmed that Kraljic's matrix remains the foundation of purchasing strategy for many organizations across different sectors" (Gelderman & Van Weele, 2003). The KPM is also a defining source for generating "a stream of conceptual and empirical research on the use and possibilities of a portfolio approach in purchasing" (Gelderman & Semeijn, 2006). The following statements highlight the value of the KPM to both industry and academia:

1. The KPM "has become the dominant approach to what the profession regards as operational professionalism" (Gelderman & Van Weele, 2005).

2. "The best known portfolio model...has had a broad influence on professional purchasing" (Gelderman & Semeijn, 2006).

3. The KPM has triggered a host of research into portfolio models among many academic writers (e.g. Olsen & Ellram, 1997; Dyer *et al.*, 1998; Bensaou, 1999; Wynstra & Ten Pierick, 2000; Croom, 2000; Nellore & Söderquist, 2000a; Lilliecreutz & Ydreskog, 2001; Gelderman & Van Weele, 2002, 2003; Dubois & Pedersen, 2002; Zolkiewski & Turnbull, 2002; Wagner & Johnson, 2004).

4. "In the field of purchasing portfolio models, despite some other suggestions with minor nuances, [the] Kraljic matrix has become the standard" (Ferreira & Kharlamov, 2012).

5. "The KPM is arguably the most widely used framework in industry today" (Wagner *et al.*, 2013).

6. "Kraljic's approach represents the most important single diagnostic and prescriptive tool available to purchasing organizations" (Wagner *et al.*, 2013).

7. "The practical application of the Kraljic matrix exceeds its original design" (Knight *et al.*, 2014).

8. The KPM "(and its variants) is the most commonly used supplier assessment framework by practitioners (Ferreira *et al.*, 2014; Knight *et al.*, 2014; Gelderman & Van Weele, 2003; Olsen & Ellram, 1997)" (Nudurupati *et al.*, 2015).

9. "Recent empirical studies have corroborated the usefulness of [the KPM] in practice (Under Secretary of Defense for Acquisition, Technology, and Logistics, 2010 [accessed 28 January 2016]; Lilliecreutz & Ydreskog, 1999; Gelderman & Van Weele, 2003, 2005; Wagner *et al.*, 2013)" (Gelderman & Mac Donald, 2008).

**Disadvantages.**

One of the KPM's main critiques revolves around the question: How does a purchasing manager position a product or service within the matrix? Most of the research regarding the KPM involves the framework itself (Olsen & Ellram, 1997; Dubois & Pedersen, 2002), movement within the framework (Gelderman & Van Weele, 2003; Caniëls & Gelderman, 2007; Nudurupati *et al.*, 2015), application of the framework to industry (Syson, 1992; De Haan *et al.*, 2003; Gelderman & Semeijn, 2006; Gelderman & Mac Donald, 2008; Liu & Xu, 2008; Lee & Drake, 2010; Ferreira & Kharlamov, 2012; Nudurupati *et al.*, 2015), strategies for the matrix categories (Caniëls & Gelderman, 2007), and buyer-supplier relationships that underpin management decisions prior to or after placement (Olsen & Ellram, 1997; Nellore & Söderquist, 2000b; Caniëls & Gelderman, 2007; Cox, 2001). However, scant research exists regarding methodologies for positioning items. In fact, Padhi *et al.* (2012), state that "positioning commodities in the KPM suggested in the literature are mainly based on subjective judgment of the decision makers to position the commodities in the different quadrants...They lack analytical rigor, where subjective positioning of commodities may lead to erroneous

outcomes." Wagner & Johnson (2004) add that "Despite the abundance of research on relationship patterns and their impact on company performance, the "how-to" question has been widely neglected." Ramsay (1994) identifies an "absence of a conceptual framework to facilitate an analytical approach." Padhi *et al.* (2012) add that "positioning of the items in the portfolio matrix by the purchasing managers are subjective and makes the portfolio models imprecise." Knight *et al.* (2014) reiterate the lack of analytical rigor, the difficulty in measuring the matrix dimensions, and the argument "for less subjective methods for positioning purchases on the matrix." Lee & Drake (2010) argue that lack of "the synthesizing of qualitative and quantitative measures" promote arbitrary classification of purchases. Olsen & Ellram (1997) emphasize that categorizing of "purchases in a portfolio model...is very subjective, and perhaps the most important part" of the implementation process and *urge* the use of quantitative methodologies.

A review of literature identified only five attempts to use analytical techniques to position items with the KPM. Again, it is important to note that this review cannot be considered exhaustive. However, the goal was to simply identify all possible quantitative methods to position items within the KPM and such findings are discussed here. Three of the five analytical techniques (Olsen & Ellram, 1997; Liu & Xu, 2008; Padhi *et al.*, 2012) rely on the concept of importance weights or importance scoring. Parnell, a staunch advocate and practitioner of multi-objective decision analysis (MODA), does not recommend the use of importance weights but advocates the use of swing weighting (Parnell *et al.*, 2013). There is a unique difference between *importance* weighting and *swing* weighting. "Importance weights are used to reflect the general importance of one attribute over another...without regard to...the difference between the worst and the best value points of each attribute." Watson states that "when this difference from worst to best is not explicitly refer-

enced in assessing weights, we obtain some general notion of importance, which is subject to great variation and argument among decision-makers" (Watson & Buede, 1987). Dillon-Merrill *et al.* (2008) point out a common pitfall of using importance weights. They argue that "importance weights do not take into account the range between the lowest and the highest levels of the value measures" resulting in the potential for important measures to not be important to the decision. Keeney adds that "when we quantify objectives by simply asking for their relative importance, considerable misinformation about values is produced and a substantial opportunity to understand values is lost" (Keeney, 1992). However, the use of swing weighting ensures we capture the full value preference structure rather than simply an arbitrary score or at best a hierarchy of importance. Swing weighting also protects against the potential for loss of information, misunderstanding of decision-maker belief, and even loss of trade-offs between values.

Zhenfeng *et al.* (2007) apply factor analysis techniques to the dimensions of the KPM. However, the model lacks sufficient detail in derivation of variable scoring and positioning of items. In all, the ability to extend this model for practical use is limited and its ease of implementation is inadequate.

The remaining quantitative method used to position items with the KPM is the Analytical Hierarchy Process (AHP) (Lee & Drake, 2010). Watson and Buede argue that although definitions for levels of importance are articulated, inconsistencies between importance pairings are common and additional methods must be used to resolve differences. He adds that "instead of getting a decision-maker to wrestle with his values, the AHP tells him what they ought to be" (Watson & Buede, 1987). They further highlight the AHP fails to provide clarity between attributes by using "a somewhat arbitrary representation of words by numbers which may be implying an underlying judgment structure which the decision-maker is unaware of and may

disagree with" (Watson & Buede, 1987). Dyer remarks that "the AHP, as it is traditionally applied to the evaluation of alternatives, generates rank orderings that are not meaningful with respect to the underlying preferences of the decision maker" (Dyer, 1990). Kirkwood adds that "the [AHP] approach seems overly complex with its need for sometimes extensive pairwise comparisons of alternatives and extensive mathematical calculations to determine rankings. These characteristics seem to obscure, rather than illuminate, the trade-offs involved in making decisions with multiple objectives" (Kirkwood, 1996).

The discussion above highlights what can be considered a gap in literature to date. The necessity to identify and apply a quantitative method to position items within the KPM is therefore a pressing need, prior to undertaking subsequent analysis.

## 2.3 Strategic Sourcing and the Federal Government

### Official Guidance.

In 2005, the Office of Management and Budget's (OMB) Office of Procurement and Policy released a memorandum to all federal agencies directing the implementation of strategic sourcing during purchasing. Two years later, OMB released a memorandum identifying the progress of, and encouraging more, strategic sourcing. For example, OMB highlighted that the DoD "achieved $538 million in cost avoidance in FY2006" (Office of Federal Procurement Policy, Office of Management and Budget, 2007 [accessed 28 October 2015]) through strategic sourcing efforts. The push continued in 2009 with a memorandum from President Barack Obama highlighting the necessity of "the Federal Government [to] have the capacity to carry out robust and thorough management and oversight of its contracts in order to achieve programmatic goals, avoid significant overcharges, and curb wasteful spending" (Obama, Barack, 2009 [accessed 6 November 2015]). In 2012, OMB released a memorandum to establish

"additional responsibilities for designing and implementing government-wide strategic sourcing solutions" through a newly formed council called the Interagency Strategic Sourcing Leadership Council (SSLC). This council was formed to "increase the use of government-wide management and sourcing of goods and services" and "to provide long-term leadership of the government's strategic sourcing efforts" (Deputy Director for Management, Office of Management and Budget, 2012 [accessed 6 November 2015]). In a 2014 memorandum, OMB touted its efforts with the SSLC to implement category management across the Federal Government for the purpose of "purchasing common goods and services" (Office of Federal Procurement Policy, Office of Management and Budget, 2014 [accessed 4 November 2015]). The SSLC was later renamed the Category Management Leadership Council (CMLC) with the express purpose of "elevating category management as one of the Obama administration's 15 Cross-Agency Priority Goals...to boost savings, [reduce] the number of new contracts and [raise] the proportion of government-wide spending under category management" (Clark, 2015 [accessed: 9 November 2015]).

**Government Accountability Office Reports.**

The purpose of the Government Accountability Office (GAO) is to investigate "how the federal government spends taxpayer dollars" (GAO, 2015 [accessed: 9 November 2015]). Results from recent GAO reports investigating government efforts to effectively use strategic sourcing are telling. In a 2013 report titled "Strategic Sourcing: Leading Commercial Practices Can Help Federal Agencies Increase Savings when Acquiring Services," the GAO identifies the portfolio framework as a means to move "away from numerous individual purchases to an aggregate approach" (GAO, 2013). In fact, their recommended framework is strikingly similar to the KPM as shown in Figure 5 below.

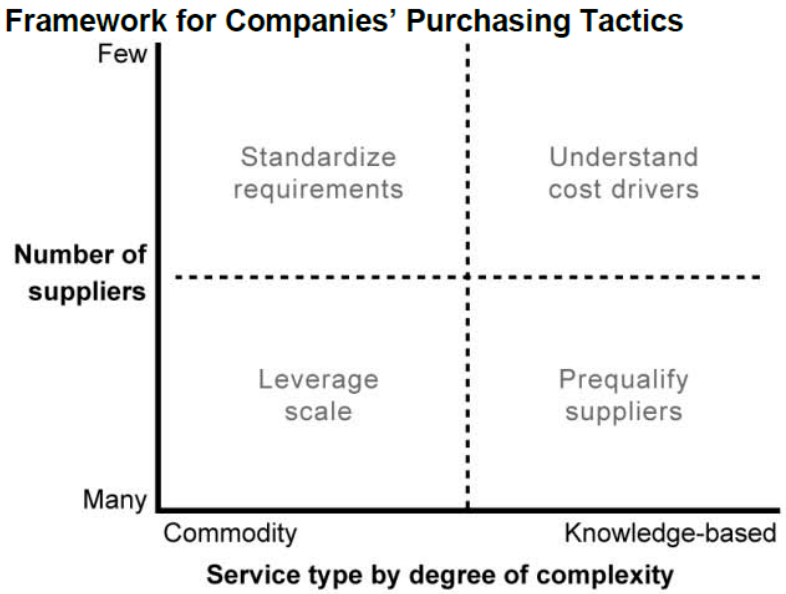


**Figure 5. GAO suggested purchasing matrix (GAO, 2013)**

This report also highlighted the potential savings achieved by implementing commercial best practices. The companies that the GAO spoke with "reported saving 4-15 percent over prior year spending through strategically sourcing the full range of services they buy" (GAO, 2013). This follows a 2012 report where the GAO discovered that the DoD has "leveraged *only a fraction* of what could potentially be managed and saved through strategic sourcing" (GAO, 2012). In its most recent report from September 2015, the GAO returns focus to the purchasing portfolio framework and emphasizes that by considering the two factors, companies can "more aggressively *leverage their buying power*...and select appropriate tactics" (GAO, 2015). The GAO has made it clear that "strategic sourcing of even one percent at the [DoD] would equate to billions of dollars" (GAO, 2012).

## 2.4 Impact of Guidance and Defense Contracting Regulations

In 2009, President Barack Obama released a memorandum reemphasizing the Federal Government's policy against engaging in noncompetitive contracts and added

that "there shall be a preference for fixed-price type contracts" (Obama, Barack, 2009 [accessed 6 November 2015]). In 2010, then Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD(AT&L)) The Honorable Ash Carter released the "Better Buying Power (BBP)" memorandum stating the following: "When robust competition already exists, or there is recent competitive pricing history, I expect components to be predisposed toward Firm-Fixed-Price (FFP) type contract arrangements" (Under Secretary of Defense for Acquisition, Technology, and Logistics, 2010 [accessed 28 January 2016]). This focus on fixed priced contracts, and specifically FFP contracts was meant to enable simplicity and cost efficiencies. However, a 2010 Defense Business Board Report to the Secretary of Defense highlighted the fact that "contracting officers frequently fall into the natural "creatures of habit" behavior, and use the contract type they are most familiar with, rather than conducting an objective review of the most appropriate contract for the requirement" (Ronald, 2010). This combination of ease of implementation and leadership preference underpin the familiarity of FFP contracts. Moreover, it has been noted that "when bound by inflexible FFP contracts, the government can miss out on savings associated with changes in requirements and may actually spend more and incur additional administrative burden" (Coombs, 2013 [accessed: 28 January 2016]).

In 2012, a shift in strategy began with the release of the "Better Buying Power 2.0" memorandum. The Honorable Frank Kendall, (OUSD(AT&L)), stated the following: "In BBP 2.0, we are refining our guidance to emphasize the use of the appropriate contract vehicle for the product or services being acquired. The Defense Federal Acquisition Regulation (DFAR) and Federal Acquisition Regulation (FAR) provide for a range of contract types for a reason: one size does not fit all" (Under Secretary of Defense for Acquisition, Technology, and Logistics, 2012 [accessed 28 January 2016]). In a 2015 memorandum, he further emphasized this shift by directing the increase of

incentive type contracts, specifically Cost Plus Incentive Fee and Fixed Price Incentive Fee contracts along with strengthened contract management at the installation level (Under Secretary of Defense for Acquisition, Technology, and Logistics, 2015 [accessed 28 January 2016]).

## 2.5 Conclusion and Way Forward

It is imperative to recognize the following:

1. The push for strategic sourcing from the highest levels of the Federal Government has continued since 2005.

2. Potential savings as suggested by the GAO through effective strategic sourcing efforts cannot be overlooked.

3. The abundance of research regarding the effectiveness of purchasing organizations implementing the Kraljic model cannot be overstated.

4. The strategic shift from fixed price contracts to incentive-based contracts necessitates analysis at the installation level.

However, the question remains: How does the Air Force implement the KPM to enable strategic sourcing, facilitate effective category management, and uncover contracts capable of provide reductions in cost? First and foremost, D'Angelo *et al.* (2008) state that "strategic sourcing inverts the traditional tactical buying structure" in order to avoid fragmented purchasing and "short-term, one-time buys." He goes on to indicate that by inverting this structure, the USAF can "develop sourcing strategies to realize the full potential of spend to influence cost and quality relative to overall strategic requirements." This process and inversion of the USAF purchasing structure began with the implementation of category management. The next logical

step is to develop sourcing strategies "by tailoring service and commodity strategies commensurate with the importance of the product and complexity of the product market" (D'Angelo *et al.*, 2008). The key tool to implement this process is the KPM. Therefore, this research fills both a research and an operational gap by:

1. providing a quantitative technique to position items within the KPM not yet found in the literature and

2. positioning AFICA's prioritized set of PSCs within the KPM to facilitate strategic sourcing efforts and category management objectives.

MODA, as advocated by Keeney, Raiffa, Kirkwood, and Parnell, is used as the technique of choice to quantitatively position PSCs within the KPM. As part of this process, a connection is made between Keeney's Value-Focused Thinking alternative generation approach and the Kraljic model. As Keeney states, "values should be the driving force for our decision-making...Value-focused thinking is proactive. It is our job, our opportunity, to create a decision opportunity" (Keeney, 1992). The KPM model creates decision opportunities for organizations. This approach will create opportunities for AFICA to more effectively manage contracting strategies and ensure value to taxpayers is maximized. This research will also highlight areas where reductions in installation spend may be realized while assuring no negative effect to the installation and subsequently the Air Force mission.

# III. Methodology

## 3.1 Multi-Objective Decision Analysis Overview

The Kraljic Portfolio Matrix (KPM) is, in essence, a multi-objective decision model. Kraljic indicates that a trade-off exists between two factors: supply risk and profit impact. The location of a commodity or service within the KPM represents this trade-off. He argues that a company can fully exploit its buying power and achieve greater profit gains when supply risk is minimized and profit impact is maximized (Kraljic, 1983). This occurs when items fall within the *Leverage* quadrant of the KPM. On the other hand, items that fall outside of the *Leverage* quadrant are not conducive to leveraging buying power and require a different approach, or strategy, for purchasing. Thus, an assumption is made regarding an overall direction of preference towards the leverage quadrant since it is in this quadrant that a purchasing organization can best achieve reductions in cost and increases in profit. Given the two factors and their respective direction of preference, Multi-Objective Decision Analysis (MODA) is implemented as a framework to quantitatively position each Product and Service Code (PSC) within the KPM. This method fills a void in literature, provides a method for future application, and reduces the subjectivity often criticized when the KPM is used as a tool by practitioners.

It is important to note that one is not "making a decision" to "select" a particular PSC. In other words, PSCs are not selected to best *maximize* installation mission impact and *minimize* supply market complexity. Additionally, for any PSC, we do not seek to manipulate the supply market or the installation mission by our use of the terms *minimize* or *maximize*. However, these preference directions are used to only aid in our understanding of value preferences by the decision maker and to enable the encoding of value functions. With this in mind, the MODA framework is

applied to the prioritized set of PSCs under the purview of the Air Force Installation Contracting Agency (AFICA) to properly position them within the KPM. As a result, this technique offers a quantitative method to minimize the subjectivity so often associated with item positioning.

### 3.2 Fundamental Objectives

We first assume that Kraljic, by identifying the two trade-off factors, has properly identified the two fundamental objectives for purchasing organizations: **Fundamental Objective 1**: *Minimize Supply Risk* and **Fundamental Objective 2**: *Maximize Profit Impact*. This assumption enables MODA to be used as a framework specifically for the KPM as specified in literature. The lack of this assumption would require the generation of a hierarchy of objectives for a very complex decision problem not easily applicable to the KPM.

Risk, according to literature, is restricted to "situations in which both the set of possibilities and the probability distribution over this set are known" whereas decisions under uncertainty "are usually made on grounds other than logical calculation" (Loasby, 2001). Kraljic uses the term *risk* to identify a supply market that is comprised of many factors that affect its complexity rather than outcomes with an associated probability and consequence. Parnell adds that risk neutrality is "often seen in Government decision making" (Parnell *et al.*, 2013). Therefore, we will narrow our focus to a *risk-less* model and rename *Fundamental Objective 1* as *Minimize Supply Market Complexity*. This simplifies the model by eliminating the requirement to incorporate risk attitude.

Given that AFICA is part of the DoD and is not profit-seeking, *Fundamental Objective 2* is properly renamed to *Maximize Installation Mission Impact*. As profit is critical to the long-term success of a private corporation, the ability of an Air Force

installation to carry out its particular mission is critical to the success of the Air Force and its overall mission. Moreover, AFICA is central to installation mission success Air Force-wide through its role as the focal point for installation contracting.

We recall that the term *minimize* or *maximize* connotes the direction of preference of the decision maker for a particular objective. In our case, a less complex supply market is preferred over a more complex supply market and higher installation mission impact is preferred over less installation mission impact. No manipulation of the market or the installation mission is required when positioning a PSC. However, the direction of preference is a requirement when using MODA and is vital to our methodology as will be seen in the following sections.

### 3.3 Alternatives

The alternatives for this research are simply the set of individual PSCs involved in AFICA contracts. Let $A$ denote the set of all PSCs.

### 3.4 Attributes

For each $a$ in $A$, we associate $n$ attributes, that is $n$ indices of value for each fundamental objective: $X_1(a), ...X_n(a)$ and $Y_1(a), ...Y_n(a)$ (Keeney & Raiffa, 1993). Attributes are the evaluation measures of the particular *Fundamental Objective* such that $X = (X_1, X_2, ..., X_n)$ and $Y = (Y_1, Y_2, ..., Y_n)$ represents the set of all attributes (indices of value). The score for attribute $X_i$ is given by $x_i$ and the score for attribute $Y_i$ is given by $y_i$. We use $n$ evaluators to map each $a$ in $A$ to a $n$-dimensional consequence space, as shown in Figure 6 below for a single fundamental objective.

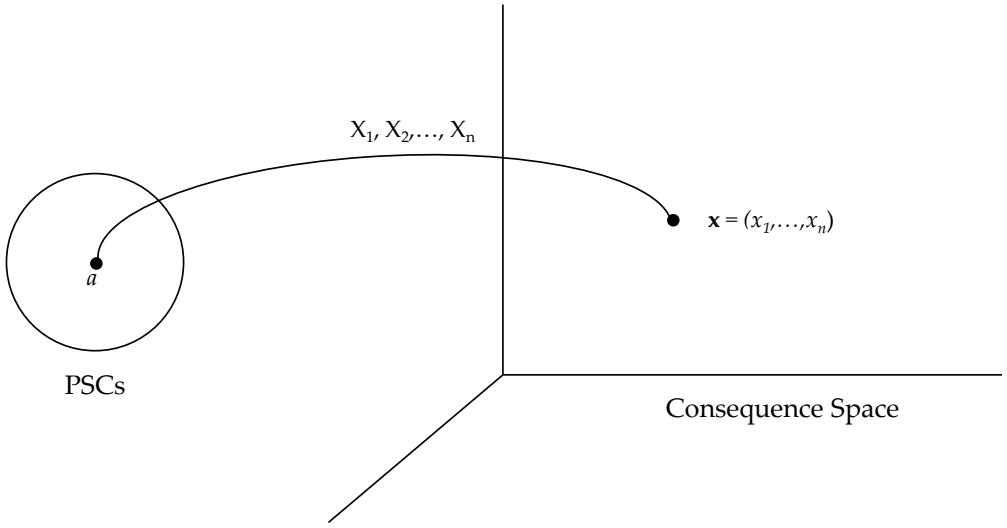


**Figure 6. Mapping of PSCs to the consequence space (modified from Keeney & Raiffa, 1993)**

### Measuring Supply Market Complexity.

IBIS *World* is a research organization that provides "valuable industry market research and procurement research" to enable better decision-making (IBIS *World*, 2015 [accessed: 8 December 2015]). The IBIS *World* Buyer Power Score is comprised of three components: price trends, market structure, and market risk. Factors within the three components are weighted and scored to produce an overall buyer power score. Some factors include availability of substitutes, market share concentration, product specialization, and switching costs are also considered. A higher score indicates greater buyer strength and a less complex market. AFICA obtains IBIS *World* reports for each PSC as part of their market research efforts. AFICA agrees that this report, and its associated Buying Power Score, properly evaluates the complexity of the market for a given PSC. A single evaluation measure will also simplify application of the MODA framework. Therefore, let $X$ be the IBIS *World* Buyer Power Score.

- **Assumption**

1. The IBIS *World* Buyer Power Score accurately reflects market complexity.

- **Limitations**

    1. Buyer Power Score calculations are proprietary.
    2. In-house data associated with factors within Buyer Power Scores are difficult to obtain within the timeframe of this study.

**Measuring Installation Mission Impact.**

We recall the term *spend* is defined as the dollars obligated by Air Force contracting agencies. AFICA installation spend data shows that sequestration in FY13 invoked budget cuts of approximately 13 percent. However, the FY14 budget for installation spend increased by nearly six percent. By comparing the slope of installation spend to the slope of individual PSC spend, we can deduce which PSCs are *critical* to the installation mission. That is, we can determine which PSCs *Maximize Installation Mission Impact*. It is our assumption that additional funds received in FY14 were spread across the most mission critical PSCs for a given installation. As a result, a PSC spend slope that is *more positive* from FY13 to FY14 than the overall installation spend slope during the same period indicates the PSC is *more critical* to the installation mission. However, a PSC spend slope that is *more negative* than the overall installation spend slope is indicative of a PSC that is *less critical* to the installation mission. As previously discussed, a single evaluation measure simplifies application of the MODA framework. Therefore, let $Y$ be the delta between the overall installation spend slope and PSC spend slope from FY13 to FY14.

- **Assumption**

    1. Once sequestration was enforced in FY13, commanders were free to *trim* their respective installation budget.

2. In like manner, budget increases in FY14 were able to be applied at commander discretion.

- **Limitations**

1. Ease of *trimming the budget* and directing *discretionary increases* is difficult to determine. That is, the range of budgetary actions accessible to commanders for individual PSCs cannot easily be assessed. Examples include:

   (a) 5-year in-place contracts may have resulted in automatic *increased* spend from FY13 to FY14.

   (b) The pool of PSCs may contain must pay bills whereby spend could not be reduced in FY13.

   (c) Policy rather than criticality of PSC impact to the installation mission may drive spend. For example, the Federal Acquisition Regulation (FAR) may require small business participation even if costs are ultimately increased. The impact of policy on spend is not considered in this study.

### 3.5 Single Attribute Value Function

Let $(X, Y)$ be the attribute space. Value functions for each attribute are developed to provide a value score such that $0 \leq v_x(x) \leq 1$ and $0 \leq v_y(y) \leq 1$. A single attribute value function (SAVF) for each attribute is all that is required since a single attribute was identified to measure each fundamental objective. Kirkwood identifies two possible SAVFs: piecewise linear and exponential (Kirkwood, 1996). To select the appropriate function for each attribute, interviews are conducted with AFICA team members who are experts in strategic sourcing and have experience using the KPM.

The goal of the interviews was to identify and build a value preference structure for each attribute by eliciting values using the fractile method as explained in Howard & Abbas, 2015. Elicitation sessions for both SAVFs determined the exponential SAVF to best represent value preference.

**Market Complexity.**

1. Let $A$ be the set of PSCs.
2. Let $x_i$ be the IBIS *World* Buyer Power Score for PSC $i \in A$.
3. Let $x^0$ and $x^*$ be the lowest and highest preferred value of attribute $X$ respectively. The corresponding values represent anchor points whereby $v_x(x)$ is scaled from 0 to 1 such that $v_x(x^0) = 0$ and $v_x(x^*) = 1$.
4. Let $v_x(x_i)$ be the SAVF of exponential form whereby each $x_i$ is an input and $\rho_x$ be the exponential constant for $v_x(x_i)$:

$$v_x(x_i) = \frac{1 - e^{[-(x_i - x^0)/\rho_x]}}{1 - e^{[-(x^* - x^0)/\rho_x]}} \ \forall i \in A \tag{3.1}$$

**Installation Mission Impact.**

1. Let $\alpha_i$ be FY14 spend for PSC $i \in A$
2. Let $\beta_i$ be FY13 spend for PSC $i \in A$
3. Let $p_i$ be the percent change of PSC $i \in A$ spend from FY13 to FY14:

$$p_i = \left( \frac{(\alpha_i - \beta_i)}{\beta_i} \right) \times 100 \ \forall i \in A \tag{3.2}$$

4. Let $I$ be the percent change of total installation spend from FY13 to FY14:

$$I = \left( \frac{\left( \sum_{i \in A} \alpha_i - \sum_{i \in A} \beta_i \right)}{\sum_{i \in A} \beta_i} \right) \times 100 \tag{3.3}$$

5. Let $y_i$ be the delta between total installation and individual PSC spend slopes from FY13 to FY14:

$$y_i = p_i - I \ \forall i \in A \tag{3.4}$$

6. Let $y^0$ and $y^*$ be the lowest and highest preferred value of attribute $Y$ respectively. The corresponding values represent anchor points whereby $v_y(y)$ is scaled such that $v_y(y^0) = 0$ and $v_y(y^*) = 1$.

7. Let $v_y(y_i)$ be the SAVF of exponential form whereby each $y_i$ is an input and $\rho_y$ is the exponential constant for $v_y(y_i)$:

$$v_y(y_i) = \frac{1 - e^{[-(y_i - y^0)/\rho_y]}}{1 - e^{[-(y^* - y^0)/\rho_y]}} \ \forall i \in A \tag{3.5}$$

### 3.6 The KPM

To position each PSC on the Kraljic model, we solve each SAVF individually to obtain a $(v_x(x_i), v_y(y_i))$ score such that $0 \leq v_x(x_i) \leq 1$ and $0 \leq v_y(y_i) \leq 1$. The $(v_x(x_i), v_y(y_i))$-pair is plotted on the coordinate plane (see Figure 7 below). The coordinate plane is also divided into 4 equal quadrants. Partitions occur at $v_x(x) = 0.5$ and $v_y(y) = 0.5$ under the assumption that $v_x(x) > 0.5$ indicates greater installation mission impact and $v_y(y) > 0.5$ indicates more supply market complexity. These partitions divide the coordinate plane into the four quadrants that represent the four quadrants of the KPM. Plotting each $(v_x(x_i), v_y(y_i))$ score, that is each PSC, using

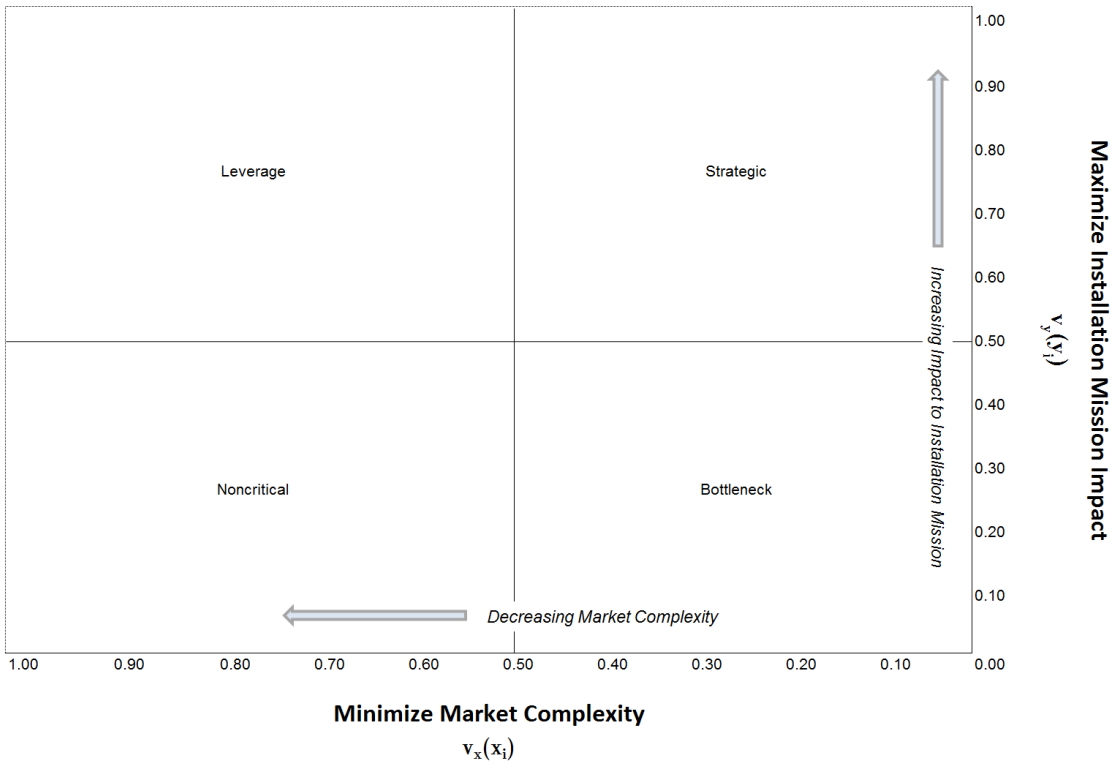


**Figure 7. KPM Framwork**

Figure 7 will help AFICA identify the full trade space among PSCs, allow comparisons between current contracting strategies with KPM-suggested strategies, and provide key information as to which PSC and its associated contracting strategy requires further analysis.

## 3.7 Multi-Attribute Value Function (MAVF) and Cost/Benefit Trade Space

The final step is to identify the weights associated with the two fundamental objectives. Given that Kraljic identifies a unique relationship between both axes of the matrix, a multilinear function must be created rather than a simple additive value model. Weights associated with each attribute and their interaction are determined following Keeney & Raiffa, 1993. First, identify $(v_x(x^0), v_y(y^0)) = 0$ as the "worst

possible value" and $(v_x(x^*), v_y(y^*)) = 100$ as the "best possible value." Next, determine which attribute AFICA prefers to swing to its *best case* while keeping the other attribute at its *worst case* and elicit its value. Next, determine the value of the opposing situation, swinging the other attribute to its *best case* while keeping the first attribute at its *worst case* and elicit this value. The results are the swing weight values for $w_x$ and $w_y$. Finally, calculate the interaction swing weight $w_{xy}$ by using equation 3.6

$$w_{xy} = 1 - w_x - w_y. \tag{3.6}$$

Finally, we calculate the MAVF by using equation 3.7 (Keeney & Raiffa, 1993):

$$V(x, y) = w_x v_x(x) + w_y v_y(y) + w_{xy} v_x(x) v_y(y) \tag{3.7}$$

After calculating the MAVF for each PSC within the KPM, a scatter plot of benefit versus FY10-14 spend is created. This identifies an efficient frontier whereby dominated and non-dominated alternatives can easily be identified. Sensitivity analysis is the final step to determine robustness of the MODA-framework as applied to the KPM and its associated results from AFICA's prioritized subset of PSCs.

# IV. Results and Analysis

## 4.1 Single Attribute Value Functions

### Supply Market Complexity.

The range of the IBIS *World* Buyer Power Score is from 1.00 to 5.00 in 0.01 increments (IBIS *World*, 2015 [accessed: 17 November 2015]). Thus, AFICA anchored the IBIS *World* Buyer Power Score attribute measure at a Low of $x^0 = 1.00$ and a High of $x^* = 5.00$ representing a value preference score of $v_x(x^0) = 0.00$ and $v_x(x^*) = 1.00$ respectively. AFICA representatives stated they prefer to operate in a market where companies score a 4.00. A series of questions revealed this score represents 90% of the overall value. Therefore, we let $v_x(4.00) = 0.90$. Difficulties in eliciting additional fractiles between 0.00 and 0.90 were encountered. Multiple approaches were used to bisect this area under the curve but were unsuccessful. However, the value preference elicitation session revealed an increasing exponential curve best represents underlying belief. Judgments were tested and consistency checks were performed to ensure AFICA representatives were comfortable with the distribution and that the curve was a good representation of value preferences. It is suggested that future attempts at value preference elicitation use the probability wheel technique as described by Howard & Abbas, 2015. Additionally, the rate of increase of the exponential function could not be determined as easily as with the PSC spend slope delta curve. To move forward, an increasing exponential function was fitted using the three points described above. Sensitivity analysis was performed specifically on the $v_x(4.00)$ value to assess the impact on KPM position should judgment surrounding a value score of 0.90 move up or down. Next, two arrays were created. One array represented the elicited fractiles and a second array represented the desired attribute score for its respective fractile. An exponential curve was fitted to the distribution by using

goal programming to minimize the sum of the squares of differences between the two arrays by changing rho. The fitted curve is shown in Figure 8. This curve was used

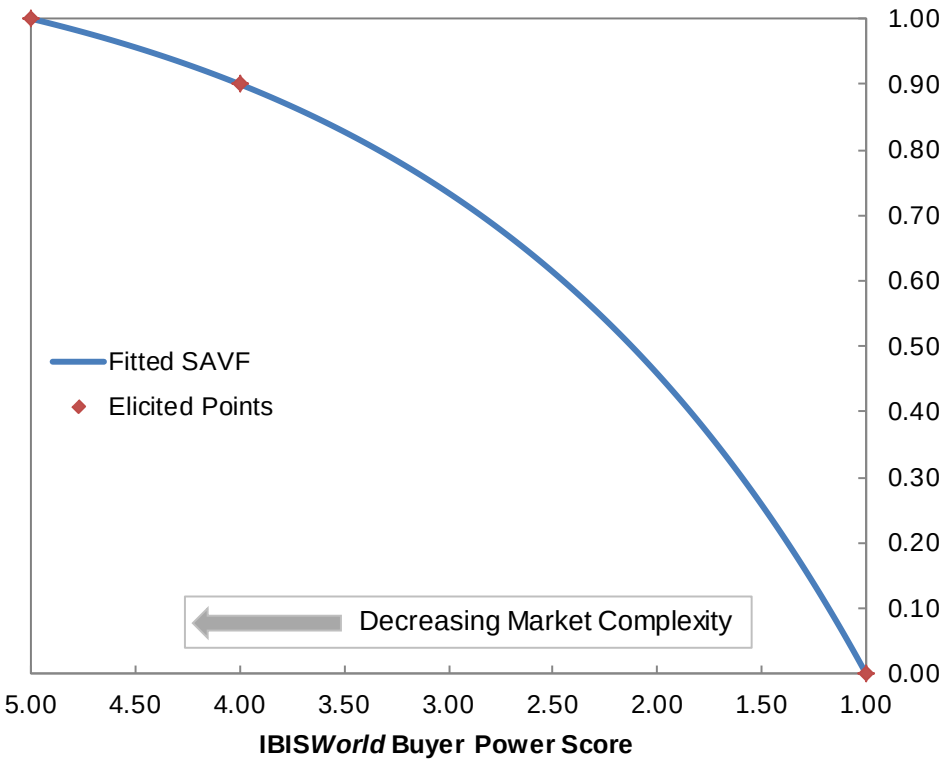


**Figure 8. SAVF used to measure Supply Market Complexity**

to calculate the IBIS *World* attribute score for each PSC by using Equation 3.1. Appendix D contains the complete list of scores. Table 1 provides summary statistics for this attribute. The higher-than-average attribute score is a result of relatively

**Table 1. SAVF 2 Summary Statistics**

| Type | Value |
|---|---|
| Min | 0.496 |
| Max | 0.980 |
| Average | 0.811 |
| Std Dev | 0.089 |
| Mode* | 0.894 |

*Mode count = 11

high IBIS *World* Buyer Power Scores which indicate a stronger than average buyer's

market. Again, this is both sensible and valid given the prioritized list of PSCs provided by AFICA. Furthermore, we expect this phenomena to present itself within the KPM.

**Installation Mission Impact.**

To build the value preference structure for the second attribute, fractiles of the distribution were elicited. AFICA anchored the spend slope delta at a Low of $y^0 = -2.00$ and a High of $y^* = +1.00$ representing a value preference score of $v_y(y^0) = 0.00$ and $v_y(y^*) = 1.00$ respectively. AFICA agreed that a match between PSC spending and installation spending, a spend slope delta of $y_i = 0$, generated 90 percent of the overall value. Therefore, let $v_y(0.00) = 0.90$. In other words, PSC spending that followed overall installation spend was indicative of a PSC that was very important to the installation mission given that budget cuts to that particular PSC were not implemented. Obtaining additional value preference fractiles were preferred in order to produce a line as close to underlying belief as possible. As with the first attribute, difficulties were experienced in fractile elicitation on the value preference range of 0.00 to 0.90. However, results from the elicitation session with AFICA revealed that an increasing exponential curve was a more accurate representation of underlying belief than a linear curve. After obtaining the fractiles, two arrays were created. One array represented the elicited fractiles and a second array represented the desired attribute score for its respective fractile. An exponential curve was fitted to the distribution by using goal programming to minimize the sum of the squares of differences between the two arrays by changing rho. The fitted curve is shown in Figure 9 below and was used to calculate the attribute score for each PSC by using Equation 3.5. Appendix D contains the complete list of scores.

Table 2 provides summary statistics for this attribute. The high average attribute

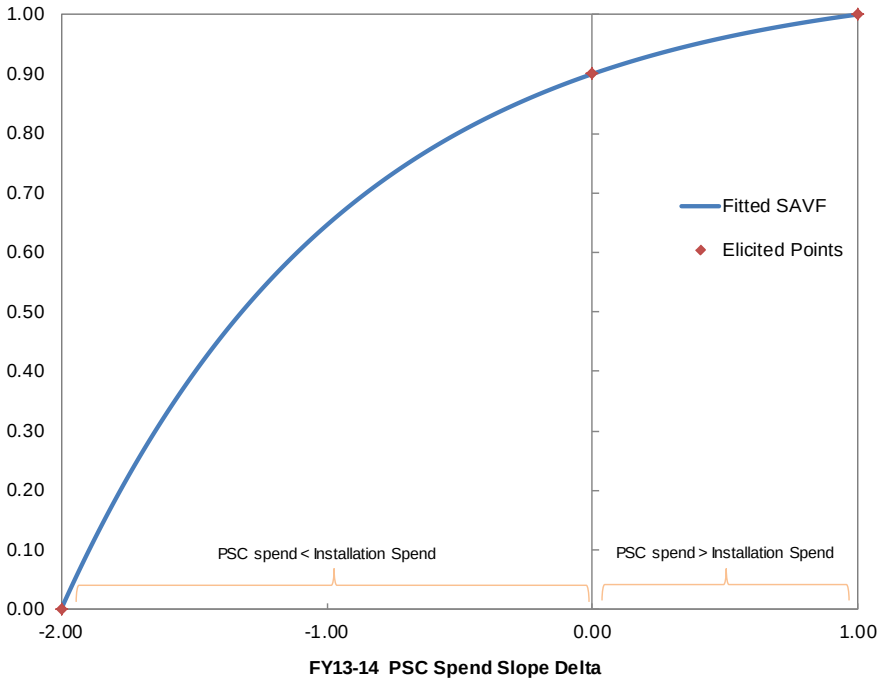


**Figure 9. SAVF used to measure Installation Mission Impact**

score indicates that this set of PSCs represents *critical* items for installation mission success and should be reflected in position on the KPM. Given that AFICA performed

**Table 2. SAVF 1 Summary Statistics**

| Type | Value |
|---|---|
| Min | 0.587 |
| Max | 1.000 |
| Average | 0.912 |
| Std Dev | 0.074 |
| Mode* | 1.000 |
| **Nr. PSCs** | 138 |
| **Nr. $>$ 0.90** | **86** |
| **% PSCs $>$ 0.90** | **62.3%** |

*Mode count = 19

a thorough analysis to create a prioritized list of PSCs most conducive for cost reduction, 62.3% of PSCs scoring higher than 0.900 along with a mode of 1.000 is both

sensible and valid. Of note, 19 of the 138 PSCs analyzed scored a 1.000. To state this another way, 19 PSCs are considered 100% critical to the installation mission. Table 3 identifies the 19 PSCs and their associated total spend for FY10-14. Although this small subset of PSCs represent only 2.5% of total installation spend, their combined total spend from FY10-14 is over $3.7 billion.

**Table 3. SAVF 1 – Installation Mission Impact: 19 PSCs Scoring 1.00**

| PSC | PSC Description | FY10 - 14 Spend |
|---|---|---|
| Z111 | Z111 (MAINT-REP-ALT/OFFICE BLDGS) | $ 1,076,718,071.12 |
| 5999 | 5999 (MISCELLANEOUS ELECTRICAL AND ELECTRONIC COMPONENTS) | $ 581,355,704.54 |
| 7025 | 7025 (ADP INPUT/OUTPUT AND STORAGE DEVICES) | $ 463,261,524.44 |
| 7050 | 7050 (ADP COMPONENTS) | $ 360,901,960.23 |
| Z2LB | Z2LB (REPAIR OR ALTERATION OF HIGHWAYS/ROADS/STREETS/BRIDGES/RAILWAYS) | $ 295,950,702.79 |
| 7021 | 7021 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), DIGITAL) | $ 288,628,521.76 |
| 6350 | 6350 (MISCELLANEOUS ALARM, SIGNAL, AND SECURITY DETECTION SYSTEMS) | $ 195,729,062.68 |
| 5410 | 5410 (PREFABRICATED AND PORTABLE BUILDINGS) | $ 99,097,618.34 |
| 2590 | 2590 (MISCELLANEOUS VEHICULAR COMPONENTS) | $ 70,531,561.18 |
| 7020 | 7020 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), ANALOG) | $ 52,812,638.83 |
| 7045 | 7045 (ADP SUPPLIES) | $ 50,673,185.57 |
| 7195 | 7195 (MISCELLANEOUS FURNITURE AND FIXTURES) | $ 48,489,014.24 |
| 4910 | 4910 (MOTOR VEHICLE MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT) | $ 36,842,294.86 |
| 7220 | 7220 (FLOOR COVERINGS) | $ 34,467,700.92 |
| 4210 | 4210 (FIRE FIGHTING EQUIPMENT) | $ 34,300,941.60 |
| 7290 | 7290 (MISCELLANEOUS HOUSEHOLD AND COMMERCIAL FURNISHINGS AND APPLIANCES) | $ 31,732,507.47 |
| 7490 | 7490 (MISCELLANEOUS OFFICE MACHINES) | $ 18,721,943.72 |
| 4120 | 4120 (AIR CONDITIONING EQUIPMENT) | $ 16,654,569.28 |
| 3590 | 3590 (MISCELLANEOUS SERVICE AND TRADE EQUIPMENT) | $ 9,465,936.98 |

**Top 50 Evaluation.**

To further examine attribute results, the top 50 scores for each SAVF were examined to determine if PSCs were present in both sets of scores. 15 PSCs were identified and their attribute scores along with FY10-14 total spend are given in Table 4 below. This list can be considered a good starting point for AFICA to compare current purchasing strategies versus commercial best practice since this set of PSCs is both important to the installation mission and in a strong buyer's market. Additionally, we expect to see this set of PSCs in a position within the KPM that connotes the potential for cost reductions.

**Table 4. PSCs in top 50 of both SAVFs**

| PSC | PSC Description | SAVF 1 Score | SAVF 2 Score | Grand Total |
|---|---|---|---|---|
| J059 | J059 (MAINT/REPAIR/REBUILD OF EQUIPMENT- ELECTRICAL AND ELECTRONIC EQUIPMENT COMPONENTS) | 0.94 | 0.87 | $ 1,779,285,662.29 |
| 7030 | 7030 (ADP SOFTWARE) | 0.97 | 0.87 | $ 1,703,974,283.28 |
| 5840 | 5840 (RADAR EQUIPMENT, EXCEPT AIRBORNE) | 0.97 | 0.87 | $ 776,035,548.60 |
| 7035 | 7035 (ADP SUPPORT EQUIPMENT) | 0.95 | 0.86 | $ 640,005,251.47 |
| 5999 | 5999 (MISCELLANEOUS ELECTRICAL AND ELECTRONIC COMPONENTS) | 1.00 | 0.86 | $ 581,355,704.54 |
| 7025 | 7025 (ADP INPUT/OUTPUT AND STORAGE DEVICES) | 1.00 | 0.94 | $ 463,261,524.44 |
| J066 | J066 (MAINT/REPAIR/REBUILD OF EQUIPMENT- INSTRUMENTS AND LABORATORY EQUIPMENT) | 0.96 | 0.86 | $ 418,840,837.44 |
| 7050 | 7050 (ADP COMPONENTS) | 1.00 | 0.86 | $ 360,901,960.23 |
| 7021 | 7021 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), DIGITAL) | 1.00 | 0.92 | $ 288,628,521.76 |
| 8415 | 8415 (CLOTHING, SPECIAL PURPOSE) | 1.00 | 0.90 | $ 162,601,633.63 |
| J049 | J049 (MAINT/REPAIR/REBUILD OF EQUIPMENT- MAINTENANCE AND REPAIR SHOP EQUIPMENT) | 0.97 | 0.86 | $ 115,220,071.38 |
| 7020 | 7020 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), ANALOG) | 1.00 | 0.92 | $ 52,812,638.83 |
| 7045 | 7045 (ADP SUPPLIES) | 1.00 | 0.92 | $ 50,673,185.57 |
| AC56 | AC56 (R&D- DEFENSE SYSTEM: WEAPONS (MANAGEMENT/SUPPORT)) | 0.96 | 0.89 | $ 50,299,696.91 |
| 7490 | 7490 (MISCELLANEOUS OFFICE MACHINES) | 1.00 | 0.98 | $ 18,721,943.72 |

## 4.2 AFICA's Prioritized PSCs and the Kraljic Portfolio Matrix

Using MODA as a framework provides a unique analytical method to score the attributes associated with each axis of the KPM. Tables 16 - 18 and Tables 19 - 21 provide the *Supply Market Complexity* and *Installation Mission Impact* scores respectively for each PSC and are located in Appendix D. Using the scores from both tables, each $(v_x(x_i), v_y(y_i))$-pair representing each PSC is positioned within the KPM as shown in Figure 10. A summary of the count of PSCs per KPM quadrant is also provided in Table 5. The discussion that follows examines each quadrant containing PSCs in more detail.

**Table 5. AFICA KPM Quadrant Breakdown**

| Quadrant Nr. | Quadrant | Count |
|---|---|---|
| I | Leverage | 137 |
| II | Strategic | 1 |
| III | Bottleneck | 0 |
| IV | Noncritical | 0 |
| | *Total:* | *138* |

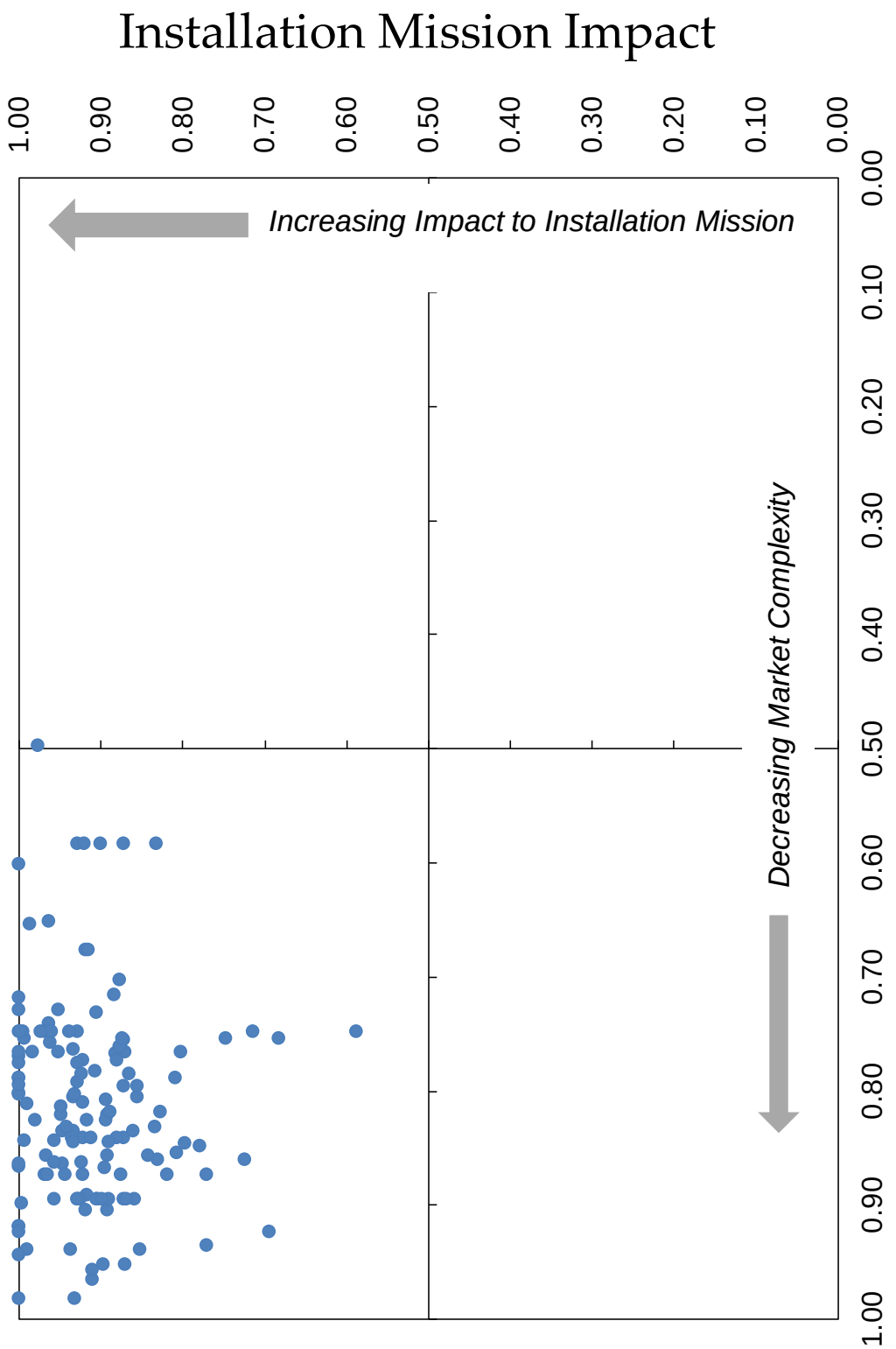


**Figure 10. AFICA PSCs Positioned in the KPM Using MODA**

**Quadrant I – Leverage.**

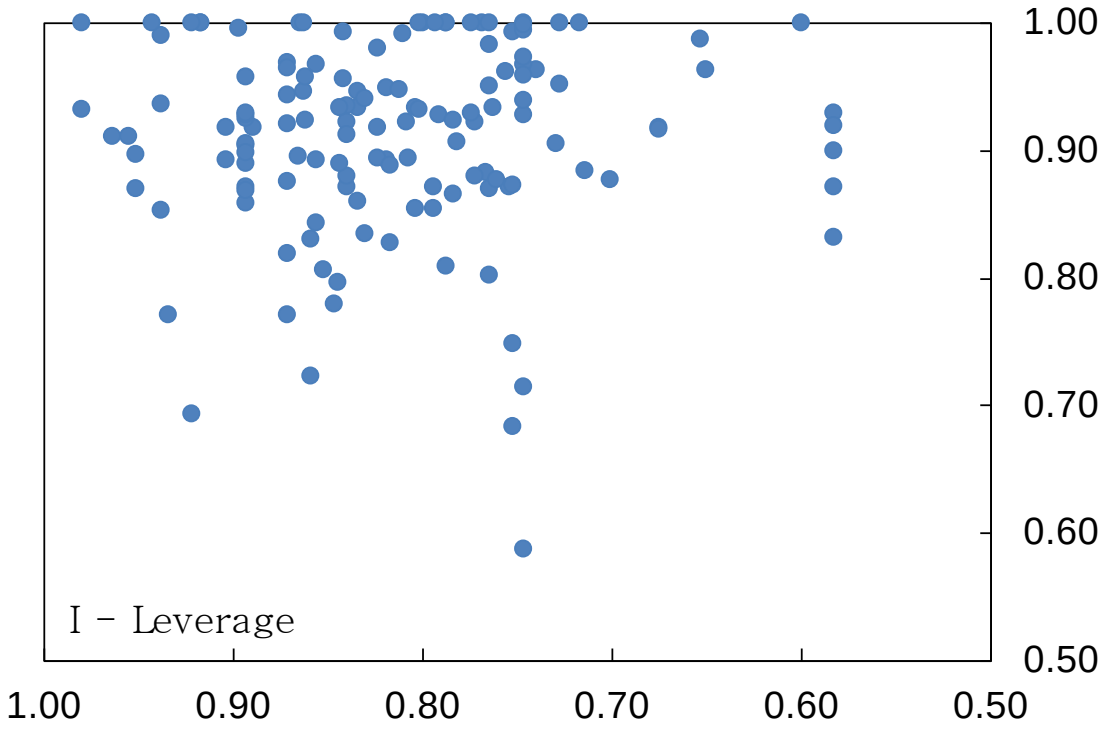


**Figure 11. Quadrant I – Leverage**

Positioning prioritized PSCs using the MODA framework method confirms AFICA internal analysis processes given that 137 of the 138 PSCs are positioned in the Leverage quadrant of the KPM. Research shows that this quadrant is best suited for reductions in cost and it is suggested the purchasing organization use its full buying power to exploit this type of market through "tough negotiations, targeted pricing and product substitution" (Gelderman & Van Weele, 2002). It is helpful to take a closer look at the Leverage quadrant by bisecting both axes to create four equal partitions or sub-quadrants. There is no mathematical or analytical thrust for this type of breakdown. It is simply a method employed to take a closer look at the Leverage Quadrant. The results of this breakdown are shown in Table 6 and their respective Figures are provided in Appendix G (Figures 22 - 25). Most importantly, AFICA's

**Table 6. Leverage Quadrant Breakdown**

| Partition Nr. | SAVF 1 Range | SAVF 2 Range | Count |
|---|---|---|---|
| 1 | (0.75, 1.00) | (0.75, 1.00) | 106 |
| 2 | (0.75, 1.00) | (0.50, 0.75) | 25 |
| 3 | (0.50, 0.75) | (0.50, 0.75) | 2 |
| 4 | (0.50, 0.75) | (0.75, 1.00) | 4 |

analysis is further justified due to the fact 106 of the 138 PSCs in this quadrant are in the partition producing the highest attribute scores. To state this another way, 106 of the 138 PSCs are located in a portion of the KPM most advantageous to exploit purchasing power and reduce costs.

**Quadrant II – Strategic.**

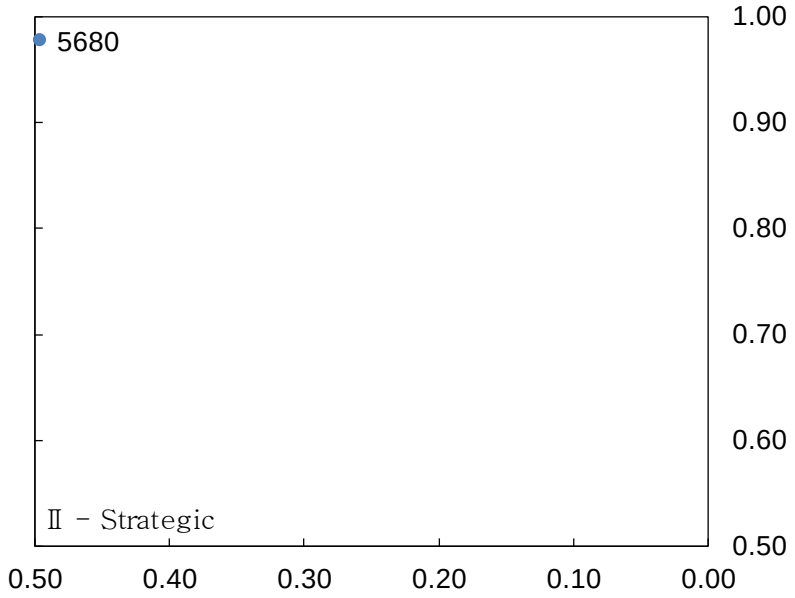


**Figure 12. Quadrant II – Strategic**

Only one PSC is located in the Strategic Quadrant, PSC 5680 - Miscellaneous Construction Materials as shown in Figure 12. Sensitivity analysis was conducted on

SAVF 2 given the difficulty of eliciting multiple value preference scores. To perform sensitivity analysis, value preference scores associated with the IBIS *World* Buyer Power Score of 4.00 were adjusted from 0.75 to 0.95 in 0.05 increments. For each increment, a new exponential curve was fit to the corresponding distribution. In each case, the only effect to the KPM was the entire plot of its PSCs shifted to the right resulting in an increase in the number of PSCs positioned within the Strategic Quadrant. Table 7 identifies the number of PSCs positioned within the Strategic Quadrant for a given value associated with the IBIS *World* Buyer Power Score of 4.00. In the worst case, reducing the value associated with an IBIS *World* Buyer

**Table 7. Strategic Quadrant Sensitivity Analysis**

| Distribution Value | Nr. PSCs in Strategic Quadrant |
|---|---|
| 0.95 | 0 |
| 0.90* | 1 |
| 0.85 | 6 |
| 0.80 | 9 |
| 0.75 | 17 |

**Current value used to create SAVF 2*

Power Score of 4.00 from its current value of 0.90 to 0.75 results in 16 additional PSCs transitioning from the Leverage Quadrant to the Strategic Quadrant and is depicted in Figure 13. This scenario *only* exists *if* the value of an IBIS *World* Buyer Power Score of 4.00 is overestimated from its current value of 90%. However, it is unlikely this value reaches 0.75 due to the fact the curve at this level is almost linear (see Figure 14). Moreover, discussions while assessing value judgments indicate a linear curve is not in line with underlying belief of AFICA representatives and therefore rules out this possibility. However, an increasing exponential curve is a better representation of value preference. AFICA can still use this information to determine if Leverage Quadrant strategies are suitable for the 16 PSCs capable of shifting quadrants.

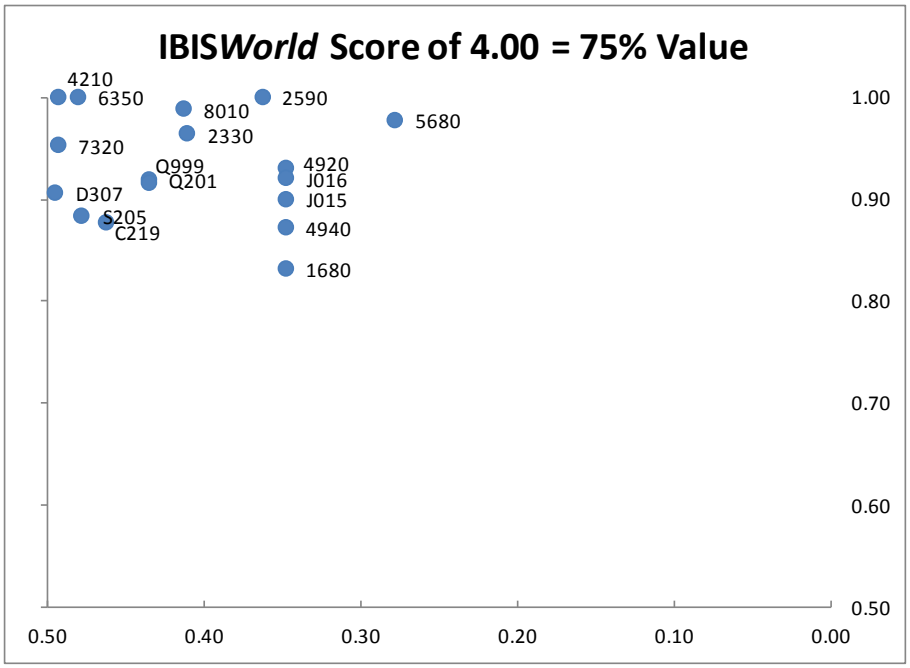


**Figure 13. New Strategic Quadrant**

### 4.3 MODA Framework Continued

To further examine PSCs positioned within the KPM, weights are elicited for both single attribute value functions by using the process outlined in section 3.7. Recall that $(v_x(x^0), v_y(y^0)) = 0$ and $(v_x(x^*), v_y(y^*)) = 100$. These two points represent opposing ends of the KPM in the Bottleneck and Leverage quadrants respectively. To determine weights, values are elicited for the following scenarios: $(v_x(x^*), v_y(y^0))$ and $(v_x(x^0), v_y(y^*))$ which also represent opposing ends of the KPM in the Noncritical and Strategic quadrants respectively. The location of these values are shown in Figure 15 below and are outlined in red. AFICA representatives revealed the two locations under consideration represent the worst possible scenario in which to operate given the limitations imposed by the Federal Acquisition Regulation (FAR). Such limitations are not discussed here. However, it can easily be understood that the weight associated with the strategic quadrant represents a scenario where an item is extremely important to the mission but is only found in a very complex market.

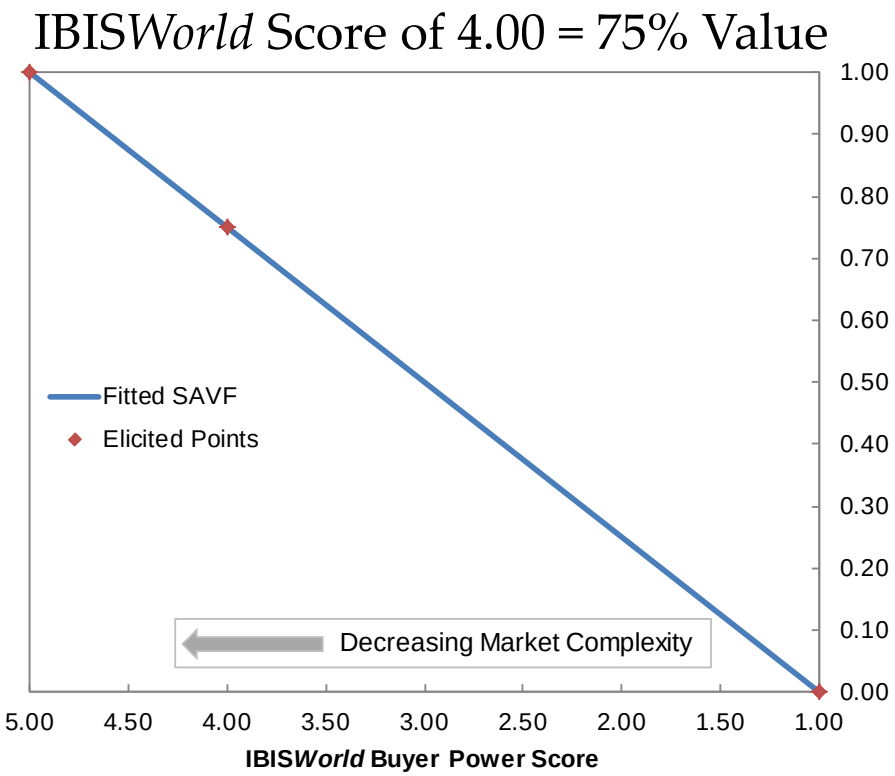


**Figure 14. SAVF 1 Curve Sensitivity Analysis**

The weight associated with the noncritical item represents an item not important to the mission yet abides in a complex market. Either scenario is not preferred by AFICA representatives. Value preference elicitation sessions revealed they preferred to swing attribute Y (Installation Mission Impact) to its best while holding attribute X (Supply Market Complexity) at its worst over the opposing situation. However, the value they assigned to this swing was roughly 50%. The same held for the opposing situation. Swinging attribute X to its best while holding attribute Y represented a value of approximately 50% to the team. To move forward, the values in Table 8 were assigned for ease of calculation. However, sensitivity analysis was performed on the weights. The weights are used to create a multi-attribute value function (MAVF) using Equation 3.7. The MAVF is a weighted sum of multiple single attribute value functions using the weights identified in Table 8. The MAVF takes the attribute

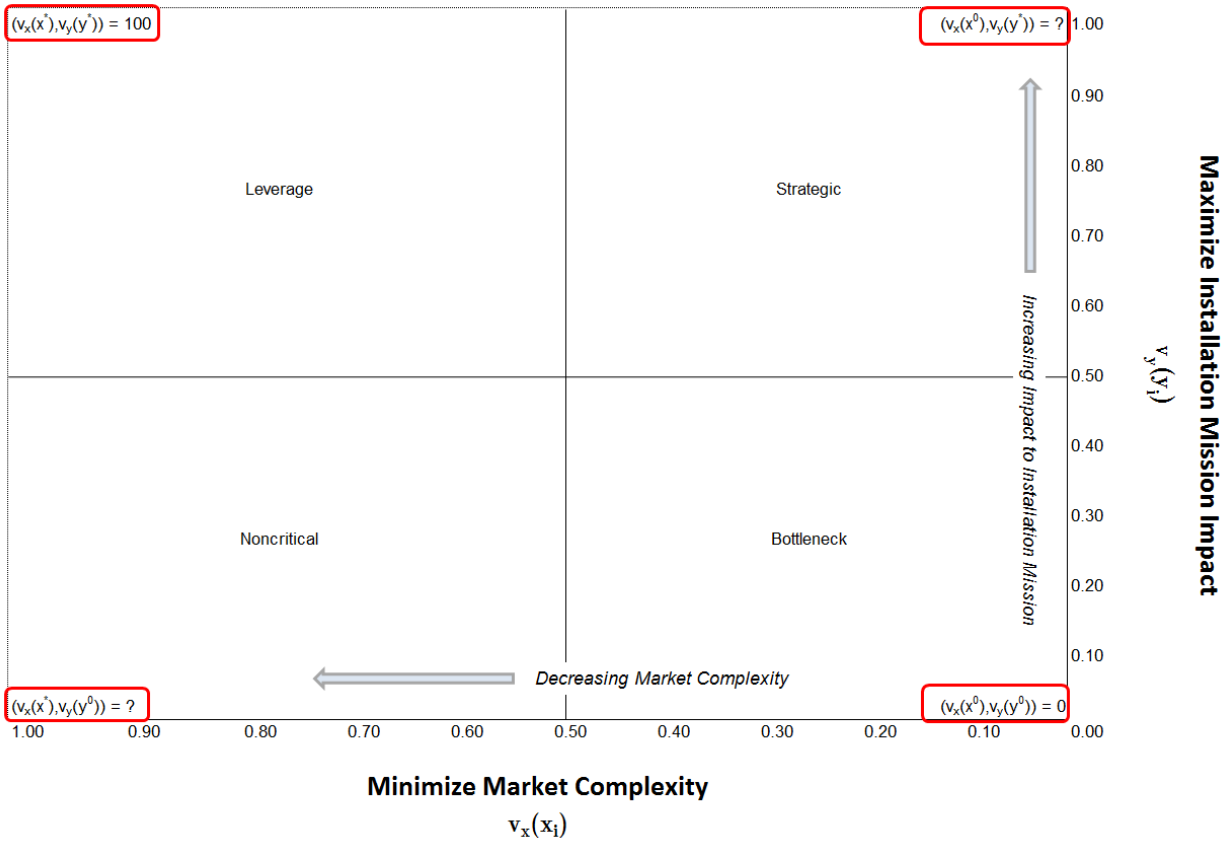


**Figure 15. Location of swing weight pairs**

**Table 8. MAVF Weights**

| Weight | Value |
|---|---|
| $w_y$ | 0.52 |
| $w_x$ | 0.48 |
| $w_{xy}$ | 0.00 |

scores for each PSC as inputs to produce a rank-order list of PSCs.The complete listing of MAVF scores is provided in Appendix D. The top 25 are listed in Table 9 for pertinent discussion. In practice, the MAVF is used to evaluate each alternative and identify the "winner," or the "best choice" among numerous alternatives, with regard to the hierarchical set of evaluation measures. To create a MAVF for the KPM is not necessary since the scoring of the two SAVFs allows positioning withing the KPM. However, the MAVF may be useful to an organization such as AFICA that is

**Table 9. Top 25 PSCs**

| PSC | PSC Description | FY10-14 Spend ($M) | MAVF Score |
|---|---|---|---|
| 7490 | 7490 (MISCELLANEOUS OFFICE MACHINES) | $ 18.72 | 0.991 |
| 7025 | 7025 (ADP INPUT/OUTPUT AND STORAGE DEVICES) | $ 463.26 | 0.973 |
| 5836 | 5836 (VIDEO RECORDING AND REPRODUCING EQUIPMENT) | $ 54.37 | 0.965 |
| 7045 | 7045 (ADP SUPPLIES) | $ 50.67 | 0.963 |
| 7020 | 7020 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), ANALOG) | $ 52.81 | 0.960 |
| 7021 | 7021 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), DIGITAL) | $ 288.63 | 0.960 |
| 7520 | 7520 (OFFICE DEVICES AND ACCESSORIES) | $ 24.17 | 0.955 |
| 8415 | 8415 (CLOTHING, SPECIAL PURPOSE) | $ 162.60 | 0.949 |
| 5810 | 5810 (COMMUNICATIONS SECURITY EQUIPMENT AND COMPONENTS) | $ 594.46 | 0.937 |
| 5985 | 5985 (ANTENNAS, WAVEGUIDES, AND RELATED EQUIPMENT) | $ 628.88 | 0.936 |
| 5999 | 5999 (MISCELLANEOUS ELECTRICAL AND ELECTRONIC COMPONENTS) | $ 581.36 | 0.935 |
| 7050 | 7050 (ADP COMPONENTS) | $ 360.90 | 0.934 |
| 7010 | 7010 (ADPE SYSTEM CONFIGURATION) | $ 666.54 | 0.932 |
| AC56 | AC56 (R&D- DEFENSE SYSTEM: WEAPONS (MANAGEMENT/SUPPORT)) | $ 50.30 | 0.927 |
| 5805 | 5805 (TELEPHONE AND TELEGRAPH EQUIPMENT) | $ 363.59 | 0.923 |
| 5840 | 5840 (RADAR EQUIPMENT, EXCEPT AIRBORNE) | $ 776.04 | 0.922 |
| V126 | V126 (TRANSPORTATION/TRAVEL/RELOCATION- TRANSPORTATION: SPACE TRANSPORTATION/LAUNCH) | $ 3,745.18 | 0.921 |
| 7030 | 7030 (ADP SOFTWARE) | $ 1,703.97 | 0.920 |
| J049 | J049 (MAINT/REPAIR/REBUILD OF EQUIPMENT- MAINTENANCE AND REPAIR SHOP EQUIPMENT) | $ 115.22 | 0.914 |
| R706 | R706 (SUPPORT- MANAGEMENT: LOGISTICS SUPPORT) | $ 5,572.89 | 0.912 |
| D316 | D316 (IT AND TELECOM- TELECOMMUNICATIONS NETWORK MANAGEMENT) | $ 716.58 | 0.912 |
| J066 | J066 (MAINT/REPAIR/REBUILD OF EQUIPMENT- INSTRUMENTS AND LABORATORY EQUIPMENT) | $ 418.84 | 0.911 |
| R497 | R497 (SUPPORT- PROFESSIONAL: PERSONAL SERVICES CONTRACTS) | $ 391.60 | 0.911 |
| AJ16 | AJ16 (R&D- GENERAL SCIENCE/TECHNOLOGY: PHYSICAL SCIENCES (MANAGEMENT/SUPPORT)) | $ 126.75 | 0.910 |
| J059 | J059 (MAINT/REPAIR/REBUILD OF EQUIPMENT- ELECTRICAL AND ELECTRONIC EQUIPMENT COMPONENTS) | $ 1,779.29 | 0.909 |

positioning items within the KPM for the first time. This is because the rank-order list *may* provide insight in answering the question: "Now that items are positioned with the KPM, where do we start?" It is important to note that the "winner" maximizes the value measures according to the assigned weights. For the list in Table 9, PSC 7490 (Miscellaneous Office Machines) has the highest MAVF score. This simply connotes this particular PSC, given the supplied weighting as discussed previously, has the highest impact to mission and is in the "best" buyer's market. It can be considered the "best" candidate for AFICA to start with in applying commercial best practice strategies to reduce costs.

### 4.4 Cost – Benefit Trade Space

MODA allows additional analysis by examining the cost-benefit trade space. To do this, a scatterplot is created using the MAVF score and its associated cost. The y-axis (MAVF Score) in this figure only considers the range of values from 0.70 to 1.00 given that this range *fully* captures the cost-benefit trade space. The non-dominated

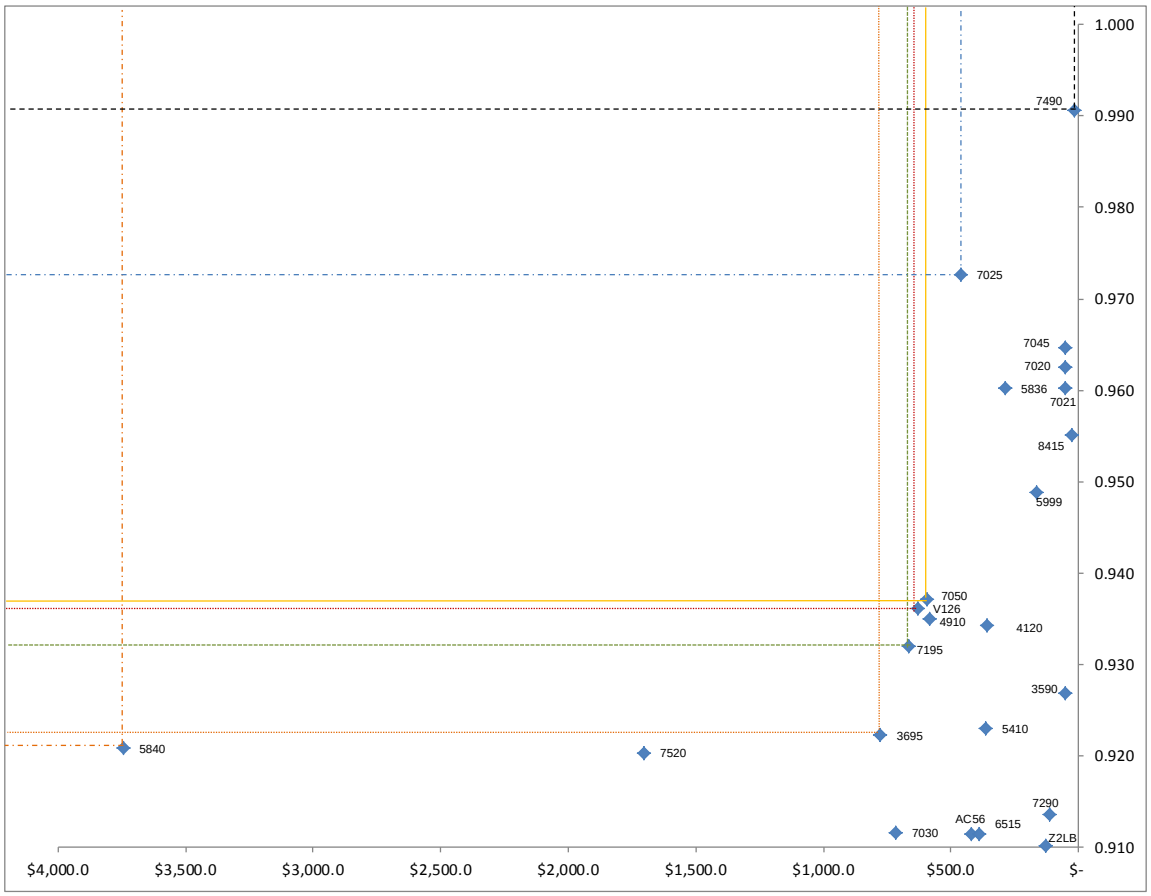


**Figure 16. Cost-Benefit Trade Space and Non-Dominated Alternatives**

PSCs are marked accordingly with the assumption that AFICA prefers to reduce costs to the most expensive PSCs with the highest "benefit" (MAVF Score) first. The nondominated PSCs form the Pareto optimal set, or efficient frontier, of PSCs. Kirkwood (1996) states that "the most preferred alternative for a decision problem will be in the efficient set." Again, identifying the Pareto optimal set is beneficial to an organization such as AFICA when positioning items within the KPM in that it may determine the "best" place to start implementing new or improved purchasing strategies. The Pareto optimal set shown in Figure 16 is also listed in Table 10 below.

**Table 10. AFICA PSC Pareto Optimal Set**

| PSC | PSC Description | FY10-14 Spend ($M) | MAVF Score |
|---|---|---|---|
| 7490 | 7490 (MISCELLANEOUS OFFICE MACHINES) | $ 18.72 | 0.991 |
| 7025 | 7025 (ADP INPUT/OUTPUT AND STORAGE DEVICES) | $ 463.26 | 0.973 |
| 7050 | 7050 (ADP COMPONENTS) | $ 360.90 | 0.934 |
| 5840 | 5840 (RADAR EQUIPMENT, EXCEPT AIRBORNE) | $ 776.04 | 0.922 |
| V126 | V126 (TRANSPORTATION/TRAVEL/RELOCATION- TRANSPORTATION: SPACE TRANSPORTATION/LAUNCH) | $ 3,745.18 | 0.921 |
| 3695 | 3695 (MISCELLANEOUS SPECIAL INDUSTRY MACHINERY) | $ 40.96 | 0.904 |
| 7195 | 7195 (MISCELLANEOUS FURNITURE AND FIXTURES) | $ 48.49 | 0.901 |

## 4.5 Sensitivity Analysis

The value of considering the MAVF is the ability to perform sensitivity analysis with regard to the weights associated with each SAVF. This analysis provides insight as to whether or not the MODA framework provides a robust technique or not with regard to changes in the swing weights. The figures below show the effect of changes in the swing weights associated with both fundamental objectives. Figure 17 illustrates

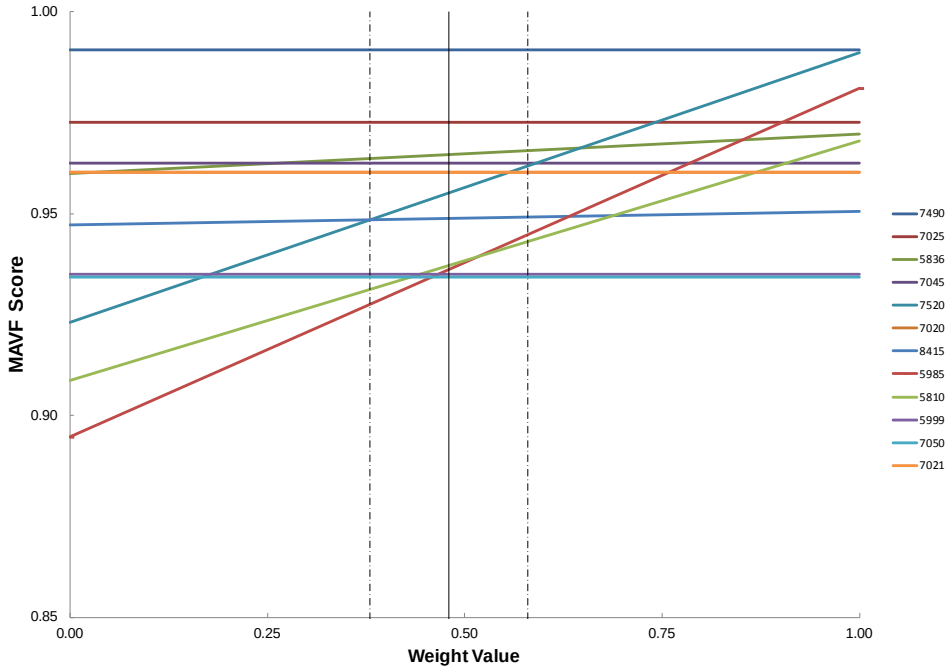


**Figure 17. Sensitivity to $w_x$**

the impact of adjusting $w_x$, the weight assigned to the first fundamental objective: Minimizing Supply Market Complexity. The dashed line in this figure represents

a range of $0.38 \leq w_x \leq 0.58$. Figure 18 illustrates the impact of adjusting $w_y$, the

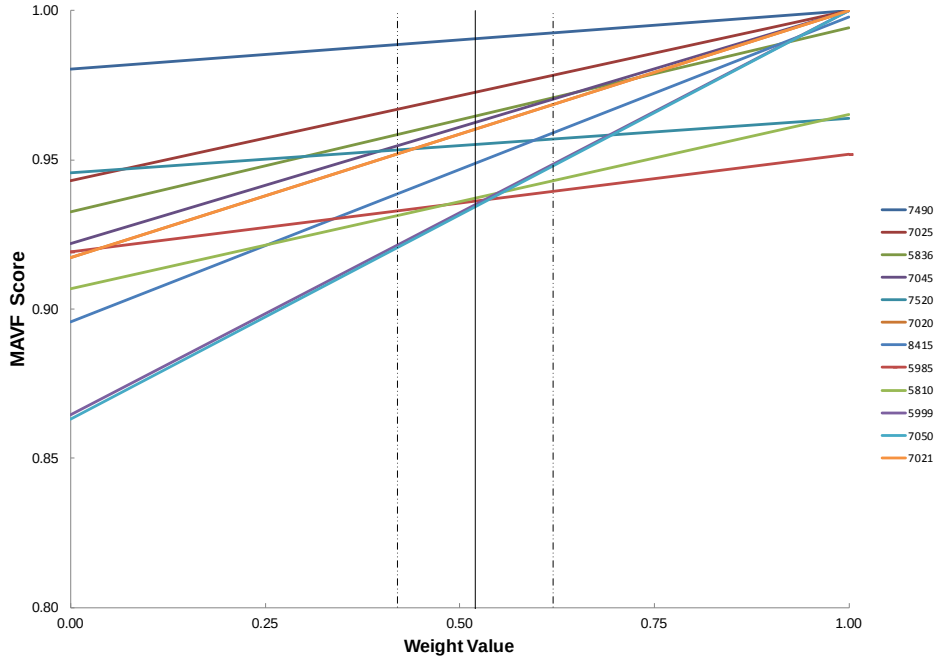


**Figure 18. Sensitivity to $w_y$**

weight assigned to the second fundamental objective: Maximizing Installation Mission Impact. The dashed line indicates a range of $0.42 \leq w_y \leq 0.62$. In both cases, the top four PSCs do not change order. Additionally, in all possible combinations of adjusting $w_1$ and $w_2$ between $(-0.10, +0.10)$, at most only twelve different PSCs were present within the top 10. They are identified in Table 11 below. Moreover, the top 8 always

**Table 11. 12 PSCs within $\pm 0.10$ of current assigned weights**

| PSC | PSC Description |
|---|---|
| 7490 | MISCELLANEOUS OFFICE MACHINES |
| 7025 | ADP INPUT/OUTPUT AND STORAGE DEVICES |
| 5836 | VIDEO RECORDING AND REPRODUCING EQUIPMENT |
| 7045 | ADP SUPPLIES |
| 7020 | ADP CENTRAL PROCESSING UNIT CPU, COMPUTER, ANALOG |
| 7021 | ADP CENTRAL PROCESSING UNIT CPU, COMPUTER, DIGITAL |
| 7520 | OFFICE DEVICES AND ACCESSORIES |
| 8415 | CLOTHING, SPECIAL PURPOSE |
| 5810 | COMMUNICATIONS SECURITY EQUIPMENT AND COMPONENTS |
| 5985 | ANTENNAS, WAVEGUIDES, AND RELATED EQUIPMENT |
| 5999 | MISCELLANEOUS ELECTRICAL AND ELECTRONIC COMPONENTS |
| 7050 | ADP COMPONENTS |

remained within the top 10 list. In only specific instances, the 9th and 10th ranking PSCs (5810 and 5985) were replaced by either 5999 or 7050. The list of twelve PSCs

can also represent a good starting point for AFICA to pursue further analysis. In all, the sensitivity analysis results confirm the robustness of using MODA, the power of using MODA as a framework to position PSCs in the KPM, the MODA's ability to accurately map PSCs, and the adequate reflection of the underlying value preference structure of decision makers.

### 4.6 AFICA's Non-Prioritized PSCs and the Kraljic Portfolio Matrix

To further examine our MODA-framework, we positioned eleven PSCs (Table 12) within the KPM that were not part of AFICA's prioritized set of 138 using the same SAVFs as described in section 4.1.

**Table 12. Non-Prioritized PSC List**

| PSC | PSC DESCRIPTION |
|---|---|
| J042 | MAINT/REPAIR/REBUILD OF EQUIP–FIRE FIGHTING/RESCUE/SAFETY EQUIP; ENVIRON PROTECT EQUIP/MATLS |
| F015 | NATURAL RESOURCES/CONSERVATION–WELL DRILLING/EXPLORATORY |
| R704 | SUPPORT–MANAGEMENT: AUDITING |
| D310 | IT AND TELECOM–CYBER SECURITY AND DATA BACKUP |
| W022 | LEASE OR RENTAL OF EQUIPMENT–RAILWAY EQUIPMENT |
| 6635 | PHYSICAL PROPERTIES TESTING AND INSPECTION |
| 6830 | GASES: COMPRESSED AND LIQUEFIED |
| G002 | SOCIAL–CHAPLAIN |
| 5640 | WALLBOARD, BUILDING PAPER, AND THERMAL INSULATION MATERIALS |
| C215 | ARCHITECT AND ENGINEERING- GENERAL: PRODUCTION ENGINEERING |
| J060 | MAINT/REPAIR/REBUILD OF EQUIPMENT- FIBER OPTICS MATERIALS, COMPONENTS, ASSEMBLIES, AND ACCESSORIES |

Appendix I provides a breakdown of their SAVF and MAVF scores and Figure 19 provides their respective position within the KPM. We immediately notice that two PSCs (6635 and R704) are positioned in the Leverage quadrant. They represent a combined annual spend of nearly $25M. However, both PSCs were not prioritized by AFICA to be considered for cost reduction. This is due to the fact that AFICA's internal analysis used overall spend with their KPI scoring criteria as a means to prioritize PSCs. Although we understand AFICA's desire to focus its efforts on PSCs that have large impacts on the USAF budget, our analysis highlights that this prioritization criteria may result in potential missed opportunities for cost reduction. In fact, this discussion promotes positioning PSCs within the KPM using the MODA-framework

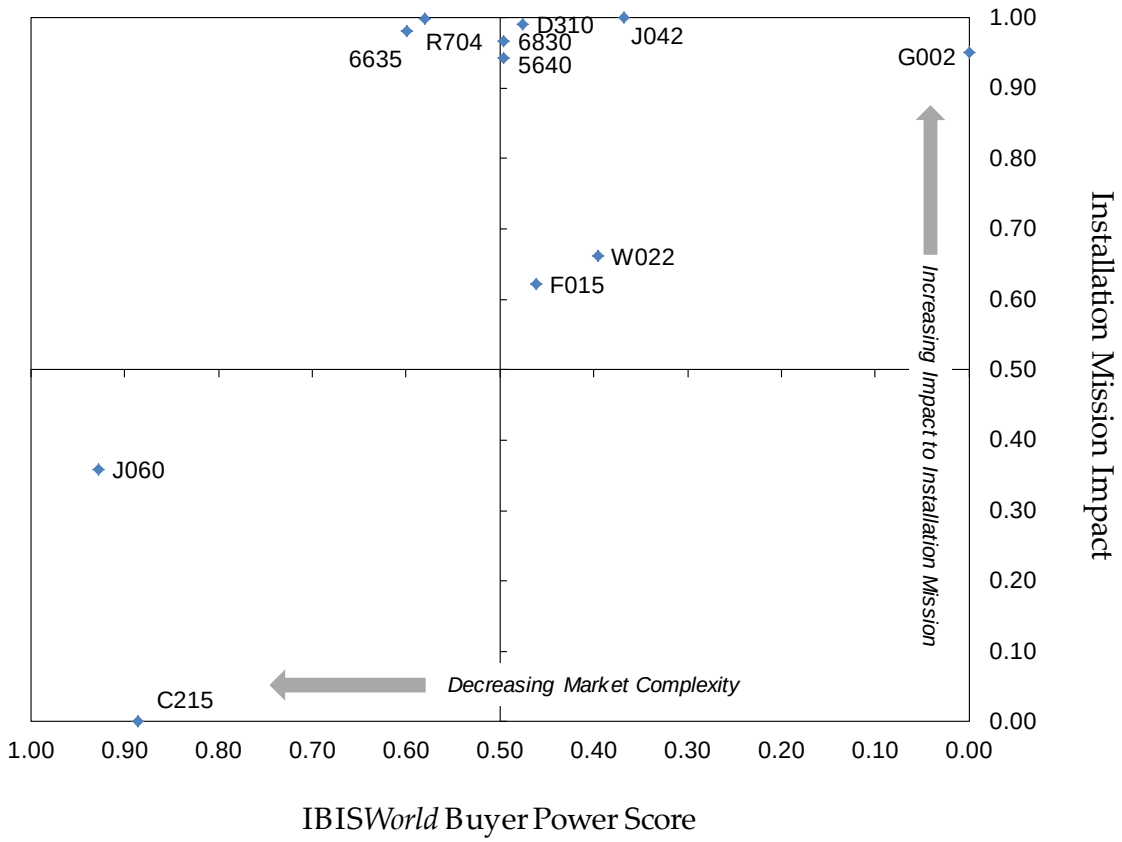


**Figure 19. KPM Plot of Non-Prioritized PSCs**

as an effective starting point *prior to* implementing AFICA internal analysis.

We noted that seven PSCs were positioned in the strategic quadrant and that the only PSC that appeared "abnormal" is PSC G002. A score of 0.00 was assigned for SAVF 1 due to the fact IBIS*world* does not provide any market research for this type of service. The question was raised: *Was the correct attribute selected to measure this particular fundamental objective?* We assumed that no market report is indicative of a market that is not a "buyer's market." Therefore, according to our scoring criteria, we assumed this is a *completely complex* market in which to operate, we ensured AFICA confirmed this assumption, and we assigned its attribute score as 0.00. This fact, along with the fact that spending remained steady from FY10-14, resulted in G002 being positioned in the strategic quadrant. Therefore, we have no reason to believe an

inappropriate evaluation measure i in use. Although G002 is only responsible for an average of $3.6M of annual spend for FY10-14, the MODA framework appropriately positions it in the strategic quadrant. Again, by not considering KPM position *first* and only relying on the combination of KPI score and overall spend, AFICA may not be able to identify PSCs that should require further investigation as a result of its divergence from the leverage quadrant.

Of interest is the fact that no PSCs were positioned within the bottleneck quadrant. Therefore the question was raised: *Do the current value functions prohibit positioning within the bottleneck quadrant?* First, we see that a PSC must obtain an IBIS *World* Buyer Power Score of less than 2.13 and a PSC – Installation spend slope delta of less than $-1.32$. Of the 967 possible IBIS *World* Buyer Power Scores, 11 are less than 2.13. Of the 1,702 PSCs involved in Installation Spend, 24 have a PSC – Installation spend slope delta of less than $-1.32$. Although relatively small, opportunities *do exist* for PSCs to be positioned within the bottleneck quadrant. At first glance, the limited number of opportunities for bottleneck positioning may seem illogical. However, two explanations lend credence to this phenomena:

1. Discussions with AFICA revealed that items procured (PSCs) to run installations are more often than not common goods and services of which markets exist beyond USAF needs.

2. In Kraljic's seminal work, he provides an example of a company that defined only 75 out of 5,000 items as either strategic or bottleneck.

Finally, after calculating their respective MAVF scores and including them in the Cost–Benefit Trade Space Plot, we find that the Pareto Optimal Set does not change. Again, this is due to the low FY10-14 spend of the non-prioritized PSCs. We noted that although non-prioritized PSCs may not land in the Pareto Optimal Set, the aggregate spend of non-prioritized PSCs within the leverage quadrant should not

be overlooked. We emphasize that the Leverage Quadrant is the *starting point* for finding PSCs with high potential for cost reduction. The KPM helps identify such PSCs. The Pareto Optimal set simply identifies which of those PSCs to select first for implementing strategic sourcing efforts.

# V. Discussion

## 5.1 Conclusions

This research demonstrated the ability to position items within the Kraljic Portfolio Matrix (KPM) both accurately and quantitatively by using multi-objective decision analysis (MODA) as a framework. We have demonstrated that this technique is effective in answering the Air Force Installation Contracting Agency's (AFICA) fundamental research question: *How does* AFICA *determine if current contracting strategies are in line with commercial best practices?* We recognized that the events surrounding sequestration offered a unique opportunity to create a KPM-positioning method based on past decision information. The mere fact we accurately reflected prior decisions is indicative of the applicability of the MODA framework for future applications. Therefore, we suggest that future applications of this framework within the U.S. Government identify a *new* evaluation measure for the Installation Mission Impact fundamental objective. This is appropriate given that MODA is a method for future decision-making and should take into consideration the current value preferences of decision makers rather than rely solely on a prior decision context. For use in the commercial sector, one can easily revert to Kraljic's work and retain the Profit Impact fundamental objective while using *Percentage of Sales* or *Sales Volume* as an evaluation measure.

During the development of our evaluation measures, we were unaware of which Product and Service Codes (PSCs) that AFICA would provide for analysis. The only information supplied was that the finalized set of PSCs would account for roughly 80% of Fiscal Year (FY) 2010-2014 spend and that AFICA *should* select PSCs well-suited for cost reductions. This insight allowed us to hypothesize that such PSCs *should* be categorized appropriately by position within the KPM. Final positioning of

the prioritized set of PSCs confirmed both AFICA internal analytic procedures and the usefulness of this methodology in that selected PSCs and KPM position were an excellent match. However, even though AFICA internal analytic procedures identified PSCs with a high potential for cost reduction, analyzing the set of "Non-Prioritized PSCs" provided quality insight that cannot be overstated. PSCs with a potential for cost reduction were identified not previously selected by AFICA. Additionally, outliers requiring further investigation were easily exposed. We therefore conclude that the accurate positioning of both the AFICA-prioritized set and the non-prioritized set of PSCs further strengthened the MODA-framework positioning method.

Moreover, where prior quantitative techniques only provided KPM position of items, the MODA framework facilitated additional analysis in at least three approaches:

1. Sensitivity analysis was performed on the value measures for each SAVF. Our analysis highlighted the robustness of the MODA approach. A $\pm 10\%$ swing on the $v_x(4.00) = 0.90$ value score for measuring supply market complexity resulted in only eight additional PSCs entering the strategic quadrant and exiting the leverage quadrant. These results showed that value preference elicitation sessions were an effective technique to obtain underlying judgment of decision makers and that the individual value preference scores and the range between them were properly captured.

2. Sensitivity analysis was performed on the weights associated with the MAVF. Our analysis again highlighted the robustness of the MODA approach. A $\pm 10\%$ swing for either weight identified a rather narrow pool of PSCs as "best" candidates for AFICA to consider for further analysis. Of the 138 possible PSCs, only 12 entered the "Top 10" for a sensitivity range of 20%.

3. Cost-benefit analysis enabled the development of a Pareto frontier that is based

on a combination of overall value and total cost. It provided a good starting point for strategic sourcing considerations that is based on the value judgments of decision makers.

## 5.2 Recommendations

When only considering the prioritized set of PSCs, Figure 13, Table 4, Table 9, and Table 10 provide AFICA the suggested PSCs with which to perform further analysis. The first step is to compare current contracting strategies with commercial best practice to determine if a mismatch exists. Discussions with AFICA revealed that most installation contracts apply a fixed price strategy, and more specifically a Firm-Fixed Price (FFP) strategy, whereby a supplier is awarded a base-year contract with four option years. Prices for the four option years typically include graduated price increases each successive year. However, commercial best practice as evidenced in literature suggests a different approach for the PSCs positioned within the leverage quadrant.

Gelderman and Van Weele, (2002) stress that the "important benefit of Kraljic's portfolio model is that the actual using and customizing lead to a better understanding of the strategic issues at hand." They go on to say that "each of the four categories requires a distinctive approach." Given that nearly all of the prioritized set of PSCs provided by AFICA are procured under a fixed price, or even a FFP-type contract, it is evident this is in sharp contrast to the approaches outlined by Gelderman and Van Weele as shown in Figure 20 below. Five-year contracts do indeed create efficiencies in processing for contracting officers. However, the result is that opportunities to reduce costs only occur every five years. This approach may be appropriate in the case of high supplier trust and limited presence of suppliers, but for the vast majority of contracts in the leverage quadrant, Gelderman and van Weele advise the exploitation

| **- Leverage -**<br>**Exploit Power Focus** | **- Strategic -**<br>**Strategic Partnership Focus** |
|---|---|
| • Tough negotiating<br>• Targeted pricing<br>• Product substitution<br>• Cost reductions<br>• If supplier trust exists and limited suppliers present, consider strategic partnership | • Thorough analysis<br>• Balance and diversify<br>• "Decomplex" purchasing<br>• Develop supplier<br>• Drive for less dependence if possible |
| **- Noncritical -**<br>**Efficient Processing Focus** | **- Bottleneck -**<br>**Volume Insurance Focus** |
| • Efficient processing<br>• Product standardization<br>• Order volume/inventory optimization via framework agreement (master contract)<br>• Consider purchase card when pooling is not an option | • Volume insurance<br>• Vendor control<br>• Security of inventories<br>• Backup plans<br>• Develop new opportunities<br>• Reduce dependence on supplier through pooled purchasing requirements |

**Figure 20. KPM Categories and Purchasing Approaches, adapted from Gelderman & van Weele (2002)**

of power through tough negotiations, targeted pricing, and product substitutions. Efforts to implement these actions may quite possibly result in substantial cost savings for the Air Force.

Once AFICA determines the correct procurement strategy, the next step is to perform a thorough cost analysis to assist in implementing the strategies supplied in Figure 20 above. To aid in this effort, Ellram (1996) maps cost analysis techniques to each of the four KPM quadrants. This mapping is provided in Figure 21 below. For the prioritized set of PSCs provided by AFICA, most of which are located in the Leverage quadrant, a thorough industry analysis is already in work; highlighted by the organizational review of IBIS *World* Buyer Power reports for each PSC and

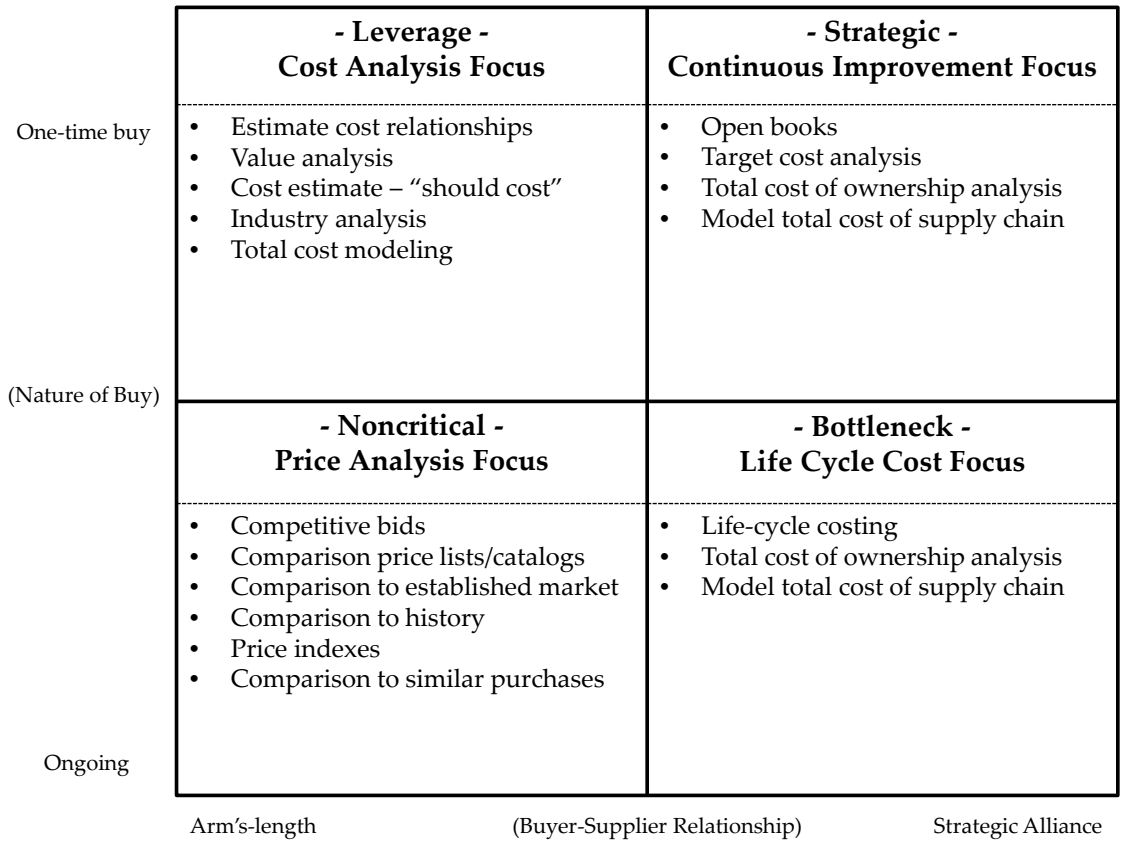


**Figure 21. KPM Categories & Cost Analysis Techniques, adapted from Ellram (1996)**

their associated IBIS*World* Buyer Power scores. It is recommended AFICA also perform a "should cost" analysis as well as total cost modeling approaches to aid in a strategic view of cost rather than a tactical view. Such analysis is *fundamental* to fully implementing strategic sourcing efforts and maximizing value to taxpayers.

### 5.3 Future Research

Rather than simply apply the MODA framework to a prioritized set of PSCs, we suggest applying this framework to all PSCs under the purview of AFICA. Results will either confirm its application or highlight weaknesses in its ability to accurately and quantitatively position PSCs within the KPM. Moreover, positioning in the KPM

prior to undergoing AFICA internal analysis ensures missed opportunities for cost reductions are minimized.

We also suggest that a new MODA approach be implemented through interaction at the category manager level for three reasons:

1. The limitations highlighted for the Installation Mission Impact fundamental objective may hide current underlying judgments not captured under the assumptions required for this research.

2. The MODA framework is meant to also provide a *strategic look* at purchasing and not be relegated to a tactical tool for contracting officers or contracting organizations only.

3. Interaction at the decision-maker level represents what Parnell calls the "Platinum Standard" which represents the highest level of credibility applicable to a MODA value model (Parnell *et al.*, 2013).

In our research, we provided a quantitative technique to position items within the KPM and identified purchasing strategies (commercial best practices) to employ based on KPM position. However, we did not consider the impact of the Federal Acquisition Regulation (FAR). Therefore, we suggest future research consider the impact of the FAR by answering the following question: *Does the FAR inhibit application of commercial best practices altogether or only within specific quadrants of the KPM?*

Given the favorable results of applying MODA as a framework to the KPM, it is suggested that a full MODA be applied to a sample of purchasing organizations to determine quantitatively how fully Kraljic captures the fundamental objectives and their associated trade-offs within his matrix. A full MODA will likely unveil an expanded objectives hierarchy for purchasing organizations. This may in turn

uncover hidden values not captured by the KPM that may influence buyer-supplier relationships, procurement strategies, and market analysis.

Finally, deciding where to position commodities, services, or PSCs within the KPM need not be a subjective experience especially when we consider the fact that the "items" we desire to position may involve an immense allocation of resources and quite possibly enormous sums of money. Therefore, we have shown the MODA framework to be well-suited for purchasing, supply chain, and category managers to make this positioning decision from a quantitative rather than a subjective approach.

# Government-Wide Category Structure (total FY 2014 spend $428B)

## Common Government Spend Categories 1-10 (total FY 2014 spend $275B)

### 1. IT – $49.9B
- 1.1 IT Software
- 1.2 IT Hardware
- 1.3 IT Consulting
- 1.4 IT Security
- 1.5 IT Outsourcing
- 1.6 Telecommunications

### 2. Professional Services – $61.9B
- 2.1 Business Administration Services
- 2.2 Legal Services
- 2.3 Management Advisory Services (Excludes R&D 17.0)
- 2.4 Marketing and Distribution
- 2.5 Public Relations and Professional Communications Services
- 2.6 Real Estate Services
- 2.7 Trade Policy and Services
- 2.8 Technical and Engineering Services (non-IT) (Excludes 1.0)
- 2.9 Financial Services
- 2.10 Social Services

### 3. Security and Protection – $5.5B
- 3.1 Security Animals & Related Services
- 3.2 Security Systems
- 3.3 Security Services

### 4. Facilities & Construction - $75.7B
- 4.1 Construction Related Materials
- 4.2 Construction Related Services
- 4.3 Facility Related Materials
- 4.4 Facility Related Services
- 4.5 Facilities Purchase & Lease

### 5. Industrial Products and Services - $10.5B
- 5.1 Machinery & Components Fire/Rescue/Safety/Environmental Protection
- 5.2 Equipment
- 5.3 Hardware & Tools
- 5.4 Test & Measurement Supplies Industrial Products
- 5.5 Install/Maintenance/Repair/Rebuild
- 5.6 Basic Materials
- 5.7 Oils, Lubricants, and Waxes

### 6. Office Management - $1.9B
- 6.1 Office Management Products
- 6.2 Office Management Services
- 6.3 Furniture

### 7. Transportation and Logistics Services – $26.8B
- 7.1 Package Delivery & Packaging
- 7.2 Logistics Support Services
- 7.3 Logistics Civil Augmentation Program
- 7.4 Transportation of Things
- 7.5 Motor Vehicles (non-combat)
- 7.6 Transportation Equipment
- 7.7 Fuels

### 8. Travel and Lodging - $2.7B
- 8.1 Passenger Travel
- 8.2 Lodging
- 8.3 Travel Agent & Misc. Services

### 9. Human Capital - $4.1B
- 9.1 Alternative Educational Systems
- 9.2 Educational Facilities
- 9.3 Educational Institutions
- 9.4 Specialized Educational Services
- 9.5 Vocational Training
- 9.6 Human Resources Services

### 10. Medical - $36.0B
- 10.1 Drugs and Pharmaceutical Products
- 10.2 Medical Equipment & Accessories & Supplies
- 10.3 Healthcare Services

## Defense-Centric Spend Categories 11-19 (total FY 2014 spend $153B)

### 11. Aircraft, Ships/Submarines & Land Combat Vehicles - $41.6B
- 11.1 Aircraft
- 11.2 Land Combat Vehicles
- 11.3 Ships & Submarines
- 11.4 Space

### 12. Weapons & Ammunition - $15.1B
- 12.1 Ammunition & Explosives
- 12.2 Fire Control
- 12.3 Guided Missiles
- 12.4 Guns
- 12.5 Nuclear Ordnance
- 12.6 Weapons

### 13. Electronic & Communication Equipment - $8.7B
- 13.1 Communication Equipment Detection & Coherent Radiation
- 13.2 Equipment
- 13.3 Electrical and Electronics Equipment
- 13.4 Night Vision Equipment

### 14. Sustainment S&E - $22.7B
- 14.1 Drones
- 14.2 Engines, Components & Spt Eq
- 14.3 Materials
- 14.4 Supply Parts
- 14.5 Support Ships & Small Craft
- 14.6 Training Aids and Devices

### 15. Clothing, Textiles & Subsistence S&E - $7.5B
- 15.1 Subsistence
- 15.2 Textiles, Clothing & Equipage

### 16. Miscellaneous S&E - $839M
- 16.1 Non-Food Items for Resale
- 16.2 S&E Not Classified Elsewhere

### 17. Research and Development - $40.0B
- 17.1 Systems Development
- 17.2 Operational Systems Development
- 17.3 Technology Base
- 17.4 Commercialization
- 17.5 Pre-FY 1998 2-Digit Category

### 18. Equipment Related Services - $16.5B
- 18.1 Maintenance, Repair and Overhaul
- 18.2 Equipment Modification
- 18.3 Installation of Equipment
- 18.4 Quality Control
- 18.5 Technical Representative Services
- 18.6 Purchases and Leases
- 18.7 Salvage Services

### 19. Electronic Communication Services - $418M
- 19.1 Equipment Maintenance
- 19.2 Equipment Leases

Note: Spend figures are based on FY14 FPDS data.

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# Comparison of Major Contract Types

| | Firm-Fixed-Price (FFP) | Fixed-Price Economic Price Adjustment (FPEPA) | Fixed-Price Incentive Firm Target (FPIF) | Fixed-Price Award-Fee (FPAF) | Fixed-Price Prospective Price Redetermination ($FP^3R$) | Cost-Plus-Incentive-Fee (CPIF) | Cost-Plus-Award-Fee (CPAF) | Cost-Plus-Fixed-Fee (CPFF) | Cost or Cost-Sharing (C or CS) | Time & Materials (T&M) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Principal Risk to be Mitigated** | None. Thus, the contractor assumes all cost risk. | Unstable market prices for labor or material over the life of the contract. | Moderately uncertain contract labor or material requirements. | Risk that the user will not be fully satisfied because of judgmental acceptance criteria. | Costs of performance after the first year because they cannot be estimated with confidence. | Highly uncertain and speculative labor hours, labor mix, and/or material requirements (and other things) necessary to perform the contract. The Government assumes the risks inherent in the contract, benefiting if the actual cost is lower than the expected cost, or losing if the work cannot be completed within the expected cost of performance. | | | | |
| **Use When . . .** | The requirement is well-defined.<br>•Contractors are experienced in meeting it.<br>•Market conditions are stable.<br>•Financial risks are otherwise insignificant. | The market prices at risk are severable and significant. The risk stems from industry-wide contingencies beyond the contractor's control. The dollars at risk outweigh the administrative burdens of an FPEPA. | A ceiling price can be established that covers the most probable risks inherent in the nature of the work. The proposed profit sharing formula would motivate the contractor to control costs and to meet other objectives. | Judgmental standards can be fairly applied by the fee determining official. The potential fee is large enough to both:<br>•Provide a meaningful incentive. [1]<br>•Justify related administrative burdens. | The Government needs a firm commitment from the contractor to deliver the supplies or services during subsequent years. The dollars at risk outweigh the administrative burdens of an FPRP. | An objective relationship can be established between the fee and such measures of performance as actual costs, delivery dates, performance benchmarks, and the like. | Objective incentive targets are not feasible for critical aspects of performance. Judgmental standards can be fairly applied. Potential fee would provide a meaningful incentive. | Relating fee to performance (e.g., to actual costs) would be unworkable or of marginal utility. | The contractor expects substantial compensating benefits for absorbing part of the costs and/or foregoing fee or the vendor is a non-profit entity. | No other type of contract is suitable (e.g., because costs are too low to justify an audit of the contractor's indirect expenses). |
| **Elements** | A firm-fixed-price for each line item or one or more groupings of line items. | •A fixed-price, ceiling on upward adjustment, and a formula for adjusting the price up or down based on:<br>•Established prices.<br>•Actual labor or material costs.<br>•Labor or material indices. | •Ceiling price<br>•Target cost<br>•Target profit<br>•Delivery, quality, or other performance targets (optional)<br>•Profit sharing formula<br>•120 % ceiling and 50/50 share are points of departure | •Fixed-price.<br>•Award amount<br>•Award fee evaluation criteria and procedures for measuring performance against the criteria | •Fixed-price for the first period.<br>•Proposed subsequent periods (at least 12 months apart).<br>•Timetable for pricing the next period(s). | •Target cost<br>•A minimum, maximum, and target fee<br>•A formula for adjusting fee based on actual costs and/or performance<br>•Performance targets (optional) | •Target cost<br>•Base amount, if applicable, and an award amount<br>•Award fee evaluation criteria and procedures for measuring performance against the criteria | •Target cost<br>•Fixed fee | •Target cost<br>•No fee<br>•If CS, an agreement on the Government's share of the cost. | •Ceiling price<br>•A per-hour labor rate that also covers overhead and profit<br>•Provisions for reimbursing direct material costs |
| **Contractor is Obliged to:** | Provide an acceptable deliverable at the time, place and price specified in the contract. | Provide an acceptable deliverable at the time and place specified in the contract at the adjusted price. | Provide an acceptable deliverable at the time and place specified in the contract at or below the ceiling price. | Perform at the time, place, and the price fixed in the contract. | Provide acceptable deliverables at the time and place specified in the contract at the price established for each period. | Make a good faith effort to meet the Government's needs within the estimated cost in the Contract, Part I the Schedule, Section B Supplies or services and prices/costs. | | | | Make a good faith effort to meet the Government's needs within the ceiling price. |
| **Contractor Incentive *(other than maximizing goodwill)*** [1] | Generally realizes an additional dollar of profit for every dollar that costs are reduced. | Generally realizes an additional dollar of profit for every dollar that costs are reduced. | Realizes profit on cost by completing work below the ceiling price. May earn higher profit by incurring costs below the target cost or by meeting objective performance targets. | Generally realizes an additional dollar of profit for every dollar that costs are reduced; earns an additional fee for satisfying the performance standards. | For the period of performance, realizes an additional dollar of profit for every dollar that costs are reduced. | Realizes a higher fee by completing the work at a lower cost and/or by meeting other objective performance targets. | Realizes a higher fee by meeting judgmental performance standards. | Realizes a higher rate of return (i.e., fee divided by total cost) as total cost decreases. | If CS, shares in the cost of providing a deliverable of mutual benefit. | |
| **Typical Application** | Commercial supplies and services. | Long-term contracts for commercial supplies during a period of high inflation. | Production of a major system based on a prototype. | Performance-based contracts. | Long-term production of spare parts for a major system. | Research and development of the prototype for a major system. | Large scale research study. | Research study. | Joint research with educational institutions. | Emergency repairs to heating plants and aircraft engines. |
| **Principal Limitations in FAR/DFARS Parts 16, 32, 35, and 52** [2] | Generally NOT appropriate for R&D. | Must be justified. | Must be justified. Must be negotiated. Contractor must have an adequate accounting system. Cost data must support targets. | Must be negotiated. | MUST be negotiated. Contractor must have an adequate accounting system that supports the pricing periods. Prompt redeterminations. | The contractor must have an adequate accounting system. The Government must exercise surveillance during performance to ensure use of efficient methods and cost controls. Must be negotiated. Must be justified. Statutory and regulatory limits on the fees that may be negotiated. Must include the applicable Limitation of Cost clause at FAR 52.232-20 through 23. | | | | D&F required (w/ HCA if over 3 years). Government MUST exercise appropriate surveillance to ensure efficient performance. Document any ceiling increases. |
| **Variants** | Firm-Fixed-Price Level-of-Effort. | | Successive Targets (FPIS) | | Retroactive Redetermination | | | Completion or Term. | | Labor Hour (LH) |

[1] Goodwill is the value of the name, reputation, location, and intangible assets of the firm.

[2] Comply with any USD(AT&L), DPAP or other memoranda that have not been incorporated into the DFARS or DoD Directives or Instructions.

# Appendix C. Prioritized PSCs

**Table 13. Prioritized PSCs**

| PSC | PSC Description |
|---|---|
| 1550 | UNMANNED AIRCRAFT |
| 1560 | AIRFRAME STRUCTURAL COMPONENTS |
| 1680 | MISCELLANEOUS AIRCRAFT ACCESSORIES AND COMPONENTS |
| 1730 | AIRCRAFT GROUND SERVICING EQUIPMENT |
| 2330 | TRAILERS |
| 2590 | MISCELLANEOUS VEHICULAR COMPONENTS |
| 2840 | GAS TURBINES AND JET ENGINES, AIRCRAFT, PRIME MOVING; AND COMPONENTS |
| 3590 | MISCELLANEOUS SERVICE AND TRADE EQUIPMENT |
| 3695 | MISCELLANEOUS SPECIAL INDUSTRY MACHINERY |
| 3990 | MISCELLANEOUS MATERIALS HANDLING EQUIPMENT |
| 4120 | AIR CONDITIONING EQUIPMENT |
| 4210 | FIRE FIGHTING EQUIPMENT |
| 4240 | SAFETY AND RESCUE EQUIPMENT |
| 4310 | COMPRESSORS AND VACUUM PUMPS |
| 4910 | MOTOR VEHICLE MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT |
| 4920 | AIRCRAFT MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT |
| 4940 | MISCELLANEOUS MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT |
| 5340 | HARDWARE, COMMERCIAL |
| 5410 | PREFABRICATED AND PORTABLE BUILDINGS |
| 5680 | MISCELLANEOUS CONSTRUCTION MATERIALS |
| 5805 | TELEPHONE AND TELEGRAPH EQUIPMENT |
| 5810 | COMMUNICATIONS SECURITY EQUIPMENT AND COMPONENTS |
| 5820 | RADIO AND TELEVISION COMMUNICATION EQUIPMENT, EXCEPT AIRBORNE |
| 5826 | RADIO NAVIGATION EQUIPMENT, AIRBORNE |
| 5836 | VIDEO RECORDING AND REPRODUCING EQUIPMENT |
| 5840 | RADAR EQUIPMENT, EXCEPT AIRBORNE |
| 5841 | RADAR EQUIPMENT, AIRBORNE |
| 5865 | ELECTRONIC COUNTERMEASURES, COUNTER-COUNTERMEASURES AND QUICK REACTION CAPABILITY EQUIPMENT |
| 5895 | MISCELLANEOUS COMMUNICATION EQUIPMENT |
| 5930 | SWITCHES |
| 5975 | ELECTRICAL HARDWARE AND SUPPLIES |
| 5985 | ANTENNAS, WAVEGUIDES, AND RELATED EQUIPMENT |
| 5995 | CABLE, CORD, AND WIRE ASSEMBLIES: COMMUNICATION EQUIPMENT |
| 5998 | ELECTRICAL AND ELECTRONIC ASSEMBLIES, BOARDS, CARDS, AND ASSOCIATED HARDWARE |
| 5999 | MISCELLANEOUS ELECTRICAL AND ELECTRONIC COMPONENTS |
| 6150 | MISCELLANEOUS ELECTRIC POWER AND DISTRIBUTION EQUIPMENT |
| 6350 | MISCELLANEOUS ALARM, SIGNAL, AND SECURITY DETECTION SYSTEMS |
| 6515 | MEDICAL AND SURGICAL INSTRUMENTS, EQUIPMENT, AND SUPPLIES |
| 6625 | ELECTRICAL AND ELECTRONIC PROPERTIES MEASURING AND TESTING INSTRUMENTS |
| 6640 | LABORATORY EQUIPMENT AND SUPPLIES |
| 6650 | OPTICAL INSTRUMENTS, TEST EQUIPMENT, COMPONENTS AND ACCESSORIES |
| 6910 | TRAINING AIDS |
| 6930 | OPERATION TRAINING DEVICES |
| 7010 | ADPE SYSTEM CONFIGURATION |
| 7020 | ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), ANALOG |
| 7021 | ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), DIGITAL |
| 7025 | ADP INPUT/OUTPUT AND STORAGE DEVICES |

**Table 14. Prioritized PSCs cont'd**

| PSC | PSC Description |
|---|---|
| 7030 | ADP SOFTWARE |
| 7035 | ADP SUPPORT EQUIPMENT |
| 7045 | ADP SUPPLIES |
| 7050 | ADP COMPONENTS |
| 7110 | OFFICE FURNITURE |
| 7125 | CABINETS, LOCKERS, BINS, AND SHELVING |
| 7195 | MISCELLANEOUS FURNITURE AND FIXTURES |
| 7220 | FLOOR COVERINGS |
| 7290 | MISCELLANEOUS HOUSEHOLD AND COMMERCIAL FURNISHINGS AND APPLIANCES |
| 7320 | KITCHEN EQUIPMENT AND APPLIANCES |
| 7490 | MISCELLANEOUS OFFICE MACHINES |
| 7510 | OFFICE SUPPLIES |
| 7520 | OFFICE DEVICES AND ACCESSORIES |
| 8010 | PAINTS, DOPES, VARNISHES, AND RELATED PRODUCTS |
| 8145 | SPECIALIZED SHIPPING AND STORAGE CONTAINERS |
| 8415 | CLOTHING, SPECIAL PURPOSE |
| 8465 | INDIVIDUAL EQUIPMENT |
| AC26 | R&D- DEFENSE SYSTEM: MISSILE/SPACE SYSTEMS (MANAGEMENT/SUPPORT) |
| AC56 | R&D- DEFENSE SYSTEM: WEAPONS (MANAGEMENT/SUPPORT) |
| AJ16 | R&D- GENERAL SCIENCE/TECHNOLOGY: PHYSICAL SCIENCES (MANAGEMENT/SUPPORT) |
| AZ16 | R&D- OTHER RESEARCH AND DEVELOPMENT (MANAGEMENT/SUPPORT) |
| B599 | SPECIAL STUDIES/ANALYSIS- OTHER |
| C211 | ARCHITECT AND ENGINEERING- GENERAL: LANDSCAPING, INTERIOR LAYOUT, AND DESIGNING |
| C219 | ARCHITECT AND ENGINEERING- GENERAL: OTHER |
| D304 | IT AND TELECOM- TELECOMMUNICATIONS AND TRANSMISSION |
| D307 | IT AND TELECOM- IT STRATEGY AND ARCHITECTURE |
| D308 | IT AND TELECOM- PROGRAMMING |
| D316 | IT AND TELECOM- TELECOMMUNICATIONS NETWORK MANAGEMENT |
| D319 | IT AND TELECOM- ANNUAL SOFTWARE MAINTENANCE SERVICE PLANS |
| D399 | IT AND TELECOM- OTHER IT AND TELECOMMUNICATIONS |
| F999 | OTHER ENVIRONMENTAL SERVICES |
| J010 | MAINT/REPAIR/REBUILD OF EQUIPMENT- WEAPONS |
| J015 | MAINT/REPAIR/REBUILD OF EQUIPMENT- AIRCRAFT AND AIRFRAME STRUCTURAL COMPONENTS |
| J016 | MAINT/REPAIR/REBUILD OF EQUIPMENT- AIRCRAFT COMPONENTS AND ACCESSORIES |
| J028 | MAINT/REPAIR/REBUILD OF EQUIPMENT- ENGINES, TURBINES, AND COMPONENTS |
| J041 | MAINT/REPAIR/REBUILD OF EQUIPMENT- REFRIGERATION, AIR CONDITIONING, AND AIR CIRCULATING EQUIPMENT |
| J049 | MAINT/REPAIR/REBUILD OF EQUIPMENT- MAINTENANCE AND REPAIR SHOP EQUIPMENT |
| J058 | MAINT/REPAIR/REBUILD OF EQUIPMENT- COMMUNICATION, DETECTION, AND COHERENT RADIATION EQUIPMENT |
| J059 | MAINT/REPAIR/REBUILD OF EQUIPMENT- ELECTRICAL AND ELECTRONIC EQUIPMENT COMPONENTS |
| J061 | MAINT/REPAIR/REBUILD OF EQUIPMENT- ELECTRIC WIRE AND POWER DISTRIBUTION EQUIPMENT |
| J063 | MAINT/REPAIR/REBUILD OF EQUIPMENT- ALARM, SIGNAL, AND SECURITY DETECTION SYSTEMS |
| J065 | MAINT/REPAIR/REBUILD OF EQUIPMENT- MEDICAL, DENTAL, AND VETERINARY EQUIPMENT AND SUPPLIES |
| J066 | MAINT/REPAIR/REBUILD OF EQUIPMENT- INSTRUMENTS AND LABORATORY EQUIPMENT |
| J069 | MAINT/REPAIR/REBUILD OF EQUIPMENT- TRAINING AIDS AND DEVICES |
| J070 | MAINT/REPAIR/REBUILD OF EQUIPMENT- ADP EQUIPMENT/SOFTWARE/SUPPLIES/ SUPPORT EQUIPMENT |
| J099 | MAINT/REPAIR/REBUILD OF EQUIPMENT- MISCELLANEOUS |
| L014 | TECHNICAL REPRESENTATIVE- GUIDED MISSILES |
| M119 | OPER OF GOVT OTHER ADMIN-SVC BLDGS |

**Table 15. Prioritized PSCs cont'd**

| PSC | PSC Description |
|---|---|
| M123 | OPER OF GOVT RADAR & NAV FACILITY |
| M127 | OPER OF GOVT ELCT & COMM SYS FAC |
| M199 | OPER OF GOVT MISC BLDGS |
| Q201 | MEDICAL- GENERAL HEALTH CARE |
| Q401 | MEDICAL- NURSING |
| Q999 | MEDICAL- OTHER |
| R408 | SUPPORT- PROFESSIONAL: PROGRAM MANAGEMENT/SUPPORT |
| R414 | SYSTEMS ENGINEERING SERVICES |
| R421 | TECHNICAL ASSISTANCE |
| R425 | SUPPORT- PROFESSIONAL: ENGINEERING/TECHNICAL |
| R426 | SUPPORT- PROFESSIONAL: COMMUNICATIONS) |
| R497 | SUPPORT- PROFESSIONAL: PERSONAL SERVICES CONTRACTS |
| R499 | SUPPORT- PROFESSIONAL: OTHER |
| R699 | SUPPORT- ADMINISTRATIVE: OTHER |
| R706 | SUPPORT- MANAGEMENT: LOGISTICS SUPPORT |
| R707 | SUPPORT- MANAGEMENT: CONTRACT/PROCUREMENT/ACQUISITION SUPPORT |
| R799 | SUPPORT- MANAGEMENT: OTHER |
| S112 | UTILITIES- ELECTRIC |
| S201 | HOUSEKEEPING- CUSTODIAL JANITORIAL |
| S203 | HOUSEKEEPING- FOOD |
| S205 | HOUSEKEEPING- TRASH/GARBAGE COLLECTION |
| S208 | HOUSEKEEPING- LANDSCAPING/GROUNDSKEEPING |
| S209 | HOUSEKEEPING- LAUNDRY/DRYCLEANING |
| S216 | HOUSEKEEPING- FACILITIES OPERATIONS SUPPORT |
| S299 | HOUSEKEEPING- OTHER |
| V126 | TRANSPORTATION/TRAVEL/RELOCATION- TRANSPORTATION: SPACE TRANSPORTATION/ LAUNCH |
| V231 | TRANSPORTATION/TRAVEL/RELOCATION-TRAVEL/LODGING/RECRUITMENT: LODGING, HOTEL/MOTEL |
| W023 | LEASE OR RENTAL OF EQUIPMENT- GROUND EFFECT VEHICLES, MOTOR VEHICLES, TRAILERS, AND CYCLES |
| Y199 | CONSTRUCT/MISC BLDGS |
| Y1AA | CONSTRUCTION OF OFFICE BUILDINGS |
| Y1JZ | CONSTRUCTION OF MISCELLANEOUS BUILDINGS |
| Z111 | MAINT-REP-ALT/OFFICE BLDGS |
| Z119 | MAINT-REP-ALT/OTHER ADMIN BLDGS |
| Z199 | MAINT-REP-ALT/MISC BLDGS |
| Z1AA | MAINTENANCE OF OFFICE BUILDINGS |
| Z1AZ | MAINTENANCE OF OTHER ADMINISTRATIVE FACILITIES AND SERVICE BUILDINGS |
| Z1JZ | MAINTENANCE OF MISCELLANEOUS BUILDINGS |
| Z1PZ | MAINTENANCE OF OTHER NON-BUILDING FACILITIES |
| Z222 | MAINT-REP-ALT/HWYS-RDS-STS-BRDGS-RA |
| Z299 | MAINT, REP/ALTER/ALL OTHER |
| Z2AA | REPAIR OR ALTERATION OF OFFICE BUILDINGS |
| Z2JZ | REPAIR OR ALTERATION OF MISCELLANEOUS BUILDINGS |
| Z2LB | REPAIR OR ALTERATION OF HIGHWAYS/ROADS/STREETS/BRIDGES/RAILWAYS |

# Appendix D. Supply Market Complexity Value Function Scores

**Table 16. Single Attribute Value Function 1 – Supply Market Complexity**

| PSC | IBIS Score – $x_i$ | Attribute Score – $v_x(x_i)$ |
|---|---|---|
| 7490 | 4.76 | 0.98 |
| 7520 | 4.76 | 0.98 |
| 5985 | 4.58 | 0.96 |
| 7010 | 4.49 | 0.96 |
| 5805 | 4.45 | 0.95 |
| 5895 | 4.45 | 0.95 |
| 7025 | 4.37 | 0.94 |
| 5810 | 4.32 | 0.94 |
| 5820 | 4.32 | 0.94 |
| 5836 | 4.32 | 0.94 |
| J058 | 4.29 | 0.93 |
| 7045 | 4.18 | 0.92 |
| 7510 | 4.18 | 0.92 |
| 7020 | 4.14 | 0.92 |
| 7021 | 4.14 | 0.92 |
| D316 | 4.03 | 0.90 |
| D399 | 4.03 | 0.90 |
| 8415 | 3.98 | 0.90 |
| AC26 | 3.95 | 0.89 |
| AC56 | 3.95 | 0.89 |
| AJ16 | 3.95 | 0.89 |
| AZ16 | 3.95 | 0.89 |
| R408 | 3.95 | 0.89 |
| R426 | 3.95 | 0.89 |
| R497 | 3.95 | 0.89 |
| R499 | 3.95 | 0.89 |
| R699 | 3.95 | 0.89 |
| R706 | 3.95 | 0.89 |
| R799 | 3.95 | 0.89 |
| 1550 | 3.92 | 0.89 |
| 5826 | 3.79 | 0.87 |
| 5840 | 3.79 | 0.87 |
| 5841 | 3.79 | 0.87 |
| 7030 | 3.79 | 0.87 |
| J059 | 3.79 | 0.87 |
| J070 | 3.79 | 0.87 |
| J099 | 3.79 | 0.87 |
| D308 | 3.75 | 0.87 |
| 5999 | 3.74 | 0.86 |
| 7035 | 3.73 | 0.86 |
| 7050 | 3.73 | 0.86 |
| 6650 | 3.72 | 0.86 |
| J066 | 3.72 | 0.86 |
| 5865 | 3.70 | 0.86 |
| 5995 | 3.70 | 0.86 |
| J010 | 3.68 | 0.86 |
| J028 | 3.68 | 0.86 |
| J049 | 3.68 | 0.86 |

**Table 17. Single Attribute Value Function 1 – Supply Market Complexity cont'd**

| PSC | IBIS Score – $x_i$ | Attribute Score – $v_x(x_i)$ |
|---|---|---|
| D319 | 3.66 | 0.85 |
| 4240 | 3.62 | 0.85 |
| 5998 | 3.61 | 0.85 |
| S201 | 3.60 | 0.84 |
| S299 | 3.60 | 0.84 |
| V126 | 3.59 | 0.84 |
| V231 | 3.59 | 0.84 |
| M119 | 3.58 | 0.84 |
| M123 | 3.58 | 0.84 |
| M127 | 3.58 | 0.84 |
| M199 | 3.58 | 0.84 |
| S216 | 3.58 | 0.84 |
| 5930 | 3.54 | 0.83 |
| 5975 | 3.54 | 0.83 |
| 7125 | 3.54 | 0.83 |
| 6640 | 3.52 | 0.83 |
| D304 | 3.52 | 0.83 |
| 6515 | 3.48 | 0.82 |
| J065 | 3.48 | 0.82 |
| Q401 | 3.48 | 0.82 |
| 1730 | 3.45 | 0.82 |
| J069 | 3.46 | 0.82 |
| 1560 | 3.44 | 0.82 |
| R707 | 3.44 | 0.82 |
| C211 | 3.41 | 0.81 |
| 3695 | 3.40 | 0.81 |
| 5340 | 3.39 | 0.81 |
| J061 | 3.38 | 0.81 |
| 6910 | 3.37 | 0.80 |
| 6930 | 3.37 | 0.80 |
| 4910 | 3.35 | 0.80 |
| S112 | 3.36 | 0.80 |
| 4120 | 3.34 | 0.80 |
| S203 | 3.31 | 0.79 |
| S209 | 3.31 | 0.79 |
| 7195 | 3.30 | 0.79 |
| 6150 | 3.29 | 0.79 |
| 3590 | 3.27 | 0.79 |
| 5410 | 3.27 | 0.79 |
| 6625 | 3.27 | 0.79 |
| R414 | 3.25 | 0.78 |
| R425 | 3.25 | 0.78 |
| 8465 | 3.24 | 0.78 |
| 7290 | 3.20 | 0.77 |
| J041 | 3.20 | 0.77 |
| 2840 | 3.19 | 0.77 |
| S208 | 3.19 | 0.77 |
| 7220 | 3.17 | 0.77 |

**Table 18. Single Attribute Value Function 1 – Supply Market Complexity cont'd**

| PSC | IBIS Score – $x_i$ | Attribute Score – $v_x(x_i)$ |
|---|---|---|
| F999 | 3.16 | 0.77 |
| B599 | 3.15 | 0.76 |
| L014 | 3.15 | 0.76 |
| R421 | 3.15 | 0.76 |
| Z222 | 3.15 | 0.76 |
| Z2LB | 3.15 | 0.76 |
| 3990 | 3.14 | 0.76 |
| J063 | 3.13 | 0.76 |
| 4310 | 3.11 | 0.76 |
| 8145 | 3.10 | 0.75 |
| W023 | 3.09 | 0.75 |
| Y199 | 3.09 | 0.75 |
| Y1AA | 3.09 | 0.75 |
| Y1JZ | 3.09 | 0.75 |
| Z111 | 3.06 | 0.75 |
| Z119 | 3.06 | 0.75 |
| Z199 | 3.06 | 0.75 |
| Z1AA | 3.06 | 0.75 |
| Z1AZ | 3.06 | 0.75 |
| Z1JZ | 3.06 | 0.75 |
| Z1PZ | 3.06 | 0.75 |
| Z299 | 3.06 | 0.75 |
| Z2AA | 3.06 | 0.75 |
| Z2JZ | 3.06 | 0.75 |
| 7110 | 3.03 | 0.74 |
| D307 | 2.98 | 0.73 |
| 4210 | 2.97 | 0.73 |
| 7320 | 2.97 | 0.73 |
| 6350 | 2.92 | 0.72 |
| S205 | 2.91 | 0.71 |
| C219 | 2.85 | 0.70 |
| Q201 | 2.74 | 0.68 |
| Q999 | 2.74 | 0.68 |
| 8010 | 2.65 | 0.65 |
| 2330 | 2.64 | 0.65 |
| 2590 | 2.45 | 0.60 |
| 1680 | 2.39 | 0.58 |
| 4920 | 2.39 | 0.58 |
| 4940 | 2.39 | 0.58 |
| J015 | 2.39 | 0.58 |
| J016 | 2.39 | 0.58 |
| 5680 | 2.11 | 0.50 |

# Appendix E. Installation Mission Impact Value Function Scores

**Table 19. Single Attribute Value Function 2 – Installation Mission Impact**

| PSC | Spend Slope Delta – $y_i$ | Attribute Score – $v_y(y_i)$ |
|---|---|---|
| 2590 | 15.06 | 1.00 |
| 7045 | 10.95 | 1.00 |
| 6350 | 4.42 | 1.00 |
| 7490 | 2.98 | 1.00 |
| 4910 | 2.36 | 1.00 |
| 5999 | 2.24 | 1.00 |
| 4120 | 2.18 | 1.00 |
| 7020 | 2.18 | 1.00 |
| 7195 | 2.10 | 1.00 |
| Z111 | 1.92 | 1.00 |
| 7220 | 1.91 | 1.00 |
| 7021 | 1.71 | 1.00 |
| 5410 | 1.44 | 1.00 |
| 7050 | 1.31 | 1.00 |
| 3590 | 1.10 | 1.00 |
| 4210 | 1.05 | 1.00 |
| 7025 | 0.98 | 1.00 |
| 7290 | 0.98 | 1.00 |
| Z2LB | 0.96 | 1.00 |
| Z1JZ | 0.91 | 0.99 |
| 8415 | 0.89 | 0.99 |
| Z1AA | 0.87 | 0.99 |
| Y1JZ | 0.85 | 0.99 |
| V126 | 0.85 | 0.99 |
| 3695 | 0.80 | 0.99 |
| 5836 | 0.78 | 0.99 |
| 8010 | 0.76 | 0.98 |
| Z222 | 0.71 | 0.98 |
| 6515 | 0.67 | 0.98 |
| 5680 | 0.63 | 0.97 |
| Z2AA | 0.58 | 0.97 |
| 5840 | 0.53 | 0.96 |
| Z199 | 0.51 | 0.96 |
| J049 | 0.51 | 0.96 |
| 7030 | 0.49 | 0.96 |
| 7110 | 0.47 | 0.96 |
| 2330 | 0.47 | 0.96 |
| 4310 | 0.46 | 0.96 |
| Z1AZ | 0.43 | 0.95 |
| AC56 | 0.41 | 0.95 |
| J066 | 0.41 | 0.95 |
| V231 | 0.40 | 0.95 |
| 7320 | 0.36 | 0.95 |
| L014 | 0.35 | 0.94 |
| 1730 | 0.33 | 0.94 |
| C211 | 0.31 | 0.94 |
| 5975 | 0.31 | 0.94 |
| 7035 | 0.31 | 0.94 |

**Table 20. Single Attribute Value Function 2 – Installation Mission Impact**

| PSC | Spend Slope Delta – $y_i$ | Attribute Score – $v_y(y_i)$ |
|---|---|---|
| J059 | 0.28 | 0.94 |
| D304 | 0.25 | 0.93 |
| Z2JZ | 0.24 | 0.93 |
| 5810 | 0.21 | 0.93 |
| S216 | 0.21 | 0.93 |
| 3990 | 0.20 | 0.93 |
| 6930 | 0.19 | 0.93 |
| 7125 | 0.19 | 0.93 |
| S299 | 0.18 | 0.93 |
| S112 | 0.18 | 0.93 |
| 7520 | 0.17 | 0.92 |
| R706 | 0.16 | 0.92 |
| 4920 | 0.16 | 0.92 |
| J041 | 0.15 | 0.92 |
| R497 | 0.15 | 0.92 |
| 6150 | 0.15 | 0.92 |
| Z1PZ | 0.14 | 0.92 |
| AJ16 | 0.13 | 0.92 |
| R425 | 0.11 | 0.92 |
| 6650 | 0.11 | 0.92 |
| M119 | 0.11 | 0.92 |
| 2840 | 0.11 | 0.91 |
| 5340 | 0.11 | 0.91 |
| J099 | 0.10 | 0.91 |
| J016 | 0.08 | 0.91 |
| D316 | 0.08 | 0.91 |
| Q201 | 0.07 | 0.91 |
| 1550 | 0.07 | 0.91 |
| J065 | 0.06 | 0.91 |
| Q999 | 0.06 | 0.91 |
| M199 | 0.03 | 0.90 |
| 5985 | 0.02 | 0.90 |
| 7010 | 0.01 | 0.90 |
| 8465 | 0.00 | 0.90 |
| D307 | -0.01 | 0.90 |
| AZ16 | -0.01 | 0.90 |
| AC26 | -0.02 | 0.90 |
| J015 | -0.05 | 0.89 |
| R799 | -0.06 | 0.89 |
| 5805 | -0.07 | 0.89 |
| D308 | -0.08 | 0.89 |
| J061 | -0.09 | 0.88 |
| Q401 | -0.10 | 0.88 |
| D399 | -0.10 | 0.88 |
| J069 | -0.10 | 0.88 |
| J028 | -0.10 | 0.88 |
| S201 | -0.11 | 0.88 |
| R499 | -0.11 | 0.88 |

**Table 21. Single Attribute Value Function 2 – Installation Mission Impact**

| PSC | Spend Slope Delta – $y_i$ | Attribute Score – $v_y(y_i)$ |
|---|---|---|
| R707 | -0.12 | 0.88 |
| S205 | -0.15 | 0.87 |
| F999 | -0.17 | 0.87 |
| S208 | -0.17 | 0.87 |
| M127 | -0.17 | 0.87 |
| J063 | -0.19 | 0.87 |
| C219 | -0.19 | 0.87 |
| 5841 | -0.20 | 0.86 |
| W023 | -0.21 | 0.86 |
| 8145 | -0.22 | 0.86 |
| M123 | -0.22 | 0.86 |
| R426 | -0.23 | 0.86 |
| 4940 | -0.23 | 0.86 |
| S203 | -0.23 | 0.86 |
| 5895 | -0.23 | 0.86 |
| B599 | -0.24 | 0.86 |
| R699 | -0.24 | 0.86 |
| R414 | -0.25 | 0.85 |
| 5930 | -0.28 | 0.85 |
| R408 | -0.29 | 0.85 |
| 6910 | -0.31 | 0.84 |
| S209 | -0.31 | 0.84 |
| 5820 | -0.32 | 0.84 |
| J010 | -0.37 | 0.83 |
| 6640 | -0.42 | 0.82 |
| 1680 | -0.42 | 0.82 |
| 5865 | -0.43 | 0.82 |
| 1560 | -0.45 | 0.81 |
| 5826 | -0.48 | 0.80 |
| 6625 | -0.52 | 0.79 |
| D319 | -0.53 | 0.79 |
| R421 | -0.56 | 0.79 |
| 5998 | -0.57 | 0.78 |
| 4240 | -0.64 | 0.77 |
| J058 | -0.67 | 0.75 |
| J070 | -0.67 | 0.75 |
| Y1AA | -0.76 | 0.73 |
| 5995 | -0.84 | 0.70 |
| Z119 | -0.86 | 0.69 |
| 7510 | -0.92 | 0.67 |
| Y199 | -0.96 | 0.66 |
| Z299 | -1.19 | 0.56 |

# Appendix F. SAVF 1 Analysis

### Table 22. SAVF 1 – Installation Mission Impact ($M): 51 PSCs Scoring 1.00

| Type | PSC | PSC Description | FY10-14 Spend |
|---|---|---|---|
| AFICA | Z111 | Z111 (MAINT-REP-ALT/OFFICE BLDGS) | $ 941.06 |
| NON AFICA | 5999 | 5999 (MISCELLANEOUS ELECTRICAL AND ELECTRONIC COMPONENTS) | $ 531.83 |
| AFICA | Z1AA | Z1AA (MAINTENANCE OF OFFICE BUILDINGS) | $ 290.82 |
| AFICA | Z2LB | Z2LB (REPAIR OR ALTERATION OF HIGHWAYS/ROADS/STREETS/BRIDGES/RAILWAYS) | $ 263.25 |
| AFICA | C219 | C219 (ARCHITECT AND ENGINEERING- GENERAL: OTHER) | $ 256.16 |
| AFICA | 7050 | 7050 (ADP COMPONENTS) | $ 181.15 |
| AFICA | 7021 | 7021 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), DIGITAL) | $ 171.84 |
| AFICA | Z1JZ | Z1JZ (MAINTENANCE OF MISCELLANEOUS BUILDINGS) | $ 170.43 |
| AFICA | 7025 | 7025 (ADP INPUT/OUTPUT AND STORAGE DEVICES) | $ 130.34 |
| AFICA | D307 | D307 (IT AND TELECOM- IT STRATEGY AND ARCHITECTURE) | $ 124.06 |
| NON AFICA | 7021 | 7021 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), DIGITAL) | $ 116.79 |
| NON AFICA | 8415 | 8415 (CLOTHING, SPECIAL PURPOSE) | $ 108.36 |
| NON AFICA | 6350 | 6350 (MISCELLANEOUS ALARM, SIGNAL, AND SECURITY DETECTION SYSTEMS) | $ 105.11 |
| AFICA | 5820 | 5820 (RADIO AND TELEVISION COMMUNICATION EQUIPMENT, EXCEPT AIRBORNE) | $ 104.99 |
| AFICA | 6350 | 6350 (MISCELLANEOUS ALARM, SIGNAL, AND SECURITY DETECTION SYSTEMS) | $ 90.62 |
| AFICA | 2590 | 2590 (MISCELLANEOUS VEHICULAR COMPONENTS) | $ 69.16 |
| AFICA | Z1PZ | Z1PZ (MAINTENANCE OF OTHER NON-BUILDING FACILITIES) | $ 37.50 |
| AFICA | 7020 | 7020 (ADP CENTRAL PROCESSING UNIT (CPU, COMPUTER), ANALOG) | $ 37.36 |
| AFICA | 7195 | 7195 (MISCELLANEOUS FURNITURE AND FIXTURES) | $ 35.45 |
| AFICA | J016 | J016 (MAINT/REPAIR/REBUILD OF EQUIPMENT- AIRCRAFT COMPONENTS AND ACCESSORIES) | $ 32.26 |
| NON AFICA | Z222 | Z222 (MAINT-REP-ALT/HWYS-RDS-STS-BRDGS-RA) | $ 31.97 |
| AFICA | 7290 | 7290 (MISCELLANEOUS HOUSEHOLD AND COMMERCIAL FURNISHINGS AND APPLIANCES) | $ 29.67 |
| AFICA | D304 | D304 (IT AND TELECOM- TELECOMMUNICATIONS AND TRANSMISSION) | $ 29.08 |
| AFICA | 7220 | 7220 (FLOOR COVERINGS) | $ 27.61 |
| AFICA | 5836 | 5836 (VIDEO RECORDING AND REPRODUCING EQUIPMENT) | $ 26.73 |
| NON AFICA | 5410 | 5410 (PREFABRICATED AND PORTABLE BUILDINGS) | $ 26.37 |
| NON AFICA | 6515 | 6515 (MEDICAL AND SURGICAL INSTRUMENTS, EQUIPMENT, AND SUPPLIES) | $ 24.14 |
| AFICA | V231 | V231 (TRANSPORTATION/TRAVEL/RELOCATION- TRAVEL/LODGING/RECRUITMENT: LODGING, HOTEL/MOTEL) | $ 24.11 |
| AFICA | 4910 | 4910 (MOTOR VEHICLE MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT) | $ 22.88 |
| AFICA | 7045 | 7045 (ADP SUPPLIES) | $ 21.60 |
| AFICA | 4240 | 4240 (SAFETY AND RESCUE EQUIPMENT) | $ 20.12 |
| NON AFICA | Y1AA | Y1AA (CONSTRUCTION OF OFFICE BUILDINGS) | $ 19.71 |
| AFICA | 5985 | 5985 (ANTENNAS, WAVEGUIDES, AND RELATED EQUIPMENT) | $ 19.60 |
| AFICA | 4940 | 4940 (MISCELLANEOUS MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT) | $ 17.35 |
| AFICA | 2330 | 2330 (TRAILERS) | $ 14.60 |
| AFICA | 7490 | 7490 (MISCELLANEOUS OFFICE MACHINES) | $ 14.32 |
| NON AFICA | 4910 | 4910 (MOTOR VEHICLE MAINTENANCE AND REPAIR SHOP SPECIALIZED EQUIPMENT) | $ 13.96 |
| NON AFICA | Y1JZ | Y1JZ (CONSTRUCTION OF MISCELLANEOUS BUILDINGS) | $ 13.72 |
| NON AFICA | 7195 | 7195 (MISCELLANEOUS FURNITURE AND FIXTURES) | $ 13.04 |
| AFICA | 7520 | 7520 (OFFICE DEVICES AND ACCESSORIES) | $ 12.95 |
| AFICA | AZ16 | AZ16 (R&D- OTHER RESEARCH AND DEVELOPMENT (MANAGEMENT/SUPPORT)) | $ 12.76 |
| NON AFICA | Y199 | Y199 (CONSTRUCT/MISC BLDGS) | $ 12.00 |
| AFICA | 3990 | 3990 (MISCELLANEOUS MATERIALS HANDLING EQUIPMENT) | $ 10.55 |
| AFICA | 5975 | 5975 (ELECTRICAL HARDWARE AND SUPPLIES) | $ 5.87 |
| NON AFICA | 7490 | 7490 (MISCELLANEOUS OFFICE MACHINES) | $ 4.40 |
| AFICA | 5865 | 5865 (ELECTRONIC COUNTERMEASURES, COUNTER-COUNTERMEASURES AND QUICK REACTION CAPABILITY EQUIPMENT) | $ 3.21 |
| NON AFICA | 7290 | 7290 (MISCELLANEOUS HOUSEHOLD AND COMMERCIAL FURNISHINGS AND APPLIANCES) | $ 2.06 |
| AFICA | 1560 | 1560 (AIRFRAME STRUCTURAL COMPONENTS) | $ 1.49 |
| NON AFICA | 2590 | 2590 (MISCELLANEOUS VEHICULAR COMPONENTS) | $ 1.37 |
| AFICA | 5826 | 5826 (RADIO NAVIGATION EQUIPMENT, AIRBORNE) | $ 1.33 |
| NON AFICA | 4120 | 4120 (AIR CONDITIONING EQUIPMENT) | $ (3.60) |
| | | Total: | $ 4,273.50 |

# Appendix G. Leverage Quadrant Breakdown

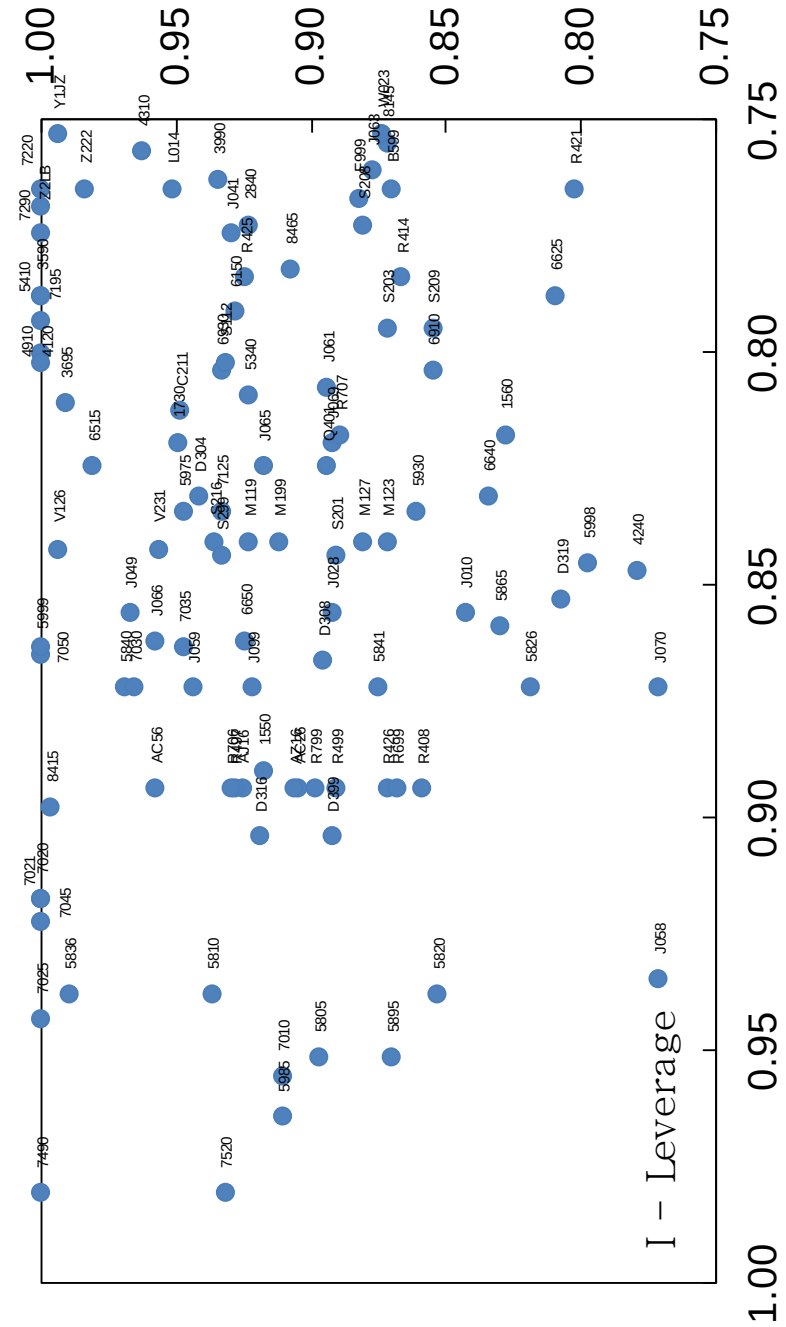


**Figure 22. Leverage Partition 1**

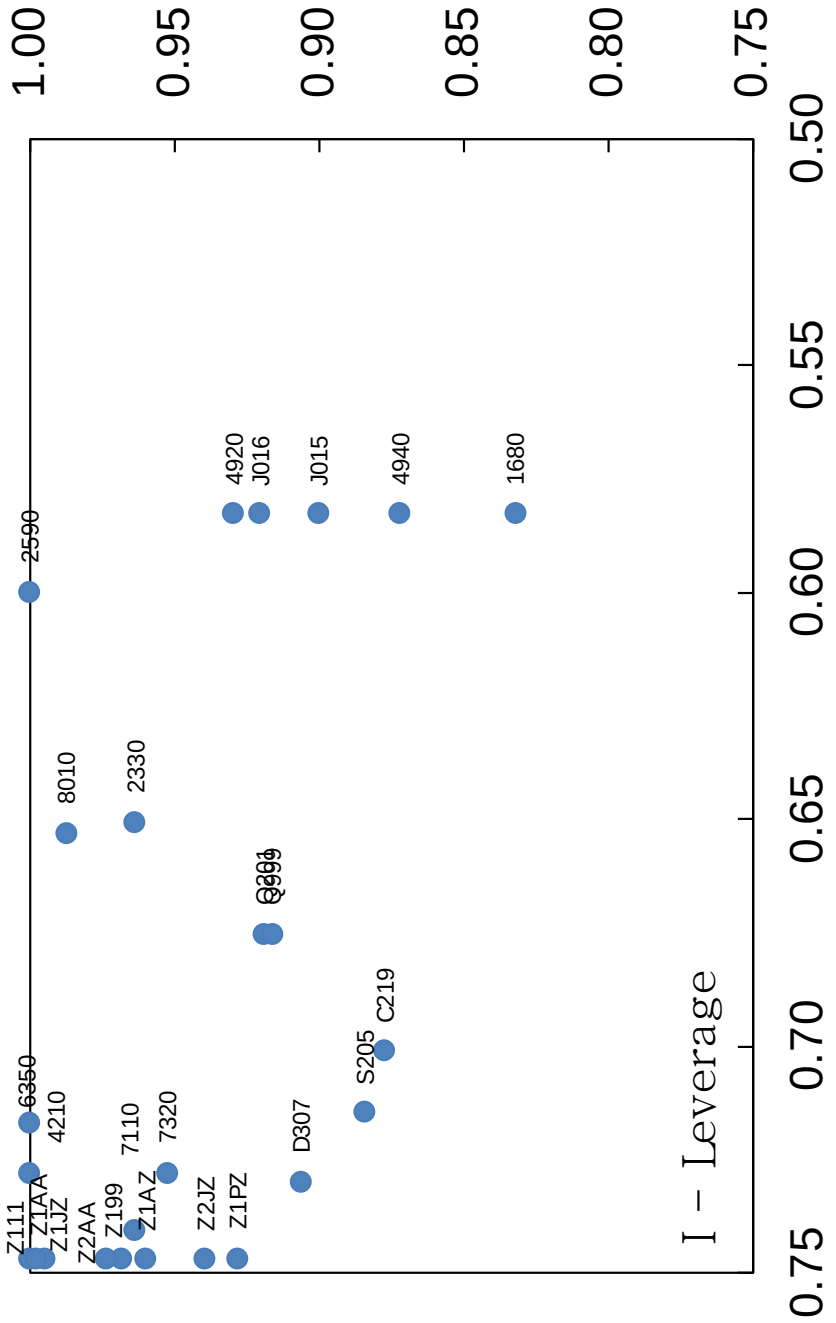


**Figure 23. Leverage Partition 2**

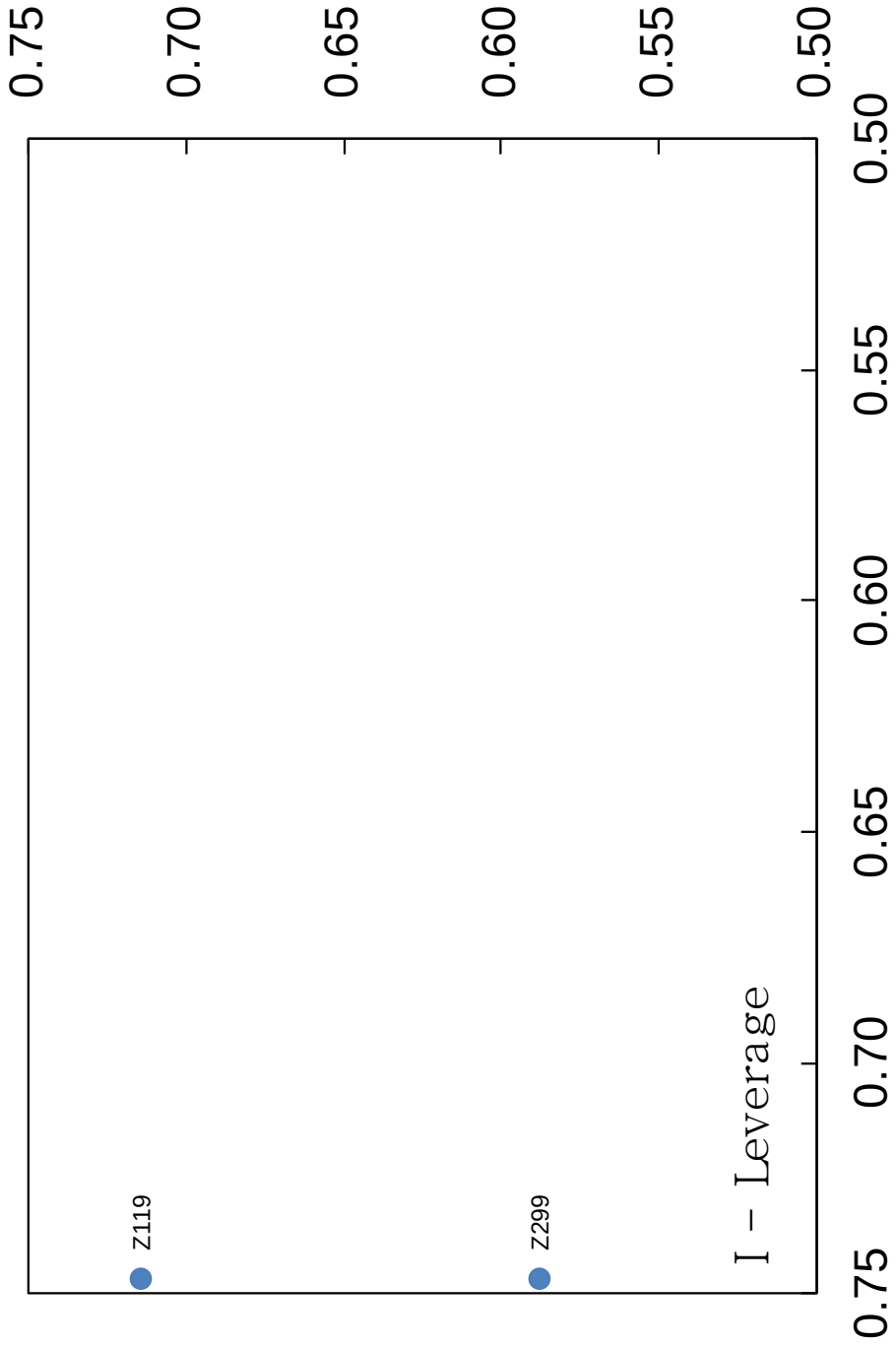


**Figure 24. Leverage Partition 3**

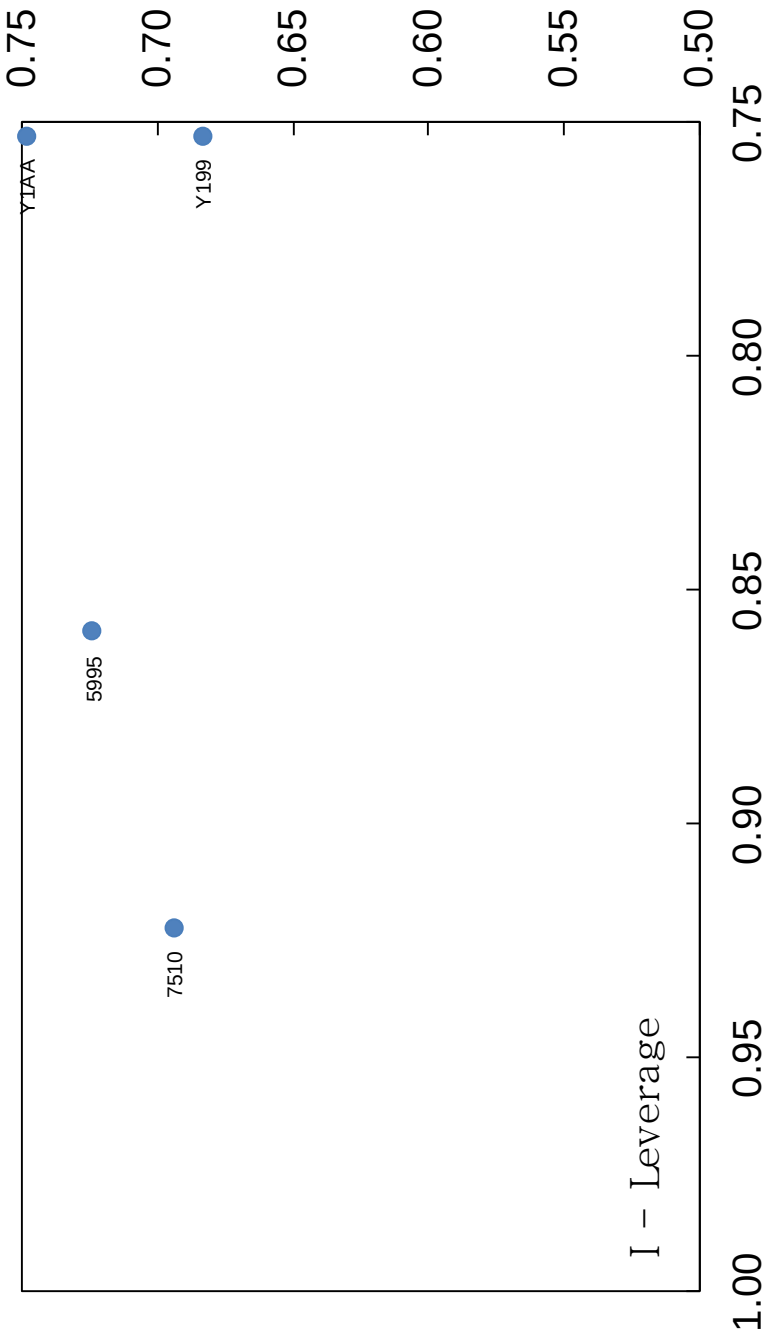


**Figure 25. Leverage Partition 4**

# Appendix H. Multi–Attribute Value Function Scores

**Table 23. Mult–Attribute Value Function (MAVF) Scores**

| PSC | MAVF Score | PSC | MAVF Score | PSC | MAVF Score |
|---|---|---|---|---|---|
| 7490 | 0.991 | 1730 | 0.887 | 6910 | 0.830 |
| 7025 | 0.973 | 7125 | 0.885 | D319 | 0.829 |
| 5836 | 0.965 | M119 | 0.883 | S208 | 0.829 |
| 7045 | 0.963 | C211 | 0.883 | 8010 | 0.827 |
| 7020 | 0.960 | R426 | 0.882 | F999 | 0.827 |
| 7021 | 0.960 | D308 | 0.881 | R414 | 0.827 |
| 7520 | 0.955 | R699 | 0.880 | S209 | 0.826 |
| 8415 | 0.949 | Z222 | 0.878 | 1560 | 0.823 |
| 5810 | 0.937 | Z111 | 0.878 | D307 | 0.821 |
| 5985 | 0.936 | Y1JZ | 0.878 | J063 | 0.821 |
| 5999 | 0.935 | M199 | 0.878 | 5998 | 0.820 |
| 7050 | 0.934 | Z1JZ | 0.877 | J070 | 0.819 |
| 7010 | 0.932 | Z1AA | 0.876 | B599 | 0.819 |
| AC56 | 0.927 | R408 | 0.875 | 8145 | 0.815 |
| 5805 | 0.923 | J028 | 0.875 | W023 | 0.815 |
| 5840 | 0.922 | 5841 | 0.874 | 2330 | 0.813 |
| V126 | 0.921 | J065 | 0.873 | 4240 | 0.811 |
| 7030 | 0.920 | 6930 | 0.871 | 2590 | 0.808 |
| J049 | 0.914 | S112 | 0.869 | 7510 | 0.803 |
| R706 | 0.912 | 4210 | 0.869 | S205 | 0.803 |
| D316 | 0.912 | 5340 | 0.868 | Q201 | 0.802 |
| J066 | 0.911 | S201 | 0.868 | Q999 | 0.800 |
| R497 | 0.911 | Z2AA | 0.864 | 6625 | 0.799 |
| AJ16 | 0.910 | 6350 | 0.864 | C219 | 0.792 |
| J059 | 0.909 | 4310 | 0.864 | 5995 | 0.788 |
| 5895 | 0.909 | 6150 | 0.862 | R421 | 0.784 |
| 7035 | 0.907 | L014 | 0.862 | 4920 | 0.763 |
| 6515 | 0.906 | Z199 | 0.862 | J016 | 0.758 |
| 4910 | 0.905 | M127 | 0.861 | Y1AA | 0.750 |
| 3695 | 0.904 | Q401 | 0.860 | J015 | 0.748 |
| 1550 | 0.904 | Z1AZ | 0.857 | 5680 | 0.746 |
| 4120 | 0.904 | J069 | 0.857 | 4940 | 0.733 |
| V231 | 0.901 | R425 | 0.857 | Z119 | 0.730 |
| 7195 | 0.901 | M123 | 0.857 | Y199 | 0.716 |
| AZ16 | 0.900 | 7110 | 0.856 | 1680 | 0.712 |
| AC26 | 0.899 | J041 | 0.855 | Z299 | 0.664 |
| 3590 | 0.898 | R707 | 0.855 | | |
| 5410 | 0.898 | J061 | 0.852 | | |
| D399 | 0.898 | 3990 | 0.852 | | |
| J099 | 0.898 | 2840 | 0.851 | | |
| R799 | 0.896 | J058 | 0.849 | | |
| 6650 | 0.894 | J010 | 0.849 | | |
| 5820 | 0.894 | 5930 | 0.848 | | |
| 5975 | 0.893 | 8465 | 0.847 | | |
| R499 | 0.892 | Z2JZ | 0.847 | | |
| 7290 | 0.892 | 7320 | 0.844 | | |
| S299 | 0.890 | 5826 | 0.844 | | |
| S216 | 0.890 | 5865 | 0.844 | | |
| 7220 | 0.889 | Z1PZ | 0.841 | | |
| D304 | 0.888 | S203 | 0.835 | | |
| Z2LB | 0.887 | 6640 | 0.833 | | |

# Appendix I. Non–Prioritized PSC Analysis

**Table 24. Non–Prioritized PSC List**

| PSC | PSC DESCRIPTION |
|---|---|
| J042 | MAINT/REPAIR/REBUILD OF EQUIP–FIRE FIGHTING/RESCUE/SAFETY EQUIP; ENVIRON PROTECT EQUIP/MATLS |
| F015 | NATURAL RESOURCES/CONSERVATION–WELL DRILLING/EXPLORATORY |
| R704 | SUPPORT–MANAGEMENT: AUDITING |
| D310 | IT AND TELECOM–CYBER SECURITY AND DATA BACKUP |
| W022 | LEASE OR RENTAL OF EQUIPMENT–RAILWAY EQUIPMENT |
| 6635 | PHYSICAL PROPERTIES TESTING AND INSPECTION |
| 6830 | GASES: COMPRESSED AND LIQUEFIED |
| G002 | SOCIAL–CHAPLAIN |
| 5640 | WALLBOARD, BUILDING PAPER, AND THERMAL INSULATION MATERIALS |
| C215 | ARCHITECT AND ENGINEERING- GENERAL: PRODUCTION ENGINEERING |
| J060 | MAINT/REPAIR/REBUILD OF EQUIPMENT- FIBER OPTICS MATERIALS, COMPONENTS, ASSEMBLIES, AND ACCESSORIES |

**Table 25. Single Attribute Value Function 1 – Supply Market Complexity**

| PSC | IBIS Score – $x_i$ | Attribute Score – $v_x(x_i)$ |
|---|---|---|
| J042 | 1.76 | 0.37 |
| F015 | 2.01 | 0.46 |
| R704 | 2.38 | 0.58 |
| D310 | 2.05 | 0.48 |
| W022 | 1.83 | 0.40 |
| 6635 | 2.45 | 0.60 |
| 6830 | 2.11 | 0.50 |
| G002 | 1.00 | 0.00 |
| 5640 | 2.11 | 0.50 |
| C215 | 3.89 | 0.89 |
| J060 | 4.23 | 0.93 |

**Table 26. Single Attribute Value Function 2 – Installation Mission Impact**

| PSC | Spend Slope Delta – $y_i$ | Attribute Score – $v_y(y_i)$ |
|---|---|---|
| J042 | 3.81 | 1.00 |
| F015 | -1.06 | 0.62 |
| R704 | 0.97 | 1.00 |
| D310 | 0.86 | 0.99 |
| W022 | -0.95 | 0.66 |
| 6635 | 0.73 | 0.98 |
| 6830 | 0.56 | 0.97 |
| G002 | 0.40 | 0.95 |
| 5640 | 0.32 | 0.94 |
| C215 | -3.19 | 0.00 |
| J060 | -1.55 | 0.36 |

**Table 27. Multi–Attribute Value Function Results**

| PSC | MAVF Score |
|---|---|
| J042 | 0.697 |
| F015 | 0.545 |
| R704 | 0.797 |
| D310 | 0.744 |
| W022 | 0.534 |
| 6635 | 0.798 |
| 6830 | 0.740 |
| G002 | 0.495 |
| 5640 | 0.728 |
| C215 | 0.425 |
| J060 | 0.632 |

# Using Multiple Objective Decision Analysis (MODA) to Position Federal Product and Service Codes (PSCs) in the Kraljic Portfolio Matrix (KPM)


**Capt Robert Montgomery**
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## Research Question

**How does the Air Force Installation Contracting Agency (AFICA) determine if current contracting strategies are in line with commercial best practices?**

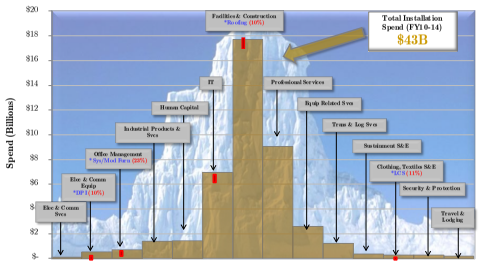
## Research Purpose

1. Facilitate Federally-directed strategic sourcing efforts
2. Ensure the USAF is leveraging its buying power
3. Generate substantial savings to the USAF budget
4. Maximize value to the American taxpayer

## AFICA

- Headquartered at WPAFB, OH
- Responsible for managing and executing above-Wing-level operational acquisition solutions, across the Air Force enterprise
- Contracting support enables effective mission and installation operations
- Leverages AF-wide reach to capitalize on strategic sourcing opportunities

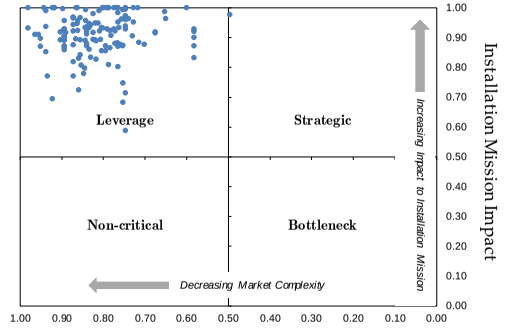
## The Mountain of Installation Spend



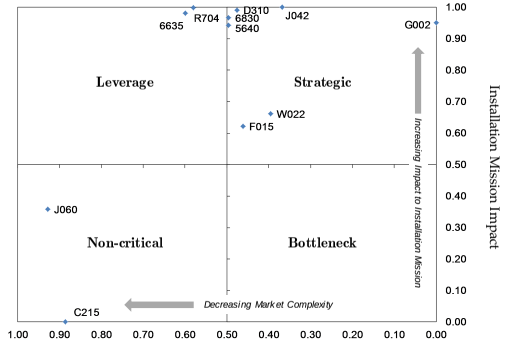

## "Our installations are warfighting platforms"

*- Former USAF Chief of Staff, General T. Michael Mosley, ret.*

## Prioritized PSC-KPM Plot




## Non-Prioritized PSC-KPM Plot




## Methodology

- MODA is used as a framework to position items in the KPM such that two fundamental objectives and their respective value functions are used to plot every alternative (PSC) on the coordinate plane (the KPM)
- KPM position indicates appropriate commercial best practice contracting strategy to pursue & allows comparisons with current employed strategies
- The two axes of Kraljic matrix represent fundamental objectives
- Alternatives are PSCs that AFICA desires to position in the KPM
- Attributes are the evaluation measures for each fundamental objective; two attributes were identified
- IBIS*World* Buyer Power Score measures supply market complexity – scores range from 1.00 to 5.00 and a higher score indicates a less complex market
- FY13-14 Spend Slope Deviation between an individual PSC and overall Installation spend measures installation mission impact. Sequestration invoked budget cuts of 13% in FY13. The budget increased by 6% in FY14. Assumption – FY14 increases are applied to an installation's most critical PSCs.
- Both attributes are inputs to their respective increasing exponential function obtained by anchoring end points, eliciting value preferences, and fitting a line to the elicited values which allow calculation of $(v_x(x_i), v_y(y_i))$ pairs (see plots at left)

## Results

- Sensitivity analysis showed value preferences of decision makers are adequately captured with corresponding value functions
- MODA framework reduces subjectivity and invokes analytical rigor to KPM positioning process and answers the often criticized "how to position" question.
- KPM plot reinforces AFICA-internal analytic procedures given prioritized PSCs represent PSCs suitable for cost reduction (a key component of leverage quadrant strategies)
- Non-prioritized plot highlights importance of positioning prior to prioritizing.
- Upper left quadrant (leverage) PSCs – nearly all acquired through fixed price contracts. This is in direct opposition to commercial best practices & connotes potential for cost reduction

## Significance of Research

**This study fills both an operational and a research gap. The operational gap is filled by positioning items procured by AFICA in the KPM facilitate strategic sourcing. The research gap is filled by using MODA; a proven effective quantitative method not yet applied for this purpose in literature.**

# Bibliography


AFICA. 2015 [accessed: 6 October 2015]. *Air Force Installation Contracting Agency (AFICA)*. http://www.wpafb.af.mil/afica/.

AFLCMC/HIBB-Hill. 2016 [accessed: 28 January 2016]. *FAR – Part 16 Types of Contracts*. http://farsite.hill.af.mil/vffara.htm.

Air Force News Service. 2013 (accessed: 6 October 2015) (April). *Air Combat Command units stand down due to sequestration*. http://www.usafa.af.mil/news/story_print.asp?id=123343694.

Air Force News Service. 2013 (accessed: 8 October 2015) (July). *Sequestration impact looms despite resumed flying operations*. http://www.usafe.af.mil/news/story.asp?id=123356253.

Alesina, A., & Sachs, J. 1986. *Political parties and the business cycle in the United States, 1948-1984*. Tech. rept. National Bureau of Economic Research.

Bensaou, M. 1999. Portfolios of buyer-supplier relationships. *Sloan management review*, **40**.

Bordelon, B. 2014 [accessed: 6 October 2015]. *Hagel, Dempsey: We're Going to Need More Money from Congress*. http://www.nationalreview.com/corner/388957/hagel-dempsey-were-going-need-more-money-congress-brendan-bordelon.

Caniëls, Marjolein C.J., & Gelderman, C.J. 2007. Power and interdependence in buyer supplier relationships: A purchasing portfolio approach. *Industrial Marketing Management*, **36**(2), 219–229.

Clark, C.S. 2015 [accessed: 9 November 2015]. *OMB and GSA Tout Progress in Federal Agencies 'Buying as One'*. http://www.govexec.com/contracting/2015/10/omb-and-gsa-tout-progress-federal-agencies-buying-one/122850/.

Coombs, J. 2013 [accessed: 28 January 2016]. *The Hidden Costs of Firm-Fixed Price Contracts*. http://www.integritymc.com/blog/2013/01/the-hidden-costs-of-firm-fixed-price-contracting/.

Cox, A. 2001. Understanding buyer and supplier power: a framework for procurement and supply competence. *Journal of Supply Chain Management*, **37**(1), 8–15.

Croom, S.R. 2000. The impact of web-based procurement on the management of operating resources supply. *Journal of Supply Chain Management*, **36**(1), 4.

CSBA. 2015 [accessed: 9 October 2015]. *USAF: Use of F-22s Target Dependent, JTACs Crucial for Air Support*. http://csbaonline.org/2014/09/29/usaf-use-of-f-22s-target-dependent-jtacs-crucial-for-air-support/.

D'Angelo, T., Houglan, D., & Ruckwardt, E. 2008. A strategic approach to contingency contracting. *Journal of Contract Management*, **9**, 35–47.

De Haan, J., de Groot, G., Loo, E., & Ypenburg, M. 2003. Flows of goods or supply chains; lessons from the natural rubber industry in Kerala, India. *International Journal of Production Economics*, **81**, 185–194.

Deputy Director for Management, Office of Management and Budget. 2005 [accessed 5 June 2015]. *Implementing Strategic Sourcing [Memorandum]*. https://www.whitehouse.gov/sites/default/files/omb/procurement/comp_src/implementing_strategic_sourcing.pdf.

Deputy Director for Management, Office of Management and Budget. 2012 [accessed 6 November 2015]. *Improving Acquisition through Strategic Sourcing [Memorandum]*. https://www.whitehouse.gov/sites/default/files/omb/memoranda/2013/m-13-02_0.pdf.

Dillon-Merrill, Robin L, Parnell, Gregory S, Buckshaw, Donald L, Hensley, William R, & Caswell, David J. 2008. Avoiding common pitfalls in decision support frameworks for Department of Defense analyses. *Military Operations Research*, **13**(2), 19–31.

DPAP. 2015 [accessed: 15 October 2015]. *Defense Procurement and Acquisition Policy (DPAP)*. http://www.wpafb.af.mil/afica/.

DPAP. Unknown [accessed: 6 October 2015]. *Air Force Strategic Sourcing Initiatives [Briefing]*. http://www.acq.osd.mil/dpap/ss/docs/AirForce%20Strategic%20Sourcing%20Initiatives.pdf.

Dubois, A., & Pedersen, A. 2002. Why relationships do not fit into purchasing portfolio modelsa comparison between the portfolio and industrial network approaches. *European Journal of Purchasing & Supply Management*, **8**(1), 35–42.

Dyer, J.H., Cho, D.S., & Chu, W. 1998. Strategic supplier segmentation: The next" best practice" in supply chain management. *California management review*, **40**(2), 57.

Dyer, J.S. 1990. Remarks on the analytic hierarchy process. *Management science*, **36**(3), 249–258.

Ferreira, L.M., & Kharlamov, A.A. 2012. Application of Kraljics purchasing portfolio matrix in construction industry - A case study. *Pages 111.1–111.11 of: International Conference on Industrial Engineering and Operations Management*.

Ferreira, L.M., Arantes, A., & Kharlamov, A.A. 2014. Development of a purchasing portfolio model for the construction industry: an empirical study. *Production Planning & Control*, 1–16.

GAO. 2012 (September). *Strategic Sourcing: Improved and Expanded Use Could Save Billions in Annual Procurement Costs*. GAO-12-919 edn. Government Accountability Office, Washington DC.

GAO. 2013 (April). *Strategic Sourcing: Leading Commercial Practices Can Help Federal Agnencies Increase Savings When Acquiring Services*. GAO-13-417 edn. Government Accountability Office, Washington DC.

GAO. 2015 (September). *Strategic Sourcing: Opportunities Exist to Better Manage Information Technology Services Spending*. GAO-15-549 edn. Government Accountability Office, Washington DC.

GAO. 2015 [accessed: 9 November 2015]. *About GAO*. http://www.gao.gov/about/.

Gelderman, C.J., & Mac Donald, D.R. 2008. Application of Kraljic's Purchasing Portfolio Matrix in an Undeveloped Logistics Infrastructure: The Staatsolie Suriname Case. *Journal of Transnational Management*, **13**(1), 77–92.

Gelderman, C.J., & Semeijn, J. 2006. Managing the global supply base through purchasing portfolio management. *Journal of Purchasing and Supply Management*, **12**(4), 209–217.

Gelderman, C.J., & Van Weele, A.J. 2002. Strategic direction through purchasing portfolio management: a case study. *Journal of Supply Chain Management*, **38**(1), 30–37.

Gelderman, C.J., & Van Weele, A.J. 2003. Handling measurement issues and strategic directions in Kraljic's purchasing portfolio model. *Journal of purchasing and supply management*, **9**(5), 207–216.

Gelderman, C.J., & Van Weele, A.J. 2005. Purchasing portfolio models: a critique and update. *Journal of Supply Chain Management*, **41**(3), 19–28.

Gould, J., & Mehta, A. 2015 [accessed: 6 October 2015]. *Sources: Congress Mulls Full-Year Continuing Resolution*. http://www.defensenews.com/story/defense/policy-budget/budget/2015/08/23/congress-mulling-full-year-cr/32009961/.

GSA. 2011 (October). *Federal Procurement Data System Product and Service Codes Manual*. U.S. General Services Administration Office of Governmentwide Policy, Washington DC.

GSA. 2015 [accessed: 4 November 2015]. *Category Management*. https://www.acquisition.gov/Category_Management.

Howard, Ronald A, & Abbas, Ali E. 2015. *Foundations of Decision Analysis*. Prentice Hall.

IBIS*World*. 2015 [accessed: 17 November 2015]. *Procurement Category Market Research Reports*. https://www.ibisworld.com/procurement/reports/.

IBIS*World*. 2015 [accessed: 8 December 2015]. *IBIS*World. https://www.ibisworld.com.

Keeney, R.L. 1992. *Value-focused thinking: A path to creative decision making*.

Keeney, R.L., & Raiffa, H. 1993. *Decisions with multiple objectives: preferences and value trade-offs*. Cambridge university press.

Kirkwood, C.W. 1996. *Strategic decision making*. Wadsworth Publ. Co.

Knight, L., Tu, Y., & Preston, J. 2014. Integrating skills profiling and purchasing portfolio management: An opportunity for building purchasing capability. *International Journal of Production Economics*, **147**, 271–283.

Kraljic, P. 1983. Purchasing must become supply management. *Harvard business review*, **61**(5), 109–117.

Lee, D.M., & Drake, P.R. 2010. A portfolio model for component purchasing strategy and the case study of two South Korean elevator manufacturers. *International Journal of Production Research*, **48**(22), 6651–6682.

Lilliecreutz, J., & Ydreskog, L. 1999. Supplier classification as an enabler for a differentiated purchasing strategy. *Global Purchasing & Supply Management*, **November**, 66–74.

Lilliecreutz, J., & Ydreskog, L. 2001. Supplier classification as an enabler for a differentiated purchasing strategy. *Best Practice Procurement: Public and Private Sector Perspective*, **8**, 73–81.

Liu, X., & Xu, J. 2008. Research on the purchasing portfolio approach for steel industry. *Pages 4911–4916 of: Intelligent Control and Automation, 2008. WCICA 2008. 7th World Congress on*. IEEE.

Loasby, BJ. 2001. Making sense of making artefacts: Reflections on John Ziman (Ed.), Technological innovation as an evolutionary process.

Muir, W.A., Keller, R.S., & Knight, L.E. 2014 (March). *Category Management: A Concept of Operations for Improving Costs at the Air Force Installation*. (Discussion Paper).

Nellore, R., & Söderquist, K. 2000a. Portfolio approaches to procurement: Analysing the missing link to specifications. *Long Range Planning*, **33**(2), 245–267.

Nellore, R., & Söderquist, K. 2000b. Portfolio approaches to procurement: Analysing the missing link to specifications. *Long Range Planning*, **33**(2), 245–267.

Nudurupati, S.S., Bhattacharya, A., Lascelles, D., & Caton, N. 2015. Strategic sourcing with multi-stakeholders through value co-creation: An evidence from global health care company. *International Journal of Production Economics*.

Obama, Barack. 2009 [accessed 6 November 2015]. *Government Contracting [Memorandum]*. https://www.whitehouse.gov/the-press-office/memorandum-heads-executive-departments-and-agencies-subject-government-contracting.

Office of Federal Procurement Policy, Office of Management and Budget. 2007 [accessed 28 October 2015]. *Strategic Sourcing Progress [Memorandum]*. https://www.whitehouse.gov/sites/default/files/omb/procurement/strat_sourc/fssi_progress_052207.pdf.

Office of Federal Procurement Policy, Office of Management and Budget. 2014 [accessed 4 November 2015]. *Transforming the Marketplace: Simplifying Federal Procurement to Improve Performance, Drive Innovation, and Increase Savings [Memorandum]*. https://www.whitehouse.gov/sites/default/files/omb/procurement/memo/simplifying-federal-procurement-to-improve-performance-drive-innovation-increase-savings.pdf.

Olsen, R.F., & Ellram, L.M. 1997. A portfolio approach to supplier relationships. *Industrial marketing management*, **26**(2), 101–113.

Padhi, S.S., Wagner, S.M., & Aggarwal, V. 2012. Positioning of commodities using the Kraljic Portfolio Matrix. *Journal of Purchasing and Supply Management*, **18**(1), 1–8.

Parnell, G.S., Bresnick, T., Tani, S.N., & Johnson, E.R. 2013. *Handbook of decision analysis*. Vol. 6. John Wiley & Sons.

Pickup, S.L., & Sullivan, M.J. 2013 (November). *Sequestration: Observations on the Department of Defense's Approach in Fiscal Year 2013*. GAO-14-177R Sequestration edn. Government Accountability Office, Washington DC.

Ramsay, J. 1994. Purchasing power. *European Journal of Purchasing & Supply Management*, **1**(3), 125–138.

Ronald, M.H. 2010. *Best Business Practices for Fixed-Price Contracting*. Tech. rept. Defense Business Board.

Syson, Russell. 1992. *Improving purchase performance*. Pitman.

Under Secretary of Defense for Acquisition, Technology, and Logistics. 2010 [accessed 28 January 2016]. *Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending [Memorandum]*. http://www.acqnotes.com/Attachments/Better%20Buying%20Power%20Guidance%20for%20Obtaining%20Greater%20Efficiency%20and%20Productivity%20in.pdf.

Under Secretary of Defense for Acquisition, Technology, and Logistics. 2012 [accessed 28 January 2016]. *Better Buying Power 2.0: Continuing the Pursuit for Greater Efficiency and Productivity in Defense Spending [Memorandum]*. http://www.acqnotes.com/Attachments/Better%20BuyingPower%202.0.pdf.

Under Secretary of Defense for Acquisition, Technology, and Logistics. 2015 [accessed 28 January 2016]. *Implementation Directive for Better Buying Power 3.0 - Achieving Dominant Capabilities through Technical Excellence and Innovation [Memorandum]*. http://acqnotes.com/wp-content/uploads/2014/09/BBP3.0ImplementationGuidanceMemorandum.pdf.

Wagner, S.M., & Johnson, J.L. 2004. Configuring and managing strategic supplier portfolios. *Industrial Marketing Management*, **33**(8), 717–730.

Wagner, S.M., Padhi, S.S., & Bode, C. 2013. The Procurement Process: Refining inputs for Kraljic matrix yields objective purchasing portfolios and strategies. *Industrial Engineer*, **45**(2), 34–39.

Watson, S.R., & Buede, D.M. 1987. *Decision synthesis: the principles and practice of decision analysis*. Cambridge University Press.

Wynstra, F., & Ten Pierick, E. 2000. Managing supplier involvement in new product development: a portfolio approach. *European Journal of Purchasing & Supply Management*, **6**(1), 49–57.

Zhenfeng, Z., Danxia, G., & Liuming, D. 2007. Positioning model of purchasing based on Kraljics purchasing portfolio matrix and factor analysis. *Globalization Challenge and Management Transformation*, 289.

Zolkiewski, J., & Turnbull, P. 2002. Do relationship portfolios and networks provide the key to successful relationship management? *Journal of Business & Industrial Marketing*, **17**(7), 575–597.

## Vita

Captain Robert T. Montgomery attended Edinburgh Community High School in Edinburgh, IN and graduated in 1995. He entered the USAF in 1997 and served 7 years as a medical services technician. He was competitively selected for the Airman Education and Commissioning Program (AECP) in 2003 and began full-time coursework in the fall of 2004. He accomplished his undergraduate studies at the University of Akron in Akron, OH earning a Bachelor of Science degree in Mathematics in May 2007. Robert was commissioned into the US Air Force as a Second Lieutenant in May 2007.

Captain Montgomery's first assignment was to the 639th Aircraft Sustainment Group at Tinker AFB, OK. Robert served as Program Manager for the Air Force Oil Analyis Program. During this assignment, he also completed a Masters in Business Administration from Oklahoma City University and deployed in 2010 in support of Operation Enduring Freedom.

Captain Montgomery was competitively selected for the Acquisition and Logistics Experience Exchange Tour (ALEET) in 2011. He was assigned to the 20th Maintenance Group at Shaw AFB, SC in October 2011 where he served in numerous leadership positions within the maintenance group in support of 20th Fighter Wing flying operations and multiple overseas contingency operations.

In 2014, Robert was competitively selected for the U.S. Air Force Academy (USAFA) Faculty Pipeline program and entered the Air Force Institute of Technology's Graduate School of Engineering and Management at Wright-Patterson AFB, Ohio in August 2014. Upon graduation, he will be assigned to the Mathematics Department at USAFA.

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**14. ABSTRACT**

Despite the best efforts of the Federal Government to implement strategic sourcing, recent Government Accountability Office (GAO) reports highlight major procurement deficiencies and encourage the use of commercial best practices to identify and reap substantial savings. The Kraljic Portfolio Matrix (KPM) is considered the premier tool for purchasing organizations to determine which commercial best practices to utilize for different categories of spend. However, critics of the KPM point to its lack of analytical rigor and the absence of a simplistic quantitative methodology for implementation. The Air Force Installation Contracting Agency (AFICA), the centralized procurement arm for 79 USAF installations worldwide, desires to exploit the KPM to determine if current contracting strategies are in line with commercial best practices. Therefore, this research seeks to fill both an operational and research gap. The operational gap is filled using multi-objective decision analysis (MODA) as a framework to position installation procured goods and services within the KPM in order to facilitate AFICAs strategic sourcing efforts. The application of MODA fills a research gap by providing a quantitative methodology not yet found in literature.

**15. SUBJECT TERMS**

Kraljic, purchasing portfolio, purchasing, strategic sourcing, MODA, multi-objective decision analysis, purchasing strategy

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