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Information Technology Portfolio Management Proof of Concept: Modern Portfolio Theory with KVA and ROI Analysis

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Information Technology Portfolio Management Proof of Concept: Modern Portfolio Theory with KVA and ROI Analysis

27 November 2010

by

LT Marco Nelson

Advisor: Dr. Thomas J. Housel, Professor, and

Glenn Cook, Senior Lecturer

Graduate School of Operational and Information Sciences

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ABSTRACT

The basic research question guiding this thesis is, How can Modern Portfolio Theory (MPT) be defensibly applied to DoD information technology (IT) portfolio optimization problems? The research will demonstrate how to derive the appropriate raw performance and volatility data required to remain consistent with MPT assumptions and methodology. This thesis accomplishes this research objective by establishing a notional IT beta (β) to apply a MPT approach for asset allocation within the Department of Defense (DoD). Data from three previous RFID implementation case studies were used, in which the knowledge-value added (KVA) methodology was applied to estimate the return on investment (ROI) produced by IT. The KVA methodology is essential for the application of this thesis because it provides the framework for the allocation of surrogate revenue and cost streams into core processes where RFID technology was implemented. The ROI estimates of volatility act as a surrogate for equity price volatility, allowing the application of the Modern Portfolio Theory (MPT) approach in the nonprofit sector.

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I. INTRODUCTION

A. PURPOSE/PROBLEM STATEMENT

On October 10, 2005, the Department of Defense (DoD) chief information officer (CIO) released Directive 8115.01, *Information Technology Portfolio Management*, which outlined the DoD policy that "IT investments shall be managed as portfolios: to ensure IT investments support the Department's vision, mission, and goals; ensure efficient and effective delivery of capabilities to the warfighter; and maximize return on investment (ROI) to the Enterprise" (p. 2). The DoD CIO further directs that IT portfolios shall be "managed and monitored using established quantifiable outcome-based performance measures, and evaluated against portfolio performance measures to determine whether to recommend continuation, modification, or termination of individual investments within the portfolio" (p. 3).

One year later, on October 30, 2006, the DOD CIO further directed how to achieve that policy in Instruction 8115.02, *Information Technology (IT) Portfolio Management Implementation*. The instruction insists that the processes should include "a knowledge-based approach" that provides analysis for "program managers to attain the right knowledge [e.g., portfolio values] at critical junctures so they can make informed program decisions throughout the acquisition process" (p. 3). The DoD CIO further instructs that "a portfolio baseline shall be established and maintained for each portfolio" (p. 15).

Since the release of these documents, there have been several approaches to estimate the return on IT investments, in order to follow the directive's guidance. All of these approaches were cost-based, except for one, which does not provide the proper ROI analysis because value is derived from cost and not revenue. Value must be derived from revenue in order to derive a true numerator. Since the directive derived the portfolio concepts from Markowitz's Modern Portfolio Theory (MPT), any method should align with the guidelines provided using the framework of MPT. In the past, it has been impossible to properly apply MPT to the DoD because the raw data of MPT relies upon stock price volatility, which could not be done within the non-profit sector because there is no revenue data and no equity market.

The research question motivating this thesis is, How can Modern Portfolio Theory (MPT) be defensibly applied to DoD information technology portfolio optimization problems? The remainder of the thesis will review the relevant literature surrounding this problem and demonstrate how the KVA method produces necessary performance volatility data, applies this data set to derive notional market and individual asset betas (β), and uses the resulting information to optimize a portfolio of DoD IT assets (i.e., RFID technology).

B. RESEARCH QUESTIONS

The following research questions drove this thesis in order to provide the correct method of evaluation to obtain the necessary data and to provide a proof of concept of how to derive a notional IT beta (β) to properly apply MPT to manage IT portfolios within the DoD, as directed by the CIO.

1. Primary Question

- How can Modern Portfolio Theory (MPT) be defensibly applied to DoD information technology (IT) portfolio optimization problems?

2. Secondary Questions

- How can the DoD derive the appropriate raw performance, volatility data, required to remain consistent with MPT assumptions and methodology?
- What methodology best aligns with the DoD CIO's Directive 8115.01, *Information Technology (IT) Portfolio Management?*

C. POTENTIAL BENEFITS

Defense Secretary Robert Gates's recent budget reallocation is "not to reduce the department's top-line budget," he said. "Rather, it is to significantly reduce its excess overhead costs and apply the savings to force structure and modernization" (McLeary, 2010). His goal is to free up close to $10 billion in FY2011 and around $100 billion over the next five years, through asset reallocation. The DoD's current assets are under scrutiny as to whether they should be continued, modified, or terminated. Key decision-makers lack an effective or accurate way to measure and compare the benefits of the assets. Key decision-makers (i.e., CIOs, program managers) can use MPT as an effective tool to help in analysis of IT alternatives, courses of action, and acquisition prioritization in the form of portfolio optimization.

This thesis will provide a method to extend MPT to the DoD asset allocation problem through the use of the KVA methodology to provide the appropriate raw performance, volatility data required to remain consistent with MPT assumptions and methodology. This thesis will demonstrate how to derive a notional information technology beta (β) to apply an MPT approach for asset allocation within the DoD IT portfolio.

D. SCOPE

This thesis will focus on solving the current IT portfolio optimization problem by using data from three previous RFID technology case studies to provide a proof of concept of how to derive a volatility beta (β) to apply MPT in accordance with the required parameters for IT portfolio management within the DoD. This thesis will also compare the current methods applied in the non-profit sector to try and provide an accurate analysis of ROI that is produced by IT.

E. METHODOLOGY

The methodology applied in this thesis research will consist of conducting a literature review of books, magazine articles, electronic media, and other library resources concerning MPT and ROI in the non-profit sector. This thesis will conduct a review of case studies that estimated ROI on implementing RFID technology using the KVA methodology. This thesis will then analyze KVA ROI data from case studies to provide a proof of concept of how to derive a beta (β) for IT investments to be used in applying MPT. This thesis will then prepare a summary and make recommendations.

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II. OVERVIEW OF PORTFOLIO MANAGEMENT

A. BACKGROUND

Modern Portfolio Theory (MPT) considers a method of managing resource allocation to avoid unnecessary risks for the investor in the for-profit sector. MPT assumes that the investor desires to maximize expected return over all feasible portfolios while limiting the risk/variance (Housel, Kanevsky, Rodgers, & Little, 2009). This thesis will demonstrate that, with the correct raw volatility performance data provided by the KVA methodology, it is possible to apply MPT to the DoD IT portfolio optimization problem outlined in Directive 8115.01. The advantage of being consistent with the underlying MPT principles and approach is that it will allow DoD decision-makers to formalize their evaluation methods concerning IT portfolio investment diversification and management of risk.

In order to apply MPT correctly, key decision-makers need to be able to compute mean values of the return for every stock in a portfolio as well as the correlation between the returns within a portfolio (Housel et al., 2009). These values are estimated based on historical data and are essential for a beta (β) calculation, which measures a stock's sensitivity to a movement in the overall market. MPT provides investors with an objective capability to measure the tradeoff between the associated return and risk of all investments within a portfolio. Thus, portfolio theory suggests a way of optimally allocating capital for the investor in the private sector (Housel et al., 2009). However, through the steps provided in this thesis, it can also be of utility as an optimization tool for the allocation of resources in the nonprofit sector to optimize the DoD IT investment portfolio in accordance with the requirements of Directive 8115.01.

Detractors have perceived a number of flaws in MPT. These include (Housel et al., 2009)

1) MPT assumes that risk is synonymous with volatility. In fact, a number of early empirical studies (e.g., Haugen & Heins, 1975) demonstrate little correlation between risk (when defined as volatility) and returns. Murphy (1977) concludes that "efficiency is not an accurate description of the capital markets and may not even be a very good description; there are serious problems with the risk/reward relationship." Fama and French (1992) find that "the relation between β and average return for 1941-1990 is weak, perhaps nonexistent, even when β is the only explanatory variable." Logically, the strict correspondence between risk and

volatility seems suspect: volatility, in treating all motion indiscriminately, punishes upward trends just as much as the downward ones investors wish to avoid. An adequate solution may be simply to use "downside risk." As Harlow (1991) explains, "downside-risk measures are attractive not only because they are consistent with investors' perception of risk, but also because the theoretical assumptions required to justify their use are very simple…a number of well known risk measures, including the traditional variance (standard deviation) measure, are special cases of the downside-risk approach."

2) MPT assumes that portfolio returns can, in general, be adequately represented by the normal distribution.

3) MPT assumes away all transaction costs and taxes.

Libby and Fishburn (1977) and Rom and Ferguson (1993) provide solutions to the first two problems through the incorporation of downside-risk and "skewness," which are features of the Post-Modern Portfolio Theory (Housel et al., 2009). The third point is not practical in the for-profit sector, but (presumably) in the application to the nonprofit sector, where the investor is represented by the leadership of an agency (e.g., DoD CIO) and by the organizations within which investments are made (i.e., are controlled), this assumption is realistic (Housel et al., 2009).

These limitations of MPT largely can be addressed using the knowledge-value added (KVA) framework (Housel & Kanevsky, 1995). This approach provides an objective way to "allocate revenue to the subcorporate level using a market comparables technique to establish nonprofit ROI volatility estimates necessary for application of the MPT approach within the DoD" (Housel et al., 2009, p. 1). This thesis will use case study data from KVA studies to generate the raw volatilities estimates needed to use MPT. The results will provide a proof of concept for deriving a baseline volatility beta (β) for IT performance to be compared to a theoretical beta (β) for a notional market. This will allow a consistent application of MPT in the context of managing IT investment portfolios within the DoD.

B. BRINGING MPT TO THE PUBLIC SECTOR

The application of MPT concepts within the public sector presents several difficult problems stemming from the fact that there is a lack of a revenue stream. The lack of a revenue stream in the public sector has lead to major inefficiencies, which may be a result of the lack of efficiency pressures normally encountered in a competitive market (Housel et al., 2009). The DoD's current asset evaluation methods base efficiency on cost (i.e., tax dollars), which is not a true substitute for revenue (Housel et al., 2009).

The public sector's growth of inefficiency has exposed disagreements regarding the proper method for measuring public sector efficiency (i.e., ROI). These inefficiencies have also led to a consensus on the difficulties of measuring ROI and to room for a great deal of improvement (Chao & Eden, 2002). According to Nissen and Barrett (2006), "Bureaucratic organizations are known well to excel in terms of efficiency when situated in stable, predictable environmental contexts, but this classic organizational structure is also known well to be exceptionally poor at anticipating and responding to change." The characteristically bureaucratic public sector, along with the DoD, is faced daily with a fast-paced ever-changing environment, "which puts them at risk of incurring greater inefficiencies and misuse of taxpayer dollars" (Housel et al., 2009). Additionally, even companies that are greatly efficient struggle with the implementation of IT investments that often have their own set of risks and inefficiencies. With the introduction of market mechanisms, the DoD can meet their "vision, mission, and goals; [and] ensure efficient and effective delivery of capabilities to the warfighter; and maximize return on investment (ROI)" (DoD, 2005, p. 2).

Some basic differences between the public and private sectors are indicative of the disparity in efficiencies often attributed to them, as shown in Figure 1.

Private Sector	Public Sector
Single Constituency: “Shareholders”	Multiple Constituencies: “Stakeholders”
NPS-AM-10-184	Mixed Focus: “Efficiency” and “Equity”
Clear Measure of Success: “Bottom Line”	No Clear Measure of Success

Figure 1. Private- and Public-Sector Attributes
(Sweeney, Perkins, & Spencer, 1989)

Many of the inefficiencies of the public sector can be attributed to these differences (Housel et al., 2009):

- In the private sector, focus (efficiency) is singular and clear, while the public sector has a split focus between efficiency and equity.
- In the private sector, the basis for performance measurement is self-evident, measured by a bottom line ROI, while the public sector lacks a clear performance measure.
- The private sector has an easily identifiable body on whose behalf accountability is upheld. The public sector consists of multiple constituencies (who may have different agendas) on which accountability is spread.

These differences are at a fundamental level that has been characteristic of the public sector for decades. In order for a change to occur at this level, key decision-makers must enforce the directives that have outlined such a change (i.e., 8115.01). In the last two decades, there has been a small effort toward such change on a micro level where market-like conditions have been introduced with success (Housel et al., 2009). These instances include the education (e.g., Zuckerman & de Kadt, 1997; Peterson, 2007), electricity (e.g., Fabrizio, Rose, & Wolfram,

2007) and health care (e.g., Klein, 2006) arms of the public sector. Although some success was achieved in these cases, the effort to isolate an instance of market forces within a particular asset could not overcome the inefficiencies of the public sector bureaucracy as a whole (Housel et al., 2009). These small efforts failed to change the overall motivations of the public sector or align them optimally as is seen in the private sector.

In order to align the motivations of the public sector to match those of the private sector, key decision-makers must realize that public assets are essentially a giant portfolio of taxpayers' investments. This realization is important in that "recasting citizens as investors introduces market forces that blur the lines between private and public sectors" (Housel et al., 2009), which may lead to private sector efficiencies and accountability. The biggest obstacle preventing this is the "concern of how public entities can be treated and tracked as corporation-like entities without the benefit of revenue streams" (Housel et al., 2009).1

Once the gap between the private and public sector has been breached, the DoD can begin to break away from the cost-based budgeting approaches, where success is measured by breaking even, and begin to apply a model where decision-makers seek to gain the highest possible returns at feasible costs (Housel et al., 2009). This type of model requires revenue, which is the "truest indicator of value and is measured in common units of money" (Housel et al., 2009). Revenue streams can be established "by opening up these operations to the influences of the market and establishing unambiguous estimates for the value of nonprofit services and products" (Housel et al., 2009). By doing this, key decision-makers will have the metrics available to "effectively gauge the impact of their investment decisions" (Housel et al., 2009). Furthermore, individual IT investments can be treated as "independent entities within a market" (Housel et al., 2009), allowing the application of MPT concepts to provide key decision-makers with the knowledge to create an optimal portfolio.[2] In order to allocate IT assets effectively, the

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[1] Some public sector activities, programs, institutions may not be amenable to a market forces-based approach due to their inherently unique purposes. We do not mean to imply that all public sector activities, programs, and institutions would benefit from our approach. However, there are a large number that have common processes such as accounting. In these cases, it may be more prudent to conduct our analysis at the process or function level rather than the whole entity level.

[2] The foregoing discussion of inefficiencies in the nonprofit sector is largely excerpted from *The Use of Modern Portfolio Theory in Non-Profits and Their IT Decisions* (Housel et al., 2009).

aid of MPT is necessary. It follows that if MPT is to be used to help balance the DoD IT portfolio, it is critical to create a credible beta (β) for the presumed "market volatility" of the IT asset class. The KVA methodology may be used for this critical task.

C. BETA DERIVATION DATA

Establishing a beta (β) for DoD-wide IT portfolio management uses the work conducted at the Naval Postgraduate School (NPS) of two MBA final projects and an ITM thesis. Their research applied the KVA methodology and analysis to estimate ROI on the implementation of RFID technology within the DoD. Major Jung and Captain Baek's research used actual implementation data of RFID technology to estimate the ROI on technology on two processes. The research found that the KVA methodology is capable of evaluating the ROI (benefits) of RFID technology objectively by quantifying the value of IT in common units of output (Jung & Baek, 2009, p. 49). They found that "KVA provided a viable option to estimate the ROI of new IT such as RFID" (Jung & Baek, 2009, p. 52).

LCDR Obellos, LCDR Colleran, and LCDR Lookabill's MBA project used data from a supply chain process at Naval Surface Warfare Center Crane, IN (NSWC Crane) to estimate projected ROI (benefits) of implementing RFID/UID technology (Obellos, Colleran, & Lookabill, 2007, p. 2). The authors concluded that the KVA methodology was the most appropriate method to identify the actual cost and revenue associated with a unit of output, allowing true ROI estimates (Obellos et al., 2007, p. 81).

LCDR Courtney's thesis focused on developing a strategy for estimating the ROI of RFID to track, tag, and inventory item level assets of organizations. The author used the KVA methodology to analyze the current (without RFID technology) and the desired (with RFID technology) state business process in order to estimate the projected ROI of RFID technology (Courtney, 2007, p. 4).

The results of the work of these studies provided the raw data for establishing a notional IT beta (β) to apply a MPT approach using ROI estimates of volatility as a surrogate for equity price volatility, allowing application of the MPT approach in the nonprofit sector. The data provided by these case studies will be used in a proof of concept to determine an IT beta (β), which will be used to apply the MPT approach consistent with its basic assumptions.

D. SUMMARY

In this chapter, the principals of MPT were outlined as an approach to the problem of DoD IT-portfolio optimization outlined in Directive 8115.01. The MPT approach provides investors with an objective capability to measure the tradeoff between associated return and risk of all investments within an IT portfolio. In order to be consistent with the underlying MPT principles within the DoD, the KVA approach was suggested as an objective way to allocate revenue streams to the nonprofit sector (Housel et al., 2009). Revenue streams are necessary for true ROI calculations, which are needed to generate the raw volatilities estimates for the derivation of betas (β). The presence of a revenue stream in the nonprofit sector may lead to greater efficiency and accountability. Chapter 3 will examine the use of the KVA approach for estimating ROI performance data needed for the beta (β) derivations and the application of MPT.

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III. LITERATURE REVIEW

A. ESTIMATING ROI

Since the IT boom of the 1990s, many companies and governments have invested billions of dollars into IT investments, hoping for significant returns in productivity. These returns did not manifest as expected, leading to Nobel Prize-winning economist Robert Solow's "productivity paradox" (Atkinson & Court, 2010). This paradox addresses the idea that even though computers and IT are embedded in more and more business processes, the returns have yet to manifest themselves in productivity statistics (Atkinson & Cook, 2010). This paradox portrays three possible conclusions: IT does not increase productivity, people are slowing down the embedded technology by not fully understanding how to properly apply it, or people cannot properly measure the returns produced by technology. The idea that IT does not increase productivity is the least possible of the conclusions. Even a longtime skeptic Alan Greenspan said, in 2002, that "the pickup in productivity growth since 1995 largely reflects the ongoing incorporation of innovations in computing and communications technologies into the capital stock and business practices" (Greenspan, 2002). This has lead to many approaches to try and measure the productivity enhancements provided by IT investments. One measure that has historically provided an adequate measure in investment finance that might be applied to this problem if the correct data can be derived is return on investment (ROI).

Return on investment (ROI), also known as rate of return, is the ratio of money gained or lost on an investment relative to the money invested. To calculate ROI, the revenue (e.g., benefits) of an investment minus its cost is divided by the cost of the investment; the result is expressed as a percentage or ratio (Pringle & VanOrden, 2009, p. 6). The ROI percentage or ratio is interpreted as a productivity measure, portraying capital (or value) growth or decay. ROI provides a clear insight into how productively an investment has been applied and, ultimately, the value of an investment. Measuring the ROI of IT systems is extremely difficult within the for-profit sector, as well as within the DoD.

The president and CEO of ROI Institute, Patti Phillips, specializes in ROI research and is an advocate of extending ROI to the nonprofit sector to increase accountability and produce consistent and compatible results (Phillips, 2010). Phillips found that ROI provides a bottom-line result of a program that other program-evaluation methods do not (Phillips, 2010). She further concluded that when applying ROI to the nonprofit sector, the major issue is that most social and military programs do not generate profits or revenue (Phillips, 2010).

Jack Phillips, chairman of the ROI Institute, developed the ROI Institute's methodology, which is a "process that provides bottom-line figures and accountability for all types of learning, performance improvement, human resource, technology, and public policy programs" (ROI Institute, 2010). Jack Phillips collaborated with Patti Phillips to try and create an ROI process that can provide a comprehensive evaluation of IT on technology projects (Phillips & Phillips, 2004, p. 512). They found that IT implementation is complex and integrated within several processes and systems, which makes it very difficult to define the actual impact of the technology (Phillips & Phillips, 2004, p. 513). They also found that it is difficult to measure ROI in the nonprofit sector because there are no profits, thus the benefits are measured as cost savings, cost reduction, or cost avoidance (Phillips, 2002, p. 7). David Brandon, a project manager at the Texas Department of State Health Service in Austin, Texas, another author who has extensive experience managing IT projects in the nonprofit sector, agrees that the lack of revenue in the nonprofit sector makes it very difficult to rely on ROI to assess government programs (Brandon, 2010).

Huy Nguyen, a consultant with the Government Finance Officers Association's Research and Consulting Center, supports the notion that ROI of IT in the nonprofit sector is essential to provide accountability, transparency, and value to key decision-makers (Nguyen, 2004). In his research, he presents several limitations of traditional ROI methodologies that include the difficulty of trying to assign monetary value of intangible and tangible benefits. He concludes that this issue stems from the fact that "traditional ROI analysis commonly measures only tangible direct costs such as hardware/software costs and tangible direct benefits such as cost reductions" (Nguyen, 2004). He further suggests that this creates an incomplete picture for decision-makers when evaluating programs and further reduces the usefulness of ROI because organizations "use dissimilar methodologies to evaluate the same project [or comparable projects], undermining the comparability of the analysis" (Nguyen, 2004). Nguyen suggests an adequate solution to this problem is a benefits-valuation method that takes into consideration both tangible and intangible benefits (Nguyen, 2004).

Greg MacSweeney, the editor-in-chief for *Wall Street & Technology*, focuses his research on narrowing down the difficulties with calculating ROI for IT initiatives. His research has revealed difficulties that stem from defining the actual impact of technology in such IT projects because "data warehousing, systems integration and e-commerce usually involve many systems and small projects encompassing both new and old systems" (MacSweeney, 2001). Technology most often enhances an existing process, making it difficult to determine the actual benefits created by the technology, often forcing decision-makers to use assumptions as to how IT will impact the ROI (MacSweeney, 2001). These assumptions are subjective and ultimately lead to inconsistencies in the ROI evaluation. MacSweeney concludes that there is a need for a standardized ROI evaluation process (MacSweeney, 2001).

Bob Violino, a writer and editor at Victory Business Communications, led a study with *InformationWeek* to determine the biggest challenges of measuring the ROI of IT projects (Violino, 1997). *InformationWeek* surveyed IT managers and found that one third cited measuring the true economic benefits of IT as the most difficult, and one quarter cited determining an accurate account of IT returns as the most difficult (Violino, 1997). Kingsley Martin, a consultant who focuses on knowledge management, has determined that this is because ROI and IT have a complex and indirect relationship, in which technology is embedded within a larger overall process (Martin, 2002). Both Violino and Martin suggest that a cost-based method that could capture these economic benefits would help to overcome these difficulties.

In summary, these professionals from varying fields all agree on five key factors that contribute to the difficulty of measuring the ROI of IT:

- Lack of profits in the nonprofit sector due to the absence of a monetary return for the product or service, or the lack of associated revenue streams because the approach does not evaluate at the sub-corporate level,

- Difficulty in defining the actual impact (benefits) of IT in terms of value because technology enhances an existing process or is embedded within many processes that are stand alone,
- Multiple ROI perspectives (such as cost-based, benefits-valuation, or residual-based) that are not compatible because their methodologies are not consistent,
- No standardized process of value for comparison because value units are not compatible (i.e., time savings, cost savings, cost avoidance), and
- Difficulty in assigning monetary value of intangible and tangible benefits (i.e. customer satisfaction, customer retention, or time savings).

Several approaches have been developed to try and address these difficulties in measuring ROI on IT at the corporate (firm) and sub-corporate (process) level.

This has led to several popular approaches at the corporate and sub-corporate level, all of which are based on three methods: residual-based methods that treat the effects of IT on ROI as a residual after accounting for all other capital investments; benefits-valuation methods, which use key performance indicators to determine a value for intangible assets; and cost-based methods that determines net benefits by using cost savings or cost avoidances as a surrogate for revenue. Several corporate-level approaches that have become common practice are the process of elimination, production theory, the resource-based view, and the option-pricing model.

Residual-based approaches treat the effects of IT on ROI as a residual after accounting for all other capital investments. While this method overcomes some of the difficulties presented earlier, it also presents limitations of its own. One major limitation is that since accounting for all capital investments is based at the firm level, this method cannot address the difficulty of defining the actual impact of IT (Pavlou, Housel, Rodgers, & Jansen, 2005, p. 205). Cost-based and benefits-valuation approaches at the corporate level lack the depth needed to properly determine the impact an IT investment has at the process level (Pavlou et al., 2005, p. 206). Chuck Johnson, VP of MetaGroup, attributes the difficulty to the fact that most technologies enhance other existing applications and are often embedded throughout several existing projects or processes (MacSweeney, 2001, p. 2). Drilling down to the process level is essential in order to accurately measure the benefits embedded in IT investments, since most IT investments are implemented at this level.

This has led to approaches that drill down to the sub-corporate level, all of which are based on benefits-valuation or cost-based methods, except for one. These approaches attempt to allocate the impact of IT at the process-level on performance by evaluating the costs associated with them. Karen E. Smith, a research director at Aberdeen Group, presents the dilemma of trying to measure ROI stemming from the fact that there are so many tangibles and intangibles (Cohen, 2002). The many tangibles and intangibles (i.e., customer satisfaction) make it very difficult to define and measure the actual benefit (value) added to the process, because they do not have a direct relationship with a unit of monetary value.

The benefits-valuation technique presents a possible method to overcome this dilemma through a weighting and scoring system that is customized to fit each IT investment. This method tries to quantify the value of technology by using specified key performance indicators to determine the performance of their intangible assets (Nguyen, 2004). The ROI of IT is measured by collecting business-impact data, where each unit of data represents an output produced by the technology (i.e., profit contribution, cost reduction, time saved, or quality improvements) (Phillips & Phillips, 2004, p. 524). The scoring system is developed by the IT stakeholders, through a process to try and isolate the effects of technology and ultimately assign a value to be placed on each unit of data connected with the technology output (Phillips & Phillips, 2004, p. 524). There are several approaches depending on the specified situation or data available to estimate the value (monetary/weight/score) tied to each data unit. Estimates on the impact of technology on the processes are determined by experts, thus the credibility of these estimations hinges on the expertise and reputation of the individuals (Phillips, 2002, p. 524). This is a purely subjective approach because each step of the process hinges on the values and benefits assigned by the IT stakeholders involved in the evaluation. This presents limitations due to the subjectivity of value estimates, which fails to create a standardized process or unit of value for comparison, creating multiple ROI perspectives that are not compatible (McSweeney, 2001, p. 3; Pavlou et al., 2005 p. 206).

Cost-based approaches were adopted to try and overcome the lack of revenue streams and the difficulties of defining and assigning monetary value to the actual impact of IT and to create a standardized process of valuation for comparison. Dr. Patti P. Phillips wrote that "there is a perception that an ROI value can only be developed when there are profits and revenues." Cost-based methods attempted to overcome this problem by showing that "the numerator in the ROI equation represents net benefits derived from either profit margin or cost savings" (Phillips, 2010). When a profit margin cannot be calculated because of the lack of a revenue stream, this view uses estimates of cost savings as a surrogate for revenue to calculate net benefits. *Cost savings* can be defined as reductions in expenditures that will be achieved by the IT project. There are several methods to derive these cost savings:

- The cost to replace or outsource IT is presumed, without proof, to be proportionate to the value it adds to process performance (Pavlou et al., 2005, p. 207).
- The cost reductions from IT such as staff reductions, consolidation of facilities, elimination of software licenses, or other results that decrease current expenditures (Brandon, 2010, p.1).
- Output data is converted to monetary value by determining the amount of impact the technology had for each unit of cost reduction (Phillips et al., 2004, p. 524).
- The cost of quality is calculated and quality improvements are directly converted to cost savings (Phillips et al., 2004, p. 524).
- When employee time is saved, the participant's wages and benefits are used for the value of time and are converted to cost savings (Phillips et al., 2004, p. 524).

All of these cost savings or cost avoidances act as surrogates for revenue and are compiled to derive the net benefits or numerator of the ROI equation. The cost of the investment, the denominator of the ROI equation, is calculated by summing all of the related costs of the IT solution. Oftentimes, the ROI calculation was based on cost savings alone (i.e., an existing process, procedure, or function that could now be automated with less cost). This assumes that the output and effectiveness of the process was at least constant before and after the technology (Phillips et al., 2004, p. 513). Essentially, this is holding the numerator of the ROI equation constant, while reducing the denominator to show a positive ROI. To carry this logic to extremes, if this were true, all costs in the denominator could be eliminated (i.e., by firing all employees and selling all assets) resulting in infinite returns with a zero in the denominator. The common result is that most often the new technology is going to either increase the output of a process or reduce the cost to produce the output.

The major limitation of cost-based approaches is that they rely on cost to determine value. This creates a major problem when estimating ROI because cost and revenue need to be derived independently in order to derive a true numerator; these approaches lack a surrogate for revenue (Pavlou et al., 2005, p. 207). Erik Brynjolfsson, professor of IT at MIT's Sloan School of Business, says that "there's a need for new metrics that go beyond the traditional industrial-age measures that focus on cost analysis and savings" (Violino, 1997, p. 1). Within the framework of KVA, estimating ROI is possible by allocating market-comparable revenue streams to outputs produced by the nonprofit sector.

B. KNOWLEDGE VALUE ADDED

The knowledge-value added (KVA) methodology overcomes the problems presented in the previous work because it provides surrogate revenue streams at the sub-process level that are uniquely derived from common units of output. The KVA methodology was created by Drs. Thomas Housel and Valery Kanevsky as an objective way to allocate revenue to the sub-corporate level. Revenue streams, which do not exist in the nonprofit sector, are essential in the for-profit sector in order to apply financial concepts such as ROI for use in MPT. However, KVA provides an objective method to estimate value in terms of common units of output, allowing allocation of surrogate revenue streams in the nonprofit sector by assuming a direct relationship between knowledge and the value stemming from it and describing all process outputs in common units (Housel et al., 2009, p. 1).

According to Housel and Mun (2010),

> KVA measures the value provided by human capital assets by analyzing an organization, process or function at the process level. It provides insights into each dollar of IT investment by monetizing the outputs of all assets, including intangible assets [e.g., assets produced by IT and humans]. By capturing the value of knowledge embedded in an organization's core processes [i.e., employees and IT], KVA identifies the actual cost and revenue of a process, product, or service. Because KVA identifies every process required to produce an

> aggregated output in terms of the historical process and cost-per-unit of output of those processes, unit costs and unit process can be easily calculated. (p. 15)

The goal of KVA for purposes of this thesis and referenced theses was to allocate surrogate revenue streams to several core processes of the DoD, in order to calculate the ROI of implementing RFID technology into those core processes. KVA is based around fundamental assumptions derived from Complexity Theory according to Rios, Housel, & Mun (2006):

> Based on the tenets of complexity theory, KVA assumes that humans and technology in organizations add value by taking inputs and changing them (measured in units of complexity) into outputs through core processes. The amount of change as asset produces within a process can be a measure of value or benefit. Additional assumptions include:
>
> - Describing all process outputs in common units (e.g., using a knowledge metaphor for the descriptive language in terms of the time it takes an average employee to learn how to produce the outputs) allows historical revenue and cost data to be assigned to those processes historically.
> - All outputs can be described in terms of the time required to learn how to produce them.
> - Learning time, a surrogate for procedural knowledge required to produce process outputs, is measured in common units of time. Consequently, Units of Learning Time = Common Units of Output (K).
> - A common unit of output makes it possible to compare all outputs in terms of cost-per-unit as well as price-per-unit, because revenue can now be assigned at the sub-organizational level.
> - Once cost and revenue streams have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied. (p. 10)

The valuation framework determines the value added to a core process by people or technology through the process of data collection and the steps of KVA methodology, which is summarized in Table 1.

Table 1. DoD IT Valuation Framework
(Rios et al., 2006, p. 8).

Data Collection	KVA Methodology
• Collect baseline data • Identify sub-process • Research market comparable data • Conduct market analysis • Determine key metrics	**Step 1:** Calculate time to learn. **Step 2:** Calculate value of output (*K*) for each sub-process **Step 3:** Calculate total *K* for process **Step 4:** Derive proxy revenue stream (when desired) **Step 5:** Develop the value equation numerator by assigning revenue streams to sub-processes **Step 6:** Develop value equation denominator by assigning cost to sub-process **Steps 7, 8, 9:** Calculate metrics: return on investment (ROI) return on knowledge (ROK)

The data collection and KVA steps are combined by using market research of cost and revenue data of all processes and sub-processes required to produce an output. Steps 1 and 2 are applied to determine the value of output (K) of each sub-process by multiplying the amount of output produced by a sub-process by the time required for an average worker (human or IT) to learn the process (knowledge required to produce a single aggregate output). Step 3 determines the total (K) for the process by combining the total (K) from each sub-process. In Steps 4 and 5, the equation numerator is developed by assigning revenue streams to the sub-processes using the market comparables valuation approach.

The Market Comparables valuation approach assumes that "though the macro functions performed by governments are monopolistic and centralized, many of the processes to accomplish those functions are comparable to those in the private [for-profit] sector" (Housel & Cook, 2005). In cases in which a sub-corporate process in the for-profit sector is similar to one in the nonprofit sector, the revenue stream can be used to provide a comparable surrogate revenue stream in the nonprofit sector (Housel et al., 2009, p. 16). Surrogate revenue is determined by multiplying the total number of outputs by the average market price-per-unit. Step 6 develops the equation denominator by assigning direct costs to the sub-processes based on the costs assigned to each of the asset-producing outputs. The final steps use the revenues and costs assigned to the sub-processes, people, and IT to calculate the value ratios of ROI, ROKA, and ROKI (Rios et al., 2006, p. 8, 31). The ROI analysis produced through the KVA methodology differs from the prior models reviewed in that it allows for comparable, objectively derived revenue estimates that enable the use of traditional accounting, financial performance, and profitability measures (Jung & Baek, 2009, p. 25).

C. PRIOR ROI ON RFID RESEARCH

The main focus of past research was to introduce the KVA methodology and analysis to estimate ROI on the implementation of IT investments within the DoD, specifically RFID technology. The prior research done by these individuals provided the raw data for the basis of this thesis.

1. Estimating the ROI on Implementation of RFID at the Ammunition Storage Warehouse and the 40th Supply Depot: KVA as a Methodology

The purpose of this project was to take real data from the implementation of RFID technology throughout the Ministry of National Defense (MND) and use the KVA methodology to estimate the ROI. RFID technology has been implemented at seven ammunition storage warehouses (ASWs) and five Air Force supply depots. The current thesis focused on an ASW and the 40th Supply Depot to use KVA to provide an objective way to determine the ROI. The KVA methodology was used to provide an objective analysis of ROI of the RFID implementation.

The KVA analysis of the first case study determined that the implementation of RFID technology into the ASW increased the total ROI from 338% to 610% (see Appendix A). The KVA analysis of the second case study of the 40th Supply Depot provided before and after ROI analysis showing a total increase from 182% to 576% (see Appendix A) (Jung & Baek, 2009, p. 48).

2. A Comparable Market Study of RFID for Manual Item-Level Accountability Inventory and Tracking Systems

The purpose of this thesis was to analyze current and desired business processes using workflow models created through the KVA methodology in order to make projections of the ROI and ROK of implementing RFID technology in manual inventory and tracking systems. The KVA ROI analysis is applied to a current "as-is" process and a future "to-be" process. The KVA analysis estimated an ROI increase from negative 73% to 44% (see Appendix B) (Courtney, 2007).

3. The Concurrent Implementation of Radio Frequency Identification and Unique Item Identification at Naval Surface Warfare Center, Crane, IN as a Model for a Navy Supply Chain Application

The purpose of this MBA project was to use the KVA methodology and analysis to project ROI of the concurrent implementation of RFID and unique item identification (UID) at the Naval Surface Warfare Center at Crane, Indiana (NSWC Crane). The KVA ROI analysis is applied to a current "as-is" process and a future "to-be" process.

Obellos, Colleran, and Lookabill determined that in sub-processes that are less than 51% automated and extremely labor intensive result in high sub-process costs and minimal ROK and ROI within the overall inventory process. The calculated ROI for the inventory process is negative 78.84% using a ten-year period as a conservative estimate of the system's useful life (see Appendix C). They determined that several sub-processes (2, 3, 4, and 8) are steps in the process that can be significantly improved with the RFID technology (see Appendix C) (Obellos et al., 2007, p. 87).

The "to-be" data and calculations in Table 11 show the future projections of the inventory process and sub-processes after the RFID/UID implementation. Sub-processes 2, 3, 4, and 8 from the "as-is" process, which were highlighted as weak contributors to ROK and ROI, were replaced by two sub-processes that utilize RFID/UID technology. The results determined the projected growth of ROI from negative 79% to positive 133% (see Appendix C) (Obellos et al., 2007, p. 88).

D. MODERN PORTFOLIO THEORY

The RFID case studies used KVA-derived surrogate revenue and real cost streams to calculate ROI of IT where each RFID case may represent an asset within the DoD. Defense Secretary Robert Gates's recent announcement of defense budget cuts to free $100 billion for future military weapons is a form of asset re-allocation within the DoD (Scully, 2010). This view aligns with DoD CIO David Wennergren's philosophy, where investments within the DoD should be managed as portfolios, derived from Modern Portfolio Theory (MPT) concepts. MPT was created in 1952 by Nobel Prize winner Harry Markowitz as a method of asset allocation among equities for the investor in the for-profit sector.

MPT can be applied to the nonprofit sector in the same way, by estimating the volatilities of ROIs in IT. High variances can lead to higher returns, but with only cost data, high variances will inevitably lead to higher costs. The current approach of cost-based budgeting focuses on controlling costs of an IT investment. A better approach might focus on gaining the most value from an IT investment. The most objective indicator of value is revenue. By establishing a KVA derived surrogate revenue stream for products and services within the nonprofit sector, high variances may include higher returns. With the ROI analysis provided by the KVA methodology, the objective volatilities data is available to properly apply MPT to effectively manage IT investment throughout the DoD.

1. Theory

MPT hinges on the assumption that rational investors are risk averse; when given two investments or portfolios with equal returns, they will choose the one with less risk. Markowitz used this assumption to "introduce the idea of a mean-variance efficient portfolio as one that (1) provides minimum variance for a given expected return and (2) provides maximum expected return for a given variance" (Pringle & VanOrden, 2009, p. 8). Assets can be combined and plotted on a risk-return graph, on which the composite of all sets of portfolios determines the "efficient frontier." The combinations along the "efficient frontier" curve that offer the highest returns for a given amount of risk (standard deviation) are the efficient portfolios. The mentioned portfolio is described as a "selection of securities or investments that belong to an individual or group of investors having certain goals" (Smith, 1971, p. 40). This theory coincides directly with the DoD CIO directive that the DoD "identifies and selects the best mix of IT investments to strengthen and achieve capability goals and objectives for the portfolio and demonstrates the impact of alternative IT investment strategies and funding levels" (DoD, 2005, p.3).

MPT is further defined according to Housel, Kanevsky, Rodgers, and Little (2009):

> As a set of probability beliefs regarding the expected return from each investment and the expected covariance between each pair of investments (based in turn upon expected standard deviations and correlation coefficients). Given these

probability beliefs, the investor can choose between various combinations of reward (expected return) and risk (variance of returns) depending on the construction of the portfolio (the identity and proportions of the investments). Of these combinations, those with the minimum variance for a given (investor-determined) level of risk or maximum return for a given variance correspond to a set of "efficient" portfolios. (p. 4)

Of these portfolios, the most efficient portfolio can be found by drawing a tangent line from the risk-free rate intercept on the vertical axis to the efficient frontier curve. This tangent line is also known as the security market line (SML), which represents the market portfolio (in competitive markets, all stocks on average will lie on the SML, where the expected risk premium varies in direct proportion to beta [β]).

Beta (β) or beta coefficient represents the propensity of an asset's returns to react to changes in the market, essentially its volatility (i.e., riskiness). An asset with a beta (β) of 1 will move with the market, while an asset with a beta (β) of less than 1 will be less volatile (i.e., risky) than the market, and an asset with a beta (β) of more than 1 will be more volatile than the market (Laverson, 2010). Beta (β) is most commonly derived using historical data of the returns of an asset and the returns of a market index, where the beta (β) estimate is the covariance of the market index and the asset divided by the variance of the market index (Laverson, 2010). Beta (β) is the measurement of an asset's sensitivity to a movement in the overall market, which is used in the Capital Asset Pricing Model (CAPM) to calculate the expected return of an asset (Pugh, 2003).

2. Capital Asset Pricing Model

As an extension and compliment to MPT, the Capital Asset Pricing Model (CAPM) provides a method to determine the discount rate for a new capital investment. The CAPM is an essential extension of MPT for "estimating the cost of capital, estimating the risk for portfolios, and developing measures for ex post portfolio performance evaluation" (McInish, 2000, p. 281). CAPM is needed in order to extend MPT to estimate a risk premium for a security to use in a present value-type equity-price formula (Pugh, 2003). Equity price is the expected return on a portfolio of securities. ROI, as defined previously, is a good surrogate for equity price (Housel et al., 2009). Therefore, the volatility of ROI is a good estimate of volatilities via the MPT model. In the context of CAPM and an IT portfolio, a theoretical beta (β) would tell how much risk (volatility) a new IT investment would add to the portfolio. The CAPM model is suitable for applying the beta (β) or baseline for IT performance, based on the KVA ROI analysis, for managing IT investment portfolios within the DoD market. The CAPM is usually expressed as

$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$, where

$E(R_i)$ = the expected return on the capital investment,

R_f = the risk-free rate of interest such as interest arising from government bonds,

β_i = the sensitivity of the asset returns to market returns, and

$E(R_m)$ = the expected return of the market.

E. SUMMARY

In this chapter, the use of ROI as an adequate tool to measure the productivity enhancements provided by IT investments was outlined. The difficulties and limitations of measuring ROI on IT investments with the current cost-based methods within the nonprofit sector were also established. To overcome these limitations, the framework of KVA was established as a method to estimate ROI by allocating market comparable surrogate revenue streams to outputs produced by the nonprofit sector. By following the KVA methodology steps outlined in this chapter, ROI analysis data can provide the objective volatilities data used to derive a notional IT beta (β), to properly apply MPT for managing IT investments throughout the DoD. A notional IT beta (β) would provide key decision-makers (i.e., CIO, program managers) critical return/risk characteristics of an IT asset "so they can make informed decisions throughout the acquisition process" (DoD, 2006, p. 3).

IV. BETA DERIVATION (PROOF OF CONCEPT)

A. BETA DERIVATION

Beta (β) or beta coefficient represents the propensity of an asset's returns to react to changes in the market, essentially its volatility (i.e., risk) (Markowitz, 1952). Knowing the volatility (i.e., riskiness) of an asset is an essential piece of information for asset allocation within a portfolio. To calculate the beta (β) of an asset within a portfolio, the covariance between the returns (e.g., ROI) of an asset and the returns of the market are divided by the variance of the market returns (i.e., the market beta). Traditionally beta (β) is used in the for-profit sector equities market within the Capital Asset Pricing Model (CAPM) to calculate the expected return of an asset (Pugh, 2003). The CAPM is used with MPT in the for-profit sector to create the optimal asset portfolio, one that produces the highest expected returns for a given level of risk (i.e., volatility) (Housel et al., 2009).

The MPT approach can be applied to the nonprofit arena when KVA derived surrogate revenue is used to estimate the ROI of a given asset. ROI estimates of a given asset within the nonprofit sector can act as a surrogate for stock earnings (i.e., returns), for the purposes of measuring an asset's volatility (Housel et al., 2009). The ROI data provided from the KVA analysis of four RFID case studies in the military were used to extrapolate a notional 60 months of data for purposes of the beta (β) derivation in this nonprofit sector.

1. Assumptions

Some assumptions were made for the purposes of this proof of concept:

- All four RFID case studies' KVA ROI analysis data was compared over the same chronological period of time for purposes of creating a quasi market index, as shown in Figure 4.
- "Before" RFID technology data was used as the surrogate for the first monthly return for each IT asset, and the "after" RFID technology data was used as the last monthly return surrogate, as shown in Figure 4.

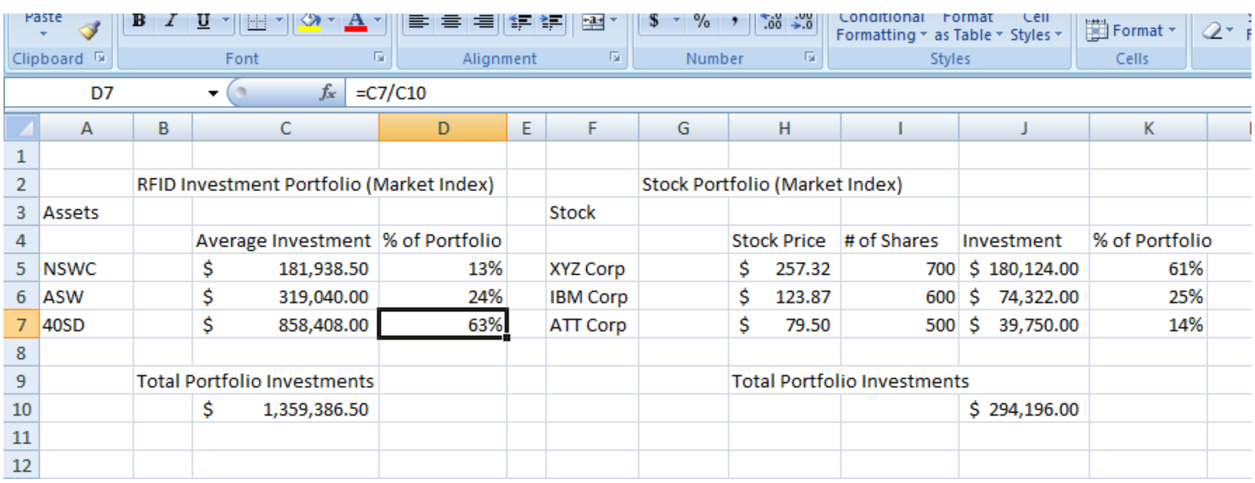
2. Beta (β) Derivation Steps

The beta (β) derivation steps provided here can be followed to evaluate new or existing IT assets within an IT portfolio. The beta (β) provided by these steps will provide critical insight about the returns/risk characteristics of an IT asset and can be used in the application of MPT to help in analysis of IT alternatives, courses of action, and acquisition prioritization in the form of portfolio optimization.

a. Step 1: Create an IT Market Portfolio

In order to create a beta (β) for an asset, a market or index is needed to compare the asset to because beta (β), as defined earlier, is the measure of an asset's volatility in comparison to the market. In the stock markets, an index like the S&P 500 that contains many assets is used (Lavine, 2010). A stock market portfolio's composition is determined by multiplying each individual stock's price by the number of its shares within the portfolio and then dividing by the price of the total stock market portfolio (Figure 2). I will create a quasi market portfolio made up of three of the RFID cases: the Ammunition Storage Warehouse (ASW), the 40th Supply Depot (40SD), and the Naval Surface Warfare Center (NSWC), used to extrapolate 60 months of notional data. The allocation composition of the IT investment portfolio is determined by dividing the cost (e.g., price) of each asset and the cost (e.g., price) of the total market portfolio (all assets combined) (see Figure 2).

As an example, the percent of portfolio calculation for the asset 40SD is shown in Figure 2 by taking the average investment for 40SD (C7, $858,408.00) divided by the total portfolio investment (C9, $1,359,386.50). The resulting value (D7, 63%) portrays the percentage of the total portfolio that is comprised of investment 40SD.



	A	B	C	D	E	F	G	H	I	J	K
1											
2		RFID Investment Portfolio (Market Index)					Stock Portfolio (Market Index)				
3	Assets					Stock					
4			Average Investment	% of Portfolio				Stock Price	# of Shares	Investment	% of Portfolio
5	NSWC		$ 181,938.50	13%		XYZ Corp		$ 257.32	700	$ 180,124.00	61%
6	ASW		$ 319,040.00	24%		IBM Corp		$ 123.87	600	$ 74,322.00	25%
7	40SD		$ 858,408.00	63%		ATT Corp		$ 79.50	500	$ 39,750.00	14%
8											
9		Total Portfolio Investments						Total Portfolio Investments			
10			$ 1,359,386.50							$ 294,196.00	
11											
12											

Figure 2. Nonprofit IT Investment Portfolio Compared to a Stock Portfolio Allocation

b. Step 2: Determine Market Returns

The next step is to determine the IT investment market index returns. In the private sector, changes in stock price determine earnings, which are used to derive returns. These returns are then multiplied by each stock's portfolio percentage to determine the market index return (Figure 3). The KVA analysis provided surrogate cost (i.e., asset price) and revenue streams, which were used to calculate surrogate earning and returns (ROI). This study will use respective surrogate returns (ROIs) for each RFID asset that were provided by the KVA analysis. The IT investment market index returns are then calculated by multiplying each asset's portfolio investment percentage by their surrogate returns (ROI) (Figure 3).

As an example, the value shown in Figure 3 for the RFID Investment Portfolio Return (C10, 186%) was calculated by taking the sum of asset NSWC's portfolio percentage (B5, 13%) multiplied by NWSC's ROI (F5, -79%), asset ASW's portfolio percentage (B6, 24%) multiplied by ASW's ROI (F6, 338%), and asset 40SD's portfolio percentage (B7, 63%) multiplied by 40SD's ROI (F7, 182%).

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C10 | f_x =(B5*F5)+(B6*F6)+(B7*F7)

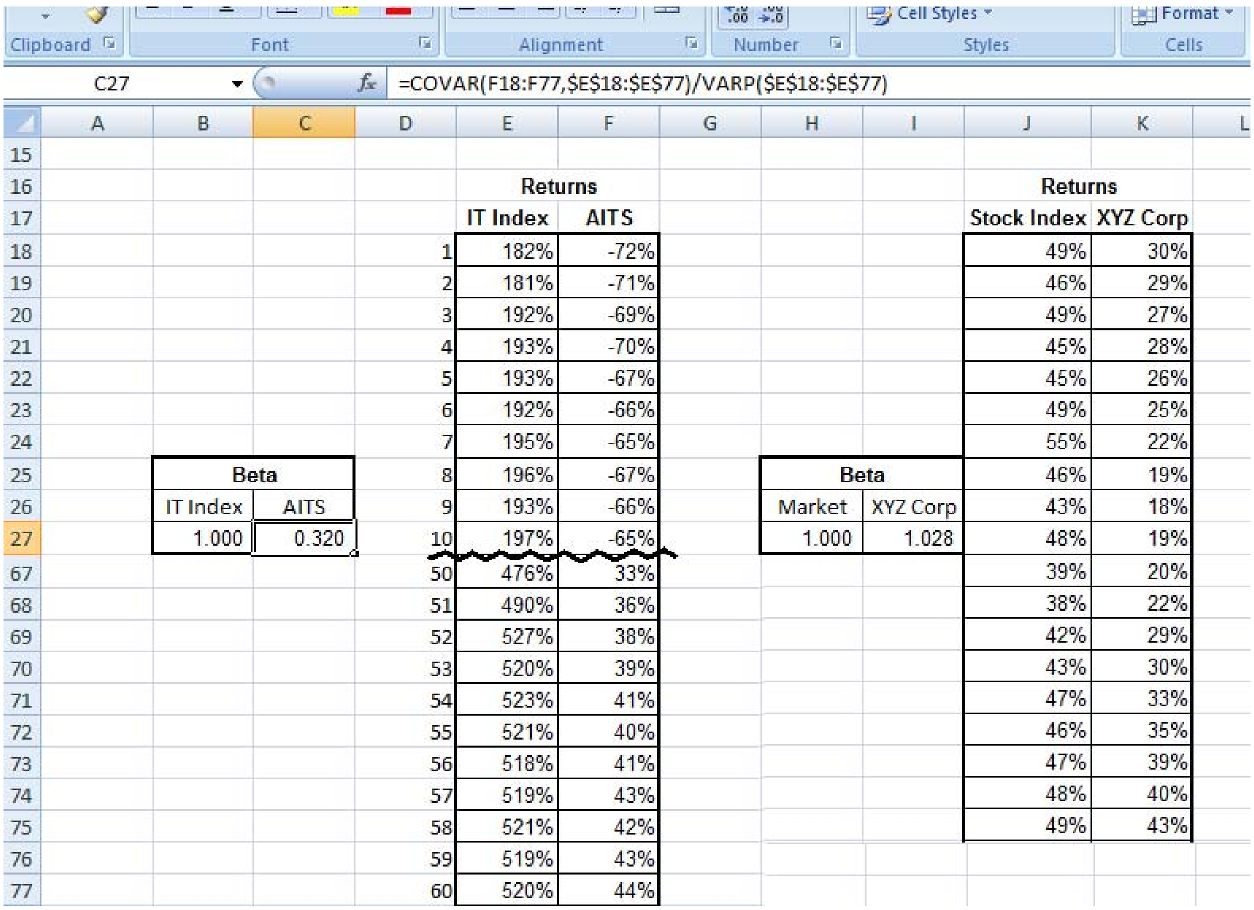
	A	B	C	D	E	F	G
1							
2		RFID Investment Portfolio (Market Index)					
3							
4	Assets	% of Portfolio	Cost (Price)	Revenue	Earnings	Returns (ROI)	
5	NSWC	13%	$ 2,616	$ 554	$ (2,062)	-79%	
6	ASW	24%	$ 20,233	$ 88,634	$ 68,401	338%	
7	40SD	63%	$ 97,473	$ 274,870	$ 177,397	182%	
8							
9		RFID Investment Portfolio Retun					
10			186%				
11							
12							
13		Stock Portfolio (Market Index)					
14							
15	Stock	% of Portfolio	Price	End Price	Earnings	Returns (ROI)	
16	XYZ Corp	61%	$ 198.50	$ 257.32	$ 58.82	30%	
17	IBM Corp	25%	$ 141.30	$ 123.87	$ (17.43)	-12%	
18	ATT Corp	14%	$ 23.40	$ 79.50	$ 56.10	240%	
19							
20			Stock Portfolio Retun				
21				49%			

Figure 3. RFID Portfolio Return Compared to Stock Portfolio Return Calculations

b. Step 3: Derive Beta (β)

Next, the calculated index returns over a given period of time (i.e., monthly over five years) are compiled in a column. The returns of an individual asset over the same period of time are compiled in a separate column. The range of returns for the notional IT market index was from 182% in the first month before RFID implementation, to 520% in the last month after five years of RFID implementation. The range of returns for the Accountability Inventory Tracking System (AITS) asset was from -72% in the first month before RFID implementation, to 44% in the last month after five years of RFID implementation. The AITS program was underwater and losing a significant amount of money on the process before RFID implementation.

To calculate beta (β) for the individual AITS asset, the covariance (COVAR) between the market index returns and the asset returns are divided by the variance (VAR) of the market index. As an example, the AITS beta (C27, .320) shown in Figure 4 was calculated by taking the covariance (COVAR) of all AITS returns from F18, -72% to F77, 44% and all IT index returns from E18, 182% to E77, 520% divided by the variance (VAR) of all the IT index returns E18, 182% to E77, 520%. This is the same calculation that is used in the private sector. The market index is assigned a beta (β) of 1.



	A	B	C	D	E	F	G	H	I	J	K
15											
16					Returns					Returns	
17					IT Index	AITS				Stock Index	XYZ Corp
18				1	182%	-72%				49%	30%
19				2	181%	-71%				46%	29%
20				3	192%	-69%				49%	27%
21				4	193%	-70%				45%	28%
22				5	193%	-67%				45%	26%
23				6	192%	-66%				49%	25%
24				7	195%	-65%				55%	22%
25		Beta		8	196%	-67%		Beta		46%	19%
26		IT Index	AITS	9	193%	-66%		Market	XYZ Corp	43%	18%
27		1.000	0.320	10	197%	-65%		1.000	1.028	48%	19%
67				50	476%	33%				39%	20%
68				51	490%	36%				38%	22%
69				52	527%	38%				42%	29%
70				53	520%	39%				43%	30%
71				54	523%	41%				47%	33%
72				55	521%	40%				46%	35%
73				56	518%	41%				47%	39%
74				57	519%	43%				48%	40%
75				58	521%	42%				49%	43%
76				59	519%	43%					
77				60	520%	44%					

Figure 4. AITS Beta (β) Calculation

3. Results

The estimated AITS beta (β) of 0.320 means that the AITS asset will move with the market and will carry less risk (volatility) than the market. We have now created a market index or IT baseline with a beta (β) of 1, which represents a theoretical IT market. The market index is given a beta (β) of 1 because all individual stocks are measured relative to the market index. In order to create a more accurate IT market index, more assets within the DoD should be used. We have also created an AITS beta (β) of 0.320. This allows the concepts of MPT to be applied to determine if AITS is an effective allocation of resources. An individual beta (β) should be created for each IT investment throughout the DoD in order to effectively provide key decision-makers with more optimal investment choices available (Housel et al., 2009).

B. APPLYING MPT

Now that this thesis has provided a method to derive a beta (β) for an IT investment and an IT baseline (market index), the AITS beta (β) can be used to apply the concepts of MPT. This section will illustrate the potential use of MPT as an effective tool to provide expected performance metrics of an IT investment for key decision-makers. With a beta (β) of 0.320, MPT would expect that because it carries less risk (volatility) than the market, one should expect it to have lower future returns than the market. The expected returns of AITS can be calculated using the CAPM as described earlier, by multiplying its beta (β) of 0.320 by the market portfolios expected return of 520%, which results in an expected return of 166% for AITS.

This suggests that in order for AITS to be an effective allocation of resources, the expected return should be at least 166%. The KVA analysis done in the AITS case study estimated a return on investment (ROI) of 44% (scale started at -79%). This would lead key decision-makers to conclude that this would not be an effective allocation of resources. They may also conclude that the KVA analysis projection of the benefits of RFID in the Navy AITS case was too conservative in comparison to the actual implementation of RFID data from the Korean ASW & 40SD case studies.

I suggest that the KVA analysis ROI projection of 44% after the implementation of RFID technology in the Navy AITS case was too conservative. The quasi RFID investment market index created in this chapter was a composition of three RFID case studies, of which 87% of the investment portfolio was based on the Korean ASW & 40SD KVA analysis data. The Korean ASW & 40SD KVA analysis provided earnings/ROI data that was rooted in actual implementation RFID data, which suggests that the expected return of 166% determined using MPT is a more accurate estimation.

V. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY OF RESEARCH

Defense Secretary Robert Gates's recent budget cut is "not to reduce the department's top-line budget," he said. "Rather, it is to significantly reduce its excess overhead costs and apply the savings to force structure and modernization" (McLeary, 2010). His goal is to free up close to $10 billion in FY2011 and around $100 billion over the next five years, through asset reallocation. The current problem is that all of the DoD's current assets are under scrutiny as to whether they should be continued, modified, or terminated. Key decision-makers are without an effective or accurate way to measure and compare the benefits of the assets. This is essentially an asset-allocation problem that is solved daily in the private sector through the use of MPT, which was recognized by the DoD CIO when he directed "IT investments shall be managed as portfolios, … monitored using established quantifiable outcome-based performance measures, and evaluated against portfolio performance measures to determine whether to recommend continuation, modification, or termination of individual investments within the portfolio" (DoD, 2005, p. 3).

This thesis addressed the central research question: How can Modern Portfolio Theory (MPT) be defensibly applied to DoD information technology portfolio optimization problems? The results demonstrated that it is possible to apply MPT to DoD IT portfolio optimization problems.

Addressing the difficulties of measuring the benefits (ROI) of IT investments and the limitations of current cost-based evaluation methods within the non-profit sector (i.e., lack of a revenue stream) was central to this application of MPT in the DoD IT portfolio optimization problem space. Surrogate revenue streams provided by the KVA framework provide a method that enables the use of traditional accounting and investment finance concepts (i.e., ROI, MPT) within the nonprofit sector. The presence of surrogate revenue streams allow the correct ROI calculation, where the numerator is derived from revenue and not cost. The ROI analysis provided by the KVA methodology provides the correct data to properly apply MPT to effectively manage IT investments throughout the nonprofit sector.

This thesis provided the steps to generate the raw volatilities estimates needed to derive a beta (β) for an IT investment and a beta (β) for a notional IT market. The calculated betas (β) provide critical insight about the return/risk characteristics of an IT asset, which is needed to apply MPT portfolio optimization. Key decision-makers within the DoD can directly apply the application of MPT to help analyze IT alternatives, courses of action, acquisition prioritization, and the allocation of assets within the DoD.

B. CONCLUSIONS

1. Research Question Findings

How can Modern Portfolio Theory (MPT) be defensibly applied to DoD information technology portfolio optimization problems?

MPT can be defensibly applied to DoD IT portfolio optimization problems by following the steps provided in this thesis to derive the appropriate raw performance, volatility data required to remain consistent with MPT assumptions and methodology. The KVA methodology is essential in order to remain consistent with the MPT methodology because it provides the framework for the allocation of surrogate revenue and cost streams into core processes where technology was implemented within the nonprofit sector. The ROI estimates of volatility provided by the KVA steps outlined in Chapter 3 act as a surrogate for equity price volatility, allowing the derivation of a notional IT market beta (β) and individual asset betas (β) to apply a MPT approach for asset allocation within the Department of Defense (DoD).

What methodology best aligns with the DoD CIO's Directive 8115.01, Information Technology Portfolio Management*?*

The DoD CIO's Directive 8115.01, *Information Technology Portfolio Management*, states that "IT investments shall be managed as portfolios: to ensure IT investments support the Department's vision, mission, and goals; ensure efficient and effective delivery of capabilities to the warfighter; and maximize return on investment (ROI) to the Enterprise" (DoD, 2005, p. 2). The CIO further directs that IT portfolios shall be "managed and monitored using established quantifiable outcome-based performance measures, and evaluated against portfolio performance measures to determine whether to recommend continuation, modification, or termination of individual investments within the portfolio" (DoD, 2005, p. 3).

The DOD CIO further directed how to achieve that policy in Instruction 8115.02, *Information Technology Portfolio Management Implementation*. The CIO instructs that the processes should include "a knowledge-based approach" that provides analysis for "program managers to attain the right knowledge [e.g., portfolio values] at critical junctures so they can make informed program decisions throughout the acquisition process" (DoD, 2006, p. 3). The DoD CIO further instructs that "a portfolio baseline shall be established and maintained for each portfolio" (DoD, 2006, p. 15).

Since the directive derived the portfolio concepts from Markowitz's Modern Portfolio Theory (MPT), any method should align with the guidelines provided using the framework of MPT. This thesis established that all of the current approaches are cost-based, except for one, which does not provide the proper ROI analysis because value is derived from cost and not revenue. Value must be derived from revenue in order to derive a true numerator. Chapter 3 demonstrated how the KVA method produces necessary performance volatility data that was used in used Chapter 4 to derive notional market and individual asset betas (β). These betas (β) were used within the MPT toolset to optimize a portfolio of DoD IT assets in accordance with Directive 8115.01.

C. RECOMMENDATIONS

Key decision-makers (e.g., DoD CIO) have made it clear that they intend to manage the assets within the DoD as a portfolio, drawing from the concepts of Harry Markowitz's Modern Portfolio Theory (MPT). To ensure MPT concepts are applied correctly, cost-based evaluation methods should be replaced by the KVA methodology in order to provide objectively derived surrogate revenue and cost streams to correctly derive expected returns (i.e., ROI) and volatilities (i.e., risk). The beta (β) derivation steps should be followed by key decision-makers to evaluate new or existing assets within an investment portfolio. The beta (β) provided by the steps will provide the key decision-makers with critical insight about the returns/risk characteristics of an asset and should be used in the application of MPT to help in analysis of alternatives, courses of action, and acquisition prioritization in the form of portfolio optimization

.

In order to effectively manage IT assets within the DoD, all current and new IT systems should have KVA analysis applied in order to provide current and historical ROI data for the direct application of MPT as outlined in this thesis. The more ROI analysis data available will provide more accurate beta (β) derivations, allowing a more effective application of the MPT toolset.

APPENDIX A

Process		Number of Employees(Total	Rank of Difficulty	RLT(hr)	ALT(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/ Process Human	Knowledge(hr)/ Process IT	Total K/Yr	Human Cost/Yr	IT cost/Yr	Automation Tools
1. Sending Requirement Paper (R.P.) of Ammo.		5	11	20	3	50%	84	0.5	15	7.5	1890	$ 5,373	$16,667	Software Program
2. Receiving R.P. & Drawing up A.P.(Approving Pap		7	10	22	3	50%	84	0.5	21	10.5	2646	$ 7,191	$16,667	Software Program
3. Transmitting the A.P through wireless system		4	9	22	3	50%	84	0.17	12	6	1512	$ 1,318	$16,667	Software Program
4. Proceed to ASP		2	3	5	0.5	30%	84	0.08	1	0.3	109.2	$ 310	$100,000	Gate Checking Program
5. Designating & A.S Arri	Designating ASW	4	8	7	1	50%	84	0.5	4	2	504	$ 3,859	$16,667	Software Program
	A.S Arrival	1	2	3	0.5	0%	84	0.3	0.5	0	42	$ 254	$0	
6. Movement to A.S.W		3	1	3	0.5	0%	84	0.3	1.5	0	126	$ 2,061	$0	
7. Loading ammo.		8	7	3	1	0%	84	1.5	8	0	672	$ 16,666	$0	
8. Confirm	Signing to confirm (Comp	4	4	3	0.5	50%	84	0.2	2	1	252	$ 1,544	$16,667	Software Program
	Signing to confirm (Batalli	6	5	4	0.5	50%	84	0.2	3	1.5	378	$ 2,277	$16,667	Software Program
9. Return to Base		2	6	8	0.5	0%	84	0.5	1	0	84	$ 1,938	$0	
Total		46		100	14		924	4.75			8215.2	$ 42,792	$200,000	

Process		Human Revenue	Human Cost	Human ROK	Human ROI	IT Revenue	IT Cost	IT ROK	IT ROI	Total Revenue	Total Cost	Total ROK	Total ROI
1. Sending Requirement Paper (R.P.) of Ammo.		$ 161,201	$ 5,373	3000%	2900%	$ 80,600	$ 16,667	484%	384%	$ 241,801	$ 22,040	1097%	997%
2. Receiving R.P. & Drawing up A.P.(Approving Pap		$ 302,008	$ 7,191	4200%	4100%	$ 151,004	$ 16,667	906%	806%	$ 453,012	$ 23,857	1899%	1799%
3. Transmitting the A.P through wireless system		$ 93,035	$ 1,318	7059%	6959%	$ 46,517	$ 16,667	279%	179%	$ 139,552	$ 17,985	776%	676%
4. Proceed to ASP		$ 3,876	$ 310	1250%	1150%	$ 1,163	$ 100,000	1%	-99%	$ 5,039	$ 100,310	5%	-95%
5. Designating & A.S Arri	Designating ASW	$ 30,873	$ 3,859	800%	700%	$ 15,437	$ 16,667	93%	-7%	$ 46,310	$ 20,526	226%	126%
	A.S Arrival	$ 424	$ 254	167%	67%	$ -	$ -			$ 424	$ 254	167%	67%
6. Movement to A.S.W		$ 10,305	$ 2,061	500%	400%	$ -	$ -			$ 10,305	$ 2,061	500%	400%
7. Loading ammo.		$ 88,885	$ 16,666	533%	433%	$ -	$ -			$ 88,885	$ 16,666	533%	433%
8. Confirm	Signing to confirm (Comp	$ 15,437	$ 1,544	1000%	900%	$ 7,718	$ 16,667	46%	-54%	$ 23,155	$ 18,210	127%	27%
	Signing to confirm (Batalli	$ 34,162	$ 2,277	1500%	1400%	$ 17,081	$ 16,667	102%	2%	$ 51,244	$ 18,944	270%	170%
9. Return to Base		$ 3,876	$ 1,938	200%	100%	$ -	$ -			$ 3,876	$ 1,938	200%	100%
Total		$ 744,083	$ 42,792	1739%	1639%	$ 319,521	$ 200,000	160%	60%	$ 1,063,604	$ 242,792	438%	338%

CORRELATION: *Order of Difficulty to Actual Learning Time* 0.84338

CORRELATION: *Relative Learning Time to Actual Avg Training* 0.967057

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E	$3,000	$1.44	$ 21,000.00	$10.10
S 1	$15,640	$7.52	$ 23,460.00	$11.28
S 2	$26,490	$12.74	$ 39,735.00	$19.10
S 3	$37,695	$18.12	$ 56,542.50	$27.18
S 4	$49,422	$23.76	$ 74,133.00	$35.64
WO	$49,992	$24.03	$ 74,988.00	$36.05
O 1	$18,984	$9.13	$ 28,476.00	$13.69
O 2	$20,683	$9.94	$ 31,024.50	$14.92
O 3	$30,000	$14.42	$ 45,000.00	$21.63

Note : Hourly wage = Base Pay /(260 working days in a year * 8 working hours per day)

Knowledge(%) Human	Knowledge(%) IT
66.67%	33.33%
66.67%	33.33%
66.67%	33.33%
76.92%	23.08%
66.67%	33.33%
100.00%	0.00%
100.00%	0.00%
100.00%	0.00%
66.67%	33.33%
66.67%	33.33%
100.00%	0.00%

	E	S2	S3	S4	WO	O1	O2	O3
Yearly Salary	$3,000	$26,490	$37,695	$49,422	$49,992	$18,984	$20,683	$30,000
Yearly Salary/hr	$1.44	$12.74	$18.12	$23.76	$24.03	$9.13	$9.94	$14.42
Mkt revenue/hr	$10.10	$11.28	$27.18	$35.64	$36.05	$13.69	$14.92	$21.63

Figure A1. “Before RFID” in ASW
(Jung & Baek, 2009)

Process		Number of Employees	Rank of Difficulty	RLT(hr)	ALT(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/ Process Human	Knowledge(hr)/ Process IT	Total K/Yr	Human Cost/Yr	IT cost/Yr	Automation Tools
1. Sending Requirement Paper (R.P.) of Ammo.		5	8	20	3	70%	168	0.5	15	10.5	4284	$ 10,747	$ 20,000	Software Program
2. Receiving R.P. & Drawing up A.P.(Approving Pape		7	9	20	3	70%	168	0.5	21	14.7	5997.6	$ 14,381	$ 20,000	Software Program
3. Transmitting the A.P through wireless system		4	6	16	3	70%	168	0.17	12	8.4	3427.2	$ 2,636	$ 20,000	Software Program
4. Proceed to ASP		2	3	2	0.5	30%	168	0.08	1	0.3	218.4	$ 620	$ 100,000	Gate Checking Program
5. Designating & A.S Arriv	Designating ASW	0	-	0	0	0%	0	0	0	0	0	$ -	$ -	-
	A.S Arrival	1	4	3	1.5	70%	168	0.08	1.5	1.05	428.4	$ 136	$ 20,000	Software Program
6. Movement to A.S.W		3	2	3	0.5	0%	168	0.08	1.5	0	252	$ 1,099	$ -	-
7. Loading ammo. And Real Information transmitting		8	7	9	1	80%	168	0.83	8	6.4	2419.2	$ 18,444	$ 139,477	RFID
8. Confirm	Signing to confirm (Compa	0	-	0	0	0%	0	0	0	0	0	$ -	$ -	-
	Signing to confirm (Batallio	6	5	24	1	70%	168	0.17	6	4.2	1713.6	$ 3,872	$ 20,000	Software Program
9. Return to Base		2	1	3	0.5	0%	168	0.5	1	0	168	$ 3,876	$ -	
Total		38		100	14		1512	2.91			18,908.40	$ 55,811	$ 339,477	

Process		Human Revenue	Human Cost	Human ROK	Human ROI	IT Revenue	IT Cost	IT ROK	IT ROI	Total Revenue	Total Cost	Total ROK	Total ROI
1. Sending Requirement Paper (R.P.) of Ammo.		$ 322,409	$ 10,747	3000%	2900%	$ 225,686	$ 20,000	1128%	1028%	$ 548,095	$ 30,747	1783%	1683%
2. Receiving R.P. & Drawing up A.P.(Approving Pape		$ 604,029	$ 14,381	4200%	4100%	$ 422,820	$ 20,000	2114%	2014%	$ 1,026,849	$ 34,381	2987%	2887%
3. Transmitting the A.P through wireless system		$ 186,077	$ 2,636	7059%	6959%	$ 130,254	$ 20,000	651%	551%	$ 316,331	$ 22,636	1397%	1297%
4. Proceed to ASP		$ 7,753	$ 620	1250%	1150%	$ 2,326	$ 100,000	2%	-98%	$ 10,079	$ 100,620	10%	-90%
5. Designating & A.S Arriv	Designating ASW	$ -	$ -	0%	0%	$ -	$ -			$ -	$ -		
	A.S Arrival	$ 25,701	$ 136	18941%	18841%	$ 17,991	$ 20,000	90%	-10%	$ 43,693	$ 20,136	217%	117%
6. Movement to A.S.W		$ 20,611	$ 1,099	1875%	1775%	$ -	$ -			$ 20,611	$ 1,099	1875%	1775%
7. Loading ammo.		$ 177,771	$ 18,444	964%	864%	$ 142,217	$ 139,477	102%	2%	$ 319,988	$ 157,921	203%	103%
8. Confirm	Signing to confirm (Compa	$ -	$ -	0%	0%	$ -	$ -			$ -	$ -		
	Signing to confirm (Batallio	$ 301,130	$ 3,872	7778%	7678%	$ 210,791	$ 20,000	1054%	954%	$ 511,921	$ 23,872	2144%	2044%
9. Return to Base		$ 7,753	$ 3,876	200%	100%	$ -	$ -			$ 7,753	$ 3,876	200%	100%
Total		$ 1,653,234	$ 55,811	2962%	2862%	$ 1,152,085	$ 339,477	339%	239%	$ 2,805,319	$ 395,288	710%	610%
CORRELATION:	*Order of Difficulty to Relative Learning Time*			0.749227									
CORRELATION:	*Relative Learning Time to Actual Avg Training*			0.755667									

Figure A2. “After RFID” in ASW
(Jung & Baek, 2009)

Process	Number of employess	Rank of Difficulty	RLT(hr)	ALT(hr)	% Auto	Times performed in a year	Average Time to complete	Knowledge(hr)/ Process		Total K/Yr(Hr)	Human Cost/Yr	IT cost/Yr	Automation Tool
								Human	IT				
1. Print inventory worksheets	3	2	2	0.5	50%	264	0.2	1.5	0.75	594	$ 4,816	$ 25,000	software program
2. Conduct inventory of items	16	10	40	2	0%	264	8	32	0	8448	$ 743,923	$ -	
3. Record count on worksheet	3	7	4	0.1	0%	240	8	0.3	0	72	$ 175,118	$ -	
4. Manually input worksheet data into computer	3	6	4	1	50%	240	1	3	1.5	1080	$ 21,890	$ 25,000	software program
5. Print inventory discrepancy report	3	3	1	0.2	50%	264	2	0.6	0.3	237.6	$ 48,157	$ 25,000	software program
6. Conduct recount	16	9	40	2	0%	12	4	32	0	384	$ 16,907	$ -	
7. Record count on worksheet	3	5	4	0.2	0%	12	4	0.6	0	7.2	$ 4,378	$ -	
8. Manually input data input from recount worksheet	3	4	1	1	50%	12	0.1	3	1.5	54	$ 109	$ 25,000	software program
9. Print final inventory discrepancy report	3	2	2	0.1	50%	12	2	0.3	0.15	5.4	$ 2,189	$ 25,000	software program
10. Print master inventory listing	3	1	2	0.1	50%	12	2	0.3	0.15	5.4	$ 2,189	$ 25,000	software program
Total	56		100	7.2		1332	31.3			10887.6	$ 1,019,676	$ 150,000	

Process	Human				IT				Total			
	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI
1. Print inventory worksheets	$ 36,118	$ 4,816	750%	650%	$ 18,059	$ 25,000	72%	-28%	$ 54,177	$ 29,816	182%	82%
2. Conduct inventory of items	$ 2,975,690	$ 743,923	400%	300%	$ -	$ -			$ 2,975,690	$ 743,923	400%	300%
3. Record count on worksheet	$ 6,567	$ 175,118	4%	-96%	$ -	$ -			$ 6,567	$ 175,118	4%	-96%
4. Manually input worksheet data into computer	$ 65,669	$ 21,890	300%	200%	$ 32,835	$ 25,000	131%	31%	$ 98,504	$ 46,890	210%	110%
5. Print inventory discrepancy report	$ 14,447	$ 48,157	30%	-70%	$ 7,224	$ 25,000	29%	-71%	$ 21,671	$ 73,157	30%	-70%
6. Conduct recount	$ 135,259	$ 16,907	800%	700%	$ -	$ -			$ 135,259	$ 16,907	800%	700%
7. Record count on inventory worksheets	$ 657	$ 4,378	15%	-85%	$ -	$ -			$ 657	$ 4,378	15%	-85%
8. Manually input data input from recount worksheet	$ 3,283	$ 109	3000%	2900%	$ 1,642	$ 25,000	7%	-93%	$ 4,925	$ 25,109	20%	-80%
9. Print final inventory discrepancy report	$ 328	$ 2,189	15%	-85%	$ 164	$ 25,000	1%	-99%	$ 493	$ 27,189	2%	-98%
10. Print master inventory listing	$ 328	$ 2,189	15%	-85%	$ 164	$ 25,000	1%	-99%	$ 493	$ 27,189	2%	-98%
Total	$ 3,238,347	$ 1,019,676	318%	218%	$ 60,087	$ 150,000	40%	-60%	$ 3,298,434	$ 1,169,676	282%	182%

Correlation	Rank of Difficulty to Relative LT	0.819208223
Correlation	Relative LT to Actual ALT	0.88536444

Pay Grade	Mil Salary/Yr	Mil salary/Hr	Mkt Comp Rev/Yr	Mkt comparable Revenue/Hr
E	$3,000	$1.44	$ 21,000.00	$10.10
S 2	$26,490	$12.74	$ 39,735.00	$19.10
S 3	$37,695	$18.12	$ 56,542.50	$27.18
S 4	$49,422	$23.76	$ 74,133.00	$35.64
WO	$49,992	$24.03	$ 74,988.00	$36.05

Note : Hourly wage = Base Pay /(260 working days in a year * 8 working hours per day)

	E	S2	S3	S4	WO
Yearly Salary	$3,000	$26,490	$37,695	$49,422	$49,992
Yearly Salary/hr	$1.44	$12.74	$18.12	$23.76	$24.03
Mkt Comp Rev/hr	$10.10	$19.10	$27.18	$35.64	$36.05

Knowledge(%)	
Human	IT
67%	33%
100%	0%
100%	0%
67%	33%
67%	33%
100%	0%
100%	0%
67%	33%
67%	33%
67%	33%

Figure A3. "Before RFID" in the 40th Supply Depot (Jung & Baek, 2009)

Process	Number of employess	Rank of Difficulty	Relative learning	Actual Average	% Auto	Times performed in a	Average Time to	Knowledge(hr)/ Process		Total K/Yr	Human Cost/Hr	IT cost/Yr	Automation Tool
								Human	IT				
1. Print inventory worksheets	3	1	2	0.5	50%	372	0.2	1.5	0.75	837.54	$ 91	$ 37,500	software program
2. Conduct inventory with PDA & Transfer data wirelessly to Comp	3	6	40	3.2	80%	372	8	9.6	7.68	6432.3072	$ 91	$ 19,247	RFID
3. Print inventory discrepancy report	3	2	2	0.2	50%	338	2	0.6	0.3	304.56	$ 91	$ 37,500	software program
4. Reconduct inventory with PDA & Transfer data wirelessly to Con	3	5	52	3.1	80%	17	8	9.3	7.44	283.2408	$ 91	$ 19,247	RFID
5. Print final inventory discrepancy report	3	3	2	0.1	50%	17	2	0.3	0.15	7.614	$ 91	$ 37,500	software program
6. Print master inventory listing	3	4	2	0.1	50%	17	2	0.3	0.15	7.614	$ 91	$ 37,500	software program
Total	18		100	7.2		1134	22.2			7872.876	$ 547	$ 188,494	

Process	Human				IT				Total			
	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI
1. Print inventory worksheets	$ 50,928	$ 6,790	750%	650%	$ 25,464	$ 37,500	68%	-32%	$ 76,392	$ 44,290	172%	72%
2. Conduct inventory with PDA & Transfer data wirelessly to Comp	$ 1,910,610	$ 271,608	703%	603%	$ 1,528,488	$ 19,247	7941%	7841%	$ 3,439,097	$ 290,855	1182%	1082%
3. Print inventory discrepancy report	$ 18,519	$ 61,729	30%	-70%	$ 9,260	$ 37,500	25%	-75%	$ 27,779	$ 99,229	28%	-72%
4. Reconduct inventory with PDA & Transfer data wirelessly to Con	$ 84,132	$ 12,346	681%	581%	$ 67,306	$ 19,247	350%	250%	$ 151,438	$ 31,593	479%	379%
5. Print final inventory discrepancy report	$ 463	$ 3,086	15%	-85%	$ 231	$ 37,500	1%	-99%	$ 694	$ 40,586	2%	-98%
6. Print master inventory listing	$ 463	$ 3,086	15%	-85%	$ 231	$ 37,500	1%	-99%	$ 694	$ 40,586	2%	-98%
Total	$ 2,065,115	$ 358,646	576%	476%	$ 1,630,980	$ 188,494	865%	765%	$ 3,696,095	$ 547,140	676%	576%

Correlation	Rank of Difficulty to Relative LT	0.788921861
Correlation	Relative LT to Actual ALT	0.978079067

Figure A4. "After RFID" in the 40th Supply Depot (Jung & Baek, 2009)

APPENDIX B

Inventory Completion Time 5280

Industry Revenue/hour $ 16 Total/month $ 139,615

Total reflects monthly portion of annual inventory cost of $1.7M

Steps	ALT	Nbr of Employees	Amount Knowledge Embedded in IT	Total Amount Knowledge units	% Total Knowledge	Market Comparable Revenue	Process Cost	ROK	Order of Magnitude
Clerk send LMVO inventory notification	15.00	3	5	50	1.12%	$ 1,560	$ 423	369%	4.32%
Clerk run exception report of missing items	90.00	3	41	311	7.01%	$ 9,785	$ 846	1156%	13.54%
Clerk send inventory team notifcation	15.00	3	5	50	1.12%	$ 1,560	$ 423	369%	4.32%
Clerk provide teams their list of items	1.50	3	0	5	0.10%	$ 142	$ 2,115	7%	0.08%
Two person team conduct inventory of listed items	115.00	20	0	2300	51.91%	$ 72,478	$ 913,462	8%	0.09%
Two person team produce soft copy of inventoried/missing iten	45.00	20	90	990	22.35%	$ 31,197	$ 365	8538%	100.00%
Clerk merge inventoried/missing item lists	115.00	3	35	380	8.57%	$ 11,959	$ 212	5653%	66.21%
Clerk reconcile exception and inventoried missing reports	90.00	3	27	297	6.70%	$ 9,359	$ 635	1475%	17.27%
Clerk report findings to RMMS supervisor	12.50	3	0	38	0.85%	$ 1,182	$ 212	559%	6.54%
RMMS supervisor brief peer division heads on missing items	12.50	1	0	13	0.28%	$ 394	$ 808	49%	0.57%
				4,431		$ 139,615	$ 919,500	15%	

Actual to Nominal Learning time Correlation 86%

Note: all value expressed per month

Cost more to perform than revenue generated from this step

Target areas for improvement in To-Be model

Figure B1. "As-Is" Inventory kva Analysis (Courtney, 2007)

Records Processed/Month 1365

Minutes/Month Spent Looking for Items 1,384

Market Comparable Revenue/month $ 1,126,420

Average Check-out time/item (min) 11.6

Steps	ALT	Nbr of Employees	Amount Knowledge Embedded in IT	Total Amount Knowledge units	% Total Knowledge	Market Comparable Revenue	Process Cost	ROK	Order of Magnitude
Customer request item per ERP showing available	7.50	120	90	990	39%	$ 434,504	$ 11,083	3920%	100.0%
Clerk verify item avail in record storage area	50.00	3	-	150	6%	$ 65,834	$ 1,155,000	6%	0.1%
Need to locate item	165.00	3	-	495	19%	$ 217,252	$ 300,300	72%	1.8%
Clerk enter customer badge number in ERP to begin check-out	90.00	3	41	311	12%	$ 136,276	$ 385,000	35%	0.9%
Clerk enter item id number in ERP against customer id number	90.00	3	41	311	12%	$ 136,276	$ 1,155,000	12%	0.3%
Clerk enter return date for all items charged to customer	90.00	3	41	311	12%	$ 136,276	$ 1,155,000	12%	0.3%
Customer receives items and exit RMMS records office	0.00	120	-	-	0%	$ -	$ -	0%	0.0%
	493			2,567		$ 1,126,420	$ 4,161,383	27.1%	

Total intellectual and IT knowledge in this subprocess

Target areas for improvement in To-

Actual to Nominal Learning time Correlation 88%

Note: all times, dollars expressed in minutes, dollars per month

Figure B2. "As-Is" Item Checkout KVA Analysis (Courtney, 2007)

Inventory Completion Time 1440

Industry Avg Revenue/hour $ 16 Total/month 456,923

Steps	ALT	No of Emp.	Amount Knowledge Embedded in	Total Amount Knowledge units	% Total Knowledge	Market Comparable Revenue	Process Cost	ROK	RFID Impact	As-Is ROK
Clerk send LMVO inventory notification	15.00	3	5	50	3.56%	$ 16,254	$ 423	3842%	up	369%
Clerk run exception report of missing items	70.00	3	168	378	27.16%	$ 124,123	$ 846	14669%	up	1156%
Clerk conduct inventory of items	90.00	3	216	486	34.93%	$ 159,587	$ 277,115	58%	up	8%
Clerk re-run exception report of missing reports	70.00	3	168	378	27.16%	$ 124,123	$ 212	58676%	up	1475%
Clerk report findings to RMMS supervisor	25.00	3	-	75	5.39%	$ 24,628	$ 212	11642	up	559%
RMMS supr brief peer division heads on missing item	25.00	1	-	25	80%	$ 8,209	$ -	#DIV/0!	up	49%
				1,392		$ 456,923	$ 278,808	164%		
				4,431		$ 139,615	$ 919,500	15%		

Estimate more evenly disbursed knowledge over difficult task resulting in reduced cycle time in completing an inventory

Estimate achieving target primary objective of significantly lowering cost to conduct inventory by reducing times fired

Actual to Nominal Learning time Correlation 95%

Note: all value expressed per month

Assumptions:

Analysis based on facility one as a baseline for other facilities

Known Facts:

Documented stastics

Subp-process Cost Calcul

Figure B3. "To-Be" Inventory KVA Analysis (Courtney, 2007)

Records Proccessed/Month 3275

Minutes/Month Spent Looking for Items 118

Market Comparable Revenue/month $ 2,702,582

Average Check-out time/item (min) 10 11.6

Estimate increasing all ROK values by lowering revenue to cost ratios

Steps	ALT	No. of Employees	Amount Knowledge Embedded in IT	Total Amount Knowledge units	% Total Knowledge	Market Comparable Revenue	Process Cost	ROK	RFID Impact	As-Is ROK
Customer request item per web-enabled view of availa	10.00	120	300	1,500	42%	$ 1,140,090	$ 15,955	7146%	up	3920%
Clerk verify item avail in record storage area	15.00	3	36	81	2%	$ 61,565	$ 27,656	223%	up	6%
Need to locate item	115.00	3	276	621	17%	$ 471,997	$ 166,269	284%	up	72%
Clerk scan customer badge number to begin check-ou	95.00	3	228	513	14%	$ 389,911	$ 554,231	70%	up	35%
Clerk scan items against customer id number	95.00	3	228	513	14%	$ 389,911	$ 554,231	70%	up	12%
Clerk enter return date for all items charged to custom	95.00	3	43	328	9%	$ 249,110	$ 554,231	45%	up	12%
Customer receives items and exit RMMS records offic	0.00	120	-	-	0%	$ -	-	0%	-	0%
	425			3,556		$ 2,702,582	$ 1,872,573	144.3%		
				2,567		$ 1,126,420	$ 4,161,383	27%		

Actual to Nominal Learning time Correlation 81%

Figure B4. "To-Be" Item Checkout kva Analysis (Courtney, 2007)

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APPENDIX C

Table C1. “As-Is” Inventory Knowledge-Value Added Analysis (Obellos, Colleran, & Lookabill, 2007, p. 89)

Steps	Estimated Learning Time (ALT) (hrs.)	Work Time (hrs.)	Number of Employees	Number of times task completed (Annual)	Sum of task completion (Annual)	Knowledge Amount Embedded in IT (%)	Amount of Knowledge Units (per task)	Total Amount of Knowledge Units (Annual)	% Total Knowledge	Market Comparable Revenue	Total Market Comparable Revenue (Annual)	Process Cost	Total Process Cost (Annual)	ROK
	A	B	C	D	E = A*C*D	F	G = (A*C)+F	H = E*G	I = G/TotalG	J	K = E*J	L = B*J	M = E*L	N = J/L
1) NCIMS-A prints inventory worksheets by location	1	0.25	1	14	14	90.0	91	1274	18%	$27.53	$385	$6.88	$96.36	400%
*2) Clerk conducts inventory of items	1	8	12	14	168	0.0	12	2016	2%	$16.50	$2,772	$132.00	$22,176	13%
*3) Clerk records count on worksheet	0.5	8	12	14	84	0.0	6	504	1%	$8.25	$693	$66.00	$5,544	13%
*4) NCIMS-A manually inputs worksheet data into ILSMIS	1	3	1	14	14	50.0	51	714	10%	$27.53	$385	$82.59	$1,156	33%
5) NCIMS-SA run exception report of missing items	1	0.15	1	14	14	90.0	91	1274	18%	$27.53	$385	$4.13	$57.81	667%
6) Clerk conducts recount	0.5	2.5	12	14	84	0.0	6	504	1%	$8.25	$693	$20.63	$1,733	40%
7) Clerk records recounts on worksheet	0.25	1	12	14	42	0.0	3	126	1%	$4.13	$173	$4.13	$173	100%
*8) NCIMS-A manually inputs data from recount worksheet	1	1	1	14	14	50.0	51	714	10%	$27.53	$385	$27.53	$385	100%
9) NCIMS-SA prints final inventory discrepancy report	1	0.1	1	14	14	90.0	91	1274	18%	$27.53	$385	$2.75	$38.54	1000%
10) NCIMS-A prints master inventory listing	1	0.1	1	14	14	90.0	91	1274	18%	$27.53	$385	$2.75	$38.54	1000%
Totals	8.25	24.1		140	462		493	9674		$202.31	$6,644	$349.39	$31,399	
										10 Year Total	**$66,440**		**$313,989**	

**** Sub-processes that will be eliminated with RFID/UID implementation are 2, 3, 4 and 8.***

ROI (Total M –Total K / Total M) = -79%

ROI is negative indicating an opportunity for IT enhancement.

Table C2. “To-Be” Inventory Knowledge-Value Added Analysis
(Obellos, Colleran, & Lookabill, 2007, p. 90)

Steps	Estimated Learning Time (ALT) (hrs.)	Work Time (hrs.)	Number of Employees	Number of times task completed (Annual)	Sum of task completion (Annual)	Knowledge Amount Embedded in IT (%)	Amount of Knowledge Units (per task)	Total Amount of Knowledge Units (Annual)	% Total Knowledge	Market Comparable Revenue	Total Market Comparable Revenue (Annual)	Process Cost	Total Process Cost (Annual)	ROK
	A	B	C	D	E = A*C*D	F	G = (A*C)+F	H = E*G	I = G/TotalG	J	K = E*J	L = B*J	M = E*L	N = J/L
1) NCIMS-A prints inventory worksheets by location	1.75	0.25	1	52	91	90.0	91.75	8349.25	16%	$27.53	$2,505	$6.88	$626	400%
2) Clerk conducts inventory of items with handheld device and data is transmitted wirelessly to NCIMS	0.625	2	2	52	65	95.0	96.25	6256.25	17%	$16.50	$1,073	$33.00	$2145	50%
3) NCIMS-A run exception report of missing items	1.75	0.15	1	52	91	90.0	91.75	8349.25	16%	$27.53	$2,505	$4.13	$376	667%
4) Clerk conducts recount with handheld device and data is transmitted wirelessly to NCIMS	0.625	2.5	2	52	65	95.0	96.25	6256.25	17%	$8.25	$536	$20.63	$1,341	40%
5) NCIMS-A prints final inventory discrepancy report	1.75	0.1	1	52	91	90.0	91.75	8349.25	16%	$27.53	$2,505	$2.75	$251	1000%
6) NCIMS-A prints master inventory listing	1.75	0.1	1	52	91	90.0	91.75	8349.25	16%	$27.53	$2,505	$2.75	$251	1000%
Totals	8.25	5.1		312	494		559.5	45909.5		$134.87	$11,630	$70.14	$4,989	
										10 Year Total	**$116,297**		**$49,888**	
													ROK (Total K / Total M) =	233%
													ROI ((Total M - Total K) / Total M) =	133%

ROK and ROI significantly improved by IT enhancement.

APPENDIX D

Beta	
IT Index	AITS
1.000	0.320

Returns

	IT Index	AITS
1	182%	-72%
2	181%	-71%
3	192%	-69%
4	193%	-70%
5	193%	-67%
6	192%	-66%
7	195%	-65%
8	196%	-67%
9	193%	-66%
10	197%	-65%
11	198%	-64%
12	196%	-62%
13	203%	-59%
14	207%	-58%
15	215%	-55%
16	225%	-56%
17	223%	-57%
18	230%	-50%
19	236%	-47%
20	241%	-41%
20	250%	-35%
22	269%	-39%
23	273%	-31%
24	304%	-27%
25	312%	-23%
26	318%	-18%
27	298%	-20%
28	330%	-19%
29	340%	-12%
30	375%	-15%
31	365%	-13%
32	374%	-12%
33	401%	-9%
34	388%	-7%
35	404%	-6%
36	396%	-3%
37	427%	4%
38	426%	7%
39	427%	16%
40	437%	11%
41	430%	8%
42	445%	17%
43	455%	20%
44	467%	22%
45	469%	19%
46	471%	25%
47	501%	30%
48	480%	29%
49	467%	35%
50	476%	33%
51	490%	36%
52	527%	38%
53	520%	39%
54	523%	41%
55	521%	40%
56	518%	41%
57	519%	43%
58	521%	42%
59	519%	43%
60	520%	44%

Figure D1. IT Index and aits returns

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