CHAPTER 1

INTRODUCTION

Military Cost-Benefit Analysis (CBA): Theory & Practice

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I. Background

Military Cost-Benefit Analysis (CBA) offers a vital tool to help guide governments through both stable and turbulent times. As countries struggle with the dual challenges of an uncertain defense environment and cloudy fiscal prospects, CBA offers a unique opportunity to transform defense forces into more efficient and effective 21st century organizations.

Defense reforms typically involve politically charged debates over *investments* (in projects, programs, or policies) as well as contentious *divestment* decisions—from base realignment and closure (BRAC) to outsourcing and asset sales. A powerful contribution of CBA is to inform such complex and contentious decisions—carefully structuring the problem and capturing relevant costs and benefits of alternative courses of action. Lifting the veil on military CBA, this edited volume reveals several systematic quantitative approaches to assess defense investments (or divestments), combined with a selection of real-world applications.

The frameworks and methods discussed in the following chapters should appeal to anyone interested or actively involved in understanding and applying CBA to improve national security. These valuable approaches also have broader government-wide applications, especially in cases where it is difficult to monetize the benefits of a public project, program, or policy.

Unprecedented government spending to counter the global financial crisis has placed enormous pressure on public budgets. Combined with alarming demographics, many countries struggle to fulfill past promises to underwrite health care expenditures, social security payments, government pensions, and unemployment programs. As debt burdens grow to finance current operations, the risk of escalating interest payments threatens to crowd out vital future public spending. As the single largest discretionary item in many national budgets,[1]

military expenditures make a tempting target. Especially vulnerable are military and civilian compensation (pay and benefits) and the purchase and operation of equipment, facilities, services, and supplies.

Anticipating future spending cuts, this book explores both conventional and unconventional approaches to contemporary defense decisions—from critical investments in facilities, equipment, and materiel to careful vendor selection to build, operate, and maintain those investments. Recognizing the value of systematic quantitative analysis, senior U.S. Army leadership has "directed that any decisions involving Army resources be supported by a CBA."[2]

Faced with severe budget cuts and an uncertain threat environment, defense officials around the world confront urgent decisions on whether or not to approve specific *projects* (e.g. infrastructure—military housing; training, and maintenance facilities, etc.) or *programs* (e.g. weapon systems—Unmanned Aerial Vehicles (UAVs), Armored Personnel Carriers (APCs), Cyber Defense, etc.). Military CBA offers a valuable set of analytical tools to increase the transparency, efficiency, and effectiveness of critical defense decisions.

A synthesis of economics, management science, statistics, and decision theory, military CBA is currently used in a wide range of defense applications in countries around the world: i) to shape national security strategy, ii) to set acquisition policy, and iii) to inform critical investments in people, equipment, infrastructure, services, and supplies. This edited volume offers a selection of carefully designed CBA approaches, and real-world applications, intended to help public officials identify affordable defense capabilities that effectively counter security risks in fiscally constrained environments.

II. A Brief History of Cost-Benefit Analysis (CBA)

The French engineer Jules Dupuit (Dupuit 1844) is widely credited with an early concept of CBA called "economic accounting." The British economist Alfred Marshall (Marshall 1920) later developed formal concepts that contributed to the analytical foundations of CBA.[3] In a pioneering survey, Prest and Turvey indicate that as early as 1902 the U.S. River and Harbor Act required the Army Corps of Engineers to report on the desirability of any project, taking into account both the

cost and the amount of "commerce benefited" (Prest and Turvey 1965). Widespread application of CBA in the U.S. is generally attributed to the 1936 Federal Navigation (Flood Control) Act. This required the Army Corps of Engineers to carry out projects to improve waterways when "the benefits to whomsoever they may accrue are in excess of the estimated costs" (Prest and Turvey 1965).

At the heart of Cost-Benefit Analysis (CBA) is the economists' concept of "allocative efficiency," in which resources are deployed to their highest valued use to maximize social welfare. A related and intuitively appealing definition called "Pareto Efficiency" underpins CBA. An allocation is Pareto-efficient if no alternative allocation can make at least one person better off without making someone else worse off (Pareto 1909).

The link between allocations that yield maximum net benefits in CBA and Pareto efficiency is straightforward: If a public policy, program, or project has positive net benefits, then it is possible to find a set of transfers (side payments) that make at least one person better off without making anyone else worse off. Unfortunately, transfers necessary to achieve Pareto efficiency are difficult to implement in practice. Therefore, out of practical necessity, CBA relies on a related decision rule called the Kaldor-Hicks criterion (Kaldor 1939; Hicks 1940). This decision rule states that a public policy, program, or project should be adopted, if and only if gainers could potentially fully compensate losers, and still be better off.[4]

Application of this decision rule is relatively straightforward:[5] Adopt all projects that have positive net benefits.[6] An important caveat is that the Kaldor-Hicks criterion only applies when costs and benefits can be monetized. Given the prevalence of non-monetary benefits in national defense, this poses a serious challenge for the security sector.

The growing interest in CBA after WWII is often attributed to rapid developments in operations research and systems analysis—techniques that helped win the war by combining economics, statistics, and decision theory. Following the allied victory, Project RAND (launched in 1946 by the Army Air Corps) received

government funding to maintain scientific expertise developed in WWII and to conduct independent and objective research in national security.

A key contribution of RAND's research was "systems analysis" pioneered by Ed Paxson and advanced by Charles Hitch who in 1948 founded RAND's Economics Division. Whereas operations research had a more immediate, wartime focus (e.g. finding the best short-run solution to a military mission, given a restricted set of equipment, etc. with specific characteristics), systems analysis was more future-oriented, focused on finding the optimal mix of doctrine, forces, equipment, etc. necessary to accomplish a military goal at the lowest possible cost (or alternatively, for a given budget, to find the optimal mix that maximizes defense capabilities).

Working at RAND in the immediate post-war era, Hitch teamed with another economist, Roland McKean, to publish a pioneering text entitled "The Economics of Defense in the Nuclear Age" (Hitch and McKean 1960). The authors emphasize two main ways in which Military CBA can be applied: i) to guide defense *policy* (i.e. the allocation of resources between major missions or military goals) and ii) to guide defense *investments* (i.e. choices between alternative projects or programs to achieve a given mission/goal). A significant challenge in applying CBA to defense decisions is the complex and often controversial task of measuring "benefits."

At the highest national strategic level, "benefits" of a specific defense policy[7] might be measured in terms of its impact on long-term economic growth, peace, and prosperity—all key contributors to social welfare. For example, suppose resource costs to achieve specific military goals are viewed as insurance payments against hazardous states of the world. Suppose further that defense policy decisions that achieve specific military goals reduce risk premiums associated with domestic and foreign direct investment (FDI). Empirical evidence suggests FDI boosts economic growth and in turn contributes to peace and prosperity.[8] In this example, high-level defense decisions could ideally be made with the aim of increasing social welfare by encouraging investment, boosting GDP, and thereby generating a virtuous cycle of peace and prosperity.

In reality, this high-level effort to capture monetary benefits of defense policy as growth in GDP is rarely explored.[9] Instead, it typically gives way to a more

familiar perspective that makes up the bulk of chapters in this edited volume—where non-monetary "measures of effectiveness" (MOEs) of a policy, project, or program substitute for monetary benefits.

Denied the opportunity to conduct controlled experiments, or full scale independent field tests to evaluate alternative policies, projects, or programs, military officials and analysts are forced to resort to "proxy" variables. These include criteria and characteristics that reflect multiple objectives and that describe essential features of the alternatives being analyzed.[10] When benefits cannot be monetized, the terms "Systems Analysis" or "Cost-Effectiveness Analysis" are often used to describe Military CBA.[11]

A related literature, alternately called Multi-criteria decision-making (MCDM) or Multi-objective decision-making (MODM), rapidly evolved after WWII to address the challenge of measuring non-monetary benefits of defense investments. The reader is encouraged to explore this literature for details on competing benefit measurement strategies, some of which are discussed in this volume. These measures have been in continuous development since the adoption of systems analysis by the U.S. Department of Defense in the early 1960s.[12]

Following his election as President in 1960, John F. Kennedy appointed Robert McNamara Secretary of Defense. McNamara subsequently hired Charles Hitch as Comptroller to implement the Planning, Programming, and Budgeting System (PPBS) that Hitch had earlier helped develop at RAND. An output-oriented budgeting framework, PPBS relies heavily on systems analysis, or military CBA, to build a defense budget.

Prior to Hitch's tenure in the Office of Secretary of Defense, U.S. defense budgets were largely based on the Services' (Army, Navy, Air Force) proposals for annual incremental increases in inputs or "appropriation" categories (Military Personnel, Procurement, Operations & Maintenance, Military Construction, etc.), often with little or no clear connection to defense outputs, joint missions, or national security goals. Having successfully employed a variant of PPBS called "program budgeting" as CEO of Ford Motor Company, McNamara recognized the value of building a defense budget that focuses on outputs (benefits) as well as costs.

The major innovation of PPBS is "Programming," which bridges the gap between long-term military planning goals and short-term civilian budget realities. Designed as a constrained optimization underpinned by systems analysis, the "programming" phase was intended to produce a cost-effective mix of forces to maximize national security subject to funding constraints.[13]

Under certain conditions, the optimal allocation of a budget across various inputs (e.g. defense resources) that contribute to a common goal (i.e. increasing national security) requires the marginal contribution of each input towards that goal, for a given incremental cost, to be the same for any input. Since this decision rule is independent of the units in which the goal is measured, in principle it provides a valid test for allocative efficiency, satisfies the condition for Pareto Optimality, and guarantees the most effective use of a defense budget.[14]

To implement PPBS, Hitch hired a RAND colleague, Dr. Alain Enthoven, as Deputy Comptroller for Systems Analysis. In 1965, the impact of military CBA was reinforced when Dr. Robert Anthony of the Harvard Business School replaced Hitch as Comptroller and elevated Enthoven's position to Assistant Secretary of Defense for Systems Analysis.[15] Throughout his tenure, Secretary McNamara consistently applied systems analysis to evaluate policy, project, and program proposals from the military services and to build defense budgets submitted to the Congress.[16] Military CBA continues to provide an analytical foundation that guides PPBS decisions in the U.S. and in countries around the world.

It is clear that politics influences defense decisions. It is also true that public officials can manipulate CBA for their own personal strategic interests. Politicians likely win more votes highlighting a program's benefits and downplaying its costs, and public administrators may be similarly rewarded. While it is clear pork-barrel politics often plays an important role in defense decisions, this book attempts to take the high road. It encourages the application of military CBA with a strict focus on national security interests.[17]

While employment, income distribution, and regional impacts of defense investment decisions often play a role in political decisions, a clean CBA can inform the process by revealing the true (opportunity) cost of decisions that drift too far from the goal of making the best use of scarce resources for the security of

the country. Ideally, a carefully constructed military CBA focused strictly on national security concerns could be used to inform voters and counter special interest lobbying and rent-seeking that often leads defense firms to inefficiently spread production across key voting districts to promote their programs.[18]

A risk for any military CBA is that benefit and cost estimates might be strategically manipulated by self-interested agencies or individual decision-makers.[19] As Robert Haveman and others have pointed out, politicians facing difficult re-election tend to prefer projects that concentrate benefits on particular interest groups that offer them support, and to camouflage or defer costs, or to spread them widely across the population. (Haveman 1976) Fortunately, as nations around the world embrace civilian control of the military, and citizens insist on greater accountability—including tighter linkages between budgets and security—an increased premium is placed on transparency in defense decisions.

While politics still dominates major defense decisions, the importance of military CBA rises alongside growing demands for transparency and accountability.[20] Costly defense procurement scandals reinforce the need for objective CBA approaches to improve transparency in vendor selection decisions.[21] Meanwhile, painful recovery from the global financial crisis,[22] combined with emergent threats, fuel public demand to carefully apply tools such as military CBA to build efficient, effective, and accountable security forces.

III. Outline

This edited volume reveals how military CBA can reduce budget pressures and improve defense decisions that contribute to national security. The dual purpose of CBA is to encourage more efficient and effective allocation of society's scarce resources to increase social welfare.[23] Governments often employ CBA to rank (mutually exclusive) portfolios of projects or programs. The typical CBA involves at least eight steps:

1) The first step is to identify key decision-makers (and other stakeholders) to clarify goals, objectives, preferences, and constraints (including realistic funding projections).

2) The second step is to carefully structure the problem and identify feasible alternatives that contribute to those goals/objectives and that satisfy the constraints.

3) The third step is to determine the relevant time horizon over which the CBA will be conducted and to select an appropriate discount rate.

4) The fourth step is to estimate relevant time-phased costs of each alternative over the relevant period.

5) The fifth step is to forecast time-phased benefits that will accrue over the relevant period.[24] This edited volume offers alternative approaches to structure a military CBA when benefits cannot be monetized. If benefits can be monetized, then the project or program with the highest Net Present Value (NPV) can be recommended.[25]

6) The sixth step is to recognize uncertainty and conduct sensitivity analyses to determine whether results change with changes in key parameters (costs, benefits, budgets, discount rates, etc.).[26]

7) The seventh step is to report the results of the analysis (rankings of projects, programs, etc., along with key assumptions).

8) The final step is to make well-informed recommendations.

These eight basic steps of a CBA are explored throughout the chapters of this edited volume. The book consists of seventeen chapters divided into five sections.

Section I: Introduction and Problem Formulation

This section includes the first four chapters. Chapter 1 which you are reading offers a broad overview and outline of the book. Chapter 2 entitled "Allocating National Security Resources" sets the strategic tone of the book through the lens of U.S. global security concerns. The Honorable J. Gansler (former U.S. Under Secretary of Defense for Acquisition, Technology & Logistics) and his co-author W. Lucyshyn discuss challenges of: wide-ranging international threats, domestic budgetary restrictions, and ongoing acquisition problems—including questions about future capacity to support current acquisitions. Revealing a possible

mismatch between the National Security Strategy and the PPBS process, the authors highlight the need for military CBA at national, departmental, and program levels to make sound resource allocation decisions.[27] They also stress the vital role played by CBA in the continual process of reassessment and innovation necessary to maintain critical linkages between resources and requirements and to guarantee effective forces in a dynamic security environment.

In Chapter 3, a prominent U.K. pioneer in defense economics, K. Hartley and his Canadian senior defense scientist co-author B. Solomon (co-editor of this volume), confront the challenge of measuring defense outputs. While the economics approach discussed in "Measuring Defense Output: An Economics Perspective" is difficult to operationalize into a set of clear and unambiguous policy precepts, it does provide an important framework to help evaluate the benefits of defense outputs and activities. Combining theory and practice, the chapter describes attempts to measure defense outputs in the U.K., U.S., Australia, New Zealand, as well as in various European nations. Later chapters in this book provide several practical methods to help address challenges posed by the authors.

While maintaining the strategic themes of Chapter 2 and recognizing measurement challenges discussed in Chapter 3, Chapter 4 by F. Melese offers a comprehensive set of military CBA approaches to structure public investment decisions. Entitled "The Economic Evaluation of Alternatives (EEoA)," six approaches are introduced that address a significant weakness in many conventional military "Analyses of Alternatives" (AoAs).[28] Historically, while AoAs correctly focused on lifecycle costs and operational effectiveness to evaluate alternatives, "affordability" was an after-thought, at best only implicitly addressed in final stages of the analysis.[29] In sharp contrast, EEoA encourages analysts and decision-makers to include affordability explicitly and up-front in structuring a military CBA. EEoA places taxpayers alongside warfighters in the defense decision-making process. This requires working with vendors to build proposals based on different funding (budget/affordability) scenarios.[30] The Decision Map in the concluding section of Chapter 4 offers a comprehensive guide for practitioners to help structure an EEoA.[31]

Section II: Measuring Costs and Future Funding

This section consists of three chapters. Chapter 5 entitled "Cost Analysis" focuses on the first of the three main components of an EEoA—Costs, Budgets, and Benefits. Having served as the U.S. Navy's chief cost analyst, D. Nussbaum along with his co-author, Professor D. Angelis, discuss approaches to collect, analyze, and estimate costs of proposed projects, programs, or activities. A unique contribution of this chapter is the explicit recognition of "transaction costs."[32] These include measurement, monitoring, management, contracting, negotiation, and other costs associated with government procurement. Depending on the nature of the transaction, it is conceivable that transaction costs could overwhelm the production costs of the desired product or service. Ignoring transaction costs creates a serious risk of underestimating the total costs of a project, program, or activity. In fact, the absence of transaction cost considerations in military CBAs may help explain the prevalence of cost overruns that often negatively impact expected returns on defense investments. To help address current biases and improve cost estimates in military CBAs, the authors recommend incorporating transaction cost considerations into traditional production cost calculations.

Chapter 6 entitled "Advances in Cost Estimating : A Demonstration of Advanced Machine Leaning Techniques for Cost Estimation" presents recent technical advancements in cost estimation. The standard methods to estimate costs of defense systems in early design phases discussed in Chapter 5 include costing by analogy and parametric approaches. Analogy methods base the costs of new systems on historical costs of similar or "analogous" systems. The traditional approach is to ask subject matter experts to make subjective evaluations of differences between the new system and the old. This leads to the application of complexity factors to adjust the analogous (old) system's cost to produce an estimate for the new system. Rather than apply subjectively obtained complexity factors, an innovative proposal by Defence Research & Development Canada scientist, B. Kaluzny, explores the use of machine learning algorithms to estimate the costs of systems in early design phases. The authors propose a cost estimation by analogy approach that involves an agglomerative hierarchical cluster analysis and nonlinear optimization that requires limited subjective input. With limited information, traditional parametric approaches to cost estimation rely on basic

statistical models to develop Cost Estimating Relationships (CERs) to help identify major cost drivers. CERs can be as simple as a ratio or involve linear regression analysis of historical systems or subsystems. The author proposes a new parametric technique, the M-system of Quinlan (a combination of decision trees and linear regression models), for learning models that predict numeric values.

Having established the importance of treating affordability (or future funding constraints) up front in an economic evaluation of alternatives (EEoA), the challenge of forecasting long-term defense budgets is explored in Chapter 7. Colonel R. Fetterly and B. Solomon begin their chapter "Facing Future Funding Realities: Forecasting Budgets beyond the FYDP (future year defense plan)" by highlighting the importance of strategic management methods, such as Capabilities-Based Planning, to link existing military capabilities and force development goals to the future security environment. These strategic management approaches are coupled with a variety of forecasting models that take into account a nation's security threats, income, spillover effects of allies' defense posture, and competing demands for a limited public purse. The authors draw on data from a selection of NATO countries to develop several valuable budget forecasting models.

Section III: Measuring Effectiveness

The next two chapters offer a standard and novel approach, respectively, to develop military measures of effectiveness (MOEs). Chapter 8 entitled "Multiple Objective Decision-Making" focuses on practical, conventional methods used to structure a military CBA when faced with the challenge of quantifying non-monetary benefits of defense projects, programs, or policies. Professors K. Wall and C. MacKenzie confront the challenge of non-monetary benefits leveraging the literature on multiple-objective (and multi-criteria) decision-making. The authors present a standard approach to help solve multiple-objective decision problems. Many contemporary decision problems in defense management and government resource allocation produce multiple, competing benefits. This chapter offers a widely employed approach in the Analysis of Alternatives (AoA).

Chapter 9 offers a new, cutting-edge approach to conduct a military CBA focused on force protection investments. If the goal is to evaluate investments to

protect soldiers, then monetizing the benefits of lives saved can help save the greatest number of lives. In this chapter, entitled "A New Approach to Evaluate Safety and Force Protection Investments: Tradeoffs between Money Spent and Lives Saved," Professors T. Kniesner, J. Leeth, and R. Sullivan cogently discuss how economists evaluate the benefits of safety investments by observing tradeoffs people actually make between safety and other job or product characteristics. The authors present a widely relevant application of their technique to evaluate the cost-effectiveness of adding armor protection to tactical wheeled vehicles. The value-of-statistical-life (VSL) approach presented in this chapter is an innovative military CBA technique highly recommended for future safety and force protection investments.

Section IV: New Approaches to Military Cost-Benefit Analysis (CBA)

In Chapter 10, entitled "The Role of Cost-Effectiveness Analysis in Allocating Defense Resources," Professor K. Wall joins forces with C.J. LaCivita and Professor A. Richter (a co-editor) to present a new CBA approach to solve multi-level (multi-tiered) resource allocation problems. Their solution method re-interprets the conventional Analysis of Alternatives (AoA) model with a twist. Applying standard operations research techniques, they incorporate bounded rationality to realistically portray how decision-makers can and do cope with the complexities of multi-level constrained optimization.[33] The bounded rationality formulation employs subjectively assessed weights derived from the judgment and expertise of a central allocator (e.g. the Minister of Defense), that offer guidance to lower-level decision-makers (e.g. the Services: Army, Navy, Air Force) to balance costs and measures of effectiveness in building defense proposals.

A new, groundbreaking military CBA approach is introduced in Chapter 11 entitled "A Risk-Based Approach to Cost-Benefit Analysis: Strategic Real Options, Monte Carlo Simulation, Knowledge Value Added, and Portfolio Optimization." Authored by renowned expert, J. Mun, and Professor T. Housel, their pioneering "real options" approach estimates military returns on investment (ROI), combining risk analysis concepts and portfolio optimization techniques. Two dramatic events unfolded in recent history that fundamentally transformed the contemporary security landscape—the collapse of the Soviet Union and the

tragedy of 9/11. From a single well-defined "Cold War" nuclear threat, countries now face a wide range of diffuse risks: anything from failed states, terrorism, and arms proliferation to human trafficking, piracy, and cyber-attacks. This historic shift in the national security environment prompted many countries to switch from "threat-based" planning to "capabilities-based" planning (see Fitzimmons 2007). With emerging threats harder to predict, strategic planners recommend diversification—building broad portfolios of flexible defense capabilities to counter a wide range of possible security concerns. Chapter 11 offers a new, unconventional approach to military CBA designed to help build "capability portfolios." The strategic intent of the U.S. and other militaries is to maintain a military edge over rivals. Bureaucratic inertia and political lobbying by established defense firms, however, often result in too heavy a focus on prior conflicts. Research & Development (R&D) expenditures represent a real options approach to future contingencies where some, but not all research, is expected to lead to the development of new systems. R&D payments are similar to premiums paid for financial options in that they grant the government the right—but not the obligation—to exploit, defer, or abandon R&D investments. Periodic adjustments are made based on research results, new budget realities, and the evolving defense environment.[34] This innovative chapter introduces hands-on applications of Monte Carlo simulation, real options analysis, stochastic forecasting, portfolio optimization, and knowledge value added.

The real options approach attempts to make the best possible decisions under uncertainty and to identify, analyze, quantify, mitigate, and manage risks for military options. In Chapter 12 entitled "Extensions of the Greenfield-Persselin Optimal Fleet Replacement Model with Applications to the Canadian Forces CP-140A Arcturus Fleet," D. Maybury adapts other recent developments in financial modeling to construct a stochastic fleet replacement/overhaul model to predict the optimal timing of replacement. The chapter provides an interesting military application that features a popular maritime surveillance aircraft (the CP-140A Arcturus, a Canadianized version of the Lockheed P-3 Orion).

Section V: Selected Applications

The last five chapters provide a selection of other valuable applications and lessons learned that correspond to the methods and concepts discussed in the preceding chapters. Chapter 13 entitled "Embedding Affordability Assessments in Military Cost-Benefit Analysis Analysis: Defense Modernization in Bulgaria" by V. Georgiev presents an application of the economic evaluation of alternatives in Bulgaria's defense organization. The next two chapters each present real-world applications of Military CBA, and are authored by subject matter experts with direct experience in high profile defense programs. Former program manager J. Dillard joins forces with Professors D. Angelis and D. Ford to review development of the Javelin Anti-Tank Weapon System in Chapter 14 entitled "Real Options in Military Acquisition: A Retrospective Case Study of the Javelin Anti-tank Missile System." Study director W. Greer reviews the C-17 strategic airlift program in Chapter 15 entitled "An Application of Military Cost-Benefit Analysis in a Major Defense Acquisition: The C-17 Transport Aircraft." Whereas the former study provides a retrospective application of the "Real Options" approach, the latter offers a valuable historical perspective of traditional military CBA.

In Chapter 16, entitled "Cost-Effectiveness Analysis of Autonomous Aerial Platforms and Communications Payloads," Commander (USN) R. Everly, Lieutenant (USN) D. Limmer and Professor C. MacKenzie build a traditional military CBA to evaluate investments in Unmanned Aerial Vehicles (UAVs). The final Chapter by Economists J. Hanson and J. Lipow tackles a thorny issue: the so-called "social rate of discount." The debate among economists on whether, and by how much, to discount future costs in public procurement remains unresolved. Chapter 17 entitled "Time-discounting in Military Cost-Benefit Analysis (CBA)" cogently summarizes the literature and contrasts it with current guidelines published by the U.S. Office of Management and Budget. (U.S. OMB 1992) This final contribution offers valuable insights and a practical way forward that could help integrate the existing literature with government guidelines to improve the quality of military CBAs.

IV. Conclusion

Tight budgets make for hard choices. The greater the pressure on public budgets the greater the opportunity to apply military CBA. Today, the impact of

government deficits and debt on military spending is inescapable.[35] As one of the largest discretionary items in government budgets, military spending is an obvious target for cuts. While wise use of military power can underpin economic growth, it is equally clear that economic strength underpins military power. Shrinking budgets place a renewed premium on affordability. As sovereign debt challenges squeeze national budgets, and emerging threats challenge existing security forces, this edited volume offers a valuable set of tools and techniques to help navigate the political landscape and meet calls to increase transparency, efficiency, and effectiveness in the defense sector.

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[1] According to the World Bank average, military expenditures globally account for 9.2% of government spending. http://data.worldbank.org/indicator/MS.MIL.XPND.ZS/countries/AU-C5-C7?display=graph (accessed February 7, 2014).

[2] Office of the Deputy Assistant Secretary of the Army, U.S. Army Cost-Benefit Analysis Guide, January 12, 2010, p.6. In general, the U.S. Federal Government's Office of Management and Budget (OMB) Circular A-94 provides guidance for the application of CBA across the entire Executive Branch. DoD Instruction 7041.3 "Economic Analysis for Decision Making" provides explicit guidance for the Department of Defense.

[3] Notable among these is the concept of "consumer surplus."

[4] Note that this criterion does not require transfers to actually occur and is occasionally debated on equity grounds (see Footnote 10).

[5] Assuming policies, projects, or programs are independent and there are no binding constraints on inputs.

[6] In theory, selecting projects with positive net benefits maximizes aggregate wealth (e.g. GDP growth) which indirectly helps those that might be made worse off. Moreover, an implicit assumption is that costs imposed on some and benefits accrued to others will tend to average out across individuals. Where interactions occur among projects, the general rule is to choose the combination of projects that maximizes net benefits.

[7] For example, benefits of a decision to allocate scarce financial resources among major military missions.

[8] For example, see Brooks (2005) or Gartzke (2007).

[9] Chapter 3 in this edited volume offers a notable exception.

[10] Examples of proximate criteria or partial measures of effectiveness include speed, operating range, weapons accuracy, armor protection, etc.

[11] For example, see OMB Circular A-94 "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" published by the U.S. Office of Management and Budget. Note that this edited volume will continue to use the generic term Military CBA to refer to cases where benefits cannot be monetized. Although CEA also produces a ranking, there is no explicit information about whether the highest ranked alternative would provide positive net social benefits. If all alternatives are mutually exclusive, and the status quo is among the alternatives, sharing similar scale and phasing of costs and benefits, then it is possible to apply CEA to select the most efficient policy.

[12] Given the vast existing literature on building Measures of Effectiveness (MOEs), this book instead focuses on the careful construction of Military CBAs. Although we occasionally explore the question of developing non-monetary benefit measures, we encourage the reader to review the extensive literature on Multi-Criteria Decision Making for alternative approaches to deriving such measures of effectiveness. (For example, see Keeney and Raiffa 1976; Buede 1986; or Kirkwood 1997)

[13] "The ultimate objective of PPBS shall be to provide operational commanders-in-chief the best mix of forces, equipment, and support attainable within fiscal constraints" (DoD Directive 7045.14 May 22, 1984). The basic questions of systems analysis are twofold: i) given a fixed budget, which weapon systems are most cost-effective and, conversely, ii) given a fixed military mission, which system(s) could generate the desired level of effectiveness at the lowest cost? The basic ideas of PPBS were: "the attempt to put defense program issues into a broader context and to search for explicit measures of national need and adequacy;" "consideration of military needs and costs together;" "explicit consideration of alternatives at the top decision level;" "the active use of an analytical

staff at the top policymaking levels;" "a plan combining both forces and costs which projected into the future the foreseeable implications of current decisions;" and "open and explicit analysis…made available to all interested parties, so that they can examine the calculations, data, and assumptions and retrace the steps leading to the conclusions" (Enthoven and Smith 2005). http://www.rand.org/content/dam/rand/pubs/commercial_books/2010/RAND_CB403.pdf.

[14] In practice, measuring contributions of various inputs towards a defense goal can be difficult and contentious, and these desirable results only hold under the assumption ("homotheticity") that optimal input ratios are independent of the budget and depend only on relative costs of each input. It is also important to recognize transaction costs associated with the application of military CBA (or systems analysis). For example, centralization of decision-making authority under Secretary of Defense Robert McNamara resulted in a proliferation of management systems to collect data required to evaluate the costs and benefits of alternative projects and programs (weapon systems). Increasingly buried in paperwork, the term "paralysis of analysis" was coined by some members of the defense establishment (personal conversation with A. Enthoven).

[15] In 1972, the Systems Analysis division evolved into the Office of Program Analysis & Evaluation (PA&E) and later, in 2009, into the Office of Cost Assessment & Program Evaluation (CAPE). Prior to his departure, Dr. Hitch launched an OSD-sponsored education institution to teach civilian and military managers in DoD (and partners and allies) basic principles of PPBS and CBA. Today it is known as the Defense Resources Management Institute (DRMI) located at the Naval Postgraduate School in Monterey, California. Two co-editors of this volume (Dr. Melese and Dr. Richter) are faculty members at this institution which celebrated its 50th Anniversary in 2015 (http://www.nps.edu/drmi/; http://www.dtic.mil/whs/directives/corres/pdf/501035p.pdf).

[16] McNamara relied heavily on systems analysis to reach several controversial weapon decisions. He canceled the B-70 bomber, begun during the Eisenhower years as a replacement for the B-52, stating that it was neither cost-effective nor needed, and later he vetoed its proposed successor, the RS-70. McNamara expressed publicly his belief that the manned bomber as a strategic weapon had no long-run future; the intercontinental ballistic missile was faster, less vulnerable, and less costly. Similarly, McNamara terminated the Skybolt project late in 1962. Begun in 1959, Skybolt was conceived as a ballistic missile with a 1,000-nautical mile range, designed for launching from B-52 bombers as a defense suppression weapon to clear the way for bombers to penetrate to targets. McNamara decided that Skybolt was too expensive, was not accurate enough, and would exceed its planned development time. He claimed other systems, including the Hound Dog missile, could do the job at less cost.

[17] Our view is that a clean military CBA is a valuable starting point for political debates. Careful analysis can constrain political attempts to turn defense spending into a jobs program or an opportunity to redistribute income. Since there exist considerably more efficient and effective ways of promoting job growth and income distribution, if these are the goals, then they should be stated explicitly and explored using a separate CBA. This may prove a valuable avenue for future research.

[18] A recent example is the case of the F-35 aircraft program. Lockheed-Martin claims to have "created 125,000 U.S.-based direct and indirect jobs in 46 states" http://www.businessweek.com/news/2014-01-22/lockheed-martin-inflating-f-35-job-growth-claims-nonprofit-says (downloaded March 21, 2014).

[19] Since costs (e.g. investment expenditures) tend to occur earlier with benefits appearing later, discount rates can also be strategically selected to make projects appear more or less attractive. (See Chapter 17)

[20] For example, see NATO's Building Integrity initiative at www.nato.int/cps/en/natolive/topics_68368.htm.

[21] For example, see Camm and Greenfield (2005).

[22] As public officials face growing resistance to tax increases, pressure increases to ensure governments work more efficiently and effectively.

[23] National defense satisfies two key characteristics of a "public good." It is: i) non-rival and ii) non-excludable. In the former case, unlike private goods, if one person in a geographic area is defended from foreign attack or invasion, his or her consumption is non-rival in that others in the area can consume the same level of national security for little or no additional cost. In the latter case, if one person is defended, others in that same area cannot be excluded from the security benefits. This leads to a classic free-rider problem making it difficult to charge people for national defense. The key here is that whereas it is generally agreed the *provision* of national defense is a public good that must be funded with taxes, the *production* of national defense depends on the relative costs (including transaction costs) and benefits of public and private sector production, which can be evaluated using Military CBA.

[24] Since benefits of proposed defense investments are often difficult to monetize, various approaches have been developed to construct "measures of effectiveness" (MOEs) that capture the value or utility of alternatives. In theory, the benefits of alternative defense investments could be monetized if their contribution to security and stability encourages foreign direct investment that contributes to economic growth and social welfare. In practice, precise linkages between defense investments and economic growth are difficult to establish. As a consequence, the benefits of most military investments are not monetized, and instead various MOEs are constructed to conduct a Cost-Effectiveness Analysis (CEA) that is referred to in this volume as a Military CBA (e.g. see OMB Circular A-94 published by the U.S. Office of Management and Budget).

[25] If benefits can be monetized, then calculate the discounted sum of net benefits (Benefits – Costs) from each alternative over the specified time period, i.e. the discounted Net Present Value (NPV). For example, consider two alternative military projects designed to achieve the goal of reducing the Navy's fuel budget. Suppose there is a fixed investment budget available, and the two mutually exclusive alternatives each require the same identically phased investment. The first proposal is to invest in a program to convert ship propulsion from conventional diesel to a less expensive bio-diesel. The second proposal is to invest in an energy conservation program at Navy installations. Since the two alternatives each require the same identically phased investments, the CBA can simply focus on the stream of benefits (savings from cheaper fuel in the first case and reduction in fuel demand in the second) that accrue from each project. Assuming a preference for present vs. future savings, the discounted present value of each stream of savings can be calculated to determine the winning project. (See Chapter 17)

[26] Alternatively, a "Real Options" approach could be adopted, conducting Monte Carlo simulations assigning probability distributions to key parameters. (For example, See Chapters 11 and 14)

[27] The authors also warn that until new mechanisms such as CBA are adopted to address the continual failure to fuse requirements with necessary resources, DoD will essentially continue to create a disjointed, ineffective framework for addressing national security concerns rather than the cohesive plan vital in confronting the changing dynamics of modern, global warfare.

[28] See Ullman and Ast (2011) and OMB Circular A-11 for discussions of the Analysis of Alternatives.

[29] In the U.S., AoAs are conducted in early phases (milestones) of major defense acquisitions. Since they frequently occur in early development before a project is fully funded, they rarely incorporate future funding forecasts. Instead, the budget estimate for the program/project is generated as an output of the AoA. As major budget cuts create funding challenges for new defense programs, "affordability" in terms of realistic budget constraints is gaining increasing importance in AoAs.

[30] A key difference between traditional AoAs and EEoA is that instead of modeling competing vendors as points in cost-effectiveness space, EEoA solicits vendor offers as functions of optimistic, pessimistic, and most likely funding (budget) scenarios. A formal mathematical model of the Economic Evaluation of Alternatives (EEoA) can be found in Simon and Melese (2011).

[31] Following the recommended EEoA approach also provides a unique opportunity to achieve a significant defense reform: to coordinate the Requirements Generation System, Defense Acquisition System, and Planning, Programming, and Budgeting System (PPBS)—to lower costs, and improve performance and schedules.

[32] For example, see Williamson and Masten (1999) or Melese, Franck, Angelis, and Dillard (2007).

[33] Finding the optimal mix of forces to accomplish a military goal at the lowest possible cost, or alternatively, for a given budget, to find the optimal mix that maximizes defense capabilities.

[34] The real options approach builds on what was previously referred to as incremental or "spiral" development of military programs and projects.

[35] The response of many governments to the global recession was to bailout banks and businesses and to stimulate their economies. Combined with falling tax receipts, this led to unprecedented increases in government spending. The result in many countries transformed the financial crisis into a chronic sovereign debt crisis. Annual deficits soared and cumulative debt loads reached unsustainable levels. Aging demographics in some countries compounded the problem, placing impossible demands on social welfare programs and introduced further pressure on government budgets. Combined with an uncertain threat environment, the fiscal crisis makes a compelling case for widespread application of military CBAs to ensure future defense decisions to produce efficient, effective, and accountable security forces.