PART I

Introduction

Chapter 1

Introduction

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1.1 INTRODUCTION

This book is concerned with the economic value of investing in people. A range of types of investments is of interest, for example:

- Investments in work technologies directly augment people's performance.
- Investments in education and training enhance people's potential to perform.
- Investments in health and safety enhance people's availability to perform.
- Investments in organizational processes enhance people's willingness to perform.

Such investments interact, as shown in Figure 1.1, to enable work performance that translates demands for products and services into supply of products and services.

Note that this line of reasoning applies to people who operate, maintain, and manage systems, as well as to those who research, design, and invest in systems. There are many stakeholders in the success of a system. It is likely that investing in the performance of several types of stakeholders can enhance this success. Therefore, for example, investing solely in enhancing the performance of

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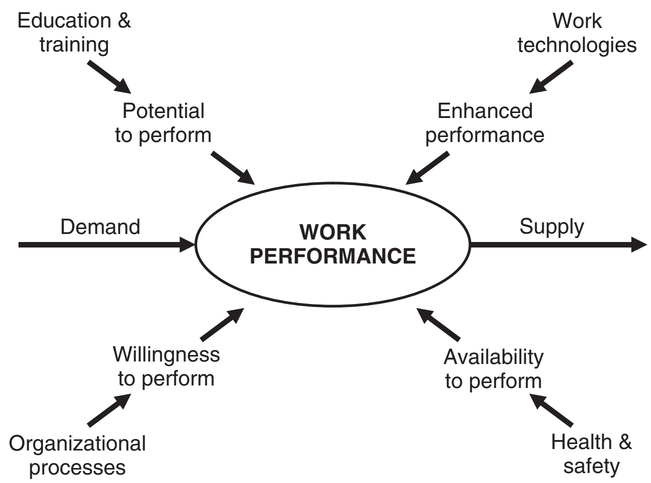

FIGURE 1.1 Examples of investments in people.

aircraft pilots will result in less success than achievable by also investing in aircraft mechanics and, perhaps, in aircraft designers.

Often the monies associated with these types of investments are simply viewed as operating costs. Investments in technologies such as computer workstations or manufacturing equipment usually show up as assets on an enterprise's balance sheet. However, monies spent on education, training, health, and safety usually only appear as expenses on the income statement. Thus, these expenditures may not be viewed as investments at all.

This book focuses on how to attach economic value to the returns provided by these expenditures. The goal is to provide an integrated view of how best to assess and project the economic value of people's performance, potential to perform, availability to perform, and willingness to perform. This involves considering both the costs of these investments and the subsequent economic returns, all over time. This also involves considering the uncertainties associated with these costs and returns.

It is useful to discuss why economic valuation of investments in people is difficult. One reason is the fact that such investments usually do not yield tangible assets—hence, they are absent from the balance sheet. One can inventory computers and equipment. However, it is difficult to "inventory" people's potential or availability to perform. An obvious reason is that one cannot own people, so they may deploy this potential elsewhere. Another complication is the fact that the circumstances may not call on people to perform (e.g., the demand in Figure 1.1 may be less than the work performance that could be supplied). Perhaps consumers will not want automobiles or refrigerators. Perhaps there will not be a war, a fire, or a crime.

Another reason for this difficulty is the typical lack of understanding of how work and work processes relate to value provided for customers or other constituencies. This makes it very difficult for enterprises to transform themselves when the nature of value fundamentally changes in a market (Rouse, 2006). Since the mids 1990s, (Hammer & Champy, 1994; Womack & Jones, 1996), there has been increased emphasis on understanding business processes and their relationships to value. Nevertheless, relatively few enterprises have mastered these skills.

Yet another reason underlying this difficulty is the lack of data upon which to base estimates of costs and returns, often in terms of cost savings. Perhaps surprisingly, organizations that have tendencies to document virtually every activity in their enterprise often have little ability to access this information for the purpose of estimating the parameters in economic models. The U.S. Department of Defense (DoD) is a notable example. The inability to estimate the costs of activities undermines the possibility of validating projected cost savings resulting from investing in people and, consequently, undermines the possibility of attaching value to these savings.

Despite such difficulties, it is very important that we have the methods and tools needed to attach economic value to investments in people. Many would agree with the general statement that a healthy, well-educated, and productive workforce is essential to a country's competitiveness. The question, however, is whether a particular health practice, educational program, or other investment will provide returns that justify the investment of scarce resources. Thus, we are less interested in the need to invest in general than we are in assessing and projecting the value of specific investments.

1.2 HUMAN SYSTEMS INTEGRATION

The issues and questions raised earlier could be addressed from a purely empirical perspective. One could collect data on the costs and returns of education, for example, and calculate an effective return on investment, for instance, for earning a college degree (see Chapters 4 and 5). Indeed, reports of such assessment frequently appear in newspapers and magazines. The general conclusion seems to be that investments in education do provide attractive returns in terms of enhanced incomes.

It this book, however, we are not concerned with investments in general. Instead, we would like to project the returns on investments in specific interventions for particular systems such as airplanes, ships, or factories. We would also like to address tradeoffs across alternative investments. For example, what are the relative returns from investments that directly augment human performance versus those that enhance the potential to perform (Rouse, 2007)? Should we invest scarce resources in a new flight management system or extended pilot training?

This book emphasizes the design, development, deployment, operation, and sustainment of complex systems. We want to engineer such systems so that the humans involved—operators, maintainers, and managers—are effective in performing their roles and in contributing to the value provided by these systems. The word "engineer" is used as a verb defining a set of activities rather than as a noun describing a discipline. Thus, the engineering of a system is perceived as involving many more disciplines than just engineering.

Systems engineering (SE) is the transdisciplinary set of activities that integrates across all the disciplines and activities involved in engineering complex systems. More specifically, "systems engineering is the management technology that controls a total system life-cycle process, which involves and which results in the definition, development, and deployment of a system that is of high quality, is trustworthy, and is cost-effective in meeting user needs" (Sage & Rouse, 2009). As might be imagined, SE involves a wide spectrum of methods, tools, and methodologies that address an enormous range of issues, many of which do not particularly relate to the humans associated with a complex system.

Human systems integration (HSI) is an element of SE that is concerned with understanding, designing, and supporting humans' roles and performance within a complex system. There are a variety of definitions of HSI. They fall into two broad classes (Booher, 1990, 2003; Pew & Mavor, 2007; Salvendy, 2006; INCOSE, 2008; Sage & Rouse, 1999):

One class of definitions focuses on integrating the knowledge, skills, and work outcomes of a range of human-related disciplines into the SE process:

- "HSI is a systems engineering process that integrates the seven technical domains of human factors engineering, manpower, personnel, training, habitability, personnel survivability, and safety/occupational health." (DoD, 2008)
- "HSI is synonymous with the traditional definition of human factors in the broadest sense. HSI adds to this traditional concept of human factors, the emphasis on integration of the individual HSI domains, and the integration of HSI into the acquisition process for emerging systems." (Malone, et al., 2007, p. 1)
- "HSI has come to be defined as the collection of development activities associated with providing the background and data needed for seamless integration of humans into the design process from various perspectives (human factors engineering, manpower, personnel, training, safety and health and, in the military, habitability and survivability) so that human capabilities and needs are considered early and throughout system design and development." (Pew & Mavor, 2007, p. 1)

The second class of definitions emphasizes HSI as a process within the SE process, with much less concern for articulating the distinct contributions of particular disciplines:

- "Human systems integration is primarily a technical and managerial concept, with specific emphasis on methods and technologies that can be utilized to apply the HSI concept to systems integration." (Booher, 1990, 2003, p. 4)
- "HSI is the interdisciplinary technical and management processes for integrating human considerations within and across all system elements." (INCOSE, 2008, p. 7)
- "Human-centered design is a process of assuring that the concerns, values, and perceptions of all stakeholders in a design effort are considered and balanced." (Rouse, 1991, 2007, p. 5)

This book is much more concerned with a process-oriented view of HSI. The seven or eight disciplines typically associated with the discipline-oriented view of HSI certainly represent important contributors to HSI, in particular, and to SE, in general. However, the human abilities, limitations, and inclinations of those who will operate, maintain, and manage the complex system of interest should be the central issues of interest rather than the extent to which these issues fall in the bailiwick of one discipline or another.

In summary, the focus is on the economics of investments in humans in the context of engineering complex systems. To many readers, this would seem to be synonymous with engineering economics (Newman et al., 2008; White et al., 2008). Chapter 7 addresses this field. However, this material is not sufficient when we are concerned with investments in people, in part because of the difficulties elaborated earlier. Furthermore, we need to understand the nature of investments in humans in the organizational contexts where these investments are considered.

1.3 ORGANIZATIONAL CONTEXTS

The two types of organizational context of interest are the system operational context (e.g., commercial airlines vs. military aircraft operations) and the systems engineering context, (e.g., commercial development vs. government procurement). These two types of context have enormous impacts on the ways in which operational value is defined and engineering value is created. Chapter 2, "Industry & Commercial Context," and Chapter 3, "Government & Defense Context," provide in-depth discussions of the ways in which operational and engineering considerations differ in these two domains. In this introductory chapter, the rationale for these distinctions is elaborated. Furthermore, a framework is outlined for characterizing the organizational contexts within which SE and HSI happens. This framework is carried forward into Chapters 2 and 3.

In studying the engineering of systems across many years, an overarching conclusion is that decision-making processes and decision outcomes occur in the context of the overall enterprise that, in turn, operates in a much broader context (Rouse, 2007). As shown in Figure 1.2, the success of an enterprise is both enabled and constrained by the nature of its markets and its internal capabilities to serve these markets, all of which occur in the broader context of the economy, which is increasingly global.

The value of investing in people depends on what an enterprise's markets value. Design, development, deployment (or distribution), and support of high-quality systems, products, and services requires investments that command higher prices than low-cost and/or commodity offerings. Some of these investments are in the people who design, develop, deploy, operate, maintain, and manage these offerings. Inadequate education and training, for example, result in less than high-quality service. Of course, investments could be made in technology that, for instance, enables Web-based self-service.

Thus, there are tradeoffs among alternative investments in people and across investments in other ways to succeed in the marketplace. The ways in which such

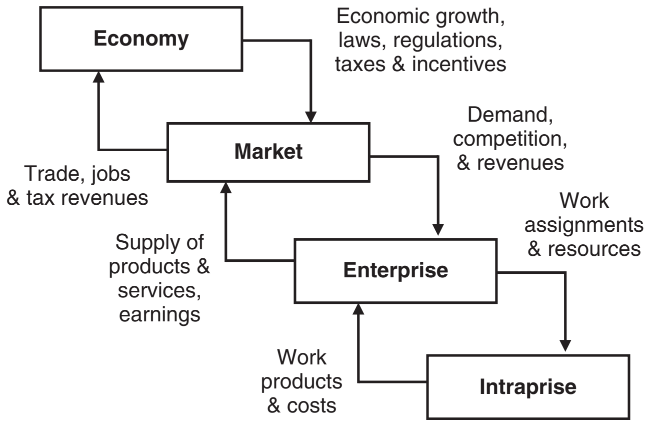

FIGURE 1.2 Context of a typical enterprise (Rouse, 2005).

tradeoffs are formulated and resolved depends, in part, on the nature of the market and, to a great extent, on the nature of the enterprise. As enterprises mature and become more successful, there is a strong tendency to develop "organizational delusions" that hinder approaching new problems in new ways (Rouse, 1998). For example, organizations where one discipline dominates (e.g., aerospace engineering in the aviation industry and electrical engineering in the semiconductor industry) tend to see all problems through these disciplinary lenses regardless of whether such a perspective is warranted.

The U.S. DoD provides a compelling example of how organizational context strongly affects how SE and HSI are pursued. As discussed in later chapters, the Government Accountability Office (GAO) has frequently criticized the DoD for acquiring weapon systems that do not meet performance requirements, far exceed original cost projections, and are deployed long after initial projections. This criticism cuts across ships, aircraft, and other large weapon systems. The GAO has concluded that these deficiencies result from not employing the best systems engineering practices. They also observe that this is not from a lack of knowledge but instead from a lack of will.

Figure 1.3 illustrates the U.S. enterprise for acquiring military ships. Note the large number of stakeholders in shipbuilding, many of whom have interests that go far beyond timely acquisition of high-performing, cost-effective ships. These stakeholders affect the ship-building enterprise in a variety of ways:

- Congressional interests and mandates (e.g., jobs and other economic interests)
- Service interests and oversights (e.g., procedures, documentation, and reviews)
- Incentives and rewards for contractors (e.g., cost-plus vs. firm fixed price)
- Lack of market-based competition (e.g., hiring and retention problems)
- Aging workforce and lack of attraction of jobs (e.g., outsourcing limitations and underutilization of capacity)

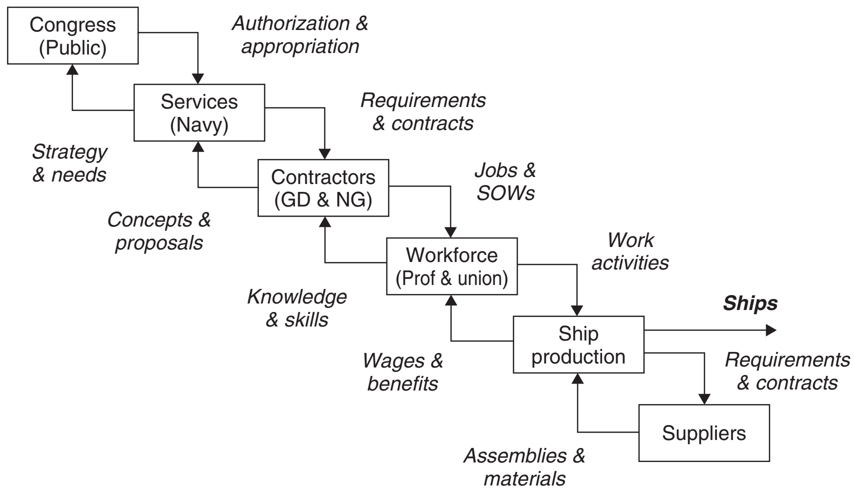

FIGURE 1.3 Enterprise for acquiring military ships (Pennock et al., 2007).

There have, in recent years, been many studies of the best commercial practices with a goal of reducing the costs and time required for military ship production. These initiatives have had positive impacts. However, there are important differences between military and commercial ships (Birkler et al., 2005). For example, the hull of a ship represents a much higher fraction of the value of a commercial ship compared with a military ship where the onboard systems are much more sophisticated.

Nevertheless, the interests of these stakeholders mitigate against acquiring ships faster and cheaper. Key stakeholders have staunchly defended the jobs and profits that would be lost were best practices adopted. Levinson's chronicle of adoption of containerized shipping by the commercial shipping industry provides an excellent illustration of key stakeholders doing their best to thwart fundamental changes (Levinson, 2006). Thus, the reactions of DoD stakeholders to attempts to adopt best SE practices and thereby transform the shipbuilding enterprise are far from unusual.

Organizational context plays an enormous role in the engineering of complex systems. The adoption of best SE and HSI practices is strongly affected by the context. Hence, the ways in which economic value is attributed to investments in people is likely to differ across contexts. The need to understand such differences has led to the following framework for characterizing organizational contexts. These ten questions provide a foundation for developing the economic models needed to assess and project economic value in a particular context:

1. What forces drive the acquisition of new systems?
2. What is the role of competition in providing new systems?
3. How large is the set of potential customers for new systems?
4. How are customers' requirements determined?

5. How are customers' budgets assessed or projected?
6. How large are production runs (i.e., number of units)?
7. How long are system life cycles (i.e., years)?
8. Who takes what risks in the system life cycle?
9. Who gains what rewards in the system life cycle?
10. How are future sales affected by past performance?

These questions are considered in depth in Chapters 2 and 3. Consequently, they are not elaborated here. Suffice it to say that comparing consumer electronics companies (e.g., Apple or Samsung) to defense contractors in shipbuilding (e.g., General Dynamics and Northup Grumman in Figure 1.3) results in very different answers to these ten questions.

Another organizational consideration of importance in this book is the scope of HSI. Adopting a human-centered perspective on this issue (Rouse, 1991, 2007), one quickly comes to the conclusion that HSI is pervasive. Beyond the humans associated with the complex system being acquired, there are the people and organizations that procure, design, and develop the system. Thus, beyond the teams or crews that operate, maintain, and manage the resulting system, there are customer teams that lead requirements definition and engineering teams that design and develop the system. There are also teams of companies that work together to engineer and manufacture the system and, increasingly, international alliances that come together to provide complex systems such as aircraft and automobiles. Human and organizational issues are pervasive among all these types of teams. Consequently, HSI can make contributions at several levels, as illustrated by the many authors who have contributed to this book.

1.4 OVERVIEW OF BOOK

This book is structured as follows. Chapters 1–3 provide the contexts of human systems integration and investment analysis. As is illustrated, context makes an enormous difference in how issues are best framed and analyzed. Chapters 4–7 provide a review of concepts, principles, models, methods, and tools drawn from economics. Chapters 8–11 discuss methods and tools of particular value for addressing the economics of human systems integration. Finally, Chapters 12–16 provide case studies of real-world economic valuations of investments in human systems integration. As emphasized in earlier discussions, all chapters in this book emphasize the monetization of the value of investments in humans. Although the intangible benefits of such investments are recognized, such benefits are not the concern of this book.

1.4.1 Introduction

This chapter sets the stage for this book. The importance of attaching economic value to investments in people is elaborated. Such investments range from work technologies, to education and training, to health and safety, to organizational processes. The reasons why such economic valuations are seldom done are elaborated. Approaches to economic valuation are addressed from the perspective of human systems integration, which is defined as a process within systems engineering. The impact of organizational context on how economic tradeoffs are formulated and resolved is considered, and a framework for characterizing and contrasting organizational contexts is introduced. This framework is employed in several subsequent chapters.

Chapter 2, "Industry and Commercial Context," considers human systems integration issues in the context of industrial organizations that primarily operate outside the aerospace and defense industry. Economic analyses of investment decisions in private versus public sectors are contrasted. A range of contemporary management practices are reviewed, including financial management, the innovation funnel, multistage decision processes, and portfolio management. Best practices are considered in terms of business process orientation, balanced scorecards, and how the "innovator's dilemma" is addressed.

Chapter 3, "Government and Defense Context," considers human systems integration issues in the context of enterprises that primarily operate in the aerospace and defense industry, as either government agencies or government contractors (e.g., defense contractors). The nature of public-sector acquisition is outlined with particular emphasis on defense acquisition. Past attempts at acquisition reform are reviewed. The acquisition enterprise is described in terms of the stakeholders and processes involved, including Congress, the military services, companies, unions, and suppliers. Management practices are reviewed and the extent to which best practices have been adopted is assessed.

1.4.2 Economics Overview

Chapter 4, "Human Capital Economics," provides a brief overview of human capital economics. The central notion is that monies used to train and educate people, as well as to ensure their health and safety, are capital investments rather than just expenditures. The measurement of returns on investments in human capital is discussed, using examples from training and health. The broader concept of human capital management is outlined, including the financial benefits of recognized management practices. Investment valuation is discussed, in terms of both attaching value to the capital created and direct valuation of investments and returns. Alternative investment metrics are reviewed. The notion of value mapping is introduced as a means for tracing process deficiencies and changes to value created. Finally, recognized best practices are summarized. These practices rely on financial models, but they extend well beyond purely monetary considerations.

Chapter 5, "Labor Economics," introduces some of the main questions studied by labor economists, their methodological approach, and some possible links between labor economics and human system integration. More specifically, the chapter discusses "human capital theory," the difference between "partial equilibrium" and "general equilibrium" approaches when considering the link between a system design and operators' skills and the difficulties in applying cost–benefit analysis in the absence of market transactions.

Chapter 6, "Defense Economics," addresses defense as a major user of scarce resources, including personnel and the human capital investments in training military personnel. The military employment contract is a distinctive feature of such training investments. Effectively, this contract "ties" labor to the Armed Forces for a specified period, allowing the Forces to obtain a return on their training investments. But defense spending raises a broader set of questions, namely, its impact on the economy and its labor markets: Are the effects harmful or beneficial? This chapter reviews the research and literature on this topic. The empirical results show all possible relationships, namely, positive, negative, and no relationships between defense spending and growth. A critique of the results and their limitations is presented.

Chapter 7, "Engineering Economics," begins with the observation that complex systems can be very expensive to research, design, develop, and deploy. They are often even more expensive to operate, maintain, sustain, and retire. Overall, 30% to 40% of the life-cycle costs can be associated with the human and organizational aspects of these systems. Upstream investments in human systems integration can yield substantial downstream savings in life-cycle costs. This chapter focuses on engineering economics and the concepts, principles, models, methods, and tools that can support analysis of HSI investments and operating costs. Engineering economics enables a much more rigorous approach to articulating the investment value of HSI than has traditionally been employed.

1.4.3 Models, Methods & Tools

Chapter 8, "Parametric Cost Estimation for Human Systems Integration," provides an approach for estimating the cost of human systems integration through the use of a cost model. As a backdrop, the authors discuss the history of HSI with respect to its role in the acquisition life cycle and its impact on systems engineering effort. They review several types of cost estimation approaches, focusing on the parametric model for systems engineering. To illustrate some of the most relevant cost drivers, they present a case study on HSI practice that highlights the importance of HSI requirements on system engineering effort. Finally, this chapter discusses how those requirements can serve as inputs into a parametric cost estimation model and provides recommendations for professional practice in HSI economics.

Chapter 9, "A Spreadsheet-Based Tool for Simple Cost–Benefit Analyses of HSI Contributions During Software Application Development," considers human systems integration applications that involve providing software applications to individual users to assist them in some aspect of performing their jobs. In this case, the HSI issue may be optimizing the productivity of the trained and experienced user (designing for "ease of use" or efficiency) or optimizing the ability of the new or casual user to get up to speed quickly with or without training (designing for "ease of learning"), or both. The focus of this chapter is to offer and explain a free spreadsheet-based tool to help estimate the potential return on investment

(ROI) in adding HSI resources and activities to an automation development effort or purchase.

Chapter 10, "Multistage Real Options," addresses the many real-world investment opportunities that are not instantaneous, now-or-never transactions but occur over time and present multiple opportunities for course corrections. This is particularly true for technology investments, which tend to be staged to mitigate risk. Traditional investment analysis fails to capture the value that staging provides, and consequently, real options analysis is required to assess appropriately multistage investments. This chapter presents both the theory required to understand real options and the methods used to solve them.

Chapter 11, "Organizational Simulation for Economic Assessment," argues that designing systems with significant levels of human integration involves substantial complexity and uncertainty. This makes economic analysis of such systems difficult. This chapter discusses the use of organizational simulation as a design tool that can aid in economic assessment. Simulation is a method of imitating a system's behavior for purposes of design and analysis. Traditional simulation methods allow for complex modeling and capture the effects of uncertainty and risk. However, they offer limited functionality for modeling human systems integration issues, especially as they relate to organizational phenomena. These phenomena are important especially in analyzing the economics of a system over its life cycle, which may be managed by multiple organizations. Organizational simulation is an emerging method that models organizational effects, processes, value creation, and the role of people. This chapter describes the current work and future directions of organizational simulation as applied to economic assessment of human systems integration.

1.4.4 Case Studies

Chapter 12, "HSI Practices in Program Management: Case Studies of Aegis," provides descriptive case studies that chronicle the operational and engineering processes used to reduce the total ownership cost for microwave tubes and radar phase shifters, components of the AEGIS Combat System, while dramatically improving their operational availability. They capture the program management practices, especially the integrated product teams, used in these processes. The processes used to achieve these results are important to understand in light of the current reductions in various acquisition support resources, including financial support, manpower, and in-house technical expertise. In particular, the cases highlight the role that Naval Warfare Centers and their resident technical staff can and do play in the acquisition process and their supporting engineering disciplines.

Chapter 13, "The Economic Impact of Integrating Ergonomics Within an Automotive Production Facility," notes that the advent of assembly-line systems has dramatically improved production efficiency. However, it often requires employees to perform similar physical activities throughout their workshifts. Because repetitive movements are linked to the development of work-related musculoskeletal disorders, care must be taken to design the human–system interface to minimize this injury risk. The case studies presented in this chapter illustrate how, by applying ergonomics principles to vehicle assembly work, companies cannot only improve employee safety but also significantly reduce production costs. Examples are given at the job level, across a facility's specific production department, and throughout a company as it launches new vehicle models.

Chapter 14, "How Behavioral and Biometric Health Risk Factors Can Predict Medical and Productivity Costs for Employers" begins with the observation that adults spend nearly a quarter of their lives at work. Businesses are beginning to recognize the potential economic benefits of investing in health-promotion and risk-reduction programs at the workplace. Researchers have developed economic models that establish the relationships between modifiable health risk factors among workers and their productivity and health-care use. Employers have developed real-world software applications that leverage research findings from these relationships. Predictive ROI models help employers build a business case for workplace health promotion programs and establish performance metrics for these programs. This chapter reviews existing evidence that supports investments in worksite health promotion and disease prevention programs and highlights two predictive models developed for the Dow Chemical Company and Novartis Pharmaceuticals.

Chapter 15, "Options for Surveillance and Reconnaissance," considers the value of defense investments in the context of a case study conducted for the Singapore Ministry of Defense. The framing of defense investment decisions is elaborated. Alternative investments for surveillance and reconnaissance missions are discussed. Economic valuations of these investments are presented, using both traditional and real options methods and tools. Economic results are integrated into a multiattribute analysis to develop an overall investment strategy. The resulting investment decisions are discussed.

Chapter 16, "Governing Opportunism in International Armaments Collaboration: The Role of Trust," notes that international joint ventures suffer high failure rates, and academic research has placed much of the blame on ungovernable problems of opportunism. Not only do partners sometimes shirk their responsibilities and hold up a given venture—for example, by failing to deliver quality products on time and within budget—but they also engage in "technology poaching" or illicit efforts to procure proprietary knowledge from the other firm(s). Although these problems are difficult enough to manage within a purely domestic setting, they become much more intractable when it comes to operating across borders, where laws and cultural norms may differ between the partner companies, rendering contracts inefficient. A particularly "hard case" where such opportunism is likely to be rife is provided by international armaments cooperation, which is the focus of Chapter 16. The argument made is that if the partners in an international armaments project are able to structure their relationship in such a way as to codevelop a complex weapons system, this suggests important lessons for the governance and management of cross-border joint ventures in high technology more generally. Drawing from behavioral economics, one finds that crucial to an effective partnership is the development of trust mechanisms. It is also suggested, however, that there are some limits associated with trust building in the context of complex international projects and indeed that trust building usually serves as a compliment to a set of strategic policies aimed at reducing the risk of opportunism.

1.5 CONCLUSIONS

The state of the art is such that we know how to attach economic value to investments in people. The concepts, principles, models, methods, and tools are readily available. However, these practices are not frequently employed. There are three overarching reasons.

First, operational costs are seldom tracked at a level that an organization can assess the benefits of enhancing human behavior and performance. Pervasive and integrated enterprise information systems are changing this situation. Thus, the lack of cost data may be less and less a barrier.

Second, investments in people do not appear as assets on balance sheets. As one cannot own people, one cannot own employees' knowledge and skills despite the fact that one may have invested in creating this knowledge and skills these employees now possess. Nevertheless, increasingly the "knowledge capital" of enterprises is their dominant asset. It will, however, probably be quite some time before including such assets on balance sheets will be a generally accepted accounting principle (also known as "GAAP").

Third, we have difficulty accounting for the value of investments where returns will accrue 5, 10, or 20 years in the future. This is particularly the case for public–private enterprises. The U.S. Congress has no balance sheet. All expenditures are operating costs, accounted for, in effect, on the income statement. Substantial savings on the future operating costs of military airplanes, for example, has no value with this approach to financial management. Overcoming this barrier to best practice would involve an enormous cultural change.

So, the good news is that we know how to address the economics of human systems integration. The bad news is that there are significant impedances to employing these means. Consequently, we are likely to continue to underinvest in people's health, education, and productivity. The implications for our long-term competitiveness are, as a result, less than rosy.

REFERENCES

Birkler, J., Rushworth, D., Chiesa, J., Pung, H., Arena, M.V., & Shank, J.F. (2005). *Differences Between Military and Commercial Shipbuilding*. Santa Monica, CA: RAND Corporation.

Booher, H.R. (Ed.). (1990). *MANPRINT: An Approach to Systems Integration*. New York: Van Nostrand Reinhold.

Booher, H.R. (2003). *Handbook of Human Systems Integration*. New York: Wiley.

DoD. (2008). Operation of the Defense Acquisition System. *Defense Directive Number 5000.02*. Washington, DC: Department of Defense, December 2.

Hammer, M., & Champy, J. (1994). *Reengineering the Corporation: A Manifesto for Business Revolution*. New York: Harper Business.

INCOSE. (2008). *Human Systems Integration Working Group Meeting*. Albuquerque, NM.

Levinson, M. (2006). *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton, NJ: Princeton University Press.

Malone, T., Savage-Knepshield, P., & Avery, L. (2007). Human-systems integration: Human factors in a systems context. *Human Factors and Ergonomics Society Bulletin*, December, 1-3.

Newman, D.G., Eschenbach, T.G., & Lavelle, J.P. (2008). *Engineering Economic Analysis* (10^{th} Edition). New York: Oxford University Press.

Pennock, M.J., Rouse, W.B., & Kollar, D.L. (2007). Transforming the acquistion enterprise: A framework for analysis and a case study of ship acquisition. *Systems Engineering*, *10*(2), 99–117.

Pew, R.W., & Mavor, A.S. (2007). *Human-System Integration in the System Development Process*. Washington, DC: National Academies Press.

Rouse, W.B. (1991). *Design for Success: A Human-Centered Approach to Designing Successful Products and Systems*. New York: Wiley.

Rouse, W.B. (1998). *Don't Jump to Solutions: Thirteen Delusions That Undermine Strategic Thinking*. San Francisco, CA Jossey-Bass.

Rouse, W.B. (2005). A theory of enterprise transformation. *Systems Engineering*, *8*(4), 279–295.

Rouse, W.B. (Ed.). (2006). *Enterprise Transformation: Understanding and Enabling Fundamental Change*. New York: Wiley.

Rouse, W.B. (2007). *People and Organizations: Explorations of Human-Centered Design*. New York: Wiley.

Sage, A.P., & Rouse, W.B. (1999). *Handbook of Systems Engineering and Management* (1^{st} Edition). New York: Wiley.

Sage, A.P., & Rouse, W.B. (2009). *Handbook of Systems Engineering and Management* (2^{nd} Edition). New York: Wiley.

Salvendy, G. (2006). *Handbook of Human Factors and Ergonomics*. New York: Wiley.

White, J.A., Case, K.E., & Pratt, D.B. (2008). *Principles of Engineering Economic Analysis* (5^{th} Edition). New York: Wiley.

Womack, J.P., & Jones, D.T. (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Simon & Schuster.