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MANAGEMENT
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Management

管理科学与工程经典教材

Science and Engineering Classics

工程

经济学

Contemporary
Engineering

(英文版·第5版)

Economics (5th Edition)

钱·S·帕克 (Chan S. Park) 著

邵颖红 改编

中国人民大学出版社

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ALWAYS LEARNING



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改编者的话

由钱·S·帕克所著的《工程经济学》一书，深入浅出地介绍了现代工程师必备的工程经济学专业基础知识，内容丰富，逻辑严密，充分运用理工类学生较擅长的数理基础，通过大量的运算实例来阐述理论与方法，非常适合各类工科学生作为工程经济学学习的入门教材。该著作从1993年首版以来，再版4次，及时吸纳了最新研究成果，并随实践和计算手段的演进而不断修订更新，做到与时俱进，长盛不衰，一直被很多高校采用，深受师生欢迎。

艾奥瓦州立大学的戴维·斯莱（David Sly）博士评论说，帕克的这本书强调个人的财务问题，清楚地解释了商业财务问题，以及为什么和什么时候该将其应用到企业当中，所以学生能学得更好。我发现当学生能够联系到自己的状况，而且明白这些金融工具对他们个人的成功非常重要的时候，他们学习工程经济就更有效率了。

确实如此，本书充分体现了学以致用特色，一切以学生为中心，以帮助学生掌握原理和方法为目的。所有章节开篇以当代著名企业的工程经济问题为引例，探讨了很多热点问题，引导读者运用所学知识解决现实世界中的问题。

本书体系完整，教学资料丰富，反映了美国工业和科学发展的最新进展，所以特别引进我国并加以改编，以惠及广大中国学子。读者可配合本书中译本一起阅读，更易于理解和掌握其中内容。

由于原著篇幅较长，本书做了改编。原著第2章介绍美国的财务报表及其分析，与财务管理课程重复，故整章删除，但并不影响全书的体系。其他删改包括：删除了章后小结；仅保留了原著约三分之一的习题；删减了一些较简单的引例；同时，在不影响全书结构的前提下删减了部分图片。尽管本书改编以尽量体现原著的面貌和精神为原则，但不得不做的删减，还是令人有遗珠之憾。

邵颖红

PREFACE*

What is “Contemporary” About Engineering Economics?

Decisions made during the engineering design phase of product development determine the majority of the costs associated with the manufacturing of that product (some say that this value may be as high as 85%). As design and manufacturing processes become more complex, engineers are making decisions that involve money more than ever before. Thus, the competent and successful engineer in the twenty-first century must have an improved understanding of the principles of science, engineering, and economics, coupled with relevant design experience. Increasingly, in the new world economy, successful businesses will rely on engineers with such expertise.

Economic and design issues are inextricably linked in the product/service life cycle. Therefore, one of my strongest motivations for writing this text was to bring the realities of economics and engineering design into the classroom and to help students integrate these issues when contemplating many engineering decisions. Of course my underlying motivation for writing this book was not simply to address contemporary needs, but to address as well the ageless goal of all educators: to help students to learn. Thus, thoroughness, clarity, and accuracy of presentation of essential engineering economics were my aim at every stage in the development of the text.

New to the Fifth Edition

Much of the content has been streamlined to provide materials in depth and to reflect the challenges in contemporary engineering economics. Some of the highlighted changes are as follows:

- All the chapter opening vignettes—a trademark of *Contemporary Engineering Economics*—have been updated or completely replaced with more current and thought-provoking issues. Selection of vignettes reflects the important segment of global economy in terms of variety and scope of business as well. With more than 80% of the total GDP (Gross Domestic Product) in the United States provided by the service sector, engineers work on various economic decision problems in the service sector as well. For this reason, many engineering economic decision problems from the service sector are presented in this 5th edition.
- Excel spreadsheet modeling techniques are incorporated into various economic decision problems to provide many “what-if” solutions to key decision problems.
- All the end-of-chapter problems are revised to reflect the materials changes in the main text. There are a total of 642 problems and 62 short case-study questions. Compared with the previous edition (509 problems and 59 short-case study problems), we have increased the number of questions by 24% by adding 136 new problems. About 40% of end-of-chapter practice problems are either new or updated.
- Added a new appendix on how to prepare for the *Fundamental Engineering Exam* with practice problems and problem-solving strategies.
- A risk simulation tool, Crystal Ball is introduced in Chapter 11 to provide a comprehensive risk analysis modeling scheme to handle project uncertainty.
- Significant content changes have been made in Chapter 12 (Real Options Analysis) to provide a new perspective on how engineers should manage risk in their strategic economic decision problems. In particular, a method of estimating project volatility has been added to make real-option analysis a more practical financial tool in managing the risk involved in long-term projects.
- Some other specific changes in each chapter are summarized as follows:

*已根据改编对相应内容进行了调整。——改编者注

Chapters	New Contents or Improvements
1	<ul style="list-style-type: none"> Revised Section 1.2 by providing the most contemporary issues – Smart Grid Project. Updated Section 1.4 to reflect technological as well as market perception changes in hybrid vehicles.
2	<ul style="list-style-type: none"> Provided Excel financial functions to solve various economic equivalence problems. Revised Section 2.4 with new examples to explore many different unconventional but useful equivalence problems.
3	<ul style="list-style-type: none"> Revised Section 3.5.3 to reflect various home mortgage financing options.
4	<ul style="list-style-type: none"> Introduced a project balance concept in Section 4.3.
5	<ul style="list-style-type: none"> Introduced Excel presentation of life-cycle-cost analysis.
6	<ul style="list-style-type: none"> Revised Section 6.3.4 (Decision Rule for Mixed Investment) to give a clear understanding on the issue of multiple-rates of return problems. Introduced Excel modeling to calculate the return on invested capital.
7	<ul style="list-style-type: none"> Created a new section on Cost-Volume-Profit Analysis (Section 7.3.3) Updated all data related to cost of owning and operating a vehicle.
8	<ul style="list-style-type: none"> Updated tax information.
9	<ul style="list-style-type: none"> Generated all cash flow statement tables by using Excel. Revised Section 9.4.3 (Lease-or-Buy Decision) to provide better understanding of various economic issues related to these outsourcing decisions in the real world.
10	<ul style="list-style-type: none"> Updated all data related to consumer price index as well as other cost data to reflect the current trend in inflation as well as deflation in various economic sectors. Generated all cash flow statements by using Excel.
11	<ul style="list-style-type: none"> Provided a procedure conducting “what if” analysis using Excel. Replaced @RISK with Crystal Ball in modeling a complex risk analysis decision problem.
12	<ul style="list-style-type: none"> Most significant content changes in terms of pedagogical aspect of presentation, by providing many graphical illustrations to explain complicate conceptual financial as well as real option problems. Created a new section on how to estimate project volatility (Section 12.6).
13	<ul style="list-style-type: none"> Adopted Excel modeling techniques to solve various replacement decision problems.
14	<ul style="list-style-type: none"> Streamlined the presentation.
15	<ul style="list-style-type: none"> Revised Section 15.2 on Economic Analysis on Healthcare Service to improve the pedagogical aspect of presentation. Provide a new detailed case example on cost-benefit-analysis.
Appendix	<ul style="list-style-type: none"> Appendix B: A new table on normal distribution function.

Overview of the Text

Although it contains little advanced math and few truly difficult concepts, the introductory engineering economics course is often a curiously challenging one for the sophomores, juniors, and seniors who take it. There are several likely explanations for this difficulty.

1. The course is the student’s first analytical consideration of money (a resource with which he or she may have had little direct contact beyond paying for tuition, housing, food, and textbooks).
2. The emphasis on theory may obscure for the student the fact that the course aims, among other things, to develop a very practical set of analytical tools for measuring project worth. This is unfortunate since, at one time or another, virtually every

engineer—not to mention every individual—is responsible for the wise allocation of limited financial resources.

3. The mixture of industrial, civil, mechanical, electrical, and manufacturing engineering, and other undergraduates who take the course often fail to “see themselves” in the skills the course and text are intended to foster. This is perhaps less true for industrial engineering students, whom many texts take as their primary audience, but other disciplines are often motivationally shortchanged by a text’s lack of applications that appeal directly to them.

Goal of the Text

This text aims not only to provide sound and comprehensive coverage of the concepts of engineering economics but also to address the difficulties of students outlined above, all of which have their basis in inattentiveness to the practical concerns of engineering economics. More specifically, this text has the following chief goals:

1. To build a thorough understanding of the theoretical and conceptual basis upon which the practice of financial project analysis is built.
2. To satisfy the very practical needs of the engineer toward making informed financial decisions when acting as a team member or project manager for an engineering project.
3. To incorporate all critical decision-making tools—including the most contemporary, computer-oriented ones that engineers bring to the task of making informed financial decisions.
4. To appeal to the full range of engineering disciplines for which this course is often required: industrial, civil, mechanical, electrical, computer, aerospace, chemical, and manufacturing engineering, as well as engineering technology.

Prerequisites

The text is intended for undergraduate engineering students at the sophomore level or above. The only mathematical background required is elementary calculus. For Chapters 11 and 12, a first course in probability or statistics is helpful but not necessary, since the treatment of basic topics there is essentially self-contained.

Taking Advantage of the Internet

The integration of computer use is another important feature of *Contemporary Engineering Economics*. Students have greater access to and familiarity with the various spreadsheet tools, and instructors have greater inclination either to treat these topics explicitly in the course or to encourage students to experiment independently.

A remaining concern is that the use of computers will undermine true understanding of course concepts. This text does not promote the use of trivial spreadsheet applications as a replacement for genuine understanding of and skill in applying traditional solution methods. Rather, it focuses on the computer’s productivity-enhancing benefits for complex project cash flow development and analysis. For spreadsheet coverage, the emphasis is on demonstrating a chapter concept that embodies some complexity that can be much more efficiently resolved on a computer than by traditional longhand solutions.

Resources for Instructors

Instructors have access online to all available resources. The following resources are available to instructors who adopt this textbook:

- TestGen, a test generator program that enables instructors to easily create paper or

- online quizzes and tests.
- Excel files of selected example problems from the text as well as end-of-chapter problems
- Instructor's Solutions Manual in both WORD and PDF version.
- PowerPoint lecture notes with live Excel file links

Resources for Students

The following resources are available for students:

- Pearson e-Text a complete on-line version of the book that includes highlighting, note-taking and search capabilities and access to the Excel media files which accompany this text (all Excel examples in the book) as well as additional student study resources. All end-of-chapter problems with asterisks (*) indicate the availability of some form of Excel template.
- FE Review problems by chapter
- **Analysis Tools from the book website:** A collection of various financial calculators is available through the book website at <http://www.pearsonhighered.com/park>. Cash Flow Analyzer is an integrated online Java program that is menu driven for convenience and flexibility; it provides (1) a flexible and easy-to-use cash flow editor for data input and modifications, and (2) an extensive array of computational modules and user-selected graphic outputs.

CHAN S. PARK
AUBURN, ALABAMA

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PART ONE

BASICS OF FINANCIAL DECISIONS

The Role of Engineers in Business

John R. Papp, Engineer, Motorola Corporation, and Sanjit Misra, Sr. Director, IBM Research, have a number of years of experience in the field of business. They are also authors of several books on business and engineering. This book is a practical guide for engineers who are interested in starting their own business or who are currently employed in a business. It covers the basics of business, from the legal aspects of starting a business to the financial aspects of running a business. The book is written in a clear and concise style, making it easy to read and understand. It is a valuable resource for any engineer who is considering starting a business or who is currently employed in a business.

1.1 Types of Business Organization

The three basic forms of business organization are sole proprietorship, partnership, and corporation. Each form has its own advantages and disadvantages. The choice of which form to use depends on the nature of the business and the preferences of the owner(s).

Proprietorship

A proprietorship is a business owned by one individual. The owner is responsible for all aspects of the business, including the financial aspects. This form of organization is the simplest and least expensive to set up. However, the owner is also responsible for all of the risks of the business. If the business fails, the owner is personally liable for all of the debts of the business. This form of organization is best suited for small businesses that are not expected to grow significantly.

Engineering Economic Decisions

CHAPTER LEARNING OBJECTIVES

After completing this chapter, you should understand the following concepts:

- The role of engineers in business.
- Types of business organization.
- The nature and types of engineering economic decisions.
- What makes the engineering economic decisions difficult.
- How a typical engineering project idea evolves in business.
- Fundamental principles of engineering economics.

1.1 Role of Engineers in Business

Yahoo, Apple Computer, Microsoft Corporation, and Sun Microsystems produce computer products and have a market value of several billion dollars each. These companies were all started by young college students with technical backgrounds. When they went into the computer business, these students initially organized their companies as proprietorships. As the businesses grew, they became partnerships and were eventually converted to corporations. This chapter begins by introducing the three primary forms of business organization and briefly discusses the role of engineers in business.

1.1.1 Types of Business Organization

The three legal forms of business, each having certain advantages and disadvantages, are proprietorships, partnerships, and corporations.

Proprietorships

A **proprietorship** is a business owned by one individual. This person is responsible for the firm's policies, owns all its assets, and is personally liable for its debts. A proprietorship has two major advantages. First, it can be formed easily and inexpensively. No legal and organizational requirements are associated with setting up a proprietorship, and organizational costs are therefore virtually nil. Second, the earnings of a proprietorship are

taxed at the owner's personal tax rate, which may be lower than the rate at which corporate income is taxed. Apart from personal liability considerations, the major disadvantage of a proprietorship is that it cannot issue stocks and bonds, making it difficult to raise capital for any business expansion.

Partnerships

A **partnership** is similar to a proprietorship, except that it has more than one owner. Most partnerships are established by a written contract between the partners. The contract normally specifies salaries, contributions to capital, and the distribution of profits and losses. A partnership has many advantages, among which are its low cost and ease of formation. Because more than one person makes contributions, a partnership typically has a larger amount of capital available for business use. Since the personal assets of all the partners stand behind the business, a partnership can borrow money more easily from a bank. Each partner pays only personal income tax on his or her share of a partnership's taxable income.

On the negative side, under partnership law, each partner is liable for a business's debts. This means that the partners must risk all their personal assets—even those not invested in the business. And while each partner is responsible for his or her portion of the debts in the event of bankruptcy, if any partners cannot meet their pro rata claims, the remaining partners must take over the unresolved claims. Finally, a partnership has a limited life, insofar as it must be dissolved and reorganized if one of the partners quits.

Corporations

A **corporation** is a legal entity created under provincial or federal law. It is separate from its owners and managers. This separation gives the corporation four major advantages:

1. It can raise capital from a large number of investors by issuing stocks and bonds.
2. It permits easy transfer of ownership interest by trading shares of stock.
3. It allows limited liability—personal liability is limited to the amount of the individual's investment in the business.
4. It is taxed differently than proprietorships and partnerships, and under certain conditions, the tax laws favor corporations. On the negative side, it is expensive to establish a corporation. Furthermore, a corporation is subject to numerous governmental requirements and regulations.

As a firm grows, it may need to change its legal form, because the form of a business affects the extent to which it has control of its own operations and its ability to acquire funds. The legal form of an organization also affects the risk borne by its owners in case of bankruptcy and the manner in which the firm is taxed. Apple Computer, for example, started out as a two-man garage operation. As the business grew, the owners felt constricted by this form of organization: It was difficult to raise capital for business expansion; they felt that the risk of bankruptcy was too high to bear; and as their business income grew, their tax burden grew as well. Eventually, they found it necessary to convert the partnership into a corporation.

In the United States, the overwhelming majority of business firms are proprietorships, followed by corporations and partnerships. However, in terms of total business volume (dollars of sales), the quantity of business transacted by proprietorships and partnerships is several times less than that of corporations. Since most business is conducted by corporations, this text will generally address economic decisions encountered in that form of ownership.

1.1.2 Engineering Economic Decisions

What role do engineers play within a firm? What specific tasks are assigned to the engineering staff, and what tools and techniques are available to it to improve a firm's profits? Engineers are called upon to participate in a variety of decisions, ranging from manufacturing, through marketing, to financing decisions. We will restrict our focus, however, to

various economic decisions related to engineering projects. We refer to these decisions as **engineering economic decisions**.

In manufacturing, engineering is involved in every detail of a product's production, from conceptual design to shipping. In fact, engineering decisions account for the majority (some say 85%) of product costs. Engineers must consider the effective use of capital assets such as buildings and machinery. One of the engineer's primary tasks is to plan for the acquisition of equipment (**capital expenditure**) that will enable the firm to design and produce products economically.

With the purchase of any fixed asset—equipment, for instance—we need to estimate the profits (more precisely, cash flows) that the asset will generate during its period of service. In other words, we have to make capital expenditure decisions based on predictions about the future. Suppose, for example, you are considering the purchase of a deburring machine to meet the anticipated demand for hubs and sleeves used in the production of gear couplings. You expect the machine to last 10 years. This decision thus involves an implicit 10-year sales forecast for the gear couplings, which means that a long waiting period will be required before you will know whether the purchase was justified.

An inaccurate estimate of the need for assets can have serious consequences. If you invest too much in assets, you incur unnecessarily heavy expenses. Spending too little on fixed assets, however, is also harmful, for then the firm's equipment may be too obsolete to produce products competitively, and without an adequate capacity, you may lose a portion of your market share to rival firms. Regaining lost customers involves heavy marketing expenses and may even require price reductions or product improvements, both of which are costly.

1.1.3 Personal Economic Decisions

In the same way that an engineer can play a role in the effective utilization of corporate financial assets, each of us is responsible for managing our personal financial affairs. After we have paid for nondiscretionary or essential needs, such as housing, food, clothing, and transportation, any remaining money is available for discretionary expenditures on items such as entertainment, travel, and investment. For money we choose to invest, we want to maximize the economic benefit at some acceptable risk. The investment choices are unlimited and include savings accounts, guaranteed investment certificates, stocks, bonds, mutual funds, registered retirement savings plans, rental properties, land, business ownership, and more.

How do you choose? The analysis of one's personal investment opportunities utilizes the same techniques that are used for engineering economic decisions. Again, the challenge is predicting the performance of an investment into the future. Choosing wisely can be very rewarding, while choosing poorly can be disastrous. Some investors in the energy stock Enron who sold prior to the fraud investigation became millionaires. Others, who did not sell, lost everything.

A wise investment strategy is a strategy that manages risk by diversifying investments. With such an approach, you have a number of different investments ranging from very low to very high risk and are in a variety of business sectors. Since you do not have all your money in one place, the risk of losing everything is significantly reduced.

1.2 What Makes the Engineering Economic Decision Difficult?

The economic decisions that engineers make in business differ very little from the financial decisions made by individuals, except for the scale of the concern. Suppose, for example, that a firm is using a lathe that was purchased 12 years ago to produce pump shafts. As the production engineer in charge of this product, you expect demand to con-