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BUSINESS ADMINISTRATION CLASSICS

Business Administration Classics

工商管理经典教材·核心课系列

数据、模型与决策

(英文版·第4版)

STATISTICS, DATA ANALYSIS, AND DECISION MODELING

(Fourth Edition)

詹姆斯·R·埃文斯（James R. Evans） 著

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总　序

随着我国加入WTO，越来越多的国内企业参与到国际竞争中来，用国际上通用的语言思考、工作、交流的能力也越来越受到重视。这样一种能力也成为我国各类人才参与竞争的一种有效工具。国家教育机构、各类院校以及一些主要的教材出版单位一直在思考，如何顺应这一发展潮流，推动各层次人员通过学习来获取这种能力。双语教学就是这种背景下的一种尝试。

双语教学在我国主要指汉语和国际通用的英语教学。事实上，双语教学在我国教育界已经不是一个陌生的词汇了，以双语教学为主的科研课题也已列入国家“十五”规划的重点课题。但从另一方面来看，双语教学从其诞生的那天起就被包围在人们的赞成与反对声中。如今，依然是有人赞成有人反对，但不论是赞成居多还是反对占上，双语教学的规模和影响都在原有的基础上不断扩大，且呈大发展之势。一些率先进行双语教学的院校在实践中积累了经验，不断加以改进；一些待进入者也在模仿中学习，并静待时机成熟时加入这一行列。由于我国长期缺乏讲第二语言（包括英语）的环境，开展双语教学面临特殊的困难，因此，选用合适的教材就成为双语教学成功与否的一个重要问题。我们认为，双语教学从一开始就应该使用原版的各类学科的教材，而不是由本土教师自编的教材，从而可以避免中国式英语问题，保证语言的原汁原味。各院校除应执行国家颁布的教学大纲和课程标准外，还应根据双语教学的特点和需要，适当调整教学课时的设置，合理选择优秀的、合适的双语教材。

顺应这样一种大的教育发展趋势，中国人民大学出版社同众多国际知名的大出版公司，如麦格劳-希尔出版公司、培生教育出版公司等合作，面向大学本科生层次，遴选了一批国外最优秀的管理类原版教材，涉及专业基础课，人力资源管理、市场营销及国际化管理等专业方向课，并广泛听取有着丰富的双语一线教学经验的教师的建议和意见，对原版教材进行了适当的改编，删减了一些不适合我国国情和不适合教学的内容；另一方面，根据教育部对双语教学教材篇幅合理、定价低的要求，我们更是努力区别于目前市场上形形色色的各类英文版、英文影印版的大部头，将目标受众锁定在大学本科生层次。本套教材尤其突出了以下一些特点：

● 保持英文原版教材的特色。本套双语教材根据国内教学实际需要，对原书进行了一定的改编，主要是删减了一些不适合教学以及不符合我国国情的内容，但在体系结构和内容特色方面都保持了原版教材的风貌。专家们的认真改编和审定，使本套教材既保持了学术上的完整性，又贴近中国实际；既方便教师教学，又方便学生理解和掌握。

● 突出管理类专业教材的实用性。本套教材既强调学术的基础性，又兼顾应用的广泛性；既侧重让学生掌握基本的理论知识、专业术语和专业表达方式，又考虑到教材和管理实践的紧密结合，有助于学生形成专业的思维能力，培养实际的管理技能。

● 体系经过精心组织。本套教材在体系架构上充分考虑到当前我国在本科教育阶段推广双语教学的进度安排，首先针对那些课程内容国际化程度较高的学科进行双语教材开发，在其专业模块内精心选择各专业教材。这种安排既有利于我国教师摸索双语教学的经验，使得双语教学贴近现实教学的需要；也有利于我们收集关于双语教学教材的建议，更好地推出后续的双语教材及教辅材料。

● 篇幅合理，价格相对较低。为适应国内双语教学内容和课时上的实际需要，本套教材进行了一定的删减和改编，使总体篇幅更为合理；而采取低定价，则充分考虑到了学生实际的购买能力，从而使本套教材得以真正走近广大读者。

● 提供强大的教学支持。依托国际大出版公司的力量，本套教材为教师提供了配套的教辅材料，如教师手册、PowerPoint 讲义、试题库等，并配有内容极为丰富的网络资源，从而使教学更为便利。

本套教材是在双语教学教材出版方面的一种尝试。我们在选书、改编及出版的过程中得到了国内许多高校的专家、教师的支持和指导，在此深表谢意。同时，为使我们后续推出的教材更适于教学，我们也真诚地期待广大读者提出宝贵的意见和建议。需要说明的是，尽管我们在改编的过程中已加以注意，但由于各教材的作者所处的政治、经济和文化背景不同，书中内容仍可能有不妥之处，望读者在阅读时注意比较和甄别。

徐二明
中国人民大学商学院

PREFACE*

INTENDED AUDIENCE

Statistics, Data Analysis, and Decision Modeling was written to meet the need for an introductory text that provides a basic introduction to business statistics and decision models/optimization, focusing on practical applications of data analysis and decision modeling, all presented in a simple and straightforward fashion.

The text consists of 14 chapters in two distinct parts. The first eight chapters deal with statistical and data analysis topics, while the remaining chapters deal with decision models and applications. Thus, the text may be used for:

- MBA or undergraduate business programs that combine topics in business statistics and management science into a single, brief, quantitative methods course.
- Business programs that teach statistics and management science in short, modular courses.
- Executive MBA programs.
- Graduate refresher courses for business statistics and management science.

SUBSTANCE

The danger in using quantitative methods does not generally lie in the inability to perform the requisite calculations, but rather in the lack of a fundamental understanding of why to use a procedure, how to use it correctly, and how to properly interpret results. The principal focus of this text is conceptual understanding using simple and practical examples rather than a plug-and-chug or point-and-click mentality, as are often done in other texts, supplemented by appropriate theory. On the other hand, the text does not attempt to be an encyclopedia of detailed quantitative procedures, but focuses in on useful concepts and tools for today's managers.

To support the presentation of topics in business statistics and decision modeling, this text integrates fundamental theory and practical applications in a spreadsheet environment using *Microsoft Excel 2007* and various spreadsheet add-ins, specifically:

- *PHStat,* a collection of statistical tools that enhance the capabilities of Excel; published by Pearson Education.
- A time limited professional version of *Crystal Ball* (including *CBPredictor* for forecasting and *OptQuest* for optimization), the most popular commercial package for risk analysis.
- *TreePlan,* a decision analysis add-in.
- *SimQuick,* an Excel-based application for process simulation, published by Pearson Education.
- *Premium Solver,* a more powerful version of Excel's Solver.

These tools have been integrated throughout the text to simplify the presentations and implement tools and calculations so that more focus can be placed on interpretation and understanding the managerial implications of results. However, as not to disrupt the flow of the text discussion and distract from conceptual understanding, we have placed boxed "Notes" for Excel, *PHStat,* and other add-ins that provide procedural details of using specific functions, tools, or techniques where appropriate.

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* 适应国内双语教学的需要，影印版删除了原著的第 8 章 "统计质量控制"，为保留原书概貌，未对前言作任何删减。有需要了解相关内容的读者可参阅中国人民大学出版社出版的翻译版。

New to This Edition

The fourth edition of this text has been substantially re-written to improve clarity and pedagogical features. Many significant changes have been made in this edition. These changes include the following.

1. Spreadsheet-based tools and applications are now compatible with *Microsoft Excel 2007*, which is used throughout this edition.
2. Every chapter has been carefully revised to improve clarity of the material. Many explanations of critical concepts have been enhanced using new business examples and data sets.
3. Key decision modeling chapters in Part 2 of this book have been significantly revised and reorganized. These are Chapter 9–*Building and Using Decision Models*, Chapter 13–*Linear Optimization*, and Chapter 14–*Integer and Nonlinear Optimization*.
4. Theory and extensive computational formulas have been relegated to end of chapter Appendixes to provide better flexibility for instructors, and not impede learning essential concepts and skills.
5. End-of-chapter material has been enhanced and reorganized to include *Basic Concepts Review Questions* that focus on the understanding of fundamental terms concepts; *Skill-Building Exercises* that facilitate experiential learning and Excel-based skills, and *Problems and Applications*, which provide a wide variety of numerical exercises and practical applications to real and/or realistic data sets or problem scenarios. New cases are introduced in most chapters.

To the Students

The CD-ROM accompanying this text contains all the data and model files used throughout the text in examples, problems, and exercises.* These are also available on the text's Web site, www.pearsonhighered.com/evans. Versions of a variety of software packages, including *PHStat*, *SimQuick*, *Crystal Ball*, and *Premium Solver*, are also available in connection with this text. For complete information on these, please also visit www.pearsonhighered.com/evans.

To the Instructors

To access instructor solutions files please visit pearsonhighered.com/evans and choose the instructor resources option. A variety of instructor resources are available for instructors who register for our secure environment. The files for each chapter, including PowerPoint presentations, are available for download.

As a registered faculty member, you can login directly to download resource files, and receive immediate access and instructions for installing Course Management content to your campus server.

Need help? Our dedicated Technical Support team is ready to assist instructors with questions about the media supplements that accompany this text. Visit: http://247.pearsoned.com/ for answers to frequently asked questions and toll-free user support phone numbers.

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* 原著配有一张光盘，影印版将光盘内容放在中国人民大学出版社工商管理分社网站（www.rdjg.com.cn）上。

简明目录

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Chapter 1

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INTRODUCTION

A phrase one often hears in many companies today is, "In God we trust; all others use data." Modern organizations truly manage by fact—they depend on complete and accurate data for performance evaluation, improvement, and decision making. However, many organizations ignore the most important data they need to make good decisions. This may occur for several reasons:

- *They may not fully understand what to measure or how to measure.*
- *They may be reluctant to spend the required time and effort.*
- *They may feel they can make decisions by instinct and do not need data.*
- *They may fear discovering problems or poor performance that data may uncover.*

Even if organizations do gather data, they may not interpret them properly.

Information derives from analysis of data. *Analysis* refers to extracting larger meaning from data to support evaluation and decision making. One of the most important tools for analyzing data in business is **statistics**, which is the science of *collecting, organizing, analyzing, interpreting,* and *presenting* data. Modern spreadsheet technology, such as Microsoft Excel, has made it quite easy to organize, analyze, and present data.

Data also provide key inputs to decision models. A **decision model** is a logical or mathematical representation of a problem or business situation. Decision models establish relationships between actions that decision makers might take and results that they might expect, thereby allowing the decision makers to predict what might happen based on the model assumptions. For instance, the manager of a grocery store might want to know how best to use price promotions, coupon programs, and advertising to increase sales. In the past, grocers have studied the relationship of sales volume to programs such as these by conducting controlled experiments to identify the relationship between actions and sales volumes.[1] That is, they implement different combinations of price promotions, coupon programs, and advertising (the decision variables) then observe

the sales that result. Using the data from these experiments and a statistical technique known as *regression analysis* (which we cover in Chapter 6), we can develop a predictive model of sales as a function of the decision variables. Such a model might look like the following:

$$\text{Sales} = a + b \times \text{Price} + c \times \text{Coupons} + d \times \text{Advertising} + e \times \text{Price} \times \text{Advertising}$$

where *a, b, c, d,* and *e* are constants that are estimated from the data. By setting levels for price, coupons, and advertising, the model estimates a level of sales. The manager can use the model to identify effective pricing, promotion, and advertising strategies.

Statistics and data analysis have long been critical to business decisions, but they are becoming more important as an increasing amount of electronic information becomes available. These techniques help managers determine trends, projections, cause-and-effect relationships, and other significant meanings of data that might not be evident. The purpose of this book is to introduce you to practical approaches for analyzing data; ways of using data effectively to make informed decisions; and approaches for developing, analyzing, and solving models of decision problems. Part I of this book (Chapters 1–7) focuses on key issues of statistics and data analysis, and Part II (Chapters 8–13) introduces you to various types of decision models that rely on good data analysis.

In this chapter, we discuss the roles of data analysis in business, discuss how data are used in evaluating business performance, introduce some fundamental issues of statistics and measurement, and introduce spreadsheets as a support tool for data analysis and decision modeling. The key concepts we will discuss are the following:

- *The importance of statistical thinking in business*
- *The importance of statistics in Six Sigma, which has become a widely accepted approach to business performance improvement*
- *The scope of business performance data and the concept of a "balanced scorecard," as well as the use of data outside the business environment*
- *The role of statistics in using sample data to understand and draw inferences about populations and monitor the effectiveness of business processes*
- *Classification of data and common types of measurement scales*
- *Basic Microsoft Excel skills and add-ins that are supplied with this book*
- *Using PivotTables to manipulate data*

Statistical Thinking in Business

The importance of applying statistical concepts to make good business decisions and improve performance cannot be overemphasized. **Statistical thinking** is a philosophy of learning and action for improvement that is based on the principles that

- all work occurs in a system of interconnected processes;
- variation exists in all processes; and
- understanding and reducing variation are keys to success.[2]

Work gets done in any organization through **processes**—systematic ways of doing things that achieve desired results. Understanding processes provides the con-

text for determining the effects of variation and the proper type of action to be taken. Any process contains many sources of variation. In manufacturing, for example, different lots of material vary in strength, thickness, or moisture content. Cutting tools have inherent variation in their strength and composition. During manufacturing, tools experience wear, vibrations cause changes in machine settings, and electrical fluctuations cause variations in power. Workers may not position parts on fixtures consistently, and physical and emotional stress may affect workers' consistency. In addition, measurement gauges and human inspection capabilities are not uniform, resulting in variation in measurements even when the true value is constant. The complex interactions of these variations in materials, tools, equipment, people, and the environment are not easily understood and are often referred to as *common causes* of variation. Other variations, which we generally call *special causes,* arise from external sources that are not inherent in the process. Some factors that lead to special causes in manufacturing are a bad batch of material from a supplier, a poorly trained substitute machine operator, a broken or worn tool, or miscalibration of measuring instruments. These typically result in unusual variations that disrupt the statistical pattern of common causes. Similar phenomena occur in service processes because of variation in employee and customer behavior, application of technology, and so on.

While variation exists everywhere, many business decisions do not often account for it, and managers frequently confuse common and special causes of variation and try to take action to eliminate a perceived special cause when it in fact is simply common cause variation. For example, if sales in some region fell from the previous year, the regional manager might quickly blame her sales staff for not working hard. If a new advertising campaign happens to coincide with a drop in sales, some managers would quickly drop the ad campaign without any further analysis. How often do managers make decisions based on a single data point or two, seeing trends when they don't exist, or manipulate financial figures they cannot truly control? Usually, it is simply a matter of ignorance of how to deal with data and information. A better approach would be to formulate a theory ("Certain ad campaigns positively affect sales") and test this theory in some way, either by collecting and analyzing some data ("Measure change in sales when advertising is adopted") and perhaps developing a model of the situation that will provide better insight ("When advertising is increased by 10%, sales increase by 15%"). Using statistical thinking in this fashion can provide much better insight into the facts and nature of relationships among the many factors that may have contributed to the event and enable managers to make better decisions.

The lack of broad and sustained use of statistical thinking in many organizations is due to two reasons.[3] First, statisticians historically have functioned as problem solvers in manufacturing, research, and development and, thereby, have focused on individual clients rather than on organizations. Second, statisticians have focused primarily on technical aspects of statistics rather than emphasizing process definition, measurement, control, and improvement—the key activities that will lead to bottom-line results. Today, many organizations, including General Electric (GE), Ford Motor Company, numerous healthcare organizations, and many others, are implementing "Six Sigma" initiatives and training all employees in statistical thinking and other problem-solving tools and techniques to improve organizational effectiveness and financial performance.

Six Sigma and Statistical Thinking[4]

Six Sigma can be best described as a business process improvement approach that seeks to find and eliminate causes of defects and errors, reduce cycle times and cost of operations, improve productivity, better meet customer expectations, and achieve higher asset use and returns on investment in manufacturing and service processes. It is based on a simple problem-solving methodology—**DMAIC**, which stands for Define, Measure, Analyze, Improve, and Control—that incorporates a wide variety

of statistical and other types of process improvement tools.

Six Sigma is appealing to top executives because of its focus on measurable bottom-line results; a disciplined, fact-based approach to problem solving; and rapid project completion. Motorola pioneered the concept as an approach to measuring product and service quality, and it has garnered significant credibility over the past decade because of its acceptance at such major firms as Allied Signal (now part of Honeywell) and GE. The term *six sigma* is actually based on a statistical measure that equates to 3.4 or fewer errors or defects per million opportunities. An ultimate "stretch" goal of all organizations that adopt a Six Sigma philosophy is to have all critical processes, regardless of functional area, at a six-sigma level of capability.

Considerable evidence exists that Six Sigma initiatives positively impact bottom-line results. In the first year of Six Sigma implementation at GE, they trained 30,000 employees at a cost of $200 million and got back about $150 million in savings. From 1996 to 1997, GE increased the number of Six Sigma projects from 3,000 to 6,000 and achieved $320 million in productivity gains and profits. By 1998, the company had generated $750 million in Six Sigma savings over and above their investment, and would receive $1.5 billion in savings the next year.

GE had many early success stories. GE Capital, for example, fielded about 300,000 calls each year from mortgage customers who had to use voicemail or call back 24% of the time because employees were busy or unavailable. A Six Sigma team analyzed one branch that had a near perfect percentage of answered calls and applied their best practices to the other 41 branches, resulting in a 99.9% chance of customers' getting a representative on the first try. A team at GE Plastics improved the quality of a product used in CD-ROMs and audio CDs from a 3.8 sigma level to 5.7 level and captured a significant amount of new business from Sony.[5] GE credits Six Sigma with a tenfold increase in the life of CT scanner X-ray tubes, a 400% improvement in return on investment in its industrial diamond business, a 62% reduction in turnaround time at railcar repair shops, and $400 million in savings in its plastics business.[6]

Six Sigma has heightened the awareness of statistics among business professionals, and the material in this book will provide the foundation for more advanced topics commonly found in Six Sigma training courses in many organizations.

Data in the Business Environment

An example from the Boeing Company shows the value of having good business data and analysis capabilities.[7] In the early 1990s, Boeing's assembly lines were morasses of inefficiency. A manual numbering system dating back to World War II bomber days was used to keep track of an airplane's four million parts and 170 miles of wiring; changing a part on a 737's landing gear meant renumbering 464 pages of drawings. Factory floors were covered with huge tubs of spare parts worth millions of dollars. In an attempt to grab market share from rival Airbus, the company discounted planes deeply and was buried by an onslaught of orders. The attempt to double production rates, coupled with implementation of a new production control system, resulted in Boeing being forced to shut down its 737 and 747 lines for 27 days in October 1997, leading to a $178 million loss and a shakeup of top management. Much of the blame was focused on Boeing's financial practices and lack of real-time financial data. With a new Chief Financial Officer and finance team, the company created a "control panel" of vital measures, such as materials costs, inventory turns, overtime, and defects, using a color-coded spreadsheet. For the first time, Boeing was able to generate a series of bar charts showing which of its programs were creating value and which were destroying it. The results were eye-opening and helped formulate a growth plan. As one manager noted, "The data will set you free."