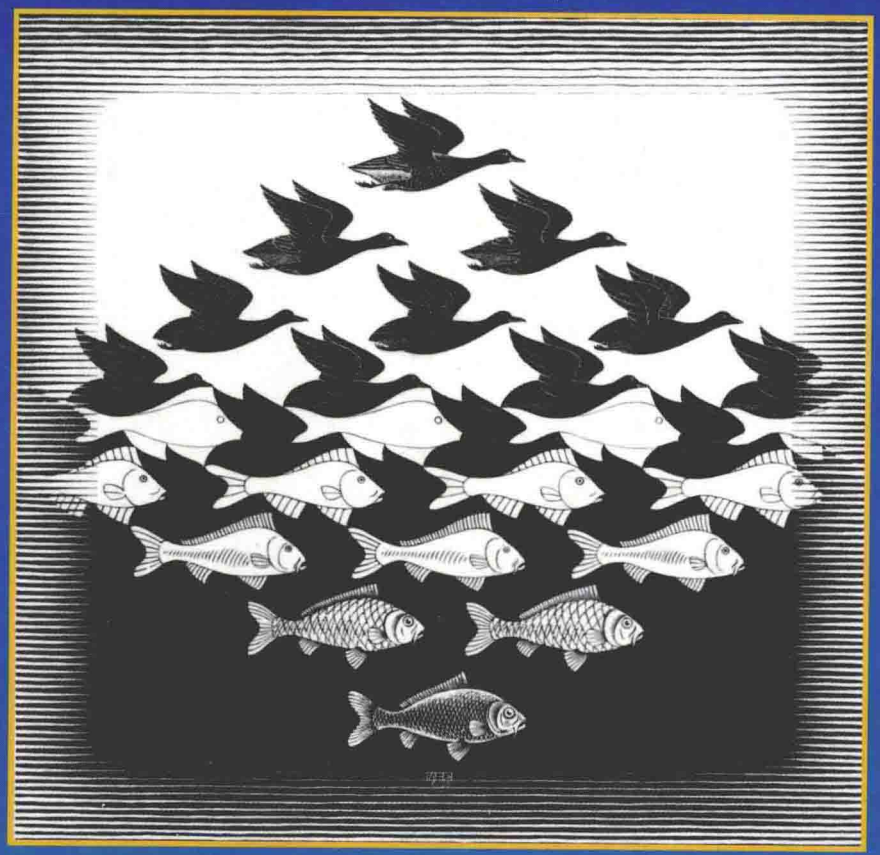
Sixth Edition

Quantitative Methods for Business Decisions

with Cases



Lawrence L. Lapin

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Lawrence L. Lapin

San Jose State University

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PREFACE

My goal in writing *Quantitative Methods for Business Decisions* has been to provide a complete and modern treatment of basic management science methodology. The book is written for college students who have only an algebra background. Even more important, it is designed to provide a feeling for the variety and power of management science tools, to alleviate apprehension of the subject, and to enable students to recognize on-the-job situations in which management science methodology can be successfully employed.

The book has been thoroughly class-tested many times in a variety of different courses, which has resulted in the culling, revising, and grading of the problem material. In general, the problems are broken into several distinct parts to make the student's job easier and to permit the instructor added flexibility in making assignments. As an added bonus, brief answers to selected problems are provided in the back of the book, so that students can check their own work. Questions for each end-of-chapter case appear with the case, and the cases themselves have been upgraded for this edition.

The Sixth Edition provides a streamlined topical sequence that minimizes jumping back and forth. This revision has several major improvements in topical coverage that make the book easier to use, more flexible, more comprehensive, and more relevant than previous editions. As the tinted areas in the diagram on the next page indicate, the overall design of the book is modular to provide maximum flexibility for adaptation to the requirements of a particular course. All or portions of any part of these subject groupings may be used in constructing a one- or two-quarter or a one- or two-semester quantitative methods course. For example, Chapters 2–4 may be bypassed by students who have had a prior course in statistics or by instructors who teach a purely deterministic course (a viable possibility with this book). The specific sequencing constraints to be followed are also shown in the diagram.

In today's computerized environment, the optimal focus in teaching quantitative methods places less emphasis on hand computations with algorithms and more emphasis on concepts. To this end, this Sixth Edition includes several improvements. Computer applications are now highlighted throughout nearly every chapter, not just at the ends. Although the Sixth Edition is flexible enough to permit *optional* computer use, so that the computer still does not need to be formally integrated into courses, computer enhancements are very easy to achieve with many software packages. With few limitations, adopters of this text will qualify

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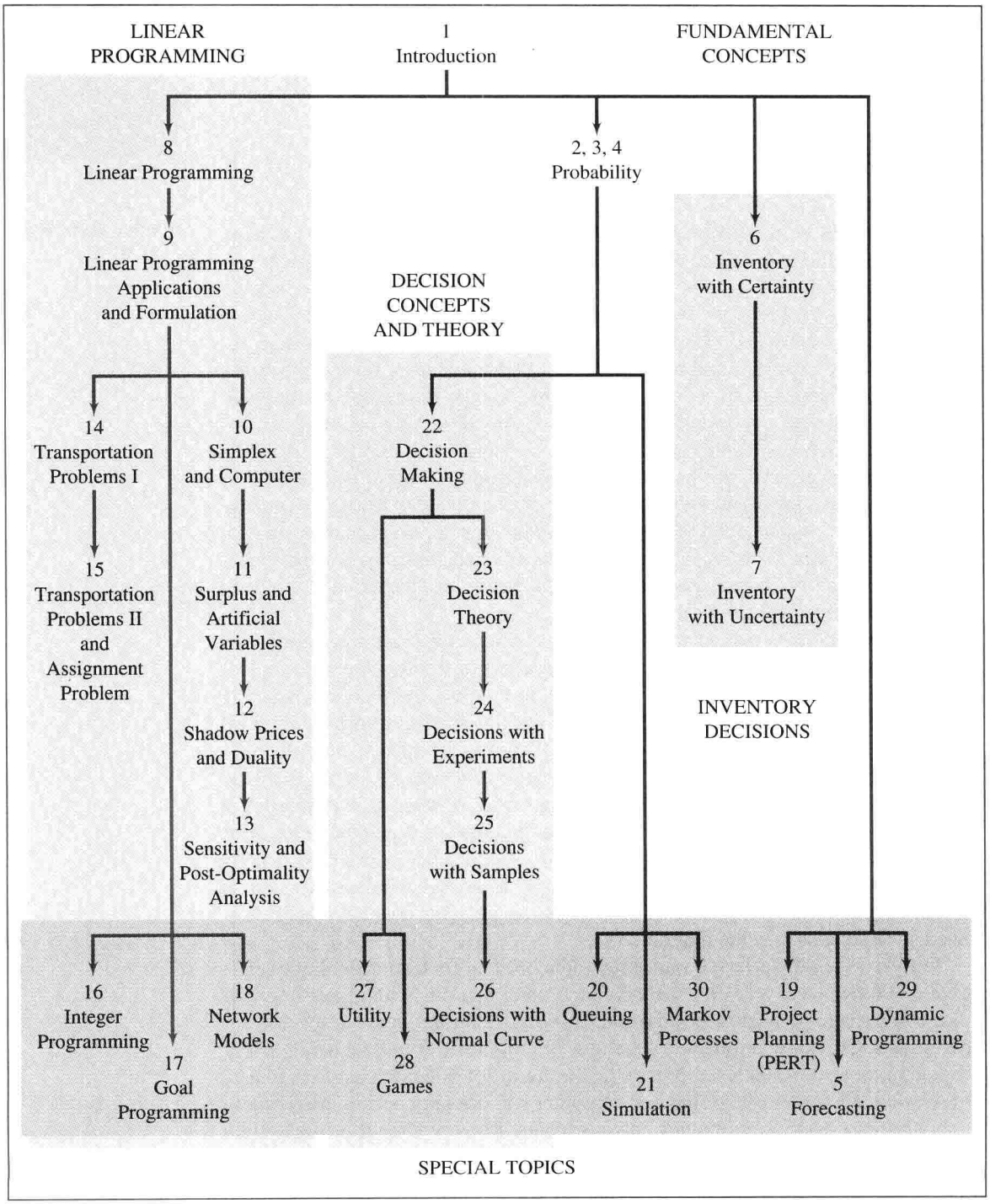
for licensed usage of the special version 4.0 of *QuickQuant*, the widely acclaimed decision-science software introduced with earlier editions of this book. This program makes it very easy and natural to bring more computer applications into courses, allowing students to work bigger problems, relieving them of messy



computational burdens. Instructors wishing even stronger computer emphasis may use with this text the separately published *Workbook and Operating Manual for QuickQuant*, which contains several hundred computer-assisted problems, in worksheet format, that can be attached to hard copies of computer solutions.

QuickQuant has been thoroughly upgraded, having undergone two major revisions since the prior edition of this book. Version 4.0 has improved user interfaces, can solve bigger problems, and has many new features and brand-new applications. A detailed listing of these may be found in the Synopsis of Major Changes and in the Guide to *QuickQuant* appearing at the end of this book. This package is available in two editions. Version 4.0 for the IBM-PC family works on all computer platforms having MS-DOS capabilities. Version 4.0 is also available for the Macintosh family.

A thorough discussion of the many changes made in the Sixth Edition is contained in the Synopsis in the following section. Some changes were motivated by my desire to improve the rigor of the book, while at the same time reducing hand-computational demands and giving better explanations in those areas where my own students had difficulties. My entrepreneurial experience has continued to provide impetus for many changes to the book. The availability of *QuickQuant* has freed me from previous computational constraints that had limited this book's scope. This increased freedom is reflected in new topical coverage and in improved presentations of original topics.

Text revisions appearing in this Sixth Edition are the most extensive ever, in accordance with the dual objectives of making better use of the computer and showing how to enhance the relevance of management science to everyday business decision making. Hundreds of new problems have been added, resulting in a new problem mix that is a bit more challenging, reflects greater realism, and gives a better representation of the various techniques and their nuances. To that end, this edition has twice as many cases as before. Most of the new cases are longer and have been contributed by my colleagues. Some are based on real-world applications and involve bigger data sets. The new cases make even greater use of the computer, allowing considerable potential for course enrichment.

The overall presentation of material has been improved by several enhancements. Every chapter includes several Managerial Applications, solved problems, nearly all new to this edition. The brand-new Computer Applications illustrate how the computer may be used in conjunction with the methodology presented. Two graphic enhancements make the book easier for students: Boxed equations set off important expressions frequently used in solving problems and Solution Procedures sections clearly list steps of important algorithms. Chapters now include a Using Judgment segment that emphasizes the role judgment plays in selecting a model, providing parameter values, formulating a problem, and selecting a solution procedure. Each chapter also ends with a detailed Summary.

This book is more intuitive than most. Discussions devoted to difficult topics therefore may be longer than those in some other books. Explanations are richly illustrated with relevant and interesting examples to provide more meaningful and *easier* learning experiences than those of briefer books. Chapter 10 thoroughly describes in nonmathematical terms the underlying rationale of the simplex method, so that the student can learn why—as well as how—this method works. More advanced concepts, such as artificial variables, are grouped in a second chapter (Chapter 11). Chapter 19 discusses network planning (PERT or CPM) in a broad context, including management implications, milestone and activity scheduling, time–cost trade-off, and probabilistic aspects. Chapter 21

introduces Monte Carlo simulation as a simple substitute for the stopwatch observation of an actual system operation. Highly intuitive decision trees are used extensively throughout to explain a variety of concepts.

The book also highlights the limitations and pitfalls associated with various mathematical models and algorithms. For example, some basic models, such as the EOQ model used in inventory decisions and the simple queuing formulas, are based on assumptions that rarely apply in real life. Wherever practical, alternative approaches such as Monte Carlo simulation are indicated and fully described. Traditional probabilistic PERT assumptions are accompanied by a critical analysis of their applicability. The severe limitations on the use of Markovian decision models are also noted.

The Instructor's Manual contains specific recommendations for course designs, teaching suggestions, and detailed solutions to the nearly 800 problems and roughly 70 end-of-chapter cases in the text. Also available is a testbook which contains a set of about 200 solved problems of slight to moderate difficulty. A comprehensive bibliography is included in the back of the book for students who wish to pursue a particular topic in greater detail.

I wish to thank my colleagues who were instrumental in helping me shape the manuscript: William D. Whisler, California State University, Hayward; Professor Whisler also contributed many of the new cases. Other contributors are: Gerald J. Maxwell and Aharon Hibshoosh, both of San Jose State University, and Manuel Bernardo, of California State University, Hayward. I also wish to acknowledge the valuable assistance of my students, and to extend special mention to Janet Anaya, who helped find errors and assisted in preparing the Instructor's Manual.

LAWRENCE L. LAPIN

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Synopsis of Major Changes to the Sixth Edition

This Sixth Edition has been improved in many ways. Some of the key changes are summarized below.

MAJOR SUBJECT-MATERIAL IMPROVEMENTS

Streamlined Probability The basic probability chapter has been simplified in such a way that only those procedures definitely needed to support models and techniques are included. It is now easier to use than before.

Modularity in Linear Programming This Sixth Edition makes it easier to skip simplex details while presenting the essence of linear programming. The formulation chapter (9) now includes large problems that must be solved on the computer, making streamlined use of the new *QuickQuant* without having to examine simplex tableaus. For those who want simplex, both of the original simplex chapters (10 and 11) are still included in their original gory detail. (And, *QuickQuant* still provides complete simplex tableaus for those who want them, but the package has the added flexibility of skipping them entirely.)

Improved Decision-Making Thrust Although a decision-making flavor is essential to any book on quantitative methods, this Sixth Edition includes further enhancements, such as greater use of sensitivity analysis and expanded discourses on optimization. Whenever appropriate, an example using a decision is employed. This makes some discussions less mechanical and improves the overall relevance.

Thoroughly Revised Presentation of Duality The dual LP is often skipped in introductory courses. This edition provides (in Chapter 12) an expanded and considerably softer discussion of this traditionally "hard" topic. This results partly from focusing on the practical aspects of shadow pricing and how dual variables improve the *environment* of an operation, as opposed to the largely tactical considerations of the primal. A new economic rationale for the dual is provided, helping to make duality discussions less mechanical and more conceptual. Greater use is made of the dual reports usually provided "for free" with computer LP solutions.

Expanded Post-Optimality LP Analysis This Sixth Edition considerably expands (in Chapter 13) the scope of the earlier LP sensitivity analysis. The

ranges thereby found for right-hand sides and objective coefficients are now merged with dual variable values to suggest a host of changes to the problem (or business environment). Use of the computer is completely integrated into the new, broader discussion, along with better problem materials that realistically apply the information for decision-making purposes.

Improved Transportation Problem Discussion and Placement The transshipment problem appears earlier (in Chapter 14) within the transportation group. The cheapest-cell starting method is described in greater detail and now includes a modification when dummy cells are present.

Hungarian Method for Solving Assignment Problems The earlier editions of this book solve assignment problems using only the transportation method. To give greater appreciation of special-purpose algorithms, the Hungarian method has been added to Chapter 15. Also included are maximization of efficiency (in addition to minimization of cost or time).

Network Models A *brand-new* Chapter 18 completes the linear programming group with a description of four network models and the special-purpose algorithms used to solve them. Included are the shortest route problem, the minimal spanning tree problem, the maximum flow problem, and the minimum-cost maximum-flow problem. The latter is solved using the out-of-kilter algorithm, considerably simplified through a special worksheet. All of these algorithms are supported by a brand new *QuickQuant* module. For comparison, some problems include finding computer solutions with the general simplex method (computer assisted, of course).

Expanded PERT Project planning with PERT considers (in Chapter 19) the concept of project compression through finding better activity logic that increases the amount of parallel effort and reduces series activities. Also included is the three-time estimate approach and probabilistic single-path evaluation as part of the main discussion. That is tied in with reference to Monte Carlo simulation (in Chapter 21), where the illustration is continued with simulated project completions. That facilitates a thorough discussion of the inadequacies of the single-path analysis. The new PERT simulations explicitly incorporate the modified beta distribution, random variates for which serve as the trial times, making use of the new *QuickQuant* simulation module. The new program actually draws the PERT network, using only the tabular precedence logic as input.

Expanded Queuing Coverage The queuing discussion in Chapter 20 includes a detailed discussion optimizing the number of servers. The issue of exponential service times is confronted. This is an opportune place to introduce goodness-of-fit testing to empirically justify using the basic queuing models.

Expanded Monte Carlo Simulation Monte Carlo simulation in Chapter 21 has been enhanced in several ways. This is due in large measure to the inclusion of PERT, with actual modified beta distributions employed, and to the new *QuickQuant* module for simulation. The inventory simulation discussion is expanded to include use of that software. the *t*-test has been included to allow testing of hypotheses using simulation.

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Improved Decision Analysis The decision analysis segment (Chapters 22–27) has been improved, with better chapter organization that places the normal form analysis together with decisions with experimental information. Decision making with sample information has an improved presentation and is now supported with better *QuickQuant* software.

Finding the Transition Probabilities in Markov Processes Earlier editions focused almost exclusively on finding steady-state probabilities. Chapter 29 of this Sixth Edition considers in greater detail how to find the *transition* probabilities themselves.

Modernized Treatment of Game Theory Chapter 30 gives a thoroughly modern treatment of game theory. Greater emphasis is place on nonzero sum games, with prominence given to Nash equilibria.

NEW FEATURES

Managerial Applications In addition to the usual examples, every chapter has solved problems that involve applying the present methods to a decision-making situation.

Computer Applications Any procedure directly supported by the *QuickQuant* ancillary software is illustrated with a computer application.

Using Judgment Each chapter contains a short discussion of how judgment is used in selecting a model, setting parameters, formulating a problem, and selecting a solution procedure.

Summaries Chapters now have summaries highlighting terms and concepts discussed.

Boxed Equations Important expressions are boxed to make the book easier to use.

Solution Procedures Algorithm steps appear in specially highlighted sections, making them easier to apply.

NEW CASES AND PROBLEMS

Cases About 25 new cases appear in this Sixth Edition. These are generally twice as long as the earlier cases (which are retained). Some involve large data sets and require computer assistance. Most of the new cases are contributed by outside authors.

Problems Nearly 200 new exercises have been added. These range in level of difficulty and give special emphasis to interpreting results. Many involve using the computer.

SOFTWARE SUPPORT

Version 4.0 of *QuickQuant* is available to adopters of this book under a special licensing arrangement with the publisher. This software has roughly twice as many program modules as the earlier version. Generally, larger problems can now be solved. Some of the major improvements are listed below.

Computer Workbook In cooperation with Alamo Publishing Co., a 600-page workbook and operating manual is available for purchase by students using *QuickQuant*.

New Network Models A brand-new program solves four types of network problems, including the out-of-kilter algorithm for minimum-cost maximum-flow problems.

Expanded PERT The PERT module now does activity crashing to determine the optimal time-cost tradeoff. Also included is the single-path probabilistic analysis. A graphical PERT network chart now appears on the screen and may be printed on hard copy.

New Simulation This brand-new program simulates queues, forecasting models, inventory policies, and PERT. The latter application explicitly uses the modified beta distribution to generate random variates from the usual three-time estimate data input. Output includes a statistical summary with histograms.

Assignment Problems These are solved within the transportation module. separate labels apply, along with automatic provision of demands and availabilities during data input.

Queuing The program now optimizes the number of servers.

Decision Analysis A new tabular segment provides expected payoffs, opportunity losses, and summary results using criteria such as maximin.

Markov Chains State probabilities may be obtained after any specified number of periods, not just for the steady state.

Production Applications The package will have three new program modules—for MRP, facilities layout, and statistical process control.

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