

# Building Intuition

Insights From Basic Operations Management  
Models and Principles

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Dilip Chhajed • Timothy J. Lowe  
Editors

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Models and Principles

 Springer

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# Dedication

*To my wife Marsha, and my children  
Marc and Carrie*

*-TL*

*To my parents, Aradhana, Avanti and Tej*  
*-DC*

## Author Bios

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Timothy J. Lowe

# Foreword

The year is 2027, the price of quantum computers is falling rapidly, and a universal solver for the leading type of quantum computer is now in its second release. Given any model instance and any well-formulated problem posed on that instance, Universal Solver 2.0 will quickly produce a solution. There are some limitations, of course: the model instance has to be specified using a given repertoire of common mathematical functions within an algebraic framework or, possibly, a system of differential or integral equations, with the data in a particular kind of database, and the problem posed has to be of a standard type: database query, equation solution, equilibrium calculation, optimization, simulation, and a few others.

As a tool for practical applications of operations management and operations research, is this all we need?

I think not. Useful as such a tool would be, we still need a solver or solution process that can explain *why* a solution is what it is, especially when the validity of the solution is not easily verifiable. The big weakness of computations and solvers is that they tell you *what* but not *why*.

Practitioners need to know why a solver gives the results it does in order to arrive at their recommendations. A single model instance—that is, a particular model structure with particular associated data—hardly ever suffices to capture sufficiently what is being modeled. In practical work, one nearly always must solve multiple model instances in which the data and sometimes even the model structure are varied in systematic ways. Only then can the practitioner deal with the uncertainties, sensitivities, multiple criteria, model limitations, etc., that are endemic to real-life applications. In this way, the practitioner gradually figures out the most appropriate course of action, system design, advice, or whatever other work product is desired.

Moreover, if a practitioner cannot clearly and convincingly explain the solutions that are the basis for recommendations—especially to the people who are paying for the work or who will evaluate and implement the recommendations—then it is unlikely that the recommendations will ever come to fruit or that the sponsor will be fully satisfied.

There are two major approaches to figuring out why a model leads to the solutions that it does. One is mainly computational. In the course of solving multiple model instances, as just mentioned, the analyst comes to understand some of the



solution characteristics well enough to justify calling them insights into why the solutions are what they are (typically at an aggregate rather than detailed level). These insights can inform much of the thinking that the model was designed to facilitate and can facilitate communicating with others.

The second approach is not primarily computational, but rather is based on developing insights into model behavior by analytical means. Direct analytical study may be possible for very simple (idealized) model structures, but this tends not to be feasible for the kinds of complex models needed for most real applications. Practical studies may have to rely on a deep understanding of greatly simplified models related to the one at hand, or on long experience with similar models. This is an art leading mainly to conjectures about solution characteristics of interest for the fully detailed model, and was the approach taken in the paper of mine that the editors cite in their preface. These conjectures are then subjected to computational or empirical scrutiny, and the ones that hold up can be called insights into why the full model's solutions are what they are.

The importance of this book, in my view, rests partly on its success in teasing out the deep understanding that is possible for some relatively simple yet common model structures, which in turn can be useful for the second approach just sketched, and partly on the sheer expository strength of the individual chapters. The profession can never have too many excellent expositions of essential topics at the foundation of operations management. These are valuable for all the usual reasons—utility to instructors, utility and motivation for students and practitioners, utility to lay readers (perhaps even the occasional manager or engineering leader) curious about developments in fields outside their own expertise, and even utility to researchers who like to accumulate insights outside their usual domain.

Having stressed the *utility* of expositions that communicate the insights attainable by avoiding too many complexities, let me balance that by pointing out how exquisitely *beautiful* the insights of such expositions can be, and also how exquisitely *difficult* such writing is.

Most readers will find a good deal of beauty as well as utility in this book's chapters, and I commend the editors and authors for their efforts.

Arthur Geoffrion  
UCLA Anderson School of Management

# Preface

The idea for this book began with a discussion at a professional meeting regarding teaching materials. As educators in schools of business, we each were looking for materials and teaching approaches to motivate students of operations management regarding the usefulness of the models and methods presented in the basic OM course. Our experience has been that many of the basic OM concepts have been “fleshed out” and so deeply developed to the point where basic insights are often lost in the details. Over the years, we both have been heavily influenced by Art Geoffrion’s classic article “The Purpose of Mathematical Programming is Insight, Not Numbers,” *Interfaces*, 1976. We believe that this principle is fundamental in educating users of the “products” we deliver in the classroom, and so our project—this book—was initiated with a great deal of enthusiasm. Our first task was to enlist the assistance of well-known individuals in the field who have the professional credentials to gain the attention of potential readers, yet are able to tell their story in language appropriate for our target audience. We think you will agree that we have been successful in our choice of authors.

The purpose of this book is to provide a means for making selected basic operations management models and principles more accessible to students and practicing managers. The book consists of several chapters, each of which is written by a well-known expert in the field. Our hope is that this user-friendly book will help the reader to develop insights with respect to a number of models that are important in the study and practice of operations management. We believe that one of the primary purposes of any model is to build intuition and generate insights. Often, a model is developed to be able to better understand phenomena that are otherwise difficult to comprehend. Models can also help in verifying the correctness of an intuition or judgment. As an example, managers may use the SPT (shortest processing time) method to schedule completion of paperwork with the objective of “clearing their desk”—removing as many jobs from their desk as quickly as possible. As it turns out, it can be easily shown that SPT sequencing minimizes average job flow time (see Chap. 1). Thus, in this case, it is comforting to know that the manager’s intuition is correct. However, it is also essential to know when (and why!) intuition fails, and a well-structured model should convey this information. In spite of the fact that many educators recognize the intuition-building power of simple models, we are not aware of any existing book that has a focus similar to ours.

As mentioned above, Chap. 1 deals with the shortest process time principle. Chapter 2 contains insight on the knapsack problem—a problem that often arises as a subproblem in more complex situations. The notion of process flexibility, and how to efficiently attain it, is the subject of Chap. 3, while queuing concepts are the subject of Chap. 4. A key relationship between flow rate, flow time, and units in the system—Little’s Law—is discussed in Chap. 5. In Chap. 6, the use of the median, as opposed to mean, is shown to be a best choice in certain situations. The news-vendor model, a means of balancing “too much” versus “not enough,” is the subject of Chap. 7, while the economic order quantity inventory model is covered in Chap. 8. The pooling principle, a means of mitigating variance, is the topic of the final chapter.

To ensure that the book is accessible by our target audience, the chapters are written with students and managers in mind. Reading the book should help in developing a deeper appreciation for models and their applications. One measure of accessibility is that individuals only vaguely familiar with OM principles should be able to read and comprehend major portions of the book. We sincerely hope that the book will meet this test.

This book should appeal to three major audiences: (a) teachers of introductory courses in OM, (b) students who are taking one of their first courses in OM, and (c) managers who face OM decisions on a regular basis.

As professors who have considerable experience in teaching OM, we have found that students value insights gained by the models and tools that are the subject of this book. In addition, early in our careers we experienced a certain level of “discomfort” in teaching some of these models. This discomfort arose because as teaching “rookies” we lacked the maturity and experience to do proper justice to the material. Thus, we hope that the background and examples provided by the book will be of considerable help to “new” teachers.

Finally, we hope that the book will also appeal to those managers who believe that decision technology tools can be brought to bear on the problems they face.

Although each chapter of this book treats a different fundamental OM concept, we have made every effort to have a uniform writing style and (as much as possible) consistency in notation, etc. With this in mind, the book can be used in its entirety in an OM course. Alternatively, individual chapters can be used in a stand-alone situation since material does not “build” progressively through the book. For our managerial audience, we see the book as an excellent reference source.

We sincerely hope that you will find the book useful and that it will be a valuable addition to your personal library.

Tim Lowe and Dilip Chhajed

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