Management Science using Excel

Harnessing Excel's advanced features for business optimization

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In memory of

Semadar Bilha Siegel

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About the Author

For more than 25 years, **Dr. Isaac Gottlieb** has been teaching Excel workshops for MBA students in several universities, including Columbia, New York, Rutgers, and other universities in the US and other countries. In addition, he taught courses in Management Science and Statistics for Managers (always) using Excel. Over 100,000 students have attended his workshops and courses over the past 25 years.

He received the Microsoft MVP – Most Valuable Professional – award for 2014-6. A Microsoft "Most Valuable Professional" (MVP) is an award for individuals who have exhibited exceptional technical expertise and a talent for sharing knowledge within their technical community." **(From Microsoft's site.)**

Isaac Gottlieb has taught how to use Excel and apply it effectively to various business disciplines to thousands of corporate professionals from leading multinational companies and small private business corporations. Among them are Johnson & Johnson, Merck, Pfizer, Procter & Gamble, Caterpillar, Vornado, El-Al Airlines, Microsoft, Intel, Boeing, NCR, Chrysler, Sealed Air, JPMorgan, Morgan Stanley, 3M, H-P, and the New York City Economic Development Corporation.

He has an Excel-Tip-Of-The-Month newsletter that goes to over 35,000 recipients.

Dr. Gottlieb has earned his Ph.D. and two Masters's Degrees from the Columbia University Department of Industrial Engineering and Operations Research. He has over 20 years of business and industry experience as a CEO of manufacturing companies and senior consultant.

His last two books were:

Excel 2022 Pro 100 + PivotTables, Charts & Reports: Explore Excel 2022 with Graphs, Animations, Sparklines, Goal Seek, Histograms, Correlations, Dashboards (English Edition), BPB.

Next Generation Excel®, Modelling in Microsoft® Excel® for Analysts and MBAs (for Windows® and Mac® OS), Wiley.

About the Reviewer

Arthur Sagy (Art) is an innovative engineer with an M.Sc. degree from Columbia University in NYC. His career has included positions in education, consulting, and manual writing. Art has extensive experience in applying technology developments to meet the operational needs of various industries, including Food, Beverage, Pharmaceutical, Cosmetics, and Petrochemical Industries. He has led the development for an International "Fortune 100" company, where he applied his knowledge of Management Science with a focus on technical applications. Art is the owner of 15 Global technical patents.

Acknowledgement

Special thanks to my friend Art Sagy for his continuous encouragement and support while writing this second book. Time and again, he acted as a sounding board, reading the draft of every chapter and providing me with feedback. Art's professional background and experience contributed to many of the topics in this book.

My wife, Gilda, has been continuously accommodating of my writing schedule. I am grateful for her encouragement while writing this book and in all my endeavors. She has been my cheering squad at every interval of the last half century, and I attribute my success to her support.

Special thanks for the support and help of the BPB Publications team, who have now helped me complete two books. I do not have enough kind words to describe their dedication and editorial skills. This is the second time I have been amazed by the team's turnaround time. I am lucky to have had such a wonderful editorial team.

Preface

With this book, you will acquire a strong understanding of Management Science in the decision-making field while mastering the solutions with Microsoft Excel. This book alleviates complicated mathematical models with easy Microsoft Excel tools.

Management science is a practice of problem-solving and decision-making in organizations, business, and other fields. It uses various analytical methods, including mathematical modeling and statistics, to improve the ability of better decision's making. The techniques in this book range from maximization of profit, performance, and Return on Investment (ROI) to minimization (cost, time, risk) through Monte Carlos simulations, sensitivity analysis, and other tools.

The readers will find countless real-life examples and case studies from banking, finance, transportation, manufacturing, manpower assignment, scheduling, and inventory management through food and product mix. This book's linear and nonlinear techniques utilize the Excel Solver for the solutions. Once you get the hang of using the Solver – you can apply the tools learned to solve problems of your background, experience, and choice.

This book takes a hands-on approach using Excel to solve these problems. Instead of using complex mathematical formulations and algorithms – you will learn to set up and solve these problems in an easy-to-follow manner in Excel.

The book has practice problems and solutions at the end of every chapter for the readers to practice independently. These examples will help you learn how to apply these techniques on their day-to-day needs.

Part 1: Business Modeling Tools

Chapter 1: Making Better Decisions with Management Science- reviews the techniques of Management Science and the areas of applications. It explains how Management Science uses mathematics, statistics, and Excel's power to make better and more intelligent decisions. The decision maker translates the challenge into a mathematical model and solves the problems using one or more Excel tools demonstrated in this book.

The chapter reviews techniques such as maximization (profit, performance, ROI, nutritional value), minimization (cost, time, risk), simulations, and others Excel's

Management Science tool enables a better approach to the solutions. The chapter will also survey the type of enterprises that utilize these techniques; airlines, shippers, manufacturers, military, government, and banking.

Chapter 2: Exploring Management Science Optimization Techniques- defines optimization and examines optimization types: Linear, Nonlinear, Integer, and Binary. You will discover how optimization models can include constraints like capacity, funds staffing, and more. This chapter starts with model formulation and continues with graphical solutions to solve two-variable models.

This chapter is an introduction to the many techniques which will introduce solutions to be used in further chapters of this book using Excel.

Part 2: Using the Solver for Management Science

Chapter 3: Unleash the Power of Excel's Solver for Optimizations- introduces the Excel Solver Add-in. The Solver is a powerful tool that finds the optimal value (maximum or minimum) of a single cell, called an objective cell, subject to a set of limits referred to as constraints. You set up a group of cells called decision variables. The Solver will compute the values of these decision variables as input to the optimal solution. It will be easiest, first, to walk through the use of the Solver while working on simple examples solved graphically in *Chapter* 2. Essentially, the Solver searches all feasible solutions – looking for the "best" target cell value. The Solver will be used in many of the following chapters to solve Management Science optimization problems.

Chapter 4: Optimize Product Mix- this is about using the Solver to determine the product mix, which maximizes profitability. The product mix problem involves determining the quantity of each product produced to maximize profits or blending ingredients to minimize the overall cost. Product mix must usually adhere to a number of constraints, such as demand, raw materials, labor availability, space, and more.

Chapter 5: Investment and Portfolio Optimization with Excel's Solver- introduces Linear Programming Models for Optimal Portfolios to select an investment mix subject to constraints. The Linear Programming model allows portfolio managers to perform portfolio analytics much faster than previous systems, enabling them to respond more quickly to changing market conditions. The chapter covers the formulation and solution of several investment problems. The solution involves the use of the Solver.

Chapter 6: The Assignment Problem Challenges and Solutions- is about an Assignment Problem. This procedure minimizes cost or time when assigning individual professionals to specific tasks. The procedure can also solve allocating salespeople to specific districts to maximize sales. These problems are set up and solved using the Linear Programming Solver.

Chapter 7: Solving Transportation Supply Chain Problems- demonstrates the use of the Transportation Problem. This is a linear programming solution - when the objective is to calculate transporting goods from several sources to a number of destinations in a way that minimizes shipping costs. The solution has to satisfy the given sources' supply capacities and destinations' demands. This solution is used by manufacturers, distributors, and other entities dealing with supply chain matters.

Chapter 8: Marketing Applications of Optimal Media Mix- Linear Programming enables the marketing manager to analyze the audience coverage and reception of advertising based on available media, given the advertising budget as the constraint. The advertisers need to decide the number of each type of advertisement media available to be considered to maximize exposure. They know which commercial or ad will reach specific potential audience numbers and the cost of each media type. This chapter covers the ways you can utilize the Solver for these problems.

Chapter 9: Integer and Binary Optimization- covers two special optimization techniques. The first is called Integer Programming **–** where the solution values must be integers, such as hiring an integer number of employees or purchasing an integer number of machines. The second, called Binary Programming, is when the decisions have a Binary yes-or-no output. An example of the second technique is when you are faced with a number of projects, and you wish to choose the correct ones (yes/no for each one of the projects – invest or do not invest) meeting given capital, space, employees, and other constraints.

Chapter 10: The Scheduling Puzzle- This chapter aims to explain how to solve your scheduling problems. When banks, restaurants, airlines, or other service companies know their labor requirements on different days of the week, they need a method to schedule their workforce efficiently. You can use Excel's Solver add-in to create a staffing schedule based on those requirements. Creating an optimal work schedule for several employees can be an arduous task. This chapter will demonstrate how to schedule the employees based on your requirement – minimizing the total number of employees or costs, considering the minimum staffing number needed requirement.

Chapter 11: Nonlinear Optimization Applied to Inventory and Facility Location- explains what *Nonlinear Optimization* Techniques can achieve in your business. The book goes through some Nonlinear Optimization application examples - helping your supply chain team - find the best location for a distribution Plant/Warehouse and your production planning or purchasing team decisions of Economic Order Quantity.

Part 3: Non-Optimizations Solutions for Management Science

Chapter 12: Monte Carlo Simulations- is about understanding what is behind the *Monte Carlo Simulation*. First, you will find out who uses simulations (and why). The next part of the chapter is about having fun applying simulations - rolling dice on a spreadsheet. The last part is about a project where we simulate a four years budget for 200 times (800 years.) The chapter will have other examples of Monte Carlo simulations.

Chapter 13: Simplifying Forecasting Using Excel's Forecast Sheet Feature- instructs the reader on using historical data to forecast the future. Using past data, you can use the feature of this chapter to create a future forecast. When you create a forecast, Excel's recently introduced Forecast Sheet tool creates a new worksheet containing a table of the historical data and predicted values, along with a chart that lets you visualize the data and the forecast.

Chapter 14: Queuing and Waiting Time- is an introduction to Queuing, which analyzes waiting lines. This study is applied to decisions involving traffic engineering, the design of hospitals, offices, banks, factories, airports, and websites to consider waiting time. Using Queuing, the business modeler can decide about the number of service channels, type of queue (single line like in a bank or multi-line like in the supermarket), average waiting time, and a number of other decisions which impact the facility.

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Chapter 1

Making Better Decisions with Management Science

Introduction

This chapter reviews the techniques of Management Science and the array of possible applications. It explains how Management Science uses mathematics and statistics along with Excel's power to solve potential problems and make better, intelligent decisions. The decision maker converts the problem into a mathematical model and solves it using the Solver or other Excel tools demonstrated in this book. Using Excel simplifies both; demonstrating and solving the problem – so that anybody familiar with Excel can unravel complicated problems which would have been difficult to solve otherwise.

The chapter reviews techniques such as maximization (profit, performance, ROI, nutritional value), minimization (cost, time, risk), simulations, and other Excel Management Science tools, enabling an easy approach to the solutions. The chapter will also review the type of enterprises that utilize these techniques, for instance, airlines, shipping companies, manufacturers, military, government, banking, and others.

Structure

The topics to be covered in this chapter are:

- The role of management science
- Creating a scientific or mathematical model of a problem
- What is management science and business modeling
- Who is using management science
- The list of management science techniques, and what are those used for

Objectives

The objectives of this chapter are to introduce the readers to the concept of management science - how, when, and where it is used. When you complete this chapter, you will be familiar with management science concepts, and you will become acquainted with where and how to apply the topics/ideas covered in this book. The idea is for you to recognize the different concepts of Management Science and where to utilize them by yourself.

The role of Management Science

Airlines would not be able to sustain their operations if they did not use Management Science techniques to schedule flights, assign personnel, select routes, overbook flights (wisely), schedule maintenance, and maintain proper inventory levels. The same goes for other establishments, such as *UPS*, *FedEx*, and countless other companies in various other industries; they would not be able to survive in today's competitive marketplace without the use of Management Science. For UPS and FedEx, - Management Science is used to plan drivers' routes and optimize air fleets' hub locations. In addition, there are thousands of Management Science applications used daily to blend the correct petroleum mix for gasoline grades, create the correct food mix for nutritional requirements and optimize data routes on the Internet.

In principle, the decision-maker translates the problem into a mathematical model and solves it using one or more of the analytical tools. Many enterprises use a variety of software tools other than Excel when Excel's capacity cannot handle some of these applications due to their size and/or complexity. This book uses Excel – so readers familiar with it can easily understand and practice the problems we are solving here. Excel is sufficient to solve many of the day-to-day problems most users confront.

Among the techniques reviewed here are maximization (profit, performance, ROI, nutritional value), minimization (cost, time, risk), simulations, and other techniques,

enabling a better approach to the solution of the problems. We will also survey the type of enterprises that utilize these techniques, such as airlines, shippers, manufacturers, military, government, banking, and more. Management Science techniques are applied in thousands of practical applications and disciplines.

The list of Management Science techniques has many topics. This list is part of the mathematical discipline called Operation Research (*http://en.wikipedia.org/wiki/Operation_research*) These are a few of the techniques reviewed in this book:

- Linear and nonlinear optimization
- Transportation
- Assignment
- Risk analysis simulation
- Marketing media
- Inventory control
- Production planning
- Blending
- Scheduling
- Portfolios
- Plan location
- Capital investment
- Forecasting
- Queuing

Business modeling and analysis is a combination of mostly quantitative techniques and the equivalent presentations used to analyze, solve and apply to business and other related problems. The idea is to convert a problem or a business situation into a mathematical formula or set of equations, namely a mathematical model, solving the problem and applying the solution to the actual problem.

Business modeling and analysis have many other names. You may have come across names like the one used here management science or operations research, decision sciences, decision modeling, analytic techniques for decision making, and very commonly, business modeling and analysis. business modeling and analysis is considered to be a sub-area of mathematics and economics.

These disciplines are being taught in universities by a variety of departments. You can find it in the business school under operations management and/or supply chain management. It is taught by the math departments as operations research. Most

Industrial Engineering departments train students to use some of these modeling techniques. As a matter of fact, almost every one of these academic departments uses it. It is part of accounting, marketing, finance, operations, economics, statistics, risk management, strategy, and a few more.

Since most people in the business world are facing making decisions for their enterprise or even personal problems, this book will be able to formalize and familiarize you with a variety of techniques, ideas, and solutions to your problems. You may be in an executive management position where you do not have to create and solve models yourself, but after reading this book, you will be able to communicate your thoughts and delegate the responsibility of applying their techniques to your company's analysts.

Creating a scientific or mathematical model of a problem

A mathematical model in business modeling is translating a real-life state of affairs to mathematical formulas and relationships to describe the behavior of a system. It has been used in sciences and engineering for thousands of years. Using it in business is what we do in business modeling.

We can describe the relationship between time and demand with an equation and use this equation to forecast sales over time. We can devise a set of mathematical formulations to describe our manufacturing product mix. We may want to describe a queuing situation in a bank in order to understand the waiting times in line. Today's business analysts build a mathematical model to define their business situation in order to solve it using mathematics and/or computer power. These are the basis for management science formulation.

In *Chapter 2*, *Exploring Management Science Optimization Techniques*, we are going to demonstrate how to formulate scientific or mathematical models of the problem. To illustrate what will be covered in the next chapter, the following is a short example:

As an example, you have two products; chairs and tables. The profit from selling one table is $39, and the profit for a chair is $20. There are two machines available. Machine A has a capacity of 400 hours a week, and machine B has a capacity of 180 hours per week. The information is shown in *Table 1.1*. Your objective to maximize profit subject to the machine's time constraints.

	Tables	Chairs
Profit per unit	$39	$20
Hours on machine A	4	3
Hours on machine B	2	1

Table 1.1: *Profit and time requires per machine of each product*

If we assign to the number of tables the letter T and to the chairs the letter C, we can set up the mathematical model to read:

$$\text{Maximize } Z = \$39T + \$20C$$

$$\text{Subject to:} \quad (1)\ 4T + 3C < 400$$

$$(2)\ 2T + 1C < 180$$

$$T > 0,\ C > 0$$

In *Figure 1.1*, you can see the two equations (1) and (2) on a two-dimensional chart. The area with the arrows → is the feasible solution area (they comply with the inequality equations.) It displays the problem visually.

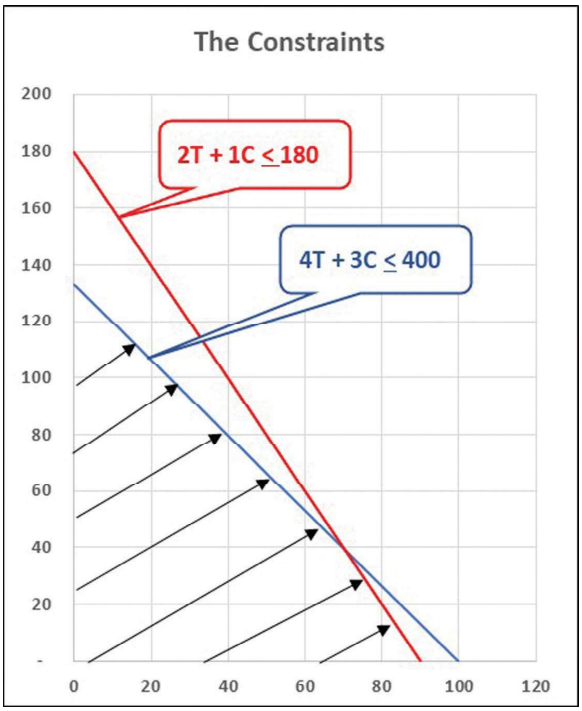

Figure 1.1: *A visual display of the chairs and tables problem*