Chapter 1
Introduction to Spreadsheet Modeling

Contents

1.1 Introduction

Spreadsheets have become as commonplace as calculators in data analysis and decision making. In this chapter, we explore the value and importance of building decision-making models with Excel. We also consider the characteristics that make spreadsheets useful, not only for ourselves, but for others with whom we collaborate. As with any tool, learning to use the tool effectively requires carefully conceived planning and practice; thus, we will terminate the chapter with an example of a poorly planned spreadsheet that is *rehabilitated* into a shining example of what a spreadsheet *can* be. Some texts provide you with very detailed and in-depth explanations of the intricacies of Excel; this text opts to concentrate on the types of analysis and model building you can perform with Excel. The principal goal of this book is to provide you with an Excel-centric approach to solving problems and to do so with *relatively simple* and *abbreviated* examples. In other words, this book is for the individual that shouts, "I'm not interested in a 900-page text, full of difficult-to-remember *Ctl-Shift-F4-R key stroke shortcuts*! What I need is a good and instructive example of analytics, so I can solve this problem before I leave the office tonight."

Finally, for many texts the introductory chapter is a "throw-away" to be read casually before getting to substantial material in the chapters that follow, but that is not the case for this chapter. It sets the stage for some important guidelines for constructing worksheets and workbooks that will be essential throughout the remaining chapters. I urge you to read this material carefully and consider the content seriously.

Let's begin by considering the following encounter between two graduate school classmates of the class of 1990. In it, we begin to answer the question that decision-makers face as Excel becomes their standard for analysis and collaboration—How can I quickly and effectively learn the capabilities of this powerful tool, Excel?

1.2   What's an MBA to do?

It was late Friday afternoon when Julia Lopez received an unexpected phone call from an MBA classmate, Ram Das, whom she had not heard from in years. They both work in Washington, DC, and after the call, they agreed to meet at a coffee shop on Connecticut Avenue to catch up and discuss their career experiences.

Ram: Julia, it's great to see you. I don't remember you looking as prosperous when we were struggling with our quantitative and computer classes in school.

Julia: No kidding! In those days, I was just trying to keep up and survive. You don't look any worse for wear yourself. Still doing that rocket-science analysis you loved in school?

Ram: Yes, but it's getting tougher to defend my status as a rocket scientist. This summer we hired an undergraduate intern that just *blew* us away. This kid could do any type of analysis we asked, and do it on one software plat- form, Excel. Now my boss expects the same from me, but many years out of school, there is no way I have the training to equal that intern's skills.

Julia: Join the club. We had an intern we called the Excel Wonder Woman. I don't know about you, but in the last few years, people are expecting more and better data analytic skills from MBAs. As a product manager, I'm expected to know as much about complex business analytics as I do about understanding my customers and markets. I even bought five or six books on business analytics with Excel. It's just impossible to get through hundreds of pages of detailed keystrokes and tricks for using Excel, much less simultaneously understand the basics of the analytics. Who has the time to do it?

Ram: I'd be satisfied with a brief, readable book that gives me a clear view of the *kinds* of things you can do with Excel, and just one straightforward example. Our intern was doing things that I would never have believed possible— analyzing qualitative data, querying databases, simulations, optimization, statistical analysis, collecting data on web pages (**web crawling**), you name it. It used to take me six separate software packages to do all those things. I would love to do it all in Excel, and I know that to some degree you can.

Julia: Just before I came over here, my boss dumped another project on my desk that he wants done in Excel. The Excel Wonder Woman convinced him that we ought to be building all our important analytical tools on Excel—**Decision Support Systems** she calls them. And, if I hear the term *collaborative* one more time, I'm going to explode!

Ram: Julia, I should go, but let's talk more about this. Maybe we can help each other learn more about the capabilities of Excel.

Julia: Ram, this is exciting. Reminds me of our study group work in the MBA.

This brief episode is occurring with uncomfortable frequency for many people in analytical and decision-making roles. Technology, in the form of desktop software and hardware, is becoming as much a part of day-to-day business analytics as the concepts and techniques that have been with us for years. Although sometimes complex, the difficulty has not been in *understanding* analytical concepts and techniques, but more often, how to put them to use. For many individuals, if analytic software *is* available for modeling problems, it is often unfriendly and inflexible; if software *is not* available, then they are limited to solving *baby* problems that are generally of little practical interest. This is why Excel has become so valuable—it is easily-managed technology.

1.3   Why Model Problems?

It may appear to be trivial to ask why we model problems, but it is worth considering. Usually, there are at least two reasons for modeling problems—(1) if a problem has important financial and organizational implications, then it deserves serious consideration, and models permit serious analytical investigation, and (2) on a very practical level, often we are directed by superiors to model a problem because *they* believe it is important. For a subordinate analyst, important problems generally call for more than a gratuitous "I think..." or "I feel..." to convincingly satisfy a superior's probing questions. Increasingly, superiors are asking questions about decisions that require careful consideration of assumptions, and about the sensitivity of decision outcomes to possible changes in environmental conditions and the assumptions (sensitivity analysis). To deal with these questions, formality in decision making is a must; thus, we build models that can accommodate this higher degree of scrutiny. Ultimately, careful modeling can (and should) lead to better overall decision making.

1.4   Why Model Decision Problems with Excel?

So, if the modeling of decision problems is important and necessary in our work, then what modeling tool(s) do we select? In recent years, there has been little doubt as to the answer of this question for most decision makers: Microsoft Excel. Excel is

the most pervasive, all-purpose and first-stop modeling tool on the planet, due to its ease of use. It has a wealth of internal capability that continues to grow as each new version is introduced. Excel also resides in Microsoft Office, a suite of similarly popular tools that permit interoperability. Finally, there are tremendous advantages to *one-stop shopping* in the selection of a modeling tool (that is, a single tool with many capabilities). There is so much power and capability built into Excel that unless you have received very recent training in its latest capabilities, you might be unaware of the variety of modeling that is possible with Excel. Of course, there are occasions where advanced tools are required, but for most circumstances, Excel is sufficient. Here is the first layer of questions that decision makers should ask when considering Excel as tool:

1. What types of analysis are possible with Excel?
2. If my modeling effort requires multiple forms of analysis, can Excel handle the various techniques required?
3. If I commit to using Excel, will it be capable of handling new forms of analysis and a potential increase in the scale and complexity of my models?

The general answer to these questions is that just about any analytical technique that you can conceive that fits in the row-column structure of spreadsheets can be modeled with Excel. Note that this is a very broad and bold statement. Obviously, if you are modeling phenomena related to high energy physics or theoretical mathematics, you are very likely to choose other modeling tools. Yet, for the individual looking to model business problems, Excel is a must, and that is why this book will be of value to you. More specifically, Table 1.1 provides a partial list of the types of analytical tools this book will address.

When we first conceptualize and plan to solve a decision problem, one of the first considerations we face is which modeling tool or approach to use. There are business problems that are sufficiently unique and complex that will require a much more targeted and specialized modeling approach than Excel. Yet, most of us are involved with business problems that span a variety of problem areas—e.g. marketing issues that require qualitative database analysis, finance problems that require simulation of financial statements, and risk analysis that requires the determination of risk profiles. Spreadsheets permit us to unify these analyses on a single modeling platform. This makes our modeling effort: (1) *durable*—a robust structure that can anticipate varied

Table 1.1 Types of analysis this book will undertake

Quantitative data visualization/presentation—Graphs and charts
Quantitative data analysis—Summary statistics and data exploration and manipulation
Qualitative data visualization/presentation—Pivot tables and Pivot charts
Qualitative data analysis—Data tables, data queries, and data filters
Advanced statistical analysis—Hypothesis testing, confidence intervals, correlation analysis, and regression models Sensitivity analysis—One-way, two-way, data tables, visualization/graphical presentation
Optimization models and goal seek—Solver, optimization-constrained/unconstrained
Modeling uncertainty—Monte Carlo simulation, scenarios

future use, (2) *flexible*—capable of adaptation as the problem changes and evolves, and (3) *shareable*—models that can be shared by a variety of individuals at many levels of the organization, all of whom are collaborating in the solution process of the problem. Additionally, the standard programming required for spreadsheets is easier to learn than other forms of sophisticated programming languages found in many modeling systems. Even so, Excel has anticipated the occasional need for more formal programming by providing a resident, powerful programming language, VBA (Visual Basic for Applications).

The ubiquitous nature of Excel spreadsheets has led to serious academic research and investigation into their use and misuse. Under the general title of **spreadsheet engineering**, academics have begun to apply many of the important principles of software engineering to spreadsheets, attempting to achieve better modeling results: more useful models, fewer mistakes in programming, and a greater impact on decision making. The growth in the importance of this topic is evidence of the potentially high costs associated with poorly-designed spreadsheets.

In the next section, I address some **best practices** that will lead to superior everyday spreadsheet and workbook design, or *good spreadsheet engineering and data analytics*. Unlike some of the high-level concepts of spreadsheet engineering, I provide very simple and specific guidance for spreadsheet development. My recommendations are aimed at day-to-day users, and just as the ancient art of **Feng Shui** provides a sense of order and wellbeing in a building, public space, or home, these best practices can do the same for builders of spreadsheets.

1.5   The Feng Shui[1] of Spreadsheets

The initial development of a spreadsheet project should focus on two areas— (1) planning and organizing the problem to be modeled, and (2) use of general practices of good spreadsheet engineering. In this section, we focus on the latter. In succeeding chapters, we will deal with the former by presenting numerous forms of analysis that can be used to model business decisions. So, let us begin by presenting the following five best practices to consider when designing a spreadsheet model:

A. Think workbooks not worksheets—Spare the worksheet; spoil the workbook. When spreadsheets were first introduced, a workbook consisted of a single worksheet. Over time, spreadsheets have evolved into multi-worksheet workbooks, with interconnectivity between worksheets and other workbooks and files. In workbooks that represent serious analytical effort, you should be conscious of not attempting to place too much information, data, or analysis on a single worksheet. Thus, I always include on separate worksheets: (1) an *introductory* or *cover page* with documentation that identifies the purpose, authors, contact information, and

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[1]The ancient Chinese study of arrangement and location in one's physical environment, currently very popular in fields of architecture and interior design.

intended use of the spreadsheet model and, (2) a *table of contents* providing users with a glimpse of how the workbook will proceed. In deciding on whether or not to include additional worksheets, it is important to ask yourself the following question—Does the addition of a worksheet make the workbook easier to view and use? If the answer is yes, then your course of action is clear. Yet, there is a cost to adding worksheets—extra worksheets lead to the use of extra computer memory for a workbook. Thus, it is always a good idea to avoid the inclusion of gratuitous worksheets which, regardless of their memory overhead cost, can be annoying to users. When in doubt, I cautiously decide in favor of adding a worksheet.

B. Place variables and parameters in a central location—Every workbook needs a "Brain." I define a workbook's "Brain" as a central location for variables and parameters. Call it what you like—data center, variable depot, etc.—these values generally do not belong in cell formulas hidden from easy viewing. Why? If it is necessary to change a value that is used in the individual cell formulas of a worksheet, the change must be made in every cell containing the value. This idea can be generalized in the following concept: if you have a value that is used in numerous cell locations, and you anticipate the possibility of changing that value, then you should have the cells that use the value reference it at some central location ("Brain"). For example, if a specific interest or discount rate is used in many cell formulas and/or in many worksheets, you should locate that value in a single cell in the Brain to make a change in the value easier to manage. As we will see later, a Brain is also quite useful in conducting the sensitivity analysis for a model.

C. Design workbook layout with users in mind—User friendliness and designer control. As the lead designer of the workbook, you should consider how you want others to interact with your workbook. User interaction should consider not only the ultimate end use of the workbook, but also the collaborative interaction by others involved in the workbook design and creation process. Here are some specific questions to consider that facilitate **user-friendliness** and designer control:

a) What areas of the workbook will the *end users* be allowed to access when the design becomes fixed?
b) Should certain worksheets or ranges be hidden from *users*?
c) What specific level of design interaction will *collaborators* be allowed?
d) What specific worksheets and ranges will *collaborators* be allowed to access?

Remember that your authority as lead designer extends to testing the workbook and determining how end users will employ the workbook. Therefore, not only do you need to exercise direction and control for the development process of the workbook, but also how it will be used.

D. Document workbook content and development—Insert text and comments liberally. There is nothing more annoying than viewing a workbook that is incomprehensible. This can occur even in carefully designed spreadsheets. What leads to spreadsheets that are difficult to comprehend? From the user perspective, the complexity of a workbook can be such that it may be necessary for you to provide explanatory documentation; otherwise, worksheet details and overall analytical approach can bewilder the user. Additionally, the designer often needs to provide

users and collaborators with perspective on how and why a workbook developed as it did—e.g. why were certain analytical approaches incorporated in the design, what assumptions were made, and what were the alternatives considered? You might view this as justification, or defense, of the workbook design.

There are a number of choices available for documentation: (1) text entered directly into cells, (2) naming cell ranges with descriptive titles (e.g. Revenue, Expenses, COGS, etc.), (3) explanatory text placed in text boxes, and (4) comments inserted into cells. I recommend the latter three approaches—text boxes for more detailed and longer explanations, range names to provide users with descriptive and understandable formulas, since these names will appear in cell formulas that reference them, and cell comments for quick and brief explanations. In later chapters, I will demonstrate each of these forms of documentation.

E. Provide convenient workbook navigation— Beam me up Scotty! The ability to easily navigate around a well-designed workbook is a must. This can be achieved using **hyperlinks**. Hyperlinks are convenient connections to other cell locations within a worksheet, to other worksheets in the same workbook, or to other workbooks or other files.

Navigation is not only a convenience, but also it provides a form of control for the workbook designer. Navigation is integral to our discussion of "Design workbook layout with users in mind." It permits control and influence over the user's movement and access to the workbook. For example, in a serious spreadsheet project, it is essential to provide a table of contents on a single worksheet. The table of contents should contain a detailed list of the worksheets, a brief explanation of what is contained in the worksheet, and hyperlinks the user can use to access the various worksheets.

Organizations that use spreadsheet analysis are constantly seeking ways to incorporate best practices into operations. By standardizing the five general practices, you provide valuable guidelines for designing workbooks that have a useful and enduring life. Additionally, standardization will lead to a common "structure and look" that allows decision makers to focus more directly on the modeling content of a workbook, rather than the *noise* often caused by poor design and layout. The five best practices are summarized in Table 1.2.

Table 1.2   Five best practices for workbook deign

A. Think workbooks, not worksheets—Spare the worksheet; spoil the workbook
B. Place variables and parameters in a central location—Every workbook needs a Brain
C. Design workbook layout with users in mind—User friendliness and designer control
D. Document workbook content and development—Insert text and comments liberally
E. Provide convenient workbook navigation—Beam me up Scotty

1.6 A Spreadsheet Makeover

Now, let's consider a specific problem that will allow us to apply the best practices we have discussed. Our friends, Julia and Ram, are meeting several weeks after their initial encounter. It is early Sunday afternoon, and they have just returned from running a 10-km road race. The following discussion takes place after the run.

Julia: Ram, you didn't do badly on the run.

Ram: Thanks, but you're obviously being kind. I can't keep up with you. I'm exhausted.

Julia: Speaking of exhaustion, remember that project I told you my boss dumped on my desk? Well, I have a spreadsheet that I think does a pretty good job of solving the problem. Can you take a look at it?

Ram: Sure. By the way, do you know that Professor Lopez from our MBA has written a book on spreadsheet analysis? The old guy did a pretty good job of it, too. I brought along a copy for you.

Julia: Thanks. I remember him as being pretty good at simplifying some tough concepts.

Ram: His first chapter discusses a simple way to think about spreadsheet structure and workbook design—workbook *Feng Shui*, as he puts it. It's actually five best practices to consider in workbook design.

Julia: Maybe we can apply it to my spreadsheet? Ram: Yes, let's do it!

1.6.1 Julia's Business Problem–A Very Uncertain Outcome

Julia works for a consultancy, Market Focus International (MFI), which advises firms on marketing to American, ethic markets—Hispanic Americans, Lebanese Americans, Chinese Americans, etc. One of her customers, Mid-Atlantic Foods Inc., a prominent food distributor in the Mid-Atlantic of the U.S., is considering the addition of a new product to their ethnic foods line—flour *tortillas*.[2] The firm is interested in a forecast of the financial effect of adding flour tortillas to their product lines. This is considered a controversial product line extension by some of the Mid-Atlantic's management, so much so, that one of the executives has named the project *A Very Uncertain Outcome*.

Julia has decided to perform a **pro forma** (forecasted or projected) profit or loss analysis, with a relatively simple structure. The profit or loss statement is one of the most important financial statements in business. After interviews with the relevant individuals at the client firm, Julia assembles the important variable values and relationships that she will incorporate into her spreadsheet analysis. These values and relationships are shown in Fig. 1.1. The information collected reveals the considerable uncertainty involved in forecasting the success of the flour tortilla

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[2]A tortilla is a form of flat, unleavened bread popular in Mexico, Latin America, and the U.S.

Sales Revenue— Sales Volume (units) * Average Selling Price ($)
      Sales Volume (units)— (low- 2,000,000 / high- 5,000,000 / most likely- 3,500,000)
      Probability of Sales Volume— (low- 17.5% / high- 17.5% / most likely- 65%)
      Average Selling Price ($)— ($4, $5, or $6 with equal probability)

Cost of Goods Sold Expense— assumed to be a percent of the Sales Revenue- either 40% **or** 80% with   equal
      probability

           Gross Margin—   **Sales Revenue- Cost of Goods Sold Expense**

Variable Operating Expenses—
      Sales Volume Driven (VOESVD)—
             Sales Revenue * VOESVD%
             VOESVD% is 10% if sales volume is low or most likely; 20% otherwise

      Sales Revenue Driven (VOESRD)— Sales Revenue * VOESRD%
             If Sales Volume is =2,000,000 ...VOESRD% = 15%
             If Sales Volume is =3,500,000 ...VOESRD% = 10%
             If Sales Volume is =5,000,000 ...VOESRD% = 7.5%

          Contribution Margin—   **Gross Margin - Variable Operating Expenses**

 Fixed Expenses—
          Operating Expenses— $300,000

          Depreciation Expense— $250,000

          Operating Earnings (EBIT)—   **Contribution Margin - Fixed Expenses**
                                             (Earnings before interest and taxes)

 Interest Expense— $170,000

          Earnings before income tax (EBT)—**Operating Earnings - Interest Expense**

 Income Tax expense—   Progressive
                                             23% Marginal tax rate for 1-5,000,000 EBT
                                             34% Marginal tax rate >5,000,000 EBT

          Net Income—   **Earnings before income tax - Income Tax**
                                             (Bottom-line Profit)

Fig. 1.1   A Very Uncertain Outcome data

introduction. For example, the *Sales Revenue* (*Sales Volume* ∗ *Average Unit Selling* Price) forecast is based on three possible values of Sales Volume and three possible values of Average Unit Selling Price. This leads to nine (3 × 3) possible combinations of *Sales Revenue*. One combination of values leading to *Sales Revenue* is volume of 3.5 million units in sales and a selling unit price of $5, or *Sales Revenue* of $17.5 million. Another source of uncertainty is the percentage of the *Sales Revenue* used to calculate *Costs of Goods Sold Expense*, either 40% or 80% with equal probability of occurrence. **Uncertainty** in sales volume and sales price also affects the variable expenses. Volume driven and revenue driven variable expenses are also dependent on the uncertain outcomes of *Sales Revenue* and *Sales Volume*.

   Julia's workbook appears in Figs. 1.2 and 1.3. These figures provide details on the cell formulas used in the calculations. Note that Fig. 1.2 consists of a single
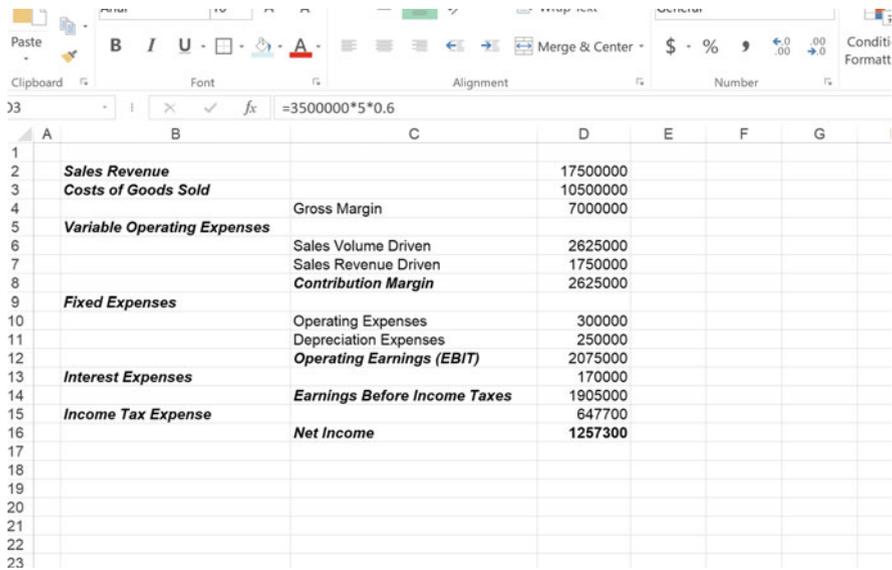
The formula bar shows: `=3500000*5*0.6`

A	B	C	D	E	F	G
1						
2	*Sales Revenue*		17500000			
3	*Costs of Goods Sold*		10500000			
4		Gross Margin	7000000			
5	*Variable Operating Expenses*					
6		Sales Volume Driven	2625000			
7		Sales Revenue Driven	1750000			
8		Contribution Margin	2625000			
9	*Fixed Expenses*					
10		Operating Expenses	300000			
11		Depreciation Expenses	250000			
12		Operating Earnings (EBIT)	2075000			
13	*Interest Expenses*		170000			
14		Earnings Before Income Taxes	1905000			
15	*Income Tax Expense*		647700			
16		Net Income	1257300			
17						
18						
19						
20						
21						
22						
23						

Fig. 1.2 Julia's initial workbook

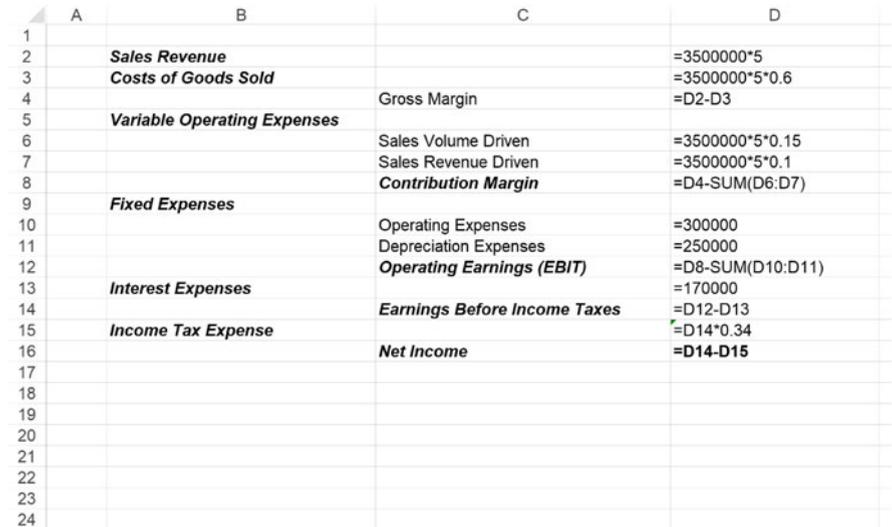|	A	B	C	D
1				
2		*Sales Revenue*		=3500000*5
3		*Costs of Goods Sold*		=3500000*5*0.6
4			Gross Margin	=D2-D3
5		*Variable Operating Expenses*		
6			Sales Volume Driven	=3500000*5*0.15
7			Sales Revenue Driven	=3500000*5*0.1
8			Contribution Margin	=D4-SUM(D6:D7)
9		*Fixed Expenses*		
10			Operating Expenses	=300000
11			Depreciation Expenses	=250000
12			Operating Earnings (EBIT)	=D8-SUM(D10:D11)
13		*Interest Expenses*		=170000
14			Earnings Before Income Taxes	=D12-D13
15		*Income Tax Expense*		=D14*0.34
16			Net Income	=D14-D15
17				
18				
19				
20				
21				
22				
23				
24				

Fig. 1.3 Julia's initial workbook with cell formulas shown

worksheet comprised of a *single* forecasted Profit or Loss scenario; that is, she has selected a single value for the uncertain variables (the most likely) for her calculations. The *Sales Revenue* in Fig. 1.3 is based on sales of 3.5 million units, the most likely value for volume, and a unit price of $5, the mean/average, of equally possible unit selling prices.

Her calculation of *Cost of Goods Sold Expense* (COGS) is not quite as simple to determine. There are two equally possible percentages, 40% or 80%, that can be multiplied times the *Sales Revenue* to determine COGS. Rather than select one, she has decided to use a percentage value that is at the midpoint of the range, 60%. Thus, she has made some assumptions in her calculations that may need explanation to the client, yet there is no documentation of her reasons for this choice, or any other assumption.

Additionally, in Fig. 1.3 the inflexibility of the workbook is apparent—all parameters and variables are imbedded in the workbook formulas; thus, if Julia wants to make changes to these assumed values, it will be difficult to undertake. To make these changes quickly and accurately, it would be wiser to place these parameters in a central location—in a *Brain*—and have the cell formulas refer to this location. It is quite conceivable that the client will want to ask some **what-if** questions about her analysis. For example, what if the unit price range is changed from 4, 5 and 6 dollars to 3, 4, and 5 dollars; what if the most likely *Sales Volume* is raised to 4.5 million. Obviously, there are many more questions that Ram could ask before providing a formal critique of Julia's workbook and analysis, a critique that is organized around the five best practices. Julia hopes that by sending the workbook to Ram, he will suggest changes to improve the workbook.

1.6.2   Ram's Critique

After considerable examination of the worksheet, Ram gives Julia his recommendations for a "spreadsheet makeover" in Table 1.3. He also makes some general analytical recommendations that he believes will improve the usefulness of the workbook. Ram has serious misgivings about her analytical approach. It does not, in his opinion, capture the substantial *uncertainty* of her *A Very Uncertain Outcome* problem. Although there are many possible avenues for improvement, it is important to provide Julia with rapid and actionable feedback; she has a deadline that must be met for the presentation of her analytical findings. His recommendations are organized in terms of the five best practices (P/A = Practice A, etc.) in Table 1.3.

1.6.3   Julia's New and Improved Workbook

Julia's initial reaction to Ram's critique is a bit guarded. She wonders what added value will result from applying the best practices to workbook, and how the sophisticated analysis that Ram is suggesting will help the client's decision-making. More importantly, she also wonders if she is capable of making the changes. Yet, she understands that the client is quite interested in the results of the analysis, and anything she can do to improve her ability to provide insight to this problem and of course, sell future consulting services, are worth considering carefully. With Ram's critique in mind, she begins the process of rehabilitating the spreadsheet

Table 1.3 Makeover recommendations for Julia

General Comment—I don't believe that you have adequately captured the uncertainty associated with the problem. In all cases you have used a single value of a set, or distribution, of possible values—e.g. you use 3,500,000 as the Sales Volume. Although this is the most likely value, 2,000,000 and 5,000,000 have a combined probability of occurrence of 35% —a non-trivial probability of occurrence. By using the full range of possible values, you can provide the user with a view of the *variability* of the resulting "bottom line value-Net Income" in the form of a *risk profile*. This requires randomly selecting (random sampling) values of the uncertain parameters from their stated distributions. You can do this through the use of the RAND() function in Excel, and repeating these experiments many times, say 100 times. This is known as **Monte Carlo Simulation**. (Chaps. 7 and 8 are devoted to this topic.)
P/A—The Workbook is simply a single spreadsheet. Although it is possible that an analysis would only require a single spreadsheet, I don't believe that it is sufficient for this complex problem, and certainly the customer will expect a more complete and sophisticated analysis. —*Modify the workbook to include more analysis, more documentation, and expanded presentation of results on separate worksheets.*
P/B—There are many instances where variables in this problem are imbedded in cell formulas (see Fig. 1.2 cell D3...3500000*5*0.6). The variables should have a separate worksheet location for quick access and presentation—a *Brain*. The cell formulas can then reference the cell location in the Brain to access the value of the variable or parameter. This will allow you to easily make changes in a single location and note the sensitivity of the model to these changes. If the client asks *what if* questions during your presentation of results, the current spreadsheet will be very difficult to use. —*Create a Brain worksheet in the workbook.*
P/C—The new layout that results from the changes I suggest should include several user-friendliness considerations— (1) *create a table of contents*, (2) *place important analysis on separate worksheets, and* (3) *place the results of the analysis into a graph that provides a "risk profile" of the problem results (see* Fig. 1.7). Number (3) *is related to a larger issue of appropriateness of analysis (see General Comment).*
P/D—Document the workbook to provide the user with information regarding the assumptions and form of analysis employed— *Use text boxes to provide users with information on assumed values (Sales Volume, Average Selling Price, etc.), use cell comments to guide users to cells where the input of data can be performed, and name cell ranges so formulas reflect directly the operation being performed in the cell.*
P/E—Provide the user with navigation from the table of content to, and within, the various worksheets of the workbook— *Insert hypertext links throughout the workbook.*

she has constructed by concentrating on three issues: reconsideration of the overall analysis to provide greater insight of the uncertainty, structuring and organizing the analysis within the new multi-worksheet structure, and incorporating the five best practices to improve spreadsheet functionality.

In reconsidering the analysis, Julia agrees that a single-point estimate of the P/L statement is severely limited in its potential to provide Mid-Atlantic Foods with a broad view of the uncertainty associated with the extension of the product line. A **risk profile**, a distribution of the net income outcomes associated with the uncertain values of volume, price, and expenses, is a far more useful tool for this purpose. Thus, to create a risk profile it will be necessary to perform the following:

1. place important input data on a single worksheet that can be referenced ("*Brain*")
2. simulate the possible P/L outcomes on a single worksheet ("*Analysis*") by randomly selecting values of uncertain factors
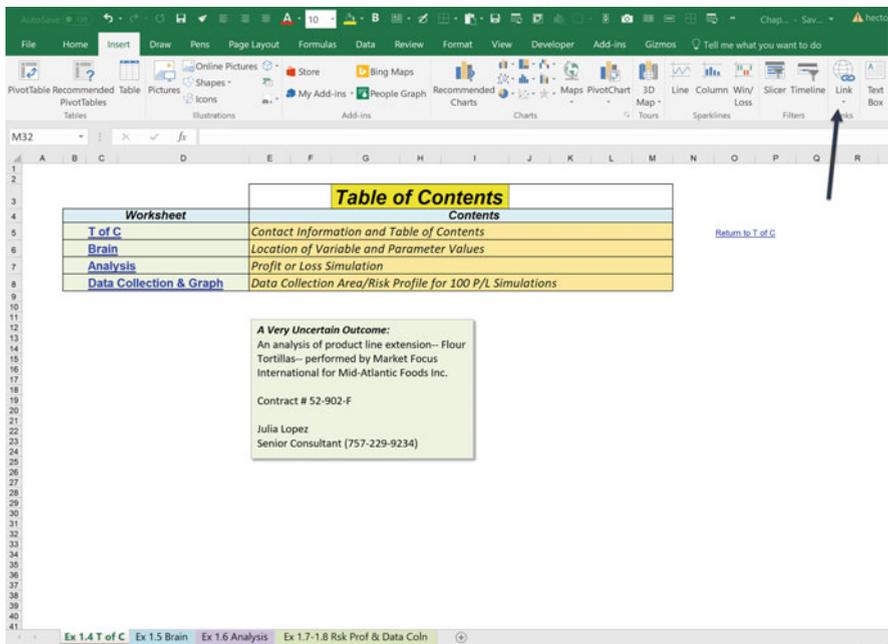
Fig. 1.4 Improved workbook—Table of Contents

3. repeat the process numerous times—100 (an arbitrary choice for this example)
4. collect the data on a separate worksheet and present the data in a graphical format that provides the Risk Profile for the simulation (*"Rsk Prof and Data Coln"*)

This suggests two worksheets associated with the analysis ("*Analysis*" and *"Rsk Prof and Data Coln"*)). If we consider the additional worksheet for the location of important parameter values ("*Brain*") and a location from which the user can navigate the multiple worksheets ("*Table of Contents*"), we are now up to a total of four worksheets. Additionally, Julia realizes that she must avoid the issues of inflexibility we discussed above in her initial workbook (Fig. 1.3). Finally, she is aware that she will have to automate the data collection process by creating a simple **macro** that generates simulated outcomes, captures the results, and stores 100 such results in worksheet. A macro is a computer program written in a simple language (**VBA**) that performs specific Excel programming tasks for the user, and it is beyond Julia's capabilities. Ram has skill in creating macros and has volunteered to help her.

Figure 1.4 presents the new four worksheet structure that Julia has settled on. Each of the colored tabs, a useful identification feature, represents a worksheet. The worksheet displayed, "Ex 1.4 T of C", is the Table of Contents. Note that the underlined text items in the table are *hyperlinks* that transfer you to the various worksheets. Moving the cursor over the link will permit you to click the link and then automatically transfer you to the specified location. Insertion of a hyperlink is

	A	B	C	D	E	F	G	H	I
1									
2		*Señor Brain*					Return to T of C		
3									
4	**Sales Revenue**								
5		Sales Volume			2,000,000	3,500,000	5,000,000		
6		Probability of Sales Volume			17.5%	17.5%	65.0%		
7		Average Selling Price			4	5	6		
8		Probability of Selling Price			33.3%	33.3%	33.3%		
9									
10	**Cost of Goods Sold Expense %**				40%	80%			
11		Probability of COGS Expense %			50%	50%			
12									
13	**Variable Operating Expense**				2,000,000	3,500,000	5,000,000		
14		Sales Volume Driven (VOESVD)			10%	10%	20%		
15		Sales Revenue Driven (VOESRD)			15%	10%	7.5%		
16									
17									
18	**Fixed Expenses**								
19		Operating Expenses			$ 300,000				
20		Depreciation Expense			$ 250,000				
21									
22	**Interest Expense**				$ 170,000				
23									
24		Income Tax expense			23%	34%			
25		(breakpoint)			5,000,000				
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									

Ex 1.4 T of C   **Ex 1.5 Brain**   Ex 1.6 Analysis   Ex 1.7-1.8 Rsk Prof & Data Coln   ⊕

Fig. 1.5 Improved workbook—Brain

performed by selecting the icon in the *Insert* menu bar that is represented by a globe and links of a chain (see the Insert menu tab in Fig. 1.4). When this Globe icon is selected, a dialog box will guide you to where you would like the link to transfer the cursor, including questions regarding whether the transfer will be to this or other worksheets, or even other workbooks or files. Note that this worksheet also provides documentation describing the project in a text box.

In Fig. 1.5, Julia has created a Brain, which she has playfully entitled Señor (Mr.) Brain. We can see how data from her earlier spreadsheet (see Fig. 1.1) is carefully organized to permit direct and simple referencing by formulas in the *Analysis* worksheet. If the client should desire a change to any of the assumed parameters or variables, the Brain is the place to perform the change. Observing the sensitivity of the P/L outcomes to these changes is simply a matter of adjusting the relevant data elements in the Brain, and noting the new outcomes. Thus, Julia is prepared for the

	A	B	C	D	E	F	G	H	I
1									
2		*Sales Revenue*					30,000,000		
3									
4		*Cost of Goods Sold Expense*					24,000,000		
5			*Gross Margin*				6,000,000		
6		*Variable Operating Expenses*							
7			*Sales Volume Driven*				6,000,000		
8			*Sales Revenue Driven*				2,250,000		
9			*Contribution Margin*				(2,250,000)		
10		*Fixed Expenses*							
11			*Operating Expenses*				300,000		
12			*Depreciation Expense*				250,000		
13			*Operating Earnings (EBIT)*				(2,800,000)		
14		*Interest Expense*					170,000		
15			*Earnings before income tax*				(2,970,000)		
16		*Income Tax expense*							
17			*Net Income*				**(2,970,000)**		
18									
19									
20									
21									
22									
23									
24									
25									
26									

Ex 1.4 T of C   Ex 1.5 Brain   **Ex 1.6 Analysis**   Ex 1.7-1.8 Rsk Prof & Data Coln   ⊕

Fig. 1.6 Improved workbook—Analysis

clients *what if* questions. In later chapters we will refer to this process as **Sensitivity Analysis**.

The heart of the workbook, the *Analysis* worksheet in Fig. 1.6, simulates individual scenarios of P/L *Net Income* based on randomly generated values of uncertain parameters. The determination of these uncertain values occurs off the screen image in columns N, O, and P. The values of sales volume, sales price, and COGS percentage are selected randomly according to the specified distributions and used to calculate a *Net Income*. This can be thought of as a single scenario: a result based on a specific set of randomly selected variables. Then, the process is repeated to generate many P/L outcome scenarios. All of this is managed by the macro that automatically makes the random selection, calculates new *Net Income*, and records the *Net Income* to a worksheet called *Data Collection Area*. The appropriate number of scenarios, or iterations, for this process is a question of simulation design. It is important to select a number of scenarios that reflect accurately the full behavior of the *Net Income*. Too few scenarios may lead to unrepresentative results, and too many scenarios can be costly and tedious to collect. Note that the particular scenario in Fig. 1.6 shows a *loss* of $2.97 million. This is a very different result from her simple analysis in Fig. 1.2, where a profit of over $1,000,000 was presented. (More discussion of the proper number of scenarios can be found in Chaps. 7 and 8.)

In Fig. 1.7, *Graph-Risk profile*, simulation results (recorded in the data collection area and shown in Fig. 1.8) are arranged into a frequency distribution by using the Data Analysis tool (more on this tool in Chaps. 2, 3, 4, and 5) available in the Data Tab. A frequency distribution is determined from a sample of variable values and provides the number of scenarios that fall into a relatively narrow range of *Net*
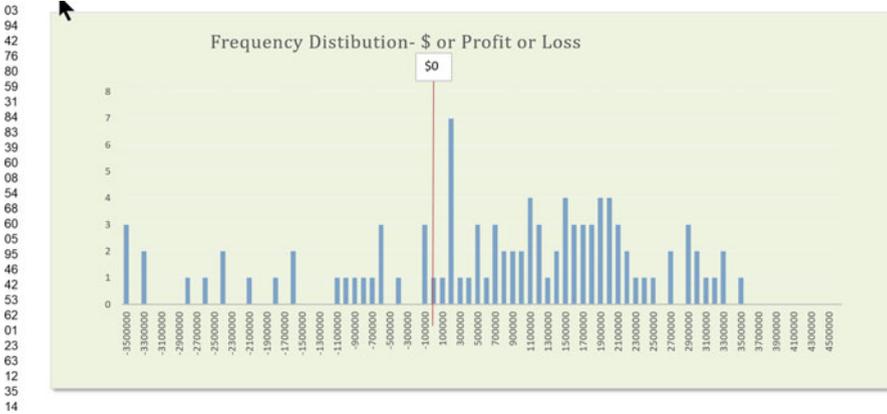
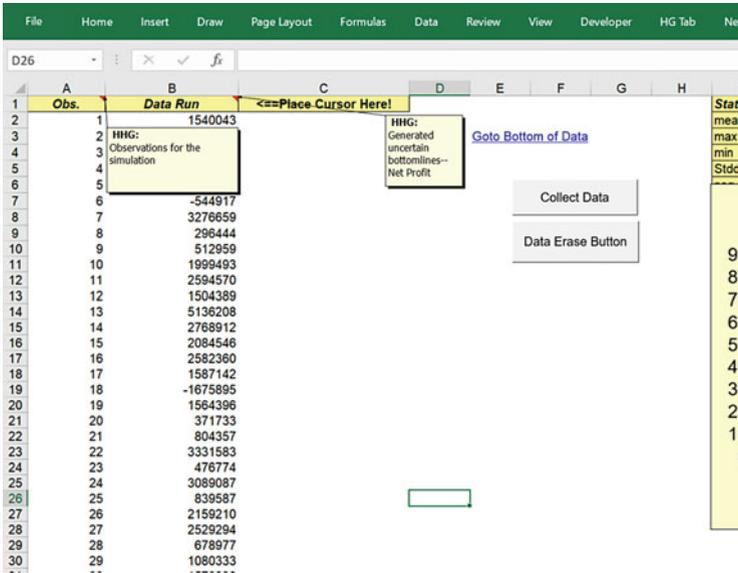**Fig. 1.7** Improved workbook—Graph-Risk profile

Fig. 1.8 Improved workbook—Data Collection Area

Income performance; for example, a range from $1,000,000 to $1,100,000. By carefully selecting these ranges, also known as bins, and counting the scenarios falling in each, a profile of outcomes can be presented graphically. We often refer to these graphs as *Risk Profiles*. This title is appropriate given that the client is presented with both the positive (higher net income) and negative (lower net income) risk associated with the adoption of the flour tortilla product line.

It is now up to the client to take this information and apply some decision criteria to either accept or reject the product line. Those executives that are *not* predisposed to adopting the product line might concentrate on the negative potential outcomes. Note that in 26 of the 100 simulations, the P/L outcome is zero or a loss, and with a substantial downside risk—13 observations are losses of at least $16 million.

This information can be gleaned from the risk profile or the frequency distribution that underlies the risk profile. Clearly, the information content of the risk profile is far more revealing than Julia's original calculation of a single profit of $1,257,300, based on her selective use of specific parameter values. As a manager seeking as thorough of an analysis as possible, there is little doubt that they would prefer the risk profile to the single scenario that Julia initially produced.

1.7   Summary

This example is one that is relatively sophisticated for the casual or first-time user of Excel. Do not worry if you do not understand every detail of the simulation. It is presented here to help us focus on how a simple analysis can be extended and how our best practices can improve the utility of a spreadsheet analysis. In later chapters, we will return to these types of models and you will see how such models can be constructed.

It is easy to convince oneself of the lack of importance of an introductory chapter of a textbook, especially one that in later chapters focuses on relatively complex analytical issues. Most readers often skip an introduction or skim the material in a casual manner, preferring instead to get the "real meat of the book." Yet, in my opinion, this chapter may be one of the most important chapters of this book. With an understanding of the important issues in spreadsheet design, you can turn an ineffective, cumbersome, and unfocused analysis into one that users will hail as an "analytical triumph." Remember that spreadsheets are used by a variety of individuals in the organization—some at higher levels and some at lower levels. The design effort required to create a workbook that can easily be used by others and serve as a collaborative document by numerous colleagues is not an impossible goal to achieve, but it does require thoughtful planning and the application of a few simple, best practices. As we saw in our example, even the analysis of a relatively simple problem can be greatly enhanced by applying the five practices in Table 1.2. Of course, the significant change in the analytical approach is also important, and the remaining chapters of the book are dedicated to these analytical topics.

In the coming chapters, we will continue to apply the five practices and explore the numerous analytical techniques that are contained in Excel. For example, in the next four chapters, we examine the data analytic capabilities of Excel with quantitative (numerical—e.g. 2345.81 or 53%) and qualitative (categorical—e.g. registered voter vs. unregistered voter or individuals born in Beijing City vs. Chengdu City) data. We will also see how both quantitative and qualitative data can be presented in charts and tables to answer many important business questions; graphical data analysis, or **data visualization**, can be very persuasive in decision-making.

Key Terms

Web Crawling
Decision Support Systems
Spreadsheet Engineering
Best Practices
Feng Shui
User Friendliness
Hyperlinks
Pro Forma
Uncertainty
What-if
Monte Carlo Simulation
Risk Profile
Macro
VBA
Sensitivity Analysis
Data Visualization

Problems and Exercises

1. Consider a workbook project that you or a colleague have developed in the past and apply the best practices of the *Feng Shui of Spreadsheets* to your old work book. Show both workbooks to a friend or colleague and ask which they prefer.

2. Create a workbook that has four worksheets—Table of Contents, Me, My Favorite Pet, and My Least Favorite Pet. Place hyperlinks on the Table of Contents to permit you to link to each of the pages and return to the Table of Contents. Insert a picture of yourself on the Me page and a picture of pets on the My Favorite Pet and My Least Favorite Pet page. Be creative and insert any text you like in text boxes explaining who you are and why these pets are your favorite and least favorite.

3. What is a *risk profile*? How can it be used for decision making?

4. Explain to a classmate or colleague why Best Practices in creating workbooks and worksheets are important. Ask them if they have a favorite or any to add.

5. *Advanced Problem*—An investor is considering the purchase of one to three condominiums in the tropical paradise of Costa Rica. The investor has no intention of using the condo for her personal use, and is only concerned with the income producing capability that it will produce. After some discussion with a long time and real estate savvy resident of Costa Rica, the investor decides to perform a simple analysis of the operating profit/loss based on the following information:

Variable property	A	B	C
Cost[a]	Based on: Most likely monthly occupancy of 20 day 12 months per year operation 2000 Colones per occupancy day cost	Based on: Most likely monthly occupancy of 25 day 12 months per year operation 1000 Colones per occupancy day cost	Based on: Most likely monthly occupancy of 15 day 10 months per year operation 3500 Colones per occupancy day cost
Fixed property cost[a]	3,000,000	2,500,000	4,500,000
Daily revenue[a]	33,800	26,000	78,000

[a]All *Cost* and *Revenues* in **Colones**–520 Costa Rican **Colones/US Dollar**

Additionally, the exchange rate may vary ±15%, and the most likely occupancy days can vary from a low and high of 15–25, 20–30, and 10–20 for A, B, and C, respectively. Based on this information, create a workbook that determines the best case, most likely, and worse case annual cash flows for each of the properties.