Excel Models

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Abstract

Personal financial planning jobs, like most other jobs in finance, require Excel skills. Students studying finance and many finance professors know most of Excel's features, such as pivot tables, but lack the skills needed to create and design financial models. Many Excel examples in finance textbooks violate obvious Best Practices or design guidelines. In this paper these Excel Best Practices are discussed and three financial models are used to illustrate them. Two of the examples are basic financial planning models and the other example illustrates Monte Carlo simulation. These examples should improve the Excel modeling skills of the professors teaching financial planning courses and their students.

Note

This PDF file has attached Excel files. A red paper clip identifies each attached file. You can either double left click or single right click the paper clip. When you double left click the paper clip the attached Excel file should open. When you single right click on the red paperclip a pop up menu should appear. From this pop up menu choose open file.

Introduction

Benninga (2006, page 7), in his finance textbook *Principles of Finance and Excel*, states that "th(e) combination of Excel and finance will … enhance your employment opportunities. Excel is practically the only financial tool used by business today."

Similarly , Craig W. Holden and Kent L. Womack ("Spreadsheet Modeling in Finance and Investment Courses, http://papers.ssrn.com, 2000, page 2) state that "it is probably safe to say

that there is no finance function in a post-college job … that does not use a spreadsheet program, such as Excel, regularly. Teaching students how to actually build financial models using a spreadsheet program like Excel is the best way to prepare them for the business world."

Additionally, Holden and Womack indicate that the "computing platform required in Business Schools is changing." The number of schools "requiring" students to own a portable computer is increasing each year. Also, many schools have wired or wireless network connections in classrooms. Excel is (or should be) replacing the financial calculator.

The appendix is an advertisement for a Wealth Management job in Chicago. It is typical of many of the financial planning jobs listed in the jobs section of ChicagoTribune.com. It indicates that the job candidate must be proficient with Excel and be able to create financial illustrations that use Monte Carlo simulation.

Students who know only Excel features but lack the best practices skills to create and design financial models have a distinct disadvantage.

Purpose and Motivation

Most Excel books explain the use of various Excel features with a limited discussion of when and why things should be done. Stated differently, most of the books are "how to" books. Two exceptions are Chapter 5, How to Build Good Excel Models, in Senguta (2004), and Chapter 5, Spreadsheet Engineering, in Power and Baker (2004). Some of the Best Practices presented in this paper are from these two chapters. Others are the Excel books written by John Walkenbach and Bill Jelen (see references). John Walkenbach is known as "Mr. Spreadsheet" and Bill Jelen is known as "Mr. Excel."

Many finance teachers and finance students have some knowledge of many of the features of Excel. However, their knowledge of when and where they should use these Excel features when creating and designing a financial model is limited. These Excel Best Practices should enhance this knowledge.

Using Excel Best Practices should result in financial models that are more efficient and useable. More efficient means financial models created in less time and with fewer errors. Useable means that the user of the financial model can easily determine what the model does and does not do and can easily use it.

Best Practices

The Excel Best Practices are presented and illustrated for Microsoft Excel 20003 (for the personal computer, PC). Most Best Practices also apply to earlier versions, Excel 2002 and Excel 2000. Significant differences amongst these three versions are mentioned.

The Best Practices are presented chronologically. That is, the Best Practices start with what you should do before starting the Excel program and end with what should be done before saving the Excel workbook the final time.

There are 11 Best Practices categories. They are

1. What to do before starting Excel.
2. What to do immediately after opening Excel.
3. Model documentation.
4. Modeling inputs, outputs, and analysis sections.
5. Key features when creating formulas (and when using Excel functions).
6. Moving around a worksheet and workbook.
7. Key chart features.
8. When to use sensitivity analysis and how best to do it.
9. When to do formatting and some formatting suggestions.
10. How to check for errors, how to minimize errors, and how to prevent errors.
11. What do to when model is completed but before saving the workbook.

The format is to mention the Best Practices in each category then discuss and illustrate them.

Assumption

The Excel presentation in this paper presumes a basic knowledge of Excel. This basic knowledge includes the basics of formatting, creating charts, writing formulas, using Excel functions, and using other features such as data tables and scenario manager. It does not use any macros (Visual Basic for Applications).

Best Practice 1: What to do before starting Excel.

Before using Excel to create a financial model there are a few issues that should be thought over.

1. How many worksheets to use.
2. How to orientate the data on each worksheet.
3. How general to make the model.

The basic design guidelines of a financial model should follow some of the basic design guidelines for web pages. For instance, it is desirable to use more than one worksheet instead of scrolling hundreds of rows on one worksheet.

The orientation of a financial model should be like a paper and pencil version. For instance, when creating a loan amortization schedule each month (or payment) should be a row. Most balance sheets and income statements should be the same as they are on web pages (accounts are on each row and data for a given time period on each column).

Decide how general the model should be. Some issues to decide for a capital budgeting problem:

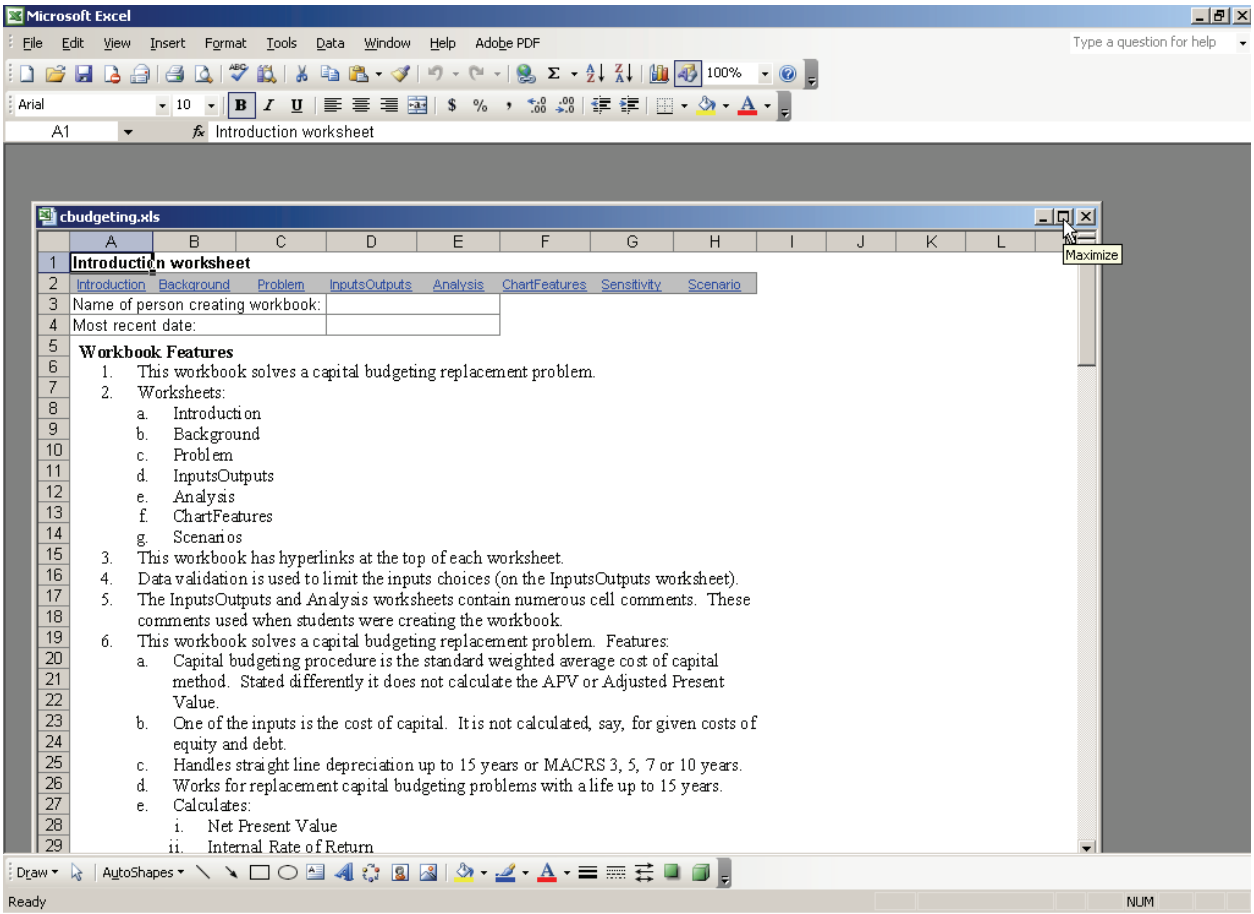
1. How many years to consider.
2. Whether to allow for nominal and real cash flows.
3. How many techniques to include (e.g. NPV, IRR, MIRR, and so forth).
4. Whether it will be for new investments, or replacement investments or both.

Best Practice 2: What to do immediately after opening Excel.

1. Immediately after opening the workbook save and rename the Excel workbook.
2. Maximize the workbook.
3. Check AutoRecover Time (Tools, Options, Save tab).
4. Show Standard and Formatting toolbars on two rows (Tools, Customize, Options tab).
5. Show all choices under each menu (Tools, Customize, Options tab).
6. Activate the Analysis ToolPak Add-ins (Tools, Add-ins).
7. Close the Task Pane. This is on the right side of the screen. It takes up valuable space.

If opening a new workbook the default filename is Book1.xls. It is best to create a more descriptive name immediately and place this file in an appropriate folder. Also, sometimes a financial model that has already been created is used as the starting point for a new model. Thus, save as a new name so that the retrieved file is not altered.

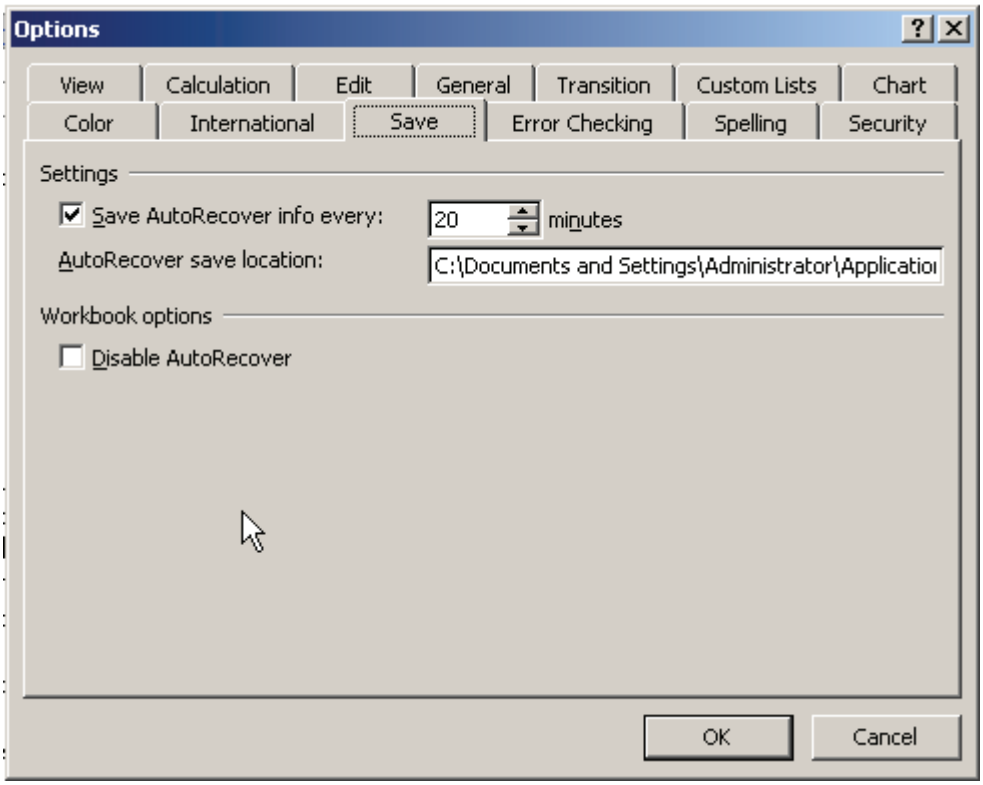
The following image shows a workbook that is not maximized.



Notice, the worksheet tabs are not visible. This is an obvious problem. To maximize the

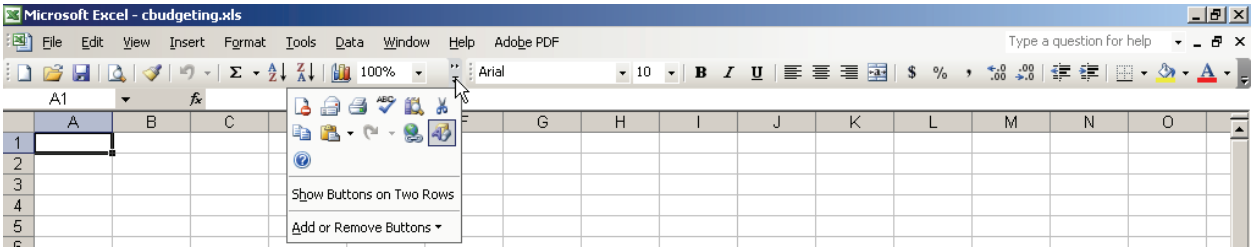
workbook select (left click) the maximize box shown above.

Excel 2003 has an Autorecove feature. To access it select, from the menu, Tools and Options. Then go to the Save tab. The following dialog box appears.

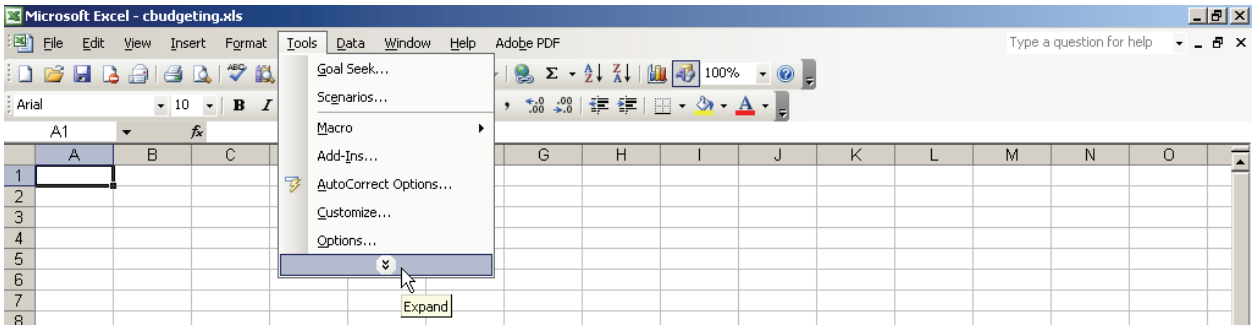


There is no warning when the AutoRecover feature is selected. When it runs a brief line appears on the bottom left of the Excel workbook. One negative effect is that all previous commands that are stored in Undo are lost each time AutoRecover runs.

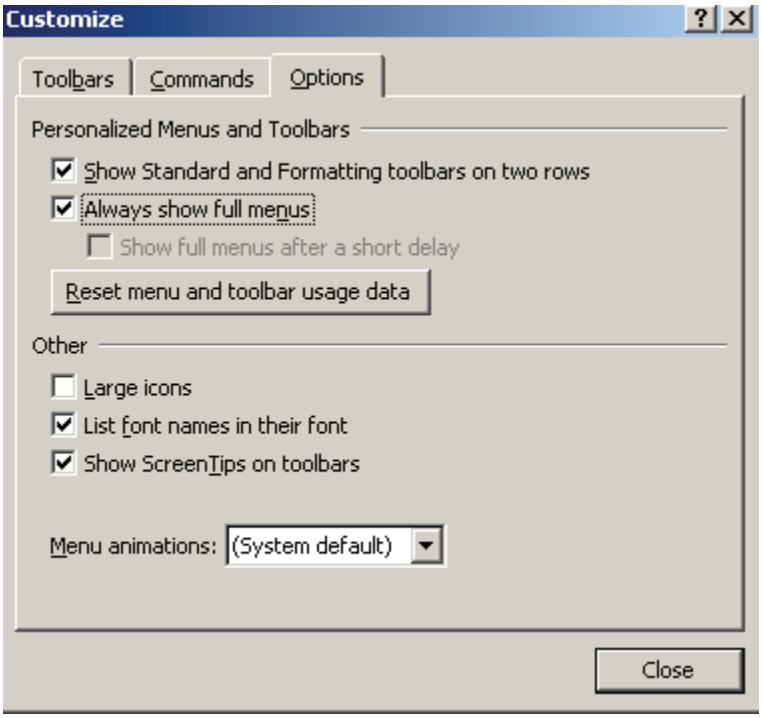
The default Excel display is to show the Standard and Formatting toolbars on one line. For most screen resolutions this hides some of the toolbar buttons. It is best to show these toolbars on two lines. The loss of worksheet space is minimal. One way to display these toolbars on two lines is to select the drop down arrow at the end of a toolbar. Another way is the menu: Tools, Customize, and the Options tab. See following image.



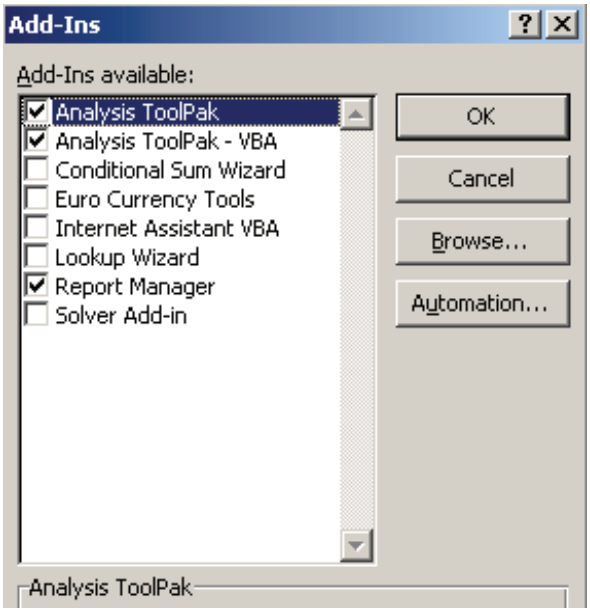
The default is to show only part of the choices. Then you have to select an arrow at the bottom of the menu choices to see (expand) the entire menu. The following image is an illustration.



When using Excel efficiently the menu is used infrequently. Thus, each time you go to the menu you have to select expand from the drop down menu (see above). To have the expanded menu, choose Tools, Customize, and the Options tab from the Excel menu. After making these selections the following screen appears. Check both boxes in the Personalized Menus and Toolbars section check. In Excel 2000 you remove the check boxes to always display the expanded menu and to show the Standard and Formatting toolbars on two lines.



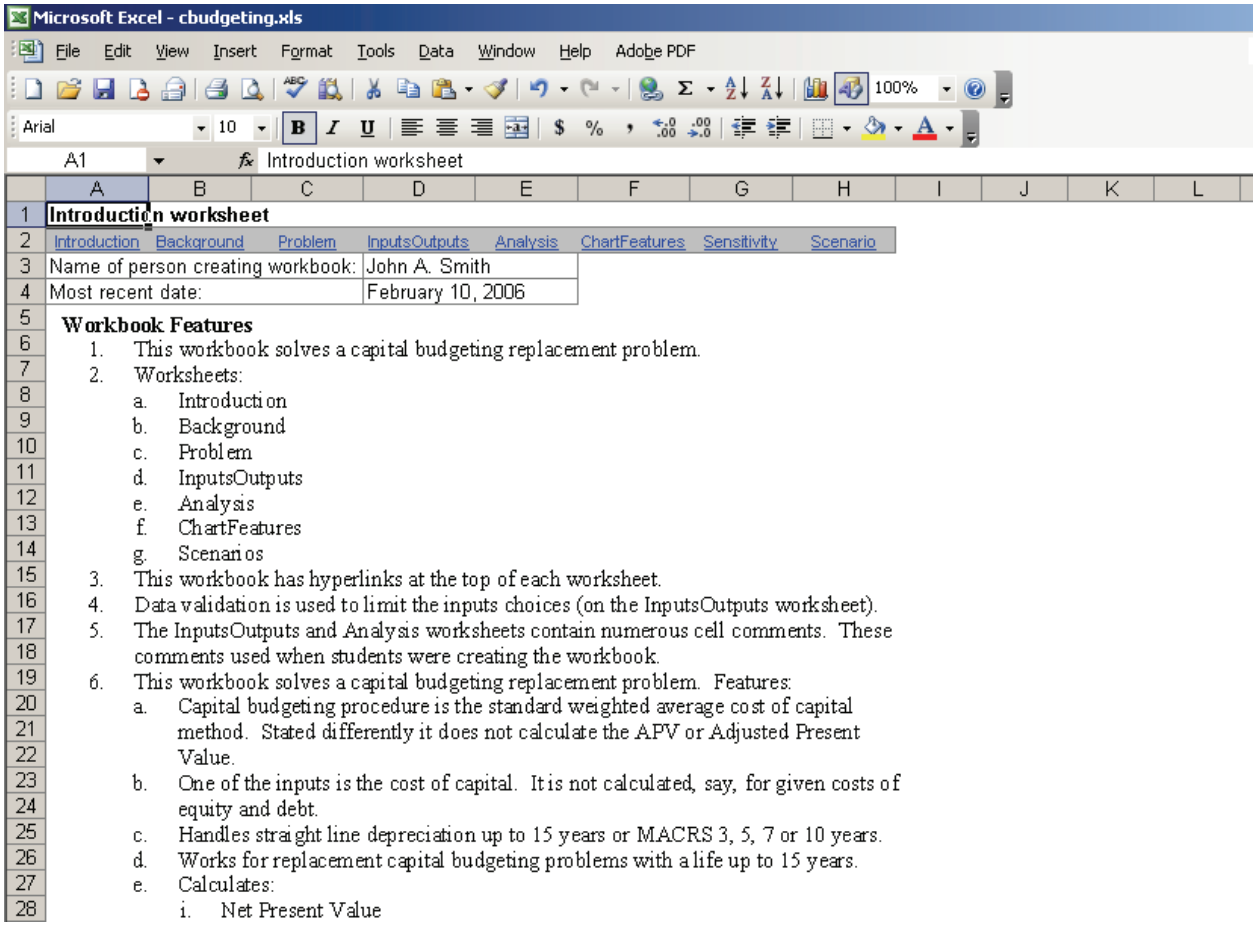
Many of Excel's financial functions are in the Analysis ToolPak add-in. For instance, all of the bond functions are part of this Add-in. To activate these Add-in select Tools, Add-ins and the Add-ins dialog box appears (see following image). Check the box to the left of Analysis ToolPak and select OK.



Best Practice 3: Model Documentation.

1. Place upper left corner of first worksheet.
2. Information to include
   a. Name of person creating model.
   b. Date model completed.
   c. Tab names of worksheets.
   d. Key model features.
   e. Key model assumptions.

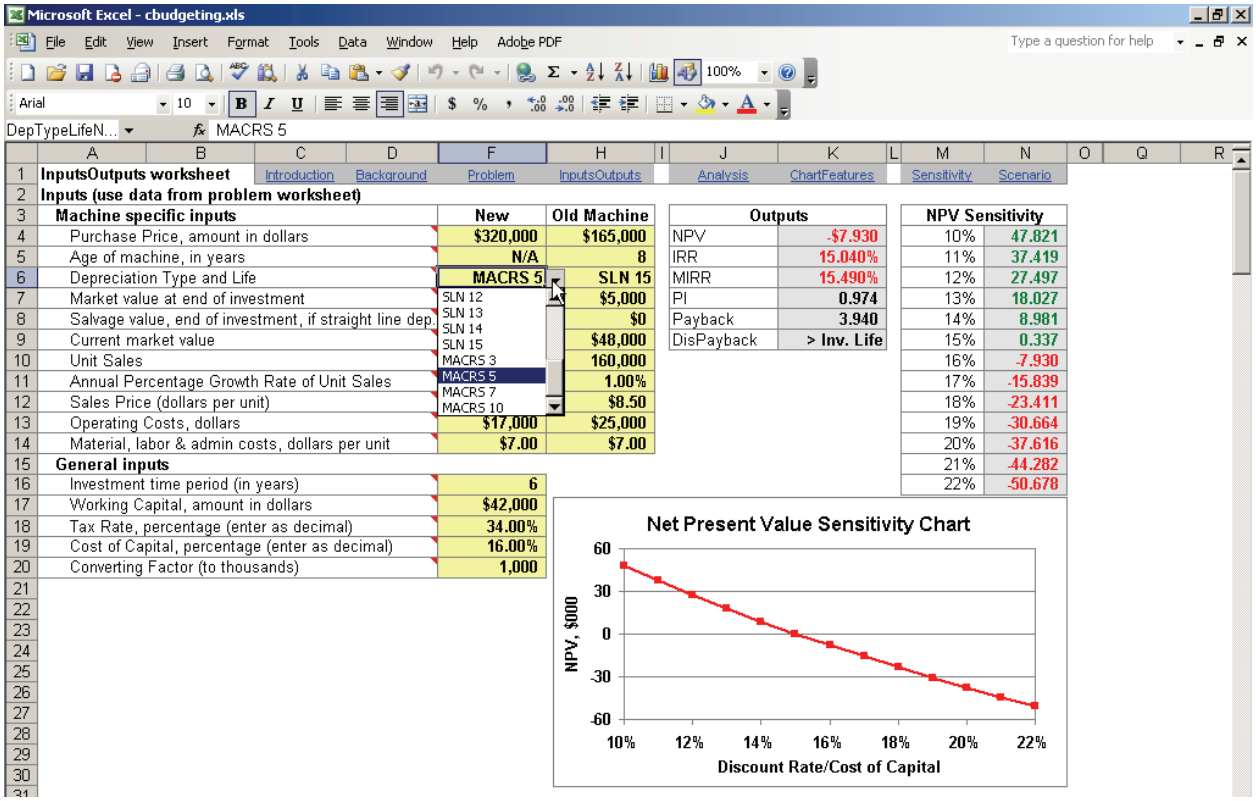
The following image illustrates some of the information that should be at the top of the first worksheet in a workbook. You see the name of the person that created the workbook, when it was finished, what it does, names of the worksheet, model assumptions and so forth.



Best Practice 4: Modeling inputs, outputs, and analysis sections.

1. Inputs above or to left of outputs.
2. Inputs at top of worksheet.
3. Both inputs and outputs visible on the screen.
4. Inputs should only be values. That is, no formulas.
5. Name input cells.
6. Use data validation to limit inputs.
7. Use cell background color to highlight inputs and outputs.
8. Cells with numerical values in outputs and analysis sections are “created” with cell references and/or cell formulas.

Consider the following inputs and outputs for a capital budgeting problem.



Notice that all of the inputs are identified by a yellow cell background. Cell comments, the red triangles, help indicate what goes in each input cell. Additionally, cell F6 uses data validation to limit the types of depreciation that can be selected.

Best Practice 5: Key features when creating formulas (and when using Excel functions).

1. When writing cell formulas that contain cell references select the cell. That is, do not type out the cell row and column identifier.
2. If needed, use the F4 function key to change the cell reference form relative to absolute.
3. Minimize the number of cell formulas to be created. That is, create a formula that can be copied to other cells.

Best Practices 6: Moving around a worksheet and workbook.

When moving around a worksheet or from worksheet to worksheet in a workbook it is best to know how to use the mouse and the key board. You can easily move from worksheet to worksheet in a workbook by clicking the tab name with the mouse or using the Ctrl + PageUp (or PageDn) set of keys (that is, hold down the Ctrl key and press the PageUp key).

One obvious way to move around a worksheet is to use the mouse. However, many times this requires extensive scrolling, which takes time. It is better to know the keyboard shortcuts to move around. To get an extensive list of keyboard shortcuts type the words keyboard shortcuts in the Excel help box (upper right corner of Excel).

Note, moving around also includes selecting ranges. If you have data in the range A10:D1000 you could use the mouse to select this range. This would require extensive scrolling. A much quicker way is a keyboard shortcut. Select any cell in the desired range, say B15, then use the keyboard shortcut Ctrl+Shift+8 (hold down the Ctrl and Shift keys and then press the 8 key).

Best Practice 7: Key chart features.

1. Select the range of data to use before using the Chart Wizard (Chart Wizard button is on formatting toolbar).
2. Check the series tab in the second step of chart creation. This is the most important tab in the Chart Wizard process. Note that it is not the default tab displayed in the second step of the Chart Wizard.
3. There are three ways to edit charts. They are to select the chart and then
   a. Use menu choices under Chart (Data choice on menu changes to chart when a chart is selected).
   b. Use the chart toolbar.
   c. Move around the selected chart and when in the desired region right click. This is the quickest method.
4. The default is to show a legend. Use only when more than one line on the chart or more than one set of columns.
5. Display all text horizontally. The default is usually to show the Y axis title vertically.
6. Minimize the use of horizontal chart gridlines.
7. Seldom, if ever, use vertical chart gridlines.
8. Scale Y axis values. For instance, if Y axis is daily stock volume do not display numerous zeros. Go to the Format Axis dialog box and the Display Units section.
9. The default is to show the plot area with a gray background. Change to white.
10. If displaying a chart on a chart worksheet select, from the menu, View and Size with Window. This removes the gray area outside the chart and plot area.
11. When formatting a chart move the pointer to the chart area, right click, from the pop up menu choose Format Chart Area, go to Font tab, select desired font, deselect Autoscale, and select OK. This formats all of the text and numbers on the chart. Then simply increase the font size for the title at the top of the chart. Note, the default is to have Autoscale selected. This means that the font sizes of the text and numbers on the chart change as the chart size changes.
12. To align the outside border of the chart with worksheet cell borders select the chart, hold down the Alt key, and move the square handles on the chart border.
13. Many times the default chart created has the values on the X axis aligned 90 degrees to the right. To change select the chart, move the pointer to the X axis, right click, from the pop up menu choose Format axis, go to the alignment tab, in the Orientation section the orientation arrow should indicate horizontal, move the arrow away from horizontal, then move it back to horizontal, finally select OK.

Best Practice 8: When and how to use sensitivity analysis.

Many financial models involve future values. One way to account for the uncertainty of these future values is to use sensitivity analysis. When using sensitivity analysis one or more input values are changed and their impact on key outputs is observed. There are basically two ways to do sensitivity analysis. They are

1. Data tables, and
2. Scenarios.

There are two types of data tables, one input and two output. The one input data table allows the user to change one input variable and observe its effect on one or more output variables. The two input data table allows you to change two inputs and see there influence on one output. To create data tables use the menu choices Data and Table.

Scenarios allow you to change at least 15 inputs.

Best Practice 9: When to do formatting and some formatting suggestions.

1. Do not use numerous colors and font sizes. Text should be black bold or black not bold. Cell backgrounds colors should be either the default color, white, or a light color. If dark it is difficult to read and most likely the cell will print black (black/gray only printer). Even light colors can print black on some black/gray laser printer. Use conditional formatting and data validation to shift between colored and white cell background colors.
2. Formatting should be done after the cell formulas have been created. If done sooner you need to use copy and paste special formulas. This way only the cell formula is copied.
3. Remove worksheet gridlines (Tools, Options, View tab). Worksheet gridlines are all or none. That is, the worksheet gridlines are displayed or not displayed. Replace the worksheet with cell borders. Gray cell borders are preferred to black cell borders. Note, to enter gray cell borders select the desired cells, right click, choose Format cells, and go to the Border tab. You must first select the color, then the style of line, and finally where to place the line.
4. In you Inputs use the word Inputs to identify the section. In the cells below, identify the inputs. Indent this text. Do likewise in the outputs section.
5. Instead of hiding rows and/or columns use the Data, Group and Outline feature.

Best Practice 10: Checking for errors, minimizing errors, and preventing errors.

There is no mathematical way to check for errors. Some obvious ways are

1. To use your financial knowledge to see if the results are reasonable. Use extreme values when doing this. Also, change inputs and see if outputs move in the desired direction. For instance, if a capital budgeting problem if you increase the discount rate the Net Present Value should decrease.
2. Find a similar problem that has a numerical solution. Test it on your model.
3. When creating a financial model one way to minimize possible errors is to create formulas using copy and paste. That is, for each row or column create one formula, say in the first row and then copy it into the other cells in the same row.
4. One way to prevent a formula from getting changed once the model is created is to use worksheet protection. The process is to select the cells that you do not want protected, right click on this range, from the pop up menu choose Format Cells, go to the Protection tab, deselect the Locked box, and select OK. Then to protect all other cells on the worksheet select, from the menu, Tools and Protection. You can password protect the rest of the worksheet.

Best Practice 11: What do to after the model is completed but before saving the workbook.

1. Delete unused worksheets. The easiest way is to simply right click on a worksheet and select delete from the pop up menu. Since the vast majority of financial models created need only one worksheet you may want to change the default worksheets displayed in a new workbook from three to one. To do this select, from the menu, Tools, Options, General, change the Sheets in new workbook form 3 to 1, and, finally, select OK.
2. Enter appropriate worksheet tab names. Note, the default tab names Sheet1, Sheet2, and so forth are not descriptive.
3. Check the spelling. The best way is to
    a. Group all worksheets (Select first worksheet, hold down Shift key, select last worksheet).
    b. Use F7.
    c. Ungroup worksheets (right click on a tab and, from the pop up menu, choose Ungroup sheets).
4. Make sure that the workbook is maximized.
5. Make sure that no worksheets are grouped. If worksheets are grouped many of the menu choices are not available.
6. Make sure that the zoom size is the same for all worksheets (Standard toolbar).
7. Make sure that cell A1 is the selected or highlighted cell on each worksheet and cell A1 is visible (Excel stores the current position of each worksheet in the workbook).
8. Make sure that the first worksheet is the active worksheet – this is the worksheet with the workbook documentation.
9. If possible, move horizontal scroll bar to about one inch to the right of the last tab name. Do this after selecting the first worksheet. If a reasonable number of worksheets this means all tab names are displayed and the horizontal scroll bar is at its max size.

Three examples

Three examples are used to illustrate some of these best practices. The three problems are mentioned and the related Excel files with the financial models are attached.

Example 1. Problem: Someone who retired in early 2000 and assumed that her $500,000 portfolio could earn an average of, say, 9 percent a year could withdraw 7 percent the first year, increase the dollar amount of the annual withdrawal by 3 percent a year for inflation and have that nest egg last 27 years, according to an analysis by T. Rowe Price in Baltimore (Source: *New York Times*, Sunday, August 17, 2003, "How to Avoid Cracking the Retirement Nest Egg," by Virginia Munger Kahn).

The output for this financial model is the number of years before the funds for retirement are used up. This is a time value of money problem with uneven cash flows (the amount to withdrawal each year). The Excel solution illustrates that all time value of money problems with multiple cash flows should be modeled like a loan amortization schedule. See the attached file, Example1.xls. 

Example 2. Problem: The parents are planning a savings program to put their 13 year old teenager through college. The child is now 13 years old and plans to enroll at the university in exactly five years and it should take the child four years to complete undergraduate education. Currently, the cost per year for everything (food, clothing, tuition, books, transportation, and so forth) is $14,500, but a 6 percent annual inflation rate in these costs is forecast. That is, the cost of college tuition is expected to increase 6 percent per year. The child recently received $10,000 from grandmother's estate. This money which is invested in a bank account paying an 8 percent annual interest rate, compounded annually, will be used to help meet part of the costs of the child's education. The rest of the costs will be met by money the parents will deposit each year from now until the child starts college. Assume that the child is given the amount needed for each school year at the beginning of the school year. For instance, five years from today the child receives the amount needed for the first year of school (freshman). The parents will make six equal deposits to the account, the first today and one deposit each subsequent year. The last, or sixth, deposit is made when the child starts college, which is five years from today. These six equal deposits beginning today will also earn an annual interest rate of 8 percent, compounded annually. Funds not being spent are invested at an annual rate of 8 percent compounded annually. How large must each deposit be for the parents to be able to put their child through college?

The output for this financial model is the amount to deposit each year. Like Example 1, this is a time value of money problem (the amount to deposit each year). This is a typical time value of money problem. Specifically, it is a variation of Problem 2-40 on page 60 in Brigham and Houston (2007). The Excel solution also illustrates that all time value of money problems with multiple cash flows should be modeled like a loan amortization schedule. See the attached file, Example2.xls. 

Example 3: Problem: The General Ford (GF) Auto Corporation is trying to determine the profitability of a new type of compact car which it is in the process of developing. The car is assumed to generate sales for the next ten years. In order to determine whether development of the car should continue, information has been gathered through focus groups in the marketing and engineering departments. In particular, GF has analyzed the fixed cost of developing the car, the variable cost of producing each car, the sales price per car, the demand during each of the next ten years, the production policy, and the interest rate used for discounting future cash flows. Based on this analysis, GF has decided to use the following inputs in a simulation model (also, see the inputs section of the Excel file for Example 3). The fixed cost of developing the car is not known with certainty. GF models this uncertainty with a normal probability distribution with a mean $2.2 billion and standard deviation $0.3 billion. The entire fixed cost is assumed to occur at the beginning of year 1. The variable production cost per unit in year 1 is also modeled by a normal distribution with a mean of $7,200 and a standard deviation of $250. Each year after year 1, the variable production cost is the previous year's variable production cost multiplied by one plus the inflation rate. Each year this inflation factor is assumed to be normally distributed with mean 1.05 (a 5% increase) and standard deviation .02. All production costs are assumed to occur at the ends of the respective years. The sales price in year 1 is assumed to be $11,000. After year

1, the sales price will increase by the same inflation factor that drives production costs. Specifically, the sales price will be the previous year's sales price multiplied by one plus the inflation rate. Like production costs, revenues from sales are assumed to occur at the ends of the respective years. The demand for cars in year 1 is assumed to be normally distributed with a mean of 100,000 units and a standard deviation of 20,000 units. After year 1, the demand in a given year is assumed to be normally distributed with mean equal to the actual demand in units in the previous year and a standard deviation of 30,000 units. For example, if the observed demand in year 3 is 105,000 units, then the demand distribution in year 4 is assumed to be normally distributed with a mean of 105,000 units and standard deviation of 30,000 units. An implication of this assumption is that demands in successive years are not probabilistically independent. If the demand in one year is large, for example, the mean demand for the next year will also be large, so that actual demand for the next year will tend to be large. In any particular year the company plans to base its production policy on the probability distribution of demand for that year – before the actual demand for that year is observed. In particular, if the expected demand in year t is ExpDemandt and the standard deviation of demand is StDev, then GF's policy is to produce ExpDemandt + k*StDev cars, where k is a decision variable that GF will have to select. For example, if it chooses k = 1, then its production quantity in any year will be one standard deviation above the expected demand. From the properties of the normal distribution, this implies that the chances are approximately five out of six meetings all demand for the year. (This is because a normal random variable has approximate probability 5/6 of being no more than one standard deviation above the mean.) If demand in any year is grater than production, the excess demand is lost. However, if production in any year is greater than demand, GF will sell the excess cars at an end-of-year with a discount of 30%. GF plans to use a

10% interest rate to discount future cash flows. This means, for example, that a cash flow of $1 at the beginning of year 1 is equivalent to a cash flow of $1.10 at the end of year 1.

Given these assumptions, GF wants to develop a simulation spreadsheet that will evaluate its NPV over the ten-year time horizon.

This simulation problem is a revised version of the problem provided in Winston and Albright (1997 pages 630-635).

The output for this financial model is the 100 simulation results and the related statistics such as the mean net present value and the frequency distribution of the net present values. The Excel solution illustrates how to do simulation using only Excel features and functions (instead of an Excel add-in such as Crystal Ball). See the attached file, Example3.xls. 

Summary

Excel is an important skill that all finance majors need to know. Here we indicate and illustrate Excel Best Practices.

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Appendix: Job Advertisement from ChicagoTribune.com (March 30, 2006).

Wealth Management Specialist
Location: Chicago
Req'd Education: 4 Year Degree
Req'd Experience: At Least 3 Years
Req'd Travel: Not Specified
Relocation Covered: No

DESCRIPTION Nuveen Investments is an investment management firm with more than $130 Billion in assets under management catering primarily to high net worth investors and the advisors that serve them. The Nuveen Investments Wealth Management Services Group provides consulting services to leading financial advisors through education and training on client-focused wealth management solutions that help them build enhanced, more holistic relationships with their clients.

The Wealth Management Specialist will work closely with Wealth Management Consultants and Nuveen Advisor Consultants (who call on financial advisors to offer Nuveen investment solutions) to extend Nuveen's business partnerships with advisors nationwide.

Primary Responsibilities:

Provide wealth management and financial planning counsel and support to financial advisor clients primarily via electronic communication and conference calls with occasional personal interface, including presentations. An integral part of this support is the preparation of a variety of financial illustrations, including Monte Carlo Simulation and Net Unrealized Appreciation analysis, utilizing analytical tools and software, and reviewing the results with advisors.

Assist in research, development, writing and updating of educational materials for advisors including white papers, program materials; research topics for media briefings to be used in Managing Director's media interviews.

REQUIREMENTS

- 3-7 years of financial services and/or investment consulting experience preferred.
- A Certified Financial Planner (CFP) is preferred; an MBA, CIMA and/or CFA would be useful.
- Familiarity with financial planning concepts, tools and software.
- Analytic/qualitative ability; proficient in Excel, the creation of scenarios, and PowerPoint.
- Polished interpersonal, written and verbal communication skills, including excellent telephone skills to communicate with financial advisors and Nuveen Advisor Consultants.
- Effective time management and follow through skills.
- Ability to work as a member of a team as well as independently.
- An interest in working with financial advisors to help them achieve success.