EXCEL® MODELING IN CORPORATE FINANCE

Fourth Edition

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Preface

For more than 25 years, since the emergence of PCs, Lotus 1-2-3, and Microsoft Excel® in the 1980's, spreadsheet models have been the dominant vehicles for finance professionals in the business world to implement their financial knowledge. Yet even today, most Corporate Finance textbooks have little or no coverage of how to build Excel models. This book fills that gap. It teaches students how to build financial models in Excel. It provides step-by-step instructions so that students can build models themselves (active learning), rather than being handed already completed spreadsheets (passive learning). It progresses from simple examples to practical, real-world applications. It spans nearly all quantitative models in corporate finance, including nearly all niche areas of corporate finance.

My goal is simply to *change finance education from being calculator based to being Excel based*. This change will better prepare students for the 21st century business world. This change will increase student evaluations of teacher performance by enabling more practical, real-world content and by allowing a more hands-on, active learning pedagogy.

Fourth Edition Changes

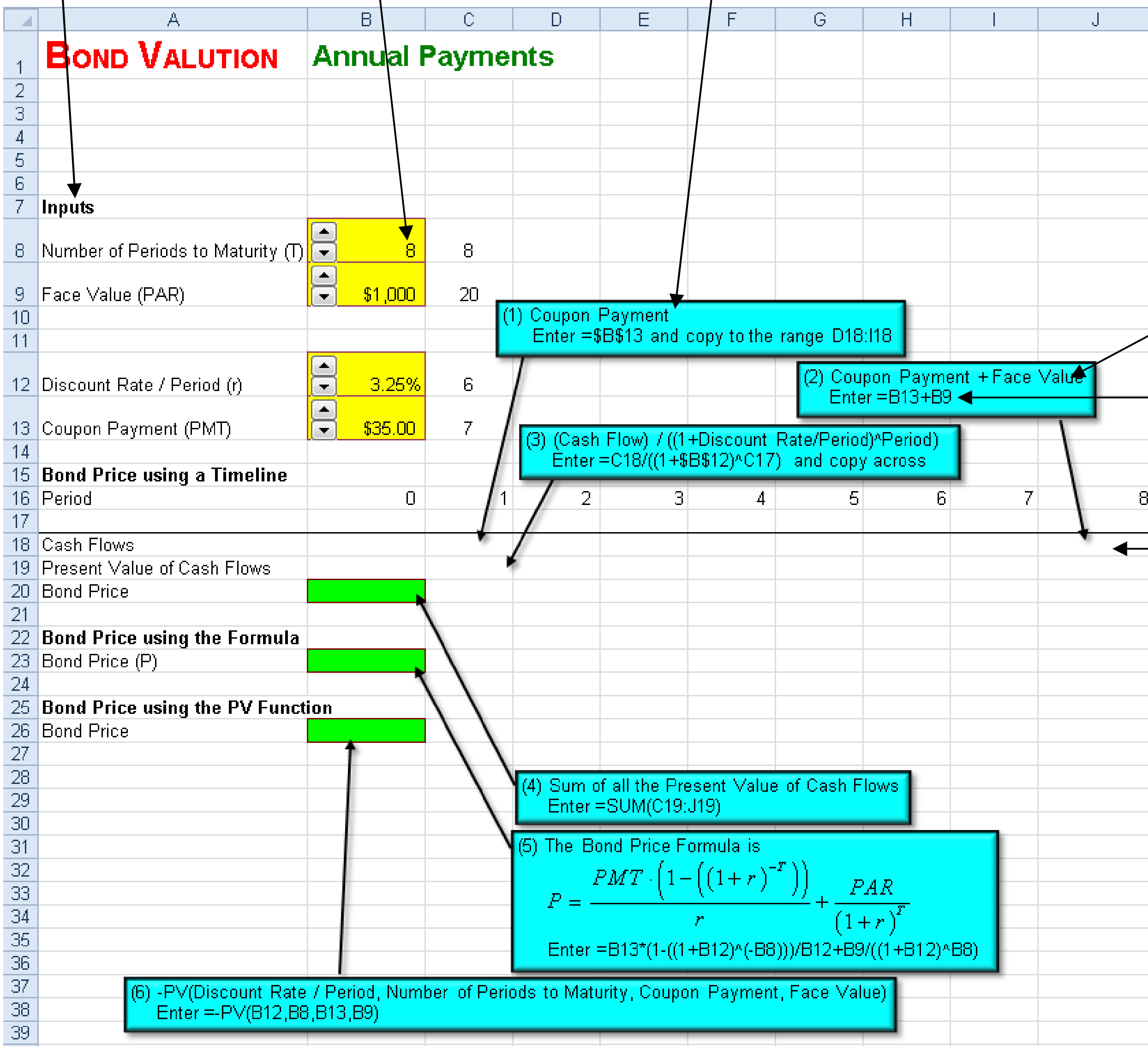
The Fourth Edition adds great new corporate finance content:

- Value a firm or project in a two-stage framework using five alternative techniques and demonstrating their equivalence:
  - Free Cash Flow to Equity
  - Free Cash Flow to the Firm
  - Residual Income
  - Dividend Discount Model
  - Adjusted Present Value
- An appendix on Reconciling the Residual Income Method with Other Approaches to Valuing Firms or Projects by Professor Robert A. Taggart of Boston College
- Analyze capital structure models:
  - Modigliani-Miller with no taxes
  - Modigliani-Miller with corporate taxes
  - Trade-off model: tax shield vs. distress cost

The CD provides **Ready-To-Build Spreadsheets** for every chapter with:

The model setup, such as input values, labels, and graphs

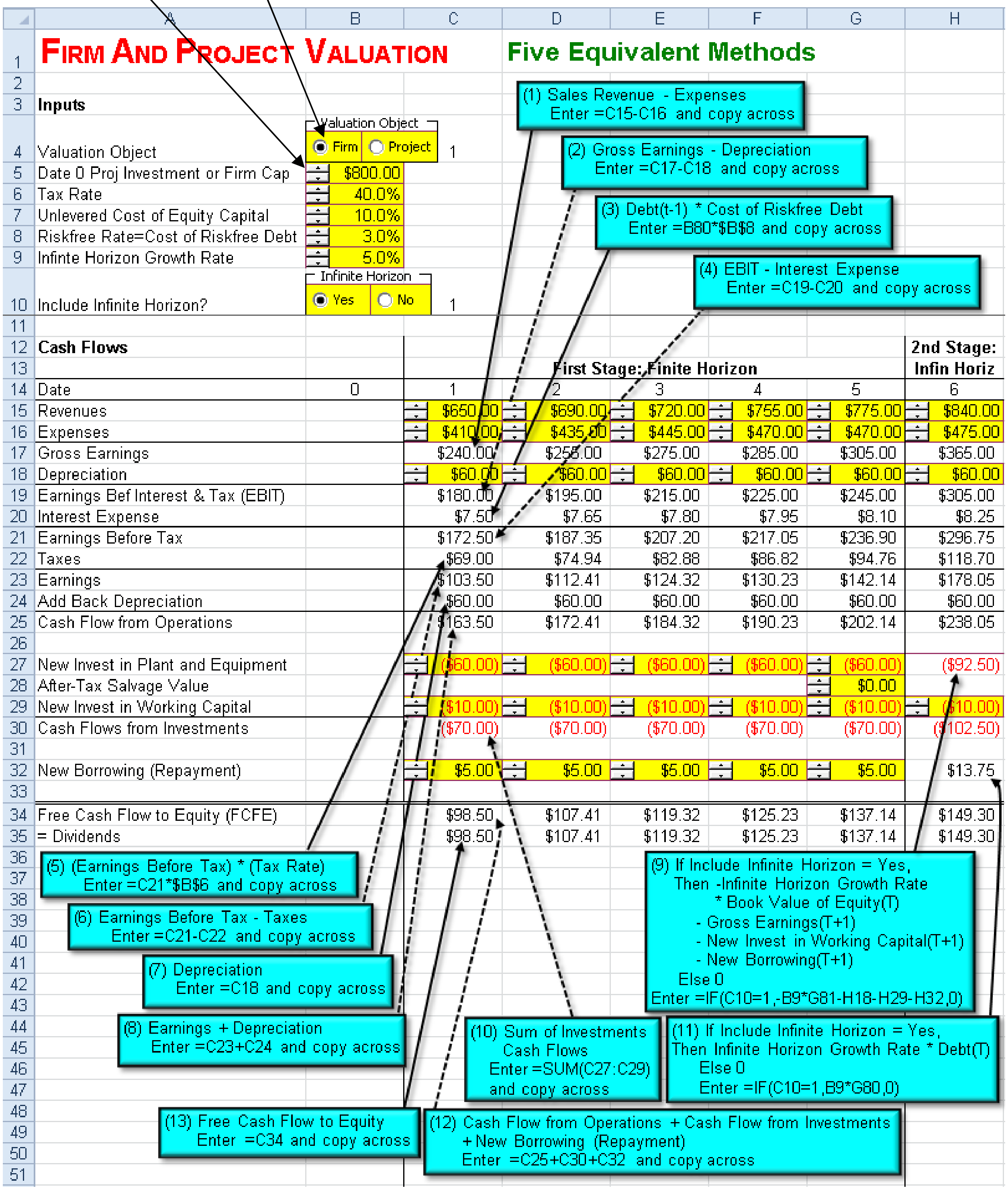
Step-by-step instructions for building and estimating the model on the spreadsheet itself



All instructions are explained twice: once in English and a second time as an Excel formula

Students enter the formulas and copy them as instructed to build the spreadsheet

Spin buttons, option buttons, and graphs facilitate visual, interactive learning



	A	B	C	D	E	F	G	H
1	FIRM AND PROJECT VALUATION			Five Equivalent Methods				
2								
3	Inputs							
4	Valuation Object	Valuation Object: Firm / Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: Yes / No	1					
11								
12	Cash Flows							2nd Stage:
13				First Stage: Finite Horizon				Infin Horiz
14	Date	0	1	2	3	4	5	6
15	Revenues		$650.00	$690.00	$720.00	$755.00	$775.00	$840.00
16	Expenses		$410.00	$435.00	$445.00	$470.00	$470.00	$475.00
17	Gross Earnings		$240.00	$255.00	$275.00	$285.00	$305.00	$365.00
18	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
19	Earnings Bef Interest & Tax (EBIT)		$180.00	$195.00	$215.00	$225.00	$245.00	$305.00
20	Interest Expense		$7.50	$7.65	$7.80	$7.95	$8.10	$8.25
21	Earnings Before Tax		$172.50	$187.35	$207.20	$217.05	$236.90	$296.75
22	Taxes		$69.00	$74.94	$82.88	$86.82	$94.76	$118.70
23	Earnings		$103.50	$112.41	$124.32	$130.23	$142.14	$178.05
24	Add Back Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
25	Cash Flow from Operations		$163.50	$172.41	$184.32	$190.23	$202.14	$238.05
26								
27	New Invest in Plant and Equipment		($60.00)	($60.00)	($60.00)	($60.00)	($60.00)	($92.50)
28	After-Tax Salvage Value						$0.00	
29	New Invest in Working Capital		($10.00)	($10.00)	($10.00)	($10.00)	($10.00)	($10.00)
30	Cash Flows from Investments		($70.00)	($70.00)	($70.00)	($70.00)	($70.00)	($102.50)
31								
32	New Borrowing (Repayment)		$5.00	$5.00	$5.00	$5.00	$5.00	$13.75
33								
34	Free Cash Flow to Equity (FCFE)		$98.50	$107.41	$119.32	$125.23	$137.14	$149.30
35	= Dividends		$98.50	$107.41	$119.32	$125.23	$137.14	$149.30

Many spreadsheets use real-world data

	A	B	C	D	E	F	G	H	I	J
1	**CORPORATE FINANCIAL PLANNING**				**Full-Scale Estimation**					
2	**Nike, Inc.**	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %	
3	**Financial Plan**	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales	
4	**Key Assumptions**									
5	Sales Growth Rate		9.2%	14.1%	2.9%	5.0%	6.0%	8.0%		
6	Tax Rate	35.0%	32.2%	24.8%	24.0%	24.0%	24.0%	24.0%		
7	Int Rate on Short-Term Debt	6.2%	6.0%	3.2%	1.3%	2.0%	2.7%	3.5%		
8	Int Rate on Long-Term Debt	6.1%	6.0%	4.5%	3.7%	4.5%	5.2%	6.0%		
9	Dividend Payout Rate	20.9%	23.0%	21.9%	31.4%	25.0%	23.0%	22.0%		
10	Price / Earnings	14.8	19.1	17.8	18.6	18.0	18.0	18.0		
11										
12										
13	**Income Statement (Mil.$)**									
14	Sales	$14,954.9	$16,325.9	$18,627.0	$19,176.1	$20,134.9	$21,343.0	$23,050.4		
15	Cost of Goods Sold	$8,367.9	$9,165.4	$10,239.6	$10,571.7	$11,184.7	$11,855.8	$12,804.3		
16	Gross Margin	$6,587.0	$7,160.5	$8,387.4	$8,604.4	$8,950.2	$9,487.2	$10,246.2		
17										
18	Selling, Gen & Adm Expenses	$4,477.8	$5,028.7	$5,953.7	$6,745.9	$6,437.4	$6,823.6	$7,369.5		
19	Non-Operating Income	$82.9	$117.8	$107.9	$138.2	$129.7	$137.4	$148.4		
20	Depreciation	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0		
21	EBIT	$2,192.1	$2,249.6	$2,541.6	$1,996.7	$2,642.4	$2,801.0	$3,025.1		
22										
23	Interest Expense	$50.5	$49.7	$38.7	$40.2	$40.3	$48.9	$67.6		
24	Taxes	$749.6	$708.4	$619.5	$469.8	$624.5	$660.5	$709.8		
25	Net Income	$1,392.0	$1,491.5	$1,883.4	$1,486.7	$1,977.6	$2,091.6	$2,247.7		
26	Shares Outstanding (Millions)	256.0	501.7	491.1	485.5	485.5	485.5	485.5		
27	Earnings Per Share	$5.44	$2.97	$3.84	$3.06	$4.07	$4.31	$4.63		

(1) Forecast key assumptions Enter forecast values in the range F5:H10 (done for you)

(2) Gross Margin - SG&AE + Non-Op Inc - Depreciation Enter =B16-B18+B19-B20 and copy across

Files in Excel 97-2003 Format

The CD contains **Ready-To-Build spreadsheets**, which are based on the **Excel 2007-2010** (xlsx) file format. However, the CD also contains a folder with Ready-To-Build spreadsheets based on **Excel 97-2003** (xls) format. By default, the explanations in the book are based on **Excel 2010**. However, the book also contains "Excel 2007 Equivalent" boxes that explains how to do the equivalent step in Excel 2007 (when it is different than Excel 2010) and "Excel 97-2003 Equivalent" boxes that explain how to do the equivalent step in Excel 97 through Excel 2003.

Excel 2007 Equivalent

To install the Analysis ToolPak in Excel 2007, click on the Office button, click on **Excel Options** at the bottom of the drop-down window, click on **Add-Ins**, highlight **Analysis TookPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

The instruction boxes on the Ready-To-Build spreadsheets are *bitmapped images* so that the formulas cannot just be copied to the spreadsheet. Both the instruction boxes and arrows are *objects*, so that all of them can be deleted in one step when the spreadsheet is complete and everything else will be left untouched. Click on **Home | Editing | Find & Select down-arrow | Select Objects**, then select all of the instruction boxes and arrows, and press the delete key. Furthermore, any blank rows can be deleted, leaving a clean spreadsheet for future use.

Excel 97-2003 Equivalent

To install the Analysis ToolPak in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Analysis TookPak** checkbox on the Add-Ins dialog box, and click on **OK**.

What Is Unique About This Book

There are many features which distinguish this book from any other:

- **Plain Vanilla Excel.** Other books on the market emphasize teaching students programming using Visual Basic for Applications (VBA) or using macros. By contrast, this book does nearly everything in plain vanilla Excel. Although programming is liked by a minority of students, it is seriously disliked by the majority. Plain vanilla Excel has the advantage of being a very intuitive, user-friendly environment that is accessible to all. It is fully capable of handling a wide range of applications, including quite sophisticated ones. Further, all that is assumed is that your students already know the basics of Excel, such as entering formulas in a cell and copying formulas from one cell to another. All other features of Excel (such as built-in functions, Data Tables, Solver, etc.) are explained as they are used.

- **Build From Simple Examples To Practical, Real-World Applications.** The general approach is to start with a simple example and build up to a practical, real-world application. In many chapters, the previous Excel model is carried forward to the next, more complex model. For example, the chapter on binomial option pricing carries forward Excel models as follows: (a.) single-period model with replicating portfolio, (b.) eight-period model with replicating portfolio, (c.) eight-period model with risk-neutral probabilities, (d.) eight-period model with risk-neutral probabilities for American or European options with discrete dividends, (e.) full-scale, fifty-period model with risk-neutral probabilities for American or European options with discrete dividends. Whenever possible, this book builds up to full-scale, practical applications using real data. Students are excited to learn practical applications that they can actually use in their future jobs. Employers are excited to hire students with Excel modeling skills, who can be more productive faster.

- **Supplement For All Popular Corporate Finance Textbooks.** This book is a supplement to be combined with a primary textbook. This means that you can keep using whatever textbook you like best. You don't have to switch. It also means that you can take an incremental approach to incorporating Excel modeling. You can start modestly and build up from there.

- **A Change In Content Too.** Excel modeling is not merely a new medium, but an opportunity to cover some unique content items which require computer support to be feasible. For example, the full-scale estimation Excel model in Corporate Financial Planning uses three years of historical 10K data on Nike, Inc. (including every line of their income statement, balance sheet, and cash flow statement), constructs a complete financial system (including linked financial ratios), and projects these financial statements three years into the future. The chapter on Estimating the Cost of Capital uses 10 years of monthly returns for individual stocks, U.S. Fama-French portfolios, and country ETFs to estimate the cost of capital using the Static CAPM based on the Fama-MacBeth method and to estimate the cost of capital using the APT or Intertemporal CAPM based on the Fama-MacBeth method. The Excel model to estimate firm valuation or project valuation demonstrates the equivalence of the Free Cash Flow To Equity, Free Cash Flow to the Firm, Residual Income, Dividend Discount Model, and Adjusted Present Value technique, not just in the perpetuity case covered by some textbooks, but for a fully general two-stage project with an arbitrary set of cash flows over an explicit forecast horizon, followed by an infinite horizon growing perpetuity. As a practical matter, all of these sophisticated applications require Excel.

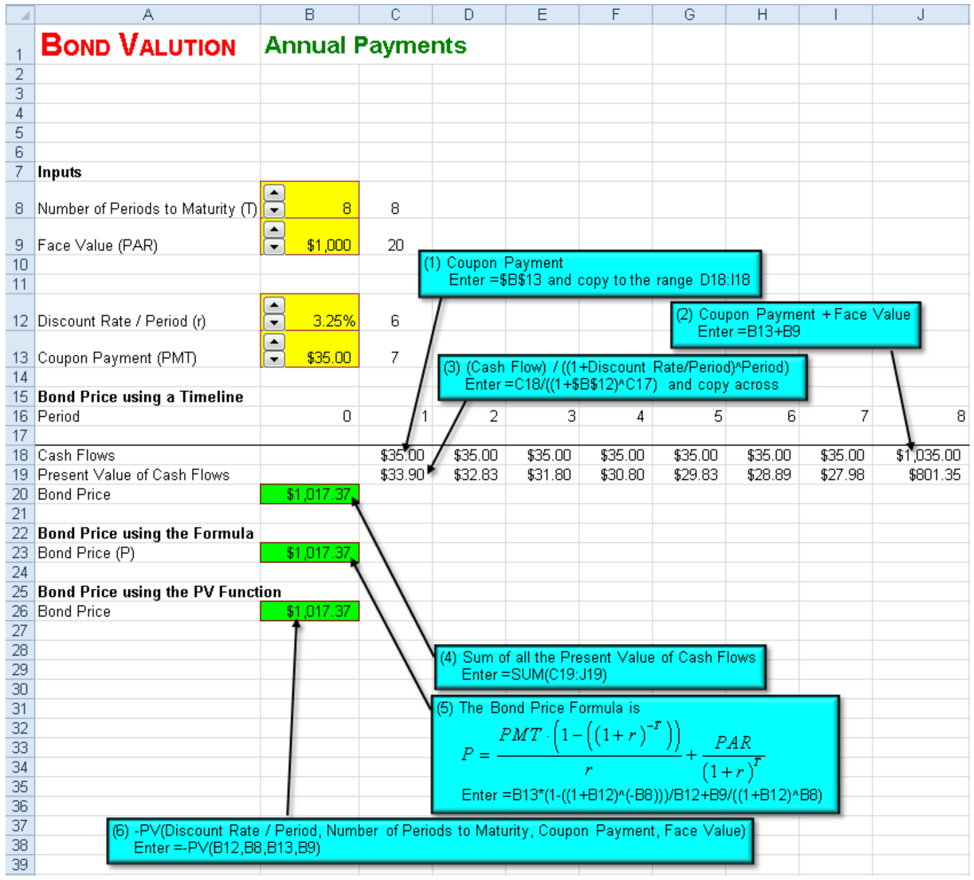
Conventions Used In This Book

This book uses a number of conventions.

- **Time Goes Across The Columns And Variables Go Down The Rows.** When something happens over time, I let each column represent a period of time. For example, in life-cycle financial planning, date 0 is in column B, date 1 is in column C, date 2 is in column D, etc. Each row represents a different variable, which is usually labeled in column A. This manner of organizing Excel models is so common because it is how financial statements are organized.

- **Color Coding.** A standard color scheme is used to clarify the structure of the Excel models. The Ready-To-Build spreadsheets on CD uses: (1) yellow shading for input values, (2) no shading (i.e. white) for throughput formulas, and (3) green shading for final results ("the bottom line"). A few Excel models include choice variables. Choice variables use blue shading. The Constrained Portfolio Optimization spreadsheet includes constraints. Constaints use pink-purple shading.

- **The Time Line Technique.** The most natural technique for discounting cash flows in an Excel model is the time line technique, where each column corresponds to a period of time. As an example, see the section labeled "Bond Price using a Timeline" in the figure below.



- **Using As Many Different Techniques As Possible.** In the figure above, the bond price is calculated using as many different techniques as possible. Specifically, it is calculated three ways: (1) discounting each cash flow on a time line, (2) using the closed-form formula, and (3) using Excel's PV function. This approach makes the point that all three techniques are equivalent. This approach also develops skill at double-checking these calculations, which is a very important method for avoiding errors in practice.

- **Symbolic Notation is Self-Contained.** Every spreadsheet that contains symbolic notation in the instruction boxes is self-contained (i.e., all symbolic notation is defined on the spreadsheet).

Craig's Challenge

I challenge the readers of this book to dramatically improve your finance education by personally constructing all of the Excel models in this book. This will take you about 10 – 20 hours hours depending on your current Excel modeling skills. Let me assure you that it will be an excellent investment. You will:

- gain a practical understanding of the core concepts of Corporate Finance,
- develop hands-on, Excel modeling skills, and
- build an entire suite of finance applications, which you fully understand.

When you complete this challenge, I invite you to send an e-mail to me at **cholden@indiana.edu** to share the good news. Please tell me your name, school, (prospective) graduation year, and which Excel modeling book you completed. I will add you to a web-based honor roll at:

http://www.excelmodeling.com/honor-roll.htm

We can celebrate together!

Excel® Modeling Books

This book is one of two **Excel Modeling** books by Craig W. Holden, published by Pearson / Prentice Hall. The other book is **Excel Modeling in Investments**. Both books teach value-added skills in constructing financial models in Excel. Complete information about my **Excel Modeling** books is available at my web site:

http://www.excelmodeling.com

If you have any suggestions or corrections, please e-mail them to me at **cholden@indiana.edu**. I will consider your suggestions and will implement any corrections in the next edition.

Suggestions for Faculty Members

There is no single best way to use **Excel Modeling in Corporate Finance**. There are as many different techniques as there are different styles and philosophies of teaching. You need to discover what works best for you. Let me highlight several possibilities:

1. **Out-of-class individual projects with help.** This is a technique that I have used and it works well. I require completion of several short Excel modeling projects of every individual student in the class. To provide help, I schedule special "help lab" sessions in a computer lab during which time myself and my graduate assistant are available to answer questions while students do each assignment in about an hour. Typically about half the questions are Excel questions and half are finance questions. I have always graded such projects, but an alternative approach would be to treat them as ungraded homework.

2. **Out-of-class individual projects without help.** Another technique is to assign Excel modeling projects for individual students to do on their own out of class. One instructor assigns seven Excel modeling projects at the beginning of the semester and has individual students turn in all seven completed Excel models for grading at the end of the semester. At the end of

each chapter are problems that can be assigned with or without help. Faculty members can download the completed Excel models and answers to end-of-chapter problems at **http://www.pearsonhighered.com/irc**. See your local Pearson representative to gain access.

3. **Out-of-class group projects.** A technique that I have used for the last fifteen years is to require students to do big Excel modeling projects in groups. I have students write a report to a hypothetical boss, which intuitively explains their method of analysis, key assumptions, and key results.

4. **In-class reinforcement of key concepts.** The class session is scheduled in a computer lab or equivalently students are required to bring their (required) laptop computers to a technology classroom, which has a data jack and a power outlet at every student station. I explain a key concept in words and equations. Then I turn to a 10-15 minute segment in which students open a Ready-To-Build spreadsheet and build the Excel model in real-time in the class. This provides real-time, hands-on reinforcement of a key concept. This technique can be done often throughout the semester.

5. **In-class demonstration of Excel modeling.** The instructor can perform an in-class demonstration of how to build Excel models. Typically, only a small portion of the total Excel model would be demonstrated.

6. **In-class demonstration of key relationships using Spin Buttons, Option Buttons, and Charts.** The instructor can dynamically illustrate comparative statics or dynamic properties over time using visual, interactive elements. For example, one spreadsheet provides a "movie" of 37 years of U.S. term structure dynamics. Another spreadsheet provides an interactive graph of the sensitivity of bond prices to changes in the coupon rate, yield-to-maturity, number of payments / year, and face value.

I'm sure I haven't exhausted the list of potential teaching techniques. Feel free to send an e-mail to **cholden@indiana.edu** to let me know novel ways in which you use this book.

Acknowledgements

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About The Author

CRAIG W. HOLDEN

Craig W. Holden is a Professor of Finance at the Kelley School of Business at Indiana University. His M.B.A. and Ph.D. are from the Anderson School at UCLA. He is the winner of many teaching and research awards, including a Fama/DFA Prize. His research on security trading and market making ("market microstructure") has been published in leading academic journals. He has written **Excel Modeling in Investments** and **Excel Modeling in Corporate Finance**. The Fourth Editions in English are published by Pearson / Prentice Hall and there are International, Chinese, and Italian editions. He has chaired eighteen dissertations, been a member or chair of 51 dissertations, served on the program committee of the *Western Finance Association* for eleven years, and served as an associate editor of the *Journal of Financial Markets* for thirteen years. He chaired the finance department undergraduate committee for twelve years, chaired the finance department doctoral committee for four years, and chaired three different schoolwide committees for a combination of six years. He has led several major curriculum innovations in the finance department. More information is available at Craig's home page: **www.kelley.iu.edu/cholden**.

PART 1 TIME VALUE OF MONEY

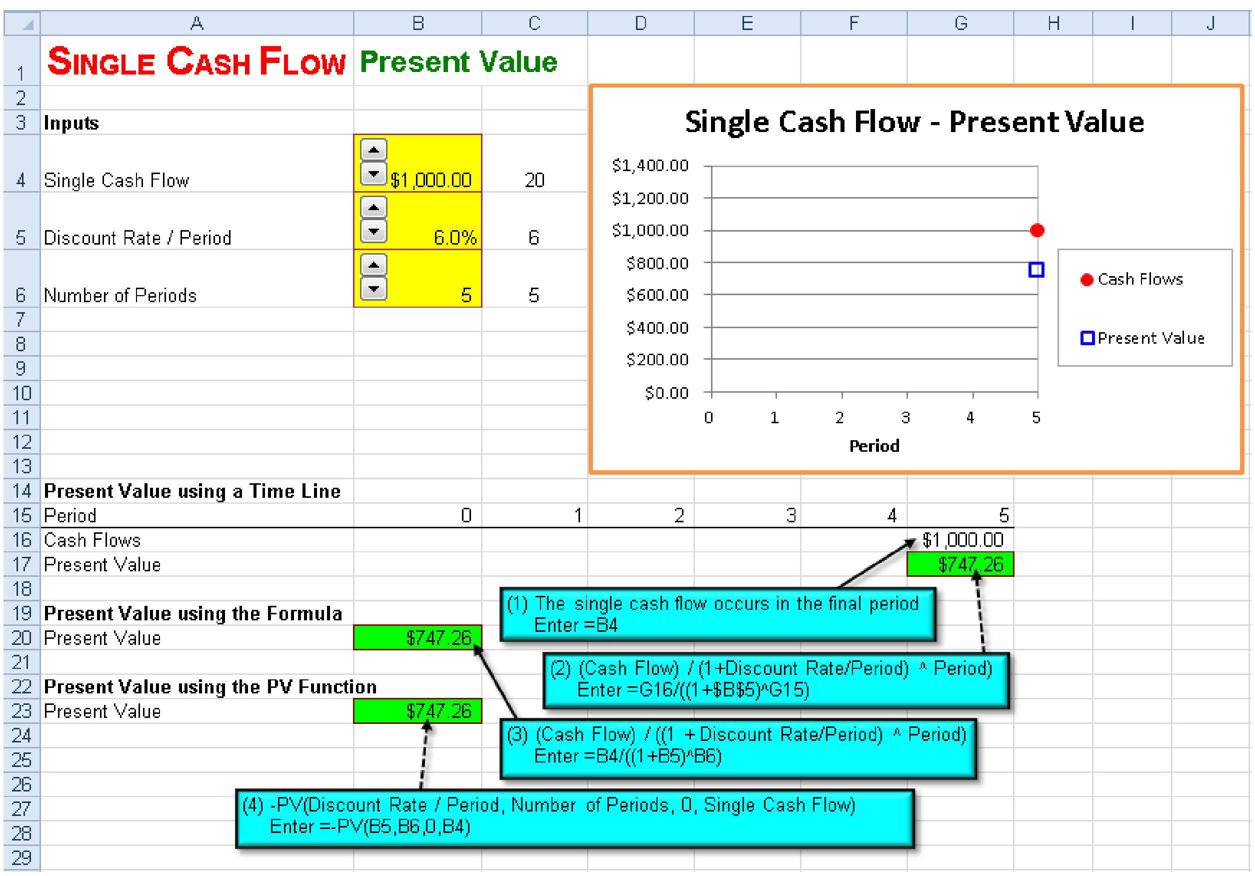
Chapter 1 Single Cash Flow

1.1 Present Value

Problem. A single cash flow of $1,000.00 will be received in 5 periods. For this cash flow, the appropriate discount rate / period is 6.0%. What is the present value of this single cash flow?

Solution Strategy. We will calculate the present value of this single cash flow in three equivalent ways. First, we will calculate the present value using a time line, where each column corresponds to a period of calendar time. Second, we use a formula for the present value. Third, we use Excel's **PV** function for the present value.

FIGURE 1.1 Excel Model for Single Cash Flow - Present Value.



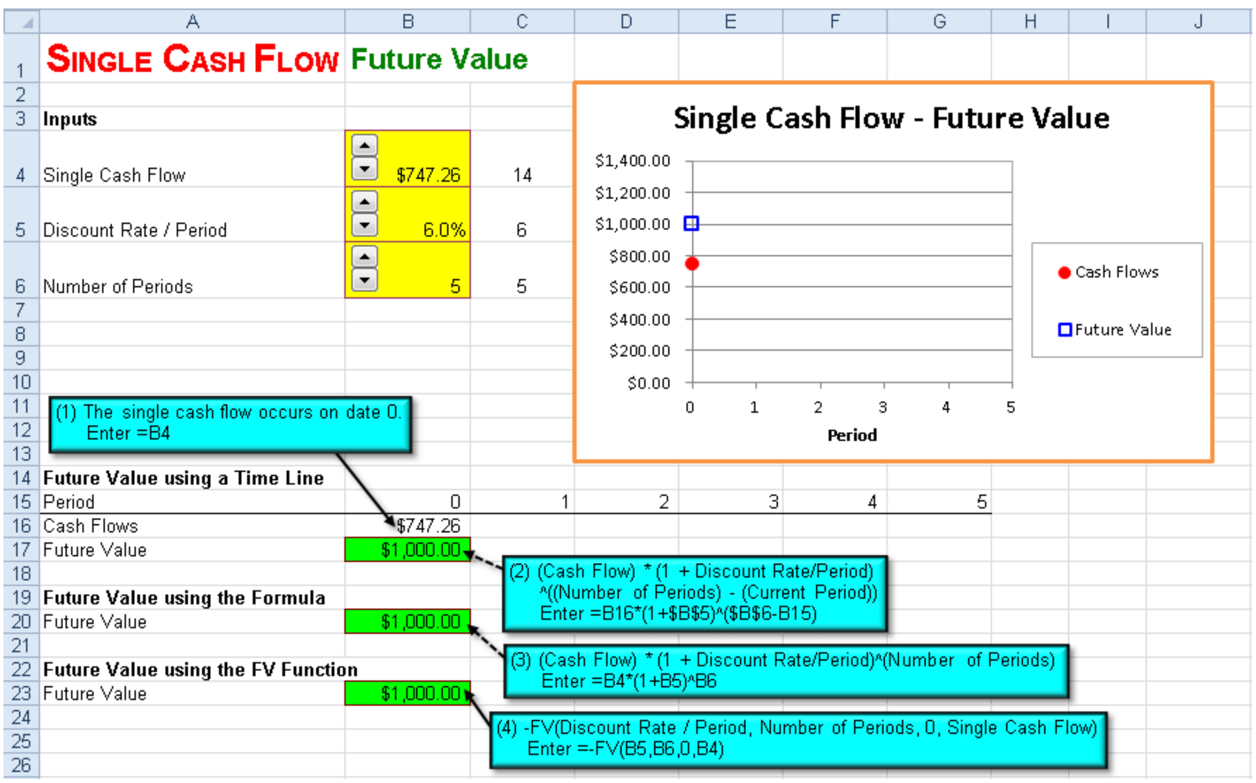
The Present Value of this Single Cash Flow is $747.26. Notice you get the same answer all three ways: using the time line, using the formula, or using the PV function!

1.2 Future Value

Problem. A single cash flow of $747.26 is available now (in period 0). For this cash flow, the appropriate discount rate / period is 6.0%. What is the period 5 future value of this single cash flow?

Solution Strategy. We will calculate the future value of the single cash flow in three equivalent ways. First, we will calculate the future value using a time line, where each column corresponds to a period of calendar time. Second, we use a formula for the future value. Third, we use Excel's **FV** function for the future value.

FIGURE 1.2 Excel Model for Single Cash Flow - Future Value.



The Future Value of this Single Cash Flow is $1,000.00. Notice you get the same answer all three ways: using the time line, using the formula, or using the FV function!

Comparing Present Value and Future Value, we see that they are opposite operations. That is, one operation "undoes" the other. The Present Value of $1,000.00 in period 5 is $747.26 in period 0. The Future Value of $747.26 in period 0 is $1,000.00 in period 5.

Problems

1. A single cash flow of $1,673.48 will be received in 4 periods. For this cash flow, the appropriate discount rate / period is 7.8%. What is the present value of this single cash flow?

2. A single cash flow of $932.47 is available now (in period 0). For this cash flow, the appropriate discount rate / period is 3.9%. What is the period 4 future value of this single cash flow?

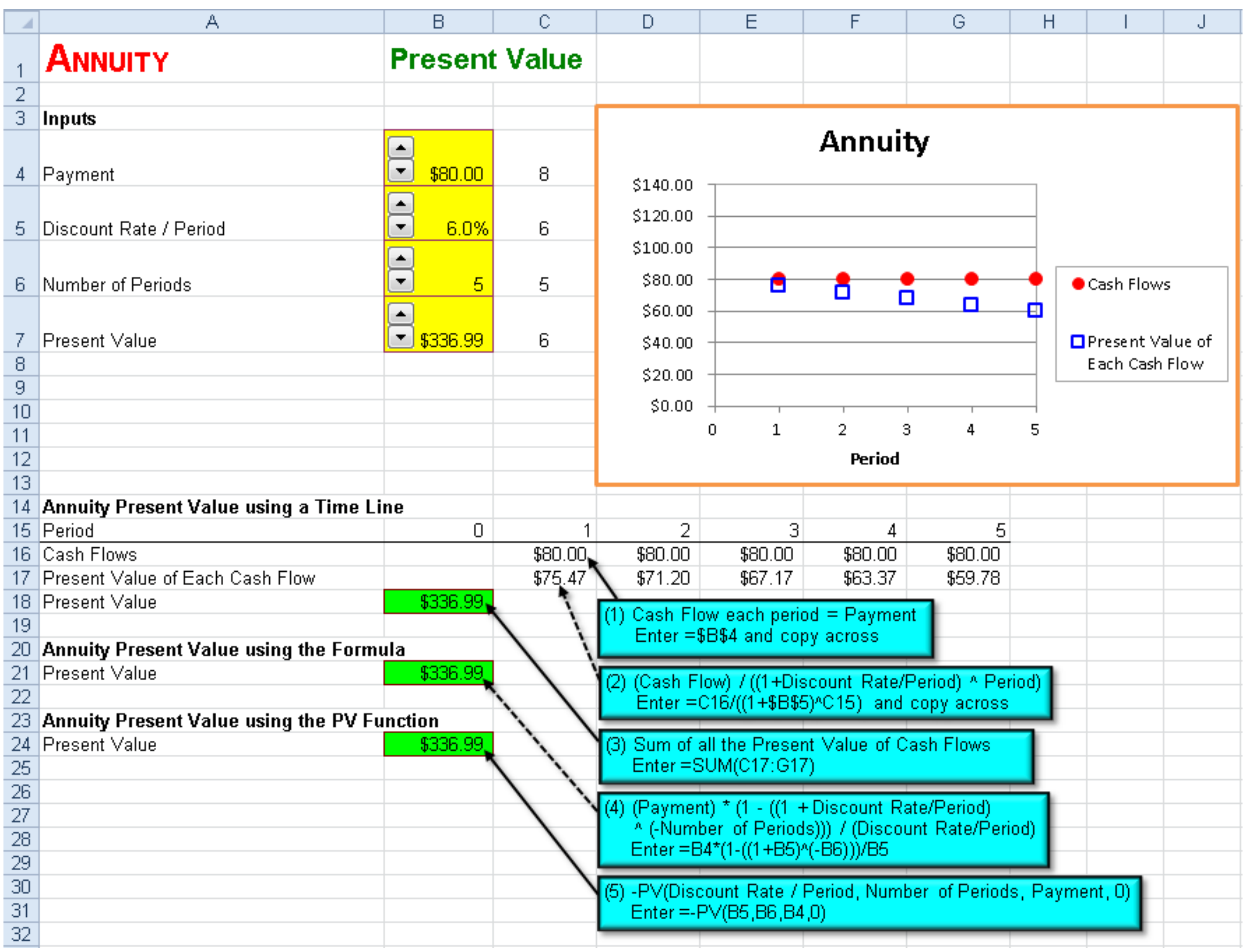
Chapter 2 Annuity

2.1 Present Value

Problem. An annuity pays $80.00 each period for 5 periods. For these cash flows, the appropriate discount rate / period is 6.0%. What is the present value of this annuity?

Solution Strategy. We will calculate the present value of this annuity in three equivalent ways. First, we will calculate the present value using a time line, where each column corresponds to a period of calendar time. Second, we use a formula for the present value. Third, we use Excel's **PV** function for the present value.

FIGURE 2.1 Excel Model for Annuity - Present Value.



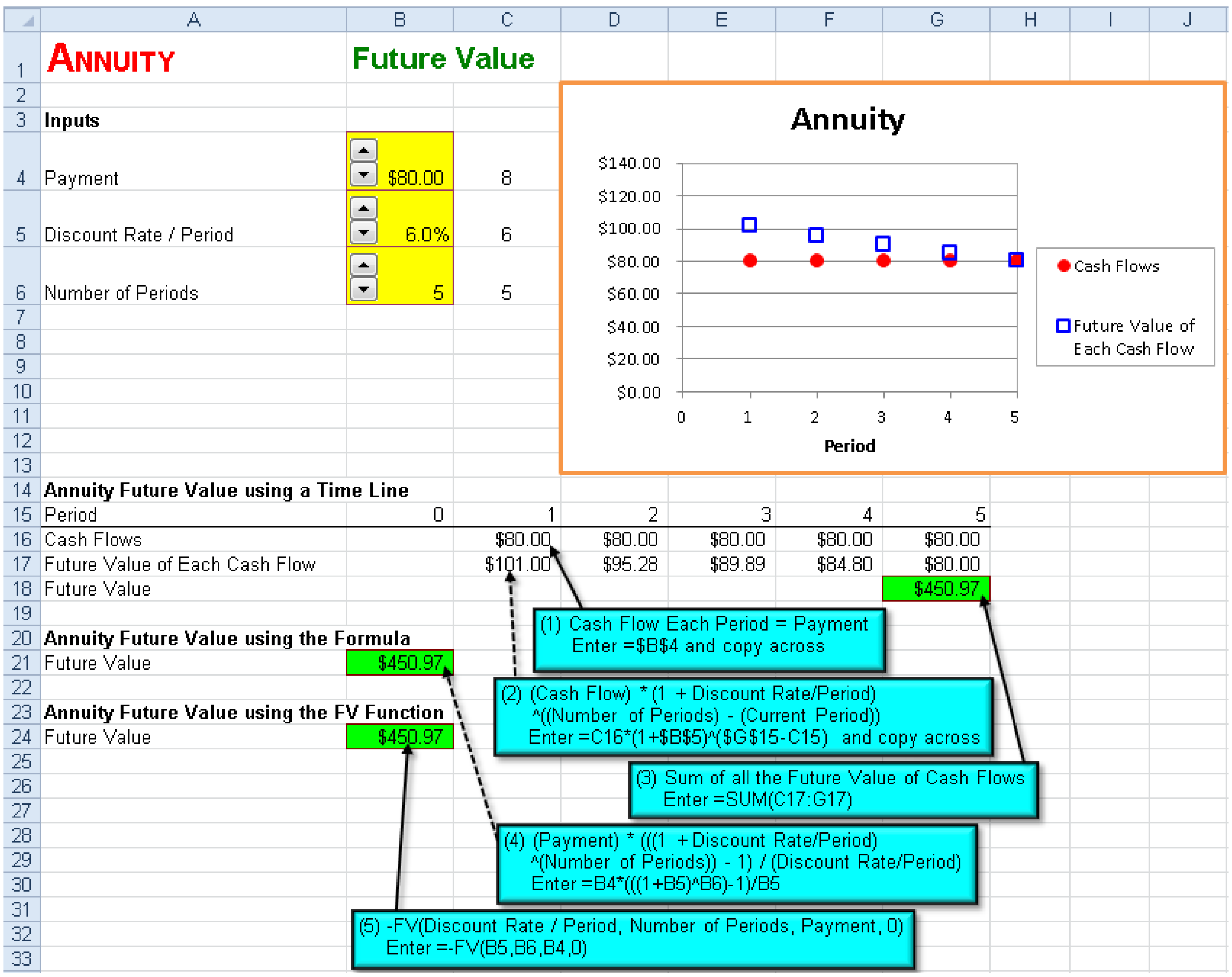
The Present Value of this Annuity is $336.99. Notice you get the same answer all three ways: using the time line, using the formula, or using the PV function.

2.2 Future Value

Problem. An annuity pays $80.00 each period for 5 periods. For these cash flows, the appropriate discount rate / period is 6.0%. What is the period 5 future value of this annuity?

Solution Strategy. We will calculate the future value of this annuity in three equivalent ways. First, we will calculate the future value using a time line, where each column corresponds to a period of calendar time. Second, we use a formula for the future value. Third, we use Excel's **FV** function for the future value.

FIGURE 2.2 Excel Model for Annuity - Future Value.



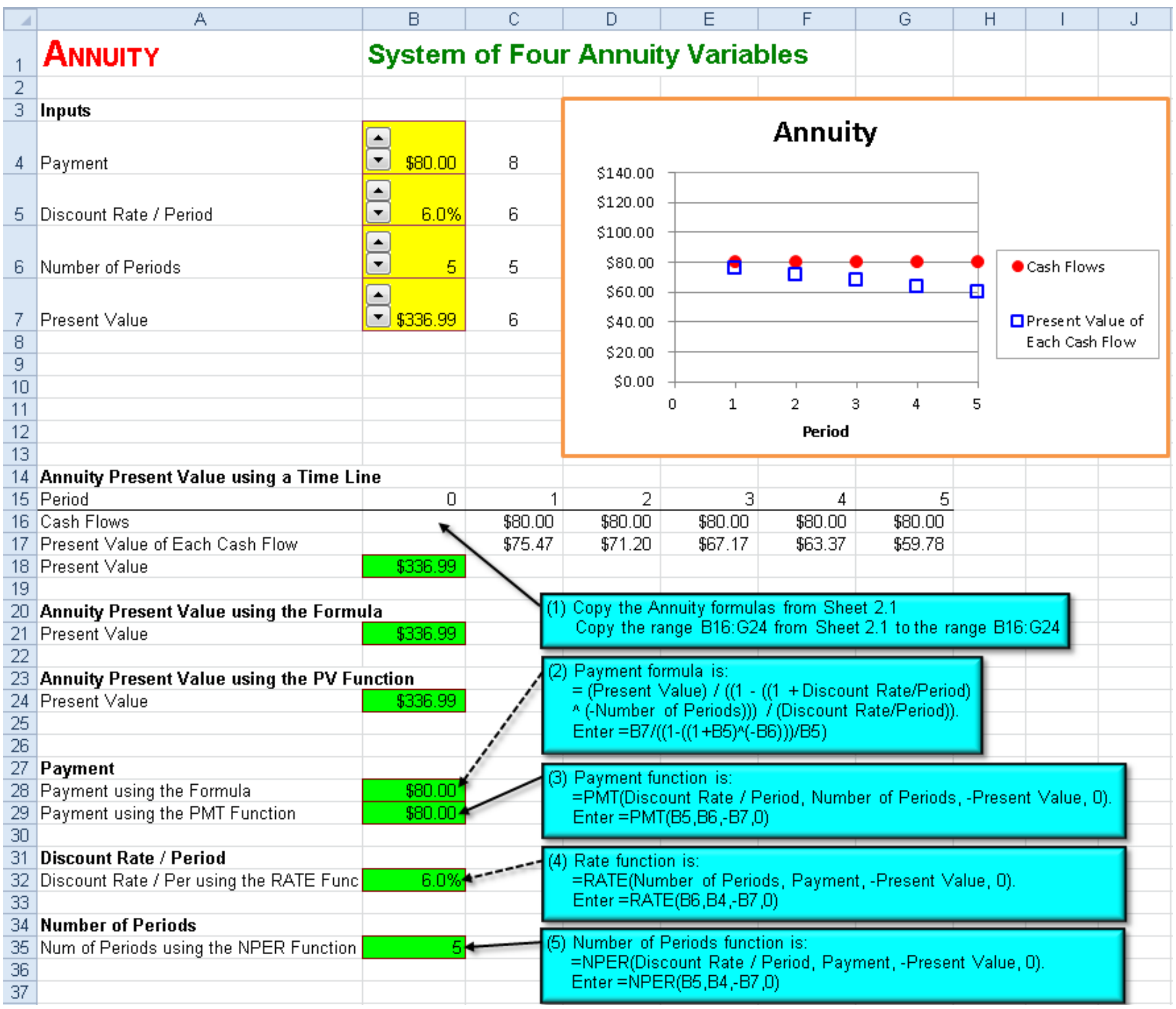
The Future Value of this Annuity is $450.97. Notice you get the same answer all three ways: using the time line, using the formula, or using the FV function.

2.3 System of Four Annuity Variables

Problem. There is a tight connection between all of the inputs and output to annuity valuation. Indeed, they form a system of four annuity variables: (1) Payment, (2) Discount Rate / Period, (3) Number of Periods, and (4) Present Value. Given any three of these variables, find the fourth variable.

Solution Strategy. Given any three of these variable, we will use as many equivalent ways of solving for the fourth variable as possible. The Annuity – Present Value spreadsheet solves for the present value using a Time Line, a formula, and the **PV** function. Building on that spreadsheet, add the Payment using the formula and **PMT** function. Then add the Discount Rate / Period using the **RATE** function. Then add the Number of Periods, use the **NPER** function.

FIGURE 2.3 Excel Model for Annuity - System of Four Annuity Variables.



We see that the system of four annuity variables is internally consistent. The four outputs in rows **13** through **32** (Present Value = $336.99, Payment = $80.00, Discount Rate / Period = 6.0%, and Number of Periods = 5) are identical to the four inputs in rows **4** through **7**. Thus, any of the four annuity variables can be calculated from the other three in a fully consistent manner.

Problems

1) An annuity pays $142.38 each period for 6 periods. For these cash flows, the appropriate discount rate / period is 4.5%. What is the present value of this annuity?

2) An annuity pays $63.92 each period for 4 periods. For these cash flows, the appropriate discount rate / period is 9.1%. What is the period 5 future value of this annuity?

3) Consider a system of four annuity variables.
   (a) An annuity pays $53.00 each period for 4 periods. For these cash flows, the appropriate discount rate / period is 7.0%. What is the present value of this annuity?
   (b) An annuity pays each period for 10 period, the appropriate discount rate / period is 7.0%, and the present value is $142.38. What is the payment each period?
   (c) An annuity pays $173.00 each period for 13 periods, and the present value is $513.94. What is the discount rate / period of this annuity?
   (d) An annuity pays $40.00 each period, the appropriate discount rate / period is 6.0%, and the present value is $168.49. What is the number of periods?

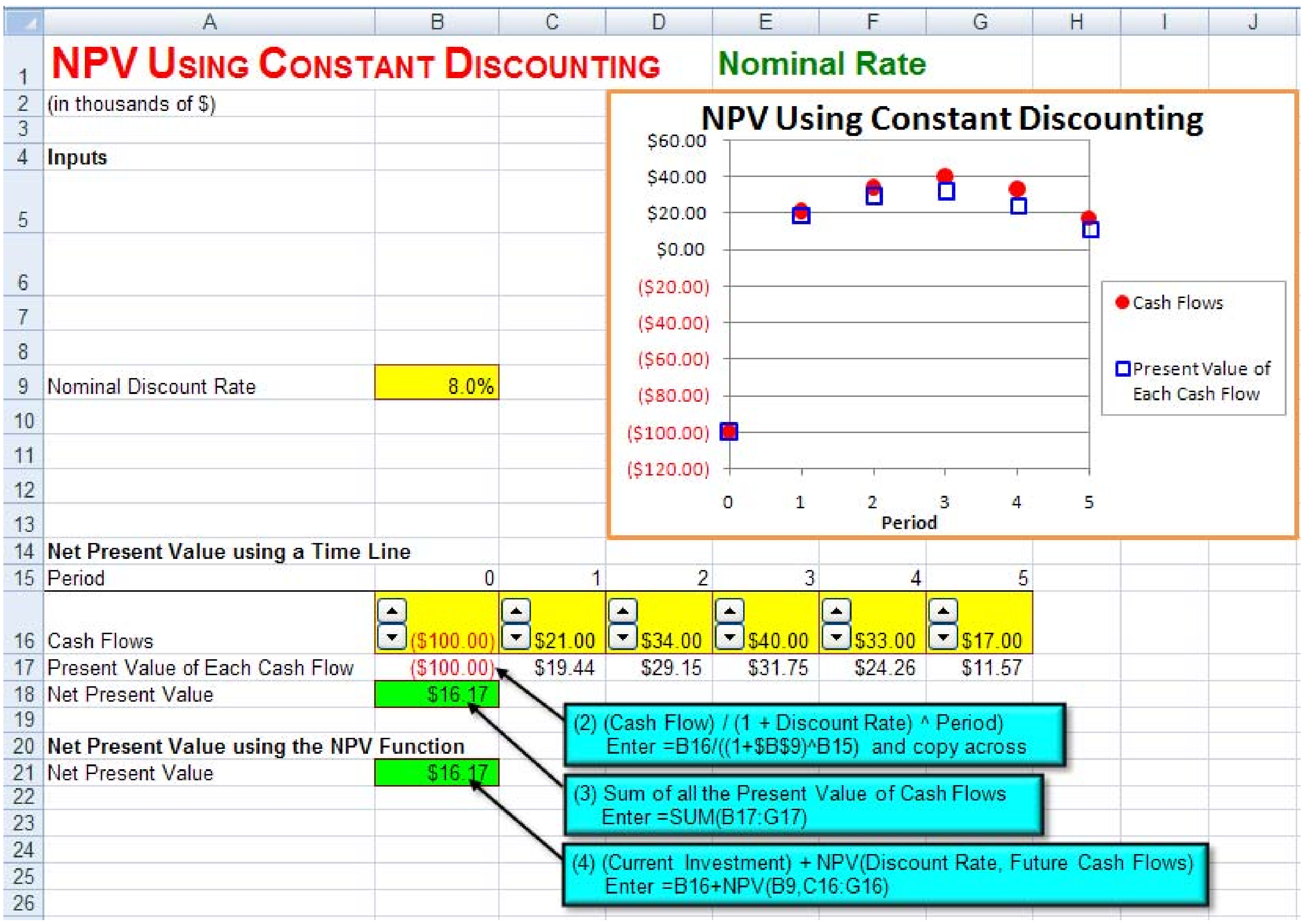
Chapter 3 NPV Using Constant Discounting

3.1 Nominal Rate

Problem. A project requires a current investment of $100.00 and yields future expected cash flows of $21.00, $34.00, $40.00, $33.00, and $17.00 in periods 1 through 5, respectively. All figures are in thousands of dollars. For these expected cash flows, the appropriate nominal discount rate is 8.0%. What is the net present value of this project?

Solution Strategy. We will calculate the net present value of this project in two equivalent ways. First, we will calculate the net present value using a time line, where each column corresponds to a period of calendar time. Second, we use Excel's **NPV** function for the net present value.

FIGURE 3.1 NPV Using Constant Discounting – Nominal Rate.



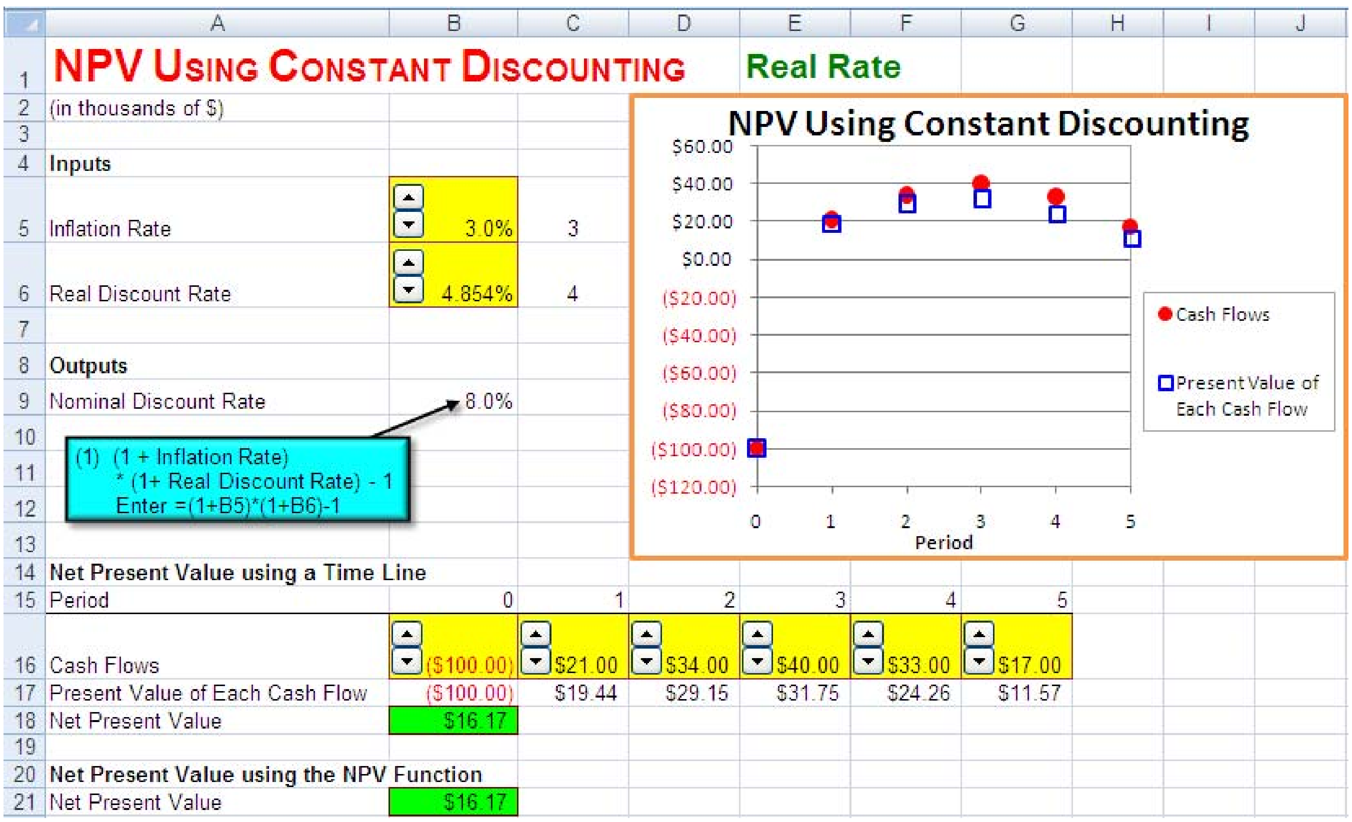
The Net Present Value of this project is $16.17. Notice you get the same answer both ways: using the time line or using the NPV function.

3.2 Real Rate

Problem. A project requires a current investment of $100.00 and yields future expected cash flows of $21.00, $34.00, $40.00, $33.00, and $17.00 in periods 1 through 5, respectively. All figures are in thousands of dollars. The inflation rate is 3.0%. For these expected cash flows, the appropriate Real Discount Rate is 4.854%. What is the net present value of this project?

Solution Strategy. We begin by calculating the (nominal) discount rate from the inflation rate and the real discount rate. The rest of the net present value calculation is the same as the Net Present Value - Constant Discount Rate Excel model.

FIGURE 3.2 NPV Using Constant Discounting – Real Rate.



The inflation rate of 3.0% and the real discount rate of 4.854%, combine to yield a nominal discount rate of 8.0%, which is the same as before. Therefore, the Net Present Value of this project is $16.17, which is the same as before.

Problems

1. A project requires a current investment of $189.32 and yields future expected cash flows of $45.19, $73.11, $98,54, $72.83, and $58.21 in periods 1 through 5, respectively. All figures are in thousands of dollars. For these expected cash flows, the appropriate discount rate is 6.3%. What is the net present value of this project?

2. A project requires a current investment of $117.39 and yields future expected cash flows of $38.31, $48.53, $72.80, $96.31, and $52.18 in periods 1 through 5, respectively. All figures are in thousands of dollars. The inflation rate is 2.7%. For these expected cash flows, the appropriate Real Discount Rate is 8.6%. What is the net present value of this project?

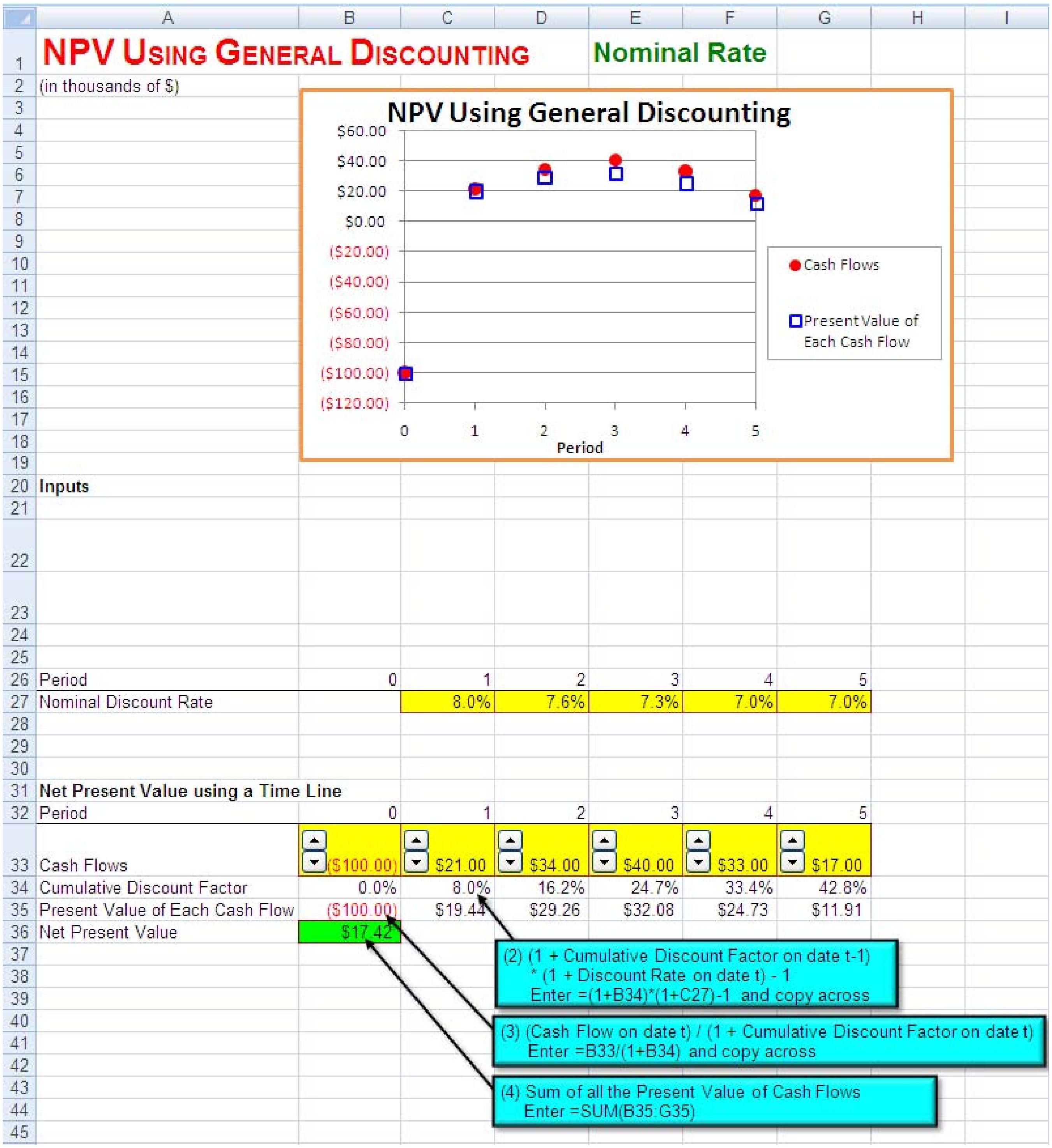
Chapter 4 NPV Using General Discounting

4.1 Nominal Rate

Problem. A project requires a current investment of $100.00 and yields future expected cash flows of $21.00, $34.00, $40.00, $33.00, and $17.00 in periods 1 through 5, respectively. All figures are in thousands of dollars. For these expected cash flows, the appropriate nominal discount rates are 8.0% in period 1, 7.6% in period 2, 7.3% in period 3, 7.0% in period 4, and 7.0% in period 5. What is the net present value of this project?

Solution Strategy. We will calculate the Net Present Value of this project using a Time Line. This is the *only* possible way to calculate the project NPV in the general case where the discount rate changes over time. Excel's **NPV** function cannot be used because it is limited to the special case of a constant discount rate. And there is no simple formula for NPV, short of typing in a term for each cash flow.

FIGURE 4.1 NPV Using General Discounting – Nominal Rate.



The Net Present Value of this project is $17.42.

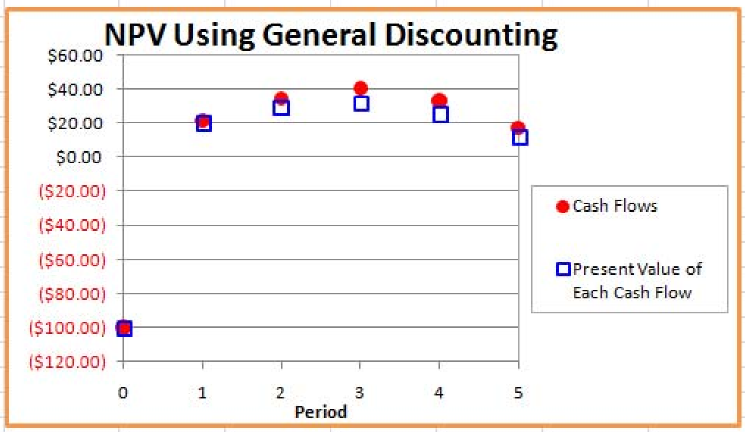
4.2 Real Rate

Problem. A project requires a current investment of $100.00 and yields future expected cash flows of $21.00, $34.00, $40.00, $33.00, and $17.00 in periods 1 through 5, respectively. All figures are in thousands of dollars. The forecasted inflation rate is 3.0% in period 1, 2.8% in period 2, 2.5% in period 3, 2.2% in period 4, and 2.0% in period 5. For these expected cash flows, the appropriate REAL discount rate is 4.854% in period 1, 4.669% in period 2, 4.683% in period 3, 4.697% in period 4, and 4.902% in period 5. What is the net present value of this project?

Solution Strategy. We begin by calculating the (nominal) discount rate for each period from the inflation rate in each period and corresponding real discount rate. The rest of the net present value calculation is the same as the Net Present Value - General Discount Rate Excel model.

FIGURE 4.2 NPV Using General Discounting – Real Rate.

	A	B	C	D	E	F	G	H	I	J
1	NPV USING GENERAL DISCOUNTING			Nominal and Real Rates						
2	(in thousands of $)									



	A	B	C	D	E	F	G	H	I	J
20	**Inputs**									
21	Period	0	1	2	3	4	5			Add to All Periods
22	Inflation Rate		3.0%	2.8%	2.5%	2.2%	2.0%			0.0%
23	Real Discount Rate		4.854%	4.669%	4.683%	4.697%	4.902%			0.0%
24										
25	**Outputs**									
26	Period	0	1	2	3	4	5			
27	Nominal Discount Rate		8.0%	7.6%	7.3%	7.0%	7.0%			
28										
29			(1) (1 + Inflation Rate) * (1 + Real Discount Rate) - 1 Enter =(1+C22)*(1+C23)-1 and copy across							
30										
31	**Net Present Value using a Time Line**									
32	Period	0	1	2	3	4	5			
33	Cash Flows	($100.00)	$21.00	$34.00	$40.00	$33.00	$17.00			
34	Cumulative Discount Factor	0.0%	8.0%	16.2%	24.7%	33.4%	42.8%			
35	Present Value of Each Cash Flow	($100.00)	$19.44	$29.26	$32.08	$24.73	$11.91			
36	Net Present Value	$17.42								

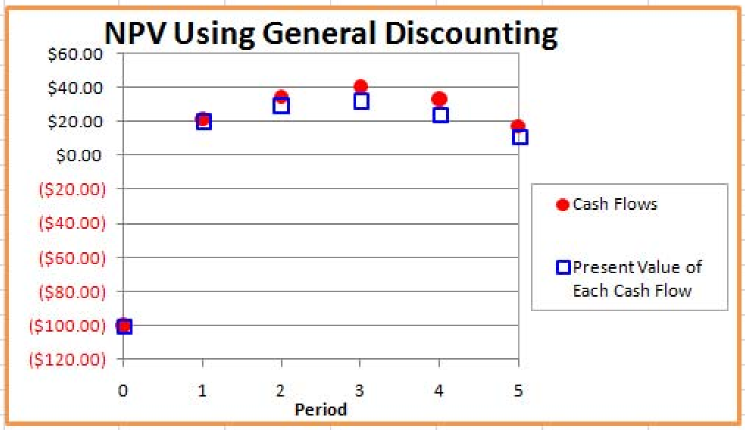
The Net Present Value of this project is $17.42, the same as above.

You can experiment with different inflation rates or real discount rates by clicking the corresponding spin button for each period. Alternative you can raise or lower the inflation rates or real discount rates for *all periods* by click on the spin button in the range **J22:J23**.

This Excel model can handle *any* pattern of discount rates. For example, it can handle the special case of a constant inflation rate at 3.0% and a constant real discount rate at 4.854%.

FIGURE 4.3 NPV Using General Discounting – Real Rate.

	A	B	C	D	E	F	G	H	I	J
1	NPV Using General Discounting				Nominal and Real Rates					
2	(in thousands of $)									



	A	B	C	D	E	F	G	H	I	J
20	**Inputs**									
21	Period	0	1	2	3	4	5			Add to All Periods
22	Inflation Rate		3.0%	3.0%	3.0%	3.0%	3.0%			0.0%
23	Real Discount Rate		4.854%	4.854%	4.854%	4.854%	4.854%			0.0%
24										
25	**Outputs**									
26	Period	0	1	2	3	4	5			
27	Nominal Discount Rate		8.0%	8.0%	8.0%	8.0%	8.0%			
28										
29			(1) (1 + Inflation Rate) * (1 + Real Discount Rate) - 1 Enter =(1+C22)*(1+C23)-1 and copy across							
30										
31	**Net Present Value using a Time Line**									
32	Period	0	1	2	3	4	5			
33	Cash Flows	($100.00)	$21.00	$34.00	$40.00	$33.00	$17.00			
34	Cumulative Discount Factor	0.0%	8.0%	16.6%	26.0%	36.0%	46.9%			
35	Present Value of Each Cash Flow	($100.00)	$19.44	$29.15	$31.75	$24.26	$11.57			
36	Net Present Value	$16.17								

The Net Present Value of this project is $16.17, which is the same answer as the previous chapter on NPV Using Constant Discounting. The general discount rate Excel model is the most general way to do discounting and is the most common approach that we will use in the rest of this book.

Problems

1. A project requires a current investment of $54.39 and yields future expected cash flows of $19.27, $27.33, $34.94, $41.76, and $32.49 in periods 1 through 5, respectively. All figures are in thousands of dollars. For these expected cash flows, the appropriate nominal discount rates are 6.4% in period 1, 6.2% in period 2, 6.0% in period 3, 5.7% in period 4, and 5.4% in period 5. What is the net present value of this project?

3. A project requires a current investment of $328.47 and yields future expected cash flows of $87.39, $134.97, $153.28, $174.99, and $86.41 in periods 1 through 5, respectively. All figures are in thousands of dollars. The forecasted inflation rate is 3.4% in period 1, 3.6% in period 2, 3.9% in period 3, 4.4% in period 4, and 4.7% in period 5. For these expected cash flows, the appropriate REAL discount rate is 7.8% in period 1, 7.1% in period 2, 6.5% in period 3, 6.0% in period 4, and 5.4% in period 5. What is the net present value of this project?

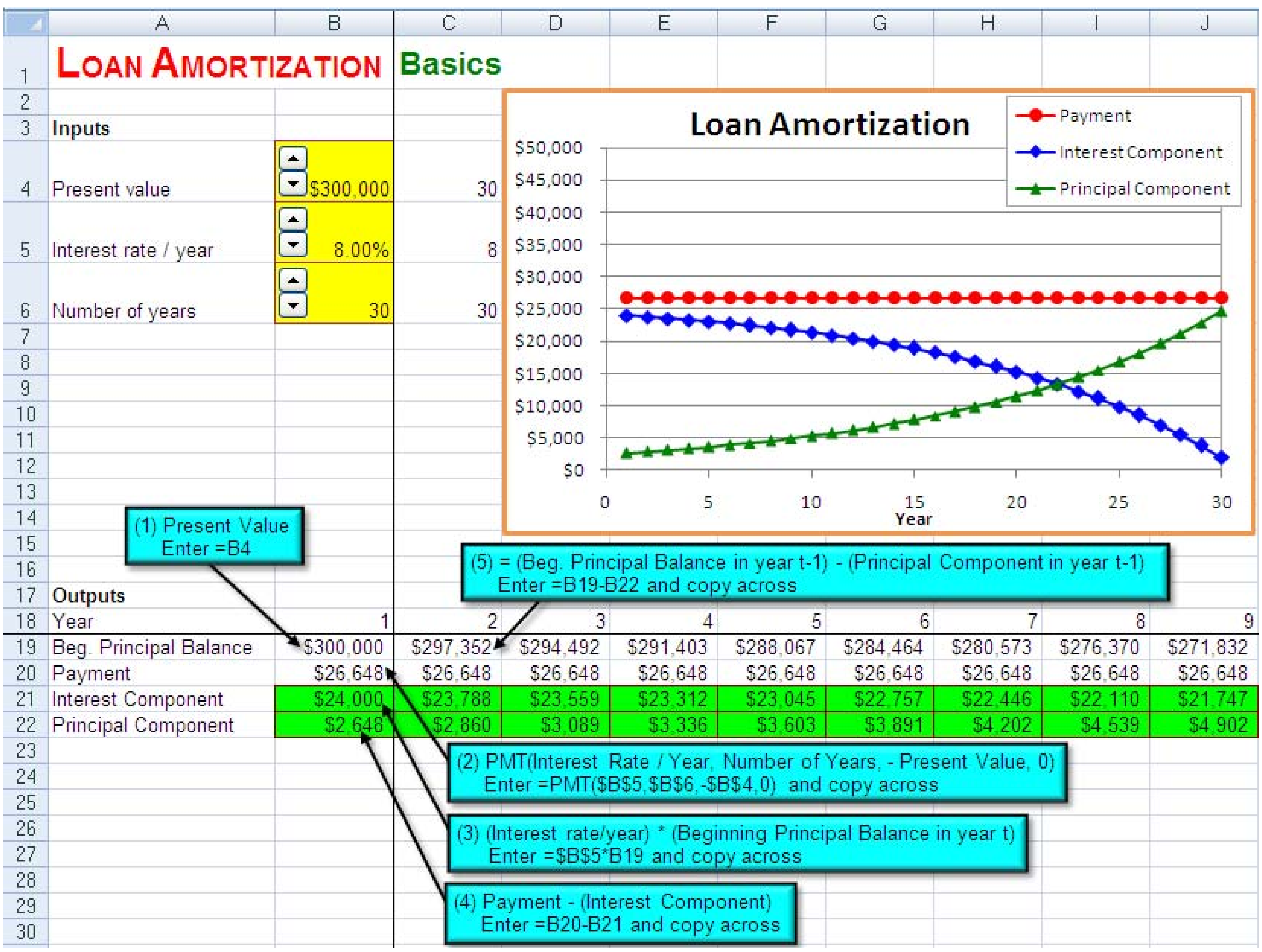
Chapter 5 Loan Amortization

5.1 Basics

Problem. To purchase a house, you take out a 30 year mortgage. The present value (loan amount) of the mortgage is $300,000. The mortgage charges an interest rate / year of 8.00%. What is the annual payment required by this mortgage? How much of each year's payment goes to paying interest and how much reducing the principal balance?

Solution Strategy. First, we use Excel's **PMT** function to calculate the annual payment of a 30 year annuity (mortgage). Then we will use a time line and simple recursive formulas to split out the payment into the interest component and the principal reduction component.

FIGURE 5.1 Excel Model for Loan Amortization - Basics.



The Annual Payment is $26,648. The figure below shows the final years of the time line for the loan.

FIGURE 5.2 Final Years of the Time Line of Loan Amortization - Basics.

	A	B	Z	AA	AB	AC	AD	AE	AF
17	**Outputs**								
18	Year	1	25	26	27	28	29	30	31
19	Beg. Principal Balance	$300,000	$123,192	$106,399	$88,262	$68,675	$47,521	$24,674	($0)
20	Payment	$26,648	$26,648	$26,648	$26,648	$26,648	$26,648	$26,648	
21	Interest Component	$24,000	$9,855	$8,512	$7,061	$5,494	$3,802	$1,974	
22	Principal Component	$2,648	$16,793	$18,136	$19,587	$21,154	$22,847	$24,674	

The principal balance drops to zero in year 31 after the final payment is made in year 30. The loan is paid off! It doesn't matter whether the zero amount in cell AF10 displays as positive or negative. The only reason it would display as negative is due to round off error in the eighth decimal or higher, which is irrelevant of our purposes.

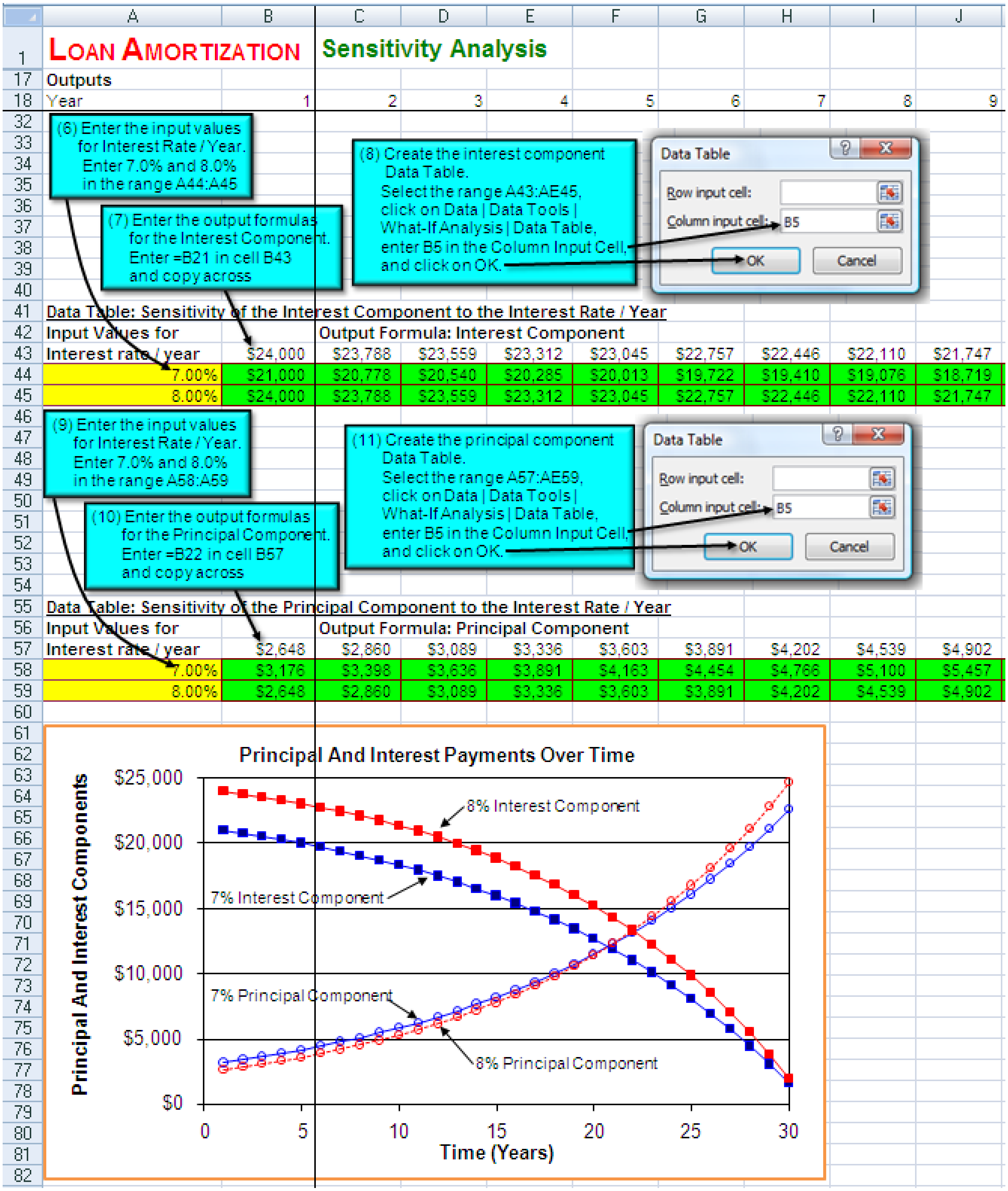
The Interest Component depends on the size of the Beg. Principal Balance. In year 1 the interest component starts at its highest level of $24,000 because the Beg. Principal Balance is at its highest level of $300,000. The interest component gradually declines over time as the Principal Balance gradually declines over time. The interest component reaches its lowest level of $1,974 as the Beg. Principal Balance reaches its lowest level of $24,674. The principal repayment component is the residual part of the payment that is left over after the interest component is paid off. In year 1 when the interest component is the highest, the principal component is the lowest. Even though you made a payment of $26,648 in year 1, only $2,648 of it went to paying off the principal! The principal payment gradually increases over time until it reaches its highest level of $24,674 in year 30.

5.2 Sensitivity Analysis

Problem. Examine the same 30 year mortgage for $300,000 as in the previous section. Consider what would happen if the interest rate / year dropped from 8.00% to 7.00%. How much of each year's payment goes to paying interest vs. how much goes to reducing the principal under the two interest rates?

Solution Strategy. Construct a data table for the interest component under the two interest rates. Construct another data table for the principal component under the two interest rates. Create a graph of the two interest components and two principal components.

FIGURE 5.3 Excel Model for Loan Amortization – Sensitivity Analysis.



Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

From the graph, we see that the Interest Component is much lower at 7% than it is at 8%. Indeed you pay $3,000 less in interest ($21,000 vs. $24,000) in year 1. The difference in interest component gradually declines over time. The principal component stays nearly the same over time. The principal component is slightly more frontloaded at 7% than at 8%. That is, $528 *more* of your payment goes to principal in year 1 at 7% than at 8%. Then it switches and $2,080 *less* of your payment goes to principal in year 30.

Problems

1. To purchase a house, you take out a 30 year mortgage. The present value (loan amount) of the mortgage is $217,832. The mortgage charges an interest rate / year of 9.27%. What is the annual payment required by this mortgage? How much of each year's payment goes to paying interest and how much reducing the principal balance?

2. In purchasing a house, you need to obtain a mortgage with a present value (loan amount) of $175,000. You have a choice of: (A) a 30 year mortgage at an interest rate / year of 9.74% or (B) a 15 year mortgage at an interest rate / year of 9.46%. What is the annual payment required by the two alternative mortgages? How much of each year's payment goes to paying interest and how much reducing the principal balance by the two alternative mortgages? Which mortgage would you prefer?

3. Consider a 30 year mortgage for $442,264 as in the previous section. What would happen if the interest rate / year dropped from 9.21% to 7.95%. How much of each year's payment goes to paying interest vs. how much goes to reducing the principal under the two interest rates?

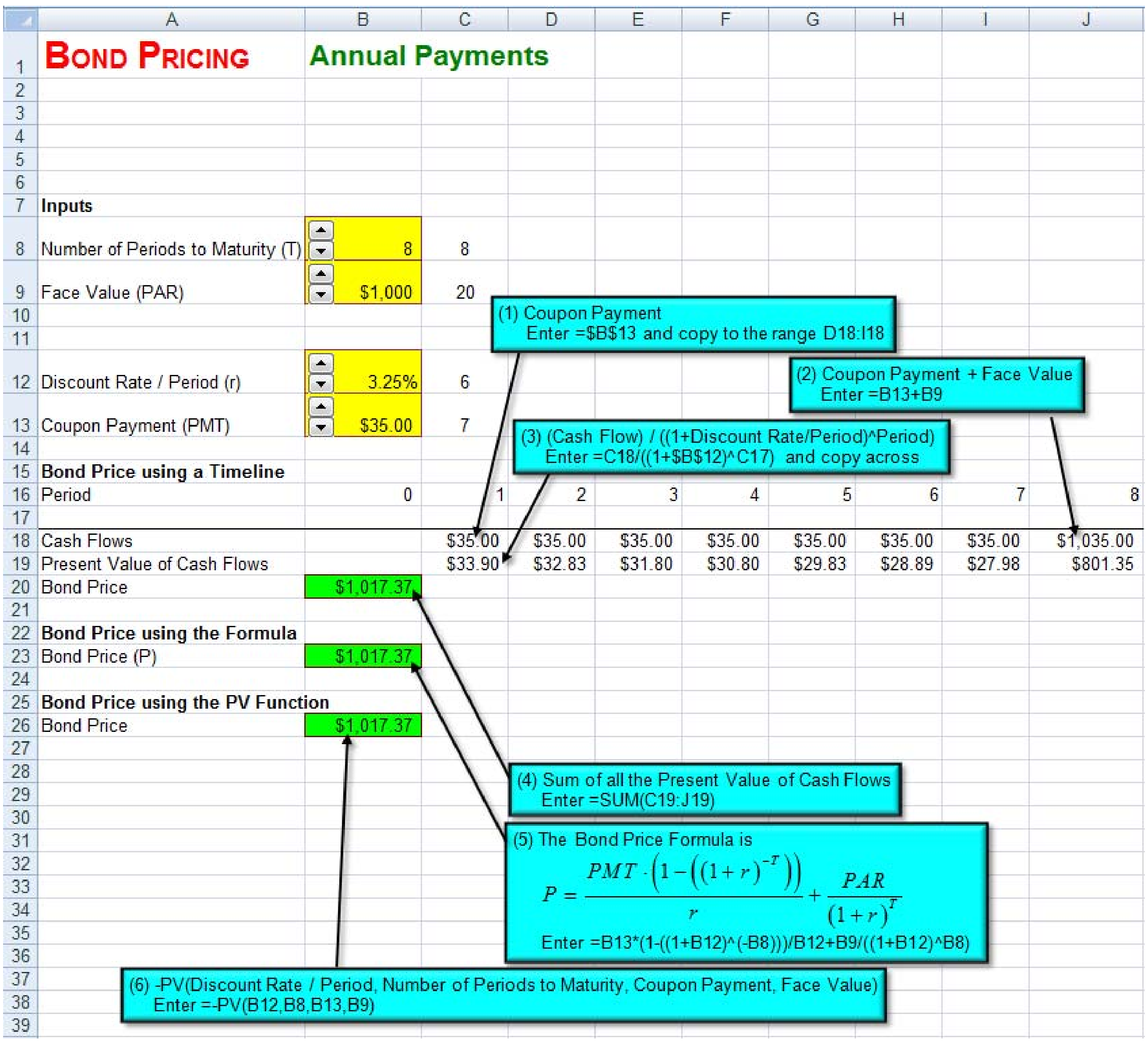
PART 2 VALUATION

Chapter 6 Bond Pricing

6.1 Annual Payments

Problem. On February 26, 2010, an 8 year Treasury Bond with a face value of $1,000.00, paying $35.00 in coupon payments per year had a discount rate per year (yield) of 3.25%. Consider a bond that paid a $35.00 coupon payment once per year. What is price of this annual payment bond?

FIGURE 6.1 Bond Pricing – Annual Payments.



	A	B	C	D	E	F	G	H	I	J
1	BOND PRICING	Annual Payments								
2										
3										
4										
5										
6										
7	**Inputs**									
8	Number of Periods to Maturity (T)	8	8							
9	Face Value (PAR)	$1,000	20							
10										
11										
12	Discount Rate / Period (r)	3.25%	6							
13	Coupon Payment (PMT)	$35.00	7							
14										
15	**Bond Price using a Timeline**									
16	Period	0	1	2	3	4	5	6	7	8
17										
18	Cash Flows		$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$1,035.00
19	Present Value of Cash Flows		$33.90	$32.83	$31.80	$30.80	$29.83	$28.89	$27.98	$801.35
20	Bond Price	$1,017.37								
21										
22	**Bond Price using the Formula**									
23	Bond Price (P)	$1,017.37								
24										
25	**Bond Price using the PV Function**									
26	Bond Price	$1,017.37								
27–39										

The resulting annual bond price is $1,017.37. Notice you get the same answer all three ways: using the cash flows, using the formula, or using the PV function!

6.2 EAR, APR, and Foreign Currencies

Problem. On February 26, 2010, a 4 year Treasury Bond with a face value of $1,000 and an annual coupon rate of 4.00% had a yield to maturity of 1.74%. This bond makes 2 (semi-annual) coupon payments per year and thus has 8 periods until maturity. What is the price of this bond based on the Effective Annual Rate (EAR) convention? What is the price of this bond based on the Annual Percentage Rate (APR) convention? On the same date, the following exchanges rates were observed: $1.00 = ¥7.3790, $1.00 = €0.6805, and $1 = IDR 39.30. Under both the EAR and APR conventions, what is the price of the bond in Chinese Yuan (¥), European Euros (€), and in Indian Rupees (IDR)?

Solution Strategy. We will create an option button that can be used to select either the EAR or APR rate convention. The choice of rate convention will determine the discount rate / period. For a given discount rate / period, we will calculate the bond price in four equivalent ways. First, we will calculate the bond price as the present value of the bond's cash flows. Second, we use a formula for the bond price. Third, we use Excel's PV function for a bond price. Fourth, we use Excel's Analysis ToolPak Add-In **PRICE** function, which only works under the APR convention.

Excel 2007 Equivalent
To install the Analysis ToolPak in Excel 2007, click on , click on 

at the bottom of the drop-down window, click on **Add-Ins**, highlight **Analysis TookPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

Excel 97-2003 Equivalent
To install the Analysis ToolPak in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Analysis TookPak** checkbox on the Add-Ins dialog box, and click on **OK**.

Excel's Analysis ToolPak contains several advanced bond functions, including the **PRICE** function which uses the APR convention. To access any of these functions, you need to install the Analysis ToolPak. Otherwise you will get the error message #NAME?.

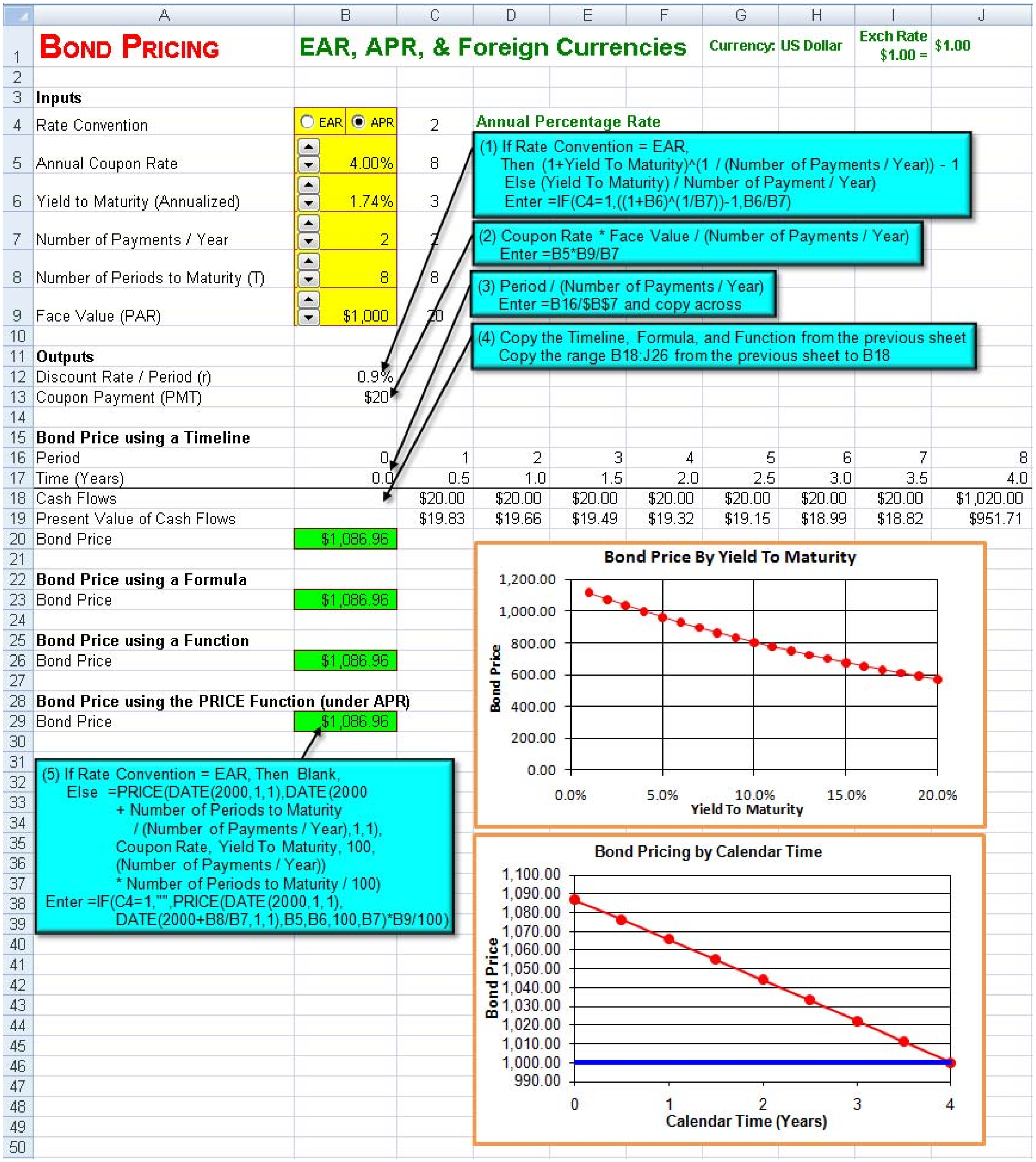
To install the Analysis ToolPak, click on 

, click on 

, click on **Add-Ins**, highlight the **Analysis ToolPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

The bond price function is =PRICE(Settlement Date, Maturity Date, Annual Coupon Rate, Yield To Maturity, Redemption Value, Number of Payments). The Settlement Date is the date when you exchange money to purchase the bond. Specifying the exact day of settlement and maturity allows a very precise calculation. For our purpose, we simply want the difference between the two dates to equal the (8 Periods To Maturity) / (2 Payments / Year) = 4 Years To Maturity. This is easily accomplished by the use of the DATE function. The DATE Function has the format =DATE(Year, Month, Day). We will enter an arbitrary starting date of 1/1/2000 for the Settlement Date and then specify a formula for 1/1/2000 plus T / NOP for the Maturity Date. We also add an IF statement to test for the rate convention being used.

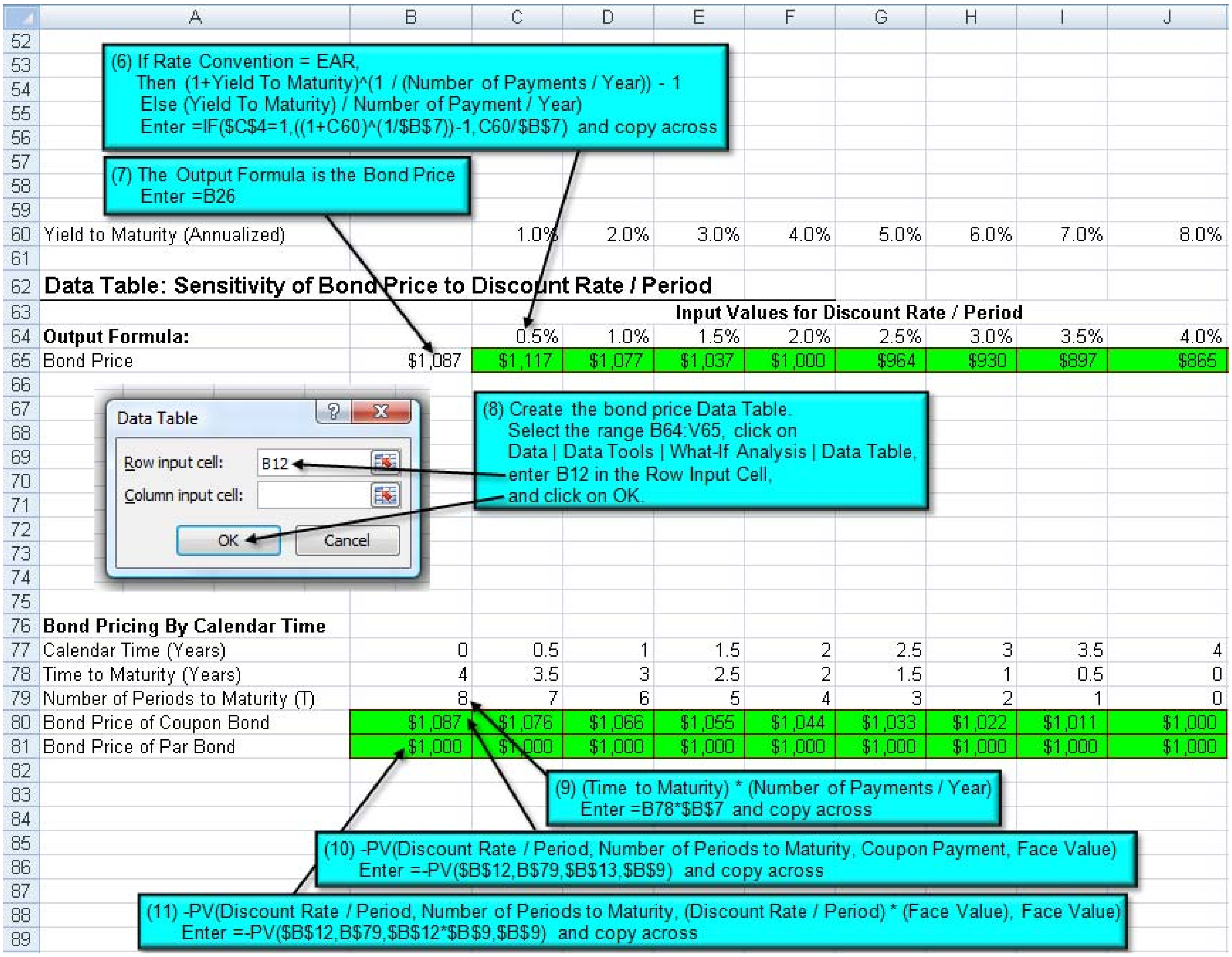
FIGURE 6.2 Bond Pricing – EAR, APR, & Foreign Currencies.



The resulting semi-annual bond price is $1,086.96 under APR and $1,087.26 under EAR. Notice you get the same answer all ways: using the cash flows, using the formula, using the PV function, or using the PRICE function under APR!

It is interesting to link two graphs: (1) bond pricing by yield to maturity and (2) bond pricing by calendar time. The former is done with a Data Table and the later with the PV formula.

FIGURE 6.3 Bond Pricing – EAR, APR, & Foreign Currencies.



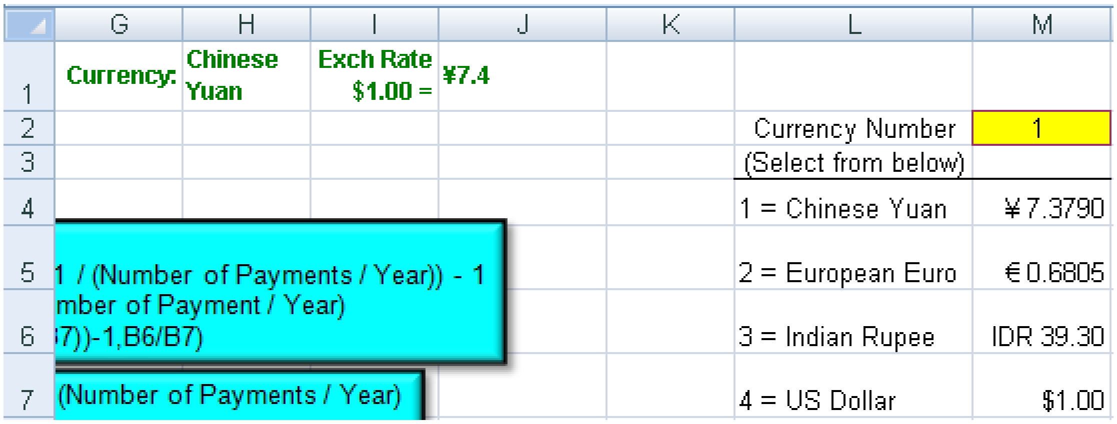
Excel 97-2003 Equivalent
To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

These graphs allow you to change the inputs and instantly see the impact on the bond price by yield to maturity and by calendar time. This allows you to perform instant experiments on the bond price, such as the following:

- What happens when the annual coupon rate is increased?
- What happens when the yield to maturity is increased?
- What happens when the number of payments / year is increased?
- What happens when the face value is increased?
- How does the price of coupon bond change over time when it is at a premium (above par) vs. at a discount (below par)?

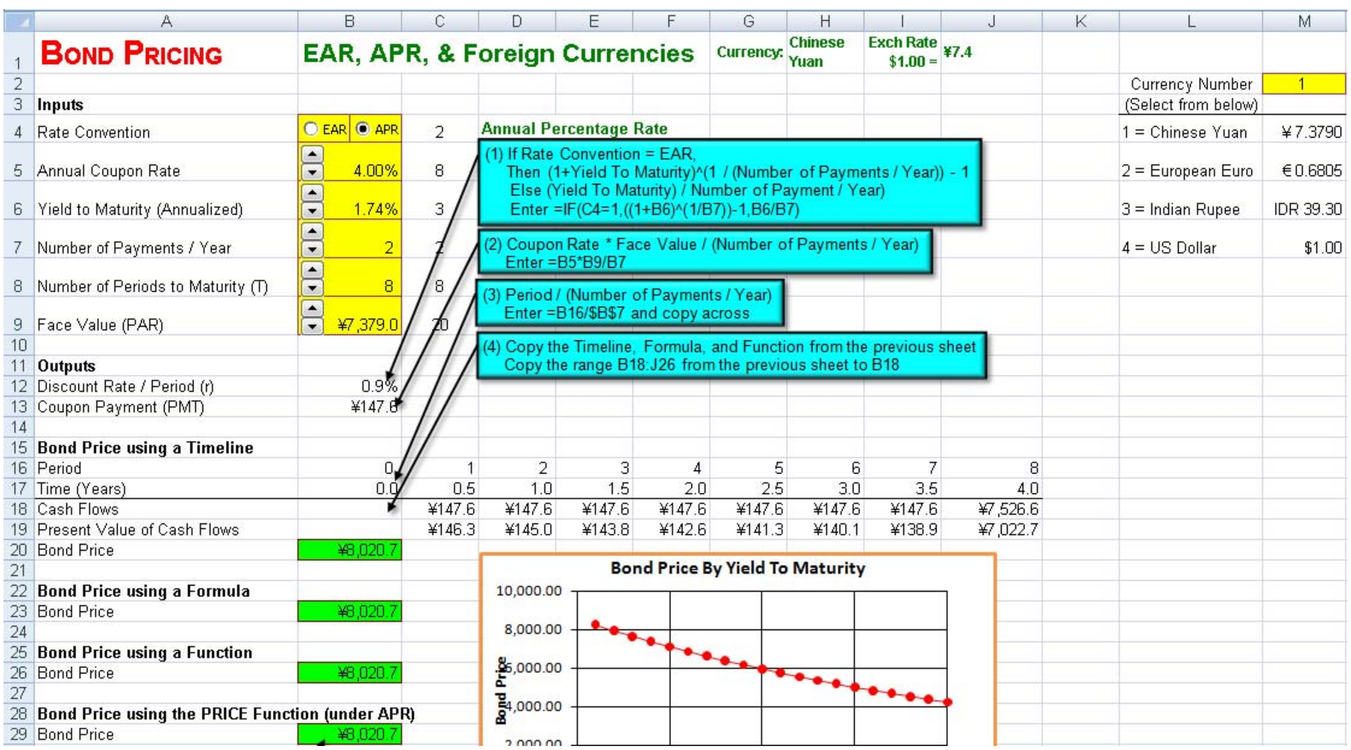
What happens when the annual coupon rate is decreased to the point that it equals the yield to maturity? What happens when it is decreased further?

FIGURE 6.4 Bond Pricing – EAR, APR, & Foreign Currencies.



This spreadsheet has foreign currency conversion built into it. Cell **M2** is the currency selection cell. The default is currency 4, which is US Dollars. If you enter 1 in cell **M2**, then the spreadsheet converts to Chinese Yuan.

FIGURE 6.5 Bond Pricing – EAR, APR, & For. Cur. – in Chinese Yuan.



The selected exchange rate is displayed in cell **J1**, $1.00 = ¥7.3790 (rounded to ¥7.4). This exchange rate is multiplied by the $1,000 face value in cell B9 to get a ¥7,379 face value and this in turn spread throughout the spreadsheet. The resulting semi-annual bond price is ¥8,020.7 under APR and ¥8,022.9 under

EAR. All of the dollar amount cells have conditional formatting rule to display ¥ for Chinese Yuan, € for European Euros, and IDR for Indian Rupees (see below).

FIGURE 6.6 Bond Pricing – EAR, APR, & For. Cur. – in European Euros.

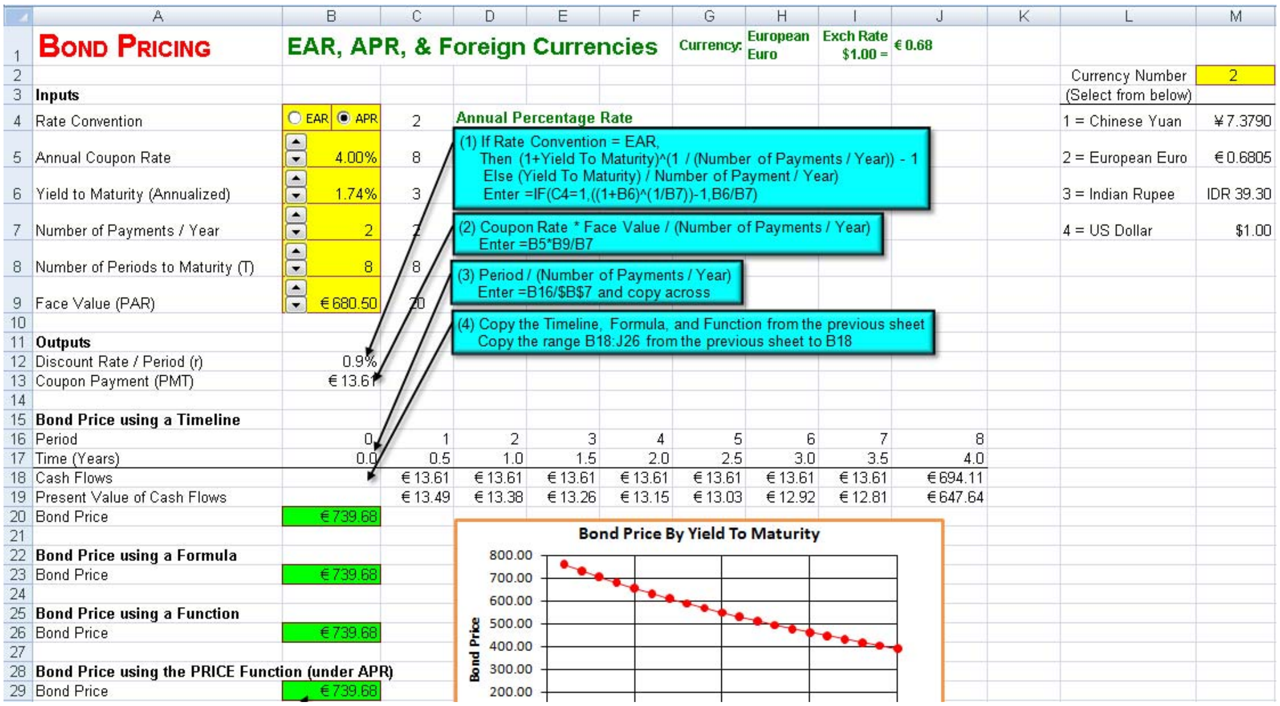
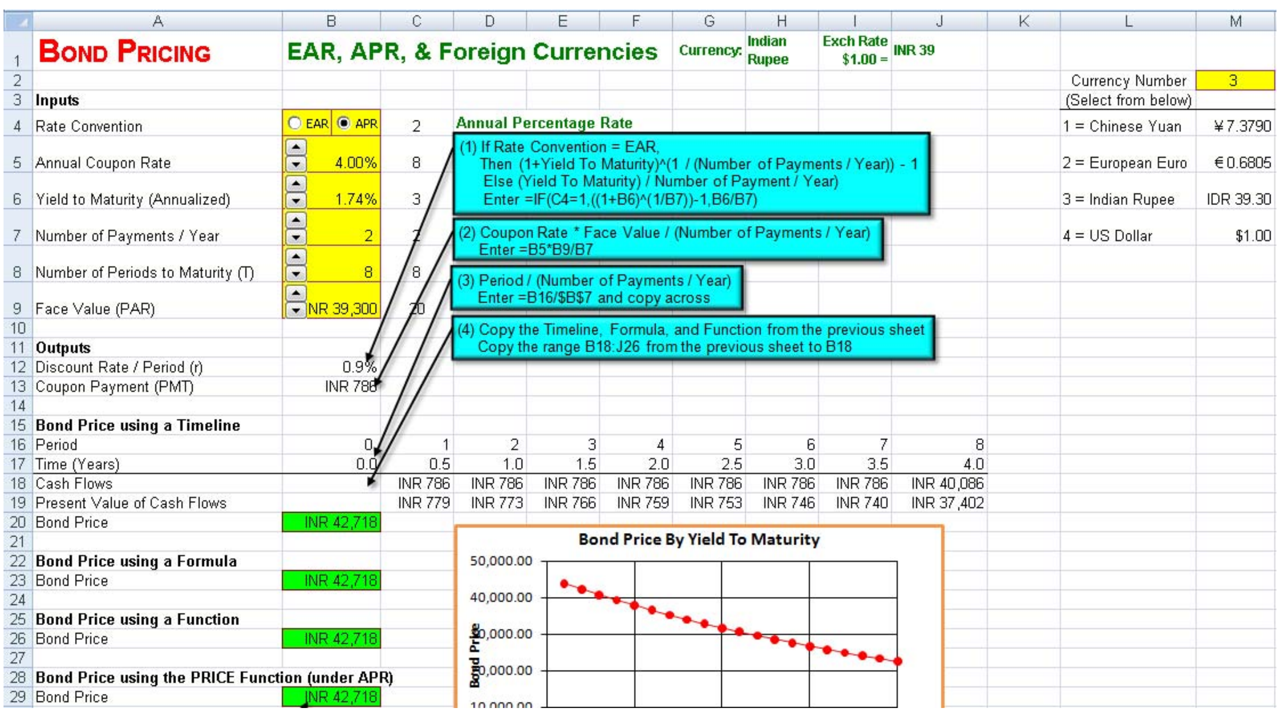


FIGURE 6.7 Bond Pricing – EAR, APR, & For. Cur. – in Indian Rupees.

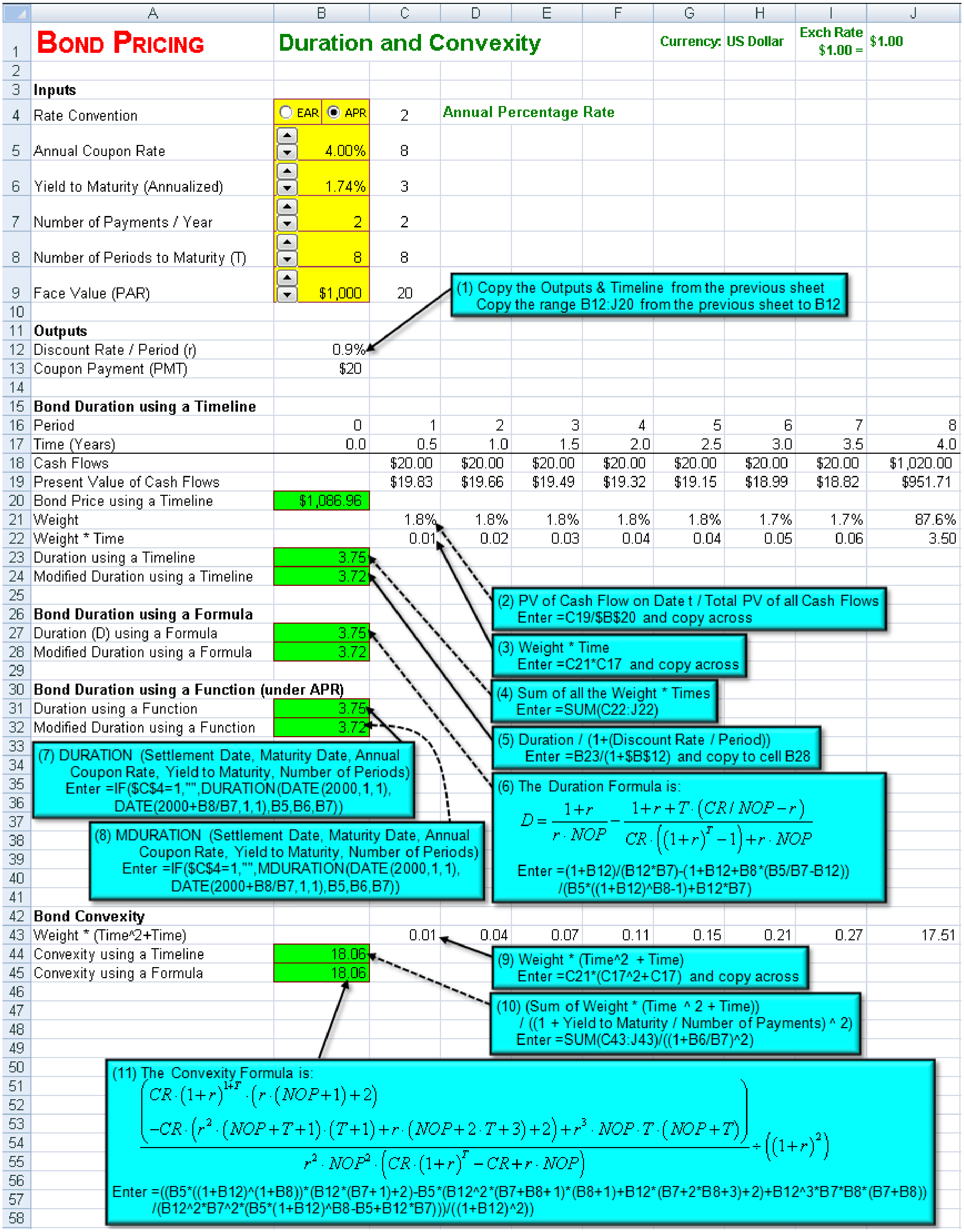


6.3 Duration and Convexity

Problem. On February 26, 2010, a 4 year Treasury Bond with a face value of $1,000 and an annual coupon rate of 4.00% had a yield to maturity of 1.74%. This bond makes 2 (semi-annual) coupon payments per year and thus has 8 periods until maturity. What is the duration, modified duration, and convexity of this bond based on the Annual Percentage Rate (APR) convention? What is the duration, modified duration, and convexity of this bond based on the Effective Annual Rate (EAR) convention? What is the intuitive interpretation of duration?

Solution Strategy. The choice of either the EAR or APR rate convention will determine the discount rate / period. For a given the discount rate / period, we will calculate duration and modified duration three equivalent ways. First, we will calculate duration as the weighted-average time to the bond's cash flows. This method illustrates the intuitive interpretation of duration. Second, we use a formula for duration. In both cases, modified duration is a simple adjustment of regular duration (also called Macaulay's Duration). Third, we use Excel's Analysis ToolPak Add-In **DURATION** and **MDURATION** functions, which only work under the APR convention. We will calculate convexity two equivalent ways. First, we will calculate convexity as the weighted-average (time-squared plus time) to the bond's cash flows. Second, we use a formula for convexity.

FIGURE 6.8 Bond Pricing – Duration and Convexity.



Excel 2007 Equivalent

To install the Analysis ToolPak in Excel 2007, click on , click on Excel Options at the bottom of the drop-down window, click on **Add-Ins**, highlight **Analysis TookPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

Excel 97-2003 Equivalent

To install the Analysis ToolPak in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Analysis TookPak** checkbox on the Add-Ins dialog box, and click on **OK**.

The timeline method of calculation directly illustrates the key intuition that (Macaulay's) duration is the weighted-average of the time until cash flows are received. The weights are based on the ratio of the present value of each cash flow over the present value of the total bond.

Excel's Analysis ToolPak contains several advanced bond functions, including the **DURATION** and **MDURATION** functions, which use the APR convention.

To install the Analysis ToolPak, click on File, click on Options, click on **Add-Ins**, highlight the **Analysis ToolPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

The duration is 3.75 years and the modified duration is 3.72 years. Notice you get the same answer all three ways: using the cash flows, using the formula, or using the Analysis ToolPak Add-In function!
The value of bond convexity is 18.06. Again you get the same answer both ways: using the cash flows or using the formula!

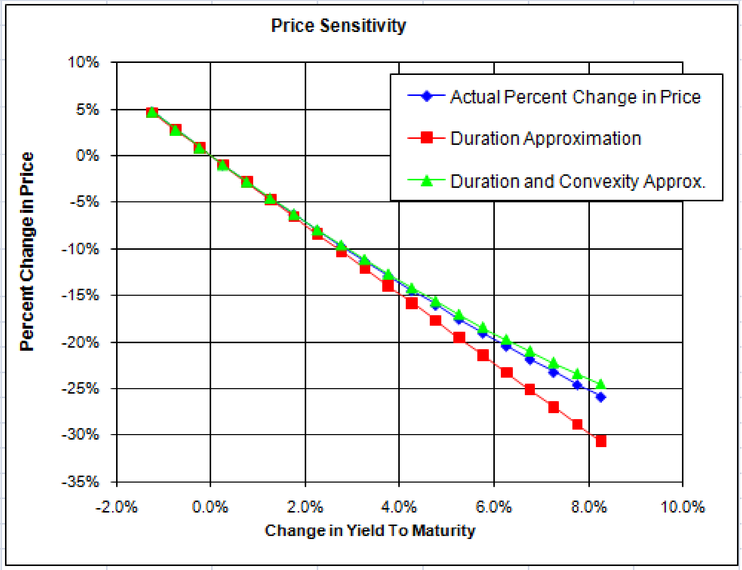
6.4 Price Sensitivity

Bond duration is a measure of the price sensitivity of a bond to changes in interest rates. In other words, it is a measure of the bond's interest rate risk. Duration tells you approximately what percent change in bond price will result from a given change in yield to maturity.
Bond convexity complements bond duration in measuring of the price sensitivity of a bond to changes in interest rates. In other words, duration and convexity combined give you a better approximation of what percent change in bond price will result from a given change in yield to maturity than you can get from duration alone. To get the overall picture we will compare all three on a graph: the duration approximation, the duration and convexity approximation, and the actual percent change in the bond price.

Problem. On February 26, 2010, a 4 year Treasury Bond with a face value of \$1,000 and an annual coupon rate of 4.00% had a yield to maturity of 1.74%. This bond makes 2 (semi-annual) coupon payments per year and thus has 8 periods until maturity. What is the price sensitivity of a bond to changes in yield and how does that compare to the duration approximation, and compare to the duration plus convexity approximation?

FIGURE 6.9 Bond Pricing – Price Sensitivity.

A	B	C	D	E	F	G	H	I	J
Bond Pricing	**Price Sensitivity**					**Currency:**	**US Dollar**	**Exch Rate $1.00 =**	**$1.00**
Inputs	**Annual Percentage Rate**								
Rate Convention	EAR / APR	2							
Annual Coupon Rate (CR)	4.00%	8							
Yield to Maturity (Annualized)	1.74%	3							
Number of Payments / Year (NOP)	2	2							
Number of Periods to Maturity (T)	8	8							
Face Value	$1,000	20							
Outputs									
Discount Rate / Period (r)	0.9%								
Coupon Payment	$20								



(1) If Rate Convention = EAR,
Then (1+Yield To Maturity)
^(1 / (Number of Payments / Year)) - 1
Else (Yield To Maturity) / Number of Payment / Year)
Enter =IF($C$4=1,((1+B21)^(1/$B$7))-1,B21/$B$7)
and copy across

A	B	C	D	E	F	G	H	I	J
Chart Outputs									
Yield to Maturity (Annualized)	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%	4.50%
Discount Rate / Period	0.3%	0.5%	0.8%	1.0%	1.3%	1.5%	1.8%	2.0%	2.3%
Change in Yield to Maturity	-1.2%	-0.7%	-0.2%	0.3%	0.8%	1.3%	1.8%	2.3%	2.8%
Actual Bond Price	$1,138	$1,117	$1,097	$1,077	$1,057	$1,037	$1,019	$1,000	$982
Current Bond Price	$1,087	$1,087	$1,087	$1,087	$1,087	$1,087	$1,087	$1,087	$1,087
Actual Percent Change in Price	4.7%	2.8%	0.9%	-1.0%	-2.8%	-4.6%	-6.3%	-8.0%	-9.7%
Modified Duration	3.72	3.72	3.72	3.72	3.72	3.72	3.72	3.72	3.72
Duration Approximation	4.6%	2.8%	0.9%	-1.0%	-2.8%	-4.7%	-6.5%	-8.4%	-10.3%
Convexity	18.06	18.06	18.06	18.06	18.06	18.06	18.06	18.06	18.06
Duration and Convexity Approx.	4.7%	2.8%	0.9%	-1.0%	-2.8%	-4.5%	-6.3%	-7.9%	-9.6%

(2) New YTM - Current YTM
Enter =B21-$B$6 and copy across

(3) -PV(Actual Discount Rate / Period,
Number of Periods to Maturity,
Coupon Payment, Face Value)
Enter =-PV(B22,$B$8,$B$13,$B$9)
and copy across

(4) -PV(Current Discount Rate / Period,
Number of Periods to Maturity,
Coupon Payment, Face Value)
Enter =-PV($B$12,$B$8,$B$13,$B$9)
and copy across

(5) (Actual Bond Price
- Current Bond Price)
/ Current Bond Price
Enter =(B24-B25)/B25
and copy across

(6) The Modified Duration Formula is:

$$D^* = \left(\frac{1+r}{r \cdot NOP} - \frac{1+r+T\cdot(CR/NOP-r)}{CR\cdot\left((1+r)^T-1\right)+r\cdot NOP} \right) \div (1+r)$$

Enter =((1+$B$12)/($B$12*$B$7)
-(1+$B$12+$B$8*($B$5/$B$7-$B$12))
/($B$5*((1+$B$12)^$B$8-1)+$B$12*$B$7))/(1+$B$12)
and copy across

(7) -Modified Duration
* Change in YTM
Enter =-B27*B23
and copy across

(9) Duration Approximation
\+ (1/2) * Convexity * (Change in YTM)^2
Enter =B28+(1/2)*B29*B23^2 and copy across

(8) The Convexity Formula is:

$$\frac{\left(\begin{array}{l} CR\cdot(1+r)^{1+T}\cdot\left(r\cdot(NOP+1)+2\right) \\ -CR\cdot\left(r^2\cdot(NOP+T+1)\cdot(T+1)+r\cdot(NOP+2\cdot T+3)+2\right)+r^3\cdot NOP\cdot T\cdot(NOP+T) \end{array} \right)}{r^2\cdot NOP^2\cdot\left(CR\cdot(1+r)^T-CR+r\cdot NOP\right)} \div \left((1+r)^2\right)$$

Enter =(($B$5*((1+$B$12)^(1+$B$8))*($B$12*($B$7+1)+2)-$B$5*($B$12^2*($B$7+$B$8+1)*($B$8+1
+$B$12*($B$7+2*$B$8+3)+2)+$B$12^3*$B$7*$B$8*($B$7+$B$8))/($B$12^2*$B$7^2*
($B$5*(1+$B$12)^$B$8-$B$5+$B$12*$B$7)))/((1+$B$12)^2) and copy across

It is clear from the graph that duration does a very good job of approximating the price sensitivity of a bond. That is, the percent change in bond price from the duration approximation is very close to the actual percent change. This is especially true for relatively small changes in yield to maturity (say, plus or minus 3%). For larger changes in yield to maturity, there is a gap between the duration approximation and the actual percent change. The gap comes from the fact that the actual percent change is curved, whereas the duration approximation is a straight line.

One could do a better job of approximating the price sensitivity of a bond for larger changes in yield to maturity if one could account for the curvature. That is exactly what bond convexity does. The graph illustrates that duration and convexity approximation of the price sensitivity of a bond is better than the duration approximation alone. That is, the percent change in bond price from the duration and convexity approximation is very close to the actual percent change over a wide range of changes in yield to maturity (say, plus or minus 7%). Only for a very large change in yield to maturity is there any gap between the duration and convexity approximation and the actual percent change and the gap is pretty small.

In summary, duration alone does a good job of approximating the actual percent change using the slope only. Then convexity does a good job of adding the curvature. Together they do a great job of approximating the price sensitivity (i.e., interest rate risk) of a bond over a wide range of changes in yields.

6.5 Immunization

Problem. Suppose that an insurance company sells a guaranteed investment contract (GIC) to make a $4,000,000 lump-sum payment in 3 years. The company wishes to construct a portfolio of assets to cover this single liability, such that it is immunized against interest rate risk right now. The company is considering investing in two bonds: (1) a 2-year Treasury bond with a face value of $1,000 and an annual coupon rate of 1.50% and (2) a 4-year Treasury bond with a face value of $1,000 and an annual coupon rate of 2.00%.Both bonds make 2 (semi-annual) coupon payments per year. Thus they have 4 periods until maturity and 8 periods until maturity, respectively. The current yield on all bonds is 1.74%. How many 2-year and 4-year Treasury bonds should the insurance company buy in order to fully fund the liability and be immunized against interest rate risk right now?

Solution Strategy. To fully fund the liability, the present value of the assets must be equal to the present value of the liabilities. To be fully immunized right now, the duration of the assets must be equal to the duration of the liabilities. We will use Solver to find the number of 2-year and 4-year Treasury bonds that satisfy these requirements.

FIGURE 6.10 Bond Pricing – Immunization – A Single Liability.

	A	B	C	D	E	F	G	H	I	J
1	BOND PRICING	Immunization					Currency:	US Dollar	Exch Rate $1.00 =	$1.00
2										
3	**Inputs**									
4	Rate Convention	EAR APR	2	Annual Percentage Rate						
5	Yield to Maturity (Annualized)	1.74%								
6	Number of Payments / Year	2								
7		Annual Coupon Rate	Number of Periods to Maturity (T)	Face Value (PAR)	Number of Bonds	Coupon Payment (PMT)				
8	Bond 1	1.50%	4	$1,000	1,783	$8				
9	Bond 2	2.00%	8	$1,000	2,042	$10				
10	Bond 3	1.90%	6	$1,000	0	$10				
11	Bond 4	2.30%	8	$1,000	0	$12				
12	Bond 5	1.70%	5	$1,000	0	$9				
13	Bond 6	1.90%	6	$1,000	0	$10				
14	Bond 7	2.10%	7	$1,000	0	$11				
15	Bond 8	2.30%	8	$1,000	0	$12				
16										
17	**Outputs**									
18	Discount Rate / Period (r)	0.9%								
19										
20	**Bond Present Value, Duration, and Convexity using a Timeline**									
21	Period	0	1	2	3	4	5	6	7	8
22	Time (Years)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
23	Liabilities		$0	$0	$0	$0	$0	$4,000,000	$0	$0
24	Present Value of Liabilities		$0	$0	$0	$0	$0	$3,797,413	$0	$0
25	Total Present Value of Liabilities	$3,797,413								
26	Weight		0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
27	Weight * Time		0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00
28	Duration of Liabilities	3.00								
29	Modified Duration of Liabilities	2.97								
30	Weight * (Time^2+Time)		0.00	0.00	0.00	0.00	0.00	12.00	0.00	0.00
31	Convexity of Liabilities	11.79								
32										
33										
34	Assets									
35	Bond 1		$13,371	$13,371	$13,371	$1,796,227	$0	$0	$0	$0
36	Bond 2		$15,313	$15,313	$15,313	$15,313	$15,313	$15,313	$15,313	$2,057,101
37	Bond 3		$0	$0	$0	$0	$0	$0	$0	$0
38	Bond 4		$0	$0	$0	$0	$0	$0	$0	$0
39	Bond 5		$0	$0	$0	$0	$0	$0	$0	$0
40	Bond 6		$0	$0	$0	$0	$0	$0	$0	$0
41	Bond 7		$0	$0	$0	$0	$0	$0	$0	$0
42	Bond 8		$0	$0	$0	$0	$0	$0	$0	$0
43	Total Assets		$28,685	$28,685	$28,685	$1,811,540	$15,313	$15,313	$15,313	$2,057,101
44	Present Value of Assets		$28,437	$28,192	$27,949	$1,749,846	$14,664	$14,538	$14,412	$1,919,374
45	Total Present Value of Assets	$3,797,413								
46	Weight		0.7%	0.7%	0.7%	46.1%	0.4%	0.4%	0.4%	50.5%
47	Weight * Time		0.00	0.01	0.01	0.92	0.01	0.01	0.01	2.02
48	Duration of Assets	3.00								
49	Modified Duration of Assets	2.97								
50	Weight * (Time^2+Time)		0.01	0.01	0.03	2.76	0.03	0.05	0.06	10.11
51	Convexity of Assets	12.84								
52										
53	Differences									
54	Total Assets - Liabilities		$28,685	$28,685	$28,685	$1,811,540	$15,313	($3,984,687)	$15,313	$2,057,101
55	PV of Assets - PV of Liabilities	$0								
56	Duration of Assets - Duration of Liab	0.00								
57	Convexity of Assets - Convexity of Liab	1.04								
58										
59										

(1) Coupon Rate * Face Value / (Number of Payments / Year)
Enter =B8*D8/$B$6 and copy down

(2) If Rate Convention = EAR,
Then (1+Yield To Maturity)^(1 / (Number of Payments / Year)) - 1
Else (Yield To Maturity) / Number of Payment / Year)
Enter =IF(C4=1,((1+B5)^(1/B6))-1,B5/B6)

(3) Copy the Present Value & Duration formulas from the Duration and Convexity sheet
Copy the range B19:J24 from the Duration and Convexity sheet to B24

(4) Weight * (Time^2 + Time)
Enter =C26*(C22^2+C22) and copy across

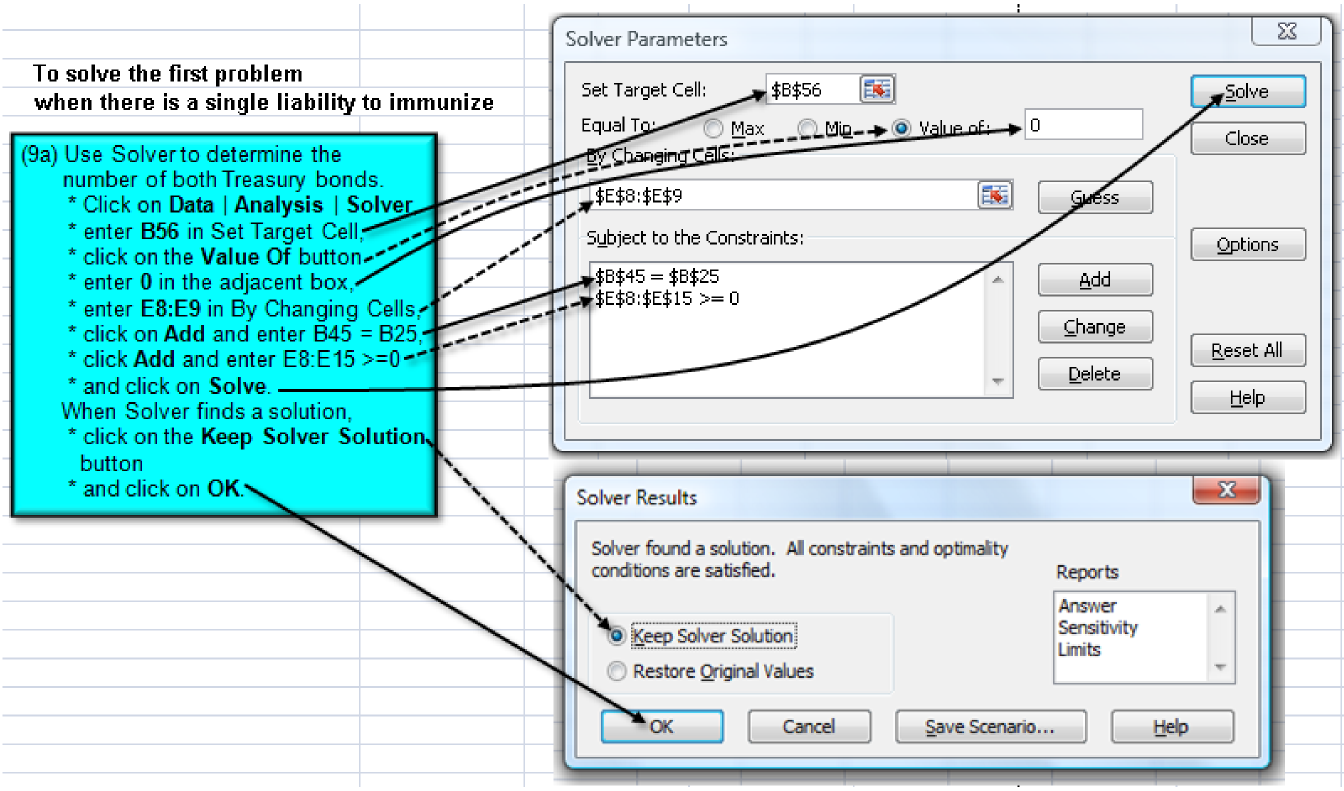
(5) (Sum of Weight * (Time ^ 2 + Time))
/ ((1 + Yield to Maturity / Number of Payments) ^ 2)
Enter =SUM(C30:J30)/((1+B18)^2)

(6) Copy the Present Value, Duration, and Convexity formulas from above
Copy the range B24:J31 to B44

(7) Total Assets - Liabilities
Enter =C43-C23 and copy across

(8) Compute the differences between Assets and Liabilities in Present Value, Duration, and Convexity
Enter =B45-B25 in B55, =B48-B28 in B56, and =B51-B31 in B57

FIGURE 6.11 Bond Pricing – Immunization – A Single Liability.



The answer is buy 1,783 2-year Treasury bonds and buy 2,042 4-year Treasury bonds. This portfolio of assets has a present value of $3,797,413, which equals the present value of the liability. This portfolio of assets has a duration of 3.00 years, which equals the duration of the liability. Thus, there is no interest rate risk at this moment. This portfolio of assets has a convexity of 12.84, which is greater than the liability convexity of 11.79. Thus, a change in yields will cause the portfolio to acquire interest rate risk in the future.

Problem 2. Suppose that a pension fund has a series of liabilities to be paid every six months to the pension plan beneficiaries: $2,000,000, $2,200,000, $2,500,000, $3,200,000, $3,700,000, $4,300,000, $4,700,000, and $5,100,000. The company wishes to construct a portfolio of assets to cover this series of liabilities, such that it is immunized against interest rate risk right now. The company is considering investing in four bonds: (1) a 1-year Treasury bond with a face value of $1,000 and an annual coupon rate of 0.90%, (2) a 2-year Treasury bond with a face value of $1,000 and an annual coupon rate of 1.50%, (3) a 3-year Treasury bond with a face value of $1,000 and an annual coupon rate of 1.90%, and (4) a 4-year Treasury bond with a face value of $1,000 and an annual coupon rate of 2.30%. All four bonds make 2 (semi-annual) coupon payments per year. Thus they have 2 periods, 4 periods, 6 periods, and 8 periods until maturity, respectively. The current yield on all bonds is 1.74%. How many of each of these four Treasury bonds should the pension fund buy in order to fully fund the liability and be immunized against interest rate risk right now?

Solution Strategy 2. To fully fund the liability, the present value of the assets must be equal to the present value of the liabilities. To be fully immunized right now, the duration of the assets must be equal to the duration of the liabilities. We will use Solver to find the number of each of the four Treasury bonds that satisfy these requirements.

FIGURE 6.12 Bond Pricing – Immunization – A Series of Liabilities.

	A	B	C	D	E	F	G	H	I	J
1	BOND PRICING	Immunization					Currency:	US Dollar	Exch Rate $1.00 =	$1.00
2										
3	**Inputs**									
4	Rate Convention	○ EAR ◉ APR	2	Annual Percentage Rate						
5	Yield to Maturity (Annualized)	1.74%								
6	Number of Payments / Year	2								
7		Annual Coupon Rate	Number of Periods to Maturity (T)	Face Value (PAR)	Number of Bonds	Coupon Payment (PMT)				
8	Bond 1	0.90%	2	$1,000	6,038	$5				
9	Bond 2	1.50%	4	$1,000	5,937	$8				
10	Bond 3	1.90%	6	$1,000	7,017	$10				
11	Bond 4	2.30%	8	$1,000	8,068	$12				
12	Bond 5	1.70%	5	$1,000	0	$9				
13	Bond 6	1.90%	6	$1,000	0	$10				
14	Bond 7	2.10%	7	$1,000	0	$11				
15	Bond 8	2.30%	8	$1,000	0	$12				
16										
17	**Outputs**									
18	Discount Rate / Period (r)	0.9%								
19										
20	**Bond Present Value, Duration, and Convexity using a Timeline**									
21	Period	0	1	2	3	4	5	6	7	8
22	Time (Years)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
23	Liabilities		$2,000,000	$2,200,000	$2,500,000	$3,200,000	$3,700,000	$4,300,000	$4,700,000	$5,100,000
24	Present Value of Liabilities		$1,982,750	$2,162,214	$2,435,869	$3,091,021	$3,543,167	$4,082,219	$4,423,476	$4,758,543
25	Total Present Value of Liabilities	$26,479,259								
26	Weight		7.5%	8.2%	9.2%	11.7%	13.4%	15.4%	16.7%	18.0%
27	Weight * Time		0.04	0.08	0.14	0.23	0.33	0.46	0.58	0.72
28	Duration of Liabilities	2.59								
29	Modified Duration of Liabilities	2.57								
30	Weight * (Time^2+Time)		0.06	0.16	0.34	0.70	1.17	1.85	2.63	3.59
31	Convexity of Liabilities	10.33								
32										
33										
34	Assets									
35	Bond 1		$27,171	$6,065,128	$0	$0	$0	$0	$0	$0
36	Bond 2		$26,715	$26,715	$26,715	$5,963,327	$0	$0	$0	$0
37	Bond 3		$31,575	$31,575	$31,575	$31,575	$31,575	$7,048,286	$0	$0
38	Bond 4		$36,306	$36,306	$36,306	$36,306	$36,306	$36,306	$36,306	$8,104,284
39	Bond 5		$0	$0	$0	$0	$0	$0	$0	$0
40	Bond 6		$0	$0	$0	$0	$0	$0	$0	$0
41	Bond 7		$0	$0	$0	$0	$0	$0	$0	$0
42	Bond 8		$0	$0	$0	$0	$0	$0	$0	$0
43	Total Assets		$121,767	$6,159,723	$94,596	$6,031,208	$67,881	$7,084,592	$36,306	$8,104,284
44	Present Value of Assets		$120,716	$6,053,927	$92,169	$5,825,809	$65,004	$6,725,781	$34,170	$7,561,683
45	Total Present Value of Assets	$26,479,259								
46	Weight		0.5%	22.9%	0.3%	22.0%	0.2%	25.4%	0.1%	28.6%
47	Weight * Time		0.00	0.23	0.01	0.44	0.01	0.76	0.00	1.14
48	Duration of Assets	2.59								
49	Modified Duration of Assets	2.57								
50	Weight * (Time^2+Time)		0.00	0.46	0.01	1.32	0.02	3.05	0.02	5.71
51	Convexity of Assets	10.41								
52										
53	Differences									
54	Total Assets - Liabilities		($1,878,233)	$3,959,723	($2,405,404)	$2,831,208	($3,632,119)	$2,784,592	($4,663,694)	$3,004,284
55	PV of Assets - PV of Liabilities	$0								
56	Duration of Assets - Duration of Liab	0.00								
57	Convexity of Assets - Convexity of Liab	0.08								
58										
59										

(1) Coupon Rate * Face Value / (Number of Payments / Year)
Enter =B8*D8/$B$6 and copy down

(2) If Rate Convention = EAR,
Then (1+Yield To Maturity)^(1 / (Number of Payments / Year)) - 1
Else (Yield To Maturity) / Number of Payment / Year)
Enter =IF(C4=1,((1+B5)^(1/B6))-1,B5/B6)

(3) Copy the Present Value & Duration formulas from the Duration and Convexity sheet
Copy the range B19:J24 from the Duration and Convexity sheet to B24

(4) Weight * (Time^2 + Time)
Enter =C26*(C22^2+C22) and copy across

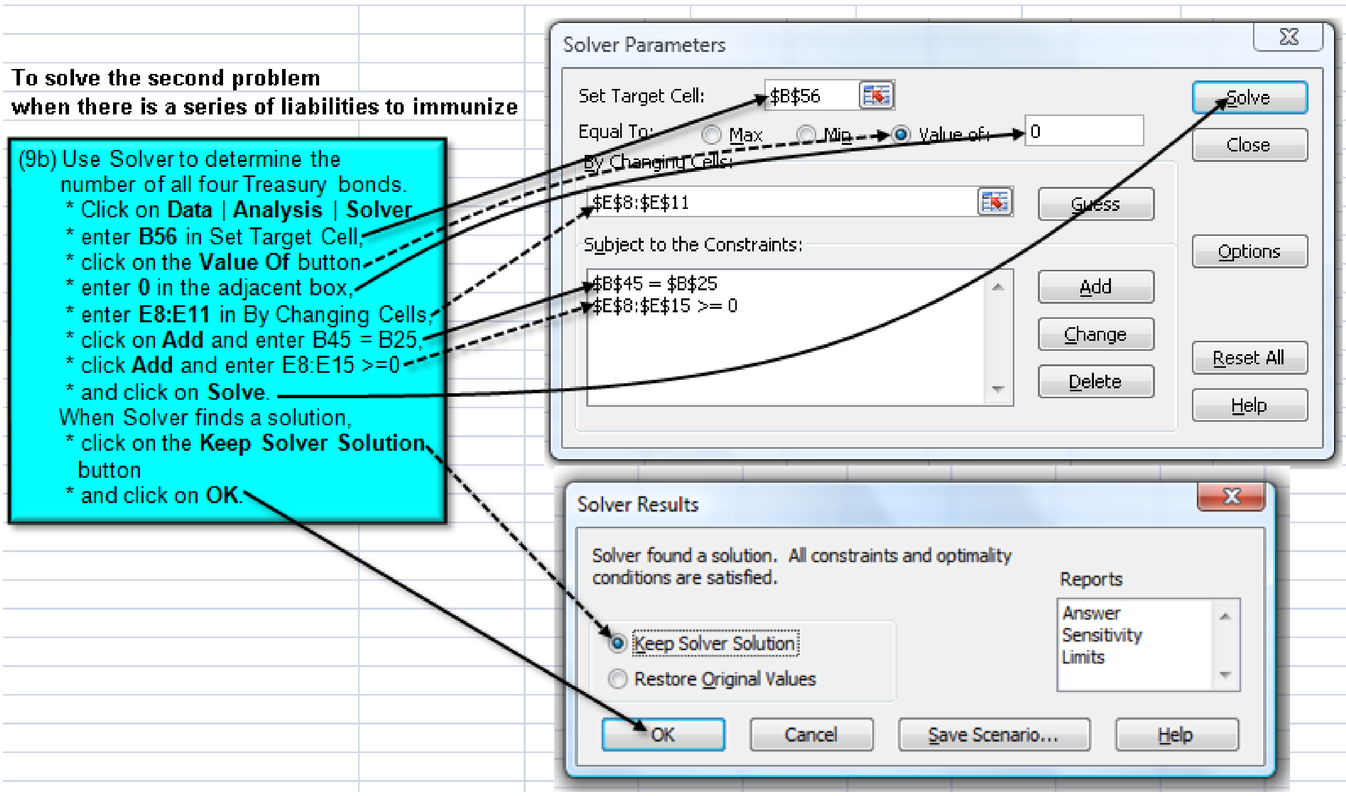
(5) (Sum of Weight * (Time ^ 2 + Time))
/ ((1 + Yield to Maturity / Number of Payments) ^ 2)
Enter =SUM(C30:J30)/((1+B18)^2)

(6) Copy the Present Value, Duration, and Convexity formulas from above
Copy the range B24:J31 to B44

(7) Total Assets - Liabilities
Enter =C43-C23 and copy across

(8) Compute the differences between Assets and Liabilities in Present Value, Duration, and Convexity
Enter =B45-B25 in B55, =B48-B28 in B56, and =B51-B31 in B57

FIGURE 6.13 Bond Pricing – Immunization – A Series of Liabilities.



The answer is buy 6,038 1-year Treasury bonds, buy 5,937 2-year Treasury bonds, buy 7,017 3-year Treasury bonds, and buy 8,068 4-year Treasury bonds. This portfolio of assets has a present value of $26,479,259, which equals the present value of the liability. This portfolio of assets has a duration of 2.50 years, which equals the duration of the liability. Thus, there is no interest rate risk at this moment. This portfolio of assets has a convexity of 10.41, which is greater than the liability convexity of 10.33. Thus, a change in yields will cause the portfolio to acquire interest rate risk in the future.

Problem 3. Reconsider the same series of liabilities as in **Problem 2**. Suppose that the company wishes to construct a portfolio of assets to cover this series of liabilities, such that it is fully immunized against interest rate over the entire four year timeframe. Further suppose that the company has available eight Treasury Strips that mature in each of the eight periods. Treasury strips have no intermediate coupons (i.e., their annual coupon rate is 0.00%) and they just pay a single cash flow on the maturity date. The current yield on all bonds is 1.74%. How many of each of these eight Treasury strips should the pension fund buy in order to fully fund the liability and be fully immunized against interest rate risk over the entire four year timeframe?

FIGURE 6.14 Bond Pricing – Immunization – A Series of Liabilities.

	A	B	C	D	E	F	G	H	I	J
1	**BOND PRICING**	**Immunization**					Currency: US Dollar		Exch Rate $1.00 =	$1.00
2										
3	**Inputs**									
4	Rate Convention	○ EAR ◉ APR	2	Annual Percentage Rate						
5	Yield to Maturity (Annualized)	1.74%								
6	Number of Payments / Year	2								
7		Annual Coupon Rate	Number of Periods to Maturity (T)	Face Value (PAR)	Number of Bonds	Coupon Payment (PMT)				
8	Bond 1	0.00%	1	$1,000	2,000	$0				
9	Bond 2	0.00%	2	$1,000	2,200	$0				
10	Bond 3	0.00%	3	$1,000	2,500	$0				
11	Bond 4	0.00%	4	$1,000	3,200	$0				
12	Bond 5	0.00%	5	$1,000	3,700	$0				
13	Bond 6	0.00%	6	$1,000	4,300	$0				
14	Bond 7	0.00%	7	$1,000	4,700	$0				
15	Bond 8	0.00%	8	$1,000	5,100	$0				
16										
17	**Outputs**									
18	Discount Rate / Period (r)	0.9%								
19										
20	**Bond Present Value, Duration, and Convexity using a Timeline**									
21	Period	0	1	2	3	4	5	6	7	8
22	Time (Years)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
23	Liabilities		$2,000,000	$2,200,000	$2,500,000	$3,200,000	$3,700,000	$4,300,000	$4,700,000	$5,100,000
24	Present Value of Liabilities		$1,982,750	$2,162,214	$2,435,869	$3,091,021	$3,543,167	$4,082,219	$4,423,476	$4,758,543
25	Total Present Value of Liabilities	$26,479,259								
26	Weight		7.5%	8.2%	9.2%	11.7%	13.4%	15.4%	16.7%	18.0%
27	Weight * Time		0.04	0.08	0.14	0.23	0.33	0.46	0.58	0.72
28	Duration of Liabilities	2.59								
29	Modified Duration of Liabilities	2.57								
30	Weight * (Time^2+Time)		0.06	0.16	0.34	0.70	1.17	1.85	2.63	3.59
31	Convexity of Liabilities	10.33								
32										
33										
34	Assets									
35	Bond 1		$2,000,000	$0	$0	$0	$0	$0	$0	$0
36	Bond 2		$0	$2,200,000	$0	$0	$0	$0	$0	$0
37	Bond 3		$0	$0	$2,500,000	$0	$0	$0	$0	$0
38	Bond 4		$0	$0	$0	$3,200,000	$0	$0	$0	$0
39	Bond 5		$0	$0	$0	$0	$3,700,000	$0	$0	$0
40	Bond 6		$0	$0	$0	$0	$0	$4,300,000	$0	$0
41	Bond 7		$0	$0	$0	$0	$0	$0	$4,700,000	$0
42	Bond 8		$0	$0	$0	$0	$0	$0	$0	$5,100,000
43	Total Assets		$2,000,000	$2,200,000	$2,500,000	$3,200,000	$3,700,000	$4,300,000	$4,700,000	$5,100,000
44	Present Value of Assets		$1,982,750	$2,162,214	$2,435,869	$3,091,021	$3,543,167	$4,082,219	$4,423,476	$4,758,543
45	Total Present Value of Assets	$26,479,259								
46	Weight		7.5%	8.2%	9.2%	11.7%	13.4%	15.4%	16.7%	18.0%
47	Weight * Time		0.04	0.08	0.14	0.23	0.33	0.46	0.58	0.72
48	Duration of Assets	2.59								
49	Modified Duration of Assets	2.57								
50	Weight * (Time^2+Time)		0.06	0.16	0.34	0.70	1.17	1.85	2.63	3.59
51	Convexity of Assets	10.33								
52										
53	Differences									
54	Total Assets - Liabilities		$0	$0	($0)	$0	$0	$0	$0	($0)
55	PV of Assets - PV of Liabilities	$0								
56	Duration of Assets - Duration of Liab	0.00								
57	Convexity of Assets - Convexity of Liab	0.00								
58										
59										

(1) Coupon Rate * Face Value / (Number of Payments / Year)
Enter =B8*D8/$B$6 and copy down

(2) If Rate Convention = EAR,
Then (1+Yield To Maturity)^(1 / (Number of Payments / Year)) - 1
Else (Yield To Maturity) / Number of Payment / Year)
Enter =IF(C4=1,((1+B5)^(1/B6))-1,B5/B6)

(3) Copy the Present Value & Duration formulas from the Duration and Convexity sheet
Copy the range B19:J24 from the Duration and Convexity sheet to B24

(4) Weight * (Time^2 + Time)
Enter =C26*(C22^2+C22) and copy across

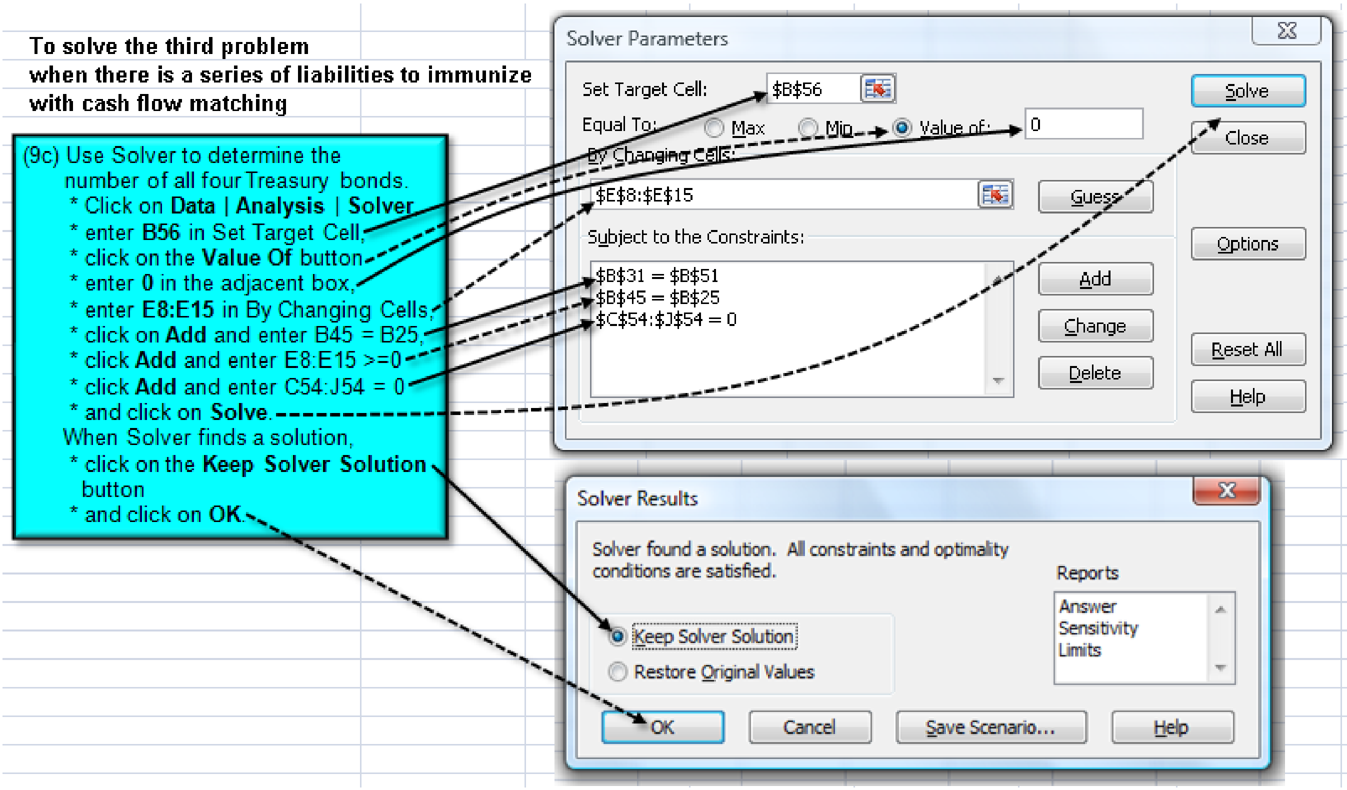
(5) (Sum of Weight * (Time ^ 2 + Time))
/ ((1 + Yield to Maturity / Number of Payments) ^ 2)
Enter =SUM(C30:J30)/((1+B18)^2)

(6) Copy the Present Value, Duration, and Convexity formulas from above
Copy the range B24:J31 to B44

(7) Total Assets - Liabilities
Enter =C43-C23 and copy across

(8) Compute the differences between Assets and Liabilities in Present Value, Duration, and Convexity
Enter =B45-B25 in B55, =B48-B28 in B56, and =B51-B31 in B57

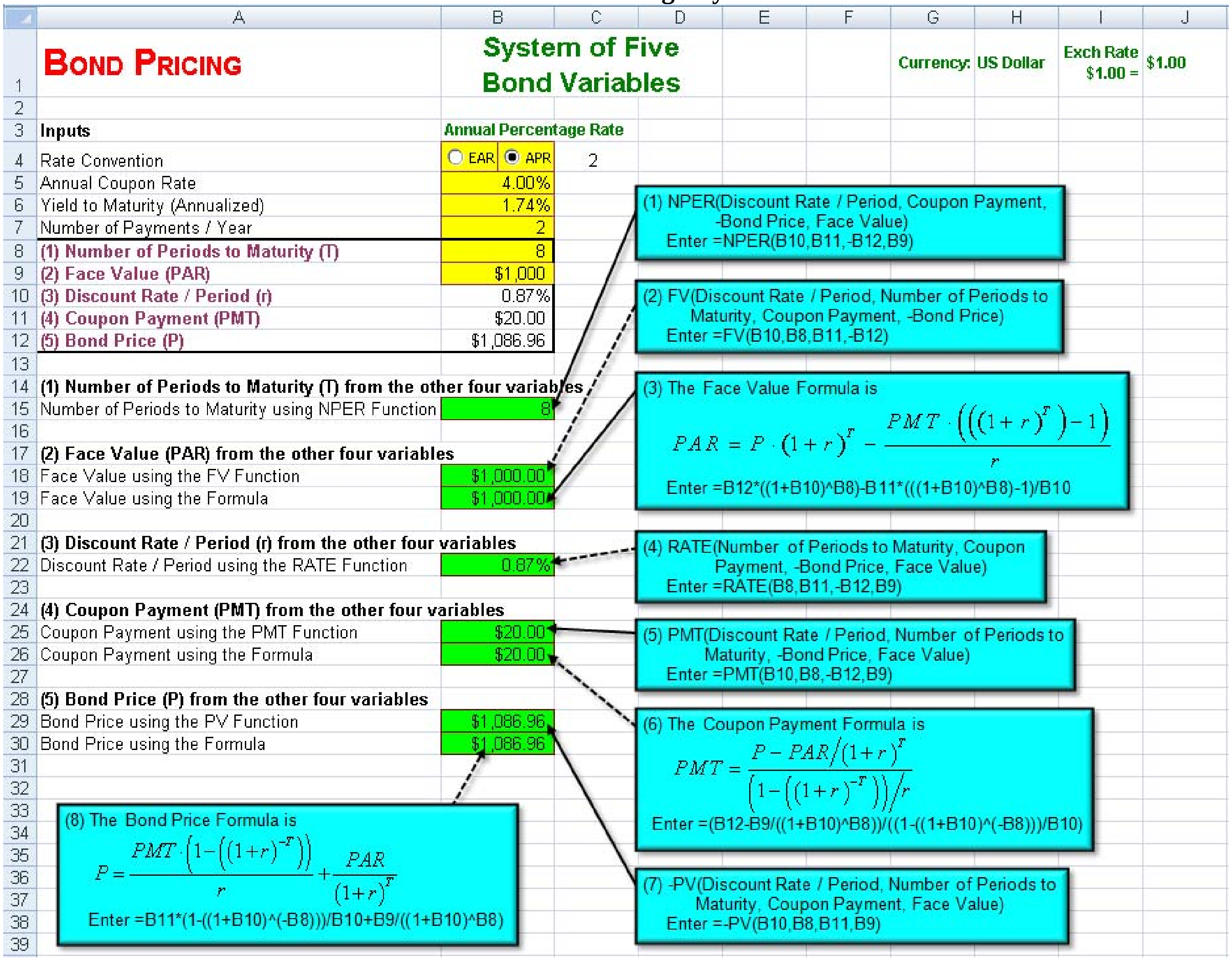
FIGURE 6.15 Bond Pricing – Immunization – A Series of Liabilities.



6.6 System of Five Bond Variables

Problem. There is a system of five bond variables: (1) Number of Periods to Maturity (T), (2) Face Value (PAR), (3) Discount Rate / Period (r), (4) Coupon Payments (PMT), and (5) Bond Price (P). Given any four of these variables, show how the fifth variable can be found by using Excel functions (and in some cases by formulas).

FIGURE 6.16 Bond Pricing - System of Five Bond Variables.



We see that the system of five bond variables is internally consistent. The five outputs in rows **15** through **30** (T=8, PAR=$1000.00, r=0.87%, PMT=$20.00, P=$1,086.96) are identical to the five inputs in rows **8** through **12**. Thus, any of the five bond variables can be calculated from the other four in a fully consistent manner.

Problems

1. An annual bond has a face value of $1,000.00, makes an annual coupon payment of $12.00 per year, has a discount rate per year of 4.37%, and has 8 years to maturity. What is price of this bond?

2. A 4 year Treasury Bond with a face value of $1,000 and an annual coupon rate of 6.50% had a yield to maturity of 3.15%. This bond makes 2 (semi-annual) coupon payments per year and thus has 8 periods until maturity. What is price of this bond based on the Effective Annual Rate (EAR) convention? What is price of this bond based on the Annual Percentage Rate (APR) convention? On the same date, the following exchanges rates were

observed: \$1.00 = ¥9.5350, \$1.00 = €0.4206, and \$1 = IDR 52.75. Under both the EAR and APR conventions, what is the price of the bond in Chinese Yuan (¥), European Euros (€), and in Indian Rupees (IDR)?

3. Determine the relationship between bond price and yield to maturity by constructing a graph of the relationship.

4. Perform instant experiments on whether changing various inputs causes an increase or decrease in the Bond Price and by how much.

   (a.) What happens when the annual coupon rate is increased?
   (b.) What happens when the yield to maturity is increased?
   (c.) What happens when the number of payments / year is increased?
   (d.) What happens when the face value is increased?
   (e.) What is the relationship between the price of a par bond and time to maturity?
   (f.) What happens when the annual coupon rate is increased to the point that it equals the yield to maturity? What happens when it is increased further?

5. A 4 year Treasury Bond with a face value of \$1,000 and an annual coupon rate of 3.20% had a yield to maturity of 2.53%. This bond makes 2 (semi-annual) coupon payments per year and thus has 8 periods until maturity. What is the duration, modified duration, and convexity of this bond based on the Annual Percentage Rate (APR) convention? What is the duration, modified duration, and convexity of this bond based on the Effective Annual Rate (EAR) convention? What is the intuitive interpretation of duration?

6. A 4 year Treasury Bond with a face value of \$1,000 and an annual coupon rate of 5.80% had a yield to maturity of 4.29%. This bond makes 2 (semi-annual) coupon payments per year and thus has 8 periods until maturity. What is the price sensitivity of a bond to changes in yield and how does that compare to the duration approximation, and compare to the duration plus convexity approximation?

7. Suppose that an insurance company sells a guaranteed investment contract (GIC) to make a \$7,300,000 lump-sum payment in 3 years. The company wishes to construct a portfolio of assets to cover this single liability, such that it is immunized against interest rate risk right now. The company is considering investing in two bonds: (1) a 2-year Treasury bond with a face value of \$1,000 and an annual coupon rate of 3.25% and (2) a 4-year Treasury bond with a face value of \$1,000 and an annual coupon rate of 4.25%.Both bonds make 2 (semi-annual) coupon payments per year. Thus they have 4 periods until maturity and 8 periods until maturity, respectively. The current yield on all bonds is 3.17%. How many 2-year and 4-year Treasury bonds should the insurance company buy in order to fully fund the liability and be immunized against interest rate risk right now?

8. Suppose that a pension fund has a series of liabilities to be paid every six months to the pension plan beneficiaries: \$4,500,000, \$5,100,000, \$5,600,000, \$6,300,000, \$6,800,000, \$7,200,000, \$7,900,000, and

$8,600,000. The company wishes to construct a portfolio of assets to cover this series of liabilities, such that it is immunized against interest rate risk right now. The company is considering investing in four bonds: (1) a 1-year Treasury bond with a face value of $1,000 and an annual coupon rate of 1.50%, (2) a 2-year Treasury bond with a face value of $1,000 and an annual coupon rate of 2.70%, (3) a 3-year Treasury bond with a face value of $1,000 and an annual coupon rate of 2.90%, and (4) a 4-year Treasury bond with a face value of $1,000 and an annual coupon rate of 3.20%. All four bonds make 2 (semi-annual) coupon payments per year. Thus they have 2 periods, 4 periods, 6 periods, and 8 periods until maturity, respectively. The current yield on all bonds is 3.17%. How many of each of these four Treasury bonds should the pension fund buy in order to fully fund the liability and be immunized against interest rate risk right now?

9. Reconsider the same series of liabilities as in **Problem 8**. Suppose that the company wishes to construct a portfolio of assets to cover this series of liabilities, such that it is fully immunized against interest rate over the entire four year timeframe. Further suppose that the company has available eight Treasury Strips that mature in each of the eight periods. Treasury strips have no intermediate coupons (i.e., their annual coupon rate is 0.00%) and they just pay a single cash flow on the maturity date. The current yield on all bonds is 3.17%. How many of each of these eight Treasury strips should the pension fund buy in order to fully fund the liability and be fully immunized against interest rate risk over the entire four year timeframe?

10. Given four of the bond variables, determine the fifth bond variable.

    (a.) Given Number of Periods to Maturity is 10, Face Value is $1,000.00, Discount Rate / Period is 3.27%, and Coupon Payment is $40.00, determine the Bond Price.
    (b.) Given Number of Periods to Maturity is 8, Face Value is $1,000.00, Discount Rate / Period is 4.54%, and the Bond Price is $880.00, determine the Coupon Payment.
    (c.) Given Number of Periods to Maturity is 6, Face Value is $1,000.00, Coupon Payment is $30.00, and the Bond Price is $865.00, determine Discount Rate / Period.
    (d.) Given Number of Periods to Maturity is 8, Discount Rate / Period is 3.81%, Coupon Payment is $45.00, and the Bond Price is $872.00, determine Face Value.
    (e.) Given Face Value is $1,000.00, Discount Rate / Period is 4.38%, Coupon Payment is $37.00, and the Bond Price is $887.00, determine the Number of Periods to Maturity.

Chapter 7 Estimating the Cost of Capital

7.1 Static CAPM Using Fama-MacBeth Method

Problem. Given monthly total return data on individual stocks, US portfolios, and country portfolios, estimate the Static CAPM under three market portfolio benchmarks (SPDR "Spider" Exchange Traded Fund, CRSP Value-Weighted Market Return, and Dow Jones World Stock Index) and using the standard Fama-MacBeth methodology. Then use the Static CAPM estimates from Jan 2000 – Dec 2009 data to forecast each asset's expected return over the next month (Jan 2010), or equivalently, each asset's cost of equity capital. Finally, determine how much variation of individual stocks, US portfolios, or country portfolios is explained by the Static CAPM.

Solution Strategy. First compute the monthly excess return of each asset. Then stage one of the Fama-MacBeth method is estimating the CAPM beta of an asset by doing a five-year, time-series regression of the asset's excess return on the excess return of a market portfolio benchmark. Repeat this time-series regression for many five-year windows and compute the average of the estimated CAPM betas. Then stage two of the Fama-Beth method is estimating the CAPM risk premium and intercept by doing a cross-sectional regression of the excess returns across assets in the following month on the CAPM beta from the immediately prior five-year window. Repeat this cross-sectional regression for many following months and compute the average of the estimated CAPM risk premium and intercept. Then use the estimated CAPM risk premium and intercept to forecast each asset's expected return, or equivalently, each asset's cost of equity capital. Finally, compute the R^2 ("explained variation") of both regressions.

FIGURE 7.1 Static CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H	I
1	ESTIMATING THE COST OF CAPITAL				Static CAPM Using Fama-MacBeth Method				
2									
3	**Inputs**								
4	Market Portfolio Benchmark	Market Portfolio Benchmark: ○ SPDR ETF ○ CRSP VWMR ◉ DJ World Stock			3				
5	Asset Type	Asset Type: ○ Stock ○ US FF Port ◉ Country ETF			3				
6									
7		Stock	Stock	Stock	Stock	Stock	Stock	US FF Port	US FF Port
8		Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-Growth	Small-Neutral
130									
131									
132	**Monthly Excess Returns**								
133	Dec 2009	-7.75%	3.60%	5.98%	-3.09%	-3.18%	17.39%	8.58%	8.38%
134	Nov 2009	19.37%	5.22%	-1.15%	5.15%	8.07%	2.70%	1.60%	1.85%
135	Oct 2009	-5.20%	0.84%	-8.92%	-13.75%	-4.76%	-0.63%	-6.92%	-6.31%
136	Sep 2009	9.22%	1.32%	23.40%	4.35%	-5.25%	-2.41%	6.52%	5.63%
137	Aug 2009	-0.58%	0.56%	-7.64%	5.01%	17.57%	9.96%	0.89%	3.03%
138	Jul 2009	4.01%	12.93%	16.25%	-8.51%	-2.48%	16.19%	6.77%	10.10%
139	Jun 2009	-11.90%	-1.75%	0.17%	-4.71%	-1.38%	-10.93%	5.18%	1.04%

(1) Monthly Return(Asset i, Month t) - Riskfree Rate(Month t)
Enter =B10-$AC10 and copy to B133:V252

FIGURE 7.2 Static CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H	I	J	K
1	ESTIMATING THE COST OF CAPITAL				Static CAPM Using Fama-MacBeth Method						
2											
3	**Inputs**										
4	Market Portfolio Benchmark	Market Portfolio Benchmark: ○ SPDR ETF ○ CRSP VWMR ◉ DJ World Stock			3						
5	Asset Type	Asset Type: ○ Stock ○ US FF Port ◉ Country ETF			3						
6											
7		Stock	Stock	Stock	Stock	Stock	Stock	US FF Port	US FF Port	US FF Port	US FF Port
8		Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-Growth	Small-Neutral	Small-Value	Big-Growth
253											
254											
255	**CAPM Beta from the First Pass, Time-Series Regression**										
256											
257	5 Yr Estimation Per:										
258	Beg Mon - End Mon	Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-Growth	Small-Neutral	Small-Value	Big-Growth
259	Dec 2004 - Nov 2009	0.81	0.67	1.38	1.32	0.98	0.82	1.03	0.98	1.11	0.74
260	Nov 2004 - Oct 2009	0.79	0.67	1.42	1.32	0.96	0.83	1.04	0.99	1.12	0.73
261	Oct 2004 - Sep 2009	0.79	0.68	1.42	1.31	0.96	0.83	1.04	0.98	1.11	0.73
262	Sep 2004 - Aug 2009	0.78	0.68	1.38	1.33	0.99	0.85	1.04	0.99	1.10	0.73
263	Aug 2004 - Jul 2009	0.79	0.69	1.41	1.33	0.96	0.83	1.04	0.99	1.09	0.73
264	Jul 2004 - Jun 2009	0.82	0.65	1.38	1.48	1.04	0.77	1.07	0.98	1.07	0.73
265	Jun 2004 - May 2009	0.80	0.65	1.38	1.49	1.03	0.77	1.07	0.99	1.07	0.73

(2) LINEST(Asset Excess Returns over 5 Years, Market Port Benchmark Excess Returns over 5 Yrs)
INDEX(LINEST(...), 1, 1) selects the slope coefficient ("Beta") of the regression above
Enter =INDEX(LINEST(B134:B193,OFFSET($T134,0,($E$4-1)):OFFSET($T193,0,$E$4-1)),1,1)
and copy to B259:S318

FIGURE 7.3 Static CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H	I
1	ESTIMATING THE COST OF CAPITAL				Static CAPM Using Fama-MacBeth Method				
2									
3	**Inputs**								
4	Market Portfolio Benchmark	Market Portfolio Benchmark: ○ SPDR ETF ○ CRSP VWMR ◉ DJ World Stock			3				
5	Asset Type	Asset Type: ○ Stock ○ US FF Port ◉ Country ETF			3				
6									
7		Stock	Stock	Stock	Stock	Stock	Stock	US FF Port	US FF Port
8		Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-Growth	Small-Neutral
316	Mar 2000 - Feb 2005	0.40	1.48	1.19	1.69	0.85	1.22	1.49	0.91
317	Feb 2000 - Jan 2005	0.36	1.47	1.17	1.71	0.89	1.14	1.55	0.94
318	Jan 2000 - Dec 2004	0.38	1.42	1.19	1.68	0.89	1.16	1.51	0.92
319									
320	Average Beta	0.72	1.14	1.12	1.55	0.86	1.11	1.34	1.04

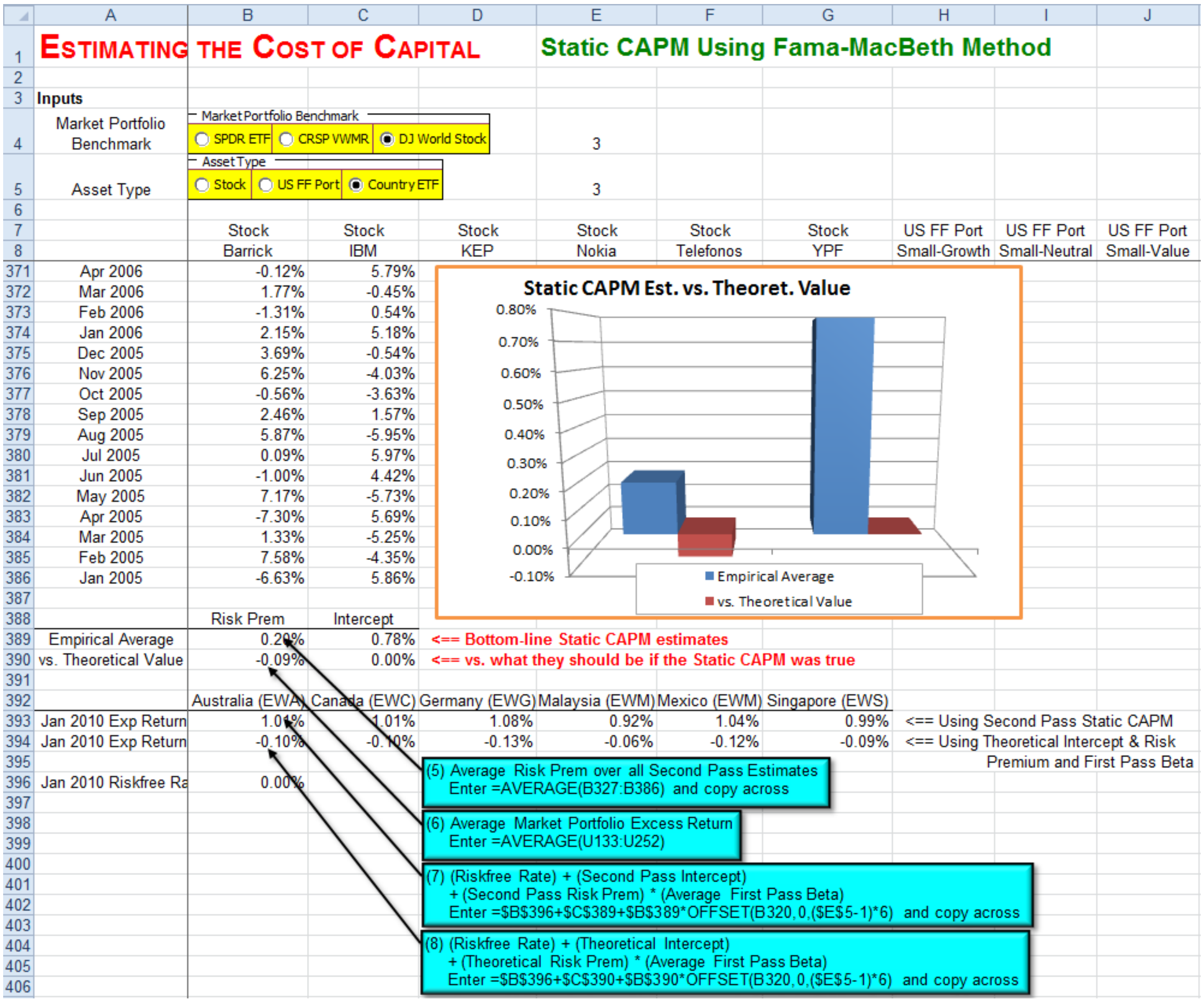
(3) Average Beta over all 5 Year Estimation Windows
Enter =AVERAGE(B259:B318) and copy across

324 Risk Premium and Intercept from the Second Pass, Cross-Sectional Regression in the Following Month

	A	B	C
325			
326	Following Month	Risk Prem	Intercept
327	Dec 2009	5.16%	-5.03%
328	Nov 2009	8.19%	-2.85%
329	Oct 2009	-10.19%	10.33%
330	Sep 2009	1.62%	4.24%
331	Aug 2009	4.81%	-4.46%
332	Jul 2009	4.87%	6.38%
333	Jun 2009	-5.38%	5.28%
334	May 2009	12.31%	1.79%
335	Apr 2009	-4.41%	19.76%

(4) LINEST(Excess Returns across Assets in Month t, Beta across Assets in Month t-1)
Enter this linear regression as an Excel matrix (Shift-Control-Enter)
Select the range B327:C327
Type =LINEST(OFFSET(B133,0,($E$5-1)*6):OFFSET(G133,0,($E$5-1)*6),
OFFSET(B259,0,($E$5-1)*6):OFFSET(G259,0,($E$5-1)*6))
Hold down the Shift and Control buttons and then press Enter
Then copy to the range B327:C327 to the range B328:C386

FIGURE 7.4 Static CAPM Using Fama-MacBeth Method.



	A	B	C	D	E	F	G	H	I	J
1	ESTIMATING THE COST OF CAPITAL				Static CAPM Using Fama-MacBeth Method					
2										
3	Inputs									
4	Market Portfolio Benchmark	Market Portfolio Benchmark: SPDR ETF / CRSP VWMR / (•) DJ World Stock			3					
5	Asset Type	Asset Type: Stock / US FF Port / (•) Country ETF			3					
6										
7		Stock	Stock	Stock	Stock	Stock	Stock	US FF Port	US FF Port	US FF Port
8		Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-Growth	Small-Neutral	Small-Value
371	Apr 2006	-0.12%	5.79%							
372	Mar 2006	1.77%	-0.45%							
373	Feb 2006	-1.31%	0.54%							
374	Jan 2006	2.15%	5.18%							
375	Dec 2005	3.69%	-0.54%							
376	Nov 2005	6.25%	-4.03%							
377	Oct 2005	-0.56%	-3.63%							
378	Sep 2005	2.46%	1.57%							
379	Aug 2005	5.87%	-5.95%							
380	Jul 2005	0.09%	5.97%							
381	Jun 2005	-1.00%	4.42%							
382	May 2005	7.17%	-5.73%							
383	Apr 2005	-7.30%	5.69%							
384	Mar 2005	1.33%	-5.25%							
385	Feb 2005	7.58%	-4.35%							
386	Jan 2005	-6.63%	5.86%							
387										
388		Risk Prem	Intercept							
389	Empirical Average	0.20%	0.78%	<== Bottom-line Static CAPM estimates						
390	vs. Theoretical Value	-0.09%	0.00%	<== vs. what they should be if the Static CAPM was true						
391										
392		Australia (EWA)	Canada (EWC)	Germany (EWG)	Malaysia (EWM)	Mexico (EWM)	Singapore (EWS)			
393	Jan 2010 Exp Return	1.04%	1.01%	1.08%	0.92%	1.04%	0.99%	<== Using Second Pass Static CAPM		
394	Jan 2010 Exp Return	-0.10%	-0.10%	-0.13%	-0.06%	-0.12%	-0.09%	<== Using Theoretical Intercept & Risk Premium and First Pass Beta		
395										
396	Jan 2010 Riskfree Ra	0.00%								

Row 389 contains the empirical average of the CAPM risk premium and intercept from the second-pass, cross-sectional regressions. Row 390 contains the theoretical value of the CAPM risk premium and intercept based on the CAPM beta from the first-pass, time-series regressions.

With a lot of extra work it would be possible to compute the statistical significance of the Static CAPM estimates. However, it is much simpler to just compare the empirical average and the theoretical value on a graph. It is clear at a glance that the empirical average and the theoretical value don't match very well.

It is interesting to make the same comparison for different market portfolio benchmarks by clicking on the option buttons in row 4 and for different asset types by clicking on the option buttons in row 5. Often the empirical average CAPM risk premium is negative, which doesn't make any economic sense. Often the empirical average of the CAPM intercept is far away from zero, which doesn't make any economic sense.

Row 393 contains the Static CAPM forecast of each asset's expected return in the next month (Jan 2010), or equivalently, of each asset's cost of equity capital. This is a key output of this spreadsheet. However, given lack of economically sensible estimates for the Static CAPM, one should be very cautious about using the forecasts of each asset's expected return / cost of equity capital.

FIGURE 7.5 Static CAPM Using Fama-MacBeth Method.

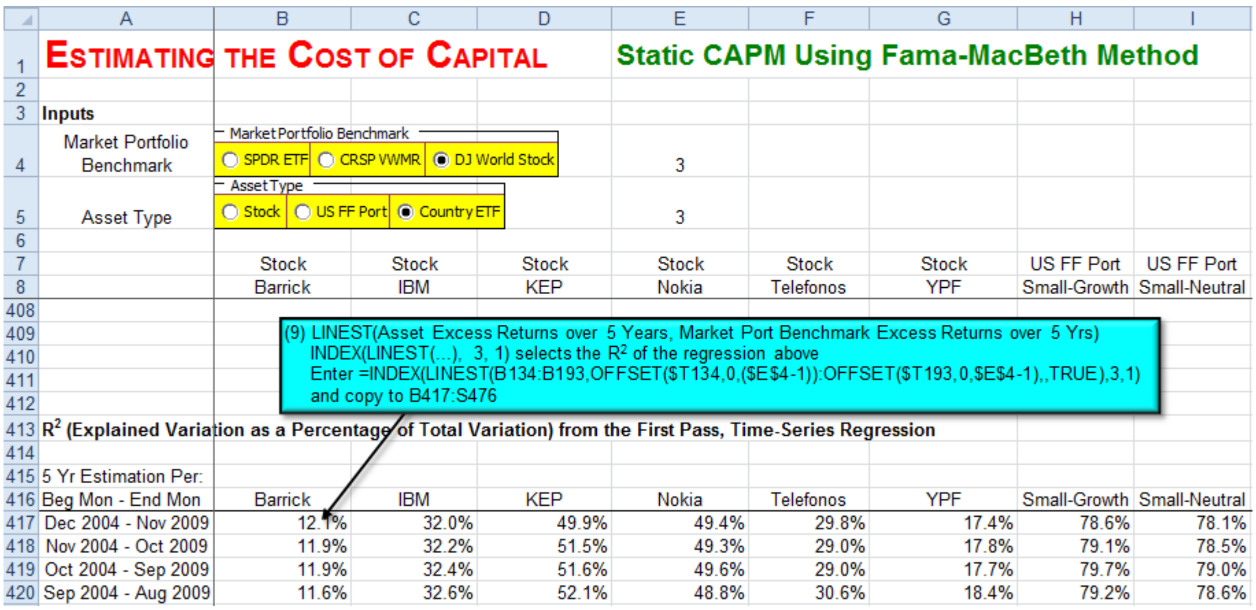


FIGURE 7.6 Static CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H	I
1	ESTIMATING THE COST OF CAPITAL				Static CAPM Using Fama-MacBeth Method				
2									
3	**Inputs**								
4	Market Portfolio Benchmark	Market Portfolio Benchmark: ○ SPDR ETF ○ CRSP VWMR ◉ DJ World Stock			3				
5	Asset Type	Asset Type: ○ Stock ○ US FF Port ◉ Country ETF			3				
6									
7		Stock	Stock	Stock	Stock	Stock	Stock	US FF Port	US FF Port
8		Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-Growth	Small-Neutral
474	Mar 2000 - Feb 2005	4.3%	44.1%	33.9%	28.8%	34.3%	24.0%	66.3%	62.4%
475	Feb 2000 - Jan 2005	3.6%	42.8%	32.0%	28.9%	31.5%	23.6%	60.1%	59.5%
476	Jan 2000 - Dec 2004	4.0%	40.6%	33.6%	28.7%	32.1%	24.6%	58.4%	58.9%
477									
478	Average R^2	9.5%	35.4%	30.1%	32.0%	26.4%	17.7%	73.7%	71.1%

(10) Average R^2 over all 5 Year Estimation Windows
Enter =AVERAGE(B417:B476) and copy across

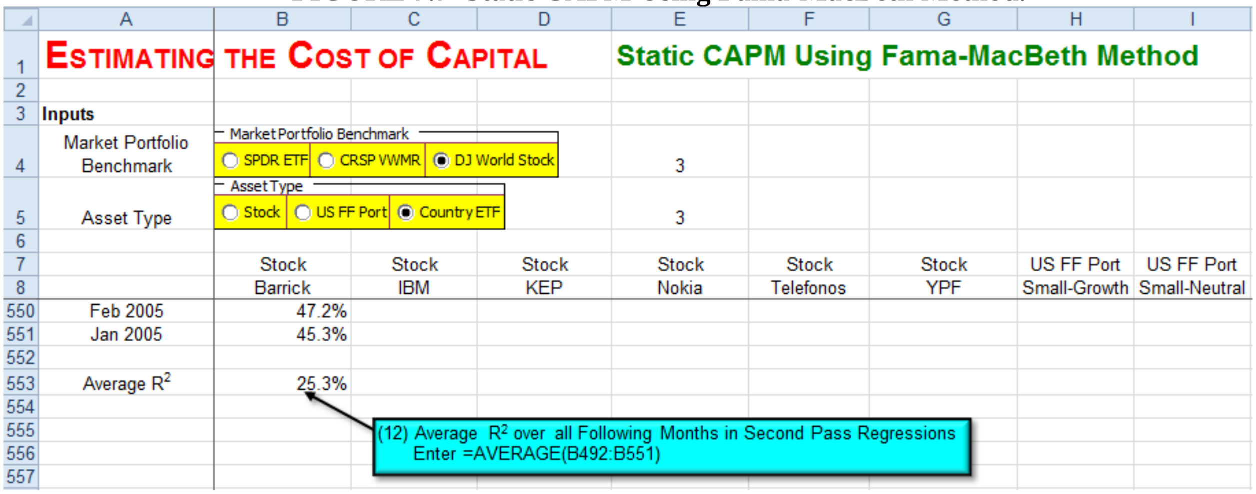
(11) LINEST(Excess Returns across Assets in Month t, Beta across Assets in Month t)
INDEX(LINEST(...), 3, 1) selects the R^2 of the regression above
Enter =INDEX(LINEST(OFFSET(B133,0,($E$5-1)*6):OFFSET(G133,0,($E$5-1)*6),
OFFSET(B259,0,($E$5-1)*6):OFFSET(G259,0,($E$5-1)*6),,TRUE),3,1)
and copy down

489 R^2 (Explained Variation as a Percentage of Total Variation) from the Second Pass, Cross-sectional Regression in the Following Month

	A	B
491	Following Month	R^2
492	Dec 2009	47.6%
493	Nov 2009	76.6%
494	Oct 2009	45.0%
495	Sep 2009	1.7%
496	Aug 2009	8.4%
497	Jul 2009	23.8%

The Average R^2 of the first-pass, time-series regression tells us how much of the fluctuation in an asset's excess return can be explained by market portfolio's excess return. An R^2 of 0% means the two variables are unrelated vs. an R^2 of 100% means the two variables move together perfectly. With single-digit R^2s, the individual stocks are poorly explained. By contrast, the US portfolios are pretty well-explained by US benchmarks and country portfolios are pretty well-explained by a world benchmark.

FIGURE 7.7 Static CAPM Using Fama-MacBeth Method.



The Average R^2 of the second-pass, cross-sectional regression tells us how much of the fluctuation in the excess returns across assets in the following month can be explained by the CAPM beta from the immediately prior five-year window. With an Average R^2 of around 30%, the individual stocks and US portfolios are modestly explained by their CAPM betas. With an Average R^2 of around 25%, the country portfolio are very modestly explained by their CAPM betas.

7.2 APT or Intertemporal CAPM Using Fama-McBeth Method

Problem. Given monthly total return data on individual stocks, US portfolios, and country portfolios, estimate the APT or Intertemporal CAPM (ICAPM) under two sets of factors (Fama-French 3 factors and 3 macro factors) and using the standard Fama-MacBeth methodology. Then use the APT or ICAPM estimates from Jan 2000 – Dec 2009 data to forecast each asset's expected return in the next month (Jan 2010), or equivalently, each asset's cost of equity capital. Finally, determine how much variation of individual stocks, US portfolios, or country portfolios is explained by the APT or ICAPM.

Solution Strategy. First carry over the monthly excess return of each asset from the other sheet. Then stage one of the Fama-MacBeth method is estimating the APT or ICAPM factor betas of an asset by doing a five-year, time-series regression of the asset's excess return on sets of APT or ICAPM factors. Repeat this time-series regression for many five-year windows and compute the average of the estimated APT or ICAPM factor betas. Then stage two of the Fama-Beth method is estimating the APT or ICAPM factor risk premia and intercept by doing a cross-sectional regression of the excess returns across assets in the following month on the APT or ICAPM factor betas from the immediately prior five-year window. Repeat this cross-sectional regression for many following months and compute the average of the estimated APT or ICAPM factor risk premia and intercept. Then use the estimated APT or ICAPM factor risk premia and intercept to forecast each asset's expected return in the future (Jan 2010), or equivalently, each asset's cost of equity capital. Finally, compute the R^2 ("explained variation") of both regressions.

FIGURE 7.8 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM		
2						Using Fama-MacBeth Method		
3	**Inputs**							
4	APT or ICAPM Factors	APT or ICAPM Factors: (•) Fama-French 3 Factors ( ) 3 Macro Factors			1			
5	Asset Type	Asset Type: (•) Stock ( ) US FF Port ( ) Country ETF			1			
6								
7				Stock	Stock	Stock	Stock	Stock
8				Barrick	IBM	KEP	Nokia	Telefonos
9	**Monthly Returns**							
10	Dec 2009			-7.75%	3.60%	5.98%	-3.09%	-3.18%
11	Nov 2009			19.37%	5.22%	-1.15%	5.15%	8.07%
12	Oct 2009			-5.20%	0.84%	-8.92%	-13.75%	-4.76%
13	Sep 2009			9.22%	1.32%	23.40%	4.35%	-5.25%

(1) Monthly Return from Sheet 9.1
Enter ='9.1'!B10 and copy to D10:AE129

FIGURE 7.9 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM		
2						Using Fama-MacBeth Method		
3	**Inputs**							
4	APT or ICAPM Factors	APT or ICAPM Factors: (•) Fama-French 3 Factors ( ) 3 Macro Factors			1			
5	Asset Type	Asset Type: (•) Stock ( ) US FF Port ( ) Country ETF			1			
6								
7				Stock	Stock	Stock	Stock	Stock
8				Barrick	IBM	KEP	Nokia	Telefonos
130–138								
139	Three Factor Betas from the First Pass, Time-Series Regression							
140								
141	5 Yr Estimation Per:	Row						
142	Beg Mon - End Mon	Offset	Factors	Barrick	IBM	KEP	Nokia	Telefonos
143	Dec 2004 - Nov 2009	0	FF HML	-0.19	-0.51	0.20	0.23	0.69
144			FF SMB	-1.03	0.36	0.46	-0.32	0.04
145			FF Mkt-RF	0.93	0.84	1.30	1.40	0.93
146	Nov 2004 - Oct 2009	1	FF HML	-0.16	-0.51	0.19	0.22	0.68
147			FF SMB	-0.79	0.37	0.43	-0.39	0.00
148			FF Mkt-RF	0.86	0.83	1.37	1.43	0.92

(2) LINEST(Asset Returns over 5 Years, 3 Factor Innovations over 5 Yrs)
Enter this linear regression as an Excel matrix (Shift-Control-Enter)
Select D143:D145
Type =TRANSPOSE(LINEST(OFFSET(D$11,$B143,0):OFFSET(D$70,$B143,0),
OFFSET($Y$11,$B143,($E$4-1)*3):OFFSET($AA$70,$B143,($E$4-1)*3)))
Hold down the Shift and Control buttons and then press Enter
Then copy to the range D143:D145 to the range E143:U145; Then copy the range D143:U145 to the range D146:U148;
Then copy the doubled range D143:U148 to the range D149:U154; Keep doubling until row 322 is reached.

FIGURE 7.10 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM		
2						Using Fama-MacBeth Method		
3	**Inputs**							
4	APT or ICAPM Factors	APT or ICAPM Factors: (•) Fama-French 3 Factors ( ) 3 Macro Factors			1			
5	Asset Type	Asset Type: (•) Stock ( ) US FF Port ( ) Country ETF			1			
6								
7				Stock	Stock	Stock	Stock	Stock
8				Barrick	IBM	KEP	Nokia	Telefonos
317	Feb 2000 - Jan 2005	58	FF HML	0.86	-0.83	0.19	-0.41	-0.30
318			FF SMB	0.42	-0.77	-0.04	-0.37	0.55
319			FF Mkt-RF	0.50	1.27	1.13	1.53	0.58
320	Jan 2000 - Dec 2004	59	FF HML	0.86	-0.85	0.21	-0.41	-0.29
321			FF SMB	0.39	-0.75	-0.04	-0.35	0.53
322			FF Mkt-RF	0.51	1.22	1.17	1.52	0.60
323								
324		Average Factor Betas		Barrick	IBM	KEP	Nokia	Telefonos
325			FF HML	0.88	-0.80	0.47	-0.57	0.09
326			FF SMB	0.23	-0.20	0.21	-0.04	0.10
327			FF Mkt-RF	0.67	1.16	1.01	1.51	0.85
328								
329								
330–336		(3) LINEST(Returns across Assets in Month t, Factor Betas across Assets in Month t) Enter this linear regression as an Excel matrix (Shift-Control-Enter) Select the range D340:G340 Type =LINEST(OFFSET(D10,0,($E$5-1)*6):OFFSET(I10,0,($E$5-1)*6), OFFSET($D$143,B340,($E$5-1)*6):OFFSET($I$145,B340,($E$5-1)*6)) Hold down the Shift and Control buttons and then press Enter Then copy to the range D340:G340 to the range D341:G399						
337	<u>**Factor Risk Premia and Intercept from the Second Pass, Cross-Sectional Regression in the Following Month**</u>							
338		Row						
339	Following Month	Offset		FF Mkt-RF	FF SMB	FF HML	Intercept	
340	Dec 2009	0		-14.80%	6.89%	7.07%	16.68%	
341	Nov 2009	3		-4.86%	-10.49%	-6.67%	11.44%	
342	Oct 2009	6		-16.23%	3.31%	-1.37%	12.24%	
343	Sep 2009	9		16.76%	1.01%	-5.87%	-11.16%	
344	Aug 2009	12		-9.85%	0.20%	7.71%	12.89%	

FIGURE 7.11 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H	I	J
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM				
2						Using Fama-MacBeth Method				
3	Inputs									
4	APT or ICAPM Factors	APT or ICAPM Factors: (•) Fama-French 3 Factors ( ) 3 Macro Factors			1					
5	Asset Type	Asset Type: (•) Stock ( ) US FF Port ( ) Country ETF			1					
6										
7				Stock	Stock	Stock	Stock	Stock	Stock	US FI
8				Barrick	IBM	KEP	Nokia	Telefonos	YPF	Small-
397	Mar 2005	171		-11.99%	-19.24%	5.28%	6.51%			
398	Feb 2005	174		20.67%	18.50%	7.96%	-11.37%			
399	Jan 2005	177		18.63%	12.77%	-0.66%	-20.79%			
400										
401				FF Mkt-RF	FF SMB	FF HML				
402	Factor Premia			Premium	Premium	Premium	Intercept			
403	Average			-0.36%	0.21%	-0.02%	1.76%	<= Bottom-line APT or Intertemporal		
404								CAPM estimates		
405	Expected Return using APT or ICAPM Est.			Barrick	IBM	KEP	Nokia	Telefonos	YPF	
406	Jan 2010	Fama-French 3 Factors		1.55%	1.32%	1.43%	1.22%	1.47%	1.36%	
407										
408		Jan 2010 Riskfree Rate		0.00%						
409–418										

(4) Average Factor Risk Prem over all Second Pass Estimates
Enter =AVERAGE(D340:D399) and copy across

(5) (Riskfree Rate) + (Second Pass Intercept)
+ (Second Pass Factor 1 Risk Prem) * (First Pass Factor 1 Beta)
+ (Second Pass Factor 2 Risk Prem) * (First Pass Factor 2 Beta)
+ (Second Pass Factor 3 Risk Prem) * (First Pass Factor 3 Beta)
Enter =$D$408+$G$403+$D$403*OFFSET(D327,0,($E$5-1)*6)
+$E$403*OFFSET(D326,0,($E$5-1))
+$F$403*OFFSET(D325,0,($E$5-1)*6) and copy across

Row 403 contains the empirical average of the APT or ICAPM factor risk premia and intercept from the second-pass, cross-sectional regressions. Given the wide flexibility in specifying APT or ICAPM factors in terms of either long positions or short positions, it is legitimately possible that risk premia could be either positive or negative.

Row 406 contains the APT or ICAPM forecast of each asset's expected return in the next month (Jan 2010), or equivalently, of each asset's cost of equity capital. This is a key output of this spreadsheet.

FIGURE 7.12 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM		
2						Using Fama-MacBeth Method		
3	**Inputs**							
4	APT or ICAPM Factors	APT or ICAPM Factors: (•) Fama-French 3 Factors ( ) 3 Macro Factors			1			
5	Asset Type	Asset Type: (•) Stock ( ) US FF Port ( ) Country ETF			1			
6								
7				Stock	Stock	Stock	Stock	Stock
8				Barrick	IBM	KEP	Nokia	Telefonos
419								
425	**R^2 (Explained Variation as a Percentage of Total Variation) from the First Pass, Time-Series Regression**							
426								
427	5 Yr Estimation Per:	Row						
428	Beg Mon - End Mon	Offset		Barrick	IBM	KEP	Nokia	Telefonos
429	Dec 2004 - Nov 2009	0		11.4%	42.7%	48.0%	48.1%	35.7%
430	Nov 2004 - Oct 2009	1		9.3%	42.7%	50.2%	48.3%	34.8%
431	Oct 2004 - Sep 2009	2		9.9%	43.0%	49.6%	48.4%	34.3%
432	Sep 2004 - Aug 2009	3		9.6%	43.3%	49.5%	47.4%	36.3%

(6) LINEST(Asset Returns over 5 Years, Three Factor Innovations over 5 Yrs)
INDEX(LINEST(...), 3, 1) selects the R^2 of the regression above
Enter =INDEX(LINEST(OFFSET(D$11,$B429,0):OFFSET(D$70,$B429,0),
OFFSET($Y$11,$B429,($E$4-1)*3):OFFSET($AA$70,$B429,($E$4-1)*3),,TRUE),3,1)
and copy to D429:U488

FIGURE 7.13 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H	I
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM			
2						Using Fama-MacBeth Method			
3	**Inputs**								
4	APT or ICAPM Factors	APT or ICAPM Factors: (•) Fama-French 3 Factors ( ) 3 Macro Factors			1				
5	Asset Type	Asset Type: (•) Stock ( ) US FF Port ( ) Country ETF			1				
6									
7				Stock	Stock	Stock	Stock	Stock	Stock
8				Barrick	IBM	KEP	Nokia	Telefonos	YPF
486	Mar 2000 - Feb 2005	57		11.9%	58.4%	31.1%	31.6%	50.9%	23.7%
487	Feb 2000 - Jan 2005	58		11.4%	57.8%	29.7%	31.2%	57.9%	24.1%
488	Jan 2000 - Dec 2004	59		11.5%	56.0%	31.2%	31.1%	57.2%	25.1%
489									
490	Average R^2			15.9%	50.5%	27.1%	35.7%	31.3%	18.3%
501	**R^2 (Explained Variation as a Percentage of Total Variation) from the Second Pass, Cross-sectional Regression in the Following Month**								
502									
503	Following Month			R^2					
504	Dec 2009			49.0%					
505	Nov 2009			72.0%					
506	Oct 2009			98.9%					
507	Sep 2009			41.1%					

(7) Average R^2 over all 5 Year Estimation Windows
Enter =AVERAGE(D429:D488) and copy across

(8) LINEST(Returns across Assets in Month t, Factor Betas across Assets in Month t)
INDEX(LINEST(...), 3, 1) selects the R^2 of the regression above
Enter =INDEX(LINEST(OFFSET(D10,0,($E$5-1)*6):OFFSET(I10,0,($E$5-1)*6),
OFFSET($D$143,B340,($E$5-1)*6):OFFSET($I$145,B340,($E$5-1)*6),,TRUE),3,1)
and copy down

The Average R^2 of the first-pass, time-series regression tells us how much of the fluctuation in an asset's excess return can be explained by the APT or ICAPM factors. An R^2 of 0% means the two variables are unrelated vs. an R^2 of 100% means the two variables move together perfectly. With single-digit R^2s, the individual stocks are poorly explained. With an R^2 over 90%, the US portfolios are extremely well-explained by US-based APT or ICAPM factors. With an R^2 around 50%, country portfolios are somewhat-explained by US-based APT or ICAPM factors.

FIGURE 7.14 APT or Intertemporal CAPM Using Fama-MacBeth Method.

	A	B	C	D	E	F	G	H
1	ESTIMATING THE COST OF CAPITAL					APT or Intertemporal CAPM		
2						Using Fama-MacBeth Method		
3	**Inputs**							
4	APT or ICAPM Factors	APT or ICAPM Factors: ◉ Fama-French 3 Factors		○ 3 Macro Factors	1			
5	Asset Type	Asset Type: ◉ Stock	○ US FF Port	○ Country ETF	1			
6								
7				Stock	Stock	Stock	Stock	Stock
8				Barrick	IBM	KEP	Nokia	Telefonos
561	Mar 2005			80.3%				
562	Feb 2005			48.1%				
563	Jan 2005			62.1%				
564								
565	Average R^2			59.6%				
566								
567					(9) Average R^2 over all Following Months in Second Pass Regressions			
568					Enter =AVERAGE(D504:D563)			
569								

The Average R^2 of the second-pass, cross-sectional regression tells us how much of the fluctuation in the excess returns across assets in the following month can be explained by the APT or ICAPM factor betas from the immediately prior five-year window. With an Average R^2 of 50% - 70%, the individual stocks, US portfolios, and country portfolios are pretty well-explained by their APT or ICAPM factors.[1]

---

[1] Lewellen, Nagel and Shaken (2010) suggest that apparently high cross-sectional R^2 provide quite weak support for an asset pricing model. They offer a number of suggestions for improving empirical asset pricing tests, including expanding the set of assets tested to include industry portfolios and using Generalized Least Squares (GLS) R^2, rather than regular regression (OLS) R^2. They test five popular asset pricing models, including the Static CAPM and the Fama-French 3 Factor model. They find that for an expanded set of assets which includes industry portfolios, the GLS R^2 is less than 10% for all asset pricing models. See Lewellen, J., S. Nagel, and J. Shaken, 2010, A Skeptical Appraisal of Asset-Pricing Tests, *Journal of Financial Economics* 96, 175-194.

Problems

1. Download ten years of monthly total return data for individual stocks, US portfolios, and country portfolios. Then use that data to estimate the Static CAPM under three market portfolio benchmarks (SPDR "Spider" Exchange Traded Fund, CRSP Value-Weighted Market Return, and Dow Jones World Stock Index) and using the standard Fama-MacBeth methodology. Then use the Static CAPM estimates to forecast each asset's expected return in the next future month, or equivalently, each asset's cost of equity capital. Finally, determine how much variation of individual stocks, US portfolios, or country portfolios is explained by the Static CAPM.

2. Download ten years of monthly total return data for individual stocks, US portfolios, and country portfolios. Then use that data to estimate the APT or Intertemporal CAPM (ICAPM) under two sets of factors (Fama-French 3 factors and 3 macro factors) and using the standard Fama-MacBeth methodology. Then use the APT or ICAPM estimates to forecast each asset's expected return in the next future month, or equivalently, each asset's cost of equity capital. Finally, determine how much variation of individual stocks, US portfolios, or country portfolios is explained by the APT or ICAPM.

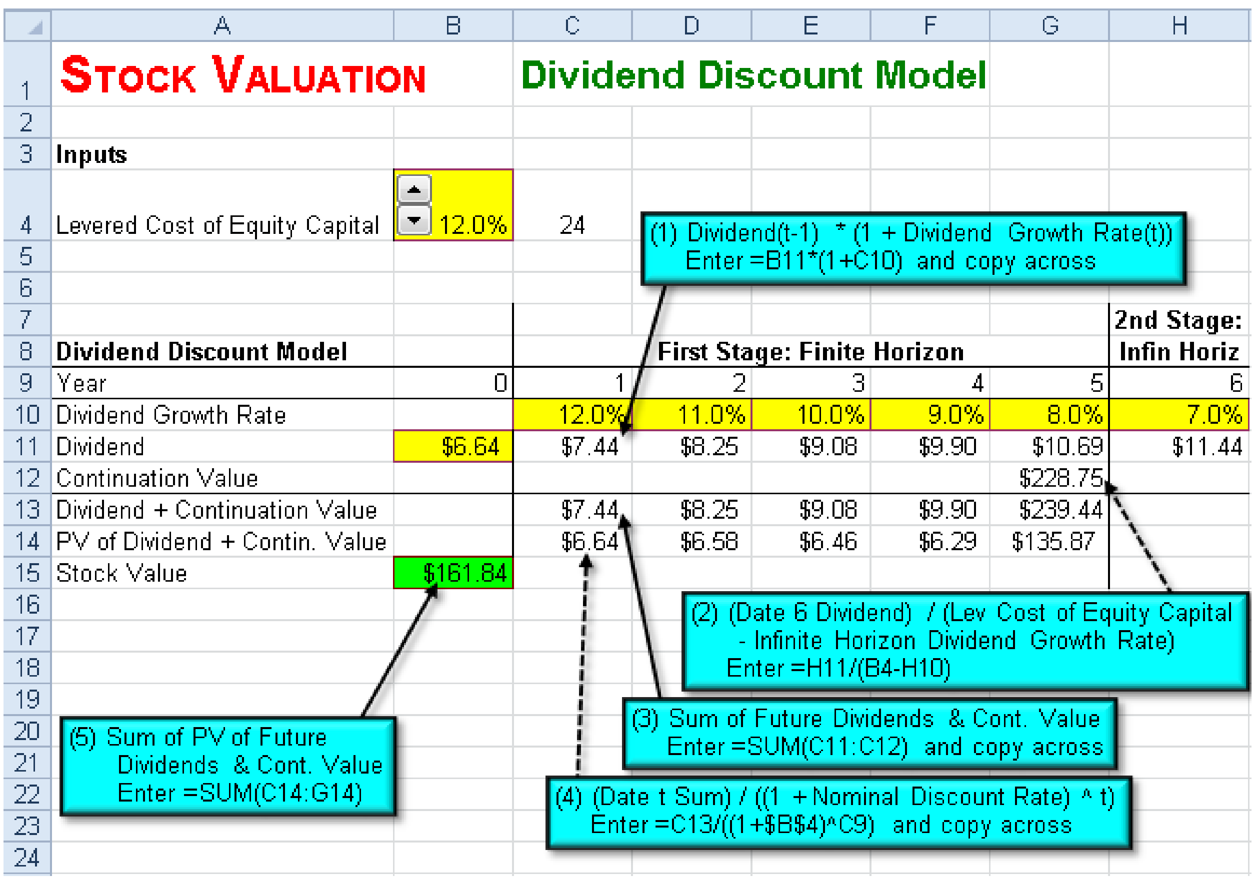
Chapter 8 Stock Valuation

8.1 Dividend Discount Model

Problem. Currently a stock pays a dividend per share of $6.64. A security analyst projects the future dividend growth rate over the next five years to be 12.0%, 11.0%, 10.0%, 9.0%, 8.0% and then 7.0% each year thereafter to infinity. The levered cost of equity capital for the firm is 12.0% per year. What is the stock's value?

Solution Strategy. Construct a two-stage discounted dividend model. In stage one, explicitly forecast the firm's dividend over a five-year horizon. In stage two, forecast the firm's dividend from year six to infinity and calculate its continuation value as the present value of this infinitely growing annuity. Then, discount the future dividends and the date 5 continuation value back to the present to get the stock's value.

FIGURE 8.1 Excel Model for Stock Valuation – Dividend Discount Model.



	A	B	C	D	E	F	G	H
1	STOCK VALUATION		Dividend Discount Model					
2								
3	**Inputs**							
4	Levered Cost of Equity Capital	12.0%	24					
5								
6								
7								**2nd Stage:**
8	**Dividend Discount Model**			**First Stage: Finite Horizon**				**Infin Horiz**
9	Year	0	1	2	3	4	5	6
10	Dividend Growth Rate		12.0%	11.0%	10.0%	9.0%	8.0%	7.0%
11	Dividend	$6.64	$7.44	$8.25	$9.08	$9.90	$10.69	$11.44
12	Continuation Value						$228.75	
13	Dividend + Continuation Value		$7.44	$8.25	$9.08	$9.90	$239.44	
14	PV of Dividend + Contin. Value		$6.64	$6.58	$6.46	$6.29	$135.87	
15	Stock Value	$161.84						

The stock value is estimated to be $161.84.

Problems

1. Currently a stock pays a dividend per share of $43.37. A security analyst projects the future dividend growth rate over the next five years to be 21.0%, 18.0%, 15.0%, 13.5%, 11.5% and then 11.0% each year thereafter to infinity. The levered cost of equity capital for the firm is 13.4% per year. What is the stock's value?

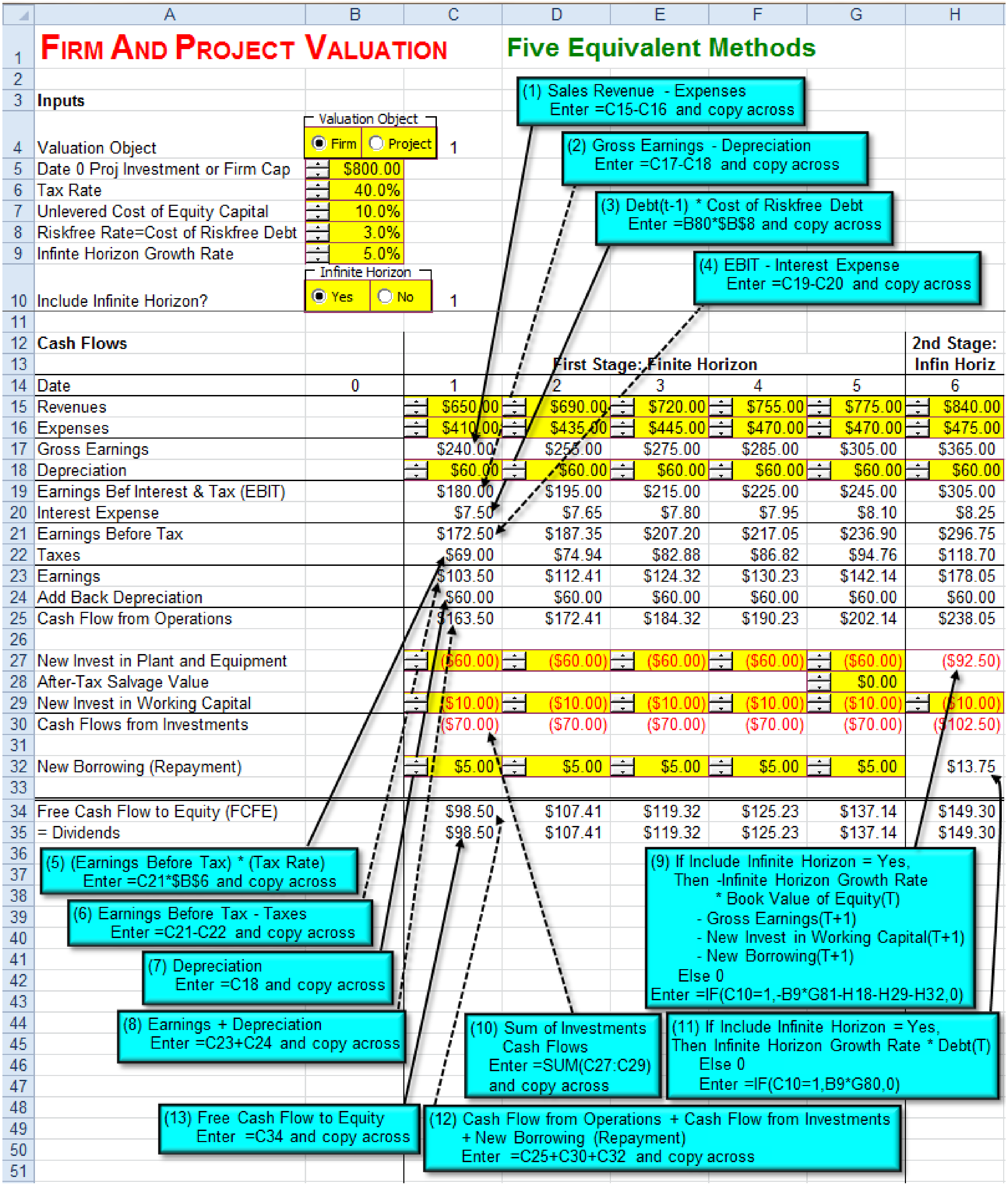
Chapter 9 Firm and Project Valuation

9.1 Cash Flows for Five Equivalent Methods

Problem. The expected future cash flows for a firm have been forecasted in two stages correspond to two time periods. Stage one is a finite horizon from years 1 to 5. Stage two is the remaining infinite horizon from year 6 to infinity. Given these forecasted cash flows, compute the current value of the firm and the value added by the firm using five equivalent methods: (1) Adjusted Present Value, (2) Free Cash Flow to Equity, (3) Free Cash Flow to the Firm, (4) Dividend Discount Model, and (5) Residual Income. Given expected future cash flows for a project, compute the present value of future cash flows and the NPV of the project using the same five equivalent methods.

Solution Strategy. In this section, compute the cash flows streams that will be used by the five valuation methods: (1) Free Cash Flow to Equity, (2) Dividends, (3) Tax Shield Benefit, (4) Free Cash Flow to the Firm, and (5) Economic Profit. In subsequent sections, compute the current value of the firm and the value added by the firm using each of the five equivalent methods in turn. In the last section, eliminate stage two cash flows and recompute the value of the firm and the value added by the firm using the same five methods. Then, switch to evaluating a project and compute the value of future cash flows and the NPV of the project using the same five methods. Finally, restore stage two cash flows and compute the value of future cash flows and the NPV of the project using the same five methods.

FIGURE 9.1 Firm and Project Valuation – Cash Flows for 5 Equiv Methods.



	A	B	C	D	E	F	G	H
1	FIRM AND PROJECT VALUATION			Five Equivalent Methods				
2								
3	**Inputs**	Valuation Object						
4	Valuation Object	Firm / Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: Yes / No	1					
11								
12	**Cash Flows**							**2nd Stage:**
13				**First Stage: Finite Horizon**				**Infin Horiz**
14	Date	0	1	2	3	4	5	6
15	Revenues		$650.00	$690.00	$720.00	$755.00	$775.00	$840.00
16	Expenses		$410.00	$435.00	$445.00	$470.00	$470.00	$475.00
17	Gross Earnings		$240.00	$255.00	$275.00	$285.00	$305.00	$365.00
18	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
19	Earnings Bef Interest & Tax (EBIT)		$180.00	$195.00	$215.00	$225.00	$245.00	$305.00
20	Interest Expense		$7.50	$7.65	$7.80	$7.95	$8.10	$8.25
21	Earnings Before Tax		$172.50	$187.35	$207.20	$217.05	$236.90	$296.75
22	Taxes		$69.00	$74.94	$82.88	$86.82	$94.76	$118.70
23	Earnings		$103.50	$112.41	$124.32	$130.23	$142.14	$178.05
24	Add Back Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
25	Cash Flow from Operations		$163.50	$172.41	$184.32	$190.23	$202.14	$238.05
26								
27	New Invest in Plant and Equipment		($60.00)	($60.00)	($60.00)	($60.00)	($60.00)	($92.50)
28	After-Tax Salvage Value						$0.00	
29	New Invest in Working Capital		($10.00)	($10.00)	($10.00)	($10.00)	($10.00)	($10.00)
30	Cash Flows from Investments		($70.00)	($70.00)	($70.00)	($70.00)	($70.00)	($102.50)
31								
32	New Borrowing (Repayment)		$5.00	$5.00	$5.00	$5.00	$5.00	$13.75
33								
34	Free Cash Flow to Equity (FCFE)		$98.50	$107.41	$119.32	$125.23	$137.14	$149.30
35	= Dividends		$98.50	$107.41	$119.32	$125.23	$137.14	$149.30

FIGURE 9.2 Firm and Project Valuation – Cash Flows for 5 Equiv Methods.

	A	B	C	D	E	F	G	H
1	Firm And Project Valuation			Five Equivalent Methods				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: (•) Firm ( ) Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Deb	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: (•) Yes ( ) No	1					
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								
65	Interest		$7.50	$7.65	$7.80	$7.95	$8.10	$8.25
66	Less New Borrowing (Repayment)		($5.00)	($5.00)	($5.00)	($5.00)	($5.00)	($13.75)
67	Cash Flow to Debtholders (CFD)		$2.50	$2.65	$2.80	$2.95	$3.10	($5.50)
68								
69	Tax Shield Benefit		$3.00	$3.06	$3.12	$3.18	$3.24	$3.30
70	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$137.00	$140.50
71								
72	**Alternative Way to get FCFF**							
73	Earnings		$103.50	$112.41	$124.32	$130.23	$142.14	$178.05
74	After-tax Interest Expense		$4.50	$4.59	$4.68	$4.77	$4.86	$4.95
75	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$183.00
76	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
77	Cash Flows from Investments		($70.00)	($70.00)	($70.00)	($70.00)	($70.00)	($102.50)
78	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$137.00	$140.50
79								
80	Debt (D)	$250.00	$255.00	$260.00	$265.00	$270.00	$275.00	
81	Book Value of Equity	$550.00	$555.00	$560.00	$565.00	$570.00	$575.00	
82	Total Capital	$800.00	$810.00	$820.00	$830.00	$840.00	$850.00	
83								
84	**Economic Profit**							
85	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$183.00
86	Capital Charge		$78.93	$79.95	$80.97	$81.99	$83.01	$84.02
87	Economic Profit		$29.07	$37.05	$48.03	$53.01	$63.99	$98.98

(14) Interest Expense
Enter =C20 and copy across

(15) - New Borrowing (Repayment)
Enter =-C32 and copy across

(16) Interest + Less New Borrow (Repay)
Enter =C65+C66 and copy across

(17) Debt(t-1) * Cost of Riskfree Debt * Tax Rate
Enter =B80*$B$8*$B$6 and copy across

(18) FCFE + CFD + Tax Shield Benefit
Enter =C34+C67-C69 and copy across

(19) Earnings
Enter =C23 and copy across

(20) (1 - Tax Rate) * Interest Expense
Enter =(1-$B$6)*C20 and copy across

(21) Earnings + After-tax Interest Expense
Enter =C73+C74 and copy across

(22) Date 0 Proj Inv or Firm Cap - Debt
Enter =B5-B80

(23) Debt + Book Value of Equity
Enter =B80+B81 and copy across

(24) Depreciation
Enter =C18 and copy across

(25) Cash Flows From Investments
Enter =C30 and copy across

(26) NOPAT + Depreciation + Cash Flow from Invest
Enter =C75+C76+C77 and copy across

(27) Debt(t-1) + New Borrowing (Repayment)
Enter =B80+C32 and copy across

(28) BV Equity(t-1) - Deprec - New Invest in Plant & Equip - New Invest in Working Cap - New Borrowing (Repayment)
Enter =B81-C18-C27-C29-C32 and copy across

(29) NOPAT
Enter =C75 and copy across

(30) Cost of Firm Capital * Book Value of Equity(t-1)
Enter =C181*B82
and copy to D86:G86

(31) If Include Inf Horiz = Yes, Then Cost of Firm Capital * Book Value of Equity(t-1) Else 0
Enter =IF(C10=1,H181*G82,0)

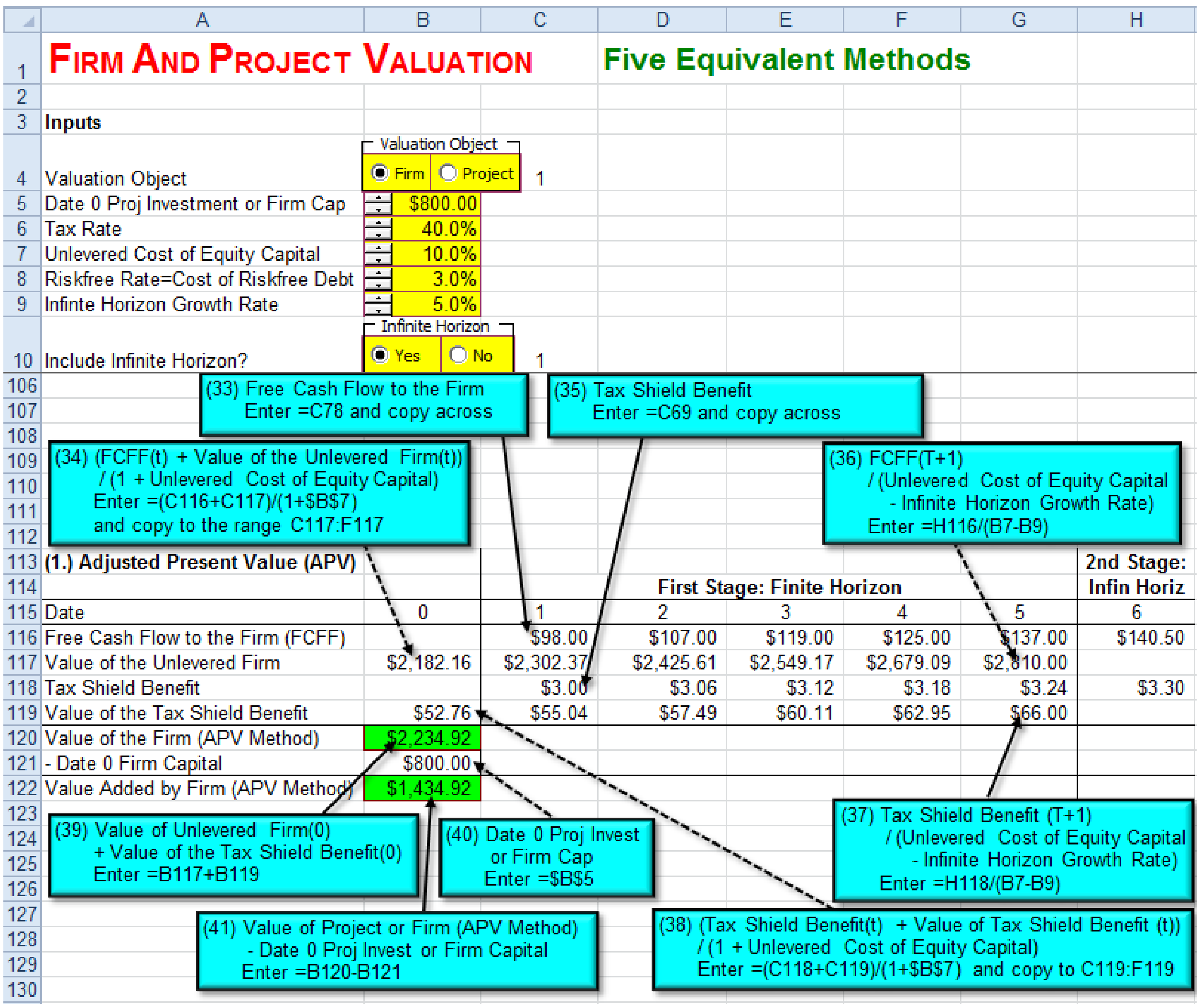
(32) NOPAT - Capital Charge
Enter =C85-C86 and copy across

9.2 Adjusted Present Value

Problem. Given the cash flow streams, compute the current value of the firm and the value added by the firm using Adjusted Present Value.

Soluton Strategy. Take the Free Cash Flow to the Firm and discount at the Unlevered Cost of Equity Capital to obtain the Value of the Unlevered Firm. Take the Tax Shield Benefit and discount at the Cost of Riskfree Debt to obtain the Value of the Tax Shield. Sum the Value of the Unlevered Firm and the Value of the Tax Shield to get the Value of the Firm. Subtract Date 0 Capital to get the Value Added by the Firm.

FIGURE 9.3 Firm and Project Valuation – Adjusted Present Value.



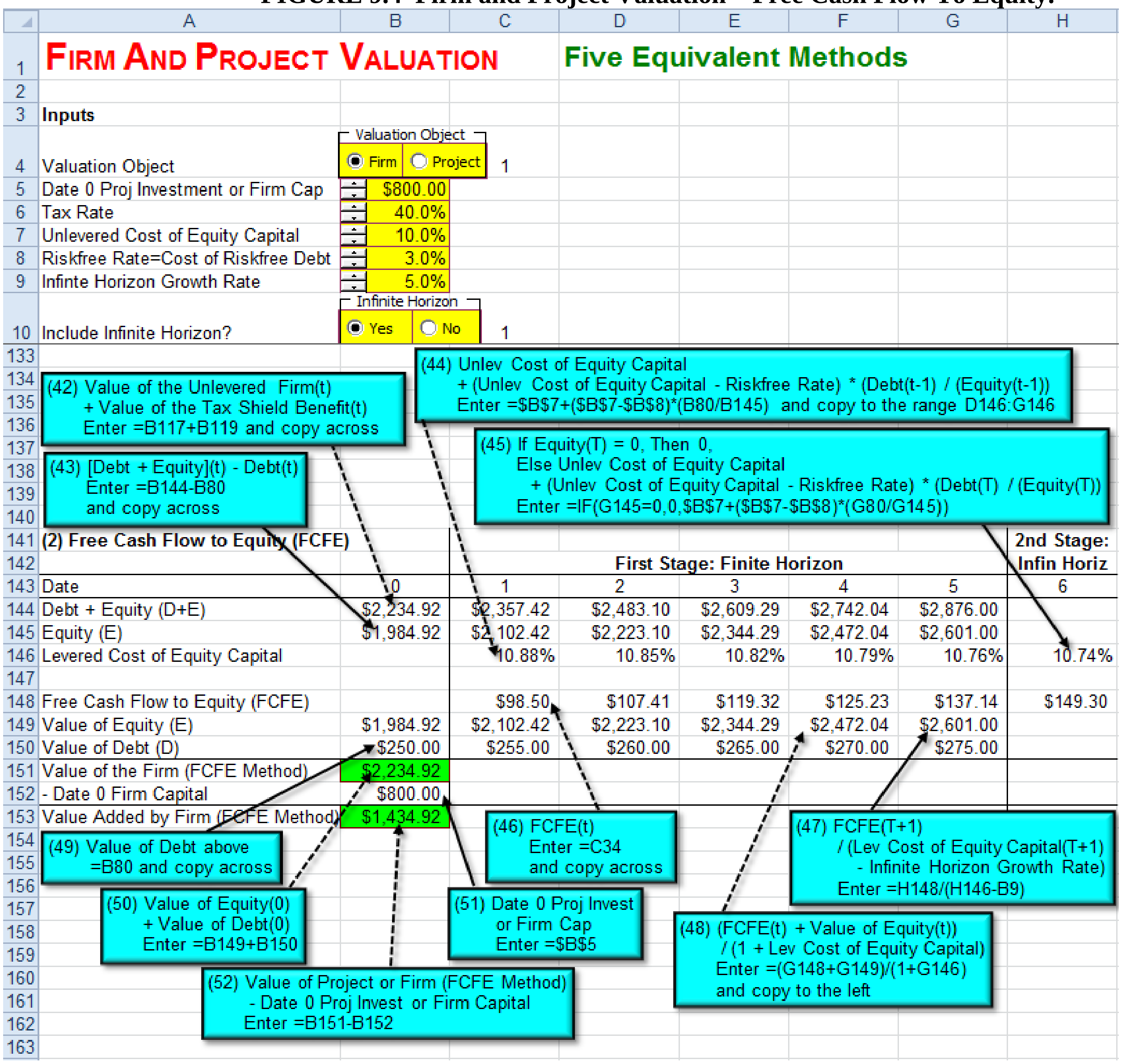
The value of the firm is $2,234.92. This is the amount of money you would be willing to pay if you were going to buy the firm on Date 0, since the Date 0 Firm Capital is already sunk into the firm. Considering that the firm is currently using $800.00 in capital, the (Net Present) Value Added by the Firm is $1,434.92.

9.3 Free Cash Flow To Equity

Problem. Given the cash flow streams, compute the current value of the firm and the value added by the firm using Free Cash Flow to Equity.

Soluton Strategy. Take the Free Cash Flow to Equity and discount at the Levered Cost of Equity Capital to obtain the Value of Equity. Take the Cash Flow to Debtholders and discount at the Cost of Riskfree Debt to obtain the Value of Debt. Sum the Value of Equity and the Value of Debt to get the Value of the Firm. Subtract Date 0 Capital to get the Value Added by the Firm.

FIGURE 9.4 Firm and Project Valuation – Free Cash Flow To Equity.



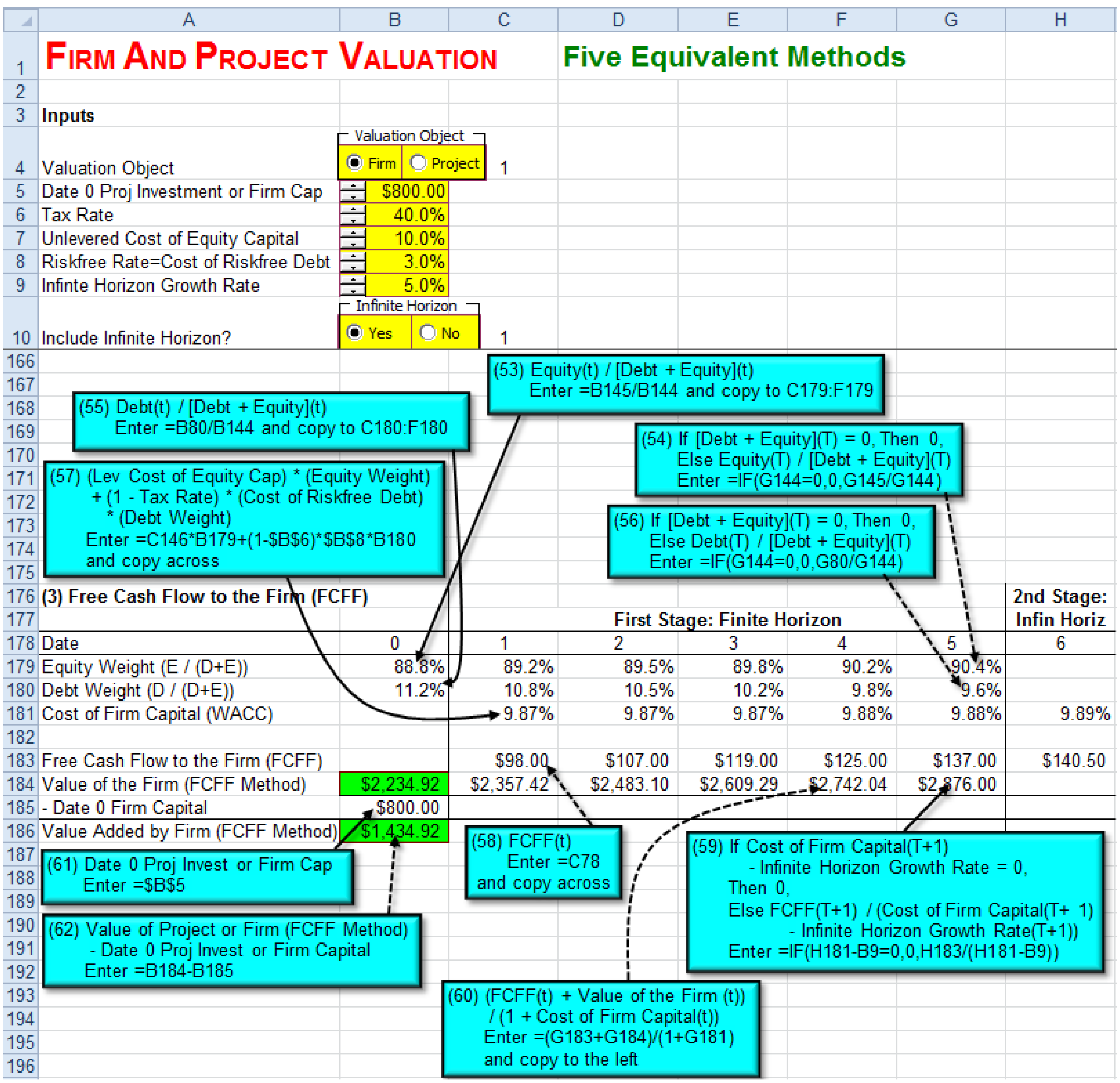
As above, the Value of the Firm is $2,234.92 and (Net Present) Value Added by the Firm is $1,434.92.

9.4 Free Cash Flow to the Firm

Problem. Given the cash flow streams, compute the current value of the firm and the value added by the firm using Free Cash Flow to the Firm.

Soluton Strategy. Take the Free Cash Flow to the Firm and discount at the Cost of Firm Capital (WACC) to obtain the Value of Firm. Subtract Date 0 Capital to get the Value Added by the Firm.

FIGURE 9.5 Firm and Project Valuation – Free Cash Flow To The Firm.



	A	B	C	D	E	F	G	H
1	FIRM AND PROJECT VALUATION			Five Equivalent Methods				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: Firm / Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: Yes / No	1					
176	**(3) Free Cash Flow to the Firm (FCFF)**							**2nd Stage:**
177				**First Stage: Finite Horizon**				**Infin Horiz**
178	Date	0	1	2	3	4	5	6
179	Equity Weight (E / (D+E))	88.8%	89.2%	89.5%	89.8%	90.2%	90.4%	
180	Debt Weight (D / (D+E))	11.2%	10.8%	10.5%	10.2%	9.8%	9.6%	
181	Cost of Firm Capital (WACC)		9.87%	9.87%	9.87%	9.88%	9.88%	9.89%
182								
183	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$137.00	$140.50
184	Value of the Firm (FCFF Method)	$2,234.92	$2,357.42	$2,483.10	$2,609.29	$2,742.04	$2,876.00	
185	- Date 0 Firm Capital	$800.00						
186	Value Added by Firm (FCFF Method)	$1,434.92						

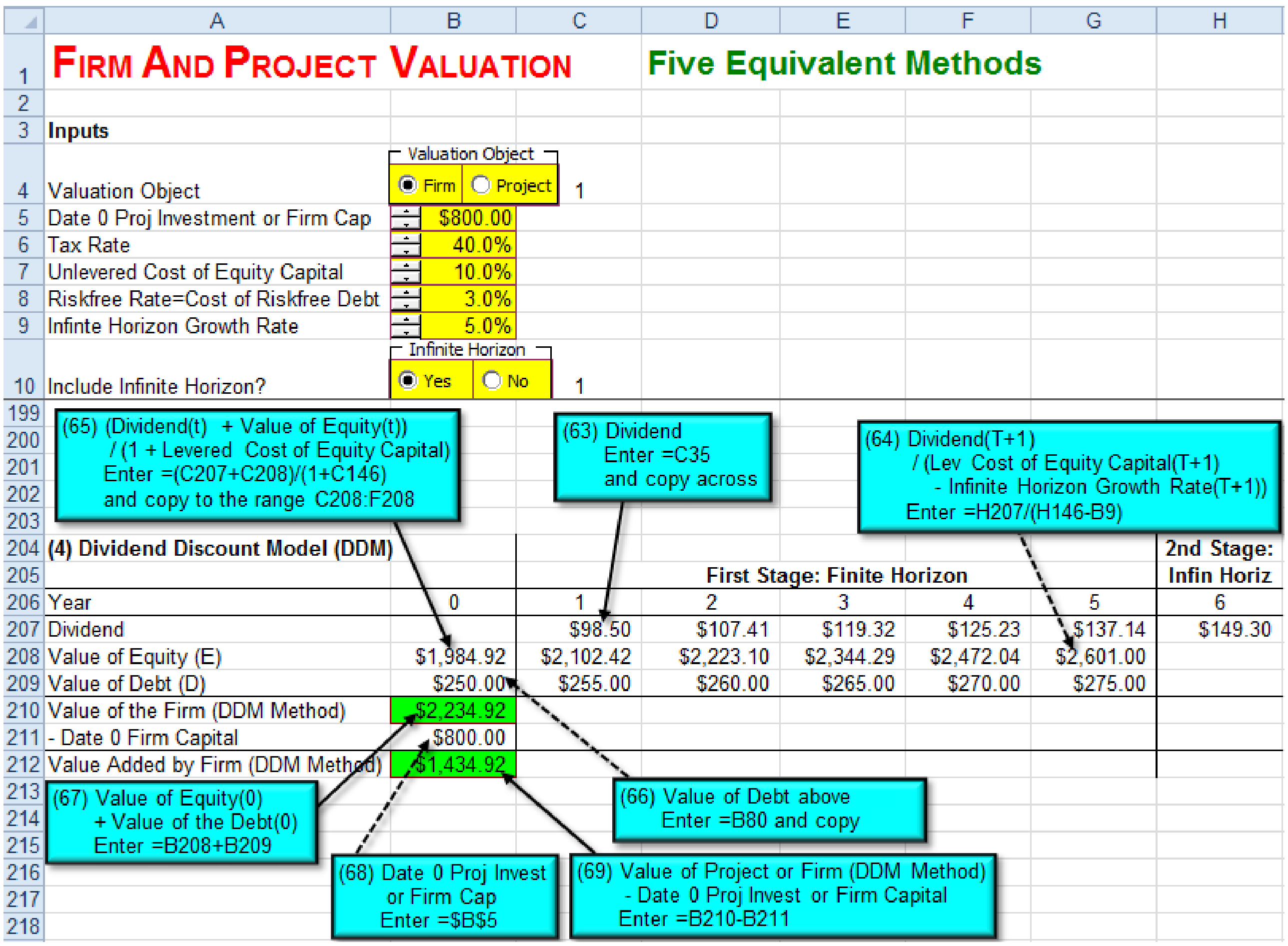
As above, the Value of the Firm is $2,234.92 and (Net Present) Value Added by the Firm is $1,434.92.

9.5 Dividend Discount Model

Problem. Given the cash flow streams, compute the current value of the firm and the value added by the firm using a Dividend Discount Model.

Soluton Strategy. Take the Dividends and discount at the Levered Cost of Equity Capital to obtain the Value of Equity. Take the Cash Flow to Debtholders and discount at the Cost of Riskfree Debt to obtain the Value of Debt. Sum the Value of Equity and the Value of Debt to get the Value of the Firm. Subtract Date 0 Capital to get the Value Added by the Firm.

FIGURE 9.6 Firm and Project Valuation – Dividend Discount Model.



As above, the Value of the Firm is $2,234.92 and (Net Present) Value Added by the Firm is $1,434.92.

9.6 Residual Income

Problem. Given the cash flow streams, compute the current value of the firm and the value added by the firm using Residual Income.

Soluton Strategy. Take the Economic Profit and discount at the Cost of Firm Capital (WACC) to obtain the Value of Economic Profit. Add the Date 0 Book Value of the Firm to get the Value of the Firm. Subtract Date 0 Capital to get the Value Added by the Firm.

FIGURE 9.7 Firm and Project Valuation – Residual Income.

	A	B	C	D	E	F	G	H
1	FIRM AND PROJECT VALUATION			Five Equivalent Methods				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: (•) Firm ( ) Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: (•) Yes ( ) No	1					
228	**(5) Residual Income (RI)**							**2nd Stage:**
229					**First Stage: Finite Horizon**			**Infin Horiz**
230	Year	0	1	2	3	4	5	6
231	Economic Profit		$29.07	$37.05	$48.03	$53.01	$63.99	$98.98
232	Economic Profit on Salvage Value						$0.00	
233	Value of the Economic Profit	$1,434.92	$1,547.42	$1,663.10	$1,779.29	$1,902.04	$2,026.00	
234	+ Date 0 Book Value of the Firm	$800.00						
235	Value of the Firm (RI Method)	$2,234.92						
236	- Date 0 Firm Capital	$800.00						
237	Value Added by Firm (RI Method)	$1,434.92						

(70) Economic Profit
Enter =C87
and copy across

(71) If Include Infinite Horizon = Yes,
Then 0
Else After-tax Salvage Value(T)
- Book Value(T)
Enter =IF(C10=1,0,G28-G81)

(72) If Cost of Firm Cap(T+1)
- Infinite Horizon Growth Rate = 0,
Then 0,
Else Economic Profit (T+1)
/ (Cost of Firm Cap(T+1)
- Infinite Horizon Growth Rate)
Enter =IF(H181-B9=0,0,H231/(H181-B9))

(73) Date 0 Book Value
of the Firm
Enter =$B$5

(74) (Economic Profit(t) + Economic Profit on
Salvage Value(t) + Value of Equity(t))
/ (1 + Cost of Firm Capital(t))
Enter =(G231+G232+G233)/(1+G181)
and copy to the left

(75) Value of the Economic Profit(0)
+ Date 0 Book Value of the Firm
Enter =B233+B234

(76) Date 0 Proj Invest
or Firm Cap
Enter =$B$5

(77) Value of Project or Firm (RI Method)
- Date 0 Proj Invest or Firm Capital
Enter =B235-B236

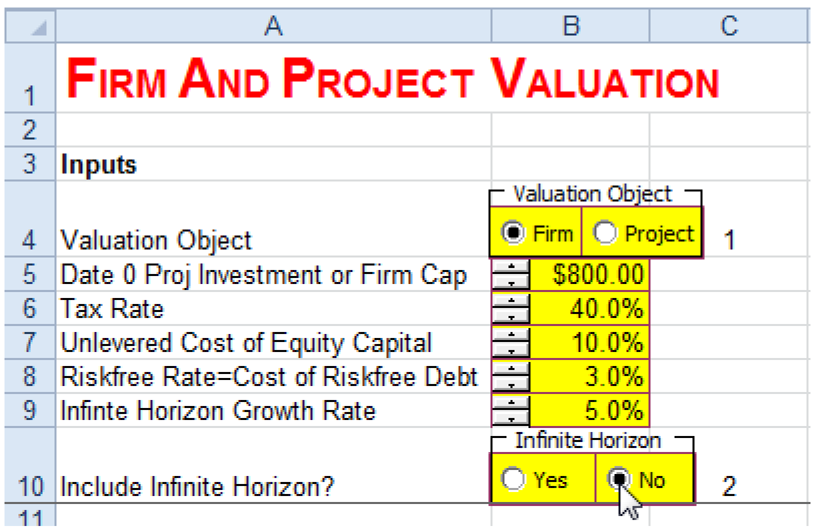
As above, the Value of the Firm is $2,234.92 and (Net Present) Value Added by the Firm is $1,434.92.

9.7 Five Equivalent Methods

Problem. Eliminate the (stage two) infinite horizon cash flows and recompute the value of the firm and the value added by the firm using the same five methods. Then, switch to evaluating a project while maintaining no infinite horizon cash flows. Compute the value of future cash flows and the NPV of the project using the same five methods. Finally, restore the infinite horizon cash flows and compute the value of future cash flows and the NPV of the project using the same five methods.

Start by considering firm valuation with no infinite. Just click on "No" option button in cell B10 (see below).

FIGURE 9.8 Five Equivalent Methods – Firm and No Infinite Horizon.



Essentially, we are assuming that that firm lasts for 5 years and then is liquidated for an After-Tax Salvage Value of $600.

FIGURE 9.9 Five Equivalent Methods – Firm and No Infinite Horizon.

	A	B	C	D	E	F	G	H
1	**FIRM AND PROJECT VALUATION**			**Five Equivalent Methods**				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: (•) Firm ( ) Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: ( ) Yes (•) No	2					
11								
12	**Cash Flows**							**2nd Stage:**
13					**First Stage: Finite Horizon**			**Infin Horiz**
14	Date	0	1	2	3	4	5	6
15	Revenues		$650.00	$690.00	$720.00	$755.00	$775.00	$0.00
16	Expenses		$410.00	$435.00	$445.00	$470.00	$470.00	$0.00
17	Gross Earnings		$240.00	$255.00	$275.00	$285.00	$305.00	$0.00
18	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$0.00
19	Earnings Bef Interest & Tax (EBIT)		$180.00	$195.00	$215.00	$225.00	$245.00	$0.00
20	Interest Expense		$7.50	$7.65	$7.80	$7.95	$8.10	$0.00
21	Earnings Before Tax		$172.50	$187.35	$207.20	$217.05	$236.90	$0.00
22	Taxes		$69.00	$74.94	$82.88	$86.82	$94.76	$0.00
23	Earnings		$103.50	$112.41	$124.32	$130.23	$142.14	$0.00
24	Add Back Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$0.00
25	Cash Flow from Operations		$163.50	$172.41	$184.32	$190.23	$202.14	$0.00
26								
27	New Invest in Plant and Equipment		($60.00)	($60.00)	($60.00)	($60.00)	($60.00)	$0.00
28	After-Tax Salvage Value						$600.00	
29	New Invest in Working Capital		($10.00)	($10.00)	($10.00)	($10.00)	($10.00)	$0.00
30	Cash Flows from Investments		($70.00)	($70.00)	($70.00)	($70.00)	$530.00	$0.00
31								
32	New Borrowing (Repayment)		$5.00	$5.00	$5.00	$5.00	($270.00)	$0.00
33								
34	Free Cash Flow to Equity (FCFE)		$98.50	$107.41	$119.32	$125.23	$462.14	$0.00
35	= Dividends		$98.50	$107.41	$119.32	$125.23	$462.14	$0.00
36								
65	Interest		$7.50	$7.65	$7.80	$7.95	$8.10	$0.00
66	Less New Borrowing (Repayment)		($5.00)	($5.00)	($5.00)	($5.00)	$270.00	$0.00
67	Cash Flow to Debtholders (CFD)		$2.50	$2.65	$2.80	$2.95	$278.10	$0.00
68								
69	Tax Shield Benefit		$3.00	$3.06	$3.12	$3.18	$3.24	$0.00
70	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$737.00	$0.00
71								
72	**Alternative Way to get FCFF**							
73	Earnings		$103.50	$112.41	$124.32	$130.23	$142.14	$0.00
74	After-tax Interest Expense		$4.50	$4.59	$4.68	$4.77	$4.86	$0.00
75	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$0.00
76	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$0.00
77	Cash Flows from Investments		($70.00)	($70.00)	($70.00)	($70.00)	$530.00	$0.00
78	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$737.00	$0.00
79								
80	Debt (D)	$250.00	$255.00	$260.00	$265.00	$270.00	$0.00	
81	Book Value of Equity	$550.00	$555.00	$560.00	$565.00	$570.00	$850.00	
82	Total Capital	$800.00	$810.00	$820.00	$830.00	$840.00	$850.00	
83								
84	**Economic Profit**							
85	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$0.00
86	Capital Charge		$77.08	$77.91	$78.69	$79.38	$79.96	$0.00
87	Economic Profit		$30.92	$39.09	$50.31	$55.62	$67.04	$0.00

FIGURE 9.10 Five Equivalent Methods – Firm and No Infinite Horizon.

	A	B	C	D	E	F	G	H
1	**FIRM AND PROJECT VALUATION**			**Five Equivalent Methods**				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: (●) Firm ( ) Project	1					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Deb	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: ( ) Yes (●) No	2					
113	**(1.) Adjusted Present Value (APV)**							**2nd Stage:**
114					**First Stage: Finite Horizon**			**Infin Horiz**
115	Date	0	1	2	3	4	5	6
116	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$737.00	$0.00
117	Value of the Unlevered Firm	$809.92	$792.92	$765.21	$722.73	$670.00	$0.00	
118	Tax Shield Benefit		$3.00	$3.06	$3.12	$3.18	$3.24	$0.00
119	Value of the Tax Shield Benefit	$11.78	$9.96	$7.90	$5.57	$2.95	$0.00	
120	Value of the Firm (APV Method)	$821.71						
121	- Date 0 Firm Capital	$800.00						
122	Value Added by Firm (APV Method)	$21.71						
123								
141	**(2) Free Cash Flow to Equity (FCFE)**							**2nd Stage:**
142					**First Stage: Finite Horizon**			**Infin Horiz**
143	Date	0	1	2	3	4	5	6
144	Debt + Equity (D+E)	$821.71	$802.88	$773.11	$728.30	$672.95	$0.00	
145	Equity (E)	$571.71	$547.88	$513.11	$463.30	$402.95	$0.00	
146	Levered Cost of Equity Capital		13.06%	13.26%	13.55%	14.00%	14.69%	0.00%
147								
148	Free Cash Flow to Equity (FCFE)		$98.50	$107.41	$119.32	$125.23	$462.14	$0.00
149	Value of Equity (E)	$571.71	$547.88	$513.11	$463.30	$402.95	$0.00	
150	Value of Debt (D)	$250.00	$255.00	$260.00	$265.00	$270.00	$0.00	
151	Value of the Firm (FCFE Method)	$821.71						
152	- Date 0 Firm Capital	$800.00						
153	Value Added by Firm (FCFE Method	$21.71						
154								
176	**(3) Free Cash Flow to the Firm (FCFF)**							**2nd Stage:**
177					**First Stage: Finite Horizon**			**Infin Horiz**
178	Date	0	1	2	3	4	5	6
179	Equity Weight (E / (D+E))	69.6%	68.2%	66.4%	63.6%	59.9%	0.0%	
180	Debt Weight (D / (D+E))	30.4%	31.8%	33.6%	36.4%	40.1%	0.0%	
181	Cost of Firm Capital (WACC)		9.63%	9.62%	9.60%	9.56%	9.52%	0.00%
182								
183	Free Cash Flow to the Firm (FCFF)		$98.00	$107.00	$119.00	$125.00	$737.00	$0.00
184	Value of the Firm (FCFF Method)	$821.71	$802.88	$773.11	$728.30	$672.95	$0.00	
185	- Date 0 Firm Capital	$800.00						
186	Value Added by Firm (FCFF Method)	$21.71						
187								
204	**(4) Dividend Discount Model (DDM)**							**2nd Stage:**
205					**First Stage: Finite Horizon**			**Infin Horiz**
206	Year	0	1	2	3	4	5	6
207	Dividend		$98.50	$107.41	$119.32	$125.23	$462.14	$0.00
208	Value of Equity (E)	$571.71	$547.88	$513.11	$463.30	$402.95	$0.00	
209	Value of Debt (D)	$250.00	$255.00	$260.00	$265.00	$270.00	$0.00	
210	Value of the Firm (DDM Method)	$821.71						
211	- Date 0 Firm Capital	$800.00						
212	Value Added by Firm (DDM Method)	$21.71						
213								
228	**(5) Residual Income (RI)**							**2nd Stage:**
229					**First Stage: Finite Horizon**			**Infin Horiz**
230	Year	0	1	2	3	4	5	6
231	Economic Profit		$30.92	$39.09	$50.31	$55.62	$67.04	$0.00
232	Economic Profit on Salvage Value						($250.00)	
233	Value of the Economic Profit	$21.71	($7.12)	($46.89)	($101.70)	($167.05)	$0.00	
234	+ Date 0 Book Value of the Firm	$800.00						
235	Value of the Firm (RI Method)	$821.71						
236	- Date 0 Firm Capital	$800.00						
237	Value Added by Firm (RI Method)	$21.71						

Now all five valuation methods match. The Value of the Firm is $821.71 and (Net Present) Value Added by the Firm is $21.71. It makes sense that these valuations are much lower than before because we have eliminated the (second stage) infinite horizon cash flows from period 6 to infinity.

Now switch to considering a project. The main difference between a firm and a project is how the date 0 cash flow is treated. With a firm, the date 0 capital is already invested in the firm, so the Value of the Firm is the present value of all future cash flows excluding the date 0 capital. With a project, the date 0 capital has not been invested yet and we are trying to decide whether to proceed with the project or not. So the Net Present Value of the project is the present value of all future cash flows minus the cost of the Date 0 Project Investment.

Switching to the project is done by clicking on the "**Project**" option button in cell **B4** (see below).

FIGURE 9.11 Five Equivalent Methods – Project and No Infinite Horizon.

	A	B	C
1	FIRM AND PROJECT VALUATION		
2			
3	**Inputs**		
4	Valuation Object	Valuation Object: ○ Firm ◉ Project	2
5	Date 0 Proj Investment or Firm Cap	$800.00	
6	Tax Rate	40.0%	
7	Unlevered Cost of Equity Capital	10.0%	
8	Riskfree Rate=Cost of Riskfree Debt	3.0%	
9	Infinte Horizon Growth Rate	5.0%	
10	Include Infinite Horizon?	Infinite Horizon: ○ Yes ◉ No	2

There is no infinite horizon, so it is assumed that the project lasts for 5 years and then is liquidated for an After-Tax Salvage Value. To highlight the contrast between a project and a firm, we have assumed that the project involved a single investment on date 0 and no further investments in plant and equipment, no further investments in working capital, and no additional borrowing on future dates. However, these assumptions could be relaxed and the spreadsheet would handle it just fine.

FIGURE 9.12 Five Equivalent Methods – Project and No Infinite Horizon.

	A	B	C	D	E	F	G	H
1	**Firm And Project Valuation**			**Five Equivalent Methods**				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: ○ Firm ◉ Project	2					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: ○ Yes ◉ No	2					
11								
12	**Cash Flows**							**2nd Stage:**
13				**First Stage: Finite Horizon**				**Infin Horiz**
14	Date	0	1	2	3	4	5	6
15	Revenues		$650.00	$690.00	$720.00	$755.00	$775.00	$0.00
16	Expenses		$410.00	$435.00	$445.00	$470.00	$470.00	$0.00
17	Gross Earnings		$240.00	$255.00	$275.00	$285.00	$305.00	$0.00
18	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$0.00
19	Earnings Bef Interest & Tax (EBIT)		$180.00	$195.00	$215.00	$225.00	$245.00	$0.00
20	Interest Expense		$7.50	$7.50	$7.50	$7.50	$7.50	$0.00
21	Earnings Before Tax		$172.50	$187.50	$207.50	$217.50	$237.50	$0.00
22	Taxes		$69.00	$75.00	$83.00	$87.00	$95.00	$0.00
23	Earnings		$103.50	$112.50	$124.50	$130.50	$142.50	$0.00
24	Add Back Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$0.00
25	Cash Flow from Operations		$163.50	$172.50	$184.50	$190.50	$202.50	$0.00
26								
27	New Invest in Plant and Equipment		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	After-Tax Salvage Value						$600.00	
29	New Invest in Working Capital		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
30	Cash Flows from Investments		$0.00	$0.00	$0.00	$0.00	$600.00	$0.00
31								
32	New Borrowing (Repayment)		$0.00	$0.00	$0.00	$0.00	($250.00)	$0.00
33								
34	Free Cash Flow to Equity (FCFE)		$163.50	$172.50	$184.50	$190.50	$552.50	$0.00
35	= Dividends		$163.50	$172.50	$184.50	$190.50	$552.50	$0.00
36								
65	Interest		$7.50	$7.50	$7.50	$7.50	$7.50	$0.00
66	Less New Borrowing (Repayment)		$0.00	$0.00	$0.00	$0.00	$250.00	$0.00
67	Cash Flow to Debtholders (CFD)		$7.50	$7.50	$7.50	$7.50	$257.50	$0.00
68								
69	Tax Shield Benefit		$3.00	$3.00	$3.00	$3.00	$3.00	$0.00
70	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$807.00	$0.00
71								
72	**Alternative Way to get FCFF**							
73	Earnings		$103.50	$112.50	$124.50	$130.50	$142.50	$0.00
74	After-tax Interest Expense		$4.50	$4.50	$4.50	$4.50	$4.50	$0.00
75	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$0.00
76	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$0.00
77	Cash Flows from Investments		$0.00	$0.00	$0.00	$0.00	$600.00	$0.00
78	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$807.00	$0.00
79								
80	Debt (D)	$250.00	$250.00	$250.00	$250.00	$250.00	$0.00	
81	Book Value of Equity	$550.00	$490.00	$430.00	$370.00	$310.00	$500.00	
82	Total Capital	$800.00	$740.00	$680.00	$620.00	$560.00	$500.00	
83								
84	**Economic Profit**							
85	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$0.00
86	Capital Charge		$77.79	$71.83	$65.85	$59.81	$53.72	$0.00
87	Economic Profit		$30.21	$45.17	$63.15	$75.19	$93.28	$0.00

FIGURE 9.13 Five Equivalent Methods – Project and No Infinite Horizon.

	A	B	C	D	E	F	G	H
1	**FIRM AND PROJECT VALUATION**			**Five Equivalent Methods**				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: Firm / Project (selected)	2					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Deb	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: Yes / No (selected)	2					
113	**(1.) Adjusted Present Value (APV)**							**2nd Stage:**
114					**First Stage: Finite Horizon**			**Infin Horiz**
115	Date	0	1	2	3	4	5	6
116	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$807.00	$0.00
117	Value of the Unlevered Firm	$1,075.28	$1,014.81	$939.29	$844.21	$733.64	$0.00	
118	Tax Shield Benefit		$3.00	$3.00	$3.00	$3.00	$3.00	$0.00
119	Value of the Tax Shield Benefit	$11.37	$9.51	$7.46	$5.21	$2.73	$0.00	
120	Value of Fut Cash Flows (APV Met)	$1,086.65						
121	- Date 0 Project Investment	$800.00						
122	NPV of Project (APV Method)	$286.65						
123								
141	**(2) Free Cash Flow to Equity (FCFE)**							**2nd Stage:**
142					**First Stage: Finite Horizon**			**Infin Horiz**
143	Date	0	1	2	3	4	5	6
144	Debt + Equity (D+E)	$1,086.65	$1,024.32	$946.75	$849.42	$736.36	$0.00	
145	Equity (E)	$836.65	$774.32	$696.75	$599.42	$486.36	$0.00	
146	Levered Cost of Equity Capital		12.09%	12.26%	12.51%	12.92%	13.60%	0.00%
147								
148	Free Cash Flow to Equity (FCFE)		$163.50	$172.50	$184.50	$190.50	$552.50	$0.00
149	Value of Equity (E)	$836.65	$774.32	$696.75	$599.42	$486.36	$0.00	
150	Value of Debt (D)	$250.00	$250.00	$250.00	$250.00	$250.00	$0.00	
151	Value of Fut Cash Flows (FCFE Met	$1,086.65						
152	- Date 0 Project Investment	$800.00						
153	NPV of Project (FCFE Method)	$286.65						
154								
176	**(3) Free Cash Flow to the Firm (FCFF)**							**2nd Stage:**
177					**First Stage: Finite Horizon**			**Infin Horiz**
178	Date	0	1	2	3	4	5	6
179	Equity Weight (E / (D+E))	77.0%	75.6%	73.6%	70.6%	66.0%	0.0%	
180	Debt Weight (D / (D+E))	23.0%	24.4%	26.4%	29.4%	34.0%	0.0%	
181	Cost of Firm Capital (WACC)		9.72%	9.71%	9.68%	9.65%	9.59%	0.00%
182								
183	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$807.00	$0.00
184	Value of Fut Cash Flows (FCFF Met	$1,086.65	$1,024.32	$946.75	$849.42	$736.36	$0.00	
185	- Date 0 Project Investment	$800.00						
186	NPV of Project (FCFF Method)	$286.65						
187								
204	**(4) Dividend Discount Model (DDM)**							**2nd Stage:**
205					**First Stage: Finite Horizon**			**Infin Horiz**
206	Year	0	1	2	3	4	5	6
207	Dividend		$163.50	$172.50	$184.50	$190.50	$552.50	$0.00
208	Value of Equity (E)	$836.65	$774.32	$696.75	$599.42	$486.36	$0.00	
209	Value of Debt (D)	$250.00	$250.00	$250.00	$250.00	$250.00	$0.00	
210	Value of Fut Cash Flows (DDM Met)	$1,086.65						
211	- Date 0 Project Investment	$800.00						
212	NPV of Project (DDM Method)	$286.65						
213								
228	**(5) Residual Income (RI)**							**2nd Stage:**
229					**First Stage: Finite Horizon**			**Infin Horiz**
230	Year	0	1	2	3	4	5	6
231	Economic Profit		$30.21	$45.17	$63.15	$75.19	$93.28	$0.00
232	Economic Profit on Salvage Value						$100.00	
233	Value of the Economic Profit	$286.65	$284.32	$266.75	$229.42	$176.36	$0.00	
234	+ Date 0 Book Value of the Firm	$800.00						
235	Value of Fut Cash Flows (RI Met)	$1,086.65						
236	- Date 0 Project Investment	$800.00						
237	NPV of Project (RI Method)	$286.65						

All five valuation methods produce the same results. The Value of Future Cash Flows is $1,086.65. After subtracting the cost of the Date 0 Project Investment, the Net Present Value of the Project is $286.65, so the project should be accepted.

Finally, restore the stage two (infinite horizon) cash flows by clicking on the "**Yes**" option button in cell **B10** (see below).

FIGURE 9.14 Five Equivalent Methods – Project and Infinite Horizon.

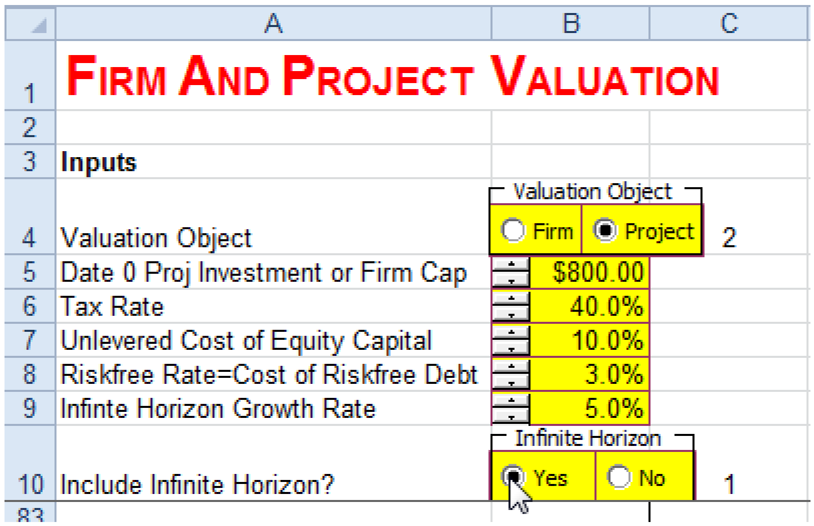


FIGURE 9.15 Five Equivalent Methods – Project and Infinite Horizon.

	A	B	C	D	E	F	G	H
1	**FIRM AND PROJECT VALUATION**			**Five Equivalent Methods**				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: ○ Firm ◉ Project	2					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Debt	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: ◉ Yes ○ No	1					
11								
12	**Cash Flows**							**2nd Stage:**
13					**First Stage: Finite Horizon**			**Infin Horiz**
14	Date	0	1	2	3	4	5	6
15	Revenues		$650.00	$690.00	$720.00	$755.00	$775.00	$840.00
16	Expenses		$410.00	$435.00	$445.00	$470.00	$470.00	$475.00
17	Gross Earnings		$240.00	$255.00	$275.00	$285.00	$305.00	$365.00
18	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
19	Earnings Bef Interest & Tax (EBIT)		$180.00	$195.00	$215.00	$225.00	$245.00	$305.00
20	Interest Expense		$7.50	$7.50	$7.50	$7.50	$7.50	$7.50
21	Earnings Before Tax		$172.50	$187.50	$207.50	$217.50	$237.50	$297.50
22	Taxes		$69.00	$75.00	$83.00	$87.00	$95.00	$119.00
23	Earnings		$103.50	$112.50	$124.50	$130.50	$142.50	$178.50
24	Add Back Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
25	Cash Flow from Operations		$163.50	$172.50	$184.50	$190.50	$202.50	$238.50
26								
27	New Invest in Plant and Equipment		$0.00	$0.00	$0.00	$0.00	$0.00	($85.00)
28	After-Tax Salvage Value						$0.00	
29	New Invest in Working Capital		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
30	Cash Flows from Investments		$0.00	$0.00	$0.00	$0.00	$0.00	($85.00)
31								
32	New Borrowing (Repayment)		$0.00	$0.00	$0.00	$0.00	$0.00	$12.50
33								
34	Free Cash Flow to Equity (FCFE)		$163.50	$172.50	$184.50	$190.50	$202.50	$166.00
35	= Dividends		$163.50	$172.50	$184.50	$190.50	$202.50	$166.00
36								
65	Interest		$7.50	$7.50	$7.50	$7.50	$7.50	$7.50
66	Less New Borrowing (Repayment)		$0.00	$0.00	$0.00	$0.00	$0.00	($12.50)
67	Cash Flow to Debtholders (CFD)		$7.50	$7.50	$7.50	$7.50	$7.50	($5.00)
68								
69	Tax Shield Benefit		$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
70	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$207.00	$158.00
71								
72	**Alternative Way to get FCFF**							
73	Earnings		$103.50	$112.50	$124.50	$130.50	$142.50	$178.50
74	After-tax Interest Expense		$4.50	$4.50	$4.50	$4.50	$4.50	$4.50
75	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$183.00
76	Depreciation		$60.00	$60.00	$60.00	$60.00	$60.00	$60.00
77	Cash Flows from Investments		$0.00	$0.00	$0.00	$0.00	$0.00	($85.00)
78	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$207.00	$158.00
79								
80	Debt (D)	$250.00	$250.00	$250.00	$250.00	$250.00	$250.00	
81	Book Value of Equity	$550.00	$490.00	$430.00	$370.00	$310.00	$250.00	
82	Total Capital	$800.00	$740.00	$680.00	$620.00	$560.00	$500.00	
83								
84	**Economic Profit**							
85	Net Oper. Profit After Tax (NOPAT)		$108.00	$117.00	$129.00	$135.00	$147.00	$183.00
86	Capital Charge		$79.12	$73.21	$67.30	$61.38	$55.46	$49.53
87	Economic Profit		$28.88	$43.79	$61.70	$73.62	$91.54	$133.47

FIGURE 9.16 Five Equivalent Methods – Project and Infinite Horizon.

	A	B	C	D	E	F	G	H
1	FIRM AND PROJECT VALUATION			Five Equivalent Methods				
2								
3	**Inputs**							
4	Valuation Object	Valuation Object: ○ Firm ◉ Project	2					
5	Date 0 Proj Investment or Firm Cap	$800.00						
6	Tax Rate	40.0%						
7	Unlevered Cost of Equity Capital	10.0%						
8	Riskfree Rate=Cost of Riskfree Det	3.0%						
9	Infinte Horizon Growth Rate	5.0%						
10	Include Infinite Horizon?	Infinite Horizon: ◉ Yes ○ No	1					
113	**(1.) Adjusted Present Value (APV)**							**2nd Stage:**
114				**First Stage: Finite Horizon**				**Infin Horiz**
115	Date	0	1	2	3	4	5	6
116	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$207.00	$158.00
117	Value of the Unlevered Firm	$2,664.84	$2,763.32	$2,862.65	$2,959.92	$3,060.91	$3,160.00	
118	Tax Shield Benefit		$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
119	Value of the Tax Shield Benefit	$48.63	$50.49	$52.54	$54.79	$57.27	$60.00	
120	Value of Fut Cash Flows (APV Met)	$2,713.46						
121	- Date 0 Project Investment	$800.00						
122	NPV of Project (APV Method)	$1,913.46						
123								
141	**(2) Free Cash Flow to Equity (FCFE)**							**2nd Stage:**
142				**First Stage: Finite Horizon**				**Infin Horiz**
143	Date	0	1	2	3	4	5	6
144	Debt + Equity (D+E)	$2,713.46	$2,813.81	$2,915.19	$3,014.71	$3,118.18	$3,220.00	
145	Equity (E)	$2,463.46	$2,563.81	$2,665.19	$2,764.71	$2,868.18	$2,970.00	
146	Levered Cost of Equity Capital		10.71%	10.68%	10.66%	10.63%	10.61%	10.59%
147								
148	Free Cash Flow to Equity (FCFE)		$163.50	$172.50	$184.50	$190.50	$202.50	$166.00
149	Value of Equity (E)	$2,463.46	$2,563.81	$2,665.19	$2,764.71	$2,868.18	$2,970.00	
150	Value of Debt (D)	$250.00	$250.00	$250.00	$250.00	$250.00	$250.00	
151	Value of Fut Cash Flows (FCFE Met	$2,713.46						
152	- Date 0 Project Investment	$800.00						
153	NPV of Project (FCFE Method)	$1,913.46						
154								
176	**(3) Free Cash Flow to the Firm (FCFF)**							**2nd Stage:**
177				**First Stage: Finite Horizon**				**Infin Horiz**
178	Date	0	1	2	3	4	5	6
179	Equity Weight (E / (D+E))	90.8%	91.1%	91.4%	91.7%	92.0%	92.2%	
180	Debt Weight (D / (D+E))	9.2%	8.9%	8.6%	8.3%	8.0%	7.8%	
181	Cost of Firm Capital (WACC)		9.89%	9.89%	9.90%	9.90%	9.90%	9.91%
182								
183	Free Cash Flow to the Firm (FCFF)		$168.00	$177.00	$189.00	$195.00	$207.00	$158.00
184	Value of Fut Cash Flows (FCFF Met	$2,713.46	$2,813.81	$2,915.19	$3,014.71	$3,118.18	$3,220.00	
185	- Date 0 Project Investment	$800.00						
186	NPV of Project (FCFF Method)	$1,913.46						
187								
204	**(4) Dividend Discount Model (DDM)**							**2nd Stage:**
205				**First Stage: Finite Horizon**				**Infin Horiz**
206	Year	0	1	2	3	4	5	6
207	Dividend		$163.50	$172.50	$184.50	$190.50	$202.50	$166.00
208	Value of Equity (E)	$2,463.46	$2,563.81	$2,665.19	$2,764.71	$2,868.18	$2,970.00	
209	Value of Debt (D)	$250.00	$250.00	$250.00	$250.00	$250.00	$250.00	
210	Value of Fut Cash Flows (DDM Met)	$2,713.46						
211	- Date 0 Project Investment	$800.00						
212	NPV of Project (DDM Method)	$1,913.46						
213								
228	**(5) Residual Income (RI)**							**2nd Stage:**
229				**First Stage: Finite Horizon**				**Infin Horiz**
230	Year	0	1	2	3	4	5	6
231	Economic Profit		$28.88	$43.79	$61.70	$73.62	$91.54	$133.47
232	Economic Profit on Salvage Value						$0.00	
233	Value of the Economic Profit	$1,913.46	$2,073.81	$2,235.19	$2,394.71	$2,558.18	$2,720.00	
234	+ Date 0 Book Value of the Firm	$800.00						
235	Value of Fut Cash Flows (RI Met)	$2,713.46						
236	- Date 0 Project Investment	$800.00						
237	NPV of Project (RI Method)	$1,913.46						

All five valuation methods produce the same results. The Value of Future Cash Flows is $2,713.46. After subtracting the cost of the Date 0 Project Investment, the Net Present Value of the Project is $1,913.46, so the project should be accepted.

Problems

1. Starting from their historical financial statements, forecast the expected future cash flows for a real firm in two stages corresponding to two time periods. Stage one is a finite horizon from years 1 to 5. Stage two is the remaining infinite horizon from year 6 to infinity. Given these forecasted cash flows, compute the current value of the firm and the value added by the firm using five equivalent methods: (1) Adjusted Present Value, (2) Free Cash Flow to Equity, (3) Free Cash Flow to the Firm, (4) Dividend Discount Model, and (5) Residual Income. Given expected future cash flows for a project, compute the present value of future cash flows and the NPV of the project using the same five equivalent methods.

2. Perform instant experiments on whether changing various inputs causes an increase or decrease in the firm's value / share and by how much.

   (a.) What happens when the date 0 firm capital is increased?
   (b.) What happens when the tax rate is increased?
   (c.) What happens when the unlevered cost of equity capital is increased?
   (d.) What happens when the riskfree rate is increased?
   (e.) What happens when the infinite horizon growth rate of unlevered equity is increased?

Appendix: Reconciling the Residual Income Method with Other Approaches to Valuing Firms or Projects

By Professor Robert A. Taggart, Boston College

Craig W. Holden's book *Excel Modeling in Corporate Finance* presents five different approaches to valuation (Adjusted Present Value, Free Cash Flow to Equity, Free Cash Flow to the Firm, Dividend Discount and Residual Income). In principle, all five methods should yield consistent results when used to value either a firm or a capital investment project. However, the Residual Income method is a difficult challenge to reconcile with the other four methods.

This note analyzes the properties of the Residual Income valuation method and then uses these properties to reconcile the Residual Income method with other approaches to valuing firms or projects. This yields consistent results across all five valuation methods.

I. Properties of the Residual Income Method

The Residual Income Method is conceptually identical to what the consulting firm Stern Stewart & Co. originally trademarked as the Economic Value Added, or EVA®, approach. Ignoring accounting adjustments that may need to be made for items such as changes in "equity equivalent" reserves or "other operating income," the EVA approach measures Economic Value Added in a given year t as:

$$EVA_t = NOPAT_t - r_t^* A_{t-1} \tag{1}$$

where: $NOPAT_t$ = net operating profit after tax in year t (= revenue minus cash operating expenses minus depreciation all multiplied by one minus the corporate tax rate.

r_t* = the company's weighted average cost of capital in year t, or

$$r_t^* = r_{Et}\left(\frac{E_{t-1}}{V_{t-1}}\right) + r_{Dt}(1-T)\left(\frac{D_{t-1}}{V_{t-1}}\right)$$

r_{Et} = the cost of equity capital in year t

r_{Dt} = the cost of debt in year t

T = the corporate tax rate

E_{t-1} = the market value of the company's equity at the beginning of year t

D_{t-1} = the market value of the company's debt at the beginning of year t

V_{t-1} = the company's total market value at the beginning of year t

A_{t-1} = the book value of the company's operating assets at the beginning of year t, net of noninterest-bearing liabilities[2]

EVA subtracts a charge for capital employed in a given year from that year's NOPAT, and it can thus be interpreted as the firm's economic profit in that year. In turn, the present value of EVA, discounted at the weighted average cost of capital over the life of a firm or project, is interpreted by Stern Stewart as MVA, or market value added:

$$MVA_0 = \sum_{t=1}^{H^*} \frac{EVA_t}{\prod_{m=1}^{t}(1+r_m^*)} = V_0 - A_0 \tag{2}$$

where H* is the horizon date (which could be infinite). MVA is the amount of value created by the firm or project, over and above the initial amount of capital committed.

II. The Relationship between Residual Income and Free Cash Flow

We can define the total free cash flow to the firm (FCFF) in year t as:

$$FCFF_t = (\mathrm{Re}v_t - OpCost_t - Dep_t)(1-T) + Dep_t - CapEx_t - \Delta NWC_t \tag{3}$$

where: Rev = revenue

OpCost = cash operating cost

Dep = depreciation

CapEx = capital expenditure

ΔNWC = change in net working capital

In contrast, NOPAT in the same year t is defined as:

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[2] See, for example, G. Bennett Stewart III, "Announcing the Stern Stewart Performance 1,000: A New Way of Viewing Corporate America, *Journal of Applied Corporate Finance* 3 (June 1990), pp. 38-59.

$$NOPAT_t = (\mathrm{Re}v_t - OpCost_t - Dep_t)(1-T) \tag{4}$$

Together, (3) and (4) imply:

$$NOPAT_t = FCFF_t + (CapEx_t + \Delta NWC_t - Dep_t) = FCFF_t + (A_t - A_{t-1}) \tag{5}$$

We can then express the company's Market Value Added as:

$$MVA_0 = \sum_{t=1}^{H*} \frac{(NOPAT_t - r_t^* A_{t-1})}{\prod_{m=1}^{t}(1+r_m^*)} = \sum_{t=1}^{H*} \frac{FCFF_t}{\prod_{m=1}^{t}(1+r_m^*)} + \sum_{t=1}^{H*} \frac{A_t - (1+r_t^*)A_{t-1}}{\prod_{m=1}^{t}(1+r_m^*)} \tag{6}$$

The first term on the right-hand side of Equation (6) is equal to V_0, the firm's initial total market value. Consider the second term when H* = 1:

$$\sum_{t=1}^{1} \frac{A_t - (1+r_t^*)A_{t-1}}{\prod_{m=1}^{t}(1+r_m^*)} = \frac{A_1}{(1+r_1^*)} - A_0 \tag{7}$$

Similarly, for H* = 2:

$$\sum_{t=1}^{2} \frac{A_t - (1+r_t^*)A_{t-1}}{\prod_{m=1}^{t}(1+r_m^*)} = \frac{A_2}{(1+r_1^*)(1+r_2^*)} - \frac{A_1}{(1+r_1^*)} + \frac{A_1}{(1+r_1^*)} - A_0$$

$$= \frac{A_2}{(1+r_1^*)(1+r_2^*)} - A_0 \tag{8}$$

Likewise, for any value of H*:

$$\sum_{t=1}^{H*} \frac{A_t - (1+r_t^*)A_{t-1}}{\prod_{m=1}^{t}(1+r_m^*)} = \frac{A_{H*}}{\prod_{m=1}^{H*}(1+r_m^*)} - A_0 \tag{9}$$

Combining (9) with (6) then implies:

$$MVA_0 = \sum_{t=1}^{H*} \frac{FCFF_t}{\prod_{m=1}^{t}(1+r_m^*)} + \frac{A_{H*}}{\prod_{m=1}^{H*}(1+r_m^*)} - A_0 = V_0 + \frac{A_{H*}}{\prod_{m=1}^{H*}(1+r_m^*)} - A_0 \tag{10}$$

From Equation (2) we know that $MVA_0 = V_0 - A_0$, and (10) will satisfy this condition whenever the second term on the right-hand side is equal to zero. One way for this to happen is if $A_{H*} = 0$, which will occur if the firm or company's capital is liquidated at the horizon date so that $A_{H*} = 0$.

In the infinite horizon case, (2) and (10) can also hold simultaneously whenever the present value of horizon-date capital is equal to zero. This will be true if the level of capital remains constant, as in a level perpetuity model, or, in the case of constant perpetual growth (i.e., $A_t = (1+g)A_{t-1}$), as long as $g < r^*$.

For a two-stage model with constant perpetual growth after H, the end of the first stage:

$$MVA_0 = \sum_{t=1}^{H} \frac{FCFF_t}{\prod_{m=1}^{t}(1+r_m^*)} + \frac{A_H}{\prod_{m=1}^{H}(1+r_m^*)} - A_0 +$$

$$\frac{1}{\prod_{m=1}^{H}(1+r_m^*)} \left[\frac{FCFF_{H+1}}{r_{H+1}^* - g} + \frac{A_H (1+g)^{H^*-H}}{(1+r_{H+1}^*)^{H^*-H}} - A_H \right] \tag{11}$$

$$= V_0 + \frac{1}{\prod_{m=1}^{H}(1+r_m^*)} \left[A_H \left(\frac{1+g}{1+r_{H+1}^*} \right)^{H^*-H} \right] - A_0$$

Equation (11) is equal to $V_0 - A_0$ when H* approaches infinity as long as $g < r^*_{H+1}$. Thus, the two-stage model poses no special difficulties. As we shall see in Section II.D, though, it does impose some constraints on the parameter choices for periods H and H+1. Note also that, in order to make use of the growing perpetuity valuation formula, the discount rate must become constant at r^*_{H+1} once constant growth begins in the second stage.

III. Residual Income and Return on Invested Capital

Before moving on, let us look at an alternative representation of the residual income method. First, define Return on Invested Capital (ROIC) as[3]:

$$ROIC_t = \frac{NOPAT_t}{A_{t-1}} \tag{12}$$

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[3] See Robert C. Higgins, Analysis for Financial Management, 7th ed. (New York: McGraw-Hill/Irwin, 2004), p. 48.

Substituting (12) into (1), we can then express EVA as:

$$EVA_t = (ROIC_t - r_t^*)A_{t-1} \tag{13}$$

In the two-stage model with constant perpetual growth in the second stage, NOPAT and total net assets must grow at the same constant rate, g, in the second stage. With constant, perpetual growth in a model tied to an income statement and balance sheet, all of the individual items must grow at the same rate, g. This implies that ROIC must be constant from Year H+1 onward. Thus, we can write MVA_0 for the two-stage model as:

$$MVA_0 = \sum_{t=1}^{H} \frac{(ROIC_t - r_t^*)A_{t-1}}{\prod_{m=1}^{t}(1+r_m^*)} + \frac{1}{\prod_{m=1}^{H}(1+r_m^*)}\left[\frac{(ROIC_{H+1} - r_{H+1}^*)A_H}{r_{H+1}^* - g}\right] \tag{14}$$

Besides the constancy of ROIC and r*, Equation (14) emphasizes that total net assets must grow at the rate g from H to H+1, H+1 to H+2, and so on, in perpetuity.

IV. Measures of the Cost of Capital

The properties of the Residual Income, or EVA method, can now be used to identify the key issue, which is the need for a constant capital structure. A potential solution is to assume a constant debt-to-value ratio throughout the second stage and to use a set of cost of capital expressions that is predicated on this assumption. There are two available choices for the set of cost of capital expressions.

One approach is based on the analysis of Miles and Ezzell[4]. They assume that capital structure is adjusted year by year to maintain the same capital structure proportions at the end of each year. With risk-free debt, this implies that the most immediate future debt tax shield is certain, because it is based on debt already outstanding at the time of the valuation. Subsequent debt tax shields are uncertain, by contrast, because the firm will adjust its debt each year to maintain a constant debt-to-value ratio, and future firm value is uncertain. Miles and Ezzell then base their valuation on the assumption that the most immediate future debt tax shield is discounted at r_F, while all subsequent debt tax shields are discounted at the unlevered cost of capital, r_U. This in turn leads to a set of cost of capital expressions that can be used to achieve consistent valuations across all of the different valuation methods. A minor drawback of the Miles-Ezzell cost of capital expressions is their complexity.

[4] J. Miles and J.R. Ezzell, "The Weighted Average Cost of Capital, Perfect Capital Markets and Project Life: A Clarification," *Journal of Financial and Quantitative Analysis* 15 (September 1980), pp. 719-730.

A second approach is based on the analysis of by Harris and Pringle (1985).[5] They assume that debt is adjusted continuously to maintain a constant capital structure. Even if debt remains risk-free, this assumption implies that all future debt tax shields are discounted at the unlevered cost of capital, r_U The resulting cost of capital expressions under this assumption are much simpler in form[6]:

$$r^* = r_E\left(\frac{E}{V}\right) + r_F(1-T)\left(\frac{D}{V}\right) \tag{15}$$

$$r^* = r_U - r_F T\left(\frac{D}{V}\right) \tag{16}$$

$$r_E = r_U + (r_U - r_F)\left(\frac{D}{E}\right) \tag{17}$$

Based on the Harris and Pringle (1985) approach, the five valuation methods in the Firm and Project Valuation spreadsheet of Holden's book *Excel Modeling in Corporate Finance, Fourth Edition* produce consistent results. Further, the valuations are consistent year by year working backwards to the present.

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[5] See R.S. Harris and J.J. Pringle, "Risk-Adjusted Discount Rates – Extensions from the Average-Risk Case," *Journal of Financial Research* 8 (Fall 1985), pp. 237-244.

[6] For a comparison between the Miles-Ezzell and Harris-Pringle expressions, see R. A. Taggart, "Consistent Valuation and Cost of Capital Expressions with Corporate and Personal Taxes," *Financial Management* 20 (Autumn 1991), pp. 8-20.

Chapter 10 The Yield Curve

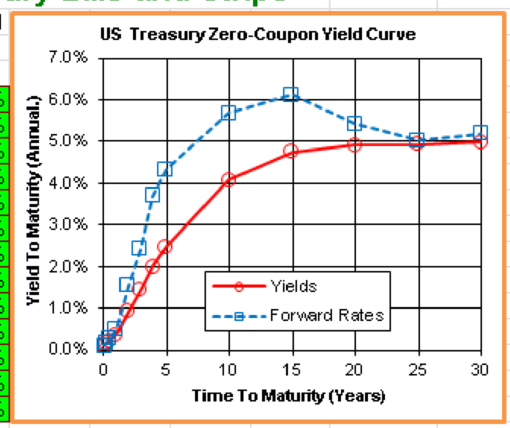
10.1 Obtaining It From Treasury Bills and Strips

Problem. Given bond prices and yields as published by the financial press or other information sources, obtain the U.S. Treasury Yield Curve.

Solution Strategy. Collect maturity date and yield to maturity (e.g., the "ask yield") from the *Wall Street Journal Online* (wsj.com) for Treasury Bills and Treasury Strips of a variety of maturity dates. Compute the time to maturity. Graph the yield to maturity of these bonds against their time to maturity.

FIGURE 10.1 The Yield Curve – Obtaining It From Bond Listings.

	A	B	C	D	E
1	THE YIELD CURVE	Obtaining It From Treasury Bills and Strips			
2		Maturity	Time To	Yield To	Forward
3	**Yield Curve Inputs**	Date	Maturity	Maturity	Rates
4	Today's Date	3/11/2010			
5	One Month Treasury Bill	4/15/2010	0.09	0.101%	0.101%
6	Three Month Treasury Bill	6/10/2010	0.25	0.147%	0.175%
7	Six Month Treasury Bill	9/9/2010	0.49	0.211%	0.275%
8	One Year Treasury Strip	3/10/2011	1.00	0.349%	0.485%
9	Two Year Treasury Strip	2/15/2012	1.93	0.920%	1.536%
10	Three Year Treasury Strip	2/15/2013	2.93	1.430%	2.420%
11	Four Year Treasury Strip	2/15/2014	3.93	2.000%	3.687%
12	Five Year Treasury Strip	2/15/2015	4.93	2.470%	4.337%
13	Ten Year Treasury Strip	2/15/2020	9.93	4.070%	5.671%
14	Fifteen Year Treasury Bond	2/15/2025	14.93	4.750%	6.113%
15	Twenty Year Treasury Bond	2/15/2030	19.93	4.920%	5.429%
16	Twenty Five Year Treasury Bond	2/15/2035	24.93	4.940%	5.020%
17	Thirty Year Treasury Bond	2/15/2040	29.93	4.980%	5.180%
18					
19	(1) Maturity Date - Today's Date				
20	Enter =YEARFRAC($B$4,B5) and copy down				
21					



Excel 2007 Equivalent

To install the Analysis ToolPak in Excel 2007, click on , click on Excel Options at the bottom of the drop-down window, click on **Add-Ins**, highlight **Analysis TookPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

For a given bond, Time To Maturity = Maturity Date - Today's Date. We can calculate the fraction of a year between two calendar dates using the **YEARFRAC** function in Excel's Analysis ToolPak Add-In. Excel's Analysis ToolPak Add-In contains several advanced date functions that are useful in finance. To access any of these functions, you need to install the Analysis ToolPak. Otherwise you will get the error message #NAME?.

To install the Analysis ToolPak, click on File, click on Options, click on **Add-Ins**, highlight the **Analysis ToolPak** in the list of Inactive Applications, click on **Go**, check the **Analysis ToolPak**, and click on **OK**.

Excel 97-2003 Equivalent

To install the Analysis ToolPak in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Analysis TookPak** checkbox on the Add-Ins dialog box, and click on **OK**.

10.2 Using It To Price A Coupon Bond

Problem. Given the yield curve as published by the financial press, consider a coupon bond has a face value of $1,000, an annual coupon rate of 5.0%, makes 2 (semiannual) coupon payments per year, and 8 periods to maturity (or 4 years to maturity). What is price and yield to maturity of this coupon bond based on the Annual Percentage Rate (APR) convention? What is price and yield to maturity of this coupon bond based on the Effective Annual Rate (EAR) convention?

FIGURE 10.2 The Yield Curve – Using It To Price A Coupon Bond.

	A	B	C	D	E
1	THE YIELD CURVE	Using It To Price A Coupon Bond			
2		Maturity	Time To	Yield To	Forward
3	**Yield Curve Inputs**	Date	Maturity	Maturity	Rates
4	Today's Date	3/11/2010			
5	One Month Treasury Bill	4/15/2010	0.09	0.101%	0.101%
6	Three Month Treasury Bill	6/10/2010	0.25	0.147%	0.175%
7	Six Month Treasury Bill	9/9/2010	0.49	0.211%	0.275%
8	One Year Treasury Strip	3/10/2011	1.00	0.349%	0.485%
9	Two Year Treasury Strip	2/15/2012	1.93	0.920%	1.536%
10	Three Year Treasury Strip	2/15/2013	2.93	1.430%	2.420%
11	Four Year Treasury Strip	2/15/2014	3.93	2.000%	3.687%
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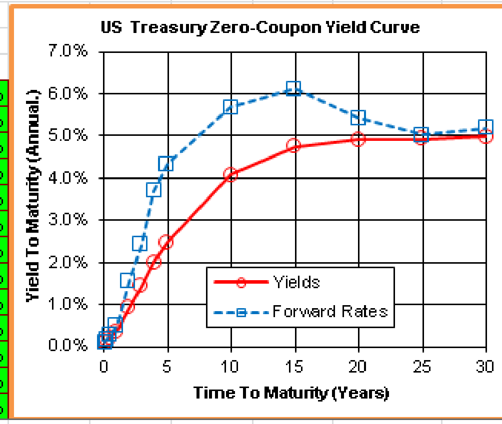
13	Ten Year Treasury Strip	2/15/2020	9.93	4.070%	5.671%
14	Fifteen Year Treasury Bond	2/15/2025	14.93	4.750%	6.113%
15	Twenty Year Treasury Bond	2/15/2030	19.93	4.920%	5.429%
16	Twenty Five Year Treasury Bond	2/15/2035	24.93	4.940%	5.020%
17	Thirty Year Treasury Bond	2/15/2040	29.93	4.980%	5.180%



	A	B	C	D	E	F	G	H	I	J
24										
25	**Bond Inputs**	Effective Annual Rate								
26	Rate Convention	(•) EAR ( ) APR	1							
27	Annual Coupon Rate	3.5%								
28	Number of Payments / Year	2								
29	Number of Periods to Maturity	8								
30	Face Value	$1,000								
31										
32	**Outputs**									
33	Coupon Payment	$18								
34										
35	**Bond Price and Yield To Maturity using a Timeline**									
36	Period	0	1	2	3	4	5	6	7	8
37	Time (Years)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
38	Cash Flows		$17.50	$17.50	$17.50	$17.50	$17.50	$17.50	$17.50	$1,017.50
39	Yield to Maturity (Annualized)		0.21%	0.35%	0.63%	0.92%	1.18%	1.43%	1.72%	2.00%
40	Discount Rate / Period		0.11%	0.17%	0.32%	0.46%	0.59%	0.71%	0.85%	1.00%
41	Present Value of Cash Flow		$17.48	$17.44	$17.33	$17.18	$17.00	$16.77	$16.49	$940.01
42	Coupon Bond Price	$1,059.71								
43	Coupon Bond Discount Rate / Period	0.97%								
44	Coupon Bond Yield to Maturity	1.95%								

(3) Coupon Rate * Face Value / (Number of Payments/Year)
Enter =B27*B30/B28

(4) Periods 1 - 7 = Coupon Payment
Enter =$B$33 and copy across

(5) Period 8 = Coupon Payment + Face Value
Enter =B33+B30

(6) Corresponding yield on the yield curve
Enter =D7 in C39, =D8 in D39, =D9 in F39, =D10 in H39, =D11 in J39
Enter =(D39+F39)/2 in E39, =(F39+H39)/2 in G39, =(H39+J39)/2 in I39

(7) If Rate Convention = EAR,
Then (1+Yield To Maturity)^(1 / (Number of Payments / Year)) - 1
Else (Yield To Maturity) / (Number of Payment / Year)
Enter =IF($C$26=1,((1+C39)^(1/$B$28))-1,C39/$B$28)
and copy across

(8) (Cash Flow) / ((1+Discount Rate / Period) ^ Period)
Enter =C38/((1+C40)^C36) and copy across

(9) Sum of all the Present Value of Cash Flows
Enter =SUM(C41:J41)

(10) RATE(Number of Periods to Maturity, Coupon Bond, -Bond Price, Par Value)
Enter =RATE(B29,B33,-B42,B30)

(11) If Rate Convention = EAR,
Then (1+Discount Rate / Period)^(Number of Payments / Year) - 1
Else (Discount Rate / Period) * (Number of Payment / Year)
Enter =IF($C$26=1,((1+B43)^(B28))-1,B43*B28)

Solution Strategy. We will use the yield curve you entered in **The Yield Curve - Obtaining It From Bond Listings**. We will calculate the bond price as the present value of the bond's cash flows, where each cash flow is discounted based on the corresponding yield on the yield curve (e.g., a cash flow in year three will be discounted based on the yield curve's yield at year three). We will use Excel's **RATE** function to determine the yield to maturity of this coupon bond.

Results. The Coupon Bond's price is $1,059.71 and its Yield To Maturity is 1.95%. Note that this yield is not the same as four year yield or any other point on the yield curve. The yield of the coupon bond is a weighted average of the yields for each of the eight periods. Since the bond's biggest cash flow is on the maturity date, the biggest weight in the weighted average is on the maturity date. Thus the coupon bond's yield is closest to the yield of the maturity date, but it is not the same.

10.3 Using It To Determine Forward Rates

Problem. Given the yield curve as published by the financial press, calculate the implied forward rates at all maturities.

Solution Strategy. We will use the yield curve that you entered in an Excel model for **The Yield Curve - Obtaining It From Bond Listings**. We will calculate the forward rates implied by the yield curve and then graph our results.

FIGURE 10.3 The Yield Curve – Using It To Determine Forward Rates.

THE YIELD CURVE — **Using It To Determine Forward Rates**

Yield Curve Inputs	Maturity Date	Time To Maturity	Yield To Maturity	Forward Rates
Today's Date	3/11/2010			
One Month Treasury Bill	4/15/2010	0.09	0.101%	0.101%
Three Month Treasury Bill	6/10/2010	0.25	0.147%	0.175%
Six Month Treasury Bill	9/9/2010	0.49	0.211%	0.275%
One Year Treasury Strip	3/10/2011	1.00	0.349%	0.485%
Two Year Treasury Strip	2/15/2012	1.93	0.920%	1.536%
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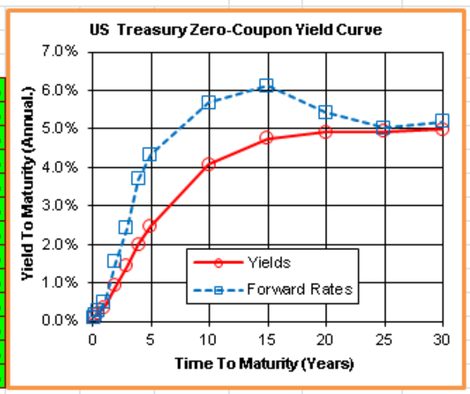
Thirty Year Treasury Bond	2/15/2040	29.93	4.980%	5.180%



(2) Forward Rate from date t to date T

$$f_{T-t} = \left((1+y_T)^T / (1+y_t)^t\right)^{1/(T-t)} - 1$$

Enter =(((1+D5)^C5)/((1+D4)^C4))^(1/(C5-C4))-1 and copy down

Notation:
t = an earlier date
T = a later date
y_t = date t yield
y_T = date T yield
$f_{t,T}$ = forward rate from date t to date T

Forward rates are an approximate forecast of future interest rates. One difficulty with taking this interpretation literally has to do with market segmentation in the demand for treasury securities. There is significantly more demand for short-term bonds than bonds of other maturities, for their use in short-term cash management. There is also extra demand by institutional bond funds for the newly-issued, longest maturity treasury bond (the so-called, "on-the-run" bond).

High demand means high prices, which means low yields. Thus, the yield curve often has lower yields at the short end and the long end due to this segmentation.

Problems

1. Given bond prices and yields as published by the financial press or other information sources, obtain the U.S. Treasury Yield Curve.

2. Given the yield curve as published by the financial press, consider a coupon bond has a face value of $2,000, an annual coupon rate of 4.2%, makes 2 (semiannual) coupon payments per year, and 8 periods to maturity (or 4 years to maturity). Determine the price and yield to maturity of this coupon bond based on the Effective Annual Rate (EAR) convention. Then use it to determine the price and yield to maturity of this coupon bond based on the Annual Percentage Rate (APR) convention.

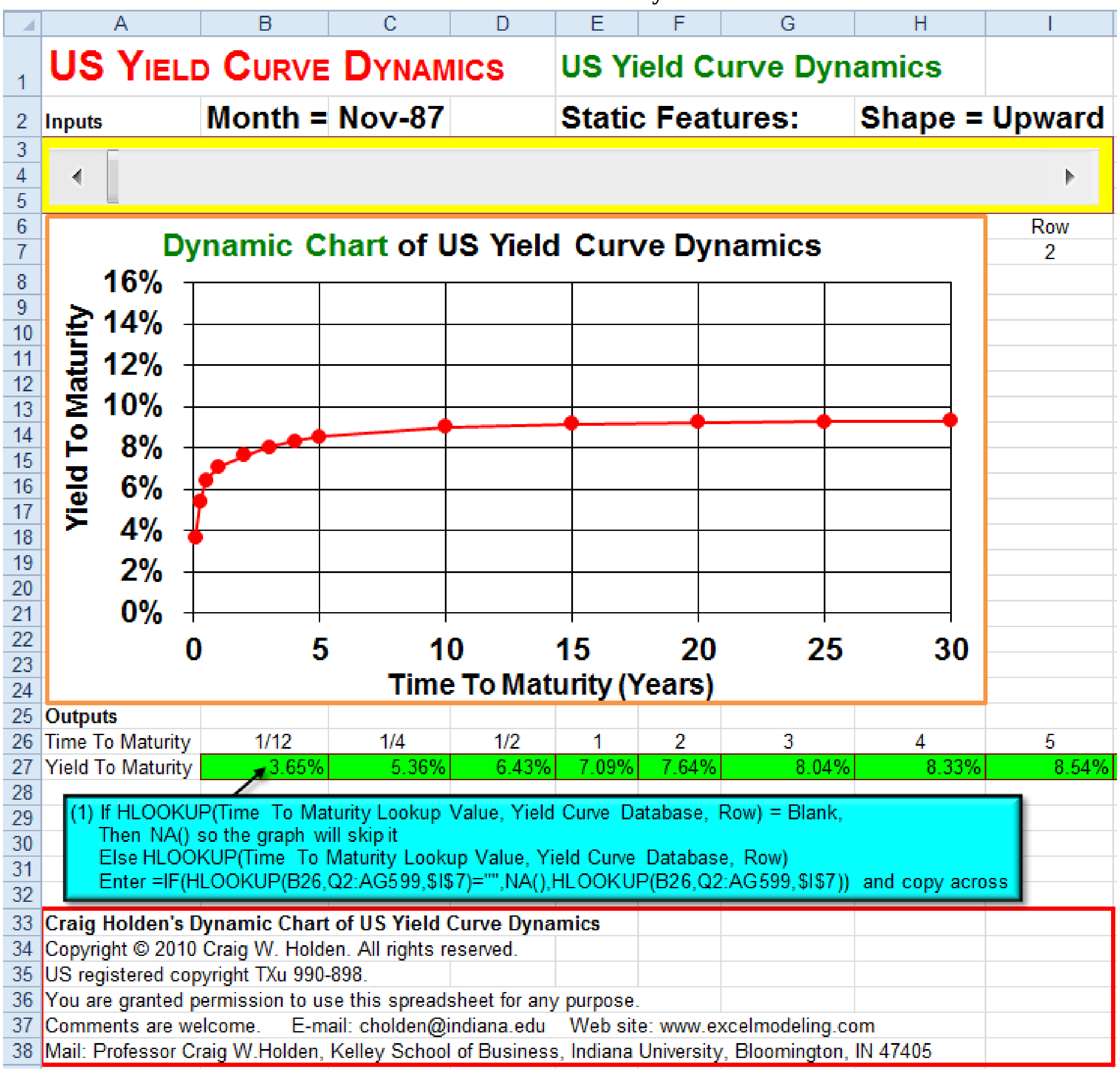
3. Given the yield curve as published by the financial press, calculate the implied forward rates at all maturities.

Chapter 11 US Yield Curve Dynamics

11.1 Dynamic Chart

How does the US yield curve change over time? What determines the volatility of changes in the yield curve? Are there differences in the volatility of short rates, medium rates, long rates, etc.? You can answer these questions and more using a *Dynamic Chart* of the yield curve, which is based on more than 37 years of monthly US zero-coupon, yield curve data. I update this Excel model each year with the latest yield curve data and make it available for free in the "Free Samples" section of www.excelmodeling.com.

FIGURE 11.1 US Yield Curve Dynamics.



The dynamic chart uses a vertical scroll bar in rows **3** to **5**. Clicking on the right arrow of the scroll bar moves the yield curve forward by one month. Clicking on the left arrow moves back by one month. Clicking right of the position bar, moves the yield curve forward by one *year*. Clicking left of the position bar moves back by one *year*. This allows you to see a dynamic "movie" or animation of the yield curve over time. Thus, you can directly observe the volatility of the yield curve and other dynamic properties. For details of what to look for, see the discussion below on "using the Excel model."

FIGURE 11.2 US Yield Curve Dynamics – Database.

	P	Q	R	S	T	U	V	W	X	Y
1					Time To Maturity	Time To Maturity	Time To Maturity	Time To Maturity	Time To Maturity	Time To Maturity
2		Title 1	Title 2	Title 3	1/12	1/4	1/2	1	2	3
3		Static Features:	Shape = Upward	11/30/87	3.65%	5.36%	6.43%	7.09%	7.64%	8.04%
4		Static Features:	Shape = Downward	11/28/80	14.83%	14.60%	14.64%	14.17%	13.22%	12.75%
5		Static Features:	Shape = Flat	01/30/70	7.73%	8.00%	8.03%	7.98%	7.95%	7.94%
6		Static Features:	Shape = Hump	12/29/78	8.82%	9.48%	9.99%	10.18%	9.76%	9.40%
7		Static Features:	Level = Low	12/31/70	4.62%	4.91%	4.95%	5.02%	5.40%	5.69%
8		Static Features:	Level = High	10/30/81	12.65%	13.13%	13.53%	13.85%	14.01%	14.06%
9		Static Features:	Curvature = Little	12/29/72	4.93%	5.24%	5.44%	5.62%	5.86%	6.01%
10		Static Features:	Curvature = Lot	09/30/82	6.67%	7.87%	9.05%	10.29%	11.16%	11.43%
11		Monthly Dynamics		01/30/70	7.73%	8.00%	8.03%	7.98%	7.95%	7.94%
12		Monthly Dynamics		02/27/70	6.23%	6.99%	6.97%	6.96%	7.02%	7.04%
13		Monthly Dynamics		03/31/70	6.33%	6.44%	6.53%	6.67%	6.85%	6.95%
14		Monthly Dynamics		04/30/70	6.48%	7.03%	7.35%	7.50%	7.60%	7.67%
15		Monthly Dynamics		05/29/70	6.22%	7.03%	7.28%	7.45%	7.58%	7.63%
16		Monthly Dynamics		06/30/70	6.14%	6.47%	6.81%	7.17%	7.43%	7.53%
17		Monthly Dynamics		07/31/70	6.32%	6.38%	6.55%	6.87%	7.19%	7.31%
18		Monthly Dynamics		08/31/70	6.22%	6.38%	6.57%	6.83%	7.07%	7.18%
19		Monthly Dynamics		09/30/70	5.32%	6.04%	6.49%	6.63%	6.64%	6.77%
20		Monthly Dynamics		10/30/70	5.23%	5.91%	6.23%	6.33%	6.50%	6.69%
21		Monthly Dynamics		11/30/70	4.86%	5.05%	5.11%	5.10%	5.29%	5.59%
22		Monthly Dynamics		12/31/70	4.62%	4.91%	4.95%	5.02%	5.40%	5.69%

The yield curve database is located in columns **Q** to **AG**. Columns **Q**, **R**, and **S** contain three sets of titles for the dataset. Columns **T**, **U**, and **V** contain yield data for bond maturities of one month, three months, and six months (1/12, 1/4, and 1/2 years, respectively). Columns **W** through **AG** contain yield data for bond maturities of 1, 2, 3, 4, 5, 7, 10, 15, 20, 25, and 30 years. Rows **2** through **9** contain examples of static features of the yield curve that can be observed from actual data in a particular month. For example, the yield curve is sometimes upward sloping (as it was in Nov 87) or downward sloping (in Nov 80) or flat (in Jan 70) or hump shaped (in Dec 78). Rows **10** through **490** contain monthly US zero-coupon, yield curve data from January 1970 through January 2010. For the period from January 1970 through December 1991, the database is based on the Bliss (1992) monthly estimates of the zero-coupon, yield curve.[7] For the period

[7] Bliss fits a parsimonious, nonlinear function that is capable of matching all of the empirically observed shapes of the zero-coupon, yield curve. For more details see Bliss, Robert, 1992, "Testing Term Structure Estimation Methods."

from January 1992 to July 2001, the yield curve is directly observed from Treasury Bills and Strips in the *Wall Street Journal*. For the period from August 2001 to January 2010, the data is from the St Louis Fed's free online economic database FRED II at research.stlouisfed.org/fred2.

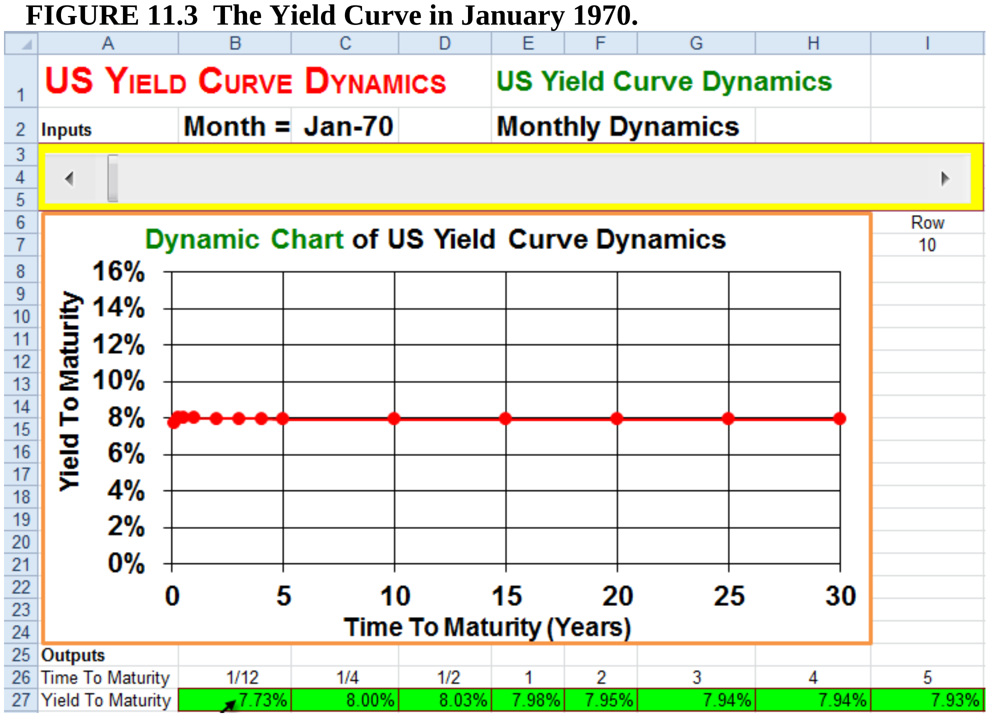
Using The US Yield Curve Dynamic Chart.

To run the Dynamic Chart, click on the right arrow of the scroll bar. The movie / animation begins with some background on the yield curve's static features. In the 40-year database we observe:

- four different **shapes**: upward-sloping, downward-sloping, flat, and hump-shaped,
- the overall **level** of the yield curve ranges from low to high, and
- the amount of **curvature** at the short end ranges from a little to a lot.

Keep clicking on the right arrow of the scroll bar and you will get to the section of the Dynamic Chart covering 40 years of the US yield curve history. This section shows the yield curve on a month by month basis. For example, the figure below shows the US yield curve in January 1970.

FIGURE 11.3 The Yield Curve in January 1970.



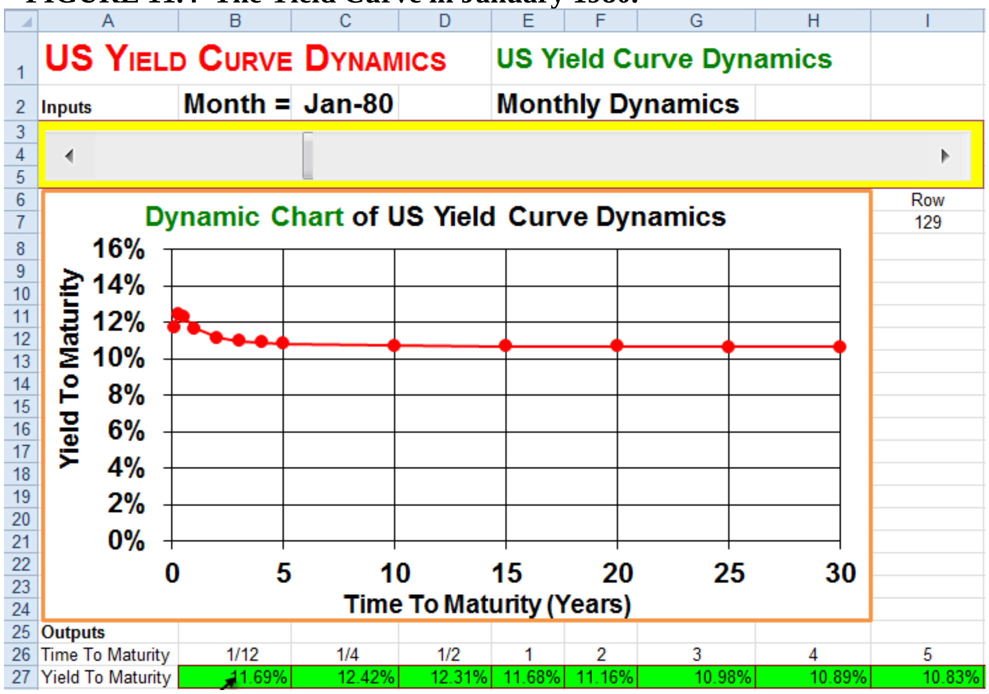
Keep clicking on the right arrow and you will see the yield curve move around over time. By observing this movie / animation, you should be able to recognize the following key **dynamic** properties of the yield curve:

- short rates (the 0 to 5 year piece of the yield curve) are more volatile than long rates (the 15 to 30 year piece),
- the overall volatility of the yield curve is higher when the level is higher (especially in the early 80's), and

- sometimes there are sharp reactions to government intervention.

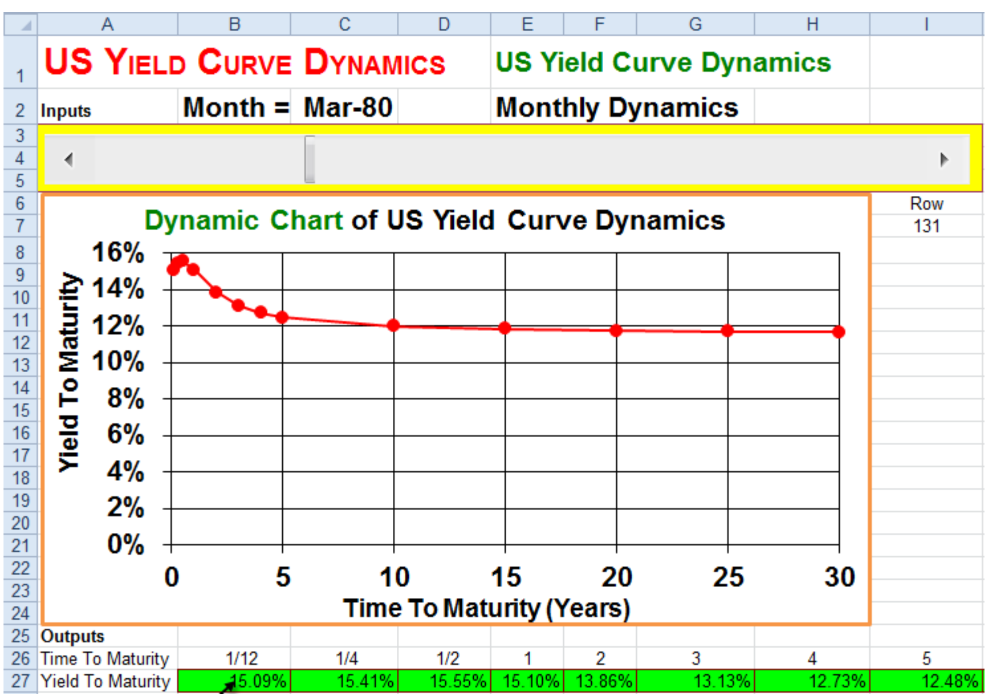
As an example of the latter, consider what happened in 1980. The figure below shows the yield curve in January 1980.

FIGURE 11.4 The Yield Curve in January 1980.



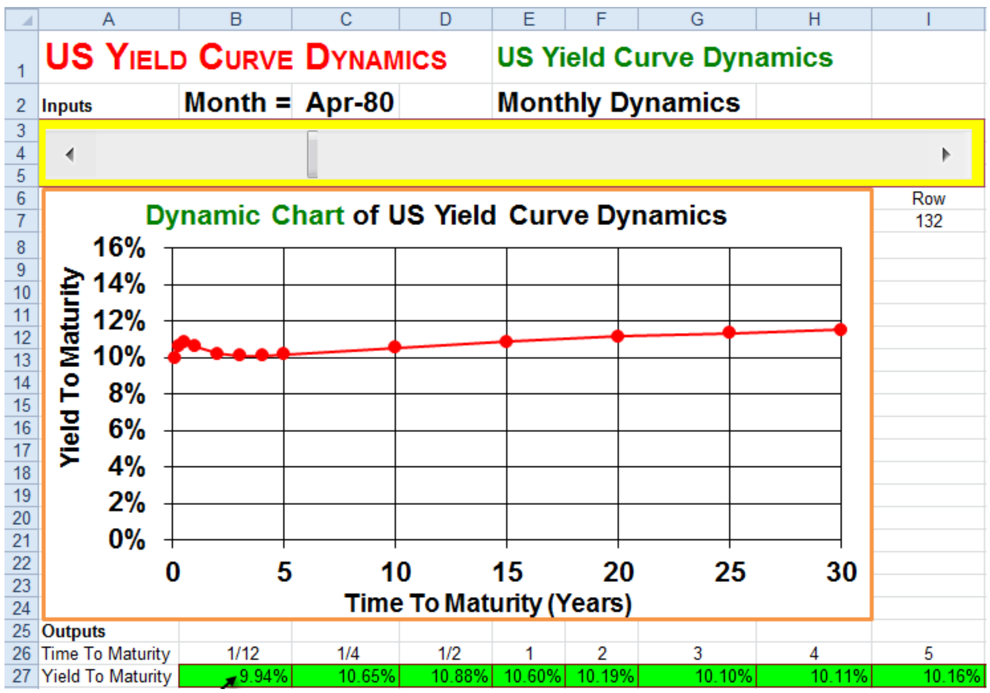
Short rates were around 12% and long rates were at 10.7%. President Jimmy Carter was running for re-election. He wished to manipulate the election year economy to make it better for his re-election bid. His strategy for doing this was to impose credit controls on the banking system. Click on the right arrow to see what the reaction of the financial market was.

FIGURE 11.5 The Yield Curve in March 1980.



In two months, the short rate went up to 15.5%, an increase of 3.5%! What a disaster! This was the opposite of the reaction that Carter had intended. Notice that long rates went up to 11.7%, an increase of only 1%. Apparently, the market expected that this intervention would only be a short-lived phenomenon. Carter quickly realized what a big political mistake he had made and announced that the credit controls were being dropped. Click on the right arrow to see what the reaction of the financial market was.

FIGURE 11.6 The Yield Curve in April 1980.



Short rates dropped to 10.9%! A drop of 4.6% in one month! The high interest rates went away, but the political damage was done. This is the single biggest one month change in the yield curve in 40 years.

Problems

1. How volatile are short rates versus medium rates versus long rates?

   (a.) Get a visual sense of the answer to this question by clicking on the right arrow of the scroll bar to run through all of the years of US Yield Curve history in the database.

   (b.) Calculate the variance of the time series of: (i) one-month yields, (ii) five-year yields, (iii) fifteen-year yields, and (iv) thirty-year yields. Use

Excel's VAR function to calculate the variance of the yields in columns **T**, **AA**, **AD**, and **AG**.

2. Determine the relationship between the volatility of the yield curve and the level of the yield curve. Specifically, for each five year time period (70-74, 75-79, 80-84, etc.) calculate the variance and the average level of the time series of: (i) one-month yields, (ii) five-year yields, (iii) fifteen-year yields, and (iv) thirty-year yields. Use Excel's VAR and AVERAGE functions to calculate the variance and the average of five-year ranges of the yields in columns **T**, **AA**, **AD**, and **AG**. For example:
   - The 70-74 time series of one-month yields is in the range **T11-T69**.
   - The 75-79 time series of one-month yields is in the range **T70-T129**.
   - The 80-84 time series of one-month yields is in the range **T130-T189**.
   - And so on.

Summarize what you have learned from this analysis.

PART 3 CAPITAL STRUCTURE

Chapter 12 Capital Structure

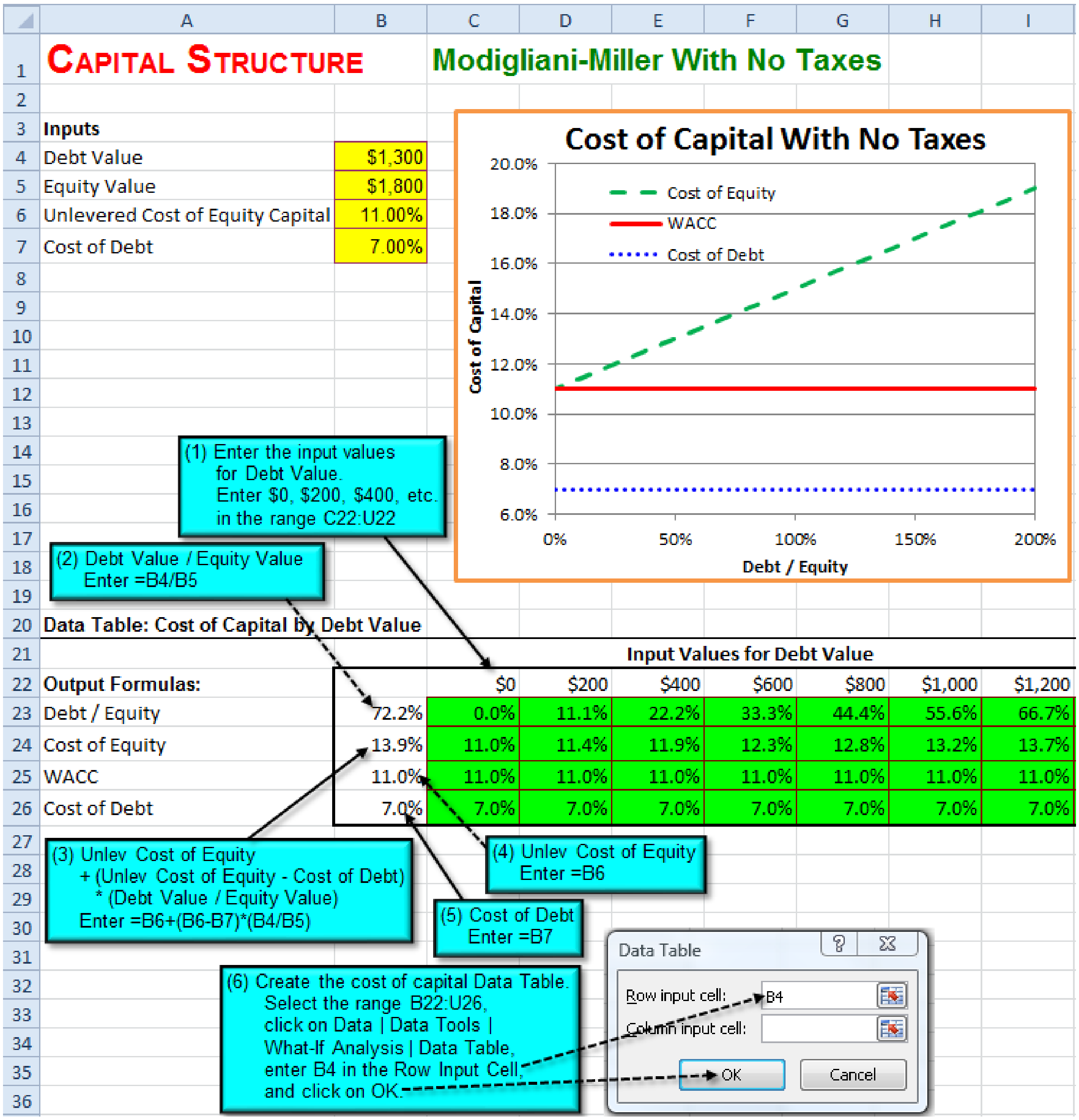
12.1 Modigliani-Miller With No Taxes

Problem. For a particular firm, the value of their debt is $1,300 and the value of their equity is $1,800. For a firm with their risk, the unlevered cost of equity capital is 11.00%. The cost of debt is 7.00%. Plot the cost of equity, the weighted average cost of capital (WACC), and the cost of debt against the debt / equity ratio.

Solution Strategy. Create a data table with various input values for debt and compute the variables to be plotted.

Results. As the Debt/Equity ratio increases, the Cost of Equity rises, but equity is a smaller fraction of all capital. The net effect is that the weighted average cost of capital (WACC) stays constant. WACC is independent of the Debt/Equity ratio and so is the value of the firm. Thus, in a world without taxes or other frictions, capital structure is irrelevant.

FIGURE 12.1 Capital Structure – Modigliani-Miller With No Taxes.



		Input Values for Debt Value						
Output Formulas:		$0	$200	$400	$600	$800	$1,000	$1,200
Debt / Equity	72.2%	0.0%	11.1%	22.2%	33.3%	44.4%	55.6%	66.7%
Cost of Equity	13.9%	11.0%	11.4%	11.9%	12.3%	12.8%	13.2%	13.7%
WACC	11.0%	11.0%	11.0%	11.0%	11.0%	11.0%	11.0%	11.0%
Cost of Debt	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%

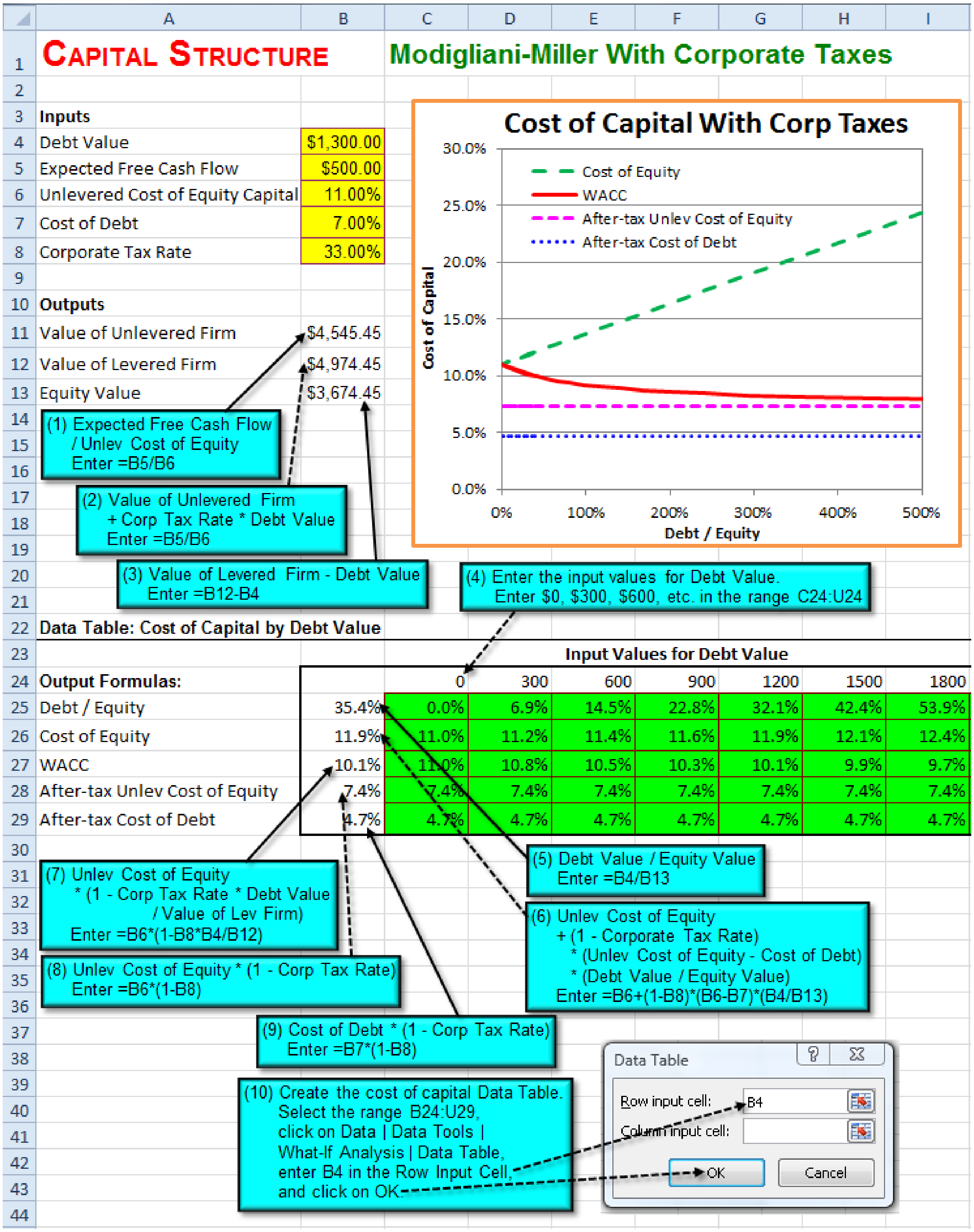
12.2 Modigliani-Miller With Corporate Taxes

Problem. For a particular firm, the value of their debt is $1,300 and the expected free cash flow on all future dates forever is $500. For a firm with their risk, the unlevered cost of equity capital is 11.00%. The cost of debt is 7.00%. The corporate tax rate is 33.00%. Plot the cost of equity, the weighted average cost of capital (WACC), the after-tax unlevered cost of equity, and the after-tax cost of debt against the debt / equity ratio.

Solution Strategy. Create a data table with various input values for debt and compute the variables to be plotted.

Results. As the Debt/Equity ratio increases, the weighted average cost of capital (WACC) decrease due to the debt tax shield. WACC continues to decline as debt increases and so it is optimal to have as much debt as possible. Thus, in a world with corporate taxes, capital structure matters.

FIGURE 12.2 Capital Structure – Modigliani-Miller With Corporate Taxes.



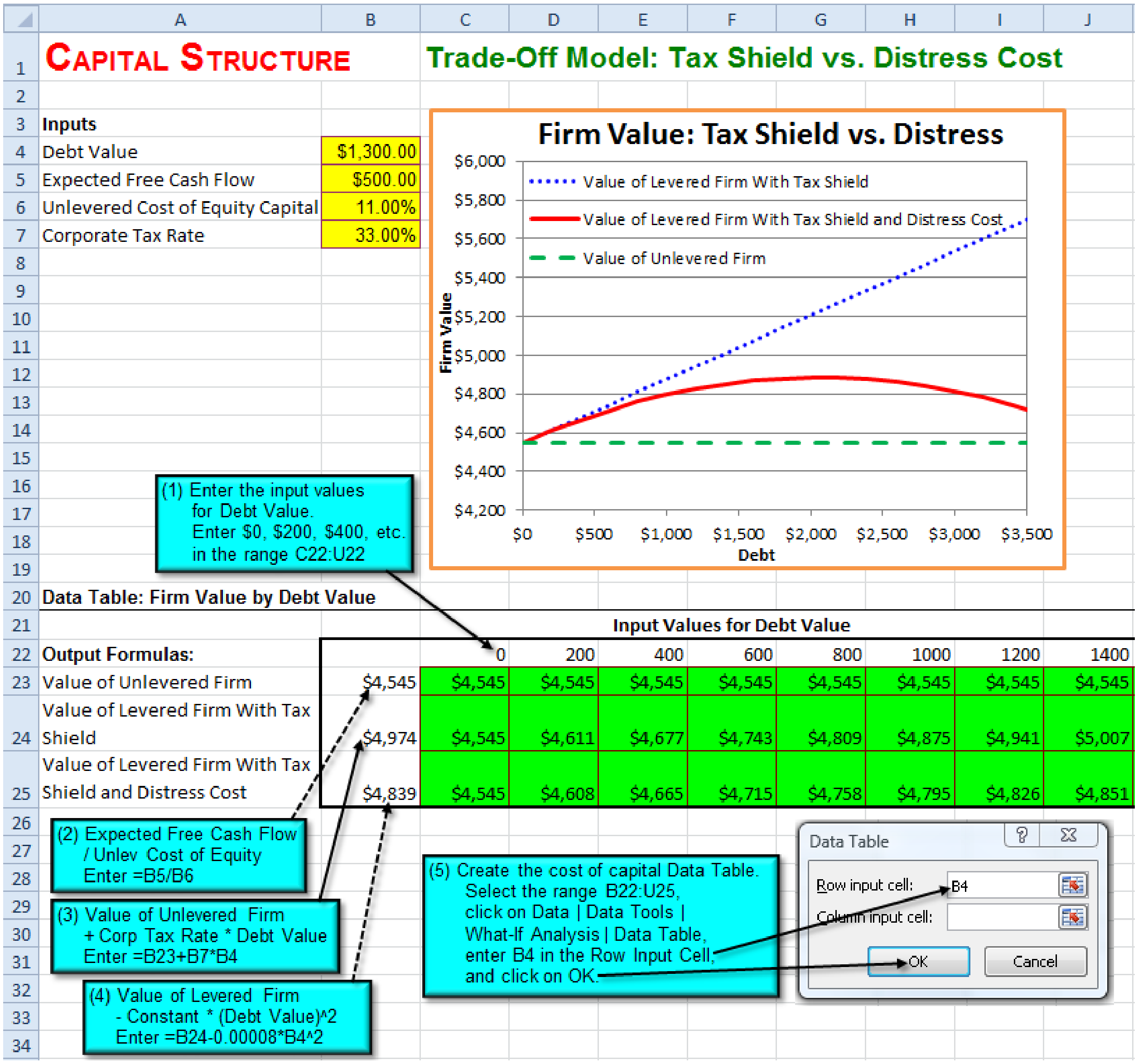
12.3 Trade-off Model: Tax Shield vs. Distress Cost

Problem. For a particular firm, the value of their debt is $1,300 and the expected free cash flow on all future dates forever is $500. For a firm with their risk, the unlevered cost of equity capital is 11.00%. The corporate tax rate is 33.00%. Distress cost is modeled as a quadratic function – specifically, as 0.00008 times debt squared. Plot the value of an unlevered firm, the value of a levered firm with a tax shield, and the value of a levered firm with a tax shield and distress cost against the amount of debt.

Solution Strategy. Create a data table with various input values for debt and compute the variables to be plotted.

Results. As the amount of debt increases, the value of a levered firm with a tax shield increases as a linear function of debt. As the amount of debt increases, the value of a levered firm with a tax shield and distress cost is a quadratic function that increases for a while, reaches a peak, and then decreases. Thus, in a world with corporate taxes and distress cost, there is an optimal amount of debt that maximizes firm value.

FIGURE 12.3 Capital Structure – Trade-Off Model: Tax Shield vs. Distress Cost.



Problems

1. For a particular firm, the value of their debt is $2,900 and the value of their equity is $3,400. For a firm with their risk, the unlevered cost of equity capital is 14.50%. The cost of debt is 8.30%. Plot the cost of equity, the weighted average cost of capital (WACC), and the cost of debt against the debt / equity ratio.

2. For a particular firm, the value of their debt is $2,900 and the expected free cash flow on all future dates forever is $1,100. For a firm with their risk, the unlevered cost of equity capital is 12.80%. The cost of debt is 7.50%. The corporate tax rate is 33.00%. Plot the cost of equity, the weighted average cost of capital (WACC), the after-tax unlevered cost of equity, and the after-tax cost of debt against the debt / equity ratio.

3. For a particular firm, the value of their debt is $2,900 and the expected free cash flow on all future dates forever is $1,100. For a firm with their risk, the unlevered cost of equity capital is 13.90%. The corporate tax rate is 33.00%. Distress cost is modeled as a quadratic function – specifically, as 0.00009 times debt squared. Plot the value of an unlevered firm, the value of a levered firm with a tax shield, and the value of a levered firm with a tax shield and distress cost against the amount of debt.

PART 4 CAPITAL BUDGETING

Chapter 13 Project NPV

13.1 Basics

Problem. Suppose a firm is considering the following project, where all of the dollar figures are in thousands of dollars. In year 0, the project requires an \$11,350 investment in plant and equipment, is depreciated using the straight-line method over seven years, and has a salvage value of \$1,400 in year 7. The project is forecast to generate sales of 2,000 units in year 1, rising to 7,400 units in year 5, declining to 1,800 units in year 7, and dropping to zero in year 8. The inflation rate is forecast to be 2.0% in year 1, rising to 4.0% in year 5, and then leveling off. The real cost of capital is forecast to be 11.0% in year 1, rising to 12.2% in year 7. The tax rate is forecast to be a constant 35.0%. Sales revenue per unit is forecast to be \$9.70 in year 1 and then grow with inflation. Variable cost per unit is forecast to be \$7.40 in year 1 and then grow with inflation. Cash fixed costs are forecast to be \$5,280 in year 1 and then grow with inflation. What is the project NPV?

Solution Strategy. Forecast key assumptions, discounting, sales revenue per unit, variable costs per unit, and fixed costs over the seven year horizon. Then, forecast the project income and expense items. Calculate the net cash flows. Discount each cash flow back to the present and sum to get the NPV.

Modeling Issue. The inflation rate is forecast separately and explicitly enters into the calculation of: (1) the discount rate (= cost of capital) and (2) price or cost / unit items. This guarantees that we are *consistent* in the way we are treating the inflation component of cash flows in the numerator of the NPV calculation and the inflation component of the discount rate in the denominator of the NPV calculation. This avoids a common error in practice that people often treat the cash flows and discount rates *as if* they were unrelated to each other and thus they are *inconsistent* in the way that they implicitly treat the inflation component of each.

FIGURE 13.1 Excel Model for Project NPV - Basics.

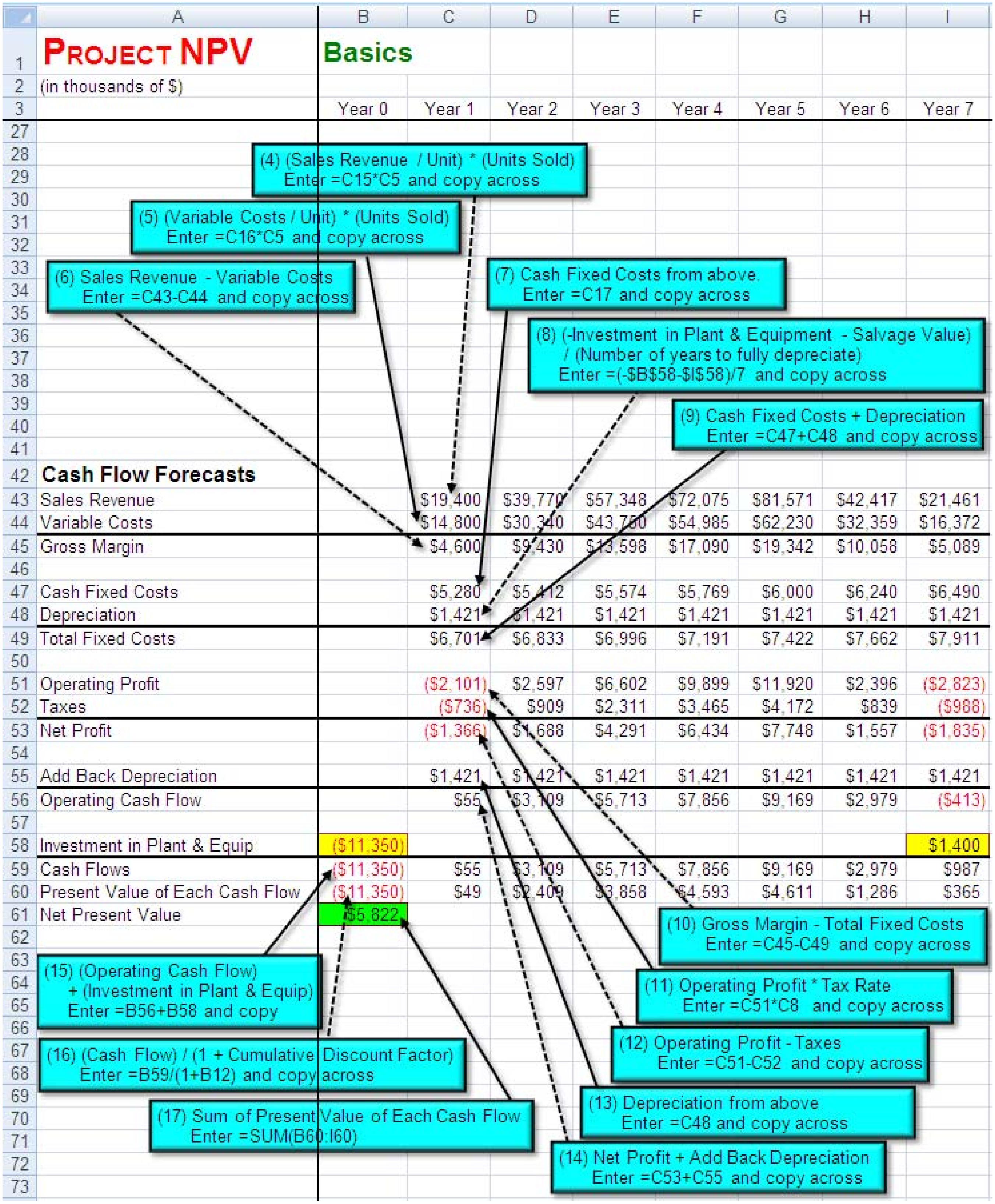
	A	B	C	D	E	F	G	H	I
1	**PROJECT NPV**	**Basics**							
2	(in thousands of $)								
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
4	**Key Assumptions**								
5	Unit Sales		2000	4000	5600	6800	7400	3700	1800
6	Inflation Rate		2.0%	2.5%	3.0%	3.5%	4.0%	4.0%	4.0%
7	Real Cost of Capital		11.0%	11.2%	11.4%	11.6%	11.8%	12.0%	12.2%
8	Tax Rate		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
9									
10	**Discounting**								
11	Discount Rate = Cost of Capital		13.2%	14.0%	14.7%	15.5%	16.3%	16.5%	16.7%
12	Cumulative Discount Factor	0.0%	13.2%	29.0%	48.1%	71.0%	98.9%	131.6%	170.3%
13									
14	**Price or Cost / Unit**								
15	Sales Revenue / Unit		$9.70	$9.94	$10.24	$10.60	$11.02	$11.46	$11.92
16	Variable Cost / Unit		$7.40	$7.59	$7.81	$8.09	$8.41	$8.75	$9.10
17	Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490

(1) (1 + Inflation Rate) * (1 + Real Discount Rate) - 1
Enter =(1+C6)*(1+C7)-1 and copy across

(2) (1 + Last Year's Cumulative Discount Factor)
* (1 + This Year's Discount Rate) - 1
Enter =(1+B12)*(1+C11)-1 and copy across

(3) (Last Year's Price/Cost) * (1 + This Year's Inflation Rate)
Enter =C15*(1+D$6) and copy to the range D15:I17

FIGURE 13.2 Excel Model for Project NPV – Basics (Continued).



	A	B	C	D	E	F	G	H	I
1	**PROJECT NPV**	**Basics**							
2	(in thousands of $)								
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
42	**Cash Flow Forecasts**								
43	Sales Revenue		$19,400	$39,770	$57,348	$72,075	$81,571	$42,417	$21,461
44	Variable Costs		$14,800	$30,340	$43,750	$54,985	$62,230	$32,359	$16,372
45	Gross Margin		$4,600	$9,430	$13,598	$17,090	$19,342	$10,058	$5,089
46									
47	Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490
48	Depreciation		$1,421	$1,421	$1,421	$1,421	$1,421	$1,421	$1,421
49	Total Fixed Costs		$6,701	$6,833	$6,996	$7,191	$7,422	$7,662	$7,911
50									
51	Operating Profit		($2,101)	$2,597	$6,602	$9,899	$11,920	$2,396	($2,823)
52	Taxes		($736)	$909	$2,311	$3,465	$4,172	$839	($988)
53	Net Profit		($1,366)	$1,688	$4,291	$6,434	$7,748	$1,557	($1,835)
54									
55	Add Back Depreciation		$1,421	$1,421	$1,421	$1,421	$1,421	$1,421	$1,421
56	Operating Cash Flow		$55	$3,109	$5,713	$7,856	$9,169	$2,979	($413)
57									
58	Investment in Plant & Equip	($11,350)							$1,400
59	Cash Flows	($11,350)	$55	$3,109	$5,713	$7,856	$9,169	$2,979	$987
60	Present Value of Each Cash Flow	($11,350)	$49	$2,409	$3,858	$4,593	$4,611	$1,286	$365
61	Net Present Value	$5,822							

The Net Present Value of the project is $5,822. The project should be accepted.

13.2 Forecasting Cash Flows

Problem. Consider the same project as Project NPV - Basics. Let's examine the details of how you forecast the project cash flows. Suppose that Direct Labor, Materials, Selling Expenses, and Other Variable Costs are forecast to be $3.50, $2.00, $1.20, and $0.70, respectively, in year 1 and then grow with inflation. Lease Payment, Property Taxes, Administration, Advertising, and Other cash fixed costs are forecast to be $2,800, $580, $450, $930, and $520, respectively, in year 1 and then grow with inflation. What is the Total Variable Cost / Unit and the Total Cash Fixed Costs?

Solution Strategy. Forecast the variable cost / unit and cash fixed costs in more detail. Then sum up all of the items in each category to get the total.

FIGURE 13.3 Excel Model for Project NPV – Forecasting Cash Flows.

	A	B	C	D	E	F	G	H	I	J
1	**PROJECT NPV**	**Forecasting Cash Flows**								
2	(in thousands of $)									
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
4	**Key Assumptions**									
5	Base Case Unit Sales		2000	4000	5600	6800	7400	3700	1800	
6	Unit Sales Scale Factor		100.0%							
7	Unit Sales		2000	4000	5600	6800	7400	3700	1800	
8	Inflation Rate		2.0%	2.5%	3.0%	3.5%	4.0%	4.0%	4.0%	
9	Real Cost of Capital Increment			0.2%	0.4%	0.6%	0.8%	1.0%	1.2%	
10	Real Cost of Capital		11.0%	11.2%	11.4%	11.6%	11.8%	12.0%	12.2%	
11	Tax Rate		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	
12										
13	**Discounting**									
14	Discount Rate = Cost of Capital		13.2%	14.0%	14.7%	15.5%	16.3%	16.5%	16.7%	
15	Cumulative Discount Factor	0.0%	13.2%	29.0%	48.1%	71.0%	98.9%	131.6%	170.3%	
16										
17	**Price or Cost / Unit**									
18	Sales Revenue / Unit		$9.70	$9.94	$10.24	$10.60	$11.02	$11.46	$11.92	
19										
20	Variable Costs / Unit:									
21	Direct Labor		$3.50	$3.59	$3.70	$3.82	$3.98	$4.14	$4.30	
22	Materials		$2.00	$2.05	$2.11	$2.19	$2.27	$2.36	$2.46	
23	Selling Expenses		$1.20	$1.23	$1.27	$1.31	$1.36	$1.42	$1.47	
24	Other		$0.70	$0.72	$0.74	$0.76	$0.80	$0.83	$0.86	
25	Total Variable Cost / Unit		$7.40	$7.59	$7.81	$8.09	$8.41	$8.75	$9.10	
26										
27	Cash Fixed Costs:									
28	Lease Payment		$2,800	$2,870	$2,956	$3,060	$3,182	$3,309	$3,442	
29	Property Taxes		$580	$595	$612	$634	$659	$685	$713	
30	Administration		$450	$461	$475	$492	$511	$532	$553	
31	Advertising		$930	$953	$982	$1,016	$1,057	$1,099	$1,143	
32	Other		$520	$533	$549	$568	$591	$615	$639	
33	Total Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490	

(3) (Last Year's Cost / Unit) * (1 + This Year's Inflation Rate)
Enter =C21*(1+D$8) and copy to the ranges D21:I24 and D28:I32

(4) Sum the components of Variable Cost / Unit
Enter =SUM(C21:C24) and copy across

(5) Sum the components of Cash Fixed Costs
Enter =SUM(C28:C32) and copy across

13.3 Working Capital

Problem. Consider the same project as above. Suppose we add that the project will require working capital in the amount of $0.87 in year 0 for every unit of next year's forecasted sales and this amount will grow with inflation going forward. What is the project NPV?

FIGURE 13.4 Excel Model for Project NPV – Working Capital.

	A	B	C	D	E	F	G	H	I
1	PROJECT NPV	Working Capital							
2	(in thousands of $)								
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
47	**Working Capital**								
48	Work Cap / Next Yr Unit Sales	$0.87	$0.89	$0.91	$0.94	$0.97	$1.01	$1.05	$1.09
49	Working Capital	$1,740	$3,550	$5,094	$6,371	$7,176	$3,731	$1,888	$0
51	**Cash Flow Forecasts**								
52	Sales Revenue		$19,400	$39,770	$57,348	$72,075	$81,571	$42,417	$21,461
53	Variable Costs		$14,800	$30,340	$43,750	$54,985	$62,230	$32,359	$16,372
54	Gross Margin		$4,600	$9,430	$13,598	$17,090	$19,342	$10,058	$5,089
56	Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490
57	Depreciation		$1,421	$1,421	$1,421	$1,421	$1,421	$1,421	$1,421
58	Total Fixed Costs		$6,701	$6,833	$6,996	$7,191	$7,422	$7,662	$7,911
60	Operating Profit		($2,101)	$2,597	$6,602	$9,899	$11,920	$2,396	($2,823)
61	Taxes		($736)	$909	$2,311	$3,465	$4,172	$839	($988)
62	Net Profit		($1,366)	$1,688	$4,291	$6,434	$7,748	$1,557	($1,835)
64	Add Back Depreciation		$1,421	$1,421	$1,421	$1,421	$1,421	$1,421	$1,421
65	Operating Cash Flow		$55	$3,109	$5,713	$7,856	$9,169	$2,979	($413)
67	Investment in Working Capital	($1,740)	($1,810)	($1,544)	($1,277)	($805)	$3,444	$1,843	$1,888
68	Investment in Plant & Equip	($11,350)							$1,400
69	Investment Cash Flow	($13,090)	($1,810)	($1,544)	($1,277)	($805)	$3,444	$1,843	$3,288
71	Cash Flows	($13,090)	($1,754)	$1,565	$4,436	$7,051	$12,614	$4,822	$2,875
72	Present Value of Each Cash Flow	($13,090)	($1,549)	$1,213	$2,996	$4,123	$6,343	$2,082	$1,063
73	Net Present Value	$3,180							

(6) (Last Year's Work Cap / Next Yr Unit Sales)
* (1 + This Year's Inflation Rate)
Enter =B48*(1+C$8) and copy across

(7) (This Year's Work Cap / Next Yr Unit Sales)
* (Next Yr Unit Sales)
Enter =B48*C7 and copy across

(8) (Last Year's Working Capital) - (This Year's Working Capital)
Enter =-B49 in cell B67 and
enter =B49-C49 in cell C67 and copy across

(9) (Investment in Working Capital) + (Investment in Plant & Equipment)
Enter =SUM(B67:B68) and copy across

(10) (Operating Cash Flow) + (Investment Cash Flow)
Enter =B65+B69 and copy across

Solution Strategy. Forecast the working capital amount per next year's unit sales. Then multiply by the forecasted unit sales to determine the required working capital each year. Include the investment in working capital to the total investment cash flows and calculate the project NPV.

The Net Present Value of the project drops to $3,180, because of the additional investment in working capital.

13.4 Sensitivity Analysis

Problem. Consider the same project as above. Assume that the product life-cycle of seven years is viewed as a safe bet, but that the scale of demand for the product is highly uncertain. Analyze the sensitivity of the project NPV to the unit sales scale factor and to the cost of capital.

Solution Strategy. Copy the pattern of unit sales in the base case to a new location and multiply this pattern by a scale factor to get the new unit sales scenario. Assume that the real cost of capital is constant. Thus, forecast the future cost of capital by taking the year 1 cost of capital and adding the change in the inflation rate. Create a two-way data table using a range of input values for unit sales scale factor and a range of input values for the year 1 cost of capital. Using the data table results, create a 3-D surface chart.

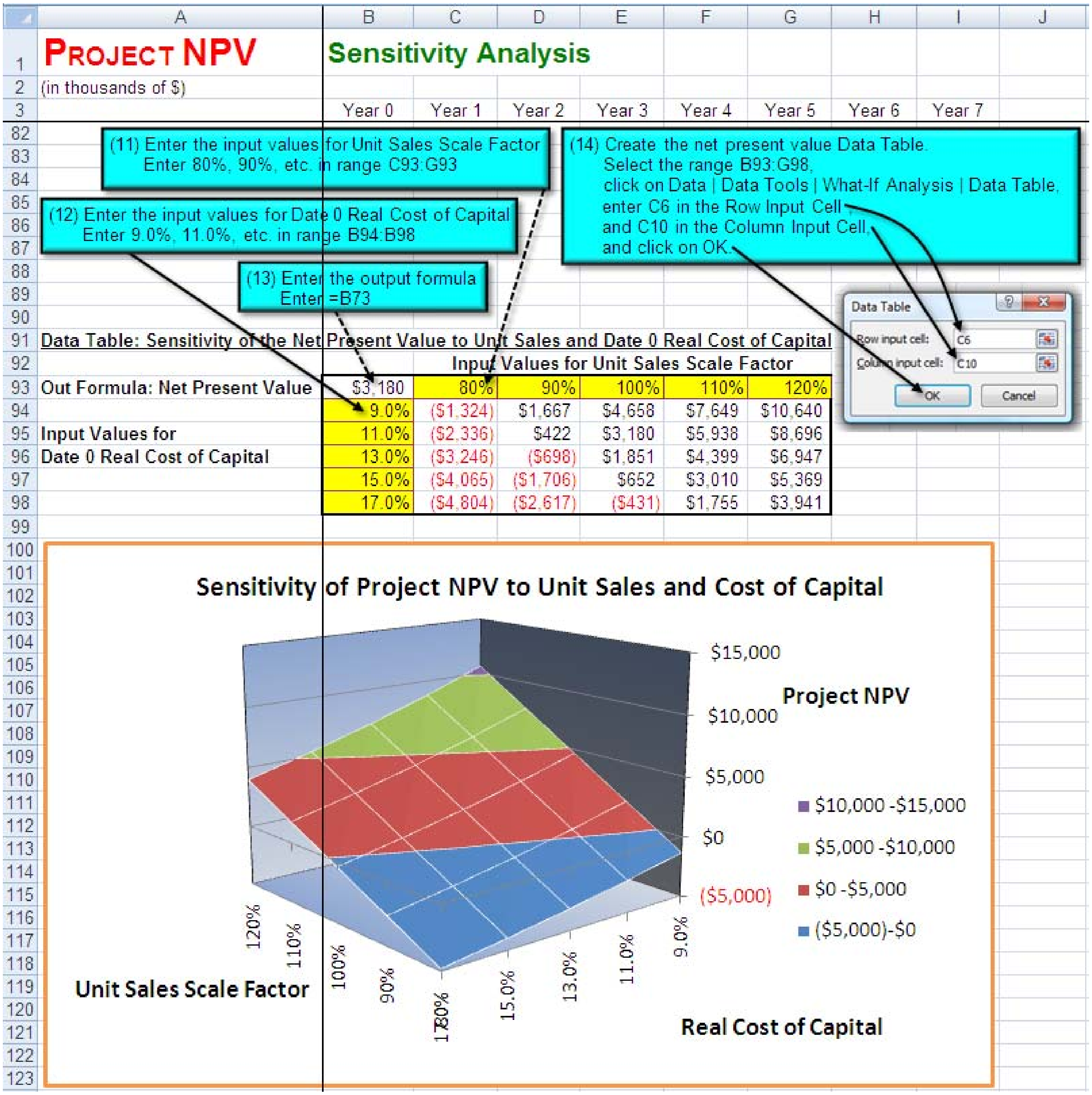
FIGURE 13.5 Excel Model for Sensitivity Analysis.

	A	B	C	D	E	F	G	H	I
1	**PROJECT NPV**	**Sensitivity Analysis**							
2	(in thousands of $)								
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
4	**Key Assumptions**								
5	Base Case Unit Sales		2000	4000	5600	6800	7400	3700	1800
6	Unit Sales Scale Factor		100.0%						
7	Unit Sales		2000	4000	5600	6800	7400	3700	1800
8	Inflation Rate		2.0%	2.5%	3.0%	3.5%	4.0%	4.0%	4.0%
9	Real Cost of Capital Increment			0.2%	0.4%	0.6%	0.8%	1.0%	1.2%
10	Real Cost of Capital		11.0%	11.2%	11.4%	11.6%	11.8%	12.0%	12.2%
11	Tax Rate		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
12									
13	**Discounting**								
14	Discount Rate = Cost of Capital		13.2%	14.0%	14.7%	15.5%	16.3%	16.5%	16.7%
15	Cumulative Discount Factor	0.0%	13.2%	29.0%	48.1%	71.0%	98.9%	131.6%	170.3%
16									
17	**Price or Cost / Unit**								
18	Sales Revenue / Unit		$9.70	$9.94	$10.24	$10.60	$11.02	$11.46	$11.92
19									
20	Variable Costs / Unit:								
21	Direct Labor		$3.50	$3.59	$3.70	$3.82	$3.98	$4.14	$4.30
22	Materials		$2.00	$2.05	$2.11	$2.19	$2.27	$2.36	$2.46
23	Selling Expenses		$1.20	$1.23	$1.27	$1.31	$1.36	$1.42	$1.47
24	Other		$0.70	$0.72	$0.74	$0.76	$0.80	$0.83	$0.86
25	Total Variable Cost / Unit		$7.40	$7.59	$7.81	$8.09	$8.41	$8.75	$9.10
26									
27	Cash Fixed Costs:								
28	Lease Payment		$2,800	$2,870	$2,956	$3,060	$3,182	$3,309	$3,442
29	Property Taxes		$580	$595	$612	$634	$659	$685	$713
30	Administration		$450	$461	$475	$492	$511	$532	$553
31	Advertising		$930	$953	$982	$1,016	$1,057	$1,099	$1,143
32	Other		$520	$533	$549	$568	$591	$615	$639
33	Total Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490

(1) (Base Case Unit Sales)
* (Unit Sales Scale Factor)
Enter =C5*$C$6 and copy across

(2) (Date 0 Real Cost of Capital) + (Increment on date t)
Enter =$C$10+D9 and copy across

FIGURE 13.6 Excel Model for Two-Way Data Table and 3-D Surface Chart.



Out Formula: Net Present Value	$3,180	80%	90%	100%	110%	120%
	9.0%	($1,324)	$1,667	$4,658	$7,649	$10,640
Input Values for	11.0%	($2,336)	$422	$3,180	$5,938	$8,696
Date 0 Real Cost of Capital	13.0%	($3,246)	($698)	$1,851	$4,399	$6,947
	15.0%	($4,065)	($1,706)	$652	$3,010	$5,369
	17.0%	($4,804)	($2,617)	($431)	$1,755	$3,941

Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

The sensitivity analysis shows that the Project NPV is highly sensitive to the Unit Sales Scale Factor and the Cost of Capital. If the sales forecast is overly optimistic and/or cost of capital estimate is too low, then the project might actually have a negative NPV. Hence, it is worth spending extra resources to verify the accuracy of the sales forecast and the cost of capital estimate.

Problems

1. Suppose a firm is considering the following project, where all of the dollar figures are in thousands of dollars. In year 0, the project requires $37,500 investment in plant and equipment, is depreciated using the straight-line method over seven years, and there is a salvage value of $5,600 in year 7. The project is forecast to generate sales of 5,700 units in year 1, rising to 24,100 units in year 5, declining to 8,200 units in year 7, and dropping to zero in year 8. The inflation rate is forecast to be 1.5% in year 1, rising to 2.8% in year 5, and then leveling off. The real cost of capital is forecast to be 9.3% in year 1, rising to 10.6% in year 7. The tax rate is forecast to be a constant 42.0%. Sales revenue per unit is forecast to be $15.30 in year 1 and then grow with inflation. Variable cost per unit is forecast to be $9.20 in year 1 and then grow with inflation. Cash fixed costs are forecast to be $7,940 in year 1 and then grow with inflation. What is the project NPV?

2. Consider the same project as problem 1, but modify it as follows. Suppose that Direct Labor, Materials, Selling Expenses, and Other Variable Costs are forecast to be $5.20, $3.70, $2.30, and $0.80, respectively, in year 1 and then grow with inflation. Lease Payment, Property Taxes, Administration, Advertising, and Other cash fixed costs are forecast to be $4,100, $730, $680, $1,120, and $730, respectively, in year 1 and then grow with inflation. What are the Total Variable Cost / Unit and the Total Cash Fixed Costs?

3. Consider the same project as problem 2, but modify it as follows. Suppose we add that the project will require working capital in the amount of $1.23 in year 0 for every unit of next year's forecasted sales and this amount will grow with inflation going forward. What is the project NPV?

4. Consider the same project as problem 3. Assume that the product life-cycle of seven years is viewed as a safe bet, but that the scale of demand for the product is highly uncertain. Analyze the sensitivity of the project NPV to the unit sales scale factor and to the cost of capital.

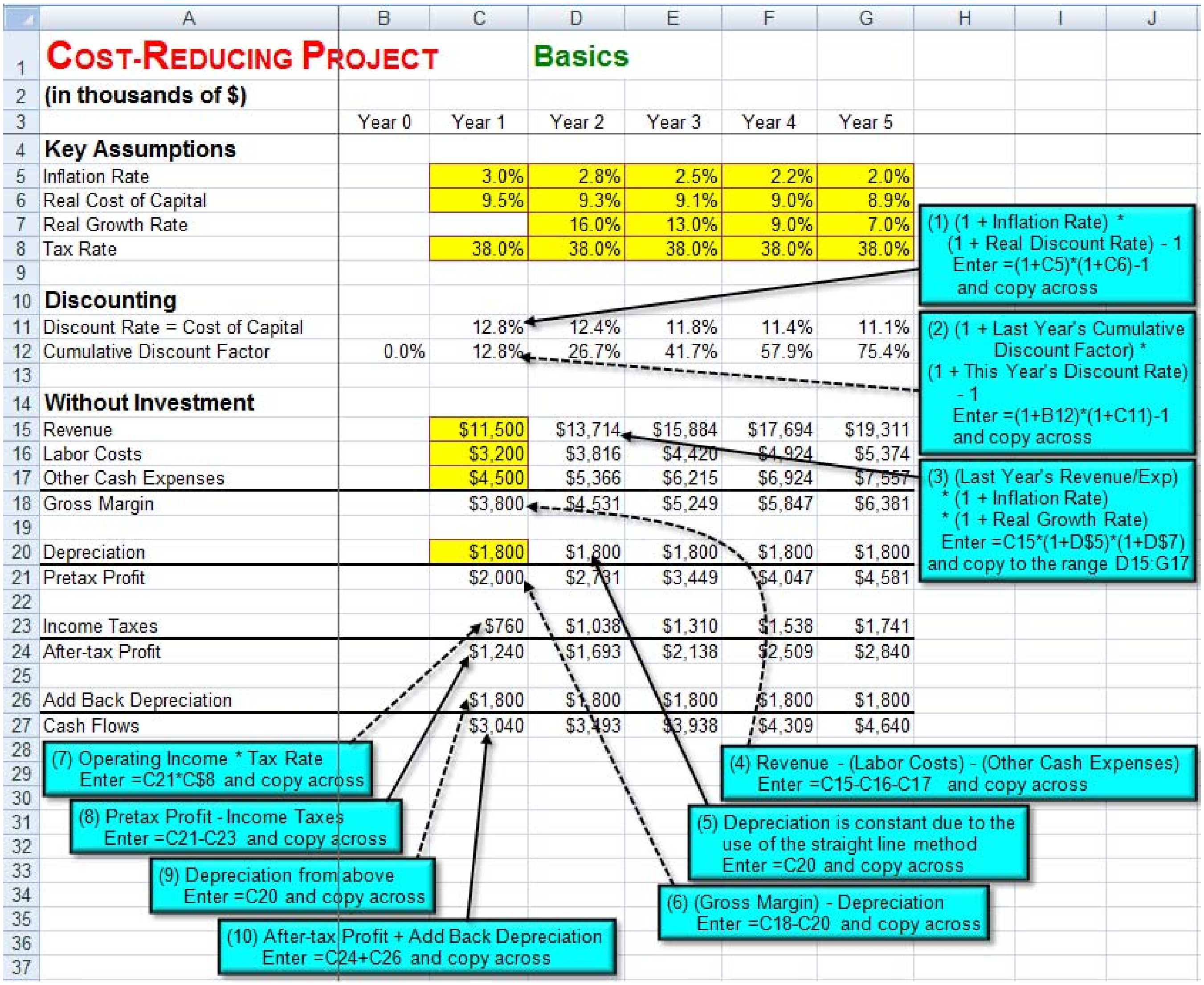
Chapter 14 Cost-Reducing Project

14.1 Basics

Problem. Suppose a firm is considering a labor-saving investment. In year 0, the project requires a \$6,300 investment in equipment (all figures are in thousands of dollars). This investment is depreciated using the straight-line method over five years and has a salvage value in year 5 of \$1,200. With or without the cost-reducing investment, all cash flows start in year 1 and end in year 5. The inflation rate is 3.0% in year 2 and declines to 2.0% in year 5. The real growth rate is 16.0% in year 2 and declines to 7.0% in year 5. The tax rate is 38.0% in all years. The real cost of capital is 9.5% in year 1 and declines to 8.9% in year 5. Without the cost-reducing investment, the firm's existing investments will generate year 1 revenue, labor costs, other cash expenses, and depreciation of \$11,500, \$3,200, \$4,500, and \$1,800, respectively. With the cost-reducing investment, the firm's year 1 labor costs will be \$1,300 and revenues and other cash expenses will remain the same. What is the cost-reducing project's NPV?

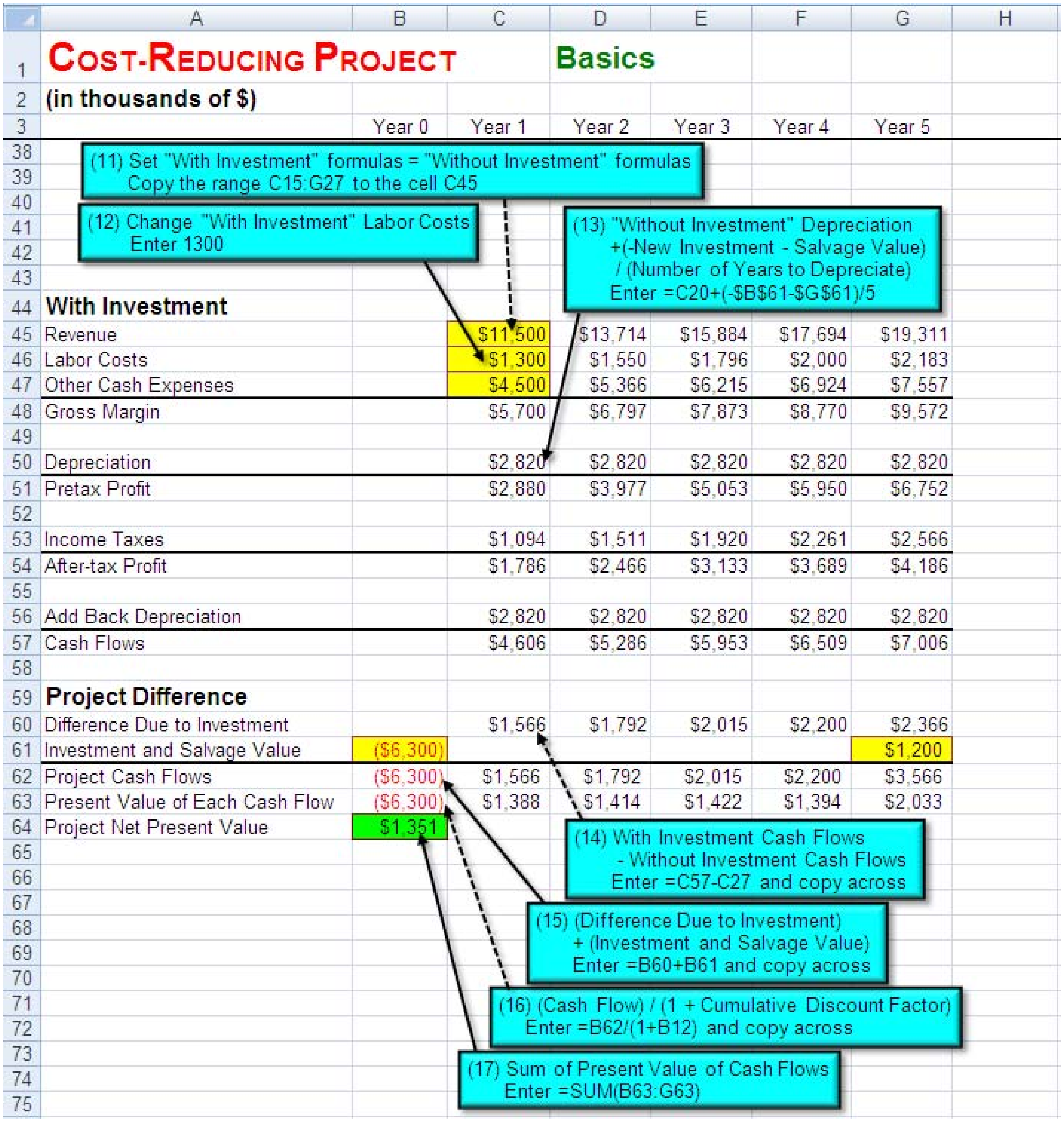
Solution Strategy. Forecast revenues and expenses both without the cost-reducing investment and with it. Calculate the Net Cash Flow both without and with the cost-reducing investment. Subtract one from the other to obtain the incremental Difference Due to Investment. Discount the project net cash flows back to the present and determine the NPV.

FIGURE 14.1 Excel Model for Cost-Reducing Project - Basics.



	A	B	C	D	E	F	G
1	**COST-REDUCING PROJECT**			**Basics**			
2	**(in thousands of $)**						
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
4	**Key Assumptions**						
5	Inflation Rate		3.0%	2.8%	2.5%	2.2%	2.0%
6	Real Cost of Capital		9.5%	9.3%	9.1%	9.0%	8.9%
7	Real Growth Rate			16.0%	13.0%	9.0%	7.0%
8	Tax Rate		38.0%	38.0%	38.0%	38.0%	38.0%
9							
10	**Discounting**						
11	Discount Rate = Cost of Capital		12.8%	12.4%	11.8%	11.4%	11.1%
12	Cumulative Discount Factor	0.0%	12.8%	26.7%	41.7%	57.9%	75.4%
13							
14	**Without Investment**						
15	Revenue		$11,500	$13,714	$15,884	$17,694	$19,311
16	Labor Costs		$3,200	$3,816	$4,420	$4,924	$5,374
17	Other Cash Expenses		$4,500	$5,366	$6,215	$6,924	$7,557
18	Gross Margin		$3,800	$4,531	$5,249	$5,847	$6,381
19							
20	Depreciation		$1,800	$1,800	$1,800	$1,800	$1,800
21	Pretax Profit		$2,000	$2,731	$3,449	$4,047	$4,581
22							
23	Income Taxes		$760	$1,038	$1,310	$1,538	$1,741
24	After-tax Profit		$1,240	$1,693	$2,138	$2,509	$2,840
25							
26	Add Back Depreciation		$1,800	$1,800	$1,800	$1,800	$1,800
27	Cash Flows		$3,040	$3,493	$3,938	$4,309	$4,640

FIGURE 14.2 Excel Model for Cost-Reducing Project – Basics (Continued).



	A	B	C	D	E	F	G
1	COST-REDUCING PROJECT			Basics			
2	(in thousands of $)						
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
44	With Investment						
45	Revenue		$11,500	$13,714	$15,884	$17,694	$19,311
46	Labor Costs		$1,300	$1,550	$1,796	$2,000	$2,183
47	Other Cash Expenses		$4,500	$5,366	$6,215	$6,924	$7,557
48	Gross Margin		$5,700	$6,797	$7,873	$8,770	$9,572
49							
50	Depreciation		$2,820	$2,820	$2,820	$2,820	$2,820
51	Pretax Profit		$2,880	$3,977	$5,053	$5,950	$6,752
52							
53	Income Taxes		$1,094	$1,511	$1,920	$2,261	$2,566
54	After-tax Profit		$1,786	$2,466	$3,133	$3,689	$4,186
55							
56	Add Back Depreciation		$2,820	$2,820	$2,820	$2,820	$2,820
57	Cash Flows		$4,606	$5,286	$5,953	$6,509	$7,006
58							
59	Project Difference						
60	Difference Due to Investment		$1,566	$1,792	$2,015	$2,200	$2,366
61	Investment and Salvage Value	($6,300)					$1,200
62	Project Cash Flows	($6,300)	$1,566	$1,792	$2,015	$2,200	$3,566
63	Present Value of Each Cash Flow	($6,300)	$1,388	$1,414	$1,422	$1,394	$2,033
64	Project Net Present Value	$1,351					

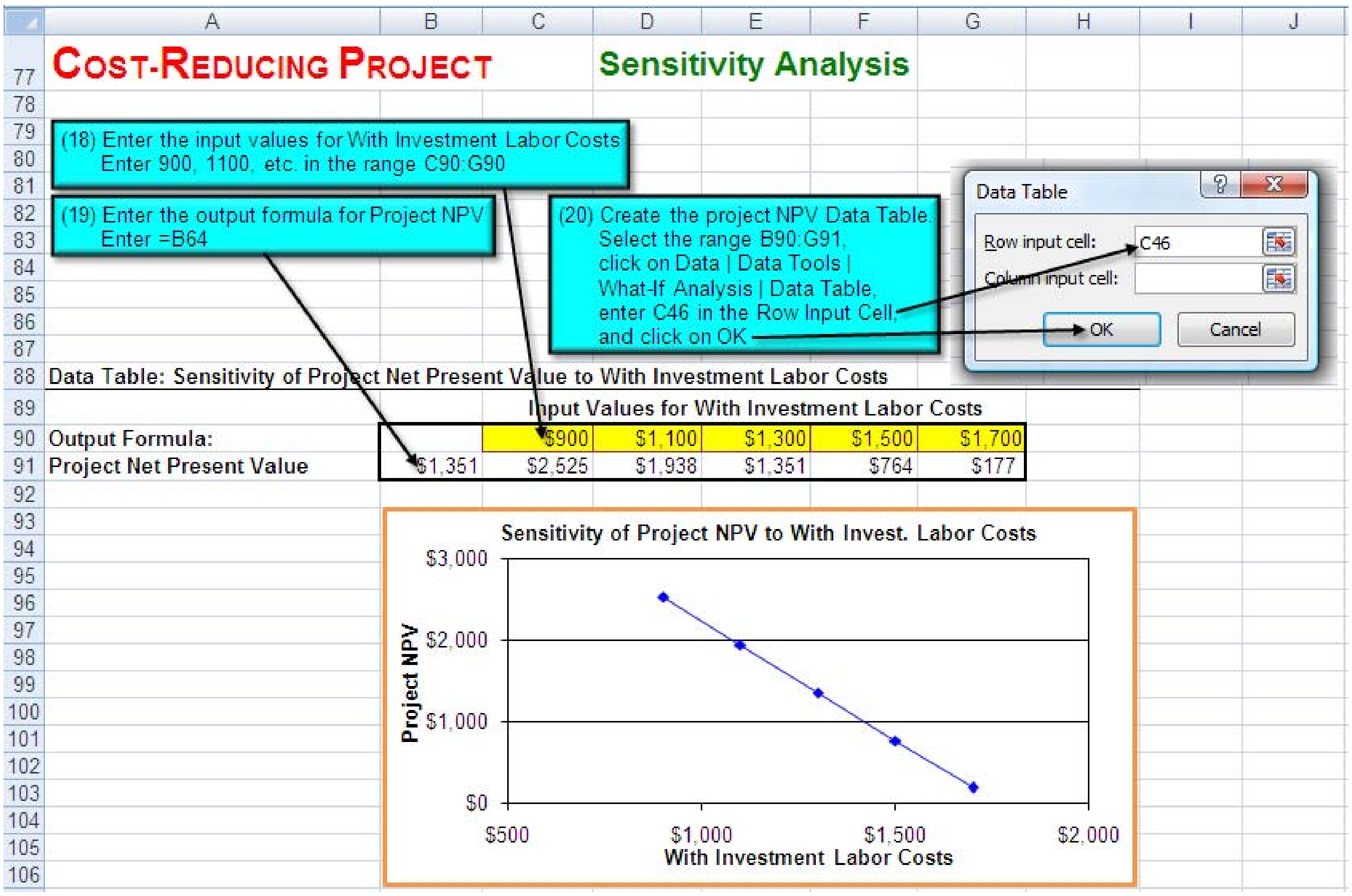
The Net Present Value of this Cost-reducing Project is $1,351. The project should be accepted.

14.2 Sensitivity Analysis

Problem. For the same cost-reducing project as the previous section, analyze the sensitivity of the Project NPV to the assumed With Investment Labor Costs.

Solution Strategy. Create a Data Table using With Investment Labor Costs as the input variable and Project NPV as the output variable. Then graph the relationship.

FIGURE 14.3 Excel Model for Cost-Reducing Project - Sensitivity Analysis.



Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

The sensitivity analysis indicates that the Project NPV is not very sensitive to a wide range of values of With Investment Labor Costs. In all cases the project has a positive NPV. This provides confidence that the project's positive NPV is robust to any reasonable error in estimating the labor cost savings.

Problems

1. Suppose a firm is considering a labor-saving investment. In year 0, the project requires a $11,700 investment in equipment (all figures are in thousands of dollars). This investment is depreciated using the straight-line

method over five years and there is salvage value in year 5 of $4,500. With or without the cost-reducing investment, all cash flows start in year 1 and end in year 5. The inflation rate is 2.6% in year 2 and declines to 1.4% in year 5. The real growth rate is 21.3% in year 2 and declines to 9.5% in year 5. The tax rate is 41.0% in all years. The real cost of capital is 8.7% in year 1 and declines to 7.5% in year 5. Without the cost-reducing investment, the firm's existing investments will generate year 1 revenue, labor costs, other cash expenses, and depreciation of $15,200, $4,100, $5,300, and $3,300, respectively. With the cost-reducing investment, the firm's year 1 labor costs will be $1,600 and revenues and other cash expenses will remain the same. What is the cost-reducing project's NPV?

2. For the same cost-reducing project as problem 1, analyze the sensitivity of the Project NPV to the assumed With Investment Labor Costs.

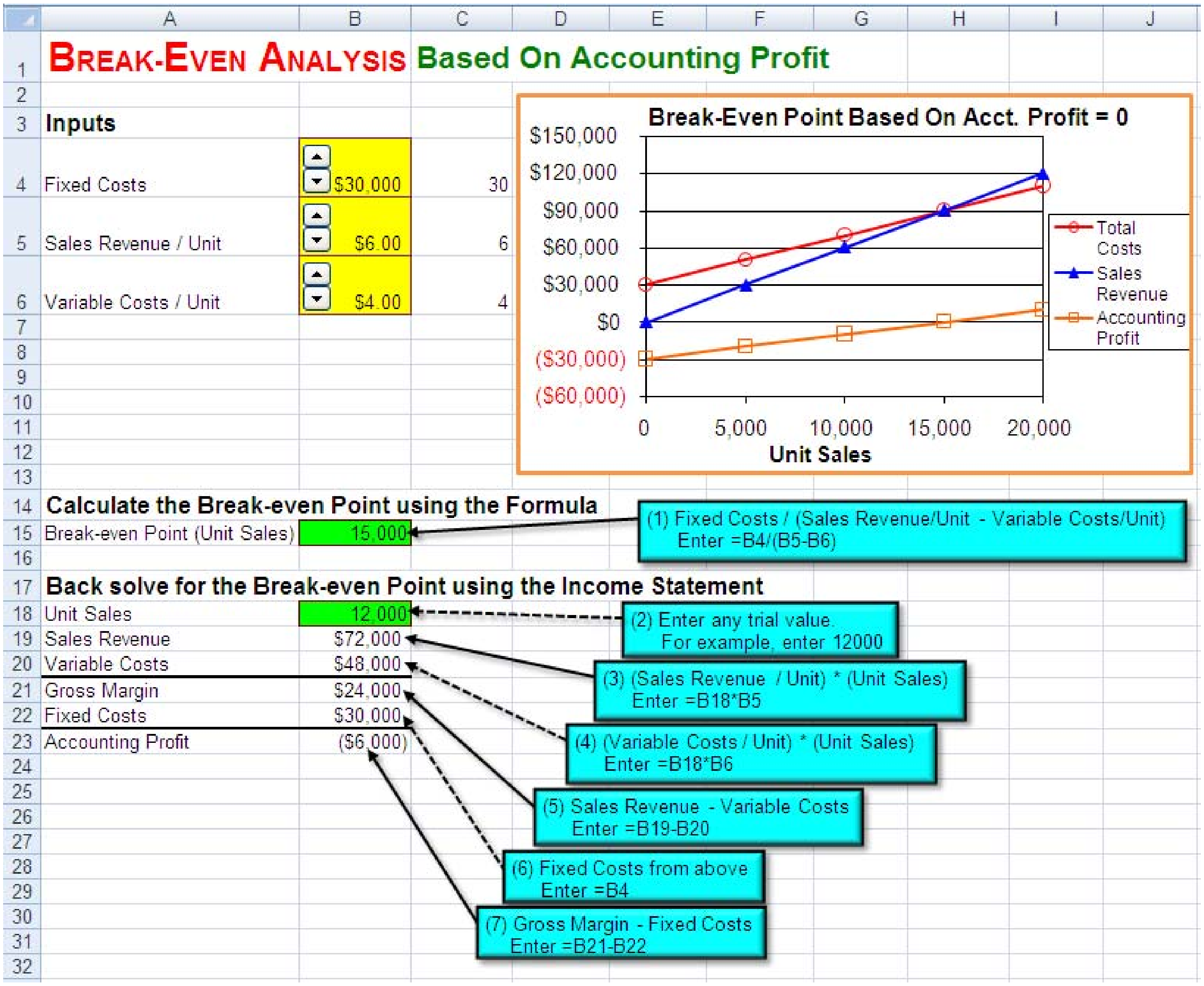
Chapter 15 Break-Even Analysis

15.1 Based On Accounting Profit

Problem. A project has a fixed cost of $30,000, variable costs of $4.00 per unit, and generates sales revenue of $6.00 per unit. What is the break-even point in unit sales, where accounting profit exactly equals zero, and what is the intuition for it?

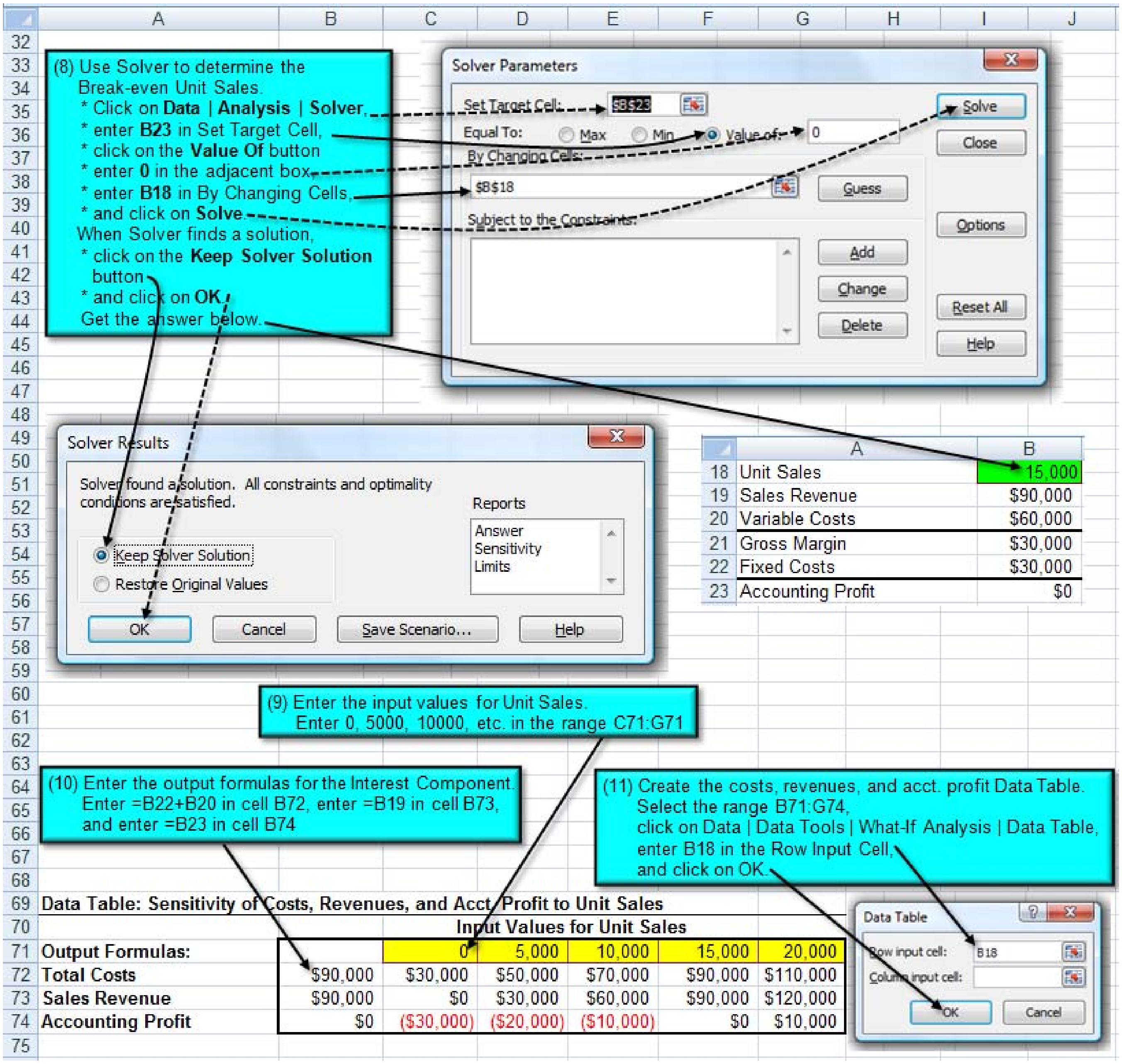
Solution Strategy. First, we solve for the break-even point in unit sales using the formula. Second, we use Excel's Solver to back solve for the break-even point using the income statement. Lastly, we will determine the sensitivity of costs, revenues, and accounting profits to unit sales. This will allow us to graphically illustrate the intuition of the break-even point.

FIGURE 15.1 Excel Model for Break-Even Analysis - Based On Acct Profit.



The formula and the graph show that the Break-Even Point is 15,000 units. The graph illustrates two equivalent intuitions for this result. First, the Break-Even Point is where the Sales Revenue line (in blue) crosses Total Costs line (in red). Second, the Break-Even Point is where **Accounting Profit (in orange)** hits zero and thus decisively switches from negative to positive.

FIGURE 15.2 Excel Model for Break-Even Analysis - Based On Acct Profit.



Excel 97-2003 Equivalent

To install Solver in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Solver** checkbox on the Add-Ins dialog box, and click on **OK**.

Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

If you don't see **Solver** on the **Data** Tab in the **Analysis** Group, then you need to install the Solver. To install the Solver, click on the **Office** button, click on the **Excel Options** button at the bottom of the drop-down window, click on **Add-Ins**, highlight **Solver** in the list of Inactive Applications, click on **Go**, check **Solver**, and click on **OK**.

By trial and error, the Solver adjusts the value of Unit Sales in cell **B18** until the Accounting Profit in cell **B23** equals zero (within a very small error tolerance). This results in a Break-even Point of 15,000, where Accounting Profit equals zero. Your results may differ by a slight amount depending on the level of precision specified for Solver's error tolerance.

15.2 Based On NPV

Problem. Suppose a firm is considering the following project, where all of the dollar figures are in thousands of dollars. In year 0, the project requires $11,350 investment in plant and equipment, is depreciated using the straight-line method over seven years, and has a salvage value of $1,400 in year 7. The project is forecast to generate sales of 2,100 units in year 1 and grow at a sales growth rate of 55.0% in year 2. The sales growth rate is forecast to decline by 15.0% in years 3 and 4, to decline by 20.0% in year 5, to decline by 25.0% in year 6, and to decline by 30.0% in year 7. Unit sales will drop to zero in year 8. The inflation rate is forecast to be 2.0% in year 1, rising to 4.0% in year 5, and then leveling off. The real cost of capital is forecast to be 11.0% in year 1, rising to 12.2% in year 5, and then leveling off. The tax rate is forecast to be a constant 35.0%. Sales revenue per unit is forecast to be $9.70 in year 1 and then to grow with inflation. Variable cost per unit is forecast to be $7.40 in year 1 and then to grow with inflation. Cash fixed costs are forecast to be $5,280 in year 1 and then to grow with inflation. What is the project NPV? What is the NPV Break-Even Point in Year 1 Unit Sales, where NPV equals zero? What is the NPV Break-Even Point in the Year 2 Sales Growth Rate, where NPV equals zero? What is the NPV Break-Even Contour in the two-dimensional space of Year 1 Unit Sales and Year 2 Sales Growth Rate?

Solution Strategy. Start with the Project NPV - Basics Excel model. Move the Unit Sales line out of the Key Assumptions area, since that is what we are going to solve for. Restructure the Unit Sales forecast to depend on the Sales Growth Rate, which will be a key variable. Structure the Sales Growth Rate forecast over the entire period to depend on how fast the growth rate is initially. This will make it easy to use Solver and to create a Data Table later on. Project the cash flows of the project and calculate the NPV. Use Solver to determine the amount of year 1 unit sales that will cause the NPV to equal zero when the sales growth rate is at the base case level of 5% per year. Use Solver to determine the sales growth rate that will cause the NPV to equal zero when the year 1 unit sales is at the base case level of 39,000. Create a two-variable data table using two input variables (year 1 unit sales and sales growth rate) and the output variable: NPV. Use the data table to create a three-dimensional graph showing the NPV Break-Even Contour.

FIGURE 15.3 Excel Model for Break-Even Analysis Based On NPV.

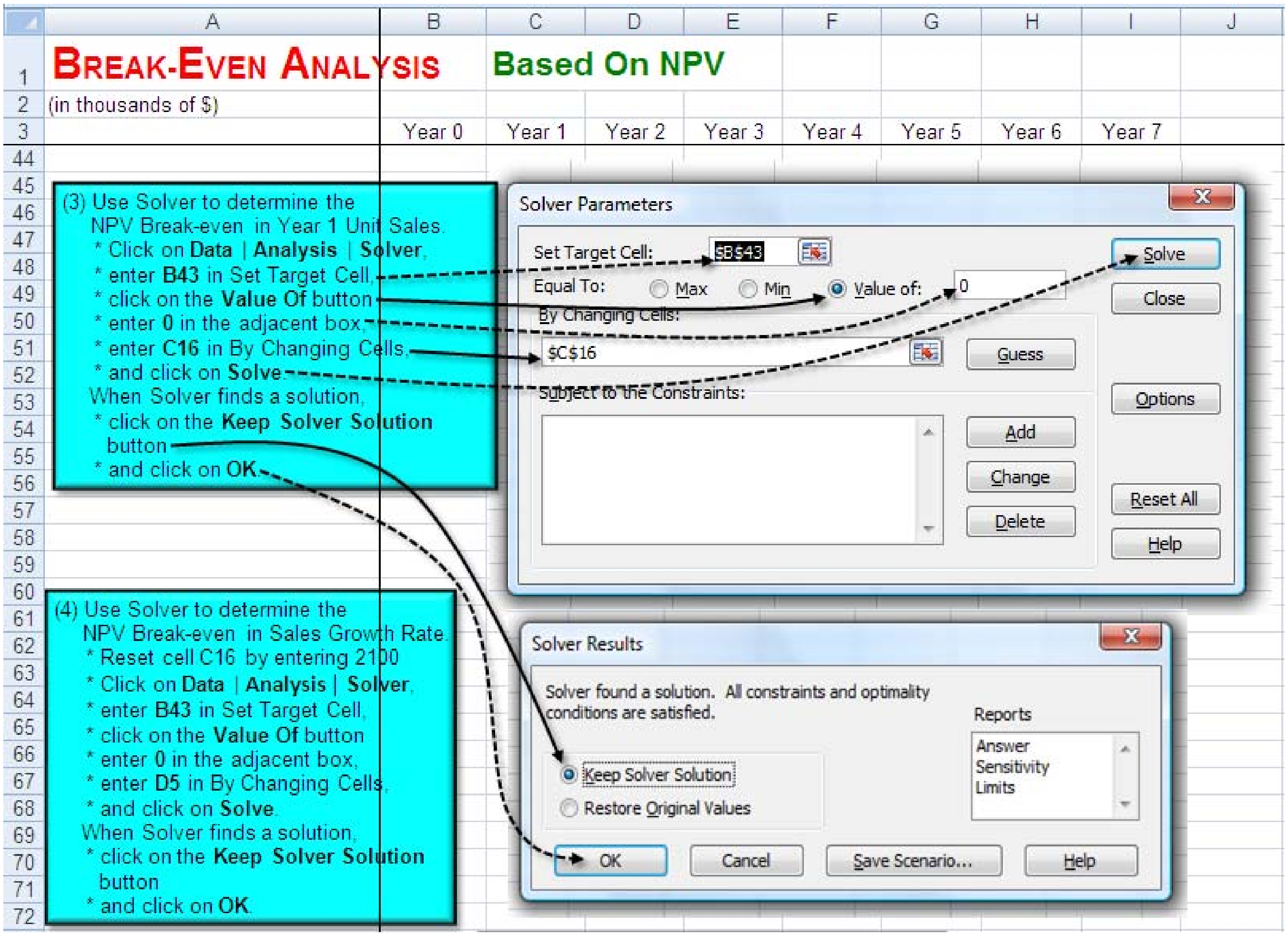
	A	B	C	D	E	F	G	H	I
1	**BREAK-EVEN ANALYSIS**		**Based On NPV**						
2	(in thousands of $)								
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
4	**Key Assumptions**								
5	Sales Growth Rate			55.0%	40.0%	25.0%	5.0%	-20.0%	-50.0%
6	Change in Sales Growth Rate				-15.0%	-15.0%	-20.0%	-25.0%	-30.0%
7	Inflation Rate		2.0%	2.5%	3.0%	3.5%	4.0%	4.0%	4.0%
8	Real Cost of Capital		11.0%	11.2%	11.4%	11.6%	11.8%	12.0%	12.2%
9	Tax Rate		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
10									
11	**Discounting**								
12	Discount Rate = Cost of Capital		13.2%	14.0%	14.7%	15.5%	16.3%	16.5%	16.7%
13	Cumulative Discount Factor	0.0%	13.2%	29.0%	48.1%	71.0%	98.9%	131.6%	170.3%
14									
15	**Price or Cost / Unit**								
16	Unit Sales		2,100	3255	4557	5696	5981	4785	2392
17	Sales Revenue / Unit		$9.70	$9.94	$10.24	$10.60	$11.02	$11.46	$11.92
18	Variable Cost / Unit		$7.40	$7.59	$7.81	$8.09	$8.41	$8.75	$9.10
19	Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490
20									
21									
22									
23									
24	**Cash Flow Forecasts**								
25	Sales Revenue		$20,370	$32,363	$46,667	$60,376	$65,930	$54,854	$28,524
26	Variable Costs		$15,540	$24,689	$35,602	$46,060	$50,297	$41,847	$21,761
27	Gross Margin		$4,830	$7,674	$11,065	$14,316	$15,633	$13,007	$6,763
28									
29	Cash Fixed Costs		$5,280	$5,412	$5,574	$5,769	$6,000	$6,240	$6,490
30	Depreciation		$1,421	$1,421	$1,421	$1,421	$1,421	$1,421	$1,421
31	Total Fixed Costs		$6,701	$6,833	$6,996	$7,191	$7,422	$7,662	$7,911
32									
33	Operating Profit		($1,871)	$840	$4,070	$7,125	$8,211	$5,345	($1,148)
34	Taxes		($655)	$294	$1,424	$2,494	$2,874	$1,871	($402)
35	Net Profit		($1,216)	$546	$2,645	$4,631	$5,337	$3,474	($746)
36									
37	Add Back Depreciation		$1,421	$1,421	$1,421	$1,421	$1,421	$1,421	$1,421
38	Operating Cash Flow		$205	$1,968	$4,067	$6,053	$6,759	$4,896	$675
39									
40	Investment in Plant & Equip	($11,350)							$1,400
41	Cash Flows	($11,350)	$205	$1,968	$4,067	$6,053	$6,759	$4,896	$2,075
42	Present Value of Each Cash Flow	($11,350)	$181	$1,525	$2,746	$3,539	$3,399	$2,114	$768
43	Net Present Value	$2,921							

(2) (Unit Sales on date t-1)
* (1 + Unit Sales Growth Rate)
Enter =C16*(1+D5) and copy across

(1) (Sales Growth Rate on date t-1) +
(Change in Sales Growth Rate on date t)
Enter =D5+E6 and copy across

The project NPV is $2,921 and should be accepted. But how sure are you of this result? How sensitive is this result to small changes in the assumptions? The Break-Even Point gives you an idea of the robustness of this result.

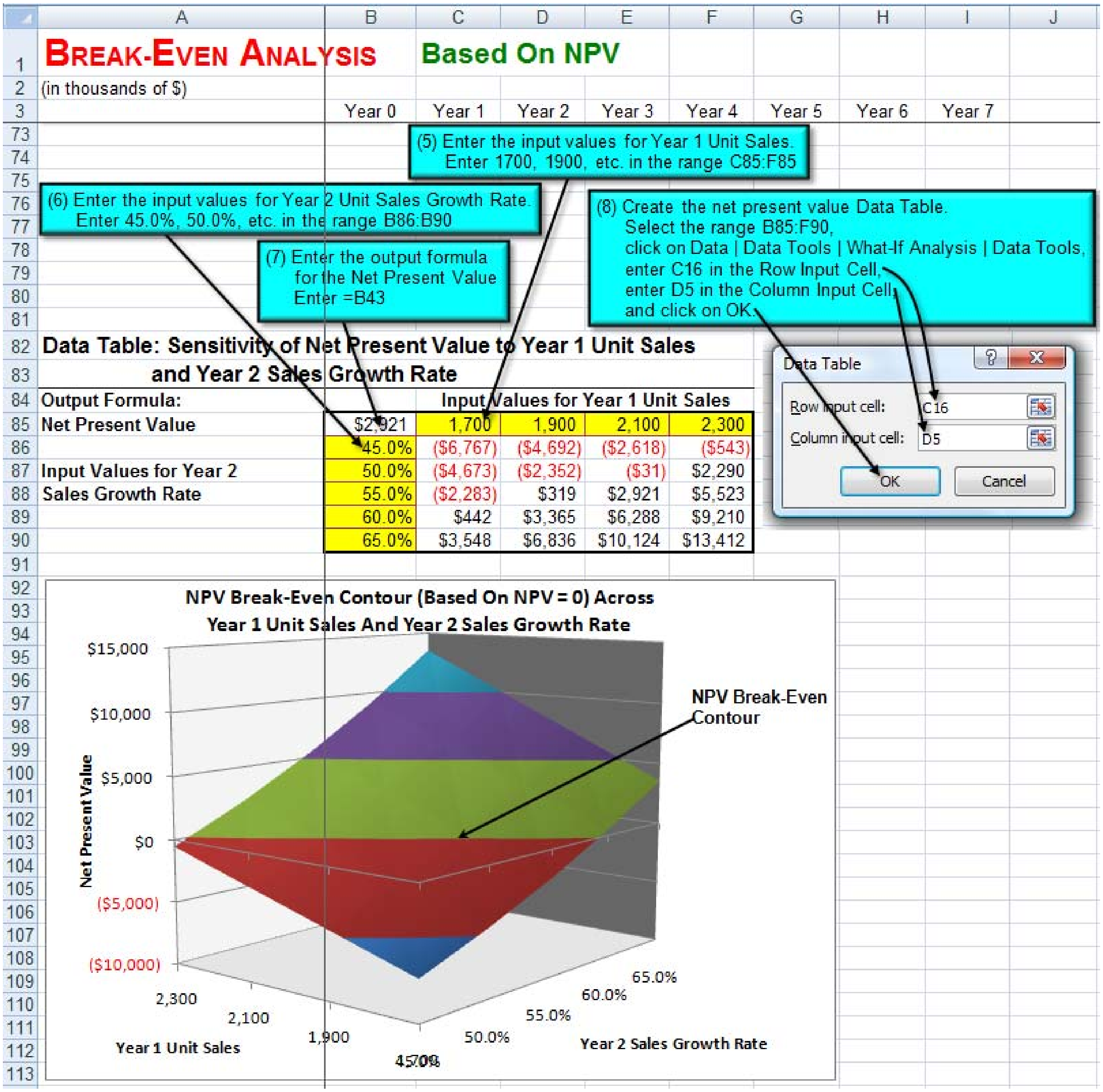
FIGURE 15.4 Excel Model for Break-Even Analysis Based On NPV (Cont.).



By trial and error, the Solver adjusts the value of the Year 1 Unit Sales in cell **C16** until the Net Present Value in cell **B40** equals zero (within a very small error tolerance). This results in a NPV Break-Even Point in Year 1 Unit Sales (shown in cell **C16**) of 1,875.

By trial and error, the Solver adjusts the value of the Sales Growth Rate in cell **D5** until the Net Present Value in cell **B40** equals zero. This results in a NPV Break-Even Point in Sales Growth Rate (shown in cell **D5**) of 50.1%.

FIGURE 15.5 Two Way Data Table and 3D Graph.



Net Present Value	$2,921	1,700	1,900	2,100	2,300
	45.0%	($6,767)	($4,692)	($2,618)	($543)
Input Values for Year 2	50.0%	($4,673)	($2,352)	($31)	$2,290
Sales Growth Rate	55.0%	($2,283)	$319	$2,921	$5,523
	60.0%	$442	$3,365	$6,288	$9,210
	65.0%	$3,548	$6,836	$10,124	$13,412

Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

The 3-D Graph shows the Net Present Value of the project for combinations of Year 1 Unit Sales and Year 2 Sales Growth Rate. The multi-color surface illustrates various ranges of NPV. In the top corner, the dark purple color is for NPV > $10,000. Below it, a medium green section is for a NPV of $5,000 to $10,000. And so on. At the intersection of the very light pink section ($0 to $5,000) and the medium purple section (-$5,000 to $0) is a contour highlighted by the arrow. This is the NPV Break-Even Contour, where NPV = 0. Every point on this contour represents a combination of Year 1 Unit Sales and Year 2 Sales

Growth Rate for which the NPV = 0. The 3-D Graph shows that project's positive NPV is *very sensitive*. If the Year 1 Unit Sales are a little bit lower than assumed or if the year 2 Sale Growth Rate is a little bit lower than assumed, then the whole project could have a negative NPV.

Problems

1. A project has a fixed cost of $73,000, variable costs of $9.20 per unit, and generates sales revenue of $15.40 per unit. What is the break-even point in unit sales, where accounting profit exactly equals zero, and what is the intuition for it?

2. Suppose a firm is considering the following project, where all of the dollar figures are in thousands of dollars. In year 0, the project requires $24,490 investment in plant and equipment, is depreciated using the straight-line method over seven years, and has a salvage value of $5,800 in year 7. The project is forecast to generate sales of 4,800 units in year 1 and grow at a sales growth rate of 72.0% in year 2. The sales growth rate is forecast to decline by 12.0% in years 3, to decline by 15.0% in year 4, to decline by 18.0% in year 5, to decline by 23.0% in year 6, to decline by 29.0% in year 7. Unit sales will drop to zero in year 8. The inflation rate is forecast to be 2.7% in year 1 and rising to 3.5% in year 7. The real cost of capital is forecast to be 10.2% in year 1, rising to 11.9% in year 7. The tax rate is forecast to be a constant 38.0%. Sales revenue per unit is forecast to be $12.20 in year 1 and then to grow with inflation. Variable cost per unit is forecast to be $7.30 in year 1 and then to grow with inflation. Cash fixed costs are forecast to be $6,740 in year 1 and then to grow with inflation. What is the project NPV? What is the NPV Break-Even Point in Year 1 Unit Sales, where NPV equals zero? What is the NPV Break-Even Point in the Year 2 Sales Growth Rate, where NPV equals zero? What is the NPV Break-Even Contour in the two-dimensional space of Year 1 Unit Sales and Year 2 Sales Growth Rate?

PART 5 FINANCIAL PLANNING

Chapter 16 Corporate Financial Planning

16.1 Actual

Problem. Construct actual (historical) financial statements for **Cutting Edge B2B Inc.** in preparation for forecasting their financial statements.

Solution Strategy. Enter actual values in the yellow input sections. Enter appropriate additions and subtractions to complete the Income Statement and Balance sheet. Then calculate the Key Assumptions over the actual years.

FIGURE 16.1 Actual Income Statement for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I
1	**CORPORATE FINANCIAL PLANNING**				**Actual**				
2	**Cutting Edge B2B Inc.**	2006	2007	2008	2009	2010	2011	2012	Ave Hist.
3	**Financial Plan**	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales
24									
25									
26									
27									
28									
29									
30									
31									
32									
33	**Income Statement (Mil.$)**								
34	Sales	$73.84	$93.28	$115.93	$138.84				
35	Cost of Goods Sold	$41.83	$58.39	$75.49	$89.83				
36	Gross Margin	$32.01	$34.89	$40.44	$49.01				
37									
38	Selling, Gen & Adm Expenses	$6.58	$7.28	$8.56	$10.21				
39	Depreciation	$5.91	$6.37	$7.31	$9.86				
40	EBIT	$19.52	$21.24	$24.57	$28.94				
41									
42	Interest Expense	$4.76	$5.23	$6.69	$8.88				
43	Taxes	$6.21	$6.96	$7.52	$7.60				
44	Net Income	$8.55	$9.05	$10.36	$12.46				
45	Shares Outstanding (Millions)	39.60	40.36	44.93	53.91				
46	Earnings Per Share	$0.22	$0.22	$0.23	$0.23				
47									
48	Allocation of Net Income:								
49	Dividends	$2.90	$3.17	$3.63	$4.36				
50	Change in Equity	$5.65	$5.88	$6.73	$8.10				
51									
52									
53									
54									
55									
56									
57									

(1) Sales - Cost of Goods Sold
Enter =B34-B35 and copy across

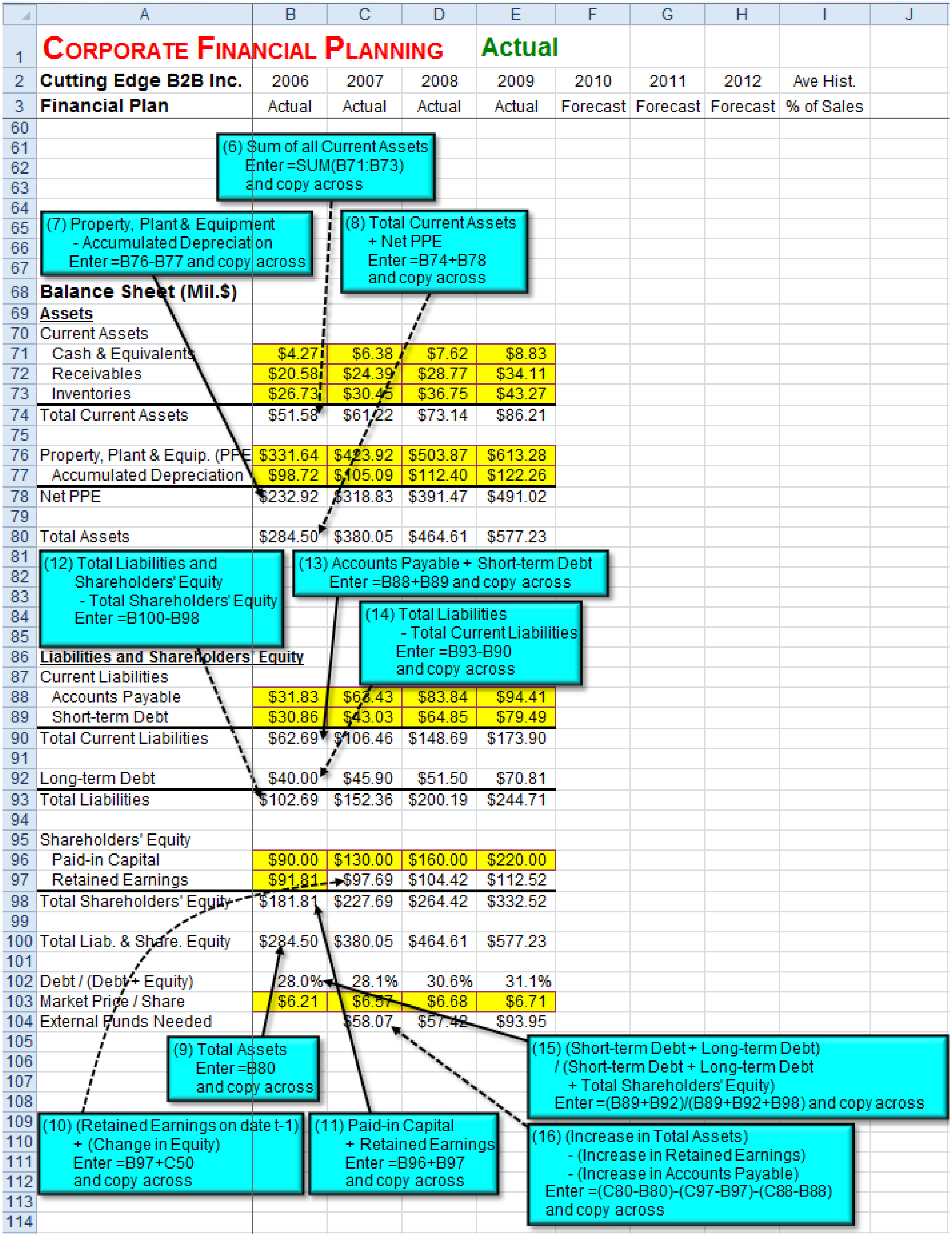
(2) Gross Margin
- SG&A Expense
- Depreciation
Enter =B36-B38-B39
and copy across

(3) EBIT - Interest Expense
- Taxes
Enter =B40-B42-B43
and copy across

(4) Net Income
/ Shares Outstanding
Enter =B44/B45
and copy across

(5) Net Income - Dividends
Enter =B44-B49 and copy across

FIGURE 16.2 Actual Balance Sheet for Cutting Edge B2B Inc.



	A	B	C	D	E	F	G	H	I
1	CORPORATE FINANCIAL PLANNING				Actual				
2	Cutting Edge B2B Inc.	2006	2007	2008	2009	2010	2011	2012	Ave Hist.
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales
68	**Balance Sheet (Mil.$)**								
69	**Assets**								
70	Current Assets								
71	Cash & Equivalents	$4.27	$6.38	$7.62	$8.83				
72	Receivables	$20.58	$24.39	$28.77	$34.11				
73	Inventories	$26.73	$30.45	$36.75	$43.27				
74	Total Current Assets	$51.58	$61.22	$73.14	$86.21				
76	Property, Plant & Equip. (PPE)	$331.64	$423.92	$503.87	$613.28				
77	Accumulated Depreciation	$98.72	$105.09	$112.40	$122.26				
78	Net PPE	$232.92	$318.83	$391.47	$491.02				
80	Total Assets	$284.50	$380.05	$464.61	$577.23				
86	**Liabilities and Shareholders' Equity**								
87	Current Liabilities								
88	Accounts Payable	$31.83	$63.43	$83.84	$94.41				
89	Short-term Debt	$30.86	$43.03	$64.85	$79.49				
90	Total Current Liabilities	$62.69	$106.46	$148.69	$173.90				
92	Long-term Debt	$40.00	$45.90	$51.50	$70.81				
93	Total Liabilities	$102.69	$152.36	$200.19	$244.71				
95	Shareholders' Equity								
96	Paid-in Capital	$90.00	$130.00	$160.00	$220.00				
97	Retained Earnings	$91.81	$97.69	$104.42	$112.52				
98	Total Shareholders' Equity	$181.81	$227.69	$264.42	$332.52				
100	Total Liab. & Share. Equity	$284.50	$380.05	$464.61	$577.23				
102	Debt / (Debt + Equity)	28.0%	28.1%	30.6%	31.1%				
103	Market Price / Share	$6.21	$6.57	$6.68	$6.71				
104	External Funds Needed		$58.07	$57.42	$93.95				

FIGURE 16.3 Actual Key Assumptions for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Actual					
2	Cutting Edge B2B Inc.	2006	2007	2008	2009	2010	2011	2012	Ave Hist.	
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales	
4	Key Assumptions									
5	Sales Growth Rate		26.3%	24.3%	19.8%					
6	Tax Rate	42.1%	43.5%	42.1%	37.9%					
7	Int Rate on Short-Term Debt	6.5%	6.7%	6.9%	7.1%					
8	Int Rate on Long-Term Debt	7.7%	7.9%	8.1%	8.3%					
9	Dividend Payout Rate	33.9%	35.0%	35.0%	35.0%					
10	Price / Earnings	28.8	29.3	29.0	29.0					

(17) (Sales (date t) - Sales (date t-1)) / Sales (date t-1)
Enter =(C34-B34)/B34 and copy across

(18) Taxes / (Before-tax Income) = Taxes / (EBIT - Interest Expense)
Enter =B43/(B40-B42) and copy across

(19) Dividend Payout Rate = Dividends / Net Income
Enter =B49/B44 and copy across

(20) Price / Earnings = (Market Price per Share) / (Earnings per Share)
Enter =B103/B46 and copy across

Now you are ready to Forecast the Financial Statements.

16.2 Forecast

Problem. Given actual financial statements for **Cutting Edge B2B Inc.**, forecast their financial statements for the next three years. Explore the impact of the financing *choice variables*: debt or equity.

Solution Strategy. Analyze the historical financial statements to determine which income statement and balance sheet items are close to being a constant percentage of sales and which items are not. Then, forecast sales as accurately as possible. Then, apply the average historical percentage of sales to generate most of the income statement and balance sheet items. Forecast other key assumptions to generate most of the rest and work out the implications for additional financing. Make the Balance Sheet balance by calculating long-term debt as the plug item. Raise (or lower) the portion of equity relative to the portion of debt by raising (or lowering) paid-in capital.

FIGURE 16.4 Forecast % of Sales for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Forecast					
2	**Cutting Edge B2B Inc.**	2006	2007	2008	2009	2010	2011	2012	Ave Hist.	
3	**Financial Plan**	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales	
116										
117										
118										
119										
120	**Income Statement (% of Sales)**									
121	Sales	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
122	Cost of Goods Sold	56.6%	62.6%	65.1%	64.7%	62.3%	62.3%	62.3%	62.3%	
123	Gross Margin	43.4%	37.4%	34.9%	35.3%	37.7%	37.7%	37.7%	37.7%	
124										
125	Selling, Gen & Adm Expense	8.9%	7.8%	7.4%	7.4%	7.9%	7.9%	7.9%	7.9%	
126	Depreciation	8.0%	6.8%	6.3%	7.1%	7.1%	7.1%	7.1%	7.1%	
127	EBIT	26.4%	22.8%	21.2%	20.8%	22.8%	22.8%	22.8%	22.8%	
128										
129	Interest Expense	6.4%	5.6%	5.8%	6.4%	7.1%	6.8%	6.7%	6.1%	
130	Taxes	8.4%	7.5%	6.5%	5.5%	6.3%	6.4%	6.4%	7.0%	
131	Net Income	11.6%	9.7%	8.9%	9.0%	9.5%	9.6%	9.6%	9.8%	
132	Shares Outstanding (Millions	53.6%	43.3%	38.8%	38.8%	37.2%	35.8%	34.2%	43.6%	
133	Earnings Per Share	0.3%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.2%	
134										
135	Allocation of Net Income:									
136	Dividends	3.9%	3.4%	3.1%	3.1%	3.3%	3.4%	3.4%	3.4%	
137	Change in Equity	7.7%	6.3%	5.8%	5.8%	6.1%	6.3%	6.3%	6.4%	
138										
139	**Balance Sheet (% of Sales)**									
140	**Assets**									
141	Current Assets									
142	Cash & Equivalents	5.8%	6.8%	6.6%	6.4%	6.4%	6.4%	6.4%	6.4%	
143	Receivables	27.9%	26.1%	24.8%	24.6%	25.9%	25.9%	25.9%	25.9%	
144	Inventories	36.2%	32.6%	31.7%	31.2%	32.9%	32.9%	32.9%	32.9%	
145	Total Current Assets	69.9%	65.6%	63.1%	62.1%	65.2%	65.2%	65.2%	65.2%	
146										
147	Property, Plant & Equip. (PP	449.1%	454.5%	434.6%	441.7%	420.1%	417.6%	416.7%	445.0%	
148	Accum Depreciation	133.7%	112.7%	97.0%	88.1%	83.0%	80.5%	79.6%	107.8%	
149	Net PPE	315.4%	341.8%	337.7%	353.7%	337.1%	337.1%	337.1%	337.1%	
150										
151	Total Assets	385.3%	407.4%	400.8%	415.8%	402.3%	402.3%	402.3%	402.3%	
152										
153	**Liabilities and Shareholders' Equity**									
154	Current Liabilities									
155	Accounts Payable	43.1%	68.0%	72.3%	68.0%	62.9%	62.9%	62.9%	62.9%	
156	Short-term Debt	41.8%	46.1%	55.9%	57.3%	50.3%	50.3%	50.3%	50.3%	
157	Total Current Liabilities	84.9%	114.1%	128.3%	125.3%	113.1%	113.1%	113.1%	113.1%	
158										
159	Long-term Debt	54.2%	49.2%	44.4%	51.0%	51.7%	50.8%	53.3%	49.7%	
160	Total Liabilities	139.1%	163.3%	172.7%	176.3%	164.9%	164.0%	166.5%	162.8%	
161										
162	Shareholders' Equity									
163	Paid-in Capital	121.9%	139.4%	138.0%	158.5%	161.4%	164.8%	163.4%	139.4%	
164	Retained Earnings	124.3%	104.7%	90.1%	81.0%	76.0%	73.5%	72.5%	100.0%	
165	Total Shareholders' Equity	246.2%	244.1%	228.1%	239.5%	237.4%	238.4%	235.9%	239.5%	
166										
167	Total Liabilities and Equity	385.3%	407.4%	400.8%	415.8%	402.3%	402.3%	402.3%	402.3%	

(21) (Each Income Statement item) / Sales
Enter =B34/B$34 and copy to the range B121:H137
Delete ranges that should be blank (B124:H124, etc.)

(24) Average of historical (actual) Percent of Sales
Enter =AVERAGE(B121:E121) and copy to range I121:I167
Delete cells that should be blank (I124, I128, etc.)

(22) (Each Balance Sheet Asset item) / Sales
Enter =B71/B$34 and copy to range B142:H151
Delete ranges that should be blank (B146:H146, etc.)

(23) (Each Balance Sheet Liab. & Equity item) / Sales
Enter =B88/B$34 and copy to range B155:H167
Delete ranges that should be blank (B158:H158, etc.)

FIGURE 16.5 Forecast Key Assumptions for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Forecast					
2	Cutting Edge B2B Inc.	2006	2007	2008	2009	2010	2011	2012	Ave Hist.	
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales	
4	Key Assumptions									
5	Sales Growth Rate		26.3%	24.3%	19.8%	16.0%	13.0%	11.0%		
6	Tax Rate	42.1%	43.5%	42.1%	37.9%	40.0%	40.0%	40.0%		
7	Int Rate on Short-Term Debt	6.5%	6.7%	6.9%	7.1%	7.0%	6.9%	6.8%		
8	Int Rate on Long-Term Debt	7.7%	7.9%	8.1%	8.3%	8.2%	8.1%	8.0%		
9	Dividend Payout Rate	33.9%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%		
10	Price / Earnings	28.8	29.3	29.0	29.0	29.4	29.4	29.4		

(25) Forecast key assumptions Enter forecast values in the range F5:H10 (done for you)

FIGURE 16.6 Forecast Income Statement for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Forecast					
2	Cutting Edge B2B Inc.	2006	2007	2008	2009	2010	2011	2012	Ave Hist.	
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales	
33	Income Statement (Mil.$)									
34	Sales	$73.84	$93.28	$115.93	$138.84	$161.05	$181.99	$202.01		
35	Cost of Goods Sold	$41.83	$58.39	$75.49	$89.83	$100.28	$113.32	$125.78		
36	Gross Margin	$32.01	$34.89	$40.44	$49.01	$60.77	$68.67	$76.23		
37										
38	Selling, Gen & Adm Expenses	$6.58	$7.28	$8.56	$10.21	$12.66	$14.31	$15.88		
39	Depreciation	$5.91	$6.37	$7.31	$9.86	$11.37	$12.85	$14.26		
40	EBIT	$19.52	$21.24	$24.57	$28.94	$36.74	$41.51	$46.08		
41										
42	Interest Expense	$4.76	$5.23	$6.69	$8.88	$11.37	$12.34	$13.62		
43	Taxes	$6.21	$6.96	$7.52	$7.60	$10.15	$11.67	$12.98		
44	Net Income	$8.55	$9.05	$10.36	$12.46	$15.22	$17.51	$19.48		
45	Shares Outstanding (Millions)	39.60	40.36	44.93	53.91	59.87	65.22	69.02		
46	Earnings Per Share	$0.22	$0.22	$0.23	$0.23	$0.25	$0.27	$0.28		
47										
48	Allocation of Net Income:									
49	Dividends	$2.90	$3.17	$3.63	$4.36	$5.33	$6.13	$6.82		
50	Change in Equity	$5.65	$5.88	$6.73	$8.10	$9.89	$11.38	$12.66		

(26) (Sales on date t-1) * (1 + Sales Growth Rate) Enter =E34*(1+F5) and copy across

(27) (Ave. Hist. Goods Sold / Sales) * Sales Enter =$I122*F$34 and copy across

(28) (Ave. Hist. SG&A / Sales) * Sales Copy cell F35 to the range F38:H39

(29) (Interest Rate on Short-term Debt) * (Prior Year Short-term Debt Amount) + (Interest Rate on Long-term Debt) * (Prior Year Long-term Debt Amount) Enter =F7*E89+F8*E92 and copy across

(30) (EBIT - Interest Expense) * (Tax Rate) Enter =(F40-F42)*F6 and copy across

(31) (Shares Outstanding on date t-1) + (Paid in Capital on date t - Paid in Capital on date t-1) / (Market Price / Share on date t-1) Enter =E45+(F96-E96)/E103 and copy across

(32) (Net Income) * (Dividend Payout Rate) Enter =F44*F9 and copy across

(33) Net Income - Dividends Enter =F44-F49 and copy across

FIGURE 16.7 Forecast Balance Sheet for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Forecast					
2	Cutting Edge B2B Inc.	2006	2007	2008	2009	2010	2011	2012	Ave Hist.	
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales	
60										
61										
62										
63										
64										
65										
66										
67										
68	Balance Sheet (Mil.$)									
69	Assets									
70	Current Assets									
71	Cash & Equivalents	$4.27	$6.38	$7.62	$8.83	$10.29	$11.63	$12.91		
72	Receivables	$20.58	$24.39	$28.77	$34.11	$41.63	$47.05	$52.22		
73	Inventories	$26.73	$30.45	$36.75	$43.27	$53.03	$59.92	$66.52		
74	Total Current Assets	$51.58	$61.22	$73.14	$86.21	$104.95	$118.60	$131.64		
75										
76	Property, Plant & Equip. (PPE	$331.64	$423.92	$503.87	$613.28	$676.62	$760.05	$841.81		
77	Accumulated Depreciation	$98.72	$105.09	$112.40	$122.26	$133.63	$146.48	$160.74		
78	Net PPE	$232.92	$318.83	$391.47	$491.02	$542.98	$613.57	$681.07		
79										
80	Total Assets	$284.50	$380.05	$464.61	$577.23	$647.94	$732.17	$812.71		
81										
82										
83										
84										
85										
86	Liabilities and Shareholders' Equity									
87	Current Liabilities									
88	Accounts Payable	$31.83	$63.43	$83.84	$94.41	$101.23	$114.39	$126.98		
89	Short-term Debt	$30.86	$43.03	$64.85	$79.49	$80.98	$91.50	$101.57		
90	Total Current Liabilities	$62.69	$106.46	$148.69	$173.90	$182.21	$205.90	$228.54		
91										
92	Long-term Debt	$40.00	$45.90	$51.50	$70.81	$83.32	$92.48	$107.71		
93	Total Liabilities	$102.69	$152.36	$200.19	$244.71	$265.53	$298.38	$336.26		
94										
95	Shareholders' Equity									
96	Paid-in Capital	$90.00	$130.00	$160.00	$220.00	$260.00	$300.00	$330.00		
97	Retained Earnings	$91.81	$97.69	$104.42	$112.52	$122.41	$133.79	$146.45		
98	Total Shareholders' Equity	$181.81	$227.69	$264.42	$332.52	$382.41	$433.79	$476.45		
99										
100	Total Liab. & Share. Equity	$284.50	$380.05	$464.61	$577.23	$647.94	$732.17	$812.71		
101										
102	Debt / (Debt + Equity)	28.0%	28.1%	30.6%	31.1%	30.1%	29.8%	30.5%		
103	Market Price / Share	$6.21	$6.57	$6.68	$6.71	$7.47	$7.89	$8.30		
104	External Funds Needed		$58.07	$57.42	$93.95	$53.99	$59.69	$55.30		

(34) (Ave. Hist. Current Asset Item / Sales) * Sales
Enter =$I142*F$34 and copy to the range F71:H73

(35) Accumulated Depreciation + Net PPE
Enter =F77+F78 and copy across

(36) Accumulated Depreciation (t-1)
+ Depreciation
Enter =E77+F39 and copy across

(37) (Ave. Hist. PPE / Sales) * Sales
Copy F71 to the range F78:H78

(38) (Ave. Hist. Liab. & Equity Item / Sales)
* Sales
Enter =$I155*F$34 and copy to
the range F88:H89

(39) Adjust Paid-in Capital to keep Debt / (Debt + Equity) in row 102 near the target level, which is 30% in this case (done for you)

(40) (Price / Earnings)
* (Earnings / Share)
Enter =F10*F46
and copy across

After all of the forecasting is done, it is important to check Long-term Debt to make sure that it isn't growing explosively or dropping rapidly (perhaps going negative!). If it is going wild, then backtrack to identify the source of sharp up or down movements and check for errors.

The forecast for the next three years is a steady increase in Earnings Per Share from $0.25 to $0.27 to $0.28.

16.3 Cash Flow

Problem. Given historical and forecasted Income Statements and Balance Sheets for **Cutting Edge B2B Inc.**, create the historical and forecasted Cash Flow Statement.

Solution Strategy. Construct the cash flow statement by starting with Net Income from the Income Statement and then picking up the year to year changes from the Balance Sheets.

FIGURE 16.8 Cash Flows for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I
1	CORPORATE FINANCIAL PLANNING				Cash Flow				
2	**Cutting Edge B2B Inc.**	2006	2007	2008	2009	2010	2011	2012	Ave Hist.
3	**Financial Plan**	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales
170									
171									
172									
173									
174									
175									
176									
177									
178									
179									
180									
181	**Cash Flow Statement (Mil.$)**								
182	Cash Flow From Operating Activities								
183	Net Income		$9.05	$10.36	$12.46	$15.22	$17.51	$19.48	
184	+ Depreciation		$6.37	$7.31	$9.86	$11.37	$12.85	$14.26	
185	- Inc in Accts Receivable		($3.81)	($4.38)	($5.34)	($7.52)	($5.41)	($5.18)	
186	- Inc in Inventories		($3.72)	($6.30)	($6.52)	($9.76)	($6.89)	($6.59)	
187	+ Inc in Accounts Payable		$31.60	$20.41	$10.57	$6.82	$13.16	$12.58	
188	Cash Flow From Operat Act		$39.49	$27.40	$21.03	$16.13	$31.21	$34.55	
189									
190	Cash Flow From Investing Activities								
191	- Invest in Plant and Equip		($92.28)	($79.95)	($109.41)	($63.34)	($83.44)	($81.75)	
192	Cash Flow From Invest Act		($92.28)	($79.95)	($109.41)	($63.34)	($83.44)	($81.75)	
193									
194	Cash Flow From Financing Activities								
195	+ Inc in Long-term Debt		$5.90	$5.60	$19.31	$12.51	$9.17	$15.23	
196	+ Inc in Short-term Debt		$12.17	$21.82	$14.64	$1.49	$10.53	$10.07	
197	+ Inc in Paid in Capital		$40.00	$30.00	$60.00	$40.00	$40.00	$30.00	
198	- Dividends Paid		($3.17)	($3.63)	($4.36)	($5.33)	($6.13)	($6.82)	
199	Cash Flow From Financ Act		$54.90	$53.79	$89.59	$48.67	$53.56	$48.48	
200									
201	Change in Cash and Equiv		$2.11	$1.24	$1.21	$1.46	$1.34	$1.28	
202	Cash and Equiv, Begin of Yr		$4.27	$6.38	$7.62	$8.83	$10.29	$11.63	
203	Cash and Equiv, End of Yr		$6.38	$7.62	$8.83	$10.29	$11.63	$12.91	
204									
205									
206									
207									
208									
209									
210									
211									
212									
213									
214									
215									
216									

(41) Net Income from above
Enter =C44 and copy across

(42) Accumulated Depreciation (t) - Accumulated Depreciation (t-1)
Enter =C77-B77 and copy across

(43) - [Receivables (t) - Receivables (t-1)]
Enter =-(C72-B72) and copy across

(44) - [Inventories (t) - Inventories (t-1)]
Enter =-(C73-B73) and copy across

(45) Accounts Payable (t) - Accounts Payable (t-1)
Enter =C88-B88 and copy across

(46) Sum of Cash Flow from Operating Activities
Enter =SUM(C183:C187) and copy across

(47) - [PPE (t) - PPE (t-1)]
Enter =-(C76-B76) and copy across

(48) - Invest in Plant and Equip
Enter =C191 and copy across

(49) Long-term Debt (t) - Long-term Debt (t-1)
Enter =C92-B92 and copy across

(50) Short-term Debt (t) - Short-term Debt (t-1)
Enter =C89-B89 and copy across

(51) Paid in Capital (t) - Paid in Capital (t-1)
Enter =C96-B96 and copy across

(52) - Dividends Paid from Income Statement
Enter =-C49 and copy across

(53) Sum of Cash Flow from Financing Activities
Enter =SUM(C195:C198) and copy across

(54) Cash Flow from Operating Activity
+ Cash Flow from Investing Activity
+ Cash Flow from Financing Activity
Enter =C188+C192+C199
and copy across

(55) Cash & Equivalents (t-1)
Enter =B71 and copy across

(56) Change in Cash and Equiv
+ Cash & Equivalents
Enter =C201+C202 and copy across

Notice that the $6.38 Cash and Equivalents at the End of Year 2004, which was obtained by summing all of the cash flows from operations, investments, and financing together with the Beginning of the Year balance for 2004, does indeed equal the $6.38 Cash and Equivalents at the Beginning of Year 2005. Thus, the sum of the cash flows from operations, investments, and financing does equal the Change in Cash and Equivalents. This balancing of the Cash Flow Statement is a direct consequence of the balancing of the Balance Sheet. It is also a good way to check for possible errors in your Excel model.

16.4 Ratios

Problem. Given historical and forecasted financial statements for **Cutting Edge B2B Inc.**, create the historical and forecasted financial ratios.

Solution Strategy. Calculate the financial ratios by referencing the appropriate items on the Income Statement or Balance Sheet.

FIGURE 16.9 Ratios for Cutting Edge B2B Inc.

	A	B	C	D	E	F	G	H	I
1	CORPORATE FINANCIAL PLANNING				Ratios				
2	Cutting Edge B2B Inc.	2006	2007	2008	2009	2010	2011	2012	Ave Hist.
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	% of Sales
229	**Financial Ratios**								
230	**Profitability**								
231	Return On Sales (ROS)	26.4%	22.8%	21.2%	20.8%	22.8%	22.8%	22.8%	
232	Return On Assets (ROA)		6.4%	5.8%	5.6%	6.0%	6.0%	6.0%	
233	Return On Equity (ROE)		4.4%	4.2%	4.2%	4.3%	4.3%	4.3%	
234									
235	**Asset Turnover**								
236	Receivables Turnover		414.9%	436.2%	441.6%	425.3%	410.4%	407.0%	
237	Inventory Turnover		204.2%	224.7%	224.5%	208.3%	200.6%	199.0%	
238	Asset Turnover		28.1%	27.5%	26.7%	26.3%	26.4%	26.2%	
239									
240	**Financial Leverage**								
241	Debt	24.9%	23.4%	25.0%	26.0%	25.4%	25.1%	25.8%	
242	Times Interest Earned	410.1%	406.1%	367.3%	325.9%	323.1%	336.5%	338.3%	
243									
244	**Liquidity**								
245	Current	82.3%	57.5%	49.2%	49.6%	57.6%	57.6%	57.6%	
246	Quick	39.6%	28.9%	24.5%	24.7%	28.5%	28.5%	28.5%	
247									
248	**Market Value**								
249	Price to Earnings	28.76	29.30	28.97	29.03	29.40	29.40	29.40	
250	Market to Book	135.3%	116.5%	113.5%	108.8%	117.0%	118.7%	120.2%	

(57) EBIT / Sales
Enter =B40/B34 and copy across

(58) EBIT / ([Total Assets (t-1) + Total Assets (t)] / 2)
Enter =C40/((B80+C80)/2) and copy across

(59) Net Income
/ ([Total Shareholders' Equity (t-1)
+ Total Shareholders' Equity (t)] / 2)
Enter =C44/((B98+C98)/2)
and copy across

(60) Sales / ([Receivables (t-1) + Receivables (t)] / 2)
Enter =C34/((B72+C72)/2) and copy across

(61) Cost of Goods Sold / ([Inventories (t-1) + Inventories (t)] / 2)
Enter =C35/((B73+C73)/2) and copy across

(62) Sales / ([Total Assets (t-1) + Total Assets (t)] / 2)
Enter =C34/((B80+C80)/2) and copy across

(63) Total Debt / Total Assets
= (Short-term Debt + Long-term Debt) / Total Assets
Enter =(B89+B92)/B80 and copy across

(64) EBIT / Interest Expense
Enter =B40/B42 and copy across

(65) Total Current Assets / Total Current Liabilities
Enter =B74/B90 and copy across

(66) (Cash & Equivalents + Receivables) / Total Current Liabilities
Enter =(B71+B72)/B90 and copy across

(67) (Market Price / Share)
/ Earnings per Share
Enter =B103/B46
and copy across

(68) (Market Price / Share)
/ (Total Shareholders' Equity
/ Shares Outstanding)
Enter =B103/(B98/B45)
and copy across

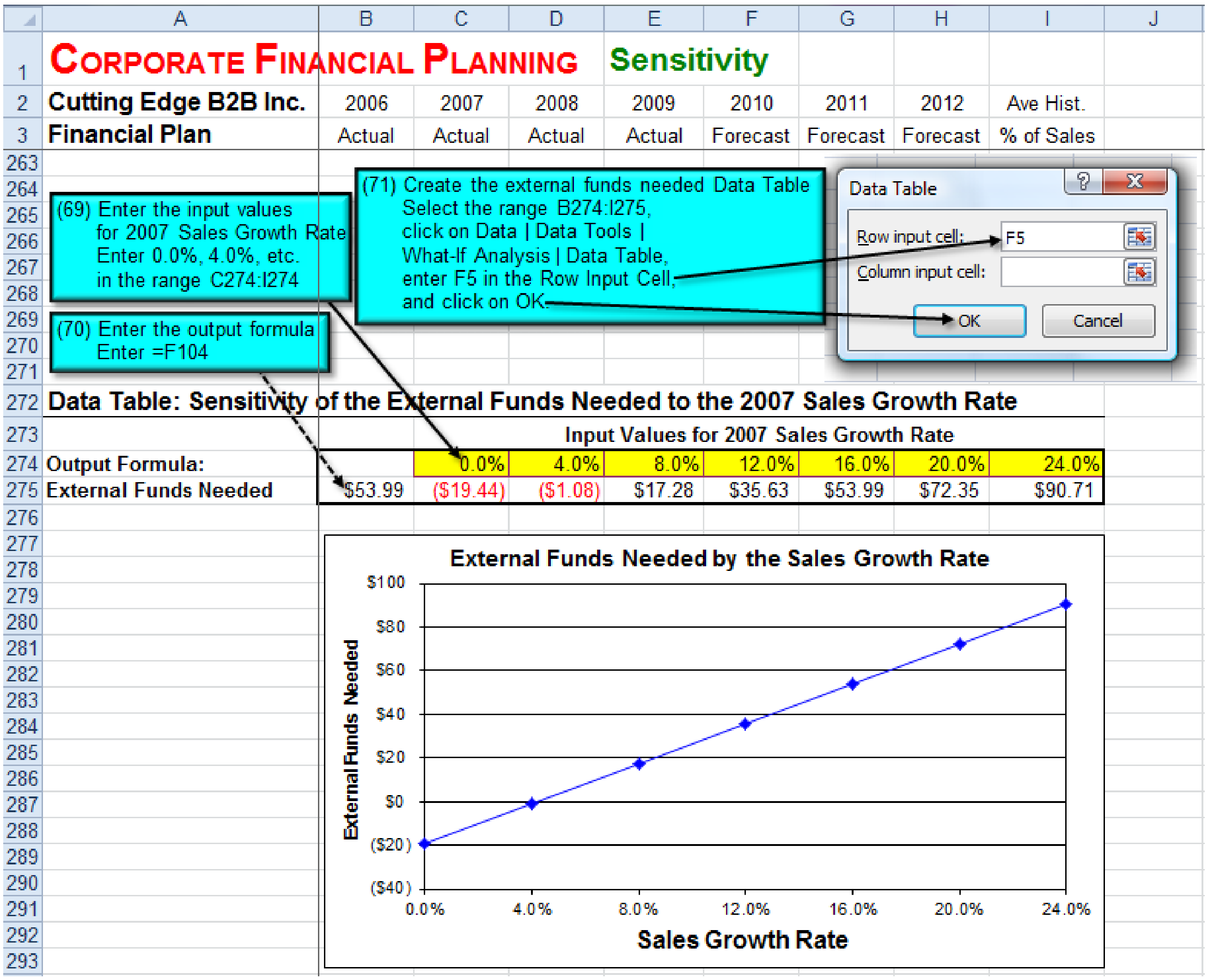
The financial ratios are very useful in interpreting the financial condition of the firm.

16.5 Sensitivity

Problem. Given historical and forecasted financial statements for **Cutting Edge B2B Inc.**, analyze the sensitivity of the 2007 External Funds Needed to the assumed 2007 Sales Growth Rate.

Solution Strategy. Create a Data Table using Sales Growth Rate as the input variable and External Funds Needed as the output variable. Then graph the relationship.

FIGURE 16.10 Sensitivity Analysis for Cutting Edge B2B Inc.



Data Table: Sensitivity of the External Funds Needed to the 2007 Sales Growth Rate

		Input Values for 2007 Sales Growth Rate						
Output Formula:		0.0%	4.0%	8.0%	12.0%	16.0%	20.0%	24.0%
External Funds Needed	$53.99	($19.44)	($1.08)	$17.28	$35.63	$53.99	$72.35	$90.71

The sensitivity analysis indicates that 2007 External Funds Needed is very sensitive to the assumption about 2007 Sales Growth Rate. Further, there is a linear relationship between 2007 Sales Growth Rate and 2007 External Funds Needed.

Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

16.6 Full-Scale Estimation

Problem. Given historical 10K financial statements for **Nike, Inc.**, forecast their financial statements over the next three years.

Solution Strategy. Modify the financial statement Excel model developed for the fictional firm **Cutting Edge B2B Inc.** by adding an additional level of detail found in the actual 10K financial statements of **Nike, Inc.** Then forecast the financial statements in the same way as before.

FIGURE 16.11 Historical and Forecasted Assumptions and Income Statement for Nike, Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Full-Scale Estimation					
2	Nike, Inc.	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %	
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales	
4	Key Assumptions									
5	Sales Growth Rate		9.2%	14.1%	2.9%	5.0%	6.0%	8.0%		
6	Tax Rate	35.0%	32.2%	24.8%	24.0%	24.0%	24.0%	24.0%		
7	Int Rate on Short-Term Debt	6.2%	6.0%	3.2%	1.3%	2.0%	2.7%	3.5%		
8	Int Rate on Long-Term Debt	6.1%	6.0%	4.5%	3.7%	4.5%	5.2%	6.0%		
9	Dividend Payout Rate	20.9%	23.0%	21.9%	31.4%	25.0%	23.0%	22.0%		
10	Price / Earnings	14.8	19.1	17.8	18.6	18.0	18.0	18.0		
11										
12										
13	Income Statement (Mil.$)									
14	Sales	$14,954.9	$16,325.9	$18,627.0	$19,176.1	$20,134.9	$21,343.0	$23,050.4		
15	Cost of Goods Sold	$8,367.9	$9,165.4	$10,239.6	$10,571.7	$11,184.7	$11,855.8	$12,804.3		
16	Gross Margin	$6,587.0	$7,160.5	$8,387.4	$8,604.4	$8,950.2	$9,487.2	$10,246.2		
17										
18	Selling, Gen & Adm Expenses	$4,477.8	$5,028.7	$5,953.7	$6,745.9	$6,437.4	$6,823.6	$7,369.5		
19	Non-Operating Income	$82.9	$117.8	$107.9	$138.2	$129.7	$137.4	$148.4		
20	Depreciation	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0		
21	EBIT	$2,192.1	$2,249.6	$2,541.6	$1,996.7	$2,642.4	$2,801.0	$3,025.1		
22										
23	Interest Expense	$50.5	$49.7	$38.7	$40.2	$40.3	$48.9	$67.6		
24	Taxes	$749.6	$708.4	$619.5	$469.8	$624.5	$660.5	$709.8		
25	Net Income	$1,392.0	$1,491.5	$1,883.4	$1,486.7	$1,977.6	$2,091.6	$2,247.7		
26	Shares Outstanding (Millions)	256.0	501.7	491.1	485.5	485.5	485.5	485.5		
27	Earnings Per Share	$5.44	$2.97	$3.84	$3.06	$4.07	$4.31	$4.63		
28										
29	Allocation of Net Income:									
30	Dividends	$290.9	$343.7	$412.9	$466.7	$494.4	$481.1	$494.5		
31	Change in Equity	$1,101.1	$1,147.8	$1,470.5	$1,020.0	$1,483.2	$1,610.5	$1,753.2		

(1) Forecast key assumptions Enter forecast values in the range F5:H10 (done for you)

(2) Gross Margin - SG&AE + Non-Op Inc - Depreciation Enter =B16-B18+B19-B20 and copy across

FIGURE 16.12 Historical and Forecasted Balance Sheet for Nike, Inc.

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Full-Scale Estimation					
2	Nike, Inc.	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %	
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales	
33	Balance Sheet (Mil.$)									
34	Assets									
35	Current Assets									
36	Cash & Equivalents	$954.2	$1,856.7	$2,133.9	$2,291.1	$2,777.3	$3,288.0	$3,828.3		
37	Marketable Securities	$1,348.8	$990.3	$642.2	$1,447.3	$1,312.8	$1,391.6	$1,502.9		
38	Receivables	$2,395.9	$2,494.7	$2,795.3	$2,883.9	$3,088.1	$3,273.3	$3,535.2		
39	Inventories	$2,076.7	$2,121.9	$2,438.4	$2,357.0	$2,630.9	$2,788.8	$3,011.9		
40	Other Current Assets	$583.4	$612.9	$829.5	$754.7	$807.6	$856.1	$924.6		
41	Total Current Assets	$7,359.0	$8,076.5	$8,839.3	$9,734.0	$10,616.7	$11,597.7	$12,802.9		
42										
43	Property, Plant & Equip., Net	$1,657.7	$1,678.3	$1,891.1	$1,957.7	$2,100.4	$2,226.4	$2,404.5		
44	Invest and Adv to Subs	$0.0	$0.0	$0.0	$14.1	$3.7	$3.9	$4.2		
45	Deferred Charges	$137.4	$173.1	$337.5	$531.2	$330.3	$350.1	$378.1		
46	Intangibles	$536.3	$540.7	$1,191.9	$660.9	$842.8	$893.4	$964.9		
47	Deposits and Other Assets	$179.2	$219.7	$182.9	$351.7	$269.8	$286.0	$308.9		
48	Total Assets	$9,869.6	$10,688.3	$12,442.7	$13,249.6	$14,163.7	$15,357.5	$16,863.4		
49										
50	Liabilities and Shareholders' Equity									
51	Current Liabilities									
52	Notes Payable	$43.4	$100.8	$177.7	$342.9	$183.7	$194.7	$210.3		
53	Accounts Payable	$952.2	$1,040.3	$1,287.6	$1,031.9	$1,260.1	$1,335.7	$1,442.6		
54	Current Portion of L.T. Debt	$255.3	$30.5	$6.3	$32.0	$105.4	$111.8	$120.7		
55	Accrued Expenses	$1,096.2	$1,120.0	$1,475.7	$1,559.3	$1,522.4	$1,613.8	$1,742.9		
56	Income Taxes Payable	$85.5	$109.0	$88.0	$86.3	$108.8	$115.4	$124.6		
57	Other Current Liabilities	$190.7	$183.4	$286.2	$224.6	$257.0	$272.5	$294.3		
58	Total Current Liabilities	$2,623.3	$2,584.0	$3,321.5	$3,277.0	$3,437.5	$3,643.8	$3,935.3		
59										
60	Long-term Debt	$410.7	$409.9	$441.1	$437.2	$286.5	$347.5	$415.2		
61	Deferred Charge/Inc.	$343.8	$416.2	$396.8	$283.7	$425.7	$451.3	$487.4		
62	Other Long Term Liab	$206.3	$252.5	$457.7	$558.3	$417.5	$442.6	$478.0		
63	Total Liabilities	$3,584.1	$3,662.6	$4,617.1	$4,556.2	$4,567.3	$4,885.1	$5,315.9		
64										
65										
66	Shareholders' Equity									
67	Preferred Stock	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3		
68	Common Stock Net	$2.8	$2.8	$2.8	$2.8	$2.8	$2.8	$2.8		
69	Capital Surplus	$1,451.4	$1,960.0	$2,497.8	$2,871.4	$2,400.0	$1,650.0	$950.0		
70	Other Equities	$117.6	$177.4	$251.4	$367.5	$258.7	$274.2	$296.1		
71	Retained Earnings	$4,713.4	$4,885.2	$5,073.3	$5,451.4	$6,934.6	$8,545.1	$10,298.3		
72	Total Shareholders' Equity	$6,285.5	$7,025.7	$7,825.6	$8,693.4	$9,596.4	$10,472.4	$11,547.5		
73										
74	Total Liab. & Share. Equity	$9,869.6	$10,688.3	$12,442.7	$13,249.6	$14,163.7	$15,357.5	$16,863.4		
75										
76	Debt / (Debt + Equity)	18.3%	18.1%	19.6%	17.2%	15.3%	15.2%	15.2%		
77	Market Price / Share	$80.31	$56.75	$68.37	$57.05	$73.32	$77.55	$83.33		
78	External Funds Needed		$871.7	$1,590.5	$403.1	($643)	($423.0)	($256.2)		

(3) Sum of Current Assets items
Enter =SUM(B36:B40) and copy across

(4) Total Current Assets + Sum of Rest of Assets
Enter =B41+SUM(B43:B47) and copy across

(5) Sum of Current Liabilities items
Enter =SUM(B52:B57) and copy across

(6) Total Liab -Total Cur Liab -Def Chg -OthLTL
Enter =F63-F58-F61-F62 and copy across

(7) Sum of Shareholders' Equity Items
Enter =SUM(B67:B71) and copy across

(8) Adjust Capital Surplus to keep Debt / (Debt + Equity) in row 77 near the target level, which is 15% in this case (done for you)

FIGURE 16.13 Historical and Forecasted Income Statement Percent of Sales for Nike, Inc.

(9) (Each Income Statement item) / Sales
Enter =B14/B$14 and copy to the range B86:H102
Delete ranges that should be blank (B88:H88, etc.)
(done for you)

(11) Average of historical (actual) Percent of Sales
Enter =AVERAGE(B85:E85) and copy to range I86:I145
Delete cells that should be blank (I88, I93, etc.)
(done for you)

	A	B	C	D	E	F	G	H	I	J
1	CORPORATE FINANCIAL PLANNING				Full-Scale Estimation					
2	**Nike, Inc.**	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %	
3	**Financial Plan**	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales	
79										
80										
81										
82										
83										
84	**Income Statement (% of Sales)**									
85	Sales	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
86	Cost of Goods Sold	56.0%	56.1%	55.0%	55.1%	55.5%	55.5%	55.5%	55.5%	
87	Gross Margin	44.0%	43.9%	45.0%	44.9%	44.5%	44.5%	44.5%	44.5%	
88										
89	Selling, Gen & Adm Expenses	29.9%	30.8%	32.0%	35.2%	32.0%	32.0%	32.0%	32.0%	
90	Non-Operating Income	0.6%	0.7%	0.6%	0.7%	0.6%	0.6%	0.6%	0.6%	
91	Depreciation	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
92	EBIT	14.7%	13.8%	13.6%	10.4%	13.1%	13.1%	13.1%	13.1%	
93										
94	Interest Expense	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	
95	Taxes	5.0%	4.3%	3.3%	2.4%	3.1%	3.1%	3.1%	3.8%	
96	Net Income	9.3%	9.1%	10.1%	7.8%	9.8%	9.8%	9.8%	9.1%	
97	Shares Outstanding (Millions)	1.7%	3.1%	2.6%	2.5%	2.4%	2.3%	2.1%	2.5%	
98	Earnings Per Share	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
99										
100	Allocation of Net Income:	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
101	Dividends	1.9%	2.1%	2.2%	2.4%	2.5%	2.3%	2.1%	2.2%	
102	Change in Equity	7.4%	7.0%	7.9%	5.3%	7.4%	7.5%	7.6%	6.9%	

FIGURE 16.14 Historical and Forecasted Balance Sheet Percent of Sales for Nike, Inc.

	A	B	C	D	E	F	G	H	I
1	CORPORATE FINANCIAL PLANNING				Full-Scale Estimation				
2	Nike, Inc.	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales
103									
104									
105	Balance Sheet (% of Sales)								
106	Assets								
107	Current Assets								
108	Cash & Equivalents	6.4%	11.4%	11.5%	11.9%	13.8%	15.4%	16.6%	10.3%
109	Short-term Investments	9.0%	6.1%	3.4%	7.5%	6.5%	6.5%	6.5%	6.5%
110	Receivables	16.0%	15.3%	15.0%	15.0%	15.3%	15.3%	15.3%	15.3%
111	Inventories	13.9%	13.0%	13.1%	12.3%	13.1%	13.1%	13.1%	13.1%
112	Other Current Assets	3.9%	3.8%	4.5%	3.9%	4.0%	4.0%	4.0%	4.0%
113	Total Current Assets	49.2%	49.5%	47.5%	50.8%	52.7%	54.3%	55.5%	49.2%
114									
115	Property, Plant & Equip., Net	11.1%	10.3%	10.2%	10.2%	10.4%	10.4%	10.4%	10.4%
116	Invest and Adv to Subs	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
117	Deferred Charges	0.9%	1.1%	1.8%	2.8%	1.6%	1.6%	1.6%	1.6%
118	Intangibles	3.6%	3.3%	6.4%	3.4%	4.2%	4.2%	4.2%	4.2%
119	Deposits and Other Assets	1.2%	1.3%	1.0%	1.8%	1.3%	1.3%	1.3%	1.3%
120	Total Assets	66.0%	65.5%	66.8%	69.1%	70.3%	72.0%	73.2%	66.8%
121									
122	Liabilities and Shareholders' Equity								
123	Current Liabilities								
124	Notes Payable	0.3%	0.6%	1.0%	1.8%	0.9%	0.9%	0.9%	0.9%
125	Accounts Payable	6.4%	6.4%	6.9%	5.4%	6.3%	6.3%	6.3%	6.3%
126	Current Portion of L.T. Debt	1.7%	0.2%	0.0%	0.2%	0.5%	0.5%	0.5%	0.5%
127	Accrued Expenses	7.3%	6.9%	7.9%	8.1%	7.6%	7.6%	7.6%	7.6%
128	Income Taxes Payable	0.6%	0.7%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
129	Other Current Liabilities	1.3%	1.1%	1.5%	1.2%	1.3%	1.3%	1.3%	1.3%
130	Total Current Liabilities	17.5%	15.8%	17.8%	17.1%	17.1%	17.1%	17.1%	17.1%
131									
132	Long-term Debt	2.7%	2.5%	2.4%	2.3%	1.4%	1.6%	1.8%	2.5%
133	Deferred Charge/Inc.	2.3%	2.5%	2.1%	1.5%	2.1%	2.1%	2.1%	2.1%
134	Other Long Term Liab	1.4%	1.5%	2.5%	2.9%	2.1%	2.1%	2.1%	2.1%
135	Total Liabilities	24.0%	22.4%	24.8%	23.8%	22.7%	22.9%	23.1%	23.7%
136									
137	Shareholders' Equity								
138	Preferred Stock	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
139	Common Stock Net	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
140	Capital Surplus	9.7%	12.0%	13.4%	15.0%	11.9%	7.7%	4.1%	12.5%
141	Other Equities	0.8%	1.1%	1.3%	1.9%	1.3%	1.3%	1.3%	1.3%
142	Retained Earnings	31.5%	29.9%	27.2%	28.4%	34.4%	40.0%	44.7%	29.3%
143	Total Shareholders' Equity	42.0%	43.0%	42.0%	45.3%	47.7%	49.1%	50.1%	43.1%
144									
145	Total Liab. & Share. Equity	66.0%	65.5%	66.8%	69.1%	70.3%	72.0%	73.2%	66.8%

(10) (Each Balance Sheet Asset item) / Sales
Enter =B36/B$14 and copy to range B108:H145
Delete ranges that should be blank (B114:H114, etc.)
(done for you)

FIGURE 16.15 Historical and Forecasted Cash Flow Statement for Nike, Inc.

	A	B	C	D	E	F	G	H	I
1	CORPORATE FINANCIAL PLANNING				Full-Scale Estimation				
2	Nike, Inc.	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales
147	**Cash Flow Statement (Mil.$)**								
148	**Cash Provided (Used) By Operating Activities**								
149	Net Income	$1,392.0	$1,491.5	$1,883.4	$1,486.7	$1,977.6	$2,091.6	$2,247.7	
150	Depreciation	$290.9	$270.2	$321.5	$383.3	$368.7	$390.8	$422.1	
151	Net Incr (Decr) Assets/Liabs	($43.2)	($64.8)	($48.4)	($411.7)	($155.7)	($165.0)	($178.2)	
152	Other Adjustments, Net	$28.2	$181.8	($220.2)	$277.8	$79.0	$83.7	$90.4	
153	Cash Provided By Operations	$1,667.9	$1,878.7	$1,936.3	$1,736.1	$2,269.6	$2,401.1	$2,582.0	
154									
155									
156	**Cash Provided (Used) By Investing Activities**								
157	(Incr) Decr in Prop, Plant	($332.1)	($285.2)	($447.3)	($423.7)	($431.8)	($457.7)	($494.3)	
158	(Incr) Decr in Securities Inv	($909.9)	$382.4	$380.4	($518.7)	($221.7)	($235.0)	($253.8)	
159	Other Cash Inflow (Outflow)	($34.6)	($4.3)	($21.8)	$144.3	$19.0	$20.2	$21.8	
160	Cash Used By Investing Act	($1,276.6)	$92.9	($88.7)	($798.1)	($634.5)	($672.6)	($726.4)	
161									
162									
163	**Cash Provided (Used) By Financing Activities**								
164	Issue (Purchase) of Equity	($535.8)	($662.3)	($904.7)	($462.6)	($750.5)	($795.5)	($859.1)	
165	Issue (Repayment) of Debt	($6.0)	($213.9)	($35.2)	($6.8)	($79.3)	($84.0)	($90.7)	
166	Incr (Decr) In Borrowing	($18.2)	$52.6	$63.7	$177.1	$73.8	$78.2	$84.5	
167	Dividends, Other Distribution	($290.9)	($343.7)	($412.9)	($466.7)	($438.0)	($464.3)	($501.4)	
168	Other Cash Inflow (Outflow)	$0.0	$55.8	$63.0	$25.1	$40.8	$43.3	$46.7	
169	Cash Used By Financing Act	($850.9)	($1,111.5)	($1,226.1)	($733.9)	($1,153.1)	($1,222.3)	($1,320.1)	
170									
171	Effect of Exch. Rate Chgs	$25.7	$42.4	($19.2)	($46.9)	$4.2	$4.5	$4.8	
172	Net Inc (Dec.) Cash & Equiv.	($433.9)	$902.5	$602.3	$157.2	$486.2	$510.7	$540.3	
173									
174	Cash and Equiv. Beg of Year	$1,388.1	$954.2	$1,856.7	$2,133.9	$2,291.1	$2,777.3	$3,288.0	
175	Cash and Equiv. End of Year	$954.2	$1,856.7	$2,459.0	$2,291.1	$2,777.3	$3,288.0	$3,828.3	

(12) Sum of Cash Provided By Operations items
Enter =SUM(B164:B168) and copy across

(13) Sum of Cash Provided by Investing items
Enter =SUM(B157:B159) and copy across

(14) Sum of Cash Provided by Financing items
Enter =SUM(B164:B168) and copy across

(15) Cash By Op + Cash By Invest + Cash By Financing + Exch Rate Chgs
Enter =B153+B160+B169+B171 and copy across

FIGURE 16.16 Historical and Forecasted Cash Flow Statement Percent of Sales for Nike, Inc.

	A	B	C	D	E	F	G	H	I	J
1	**CORPORATE FINANCIAL PLANNING**				**Full-Scale Estimation**					
2	**Nike, Inc.**	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %	
3	**Financial Plan**	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales	
179	(16) (Each Cash Flow Statement item) / Sales				(17) Average of historical (actual) Percent of Sales					
180	Enter =B149/B$14 and copy to the range B185:H209				Enter =AVERAGE(B185:E185) and copy to range I185:I209					
181	Delete ranges that should be blank (B190:H190, etc.)				Delete cells that should be blank (I190, I191, etc.)					
182	(done for you)				(done for you)					
183	**Cash Flow Statement (% of Sales)**									
184	**Cash Provided (Used) By Operating Activities**									
185	Net Income	9.3%	9.1%	10.1%	7.8%	9.8%	9.8%	9.8%	9.1%	
186	Depreciation	1.9%	1.7%	1.7%	2.0%	1.8%	1.8%	1.8%	1.8%	
187	Net Incr (Decr) Assets/Liabs	-0.3%	-0.4%	-0.3%	-2.1%	-0.8%	-0.8%	-0.8%	-0.8%	
188	Other Adjustments, Net	0.2%	1.1%	-1.2%	1.4%	0.4%	0.4%	0.4%	0.4%	
189	Cash Provided By Operations	11.2%	11.5%	10.4%	9.1%	11.3%	11.3%	11.2%	10.5%	
190										
191	**Cash Provided (Used) By Investing Activities**									
192	(Incr) Decr in Prop, Plant	-2.2%	-1.7%	-2.4%	-2.2%	-2.1%	-2.1%	-2.1%	-2.1%	
193	(Incr) Decr in Securities Inv	-6.1%	2.3%	2.0%	-2.7%	-1.1%	-1.1%	-1.1%	-1.1%	
194	Acq of subs-net assets acq	-0.2%	0.0%	-0.1%	0.8%	0.1%	0.1%	0.1%	0.1%	
195	Cash Used By Investing Act	-8.5%	0.6%	-0.5%	-4.2%	-3.2%	-3.2%	-3.2%	-3.2%	
196										
197	**Cash Provided (Used) By Financing Activities**									
198	Issue (Purchase) of Equity	-3.6%	-4.1%	-4.9%	-2.4%	-3.7%	-3.7%	-3.7%	-3.7%	
199	Issue (Repayment) of Debt	0.0%	-1.3%	-0.2%	0.0%	-0.4%	-0.4%	-0.4%	-0.4%	
200	Incr (Decr) In Borrowing	-0.1%	0.3%	0.3%	0.9%	0.4%	0.4%	0.4%	0.4%	
201	Dividends, Other Distribution	-1.9%	-2.1%	-2.2%	-2.4%	-2.2%	-2.2%	-2.2%	-2.2%	
202	Other Cash Inflow (Outflow)	0.0%	0.3%	0.3%	0.1%	0.2%	0.2%	0.2%	0.2%	
203	Cash Used By Financing Act	-5.7%	-6.8%	-6.6%	-3.8%	-5.7%	-5.7%	-5.7%	-5.7%	
204										
205	Effect of Exch. Rate Chgs	0.2%	0.3%	-0.1%	-0.2%	0.0%	0.0%	0.0%	0.0%	
206	Net Inc (Dec.) Cash & Equiv.	-2.9%	5.5%	3.2%	0.8%	2.4%	2.4%	2.3%	1.7%	
207										
208	Cash and Equiv. Beg of Year	9.3%	5.8%	10.0%	11.1%	11.4%	13.0%	14.3%	9.1%	
209	Cash and Equiv. End of Year	6.4%	11.4%	13.2%	11.9%	13.8%	15.4%	16.6%	10.7%	

FIGURE 16.17 Historical and Forecasted Financial Ratios for Nike, Inc.

	A	B	C	D	E	F	G	H	I
1	CORPORATE FINANCIAL PLANNING				Full-Scale Estimation				
2	Nike, Inc.	5/31/2006	5/31/2007	5/31/2008	5/31/2009	5/31/2010	5/31/2011	5/31/2012	Ave. %
3	Financial Plan	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	of Sales
210									
211	Financial Ratios								
212	Profitability								
213	Return On Sales (ROS)	14.7%	13.8%	13.6%	10.4%	13.1%	13.1%	13.1%	
214	Return On Assets (ROA)		21.9%	22.0%	15.5%	19.3%	19.0%	18.8%	
215	Return On Equity (ROE)		22.4%	25.4%	18.0%	21.6%	20.8%	20.4%	
216									
217	Asset Turnover								
218	Receivables Turnover		6.7	7.0	6.8	6.7	6.7	6.8	
219	Inventory Turnover		4.4	4.5	4.4	4.5	4.4	4.4	
220	Asset Turnover		1.6	1.6	1.5	1.5	1.4	1.4	
221									
222	Financial Leverage								
223	Debt	14.2%	14.5%	15.3%	13.7%	12.2%	12.2%	12.3%	
224	Times Interest Earned	43.4	45.3	65.7	49.7	65.5	57.3	44.8	
225									
226	Liquidity								
227	Current	280.5%	312.6%	266.1%	297.0%	308.8%	318.3%	325.3%	
228	Quick	127.7%	168.4%	148.4%	157.9%	170.6%	180.1%	187.1%	
229									
230	Market Value								
231	Price to Earnings	14.8	19.1	17.8	18.6	18.00	18.00	18.00	
232	Market to Book	327.1%	405.2%	429.1%	318.6%	370.9%	359.5%	350.4%	

(18) (Current Portion of L.T. Debt + Notes Payable + Long-term Debt) / (Total Assets)
Enter =(B52+B53+B60)/B48 and copy across

The percentage of sales method does a good job for most purposes. Additional refinements would increase accuracy of the forecast. For example, some items may be better projected as a trend, rather than an average. Other items, such as the Accounting Change, may have unique patterns. The bottom line of this forecast is steady growth in Earnings Per Share from $4.07 to $4.31 to $4.63.

Problems

1. Given historical financial statements for **Global Impact P2P** on the **Problems** tab, forecast their financial statements for the next three years. Then explore the company's needs for additional financing as expressed by the following *choice variables*: debt and equity (paid-in capital under shareholder's equity).

2. Given historical and forecasted Income Statements and Balance Sheets for **Global Impact P2P**, create the historical and forecasted Cash Flow Statement.

3. Given historical and forecasted financial statements for **Global Impact P2P**, create the historical and forecasted financial ratios.

4. Select a company with publicly traded stock. Locate the historical 10K financial statements for that company over the past few years. Forecast your company's financial statements over the next three years.

FIGURE 16.18 Historical Assumptions and Income Statement for Global Impact P2P

	A	B	C	D	E	F
1	CORPORATE FINANCIAL PLANNING				Problems	
2	**Global Impact P2P**	2006	2007	2008	2009	
3	**Financial Plan**	Actual	Actual	Actual	Actual	
4	**Key Assumptions**					
5	Sales Growth Rate			21.4%	19.3%	
6	Tax Rate	40.5%	38.8%	38.2%	36.0%	
7	Int Rate on Short-Term Debt	6.3%	6.3%	6.4%	6.5%	
8	Int Rate on Long-Term Debt	7.4%	7.4%	7.5%	7.6%	
9	Dividend Payout Rate	26.1%	25.9%	26.8%	24.4%	
10	Price / Earnings	8.6	8.4	8.7	9.3	
11						
12	**Income Statement (Mil.$)**					
13	Sales	$185.76	$194.29	$235.84	$281.38	
14	Cost of Goods Sold	$109.81	$112.25	$138.97	$171.57	
15	Gross Margin	$75.95	$82.04	$96.87	$109.81	
16						
17	Selling, Gen & Adm Expenses	$12.73	$13.54	$16.87	$19.94	
18	Depreciation	$11.66	$12.39	$14.58	$18.37	
19	EBIT	$51.56	$56.11	$65.42	$71.50	
20						
21	Interest Expense	$14.23	$15.69	$23.88	$24.55	
22	Taxes	$15.12	$15.68	$15.87	$16.92	
23	Net Income	$22.21	$24.74	$25.67	$30.03	
24	Shares Outstanding (Millions)	2.03	2.10	2.15	2.44	
25	Earnings Per Share	$10.94	$11.78	$11.94	$12.31	
26						
27	Allocation of Net Income:					
28	Dividends	$5.80	$6.41	$6.87	$7.33	
29	Change in Equity	$16.41	$18.33	$18.80	$22.70	

FIGURE 16.19 Historical Balance Sheet for Global Impact P2P

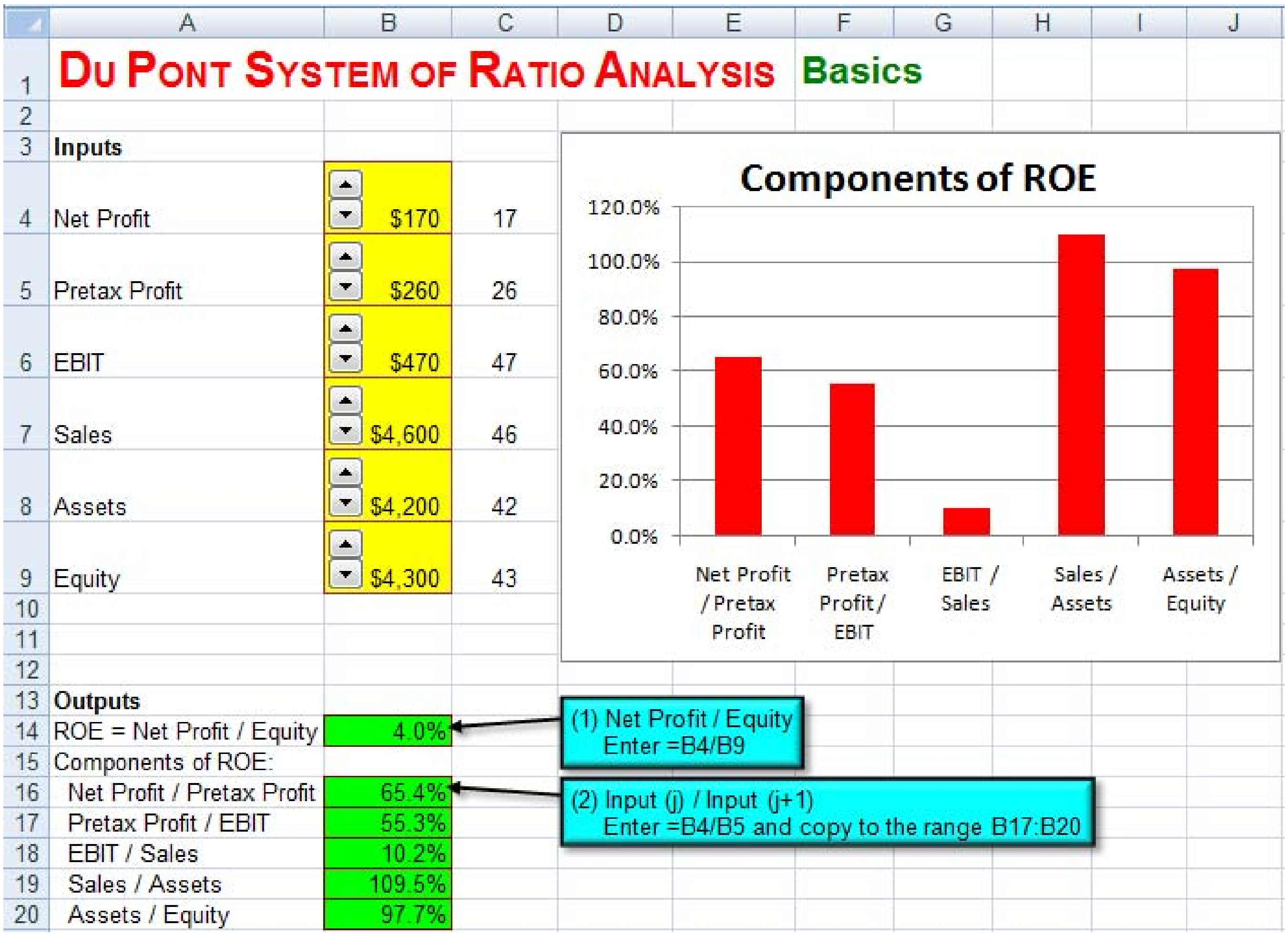
	A	B	C	D	E	F
1	CORPORATE FINANCIAL PLANNING				Problems	
2	Global Impact P2P	2006	2007	2008	2009	
3	Financial Plan	Actual	Actual	Actual	Actual	
31	Balance Sheet (Mil.$)					
32	Assets					
33	Current Assets					
34	Cash & Equivalents	$8.56	$13.97	$15.34	$17.75	
35	Receivables	$41.63	$49.52	$57.37	$68.91	
36	Inventories	$52.11	$60.94	$73.49	$86.32	
37	Total Current Assets	$102.30	$124.43	$146.20	$172.98	
38						
39	Property, Plant & Equip. (PPE	$663.29	$846.39	$910.34	$958.31	
40	Accumulated Depreciation	$189.20	$201.59	$216.17	$234.54	
41	Net PPE	$474.09	$644.80	$694.17	$723.77	
42						
43	Total Assets	$576.39	$769.23	$840.37	$896.75	
44						
45	Liabilities and Shareholders' Equity					
46	Current Liabilities					
47	Accounts Payable	$62.46	$90.48	$134.32	$174.57	
48	Short-term Debt	$202.12	$307.87	$304.96	$312.85	
49	Total Current Liabilities	$264.58	$398.35	$439.28	$487.42	
50						
51	Long-term Debt	$40.00	$55.74	$62.15	$17.69	
52	Total Liabilities	$304.58	$454.09	$501.43	$505.11	
53						
54	Shareholders' Equity					
55	Paid-in Capital	$180.00	$205.00	$210.00	$240.00	
56	Retained Earnings	$91.81	$110.14	$128.94	$151.64	
57	Total Shareholders' Equity	$271.81	$315.14	$338.94	$391.64	
58						
59	Total Liab. & Share. Equity	$576.39	$769.23	$840.37	$896.75	
60						
61	Debt / (Debt + Equity)	47.1%	53.6%	52.0%	45.8%	
62	Market Price / Share	$94.58	$99.12	$103.47	$114.95	
63	External Funds Needed		$146.49	$8.50	($6.57)	

Chapter 17 Du Pont System Of Ratio Analysis

17.1 Basics

Problem. A company's Net Profit is $170, Pretax Profit is $260, EBIT is $470, Sales is $4,600, Assets is $4,200, and Equity is $4,300. Calculate the company's ROE and decompose the ROE into its components using the Du Pont System.

FIGURE 17.1 Excel Model of Du Pont System of Ratio Analysis - Basics.



The ROE = 4.0%. The decomposition helps us see where this comes from. Here is an intuitive interpretation of the components:

- Net Profit / Pretax = 65.4% is a tax-burden ratio.
- Pretax Profits / EBIT = 55.3% is an interest-burden ratio.
- EBIT / Sales = 10.2% is the profit margin.
- Sales / Assets = 109.5% is the asset turnover.
- Asset / Equity = 97.7% is the leverage ratio.

Problems

1. A company's Net Profit is $82, Pretax Profit is $153, EBIT is $583, Sales is $3,740, Assets is $5,460, and Equity is $7,230. Calculate the company's ROE and decompose the ROE into its components using the Du Pont System.

2. A company's Net Profit is $265, Pretax Profit is $832, EBIT is $1,045, Sales is $5,680, Assets is $7,620, and Equity is $9,730. Calculate the company's ROE and decompose the ROE into its components using the Du Pont System.

Chapter 18 Life-Cycle Financial Planning

18.1 Basics

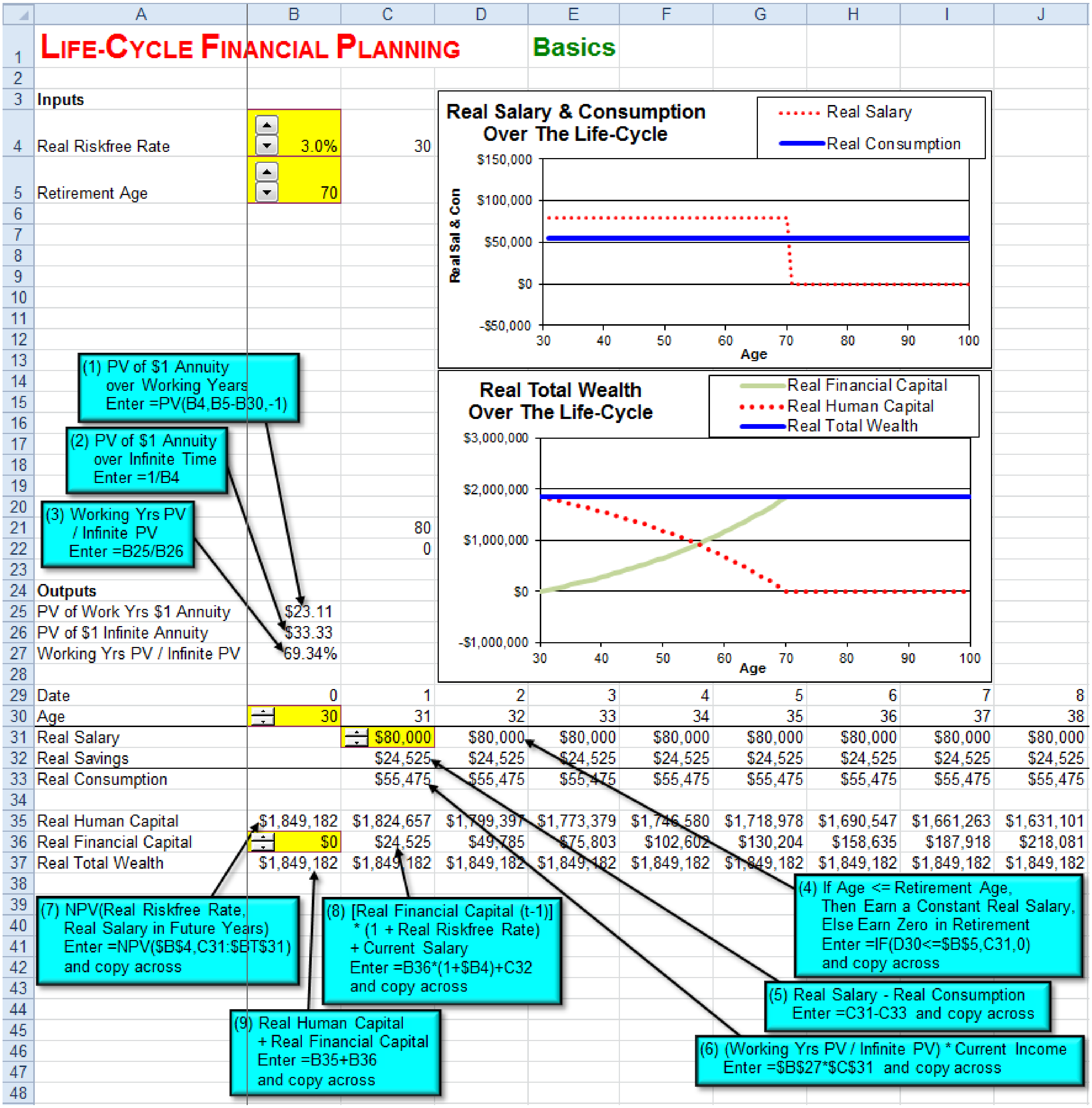
Problem. Suppose that you are currently 30 years old and expect to earn a constant real salary of $80,000 starting next year. You are planning to retire at age 70. You currently have $0 in financial capital. You are limited to investing in the riskfree asset. The real riskfree rate is 2.8%. Develop a financial plan for real savings and real consumption over your lifetime.

Solution Strategy. Develop a financial plan on a year-by-year basis over an entire lifetime. During your working years, divide your salary each year between current consumption and savings to provide for consumption during your retirement years. Put savings in a retirement fund that is invested at the riskfree rate. During your retirement years, your salary is zero, but you are able to consume each year by withdrawing money from your retirement fund. Calculate a constant level of real consumption that can be sustained in both working years and retirement years. Since there is substantial uncertainty about how long you will actually live and since it's not a good idea to run out of money, calculate real consumption based on infinite annuity. This level of real consumption can be sustained indefinitely. Finally, analyze human capital, financial capital, and total wealth over your lifetime.

Life Expectancy. How long will you live? For the US in 2007, the average age of death ("life expectancy at birth") was 78. Also in 2007, the average age of death by those 65 or older ("life expectancy at 65") was 84. Life expectancy at birth and at age 65 have both increased by approximately 1 year over the prior 5 years due to medical and health progress. By simply extrapolating this trend into the future, the next 60 years would add 12 years to life expectancy. So life expectancy at birth would rise to 90 and life expectancy at 65 would rise to 96. So averaging between those two figures, today's typical 30 year old might expect to live to 93. This is a very conservative forecast in the sense that medical and health progress is likely to accelerate, rather than just maintain the current rate of improvement.

To determine your individual life expectancy, add to (or subtract from) 93 based on your individual health-conscious practices. Not smoking adds nine years. Aerobic exercising and getting seven to eight hours of sleep per night adds three years. A healthy diet and maintaining a desirable weight based on your height adds three years. A thorough annual medical exam to catch cancer and other health problems early adds two years. The following six items add one year each: (1) daily aspirin to reduce fatal heart attacks, (2) preventing high blood pressure, (3) avoiding accidents, (4) getting immunized against pneumonia and influenza, (5) avoiding suicide and AIDS, and (6) avoiding heavy alcohol consumption. For more information on the factors effecting longevity and the long-run impact of scientific and medical progress, visit George Webster's web site at: www.george-webster.com.

FIGURE 18.1 Excel Model of Life-Cycle Financial Planning - Basics.



	A	B	C	D	E	F	G	H	I	J
1	LIFE-CYCLE FINANCIAL PLANNING			Basics						
3	Inputs									
4	Real Riskfree Rate	3.0%	30							
5	Retirement Age	70								
21			80							
22			0							
24	Outputs									
25	PV of Work Yrs $1 Annuity	$23.11								
26	PV of $1 Infinite Annuity	$33.33								
27	Working Yrs PV / Infinite PV	69.34%								
29	Date	0	1	2	3	4	5	6	7	8
30	Age	30	31	32	33	34	35	36	37	38
31	Real Salary		$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000
32	Real Savings		$24,525	$24,525	$24,525	$24,525	$24,525	$24,525	$24,525	$24,525
33	Real Consumption		$55,475	$55,475	$55,475	$55,475	$55,475	$55,475	$55,475	$55,475
35	Real Human Capital	$1,849,182	$1,824,657	$1,799,397	$1,773,379	$1,746,580	$1,718,978	$1,690,547	$1,661,263	$1,631,101
36	Real Financial Capital	$0	$24,525	$49,785	$75,803	$102,602	$130,204	$158,635	$187,918	$218,081
37	Real Total Wealth	$1,849,182	$1,849,182	$1,849,182	$1,849,182	$1,849,182	$1,849,182	$1,849,182	$1,849,182	$1,849,182

FIGURE 18.2 Transition from Working Years to Retirement Years.

	A	AN	AO	AP	AQ	AR
29	Date	38	39	40	41	42
30	Age	68	69	70	71	72
31	Real Salary	$80,000	$80,000	$80,000	$0	$0
32	Real Savings	$24,525	$24,525	$24,525	-$55,475	-$55,475
33	Real Consumption	$55,475	$55,475	$55,475	$55,475	$55,475
34						
35	Real Human Capital	$153,078	$77,670	$0	$0	$0
36	Real Financial Capital	$1,696,104	$1,771,512	$1,849,182	$1,849,182	$1,849,182
37	Real Total Wealth	$1,849,182	$1,849,182	$1,849,182	$1,849,182	$1,849,182

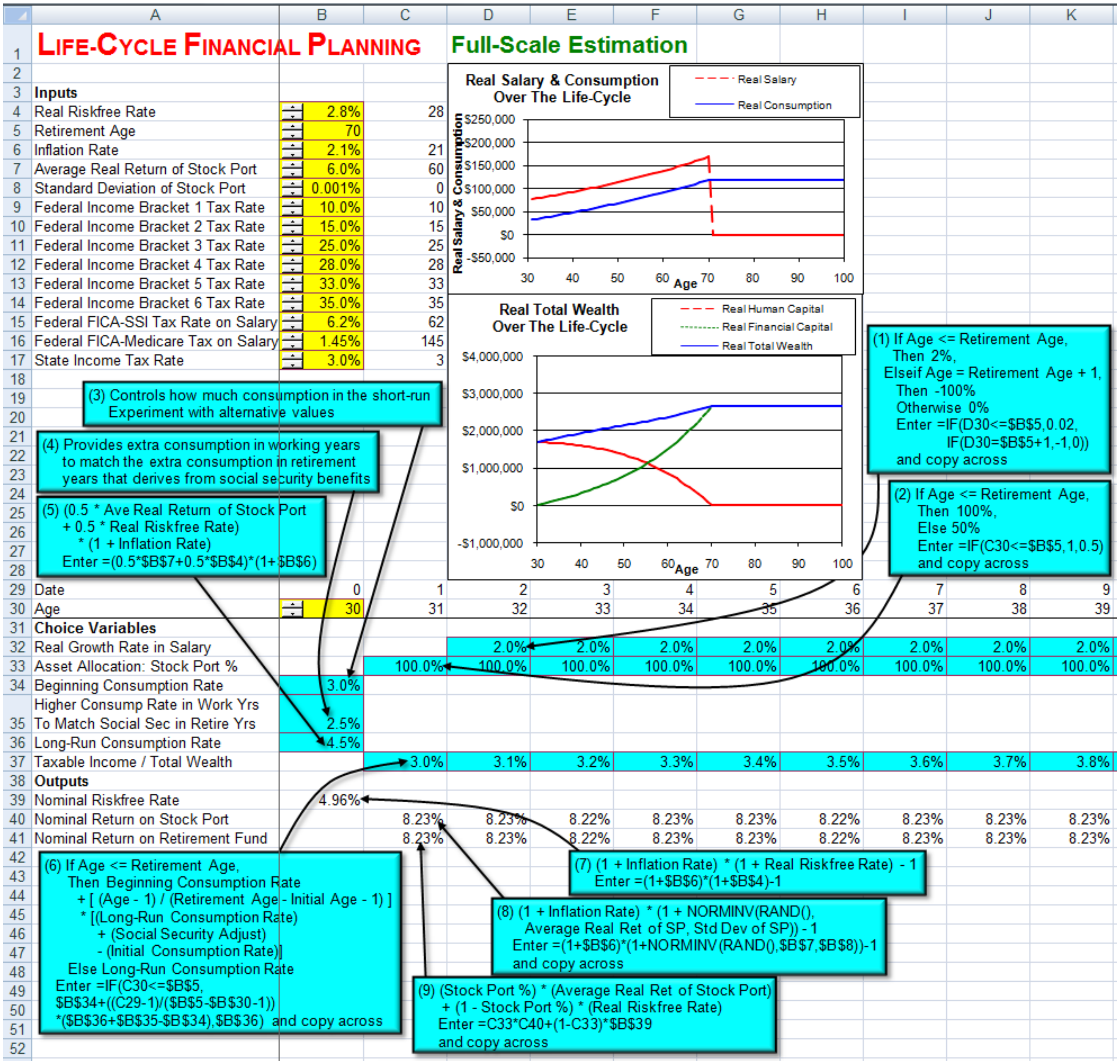
From the first graph, we see that your Real Salary from working years only is used to support a constant level of Real Consumption over an "infinite" lifetime. By using this approach, the same level of Real Consumption can be sustained even if you end up living much longer than originally anticipated. From the second graph, we see that Real Total Wealth is constant over a lifetime. At date 0, Real Total Wealth comes entirely from Real Human Capital, which is the present value of all future Real Salary. Over time Real Human Capital declines and Real Financial Capital builds up. After retirement, Real Total Wealth comes entirely from Real Financial Capital.

18.2 Full-Scale Estimation

Problem. Suppose that you are currently 30 years old and expect to earn a constant real salary of $80,000 starting next year. You are planning to retire at age 70. You currently have $0 in financial capital. You can invest in the riskfree asset or a broad stock portfolio. The inflation rate is 2.1% and the real riskfree rate is 2.8%. A broad stock portfolio offers an average real return of 6.0% and a standard deviation of 17.0%. Suppose that federal income taxes have six brackets with the following rates: 10.0%, 15.0%, 25.0%, 28.0%, 33.0%, and 35.0%. For current year, the upper cutoffs on the first five brackets are $7,550, $30,650, $74,200, $154,800, and $336,550 and these cutoffs are indexed to inflation. The state tax rate is 3.0%, federal FICA-SSI tax rate on salary up to $97,500 is 6.2%, and the federal FICA-Medicare tax rate on any level of salary is 1.45%. The current level of social security benefits is $34,368 per year and this is indexed to inflation. Develop a financial plan for real savings and real consumption over your lifetime.

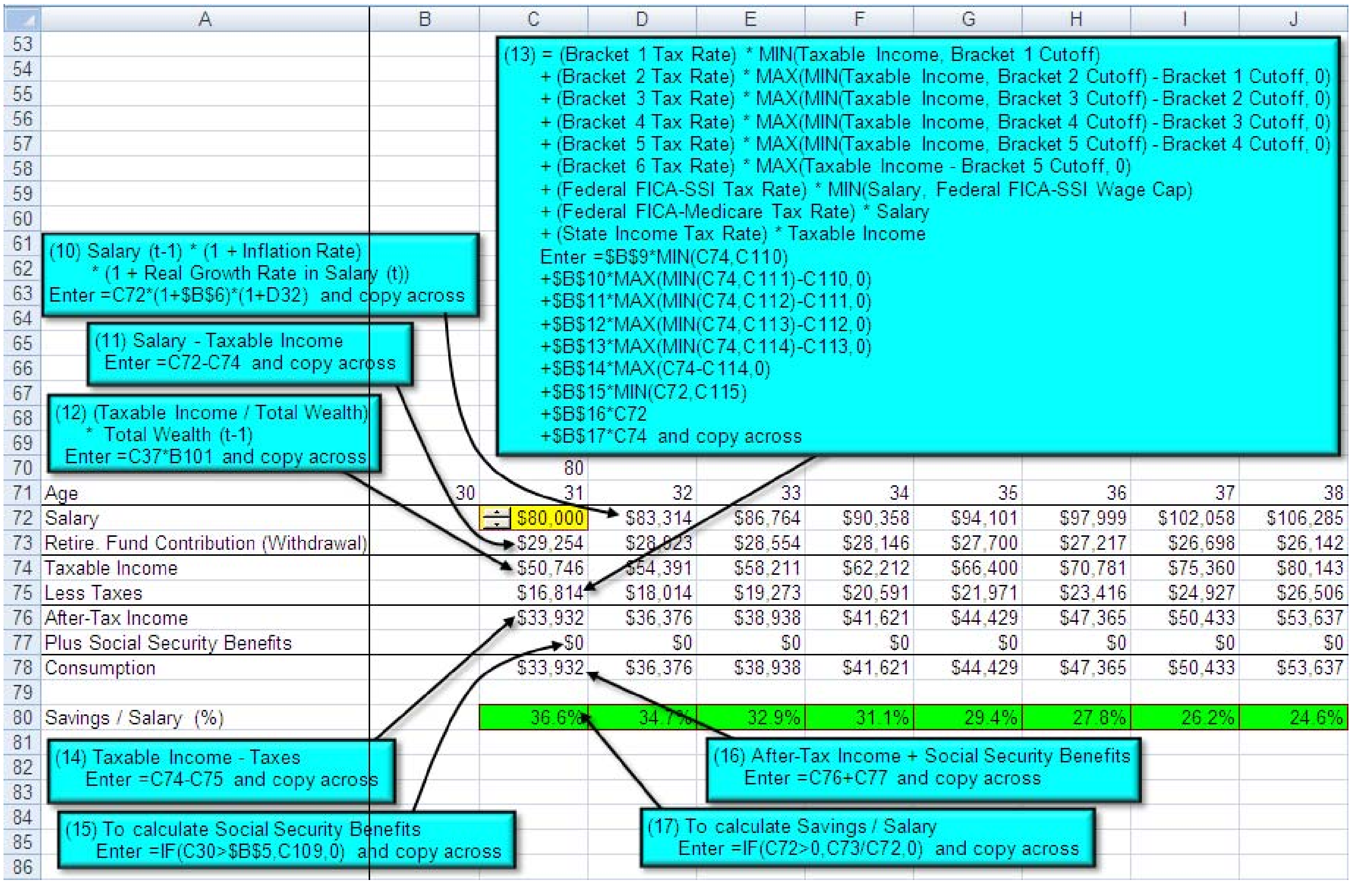
Solution Strategy. The full-scale Excel model of life-cycle financial planning adds consideration of inflation, taxes, social security, and the opportunity to invest in a broad stock index. It is assumed that your savings are put in a tax-deferred retirement fund. You pay zero taxes on contributions to the retirement fund during your working years. But you have to pay taxes on withdrawals from the retirement fund during your retirement years. This Excel model includes several *choice variables*. You need to choose your Real Growth Rate in Salary. You need to choose your Taxable Income / Total Wealth. Specifying taxable income as a percentage of total wealth indirectly determines your consumption and savings as a percentage of total wealth. You also need to choose your Asset Allocation: Stock Portfolio %, that is, what percentage of your savings to invest in the broad stock portfolio. Investing in the broad stock portfolio will give you higher average returns than the riskfree asset, but also more risk. The balance of your savings will be invested in the riskfree asset and will grow at the riskfree rate.

FIGURE 18.3 Excel Model of Life-Cycle Fin Plan – Full-Scale Estimation.



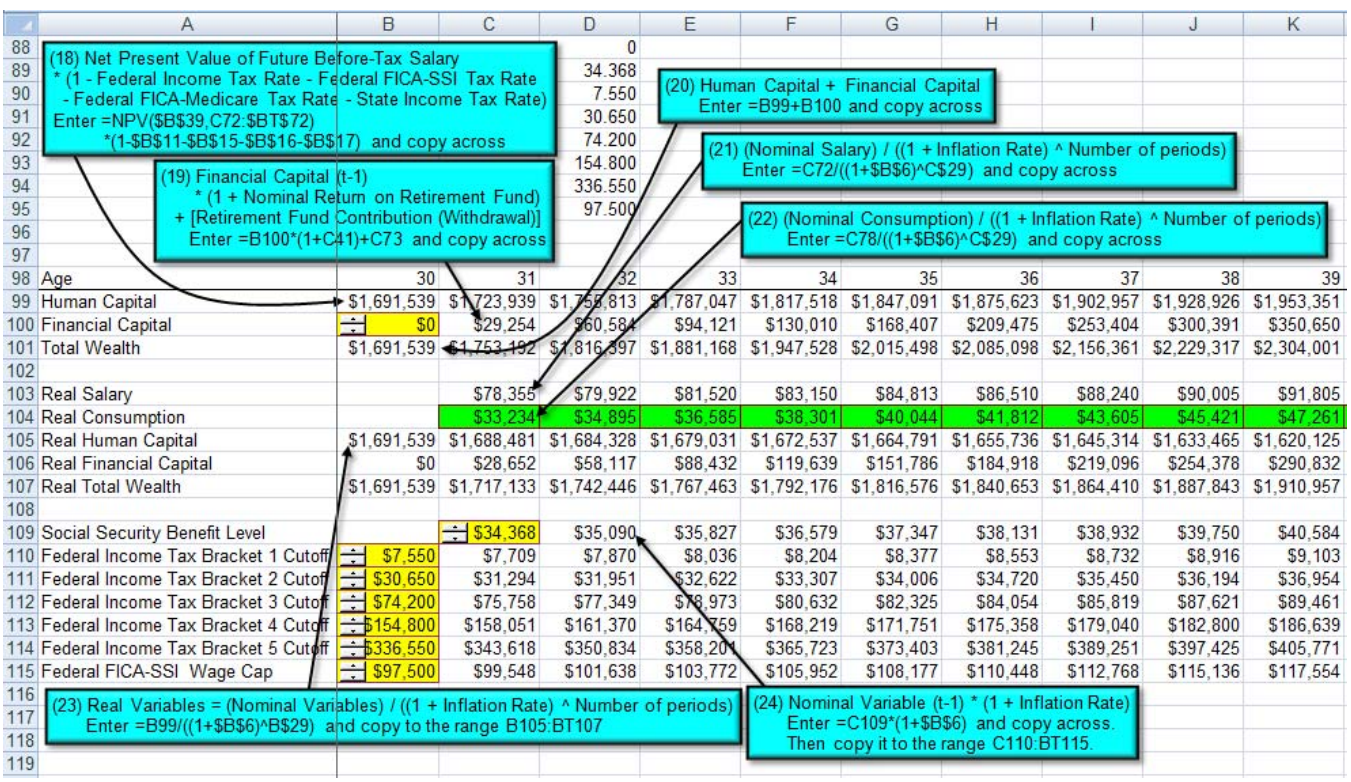
Row	A	B	C	D	E	F	G	H	I	J	K
3	**Inputs**										
4	Real Riskfree Rate	2.8%	28								
5	Retirement Age	70									
6	Inflation Rate	2.1%	21								
7	Average Real Return of Stock Port	6.0%	60								
8	Standard Deviation of Stock Port	0.001%	0								
9	Federal Income Bracket 1 Tax Rate	10.0%	10								
10	Federal Income Bracket 2 Tax Rate	15.0%	15								
11	Federal Income Bracket 3 Tax Rate	25.0%	25								
12	Federal Income Bracket 4 Tax Rate	28.0%	28								
13	Federal Income Bracket 5 Tax Rate	33.0%	33								
14	Federal Income Bracket 6 Tax Rate	35.0%	35								
15	Federal FICA-SSI Tax Rate on Salary	6.2%	62								
16	Federal FICA-Medicare Tax on Salary	1.45%	145								
17	State Income Tax Rate	3.0%	3								
29	Date	0	1	2	3	4	5	6	7	8	9
30	Age	30	31	32	33	34	35	36	37	38	39
31	**Choice Variables**										
32	Real Growth Rate in Salary			2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
33	Asset Allocation: Stock Port %		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
34	Beginning Consumption Rate	3.0%									
35	Higher Consump Rate in Work Yrs To Match Social Sec in Retire Yrs	2.5%									
36	Long-Run Consumption Rate	4.5%									
37	Taxable Income / Total Wealth		3.0%	3.1%	3.2%	3.3%	3.4%	3.5%	3.6%	3.7%	3.8%
38	**Outputs**										
39	Nominal Riskfree Rate	4.96%									
40	Nominal Return on Stock Port		8.23%	8.23%	8.22%	8.23%	8.23%	8.22%	8.23%	8.23%	8.23%
41	Nominal Return on Retirement Fund		8.23%	8.23%	8.22%	8.23%	8.23%	8.22%	8.23%	8.23%	8.23%

FIGURE 18.4 Excel Model of Life-Cycle Fin Plan – Full-Scale Estimation.



	A	B	C	D	E	F	G	H	I	J
70			80							
71	Age	30	31	32	33	34	35	36	37	38
72	Salary		$80,000	$83,314	$86,764	$90,358	$94,101	$97,999	$102,058	$106,285
73	Retire. Fund Contribution (Withdrawal)		$29,254	$28,823	$28,554	$28,146	$27,700	$27,217	$26,698	$26,142
74	Taxable Income		$50,746	$54,391	$58,211	$62,212	$66,400	$70,781	$75,360	$80,143
75	Less Taxes		$16,814	$18,014	$19,273	$20,591	$21,971	$23,416	$24,927	$26,506
76	After-Tax Income		$33,932	$36,376	$38,938	$41,621	$44,429	$47,365	$50,433	$53,637
77	Plus Social Security Benefits		$0	$0	$0	$0	$0	$0	$0	$0
78	Consumption		$33,932	$36,376	$38,938	$41,621	$44,429	$47,365	$50,433	$53,637
80	Savings / Salary (%)		36.6%	34.7%	32.9%	31.1%	29.4%	27.8%	26.2%	24.6%

FIGURE 18.5 Excel Model of Life-Cycle Fin Plan – Full-Scale Estimation.



	A	B	C	D	E	F	G	H	I	J	K
88				0							
89				34.368							
90				7.550							
91				30.650							
92				74.200							
93				154.800							
94				336.550							
95				97.500							
98	Age	30	31	32	33	34	35	36	37	38	39
99	Human Capital	$1,691,539	$1,723,939	$1,755,813	$1,787,047	$1,817,518	$1,847,091	$1,875,623	$1,902,957	$1,928,926	$1,953,351
100	Financial Capital	$0	$29,254	$60,584	$94,121	$130,010	$168,407	$209,475	$253,404	$300,391	$350,650
101	Total Wealth	$1,691,539	$1,753,192	$1,816,397	$1,881,168	$1,947,528	$2,015,498	$2,085,098	$2,156,361	$2,229,317	$2,304,001
103	Real Salary		$78,355	$79,922	$81,520	$83,150	$84,813	$86,510	$88,240	$90,005	$91,805
104	Real Consumption		$33,234	$34,895	$36,585	$38,301	$40,044	$41,812	$43,605	$45,421	$47,261
105	Real Human Capital	$1,691,539	$1,688,481	$1,684,328	$1,679,031	$1,672,537	$1,664,791	$1,655,736	$1,645,314	$1,633,465	$1,620,125
106	Real Financial Capital	$0	$28,652	$58,117	$88,432	$119,639	$151,786	$184,918	$219,096	$254,378	$290,832
107	Real Total Wealth	$1,691,539	$1,717,133	$1,742,446	$1,767,463	$1,792,176	$1,816,576	$1,840,653	$1,864,410	$1,887,843	$1,910,957
109	Social Security Benefit Level		$34,368	$35,090	$35,827	$36,579	$37,347	$38,131	$38,932	$39,750	$40,584
110	Federal Income Tax Bracket 1 Cutoff	$7,550	$7,709	$7,870	$8,036	$8,204	$8,377	$8,553	$8,732	$8,916	$9,103
111	Federal Income Tax Bracket 2 Cutoff	$30,650	$31,294	$31,951	$32,622	$33,307	$34,006	$34,720	$35,450	$36,194	$36,954
112	Federal Income Tax Bracket 3 Cutoff	$74,200	$75,758	$77,349	$78,973	$80,632	$82,325	$84,054	$85,819	$87,621	$89,461
113	Federal Income Tax Bracket 4 Cutoff	$154,800	$158,051	$161,370	$164,759	$168,219	$171,751	$175,358	$179,040	$182,800	$186,639
114	Federal Income Tax Bracket 5 Cutoff	$336,550	$343,618	$350,834	$358,201	$365,723	$373,403	$381,245	$389,251	$397,425	$405,771
115	Federal FICA-SSI Wage Cap	$97,500	$99,548	$101,638	$103,772	$105,952	$108,177	$110,448	$112,768	$115,136	$117,554

FIGURE 18.6 Transition From Working To Retirement Years.

	A	AN	AO	AP	AQ	AR
29	Date	38	39	40	41	42
30	Age	68	69	70	71	72
31	**Choice Variables**					
32	Real Growth Rate in Salary	2.0%	2.0%	2.0%	-100.0%	0.0%
33	Asset Allocation: Stock Port %	100.0%	100.0%	100.0%	50.0%	50.0%
34	Beginning Consumption Rate					
35	Higher Consump Rate in Work Yrs To Match Social Sec in Retire Yrs					
36	Long-Run Consumption Rate					
37	Taxable Income / Total Wealth	6.8%	6.9%	7.0%	4.5%	4.5%
38	**Outputs**					
39	Nominal Riskfree Rate					
40	Nominal Return on Stock Port	8.23%	8.23%	8.23%	8.23%	8.22%
41	Nominal Return on Retirement Fund	8.23%	8.23%	8.23%	6.59%	6.59%
42						
70						
71	Age	68	69	70	71	72
72	Salary	$359,128	$374,003	$389,494	$0	$0
73	Retire. Fund Contribution (Withdrawl)	-$15,466	-$19,060	-$23,015	-$274,181	-$279,940
74	Taxable Income	$374,594	$393,063	$412,509	$274,181	$279,940
75	Less Taxes	$123,841	$130,364	$137,242	$71,706	$73,212
76	After-Tax Income	$250,753	$262,698	$275,267	$202,475	$206,727
77	Plus Social Security Benefits	$0	$0	$0	$78,919	$80,577
78	Consumption	$250,753	$262,698	$275,267	$281,395	$287,304
79						
80	Savings / Salary (%)	-4.3%	-5.1%	-5.9%	0.0%	0.0%
81						
97						
98	Age	68	69	70	71	72
99	Human Capital	$456,816	$238,798	$0	$0	$0
100	Financial Capital	$5,247,985	$5,660,592	$6,103,227	$6,231,408	$6,362,232
101	Total Wealth	$5,704,801	$5,899,390	$6,103,227	$6,231,408	$6,362,232
102						
103	Real Salary	$163,031	$166,292	$169,618	$0	$0
104	Real Consumption	$113,833	$116,803	$119,874	$120,022	$120,022
105	Real Human Capital	$207,378	$106,176	$0	$0	$0
106	Real Financial Capital	$2,382,398	$2,516,853	$2,657,846	$2,657,852	$2,657,837
107	Real Total Wealth	$2,589,777	$2,623,029	$2,657,846	$2,657,852	$2,657,837
108						
109	Social Security Benefit Level	$74,149	$75,706	$77,296	$78,919	$80,577
110	Federal Income Tax Bracket 1 Cutoff	$16,631	$16,981	$17,337	$17,701	$18,073
111	Federal Income Tax Bracket 2 Cutoff	$67,516	$68,934	$70,382	$71,860	$73,369
112	Federal Income Tax Bracket 3 Cutoff	$163,449	$166,881	$170,386	$173,964	$177,617
113	Federal Income Tax Bracket 4 Cutoff	$340,996	$348,157	$355,468	$362,933	$370,555
114	Federal Income Tax Bracket 5 Cutoff	$741,358	$756,926	$772,822	$789,051	$805,621
115	Federal FICA-SSI Wage Cap	$214,775	$219,285	$223,890	$228,591	$233,392

As you adapt this model to your own situation, it is not necessary to go from full-time work to zero work. You could consider retiring to part-time work and then gradually tapering off. For example, you could drop to half-time work by setting your Real Growth in Salary to **-50%** in your first retirement year and then set your Real Growth in Salary to **-100.0%** in the year that you stop working entirely.

It is assumed that the Real Return on Broad Stock Portfolio is normally distributed with the average return given in cell **B7** and the standard deviation given in cell **B8**. The Excel function **RAND()** generates a random variable with a uniform distribution over the interval from 0 to 1 (that is, with an equal chance of getting any number between 0 and 1). To transform this uniformly distributed random variable into a normally distributed one, just place **RAND()** inside the Excel function **NORMINV**.[8]

The Human Capital computation make a fairly rough adjustment for taxes, but the year-by-year cash flow analysis has a more sophisticated calculation of taxes. The reason for doing it this way (as opposed to present valuing the After-Tax Income row) is that this approach avoids generating circular references

It doesn't make any sense to live like a king in your working years and then live in poverty in your retirement years. Similarly, it doesn't make sense to live in poverty in your working years and live like a king in your retirement years. The key idea is that you want to have a smooth pattern of real consumption over the life-cycle. Setting Taxable Income as a percentage of Total Wealth does a good job of delivering a smooth pattern. The only tricky part is when social security kicks in. Looking at the graph of Real Consumption, you should see a smooth pattern with no jump up or down at your retirement date. Notice that Taxable Income / Total Wealth is 7.0% in cell **AP37** and 4.5% the next year in cell **AQ37**, which is an adjustment of 2.5%. In other words, the drop in Taxable Income is offset by addition of Social Security Benefits (which are NOT taxable). Notice that Real Consumption transitions smoothly from $119,874 in cell **AP104** to $120,022 in cell **AQ104**. The Higher Consumption in Working Years of 2.5% in cell **B35** works well for the default input values of this Excel model. When you change input values, you may need to change the adjustment. Manually adjust the value in cell **B35** in small increments until the graph of Real Consumption shows a smooth pattern with no jump at the retirement date.

Since the standard deviation (risk) in cell **B8** is virtually zero, the results we see in the two graphs are based on *average returns*. Starting with the second graph, we see that Real Human Capital starts at $1.7 million and declines smoothly to $0 at retirement. Real Financial Capital starts at $0, rises smoothly to $2.7

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[8] The "Transformation Method" for converting a uniform random variable x into some other random variable y based on a cumulative distribution F is $y(x) = F^{-1}(x)$. See Press, W., B. Flannery, S. Teukolsky, and W. Vetterling, 1987, Numerical Recopies: The Art of Scientific Computing, Cambridge University Press, chapter on Random Numbers, subsection on the Transformation Method, page 201.

million at retirement, and then stays constant at that level. Turning to the first graph, Real Consumption starts at $33,234, rises smoothly to $120,022 at retirement, and then stays constant at that level.

How much saving does it take to reach such a comfortable lifestyle? Savings starts at 36.6% of salary at age 31 and gradually tapers off. Clearly, a lot of saving is required to live so well in retirement.

Now let's consider the risk involved. Change the standard deviation to a realistic figure. Enter **17.000%** in cell **B8**. The random variables in rows **40** and **41** spring to life and the graph of real consumption over the life-cycle reflect the high or low realizations of the broad stock portfolio. Press the function key **F9** and the Excel model is recalculated. You see a new realization of real consumption on the first graph. The three figures below show: (a) a low real consumption case due to low stock returns, (b) a medium real consumption case due to medium stock returns, and (c) a high real consumption case due to high stock returns.

FIGURE 18.7 Low Real Consumption Due To Low Stock Returns.

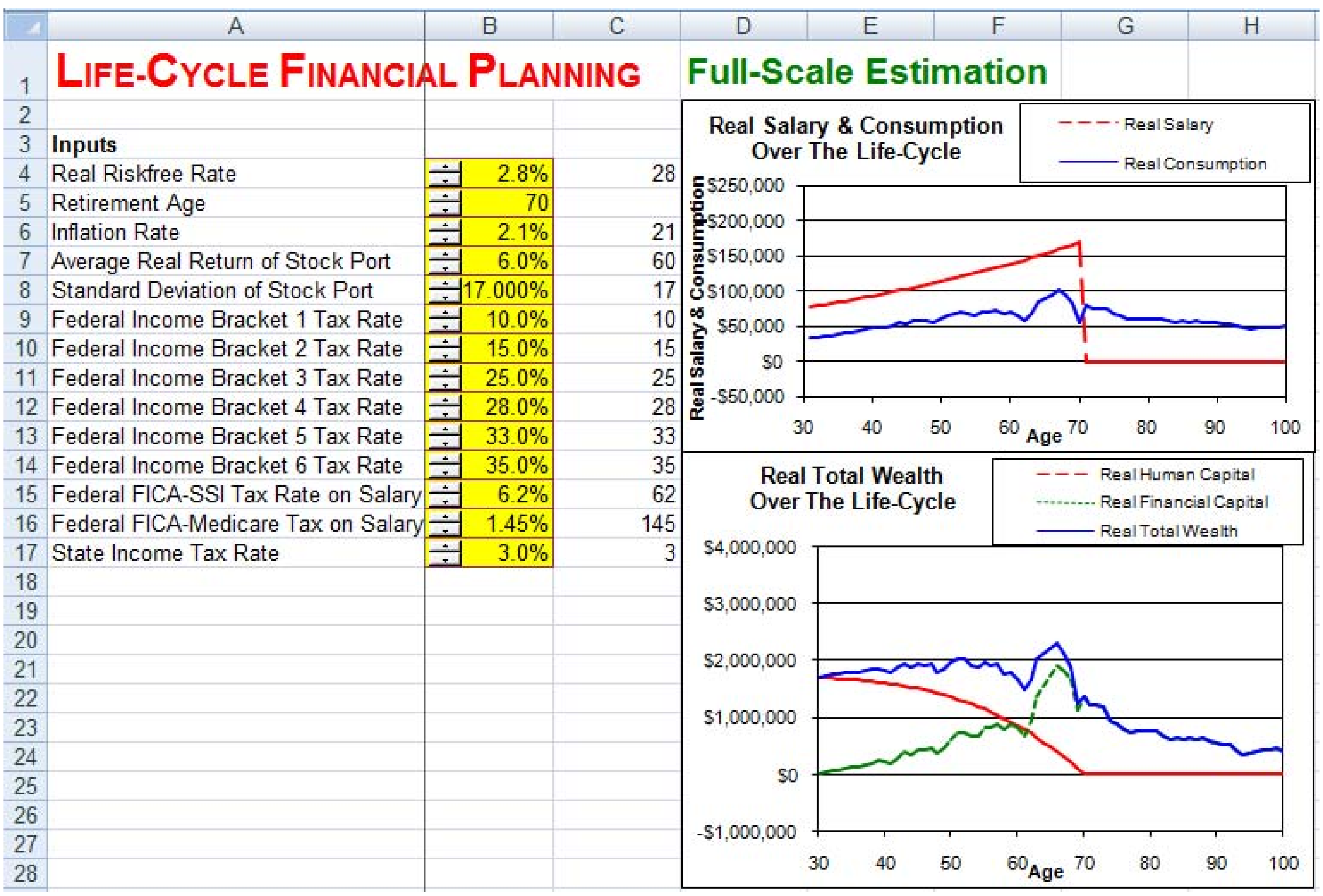


FIGURE 18.8 Medium Real Consumption Due To Medium Stock Returns.

	A	B	C
1	LIFE-CYCLE FINANCIAL PLANNING		
2			
3	**Inputs**		
4	Real Riskfree Rate	2.8%	28
5	Retirement Age	70	
6	Inflation Rate	2.1%	21
7	Average Real Return of Stock Port	6.0%	60
8	Standard Deviation of Stock Port	17.000%	17
9	Federal Income Bracket 1 Tax Rate	10.0%	10
10	Federal Income Bracket 2 Tax Rate	15.0%	15
11	Federal Income Bracket 3 Tax Rate	25.0%	25
12	Federal Income Bracket 4 Tax Rate	28.0%	28
13	Federal Income Bracket 5 Tax Rate	33.0%	33
14	Federal Income Bracket 6 Tax Rate	35.0%	35
15	Federal FICA-SSI Tax Rate on Salary	6.2%	62
16	Federal FICA-Medicare Tax on Salary	1.45%	145
17	State Income Tax Rate	3.0%	3

Full-Scale Estimation

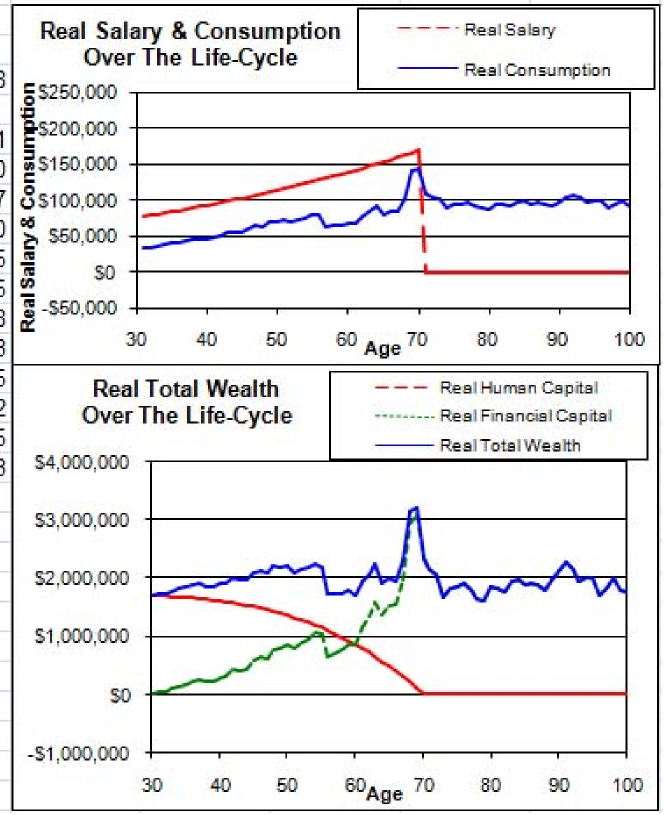
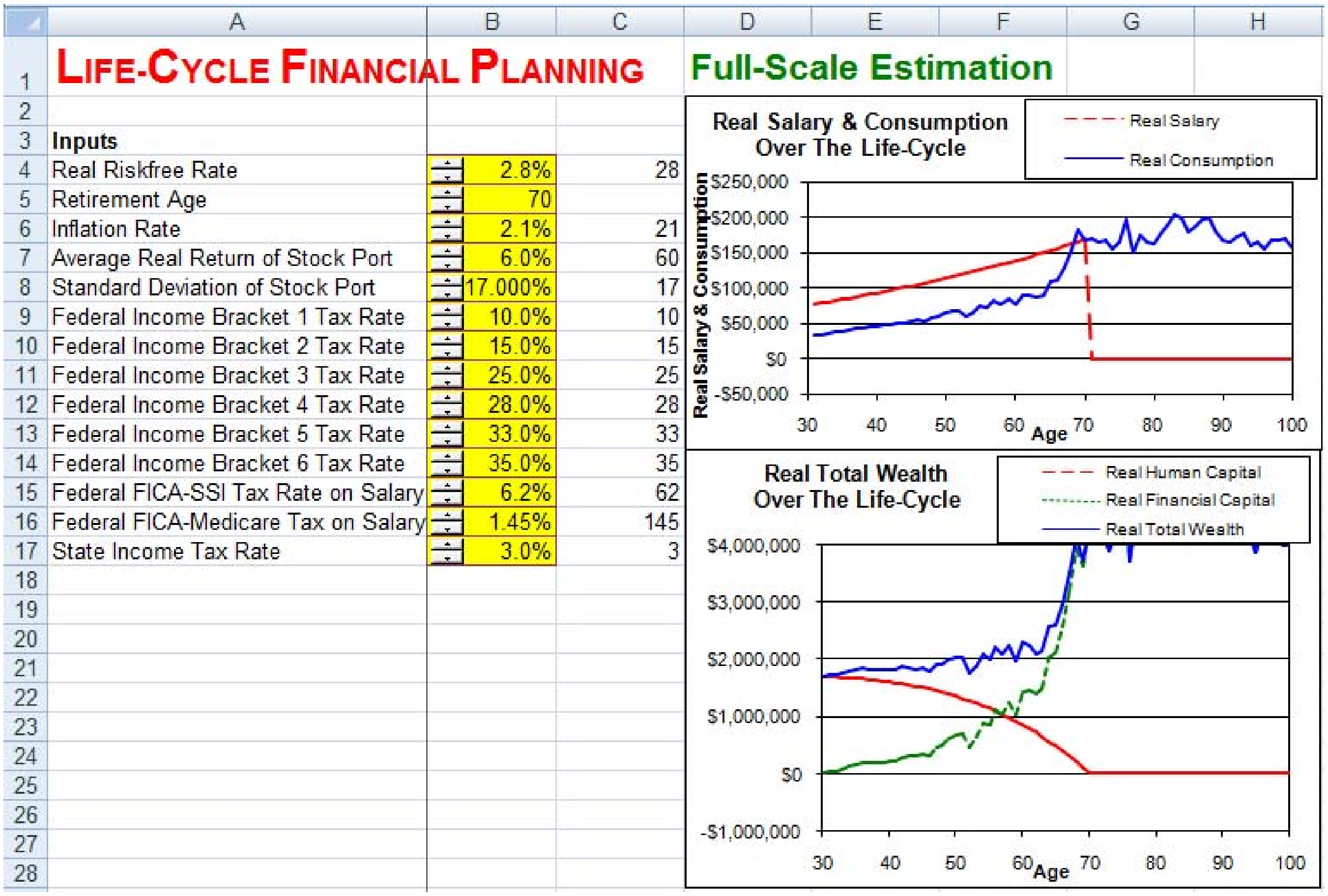


FIGURE 18.9 High Real Consumption Due To High Stock Returns.



These three graphs are "representative" of the risk you face from being heavily invested in the broad stock portfolio. In the low case, real consumption drops to about $50,000. In the medium case, real consumption fluctuates around $100,000. In the high case, real consumption fluctuates between $150,000 and $200,000. Clearly, there is substantial risk from being so heavily exposed to the broad stock portfolio.

Now that we have completed the Excel model, it is time for you to explore. Click on the spin buttons to change the inputs and/or edit the values of the choice variables and see the implications for lifetime real consumption and real total wealth. For example, if you are uncomfortable with the amount of risk implied by the three figures above, consider more conservative strategies. Many investors reduce stock exposure in retirement years to little or nothing.

A key driver in the model is the Beginning Consumption Rate in cell **B34**. Raise this value and there will be more real consumption in early working years and less real consumption in retirement years. Lower this value and it will tilt in the opposite direction.

Play around with the choice variables and have fun exploring your lifetime opportunities. Enjoy!

Problems

1. Suppose that you are currently 28 years old and expect to earn a constant real salary of $64,000 starting next year. You are planning to work for 32 years and then retire. You currently have $0 in financial capital. You are limited to investing in the riskfree asset. The real riskfree rate is 2.8%. Develop a financial plan for real savings and real consumption over your lifetime.

2. Suppose that you are currently 32 years old and expect to earn a constant real salary of $85,000 starting next year. You are planning to work for 25 years and then retire. You currently have $10,000 in financial capital. You can invest in the riskfree asset or a broad stock portfolio. The inflation rate is 3.4% and the real riskfree rate is 2.5%. A broad stock portfolio offers an average real return of 7.3% and a standard deviation of 25.0%. Suppose that federal income taxes have six brackets with the following rates: 10.0%, 15.0%, 27.0%, 30.0%, 35.0%, and 38.6%. For current year, the upper cutoffs on the first five brackets are $6,000, $27,950, $67,700, $141,250, and $307,050 and these cutoffs are indexed to inflation. The state tax rate is 4.5%, federal FICA-SSI tax rate on salary up to $87,000 is 6.2%, and the federal FICA-Medicare tax rate on any level of salary is 1.45%. You will start receiving social security benefits at age 66. The current level of social security benefits is $24,204 per year and this is indexed to inflation. Develop a financial plan for real savings and real consumption over your lifetime.

PART 6 INTERNATIONAL CORPORATE FINANCE

Chapter 19 International Parity

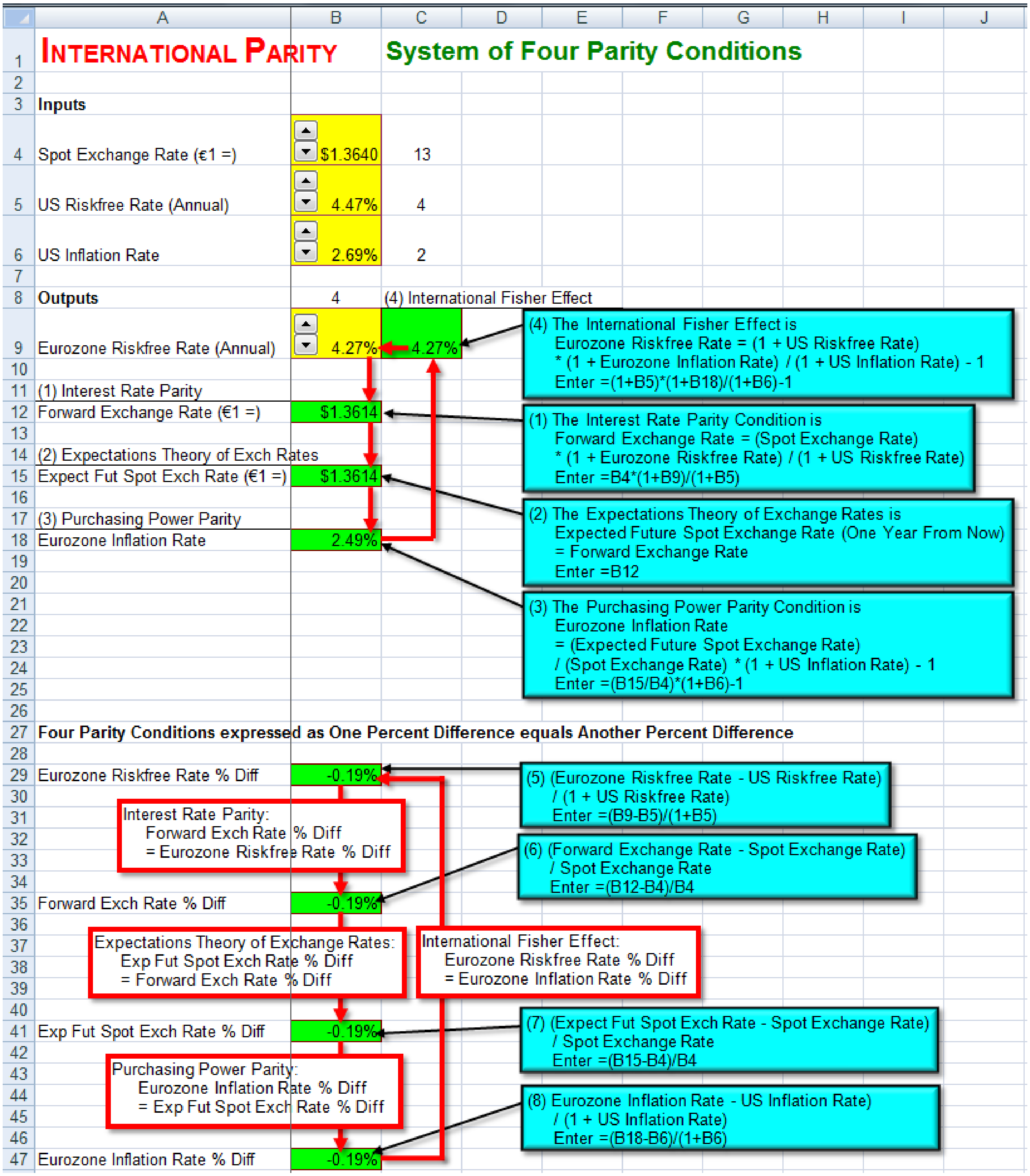
19.1 System of Four Parity Conditions

Problem. Suppose the Euro/Dollar Exchange Rate is €1 = $1.3640, the annual US riskfree rate is 4.47%, the US inflation rate is 2.69%, and the annual Eurozone riskfree rate is 4.27%. What is the one-year Forward Euro/Dollar Exchange Rate, the one-year ahead Expected Spot Euro/Dollar Exchange Rate, and Eurozone inflation rate? What is the Percent Difference in:

- the Eurozone Riskfree Rate vs. US Riskfree Rate,
- the Forward Euro/Dollar Exchange Rate vs. the Spot Rate,
- the Expected Spot Euro/Dollar Exchange Rate vs. the Spot Rate, and
- the Eurozone Inflation Rate vs. the US Inflation Rate?

Solution Strategy. Use Interest Rate Parity to determine the one-year Forward Euro/Dollar Exchange Rate. Then use the Expectations Theory of Exchange Rates to determine the one-year ahead Expected Spot Euro/Dollar Exchange Rate. Then use Purchase Power Parity to determine the Eurozone inflation rate. Finally, the International Fisher Effect to confirm the Eurozone riskfree rate. Compute the four percent differences. Under the four international parity condition, the four percent differences should be identical.

FIGURE 19.1 International Parity – System of Four Parity Conditions.



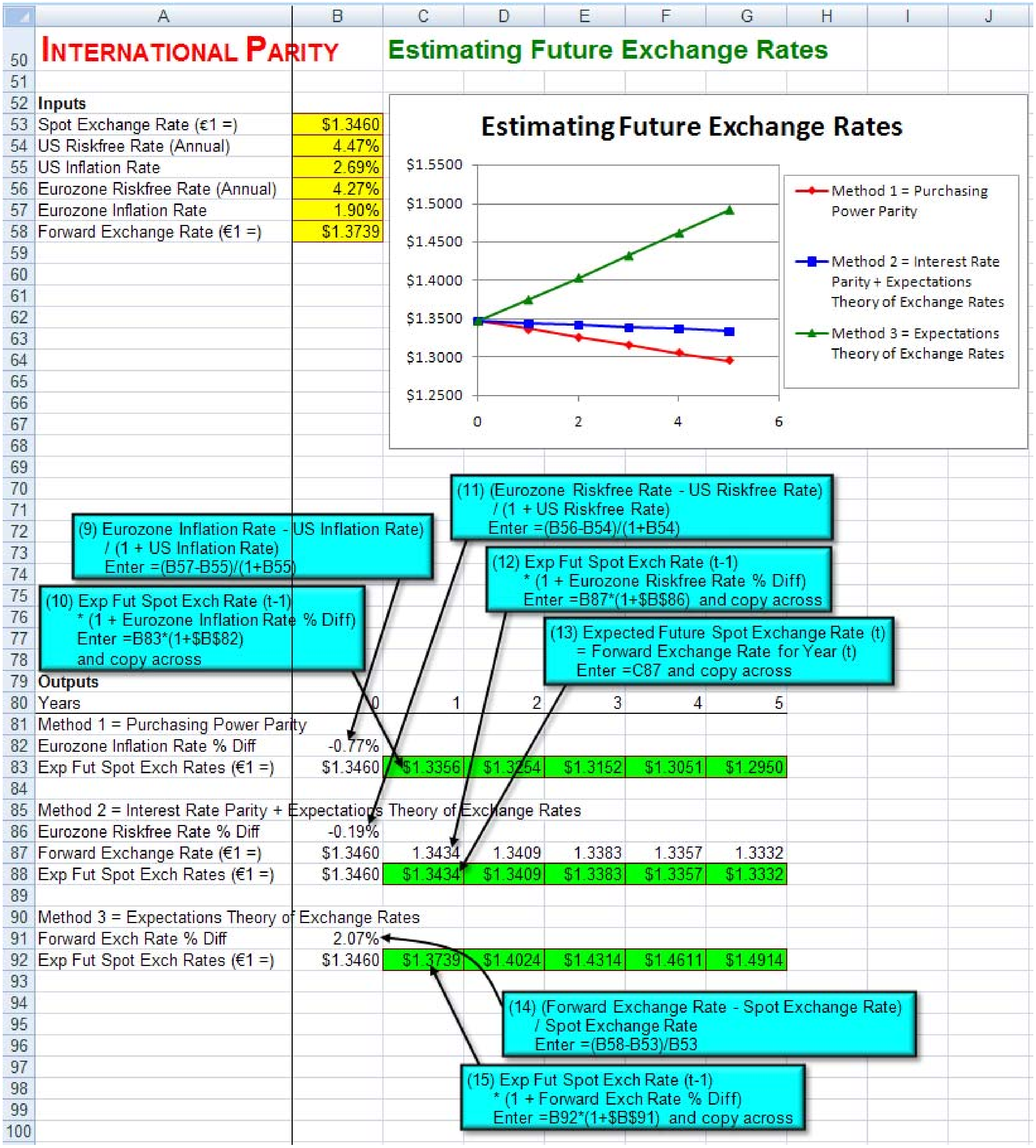
In theory, the four international parity conditions are tightly connected to each other.

19.2 Estimating Future Exchange Rates

Problem. Suppose the Euro/Dollar Exchange Rate is €1 = \$1.3640, the annual US riskfree rate is 4.47%, the US inflation rate is 2.69%, the annual Eurozone riskfree rate is 4.27%, the Eurozone inflation rate is 1.90%, and the one-year Forward Euro/Dollar Exchange Rate is €1 = \$1.3739. What will the Euro/Dollar Exchange Rate be in one-year, two-years, three-years, four-years, and five-years?

Solution. Use three different methods for forecast future exchange rates: (1) Purchasing Power Parity, (2) Interest Rate Parity + Expectations Theory of Exchange Rates, (3) Only the Expectations Theory of Exchange Rates.

FIGURE 19.2 International Parity – Estimating Future Exchange Rates.



In practice, when you use real data, the various international parity conditions yield very different forecasts of future exchange rates.

Problems

1. Suppose the Euro/Dollar Exchange Rate is €1 = \$1.283, the annual US riskfree rate is 3.61%, the US inflation rate is 2.69%, and the annual Eurozone riskfree rate is 5.39%. What is the one-year Forward Euro/Dollar Exchange Rate, the one-year ahead Expected Spot Euro/Dollar Exchange Rate, and Eurozone inflation rate? What is the Percent Difference in:
   - the Eurozone Riskfree Rate vs. US Riskfree Rate,
   - the Forward Euro/Dollar Exchange Rate vs. the Spot Rate,
   - the Expected Spot Euro/Dollar Exchange Rate vs. the Spot Rate, and
   - the Eurozone Inflation Rate vs. the US Inflation Rate?

2. Suppose the Euro/Dollar Exchange Rate is €1 = \$1.7271, the annual US riskfree rate is 6.31%, the US inflation rate is 4.52%, the annual Eurozone riskfree rate is 3.15%, the Eurozone inflation rate is 3.15%, and the one-year Forward Euro/Dollar Exchange Rate is €1 = \$1.8241. What will the Euro/Dollar Exchange Rate be in one-year, two-years, three-years, four-years, and five-years under three forecast methods: (1) purchasing power parity, (2) interest rate parity + expectations theory of exchange rates, and (3) using just the expectations theory of exchange rates?

PART 7 OPTIONS AND CORPORATE FINANCE

Chapter 20 Binomial Option Pricing

20.1 Estimating Volatility

The binomial option pricing model can certainly be used to price European calls and puts, but it can do much more. The Binomial Tree / Risk Neutral method can be extended to price *any* type of derivative security (European, American, etc.) on any underlying asset(s), with any underlying dividends or cash flows, with any derivative payoffs at maturity and/or payoffs before maturity. It is one of the most popular techniques on Wall Street for pricing and hedging derivatives.

Problem. What is the annual standard deviation of Amazon.com stock based on continuous returns?

Solution Strategy. Download three months of Amazon.com's daily stock price. Then calculate continuous returns. Finally, calculate the annual standard deviation of the continuous returns.

FIGURE 20.1 Binomial Option Pricing - Estimating Volatility.

	A	B	C	D	E	F	G	H
1	BINOMIAL OPTION PRICING					Estimating Volatility		
2								
3								
4								
5								
6	Stock:	Amazon						
7	Symbol:	AMZN						
8								
9								
10	Date	Open	High	Low	Close	Volume	Adjusted Close	Continuous Return
11	4/30/2010	$141.40	$141.40	$136.91	$137.10	6,102,200	$137.10	-3.32%
12	4/29/2010	$140.09	$142.45	$139.79	$141.73	6,314,200	$141.73	1.69%
13	4/28/2010	$142.59	$142.75	$138.69	$139.35	9,235,300	$139.35	-1.90%
14	4/27/2010	$145.55	$146.44	$141.11	$142.02	8,639,000	$142.02	-3.52%
71	2/3/2010	$117.12	$119.61	$116.56	$119.10	12,405,900	$119.10	0.83%
72	2/2/2010	$118.79	$118.98	$114.40	$118.12	23,079,700	$118.12	-0.63%
73	2/1/2010	$123.18	$124.86	$113.82	$118.87	37,774,400	$118.87	-5.36%
74	1/29/2010	$129.77	$131.85	$124.14	$125.41	29,471,300	$125.41	
75								
76				Standard Deviation (Daily)				2.02%
77				Standard Deviation (Annual)				38.67%

(1) Download three months of daily stock price data

(2) LN[(Price on date t) / (Price on date t-1)]
Enter =LN(G11/G12) and copy down

(3) Standard Deviation of the Daily Return Series
Enter =STDEV(H11:H73)

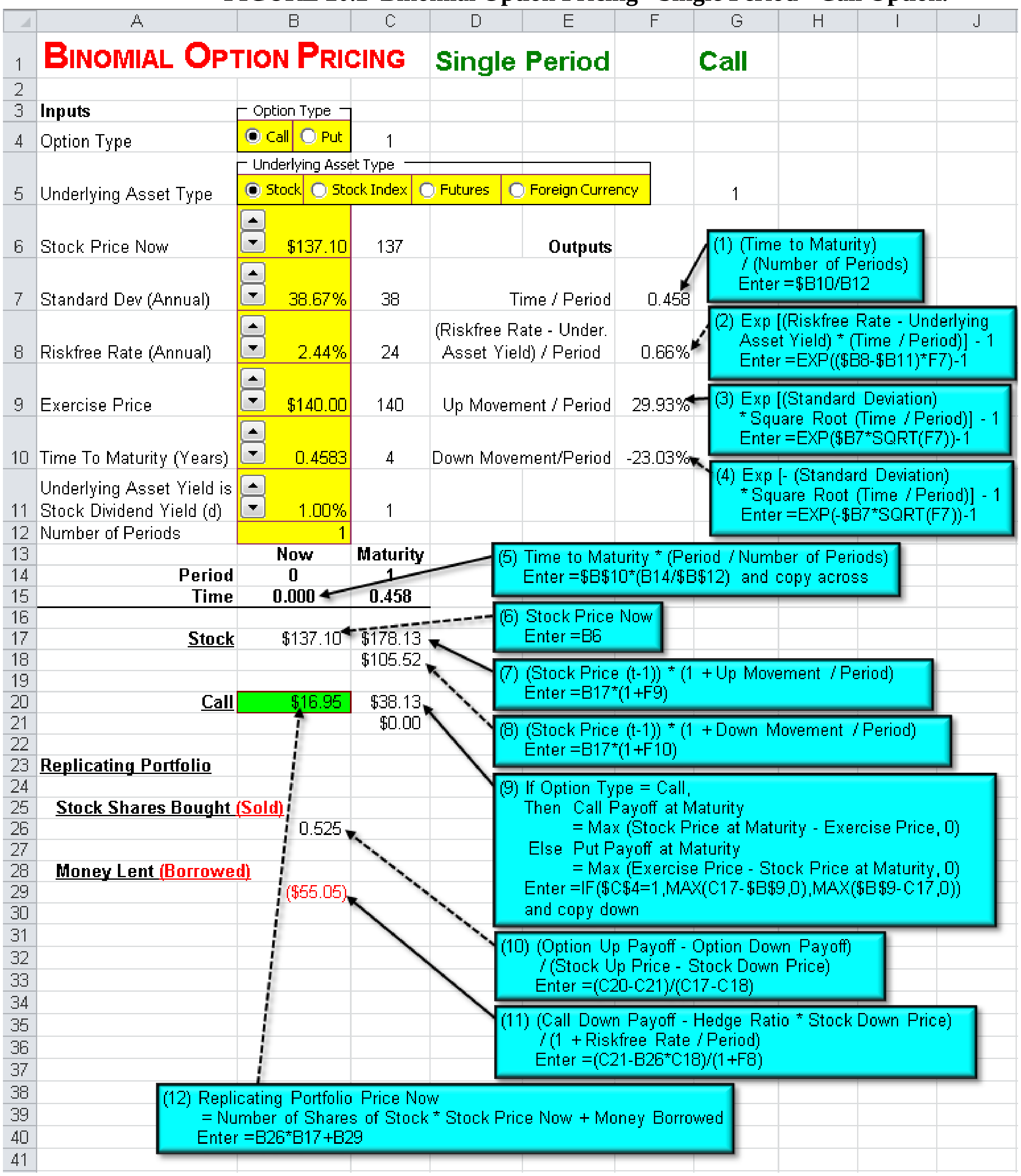
(4) (Daily Standard Deviation) * (Square Root of Days in a Year)
Enter =H76*SQRT(365)

We find that Amazon.com's annual standard deviation is 38.67%.

20.2 Single Period

Problem. At the close of trading on April 30, 2010, the stock price of Amazon.com was \$137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was \$140.00, the exercise price of an October 140 put on Amazon.com was \$140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. The dividend yield is 1.00%. What is the price of an October 140 call and an October 140 put on Amazon.com?

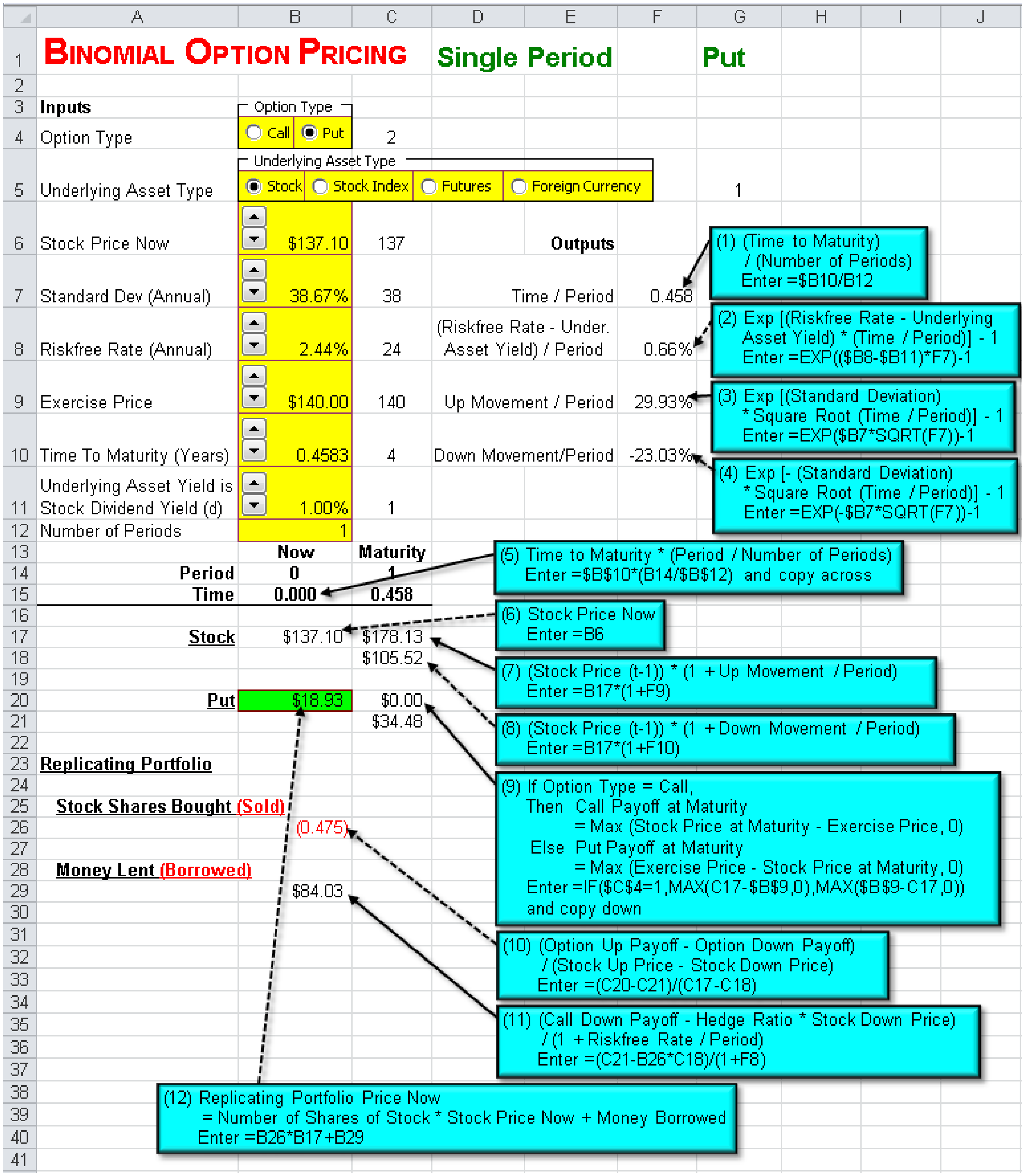
FIGURE 20.2 Binomial Option Pricing - Single Period - Call Option.



Solution Strategy. First, calculate the binomial tree parameters: time / period, riskfree rate / period, up movement / period, and down movement / period. Second, calculate the date 1, maturity date items: stock up price, stock down price, and the corresponding call and put payoffs. Third, calculate the shares of stock and money borrowed to create a replicating portfolio that replicates the option payoff at maturity. Finally, calculate the price now of the replicating portfolio and, in the absence of arbitrage, this will be the option price now.

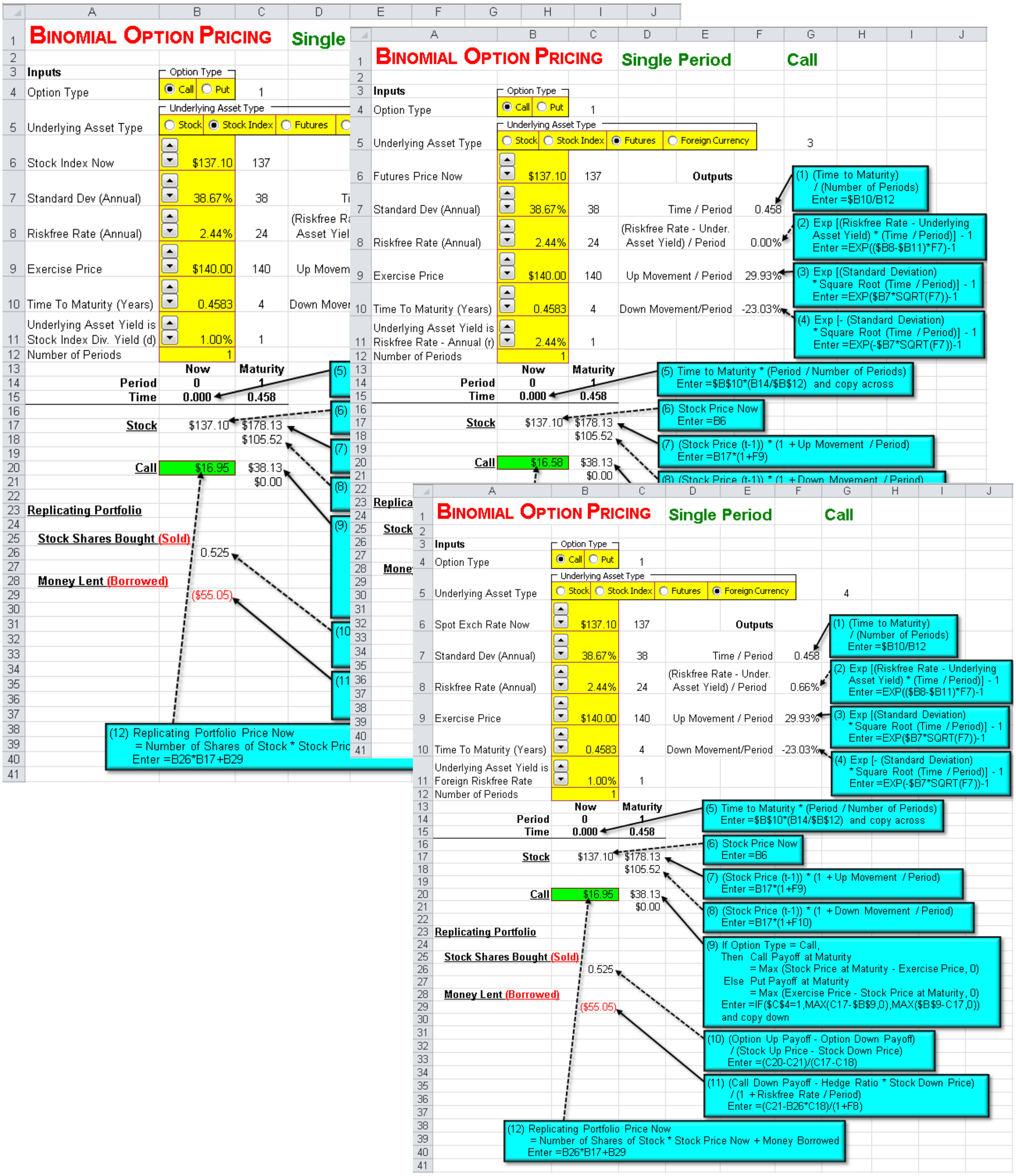
Results. We see that the Binomial Option Pricing model predicts a one-period European call price of $16.95. The put price (below) is valued at $18.93.

FIGURE 20.3 Excel Model of Binomial Option Pricing - Single Period - Put



The model can handle three additional types of underlying asset (see **row 5**): (1) stock index, (2) futures, and (3) foreign currency. Then the underlying asset yield (see **row 11**) becomes: (1) the stock index dividend yield, (2) the riskfree rate, and (3) the foreign riskfree rate, respectively.

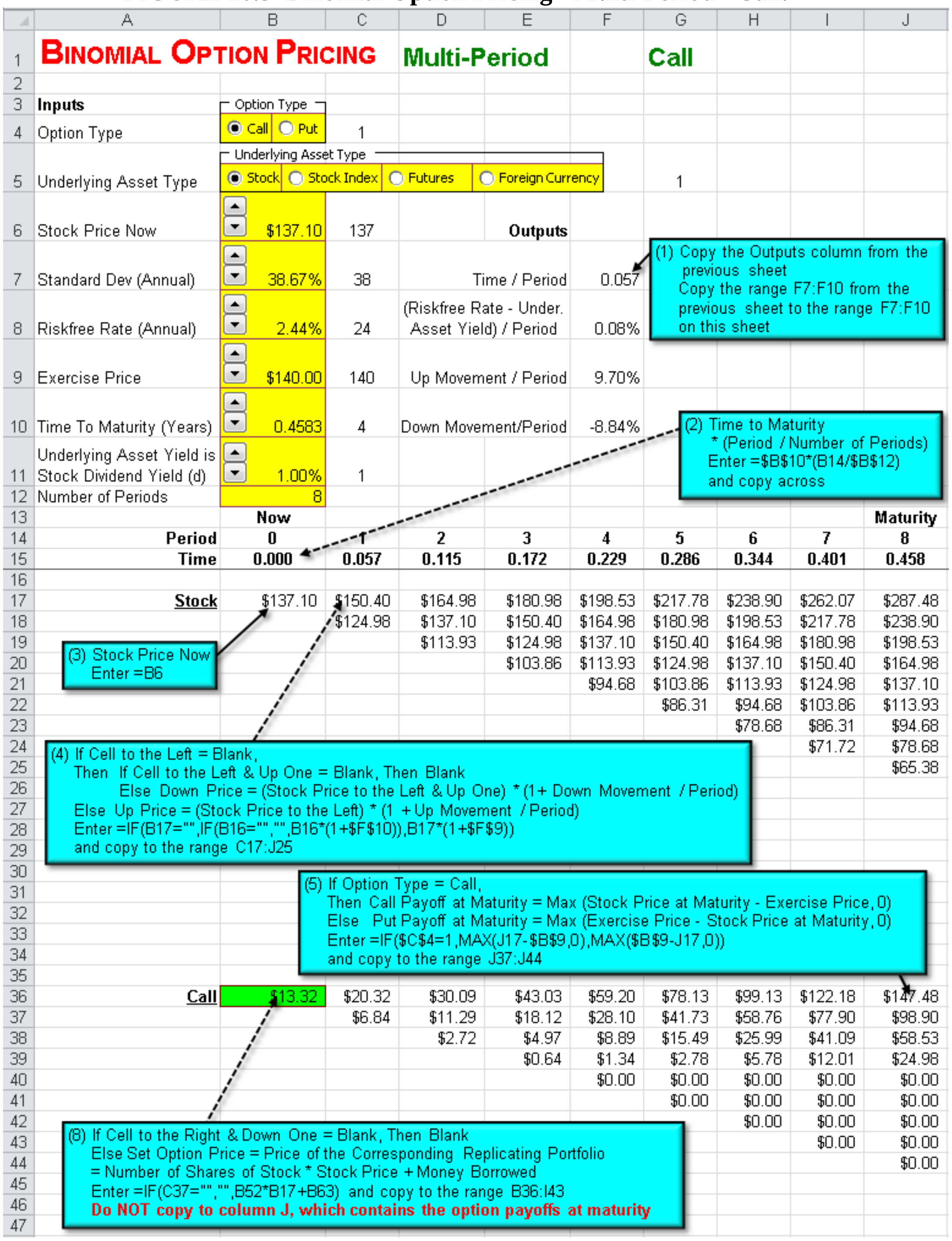
FIGURE 20.4 Binomial - Single Period – 3 Alternative Underlying Assets



20.3 Multi-Period

Problem. Same as before, except we will use an eight-period model to evaluate it. At the close of trading on April 30, 2010, the stock price of Amazon.com was $137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was $140.00, the exercise price of an October 140 put on Amazon.com was $140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. The dividend yield is 1.00%. What is the price of an October 140 call and an October 140 put on Amazon.com?

FIGURE 20.5 Binomial Option Pricing - Multi-Period - Call.



Solution Strategy. First, copy the binomial tree parameters from the single-period model. Second, build a multi-period tree of stock prices. Third, calculate call and put payoffs at maturity. Fourth, build the multi-period trees of the shares of stock and money borrowed to create a replicating portfolio that replicates the option period by period. Finally, build a multi-period tree of the value of the replicating portfolio and, in the absence of arbitrage, this will be the value of the option.

Results. We see that the Binomial Option Pricing model predicts an eight-period European call price of $13.32.

FIGURE 20.6 Binomial Option Pricing - Multi-Period - Call (Continued).

	A	B	C	D	E	F	G	H	I	J
1	**Binomial Option Pricing**			**Multi-Period**			**Call**			
2										
3	**Inputs**	Option Type								
4	Option Type	(•) Call ( ) Put	1							
5	Underlying Asset Type	Underlying Asset Type: (•) Stock ( ) Stock Index ( ) Futures ( ) Foreign Currency					1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.08%				
9	Exercise Price	$140.00	140		Up Movement / Period	9.70%				
10	Time To Maturity (Years)	0.4583	4		Down Movement/Period	-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1							
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
48										
49	**Replicating Portfolio**									
50										
51	**Stock Shares Bought (Sold)**									
52		0.530	0.674	0.815	0.927	0.989	1.000	1.000	1.000	
53			0.370	0.518	0.689	0.858	0.977	1.000	1.000	
54				0.205	0.326	0.500	0.725	0.951	1.000	
55					0.069	0.132	0.249	0.473	0.896	
56						0.000	0.000	0.000	0.000	
57							0.000	0.000	0.000	
58								0.000	0.000	
59									0.000	
60										
61										
62	**Money Lent (Borrowed)**									
63		($59.40)	($81.08)	($104.30)	($124.74)	($137.15)	($139.65)	($139.77)	($139.88)	
64			($39.37)	($59.66)	($85.49)	($113.42)	($135.05)	($139.77)	($139.88)	
65				($20.61)	($35.79)	($59.70)	($93.54)	($130.88)	($139.88)	
66					($6.57)	($13.65)	($28.39)	($59.03)	($122.74)	
67						$0.00	$0.00	$0.00	$0.00	
68							$0.00	$0.00	$0.00	
69								$0.00	$0.00	
70									$0.00	
71										
72										

(1) Copy the Outputs column from the previous sheet
Copy the range F7:F10 from the previous sheet to the range F7:F10 on this sheet

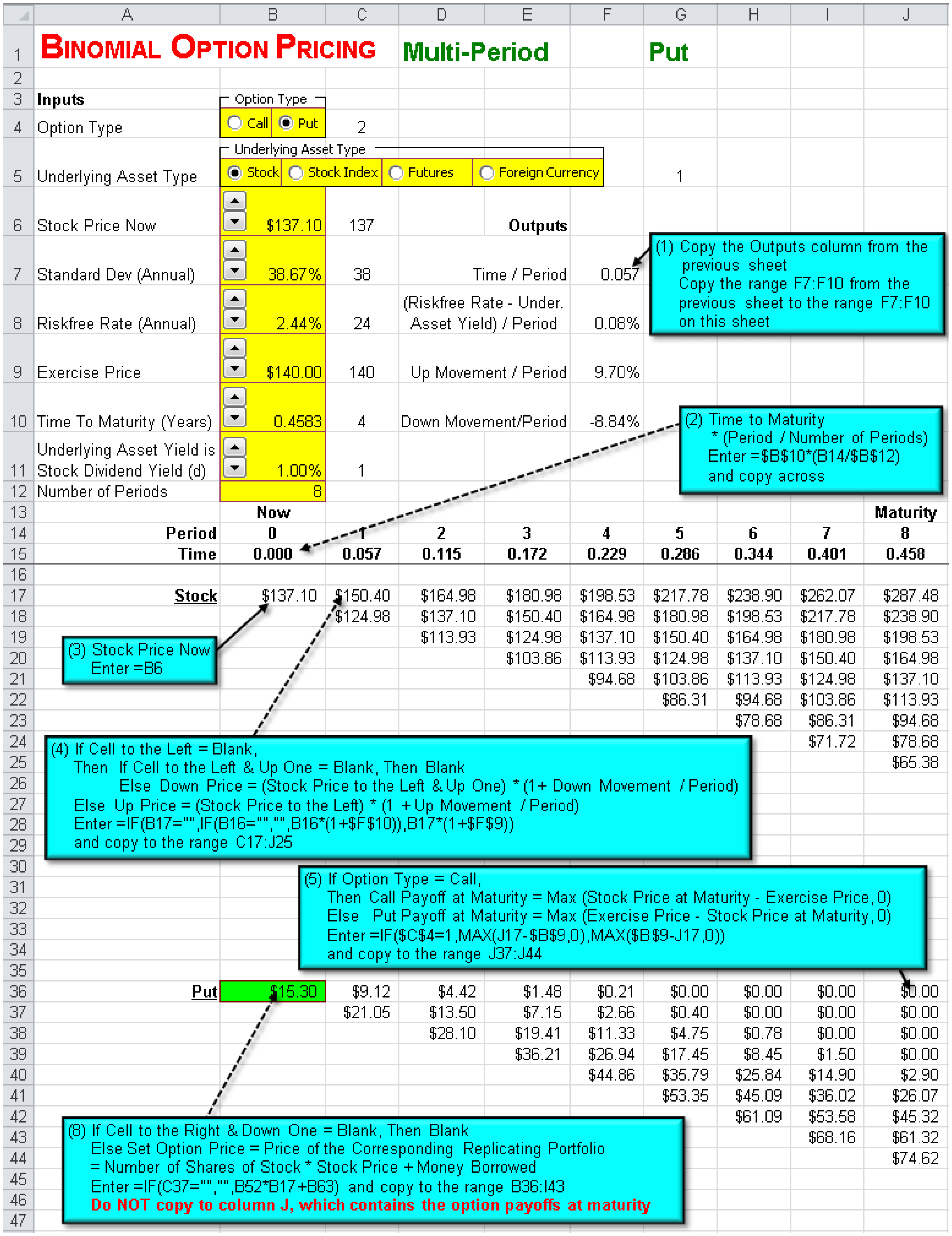
(2) Time to Maturity
* (Period / Number of Periods)
Enter =$B$10*(B14/$B$12)
and copy across

(6) If Corresponding Option Down Price = Blank, Then Blank
Else Hedge Ratio = (Option Up Price - Option Down Price)
/ (Stock Up Price - Stock Down Price)
Enter =IF(C37="","",(C36-C37)/(C17-C18)) and copy to the range B52:I59

(7) If Corresponding Option Down Price = Blank, Then Blank
Else (Option Down Price - Hedge Ratio * Stock Down Price)
/ (1 + Riskfree Rate / Period)
Enter =IF(C37="","",(C37-B52*C18)/(1+$F$8)) and copy in range B63:I70

Now let's check the put.

FIGURE 20.7 Binomial Option Pricing - Multi-Period - Put.



	A	B	C	D	E	F	G	H	I	J
1	BINOMIAL OPTION PRICING			Multi-Period			Put			
3	**Inputs**	Option Type								
4	Option Type	Call / Put	2							
5	Underlying Asset Type	Underlying Asset Type: Stock / Stock Index / Futures / Foreign Currency					1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.08%				
9	Exercise Price	$140.00	140	Up Movement / Period		9.70%				
10	Time To Maturity (Years)	0.4583	4	Down Movement/Period		-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1							
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
17	**Stock**	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90	$262.07	$287.48
18			$124.98	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90
19				$113.93	$124.98	$137.10	$150.40	$164.98	$180.98	$198.53
20					$103.86	$113.93	$124.98	$137.10	$150.40	$164.98
21						$94.68	$103.86	$113.93	$124.98	$137.10
22							$86.31	$94.68	$103.86	$113.93
23								$78.68	$86.31	$94.68
24									$71.72	$78.68
25										$65.38
36	**Put**	$15.30	$9.12	$4.42	$1.48	$0.21	$0.00	$0.00	$0.00	$0.00
37			$21.05	$13.50	$7.15	$2.66	$0.40	$0.00	$0.00	$0.00
38				$28.10	$19.41	$11.33	$4.75	$0.78	$0.00	$0.00
39					$36.21	$26.94	$17.45	$8.45	$1.50	$0.00
40						$44.86	$35.79	$25.84	$14.90	$2.90
41							$53.35	$45.09	$36.02	$26.07
42								$61.09	$53.58	$45.32
43									$68.16	$61.32
44										$74.62

(1) Copy the Outputs column from the previous sheet
Copy the range F7:F10 from the previous sheet to the range F7:F10 on this sheet

(2) Time to Maturity
* (Period / Number of Periods)
Enter =$B$10*(B14/$B$12)
and copy across

(3) Stock Price Now
Enter =B6

(4) If Cell to the Left = Blank,
Then If Cell to the Left & Up One = Blank, Then Blank
Else Down Price = (Stock Price to the Left & Up One) * (1+ Down Movement / Period)
Else Up Price = (Stock Price to the Left) * (1 + Up Movement / Period)
Enter =IF(B17="",IF(B16="","",B16*(1+$F$10)),B17*(1+$F$9))
and copy to the range C17:J25

(5) If Option Type = Call,
Then Call Payoff at Maturity = Max (Stock Price at Maturity - Exercise Price, 0)
Else Put Payoff at Maturity = Max (Exercise Price - Stock Price at Maturity, 0)
Enter =IF($C$4=1,MAX(J17-$B$9,0),MAX($B$9-J17,0))
and copy to the range J37:J44

(8) If Cell to the Right & Down One = Blank, Then Blank
Else Set Option Price = Price of the Corresponding Replicating Portfolio
= Number of Shares of Stock * Stock Price + Money Borrowed
Enter =IF(C37="","",B52*B17+B63) and copy to the range B36:I43
Do NOT copy to column J, which contains the option payoffs at maturity

We see that the Binomial Option Pricing model predicts an eight-period European put price of $15.30.

FIGURE 20.8 Binomial Option Pricing - Multi-Period - Put (Continued).

	A	B	C	D	E	F	G	H	I	J
1	**Binomial Option Pricing**			**Multi-Period**			**Put**			
2										
3	**Inputs**	Option Type								
4	Option Type	○ Call ◉ Put	2							
5	Underlying Asset Type	Underlying Asset Type: ◉ Stock	○ Stock Index	○ Futures	○ Foreign Currency		1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24		(Riskfree Rate - Under. Asset Yield) / Period	0.08%				
9	Exercise Price	$140.00	140		Up Movement / Period	9.70%				
10	Time To Maturity (Years)	0.4583	4		Down Movement/Period	-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1							
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
48										
49	**Replicating Portfolio**									
50										
51	**Stock Shares Bought (Sold)**									
52		(0.470)	(0.326)	(0.185)	(0.073)	(0.011)	0.000	0.000	0.000	
53			(0.630)	(0.482)	(0.311)	(0.142)	(0.023)	0.000	0.000	
54				(0.795)	(0.674)	(0.500)	(0.275)	(0.049)	0.000	
55					(0.931)	(0.868)	(0.751)	(0.527)	(0.104)	
56						(1.000)	(1.000)	(1.000)	(1.000)	
57							(1.000)	(1.000)	(1.000)	
58								(1.000)	(1.000)	
59									(1.000)	
60										
61										
62	**Money Lent (Borrowed)**									
63		$79.68	$58.12	$35.01	$14.68	$2.39	$0.00	$0.00	$0.00	
64			$99.82	$79.65	$53.94	$26.11	$4.61	$0.00	$0.00	
65				$118.70	$103.64	$79.84	$46.12	$8.89	$0.00	
66					$132.86	$125.89	$111.27	$80.74	$17.15	
67						$139.54	$139.65	$139.77	$139.88	
68							$139.65	$139.77	$139.88	
69								$139.77	$139.88	
70									$139.88	
71										
72										

(1) Copy the Outputs column from the previous sheet
Copy the range F7:F10 from the previous sheet to the range F7:F10 on this sheet

(2) Time to Maturity
* (Period / Number of Periods)
Enter =$B$10*(B14/$B$12)
and copy across

(6) If Corresponding Option Down Price = Blank, Then Blank
Else Hedge Ratio = (Option Up Price - Option Down Price)
/ (Stock Up Price - Stock Down Price)
Enter =IF(C37="","",(C36-C37)/(C17-C18)) and copy to the range B52:I59

(7) If Corresponding Option Down Price = Blank, Then Blank
Else (Option Down Price - Hedge Ratio * Stock Down Price)
/ (1 + Riskfree Rate / Period)
Enter =IF(C37="","",(C37-B52*C18)/(1+$F$8)) and copy in range B63:I70

As in the single period case, replicating a Call option requires **Buying** Shares of Stock and **Borrowing** Money, whereas a Put option requires **Selling** Shares of Stock and **Lending** Money. Notice that the quantity of Money Borrowed or Lent and the quantity of Shares Bought or Sold changes over time and differs for up nodes vs. down nodes. This process of changing the replicating portfolio every period based on the realized up or down movement in the underlying stock price is called dynamic replication.

Price accuracy can be increased by subdividing the option's time to maturity into more periods (15, 30, etc.). Typically, from 50 to 100 periods are required in order to achieve price accuracy to the penny.

20.4 Risk Neutral

The previous Excel model, **Binomial Option Pricing Multi-Period**, determined the price of an option by constructing a replicating portfolio, which combines a stock and a bond to replicate the payoffs of the option. An alternative way to price an option is the Risk Neutral method. Both techniques give you the same answer. The main advantage of the Risk Neutral method is that it is faster and easier to implement. The Replicating Portfolio method required the construction of four trees (stock prices, shares of stock **bought** **(sold)**, money **lent** **(borrowed)**, and option prices). The Risk Neutral method will only require two trees (stock prices and option prices).

Problem. Same as before, except we will use the risk neutral method to evaluate it. At the close of trading on April 30, 2010, the stock price of Amazon.com was $137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was $140.00, the exercise price of an October 140 put on Amazon.com was $140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. The dividend yield is 1.00%. What is the price of an October 140 call and an October 140 put on Amazon.com?

Solution Strategy. First, copy the binomial tree parameters, stock price tree, and option payoffs at maturity from the multi-period model. Second, calculate the risk neutral probability. Finally, build a option value tree using the risk neutral probability.

Results. We see that the Risk Neutral method predicts an eight-period European call price of $13.32. This is identical to previous section's Replicating Portfolio Price. Next let's check the put.

FIGURE 20.9 Binomial Option Pricing – Risk Neutral - Call.

	A	B	C	D	E	F	G	H	I	J
1	**BINOMIAL OPTION PRICING**			**Risk Neutral**			**Call**			
2										
3	**Inputs**	Option Type								
4	Option Type	◉ Call ○ Put	1							
5	Underlying Asset Type	Underlying Asset Type: ◉ Stock ○ Stock Index ○ Futures ○ Foreign Currency					1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.08%				
9	Exercise Price	$140.00	140	Up Movement / Period		9.70%				
10	Time To Maturity (Years)	0.4583	4	Down Movement/Period		-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1	Risk Neutral Probability		48.13%				
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
16										
17	**Stock**	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90	$262.07	$287.48
18			$124.98	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90
19				$113.93	$124.98	$137.10	$150.40	$164.98	$180.98	$198.53
20					$103.86	$113.93	$124.98	$137.10	$150.40	$164.98
21						$94.68	$103.86	$113.93	$124.98	$137.10
22							$86.31	$94.68	$103.86	$113.93
23								$78.68	$86.31	$94.68
24									$71.72	$78.68
25										$65.38
36	**Call**	$13.32	$20.32	$30.09	$43.03	$59.20	$78.13	$99.13	$122.18	$147.48
37			$6.84	$11.29	$18.12	$28.10	$41.73	$58.76	$77.90	$98.90
38				$2.72	$4.97	$8.89	$15.49	$25.99	$41.09	$58.53
39					$0.64	$1.34	$2.78	$5.78	$12.01	$24.98
40						$0.00	$0.00	$0.00	$0.00	$0.00
41							$0.00	$0.00	$0.00	$0.00
42								$0.00	$0.00	$0.00
43									$0.00	$0.00
44										$0.00

(1) Copy the Outputs column from the previous sheet
Copy the range F7:F10 from the previous sheet to the range F7:F10 on this sheet

(2) (Riskfree Rate / Period - Down Movement / Period) / (Up Movement / Period - Down Movement / Period)
Enter =(F8-F10)/(F9-F10)

(3) Copy the Stock Price Tree from the previous sheet
Copy the range B17:J25 from the previous sheet to the range B17:J25 on this sheet

(4) Copy the Payoffs at Maturity from the previous sheet
Copy the range J36:J44 from the previous sheet to the range J36:J44 on this sheet

(5) If Cell to the Right & Down One = Blank, Then Blank
Else Expected Value of Option Price Next Period (using the Risk Neutral Probability)
Discounted at the Riskfree Rate
= [(Risk Neutral Probability) * (Stock Up Price) + (1 - Risk Neutral Probability) * (Stock Down Price)]
/ (1 + Riskfree Rate / Period)
Enter =IF(C37="","",($F$11*C36+(1-$F$11)*C37)/(1+$F$8)) and copy to the range B36:I43
Do NOT copy to column J, which contains the option payoffs at maturity

FIGURE 20.10 Binomial Option Pricing – Risk Neutral - Put.

	A	B	C	D	E	F	G	H	I	J
1	**BINOMIAL OPTION PRICING**			**Risk Neutral**			**Put**			
2										
3	**Inputs**	Option Type								
4	Option Type	○ Call ◉ Put	2							
5	Underlying Asset Type	Underlying Asset Type: ◉ Stock ○ Stock Index ○ Futures ○ Foreign Currency					1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.08%				
9	Exercise Price	$140.00	140	Up Movement / Period		9.70%				
10	Time To Maturity (Years)	0.4583	4	Down Movement/Period		-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1	Risk Neutral Probability		48.13%				
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
16										
17	**Stock**	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90	$262.07	$287.48
18			$124.98	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90
19				$113.93	$124.98	$137.10	$150.40	$164.98	$180.98	$198.53
20					$103.86	$113.93	$124.98	$137.10	$150.40	$164.98
21						$94.68	$103.86	$113.93	$124.98	$137.10
22							$86.31	$94.68	$103.86	$113.93
23								$78.68	$86.31	$94.68
24									$71.72	$78.68
25										$65.38
36	**Put**	$15.30	$9.12	$4.42	$1.48	$0.21	$0.00	$0.00	$0.00	$0.00
37			$21.05	$13.50	$7.15	$2.66	$0.40	$0.00	$0.00	$0.00
38				$28.10	$19.41	$11.33	$4.75	$0.78	$0.00	$0.00
39					$36.21	$26.94	$17.45	$8.45	$1.50	$0.00
40						$44.86	$35.79	$25.84	$14.90	$2.90
41							$53.35	$45.09	$36.02	$26.07
42								$61.09	$53.58	$45.32
43									$68.16	$61.32
44										$74.62

(1) Copy the Outputs column from the previous sheet
Copy the range F7:F10 from the previous sheet to the range F7:F10 on this sheet

(2) (Riskfree Rate / Period
- Down Movement / Period)
/ (Up Movement / Period
- Down Movement / Period)
Enter =(F8-F10)/(F9-F10)

(3) Copy the Stock Price Tree from the previous sheet
Copy the range B17:J25 from the previous sheet
to the range B17:J25 on this sheet

(4) Copy the Payoffs at Maturity from the previous sheet
Copy the range J36:J44 from the previous sheet
to the range J36:J44 on this sheet

(5) If Cell to the Right & Down One = Blank, Then Blank
Else Expected Value of Option Price Next Period (using the Risk Neutral Probability)
Discounted at the Riskfree Rate
= [(Risk Neutral Probability) * (Stock Up Price) + (1 - Risk Neutral Probability) * (Stock Down Price)]
/ (1 + Riskfree Rate / Period)
Enter =IF(C37="","",($F$11*C36+(1-$F$11)*C37)/(1+$F$8)) and copy to the range B36:I43
Do NOT copy to column J, which contains the option payoffs at maturity

We see that the Risk Neutral method predicts an eight-period European put price of $13.49. This is identical to previous section's Replicating Portfolio Price. Again, we get the same answer either way. The advantage of the Risk Neutral method is that we only have to construct two trees, rather than four trees.

20.5 Average of N and N-1

Problem. Same as before, except we will use the average of N and N-1 method to evaluate it. At the close of trading on April 30, 2010, the stock price of Amazon.com was \$137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was \$140.00, the exercise price of an October 140 put on Amazon.com was \$140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. The dividend yield is 1.00%. What is the price of an October 140 call and an October 140 put on Amazon.com?

FIGURE 20.11 Binomial Option Pricing – Ave of N and N-1 - Call.

	A	B	C	D	E	F	G	H	I	J
1	**Binomial Option Pricing**			**Average of N and N-1**					**Call**	
2										
3	**Inputs**	Option Type								
4	Option Type	(•) Call ( ) Put	1							
5	Underlying Asset Type	Underlying Asset Type: (•) Stock ( ) Stock Index	( ) Futures	( ) Foreign Currency			1			
6	Stock Price Now	$137.10	137		**Outputs**	N Periods	N-1 Periods			
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057	0.065			
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.08%	0.09%			
9	Exercise Price	$140.00	140	Up Movement / Period		9.70%	10.40%			
10	Time To Maturity (Years)	0.4583	4	Down Movement/Period		-8.84%	-9.42%			
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1	Risk Neutral Probability		48.13%	48.00%			
12	Number of Periods	8	7							
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
16										
17	**N Period Stock**	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90	$262.07	$287.48
18			$124.98	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90
19				$113.93	$124.98	$137.10	$150.40	$164.98	$180.98	$198.53
20					$103.86	$113.93	$124.98	$137.10	$150.40	$164.98
21						$94.68	$103.86	$113.93	$124.98	$137.10
22							$86.31	$94.68	$103.86	$113.93
23								$78.68	$86.31	$94.68
24									$71.72	$78.68
25										$65.38
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										
36	**N Period Call**	$13.32	$20.32	$30.09	$43.03	$59.20	$78.13	$99.13	$122.18	$147.48
37			$6.84	$11.29	$18.12	$28.10	$41.73	$58.76	$77.90	$98.90
38				$2.72	$4.97	$8.89	$15.49	$25.99	$41.09	$58.53
39					$0.64	$1.34	$2.78	$5.78	$12.01	$24.98
40						$0.00	$0.00	$0.00	$0.00	$0.00
41							$0.00	$0.00	$0.00	$0.00
42								$0.00	$0.00	$0.00
43									$0.00	$0.00
44										$0.00

(1) Copy the Outputs column from the previous sheet
Copy the range F7:F11 from the previous sheet
to the range F7:G11 on this sheet

(2) Copy the Stock Price Tree from the previous sheet
Copy the range B17:J25 from the previous sheet
to the range B17:J25 on this sheet

(3) Copy the Call Price Tree from the previous sheet
Copy the range B36:J44 from the previous sheet
to the range B36:J44 on this sheet

Solution Strategy. First, copy the 8-period binomial model from the prior section. Second, create an analogous 7-period binominal model. Finally, compute the average derivate price from the 8-period price and 7-period price.

FIGURE 20.12 Binomial Option Pricing – Ave of N and N-1 - Call.

	A	B	C	D	E	F	G	H	I
47		**Now**							**Maturity**
48	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
49	**Time**	**0.000**	**0.065**	**0.131**	**0.196**	**0.262**	**0.327**	**0.393**	**0.458**
50									
51	**N-1 Period Stock**	$137.10	$151.36	$167.10	$184.48	$203.67	$224.85	$248.24	$274.06
52			$124.18	$137.10	$151.36	$167.10	$184.48	$203.67	$224.85
53				$112.48	$124.18	$137.10	$151.36	$167.10	$184.48
54					$101.89	$112.48	$124.18	$137.10	$151.36
55						$92.29	$101.89	$112.48	$124.18
56							$83.59	$92.29	$101.89
57								$75.72	$83.59
58									$68.59
59									
60									
61									
62									
63									
64									
65									
66									
67									
68									
69									
70	**N-1 Period Call**	$13.88	$21.38	$31.96	$46.16	$64.06	$85.12	$108.37	$134.06
71			$6.98	$11.65	$18.91	$29.71	$44.75	$63.80	$84.85
72				$2.69	$4.96	$8.98	$15.89	$27.23	$44.48
73					$0.60	$1.25	$2.61	$5.45	$11.36
74						$0.00	$0.00	$0.00	$0.00
75							$0.00	$0.00	$0.00
76								$0.00	$0.00
77									$0.00
78									
79									
80									
81									
82									
83									
84									
85									
86	**Average of N Period and N-1 Period Call**	$13.60							
87									
88									
89									
90									

(4) Stock Price Now
Enter =B6

(5) Copy the N Period Stock fromula from above, edit the formula, and copy to the full N-1 Period Stock tree
* Copy cell C17 to cell C51
* Edit the formula to substitute $G$10 for $F$10 and $G$9 for $F$9 to obtain:
=IF(B51="",IF(B50="","",B50*(1+$G$10)),B51*(1+$G$9))
* Copy the cell C49 to the range C51:I58

(6) Copy the Payoffs at Maturity from N Period Call tree
Copy the cell J36 to the range I70:I77

(7) Copy the N Period Call fromula from above, edit the formula, and copy to the full N-1 Period Call tree
* Copy cell B36 to cell B70
* Edit the formula to substitute $G$11 for $F$11 and $G$8 for $F$8 to obtain:
=IF(C71="","",($G$11*C70+(1-$G$11)*C71)/(1+$G$8))
* Copy the cell B70 to the range B70:H76

(8) (N Period Call + N-1 Period Call) / 2
Enter =(B36+B70)/2

Results. The 8-period price is $13.32 and the 7-period price is $13.88. The average of these two prices is $13.60. This is a much more accurate estimate true option price, because the binomial model alternates between overshooting the true price and undershooting the true price as additional periods are added.

20.6 Convergence to Normal

Problem. At the close of trading on April 30, 2010, the stock price of Amazon.com was $137.10, the standard deviation of daily returns is 38.67%, and the option time to maturity was 0.4583 years. Show what happens to the stock price at maturity distribution of the binomial stock price tree as the number of periods increases. Show what happens to the continuous cumulative return distribution of the binomial stock price tree as the number of periods increases.

Solution Strategy. Given a number of periods, compute the stock price at maturity for each terminal node of the binomial tree. Given the stock price at maturity for each node, compute the corresponding continuous cumulative return and the probability of each terminal node. Then see what happens to the stock price at maturity graph and continuous cumulative return graph as the number of periods increases.

FIGURE 20.13 Binomial Option Pricing – Convergence To Normal.

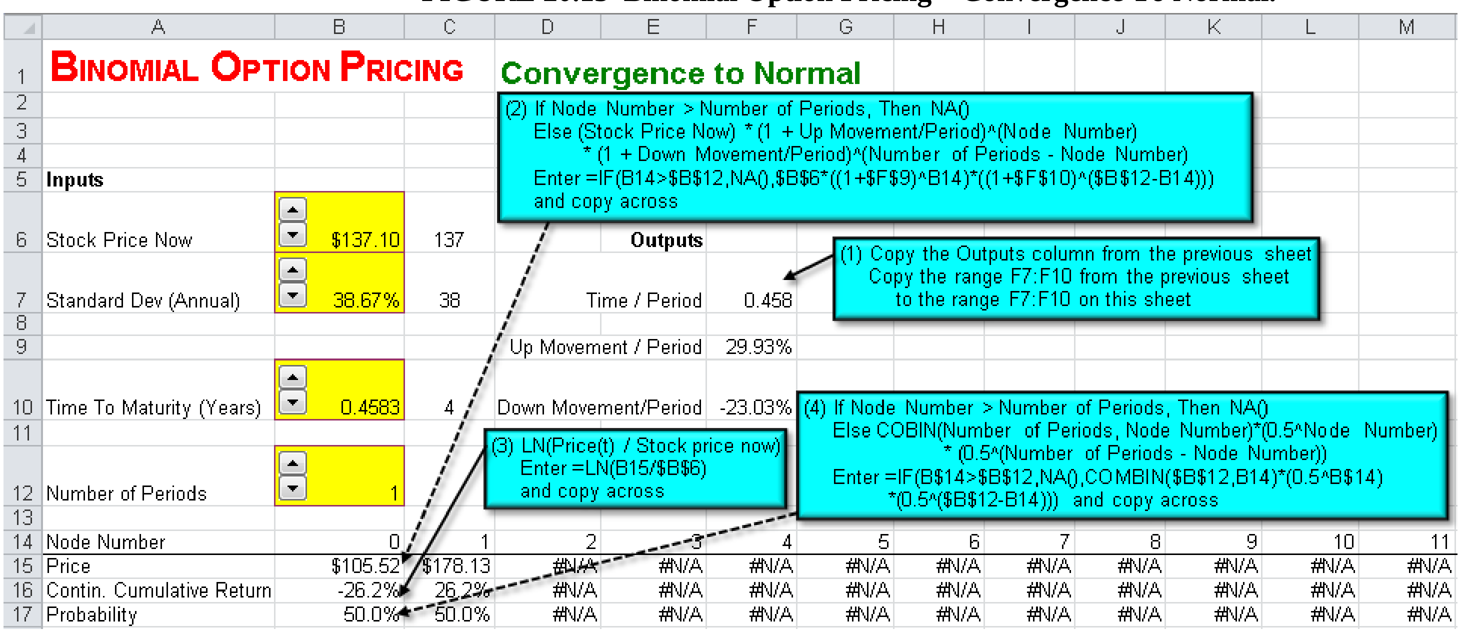


FIGURE 20.14 Number of periods = 1. Two nodes with a 50%-50% chance.

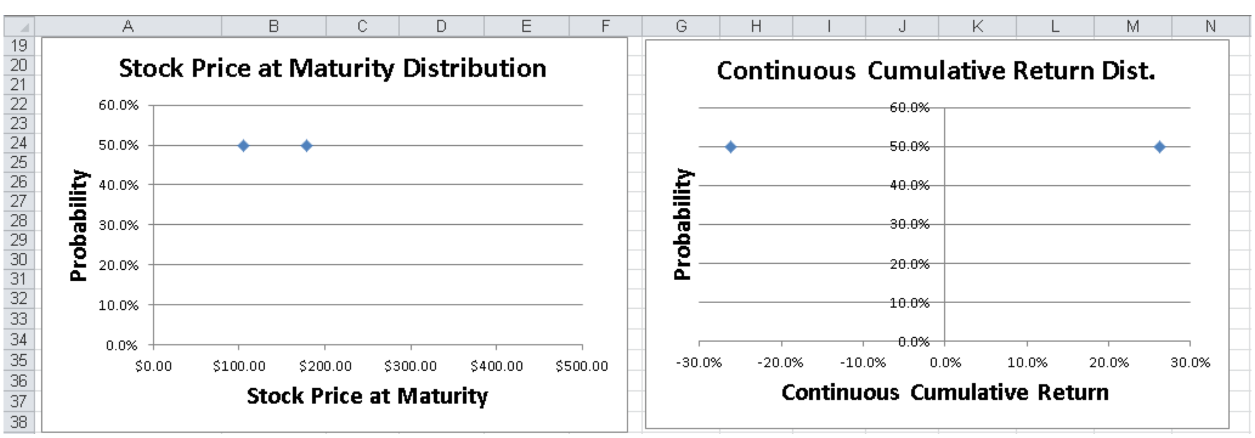


FIGURE 20.15 Number of periods = 4. Five nodes. 6.3%-25%-37.5%-%-25%-6.3% chance.

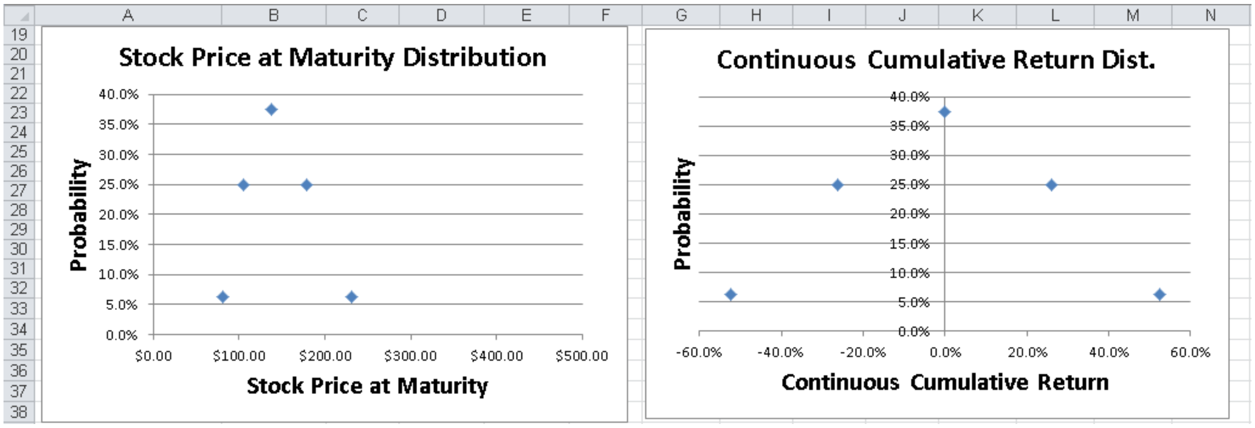


FIGURE 20.16 Number of periods = 13. Fourteen nodes.

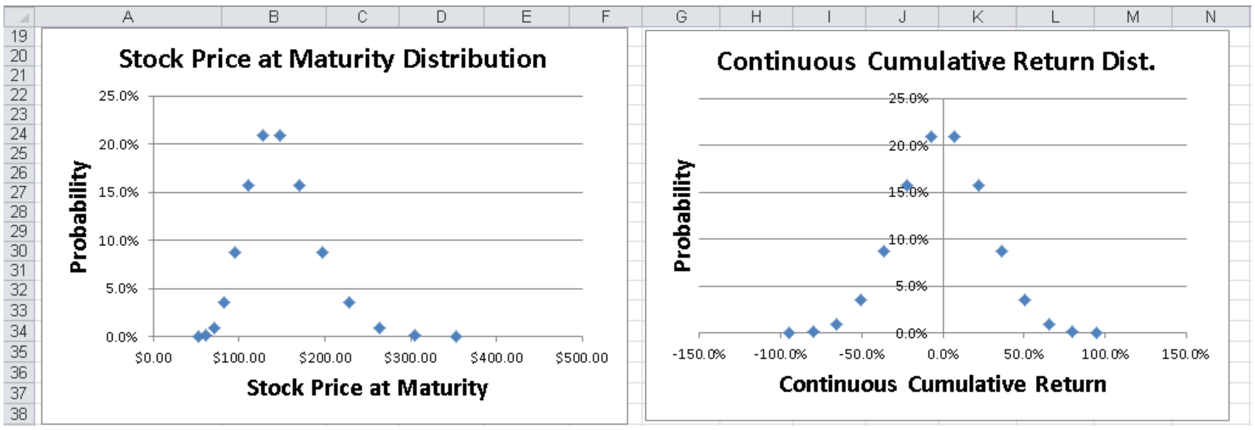
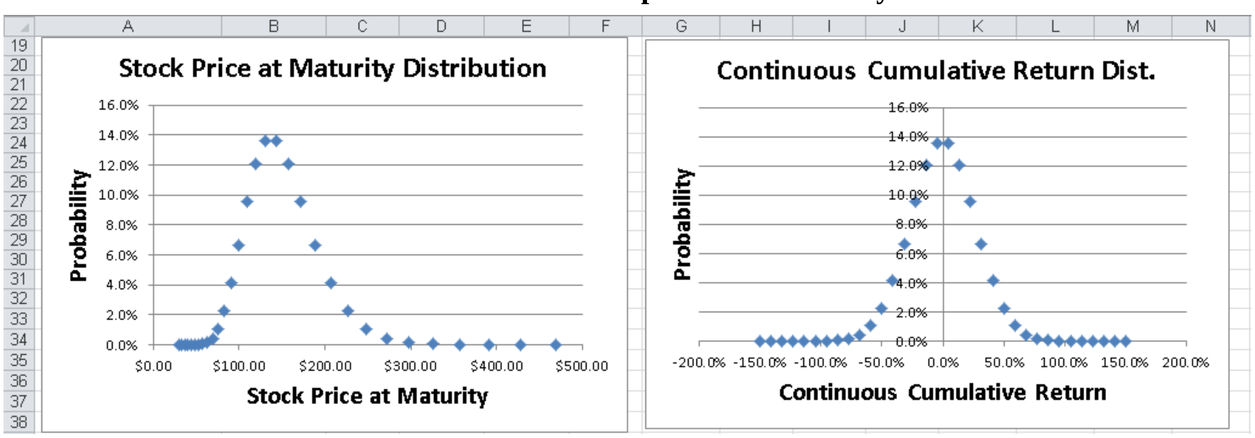


FIGURE 20.17 Number of periods = 33. Thirty-four nodes.



At the number of periods of the binomial model increases, the stock price at maturity converges to a left-skewed, lognormal distribution and the continuous cumulative return converges to the normal distribution.

20.7 American With Discrete Dividends

Problem. Same as before, except we will value American options where the underlying stock pays dividends. At the close of trading on April 30, 2010, the stock price of Amazon.com was $137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was $140.00, the exercise price of an October 140 put on Amazon.com was $140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. Assume that Amazon.com pays certain, riskfree $4.00 dividends on the periods show below. What is the price of an American October 140 call and an American October 140 put on Amazon.com?

Solution Strategy. First, copy the binomial tree parameters, the risk neutral probability, stock price tree, and option payoffs at maturity from the risk neutral model. Second, calculate the total stock price as the sum of the risky stock price plus the discounted value of future dividends. Finally, build a option value tree using the risk neutral probability and accounting for optimal early exercise.

FIGURE 20.18 Binomial – American With Discrete Dividends – Call.

	A	B	C	D	E	F	G	H	I	J
1	BINOMIAL OPTION PRICING			American With Discrete Dividends						Call
2										
3	**Inputs**	Option Type				Early Exercise				
4	Option Type	Call / Put	1		Early Exercise	European	American	2		
5	Underlying Asset Type	Underlying Asset Type: Stock / Stock Index / Futures / Foreign Currency					1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24		(Riskfree Rate - Under. Asset Yield) / Period	0.08%				
9	Exercise Price	$140.00	140		Up Movement / Period	9.70%				
10	Time To Maturity (Years)	0.4583	4		Down Movement/Period	-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1		Risk Neutral Probability	48.13%				
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
16										
17	**Risky Part of the Stock**	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90	$262.07	$287.48
18			$124.98	$137.10	$150.40	$164.98	$180.98	$198.53	$217.78	$238.90
19				$113.93	$124.98	$137.10	$150.40	$164.98	$180.98	$198.53
20					$103.86	$113.93	$124.98	$137.10	$150.40	$164.98
21						$94.68	$103.86	$113.93	$124.98	$137.10
22							$86.31	$94.68	$103.86	$113.93
23								$78.68	$86.31	$94.68
24									$71.72	$78.68
25										$65.38
26										
27	**Riskfree Dividends**		$0.00	$0.00	$0.00	$4.00	$0.00	$0.00	$4.00	$0.00
28										
29	**Cum. Pres Value Factor**	100.00%	97.62%	95.29%	93.02%	90.81%	88.64%	86.53%	84.47%	82.46%
30										
31	**Total Stock Price**	$144.11	$157.58	$172.34	$188.52	$202.25	$221.59	$242.80	$262.07	$287.48
32			$132.16	$144.46	$157.93	$168.70	$184.79	$202.43	$217.78	$238.90
33				$121.29	$132.52	$140.82	$154.21	$168.88	$180.98	$198.53
34					$111.40	$117.65	$128.79	$141.00	$150.40	$164.98
35						$98.40	$107.67	$117.84	$124.98	$137.10
36							$90.12	$98.58	$103.86	$113.93
37								$82.58	$86.31	$94.68
38									$71.72	$78.68
39										$65.38

(1) Copy the Outputs column (including the Risk Neutral Probability) from the previous sheet
Copy the range F7:F11 from the previous sheet to the range F7:F11 on this sheet

(2) Copy the Stock Price Tree from the previous sheet
Copy the range B17:J25 from the previous sheet
to the range B17:J25 on this sheet

(3) 1 / ((1 + (Riskfree Rate / Period)) ^ Period)
Enter =1/((1+$B$8)^C14) and copy across

(4) If corresponding cell on Risky Part of Stock tree is blank,
Then blank,
Else Risky Part of Stock
+ SUMPRODUCT(Riskfree Dividends Range,
Cum. Pres Value Factor Range)
/ (Cum. Pres Value Factor(t))
Enter =IF(B17="","",B17+SUMPRODUCT(C$27:$J$27,C$29:$J$29)/B$29)
and copy to the range B31:I38
Do NOT copy to column J, which contains a different formula

(5) Risky Part of the Stock Tree
Enter =J17 and copy down

FIGURE 20.19 Binomial – American With Discrete Dividends - Call.

	A	B	C	D	E	F	G	H	I	J
1	**Binomial Option Pricing**			**American With Discrete Dividends**						**Call**
2										
3	**Inputs**	Option Type				Early Exercise				
4	Option Type	Call / Put	1		Early Exercise	European / American		2		
5	Underlying Asset Type	Underlying Asset Type: Stock / Stock Index / Futures / Foreign Currency					1			
6	Stock Price Now	$137.10	137		**Outputs**					
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.057				
8	Riskfree Rate (Annual)	2.44%	24		(Riskfree Rate - Under. Asset Yield) / Period	0.08%				
9	Exercise Price	$140.00	140		Up Movement / Period	9.70%				
10	Time To Maturity (Years)	0.4583	4		Down Movement/Period	-8.84%				
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1		Risk Neutral Probability	48.13%				
12	Number of Periods	8								
13		**Now**								**Maturity**
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
15	**Time**	**0.000**	**0.057**	**0.115**	**0.172**	**0.229**	**0.286**	**0.344**	**0.401**	**0.458**
46										
47										
48										
49										
50	**American Call**	$14.57	$22.40	$33.48	$48.52	$62.66	$81.80	$102.80	$122.18	$147.48
51			$7.34	$12.15	$19.57	$30.39	$45.00	$62.43	$77.90	$98.90
52				$2.88	$5.29	$9.56	$16.89	$28.88	$41.09	$58.53
53					$0.64	$1.34	$2.78	$5.78	$12.01	$24.98
54						$0.00	$0.00	$0.00	$0.00	$0.00
55							$0.00	$0.00	$0.00	$0.00
56								$0.00	$0.00	$0.00
57									$0.00	$0.00
58										$0.00

(1) Copy the Outputs column (including the Risk Neutral Probability) from the previous sheet
Copy the range F7:F11 from the previous sheet to the range F7:F11 on this sheet

(6) Copy the Payoffs at Maturity from the previous sheet
Copy the range J36:J44 from the previous sheet
to the range J50:J58 on this sheet

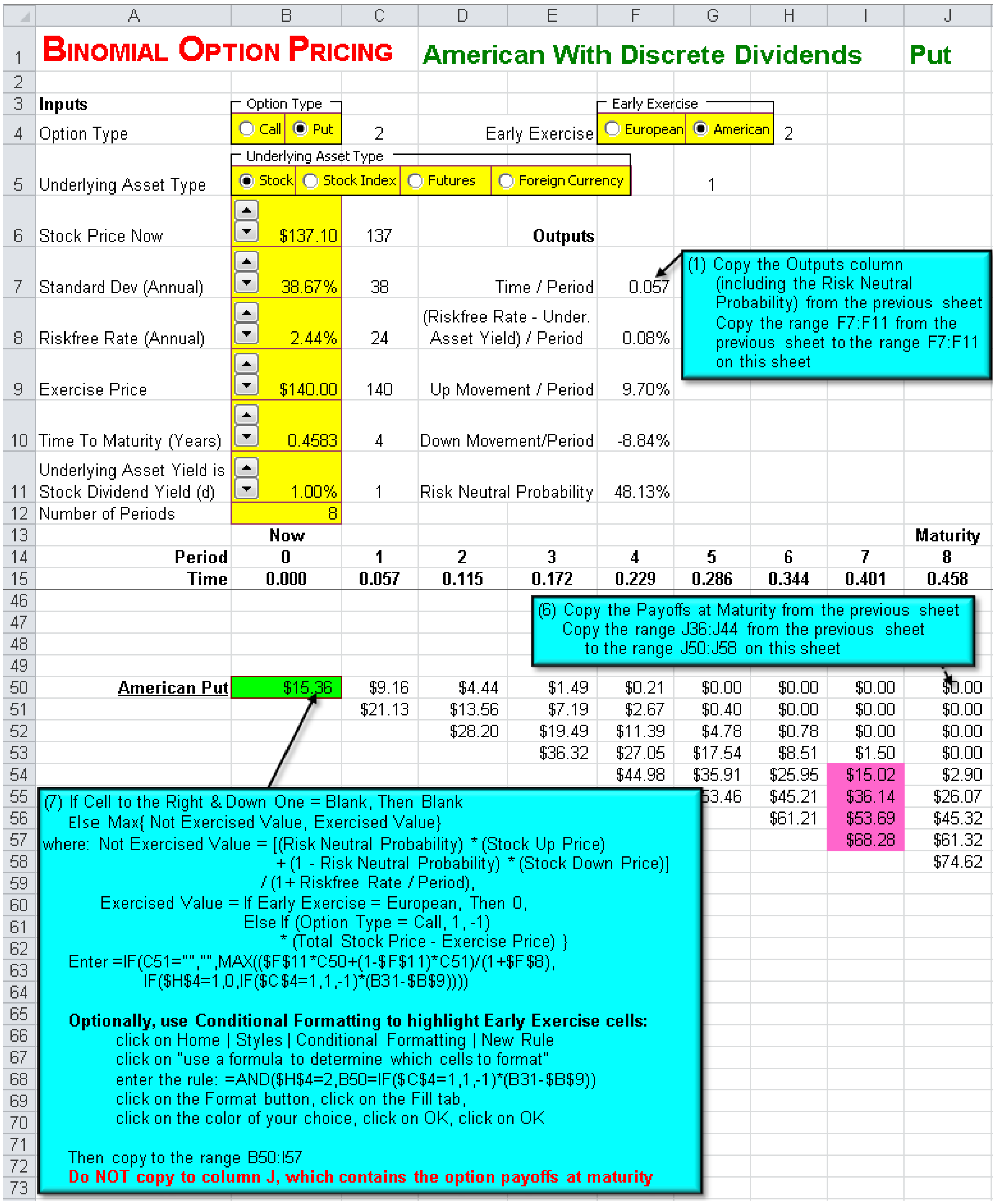
(7) If Cell to the Right & Down One = Blank, Then Blank
Else Max{ Not Exercised Value, Exercised Value}
where: Not Exercised Value = [(Risk Neutral Probability) * (Stock Up Price)
+ (1 - Risk Neutral Probability) * (Stock Down Price)]
/ (1 + Riskfree Rate / Period),
Exercised Value = If Early Exercise = European, Then 0,
Else If (Option Type = Call, 1, -1)
* (Total Stock Price - Exercise Price) }
Enter =IF(C51="","",MAX(($F$11*C50+(1-$F$11)*C51)/(1+$F$8),
IF($H$4=1,0,IF($C$4=1,1,-1)*(B31-$B$9))))

Optionally, use Conditional Formatting to highlight Early Exercise cells:
click on Home | Styles | Conditional Formatting | New Rule
click on "use a formula to determine which cells to format"
enter the rule: =AND($H$4=2,B50=IF($C$4=1,1,-1)*(B31-$B$9))
click on the Format button, click on the Fill tab,
click on the color of your choice, click on OK, click on OK

Then copy to the range B50:I57
Do NOT copy to column J, which contains the option payoffs at maturity

The purple-shading highlights the periods and call prices where it is optimal to exercise the American call early. Notice that it is optimal to exercise an American call early just before a dividend is paid, which will reduce the value of the underlying stock and thus reduce the value of an unexercised call option. We see that the model predicts an eight-period American call price of $14.57.

FIGURE 20.20 American With Discrete Dividends - Put.



The purple-shading highlights the periods and call prices where it is optimal to exercise the American put early. Notice that it is optimal to exercise an American put early just when a dividend is paid, which will reduce the value of the underlying stock and thus increases the value of the put option. We see that the model predicts an eight-period American put price of $15.36.

20.8 Full-Scale

Problem. Same as before, except we will use a fifty-period model to evaluate it in order to increase accuracy. At the close of trading on April 30, 2010, the stock price of Amazon.com was $137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was $140.00, the exercise price of an October 140 put on Amazon.com was $140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. Assume that Amazon.com pays certain, riskfree $4.00 dividends on the periods show below. What is the price of an American October 140 call and an American October 140 put on Amazon.com?

FIGURE 20.21 Binomial Option Pricing - Full-Scale - Call.

	A	B	C	D	E	F	G	H
1	**Binomial Option Pricing**			**Full-Scale**			**American Call**	
2								
3	**Inputs**	Option Type				Early Exercise		
4	Option Type	◉ Call ○ Put	1		Early Exercise	○ European	◉ American	2
5	Underlying Asset Type	Underlying Asset Type: ◉ Stock ○ Stock Index ○ Futures ○ Foreign Currency					1	
6	Risky Part of Stock	$137.10	137		**Outputs**			
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.009		
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.01%		
9	Exercise Price	$140.00	140	Up Movement / Period		3.77%		
10	Time To Maturity (Years)	0.4583	4	Down Movement/Period		-3.63%		
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1	Risk Neutral Probability		49.25%		
12	Number of Periods	50						
13		**Now**						
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
15	**Time**	**0.000**	**0.009**	**0.018**	**0.027**	**0.037**	**0.046**	**0.055**
16								
17	**Risky Part of the Stock**	$137.10	$142.27	$147.64	$153.21	$158.98	$164.98	$171.20
18			$132.12	$137.10	$142.27	$147.64	$153.21	$158.98
19				$127.32	$132.12	$137.10	$142.27	$147.64
20					$122.69	$127.32	$132.12	$137.10
21						$118.23	$122.69	$127.32
22							$113.93	$118.23
23								$109.79
24								
25								
26								

(1) Risky Part of Stock Now
Enter =B6

(2) Copy the Stock Price fomula from the previous sheet
and expand it to a larger range
Copy the cell C17 from the previous sheet
to the range C17:AZ67 on this sheet

Solution Strategy. First, copy the binomial tree parameters, the risk neutral probability, stock price tree, and option payoffs at maturity from the risk neutral model. Second, calculate the total stock price as the sum of the risky stock price plus the discounted value of future dividends. Finally, build a option value tree using the risk neutral probability and accounting for optimal early exercise.

FIGURE 20.22 Binomial Option Pricing - Full-Scale - Call (Continued).

	A	B	C	D	E	F	G	H
1	BINOMIAL OPTION PRICING			Full-Scale			American Call	
2								
3	**Inputs**	Option Type				Early Exercise		
4	Option Type	Call / Put	1		Early Exercise	European / American		2
5	Underlying Asset Type	Underlying Asset Type: Stock / Stock Index / Futures / Foreign Currency					1	
6	Risky Part of Stock	$137.10	137		**Outputs**			
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.009		
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.01%		
9	Exercise Price	$140.00	140		Up Movement / Period	3.77%		
10	Time To Maturity (Years)	0.4583	4		Down Movement/Period	-3.63%		
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1		Risk Neutral Probability	49.25%		
12	Number of Periods	50						
13		**Now**						
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
15	**Time**	**0.000**	**0.009**	**0.018**	**0.027**	**0.037**	**0.046**	**0.055**
64								
65								
66								
67								
68								
69	**Riskfree Dividends**		$0.00	$0.00	$0.00	$0.00	$5.00	$0.00
70								
71	**Cum. Pres Value Factor**	100.000%	99.987%	99.974%	99.960%	99.947%	99.934%	99.921%
72								
73	**Total Stock Price**	$152.06	$157.23	$162.60	$168.17	$173.95	$174.95	$181.17
74			$147.08	$152.06	$157.24	$162.61	$163.18	$168.96
75				$142.28	$147.08	$152.07	$152.24	$157.61
76					$137.65	$142.28	$142.09	$147.07
77						$133.20	$132.66	$137.29
78							$123.90	$128.20
79								$119.76
80								
81								
82								
83								
84								
85								
86								

(3) (Cum. Pres Value Factor(t-1)) * EXP(- (Riskfree Rate / Period))
Enter =B71*EXP(-$F$8) and copy across

(4) If corresponding cell on Risky Part of Stock tree is blank,
Then blank,
Else Risky Part of Stock
+ SUMPRODUCT(Riskfree Dividends Range,
Cum. Pres Value Factor Range)
/ (Cum. Pres Value Factor(t))
Enter =IF(B17="","",B17+SUMPRODUCT(C$69:$AZ$69,C$71:$AZ$71)/B$71)
and copy to the range B73:AY122
Do NOT copy to column AZ, which contains a different formula

The up movement / period and down movement / period are calibrated to correspond to the stock's annual standard deviation. It is not necessary to calibrate them to the stock's expected return.[9]

FIGURE 20.23 Binomial Option Pricing - Full-Scale - Call (Continued).

	AU	AV	AW	AX	AY	AZ
13						**Maturity**
14	**45**	**46**	**47**	**48**	**49**	**50**
15	**0.412**	**0.422**	**0.431**	**0.440**	**0.449**	**0.458**
64			$24.06	$24.97	$25.91	$26.89
65				$23.19	$24.06	$24.97
66					$22.35	$23.19
67						$21.53
68						
69	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
70						
71	99.408%	99.395%	99.382%	99.368%	99.355%	99.342%
72						
73	$725.40	$752.75	$781.15	$810.61	$841.18	$872.91
74	$673.62	$699.03	$725.40	$752.75	$781.15	$810.61
75	$625.55	$649.14	$673.62	$699.03	$725.40	$752.75

(5) Risky Part of the Stock Tree
Enter =AZ17 and copy down

FIGURE 20.24 Binomial Option Pricing - Full-Scale - Call (Continued).

	AR	AS	AT	AU	AV	AW	AX	AY	AZ
13									**Maturity**
14	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
15	**0.385**	**0.394**	**0.403**	**0.412**	**0.422**	**0.431**	**0.440**	**0.449**	**0.458**
120						$24.06	$24.97	$25.91	$26.89
121							$23.19	$24.06	$24.97
122								$22.35	$23.19
123									$21.53
124									
125									
126									
127	$509.29	$533.75	$559.14	$585.49	$612.83	$641.20	$670.64	$701.20	$732.91
128	$462.96	$485.68	$509.25	$533.72	$559.10	$585.45	$612.79	$641.16	$670.61
129	$419.94	$441.03	$462.92	$485.64	$509.21	$533.68	$559.07	$585.41	$612.75

(6) If Option Type = Call,
Then Call Payoff at Maturity = Max (Stock Price at Maturity - Exercise Price, 0)
Else Put Payoff at Maturity = Max (Exercise Price - Stock Price at Maturity, 0)
Enter =IF($C$4=1,MAX(AZ73-$B$9,0),MAX($B$9-AZ73,0))
and copy to the range AZ128:AZ177

---

[9] At full-scale (50 periods), the binomial option price is very insensitive to the expected return of the stock. For example, suppose that you calibrated this Amazon.com case to an annual expected return of 10%. Just add **.1*F7** to the formulas for the up and down movements / period. So the up movement / period in cell **F9** would become **=EXP(.1*F7+B7*SQRT(F7))-1** and the down movement / period in cell **F10** would become **=EXP(.1*F7-B7*SQRT(F7))-1**. This changes the option price by less than 1/100th of one penny! In the (Black-Scholes) limit as the number of (sub)periods goes to infinity, the option price becomes totally insensitive to the expected return of the stock. Because of this insensitivity, the conventions for calculating the up movement / period and down movement / period ignore the expected return of the stock.

FIGURE 20.25 Binomial Option Pricing - Full-Scale - Call (Continued).

	A	B	C	D	E	F	G	H
1	**BINOMIAL OPTION PRICING**			**Full-Scale**			**American Call**	
2								
3	**Inputs**	Option Type				Early Exercise		
4	Option Type	(•) Call ( ) Put	1		Early Exercise	( ) European	(•) American	2
5	Underlying Asset Type	Underlying Asset Type (•) Stock	( ) Stock Index	( ) Futures	( ) Foreign Currency		1	
6	Risky Part of Stock	$137.10	137		**Outputs**			
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.009		
8	Riskfree Rate (Annual)	2.44%	24		(Riskfree Rate - Under. Asset Yield) / Period	0.01%		
9	Exercise Price	$140.00	140		Up Movement / Period	3.77%		
10	Time To Maturity (Years)	0.4583	4		Down Movement/Period	-3.63%		
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1		Risk Neutral Probability	49.25%		
12	Number of Periods	50						
13		**Now**						
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
15	**Time**	**0.000**	**0.009**	**0.018**	**0.027**	**0.037**	**0.046**	**0.055**
126								
127	**American Call**	$15.59	$19.09	$23.25	$28.19	$33.95	$36.29	$41.98
128			$12.20	$15.05	$18.47	$22.61	$26.01	$30.77
129				$9.44	$11.73	$14.46	$17.67	$21.40
130					$7.21	$9.08	$11.35	$14.06
131						$5.39	$6.89	$8.72
132							$3.95	$5.11
133								$2.82

(7) If Cell to the Right & Down One = Blank, Then Blank
Else Max{ Not Exercised Value, Exercised Value}
where: Not Exercised Value = [(Risk Neutral Probability) * (Stock Up Price)
+ (1 - Risk Neutral Probability) * (Stock Down Price)]
/ (1+ Riskfree Rate / Period),
Exercised Value = If Early Exercise = European, Then 0,
Else If (Option Type = Call, 1, -1)
* (Total Stock Price - Exercise Price) }
Enter =IF(C128="","",MAX(($F$11*C127+(1-$F$11)*C128)/(1+$F$8),
IF($H$4=1,0,IF($C$4=1,1,-1)*(B73-$B$9))))

Optionally, use Conditional Formatting to highlight Early Exercise cells:
click on Home | Styles | Conditional Formatting | New Rule
click on "use a formula to determine which cells to format"
enter the rule: =AND($H$4=2,B127=IF($C$4=1,1,-1)*(B73-$B$9))
click on the Format button, click on the Fill tab,
click on the color of your choice, click on OK, click on OK

Then copy to the range B127:AY176
Do NOT copy to column AZ, which contains the option payoffs at maturity

Again, optimal early exercise for an American call occurs just before a dividend is paid. We see that the Full-Scale model predicts an American call price of $15.59. Now let's check the put.

FIGURE 20.26 Binomial Option Pricing - Full-Scale - Put Option.

	AJ	AK	AL	AM	AN	AO	AP
14	**34**	**35**	**36**	**37**	**38**	**39**	**40**
15	**0.312**	**0.321**	**0.330**	**0.339**	**0.348**	**0.357**	**0.367**
68							
69	$0.00	$5.00	$0.00	$0.00	$0.00	$0.00	$0.00
70							
147	$30.44	$26.52	$22.58	$18.68	$14.88	$11.29	$8.03
148	$38.05	$34.25	$30.35	$26.38	$22.37	$18.36	$14.46
149	$45.30	$41.75	$38.04	$34.22	$30.28	$26.25	$22.16
150	$52.06	$48.76	$45.32	$41.75	$38.04	$34.20	$30.23
151	$58.34	$55.27	$52.08	$48.76	$45.32	$41.75	$38.04
152	$64.16	$61.32	$58.35	$55.27	$52.08	$48.76	$45.32
153	$69.57	$66.94	$64.18	$61.32	$58.35	$55.27	$52.08
154	$74.60	$72.15	$69.59	$66.94	$64.18	$61.32	$58.35
155	$79.26	$76.99	$74.62	$72.15	$69.59	$66.94	$64.18
156	$83.60	$81.49	$79.28	$76.99	$74.62	$72.15	$69.59
157	$87.62	$85.67	$83.62	$81.49	$79.28	$76.99	$74.62
158	$91.36	$89.54	$87.64	$85.67	$83.62	$81.49	$79.28
159	$94.83	$93.14	$91.38	$89.54	$87.64	$85.67	$83.62
160	$98.05	$96.49	$94.85	$93.14	$91.38	$89.54	$87.64
161	$101.04	$99.59	$98.07	$96.49	$94.85	$93.14	$91.38
162		$102.48	$101.06	$99.59	$98.07	$96.49	$94.85
163			$103.84	$102.48	$101.06	$99.59	$98.07
164				$105.16	$103.84	$102.48	$101.06
165					$106.42	$105.16	$103.84
166						$107.64	$106.42
167							$108.82

Optimal early exercise for an American put often occurs on the date that the dividend is paid. More generally, it is optimal to exercise an American put option when the underlying stock price is very low for a given amount of time to maturity.

FIGURE 20.27 Binomial Option Pricing - Full-Scale - Put (Continued).

	A	B	C	D	E	F	G	H
1	BINOMIAL OPTION PRICING			Full-Scale			American Put	
2								
3	**Inputs**	Option Type				Early Exercise		
4	Option Type	○ Call ◉ Put	2		Early Exercise	○ European	◉ American	2
5	Underlying Asset Type	Underlying Asset Type: ◉ Stock ○ Stock Index ○ Futures ○ Foreign Currency					1	
6	Risky Part of Stock	$137.10	137		**Outputs**			
7	Standard Dev (Annual)	38.67%	38		Time / Period	0.009		
8	Riskfree Rate (Annual)	2.44%	24	(Riskfree Rate - Under. Asset Yield) / Period		0.01%		
9	Exercise Price	$140.00	140	Up Movement / Period		3.77%		
10	Time To Maturity (Years)	0.4583	4	Down Movement/Period		-3.63%		
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.00%	1	Risk Neutral Probability		49.25%		
12	Number of Periods	50						
13		**Now**						
14	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
15	**Time**	**0.000**	**0.009**	**0.018**	**0.027**	**0.037**	**0.046**	**0.055**
126								
127	**American Put**	$15.50	$13.07	$10.85	$8.85	$7.08	$5.55	$4.25
128			$17.87	$15.24	$12.80	$10.57	$8.57	$6.81

We see that the Full-Scale model predicts an American put price of $15.5002.

Problems

1. Download three months of daily stock price for any stock that has listed options on it. What is the annual standard deviation of your stock based on continuous returns?

2. Lookup the current stock price of your stock, use the standard deviation of daily returns you computed, lookup the yield on a six-month U.S. Treasury Bill, lookup the exercise price of a call on your stock that matures in approximately six months, lookup the exercise price of a put on your stock that matures in approximately six months, and compute the time to maturity for both options in fractions of a year. For the call and put that you identified on your stock, determine the replicating portfolio and the price of the call and put using a single-period, replicating portfolio model.

3. For the same inputs as problem 2, determine the replicating portfolio and the price of the call and put using an eight-period, replicating portfolio model.

4. For the same inputs as problem 3, determine the price of the call and put using an eight-period, risk neutral model.

5. For the same inputs as problem 4 determine the price of the call and put using the average of N and N-1 method to evaluate them.

6. For the same inputs as problem 4, show what happens to the stock price at maturity distribution of the binomial stock price tree as the number of periods increases. Show what happens to the continuous cumulative return distribution of the binomial stock price tree as the number of periods increases.

7. Use the same inputs as problem 4. Further, forecast the dividends that you stock pays or make an assumption about the dividends that your stock pays. What is the price of an American call and an American put using an eight-period, risk neutral model of American options with discrete dividends?

8. For the same inputs as problem 7, determine the price of an American call and an American put using a fifty-period, risk neutral model of American options with discrete dividends?

9. For the same inputs as problem 7, determine the price of an American call and an American put using a fifty-period, risk neutral model of American options with discrete dividends?Extend the Binomial Option Pricing model to analyze Digital Options. The only thing which needs to be changed is the option's payoff at maturity.
   (a.) For a Digital Call, the Payoff At Maturity
   = $1.00 When Stock Price At Mat > Exercise Price
   Or $0.00 Otherwise.
   (b.) For a Digital Put, the Payoff At Maturity
   = $1.00 When Stock Price At Mat < Exercise Price
   Or $0.00 Otherwise.

10. Extend the **Binomial Option Pricing – Full-Scale Estimation** model to determine how fast the binomial option price converges to the price in the **Black-Scholes Option Pricing – Basics** model. Reduce the Full-Scale model to a 10 period model and to a 20 period model. Increase the 50 period model to a 100 period model. Then for the same inputs, compare call and put prices of the 10 period, 20 period, 50 period, 100 period, and Black-Scholes models.

11. Extend the **Binomial Option Pricing – Full-Scale Estimation** model to determine how fast the binomial option price with averaging of adjacent odd and even numbers of periods converges to the price in the **Black-Scholes Option Pricing – Basics** model. As you increase the number of periods in the binomial model, it oscillates between overshooting and undershooting the true price. A simple technique to increase price efficiency is to average adjacent odd and even numbers of periods. For example, average the 10 period call price and the 11 period call price. Reduce the Full-Scale model to a 10 period, 11 period, 20 period, and 21 period model. Increase the 50 period model to a 51 period, 100 period, and 101 period model. Then for the same inputs, compare call and put prices of the average of the 10 and 11 period models, 20 and 21 period models, 50 and 51 period models, 100 and 101 period models, and Black-Scholes model.

Chapter 21 Real Options

21.1 NPV Correctly vs. NPV Ignoring Option

Problem. You have the opportunity to purchase a piece of land for $0.4 million which has known reserves of 200,000 barrels of oil. The reserves are worth $5.3 million based on the current crude oil price. The cost of building the plant and equipment to develop the oil is $5.7 million, so it is not profitable to develop these reserves right now. However, development may become profitable in the future if the price of crude oil goes up. For simplicity, assume there is a single date in 1.0 year when you can decide whether to develop the oil or not. Further assume that all of the oil can be produced immediately. Using historical data on crude oil prices, you determine that the mean value of the reserves is $6.0 million based on a mean value of the one-year ahead oil prices and the standard deviation is 30.0%. The riskfree rate is 6.0% and cost of capital for a project of this type is 13.80%. What is the project's NPV when correctly calculated as an option to develop the oil only if it is profitable? What would the NPV be if you committed to develop it today no matter what and thus, (incorrectly) ignored the option feature?

Solution Strategy. One year from now, you will develop the oil if it is profitable and won't develop it if it is not. Thus, the payoff is Max (Value of the Reserves - Cost of Development, 0). This is identical to the payoff of a call option, where the Cost of Development is the Exercise Price and the Value of the Reserves Now is the Asset Price Now. This call option can be valued using the Binomial Option Pricing model. Open the Excel model that you created for Binomial Option Pricing - Risk Neutral. Calculate the NPV Using Binomial by taking the Binomial Option Value and subtracting the cost of the option (i.e., cost of the land). Calculate the NPV Ignoring Option projecting expected cash flows from developing the oil no matter whether it is profitable or not and discounting these expected cash flows back to the present.

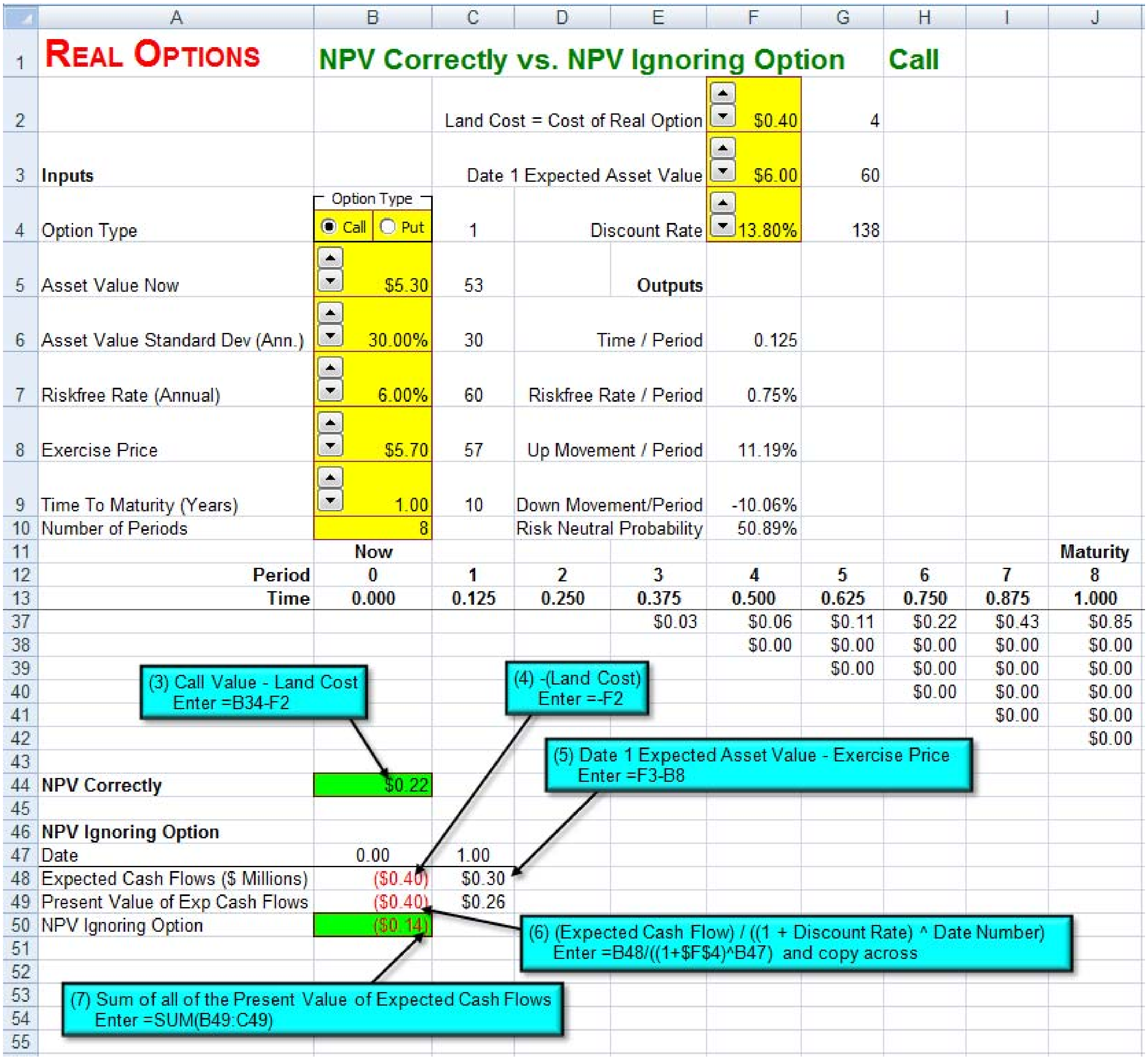
FIGURE 21.1 Real Options – NPV Correctly vs. NPV Ignoring Option.

	A	B	C	D	E	F	G	H	I	J
1	REAL OPTIONS	NPV Correctly vs. NPV Ignoring Option					Call			
2					Land Cost = Cost of Real Option	$0.40	4			
3	**Inputs**				Date 1 Expected Asset Value	$6.00	60			
4	Option Type	Option Type: (•) Call ( ) Put	1		Discount Rate	13.80%	138			
5	Asset Value Now	$5.30	53		**Outputs**					
6	Asset Value Standard Dev (Ann.)	30.00%	30		Time / Period	0.125				
7	Riskfree Rate (Annual)	6.00%	60		Riskfree Rate / Period	0.75%				
8	Exercise Price	$5.70	57		Up Movement / Period	11.19%				
9	Time To Maturity (Years)	1.00	10		Down Movement/Period	-10.06%				
10	Number of Periods	8			Risk Neutral Probability	50.89%				
11		**Now**								**Maturity**
12	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
13	**Time**	**0.000**	**0.125**	**0.250**	**0.375**	**0.500**	**0.625**	**0.750**	**0.875**	**1.000**
14										
15	**Stock**	$5.30	$5.89	$6.55	$7.29	$8.10	$9.01	$10.02	$11.14	$12.38
16			$4.77	$5.30	$5.89	$6.55	$7.29	$8.10	$9.01	$10.02
17				$4.29	$4.77	$5.30	$5.89	$6.55	$7.29	$8.10
18					$3.86	$4.29	$4.77	$5.30	$5.89	$6.55
19						$3.47	$3.86	$4.29	$4.77	$5.30
20							$3.12	$3.47	$3.86	$4.29
21								$2.80	$3.12	$3.47
22									$2.52	$2.80
23										$2.27
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34	**Call**	$0.62	$0.92	$1.34	$1.89	$2.59	$3.43	$4.40	$5.48	$6.68
35			$0.31	$0.50	$0.78	$1.19	$1.76	$2.49	$3.35	$4.32
36				$0.12	$0.21	$0.37	$0.63	$1.03	$1.63	$2.40
37					$0.03	$0.06	$0.11	$0.22	$0.43	$0.85
38						$0.00	$0.00	$0.00	$0.00	$0.00
39							$0.00	$0.00	$0.00	$0.00
40								$0.00	$0.00	$0.00
41									$0.00	$0.00
42										$0.00

(1) Copy the Outputs column (including the Risk Neutral Probability) from Binomial Option Pricing - Risk Neutral model
Copy the range F6:F10 from Binomial Option Pricing - Risk Neutral model to the range F6:F10 on this sheet

(2) Copy the Stock and Option Price Trees from Binomial Option Pricing - Risk Neutral model
Copy the range B15:J42 from Binomial Option Pricing - Risk Neutral model to the range B15:J42 on this sheet

FIGURE 21.2 Real Options – NPV Correctly vs. NPV Ignoring Option.



	A	B	C	D	E	F	G	H	I	J
1	REAL OPTIONS	NPV Correctly vs. NPV Ignoring Option						Call		
2					Land Cost = Cost of Real Option	$0.40	4			
3	**Inputs**				Date 1 Expected Asset Value	$6.00	60			
4	Option Type	Option Type: Call / Put	1		Discount Rate	13.80%	138			
5	Asset Value Now	$5.30	53		**Outputs**					
6	Asset Value Standard Dev (Ann.)	30.00%	30		Time / Period	0.125				
7	Riskfree Rate (Annual)	6.00%	60		Riskfree Rate / Period	0.75%				
8	Exercise Price	$5.70	57		Up Movement / Period	11.19%				
9	Time To Maturity (Years)	1.00	10		Down Movement/Period	-10.06%				
10	Number of Periods	8			Risk Neutral Probability	50.89%				
11		**Now**								**Maturity**
12	**Period**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
13	**Time**	**0.000**	**0.125**	**0.250**	**0.375**	**0.500**	**0.625**	**0.750**	**0.875**	**1.000**
37					$0.03	$0.06	$0.11	$0.22	$0.43	$0.85
38						$0.00	$0.00	$0.00	$0.00	$0.00
39							$0.00	$0.00	$0.00	$0.00
40								$0.00	$0.00	$0.00
41									$0.00	$0.00
42										$0.00
43										
44	**NPV Correctly**	$0.22								
45										
46	**NPV Ignoring Option**									
47	Date	0.00	1.00							
48	Expected Cash Flows ($ Millions)	($0.40)	$0.30							
49	Present Value of Exp Cash Flows	($0.40)	$0.26							
50	NPV Ignoring Option	($0.14)								
51										
52										
53										
54										
55										

We obtain opposite results from the two approaches. The NPV Using Black-Scholes is positive $0.22 million, whereas the Ignore Option NPV is negative ($0.14) million. NPV Ignoring Option incorrectly concludes that the project should be rejected. This mistake happened precisely because it ignores the option to develop oil only when profitable and avoid the cost of development when it is not. NPV using Black-Scholes correctly demonstrates that the project should be accepted. This is because the *value of the option* to develop the oil when profitable is greater than the *cost of the option* (i.e., the cost of the land).

Problems

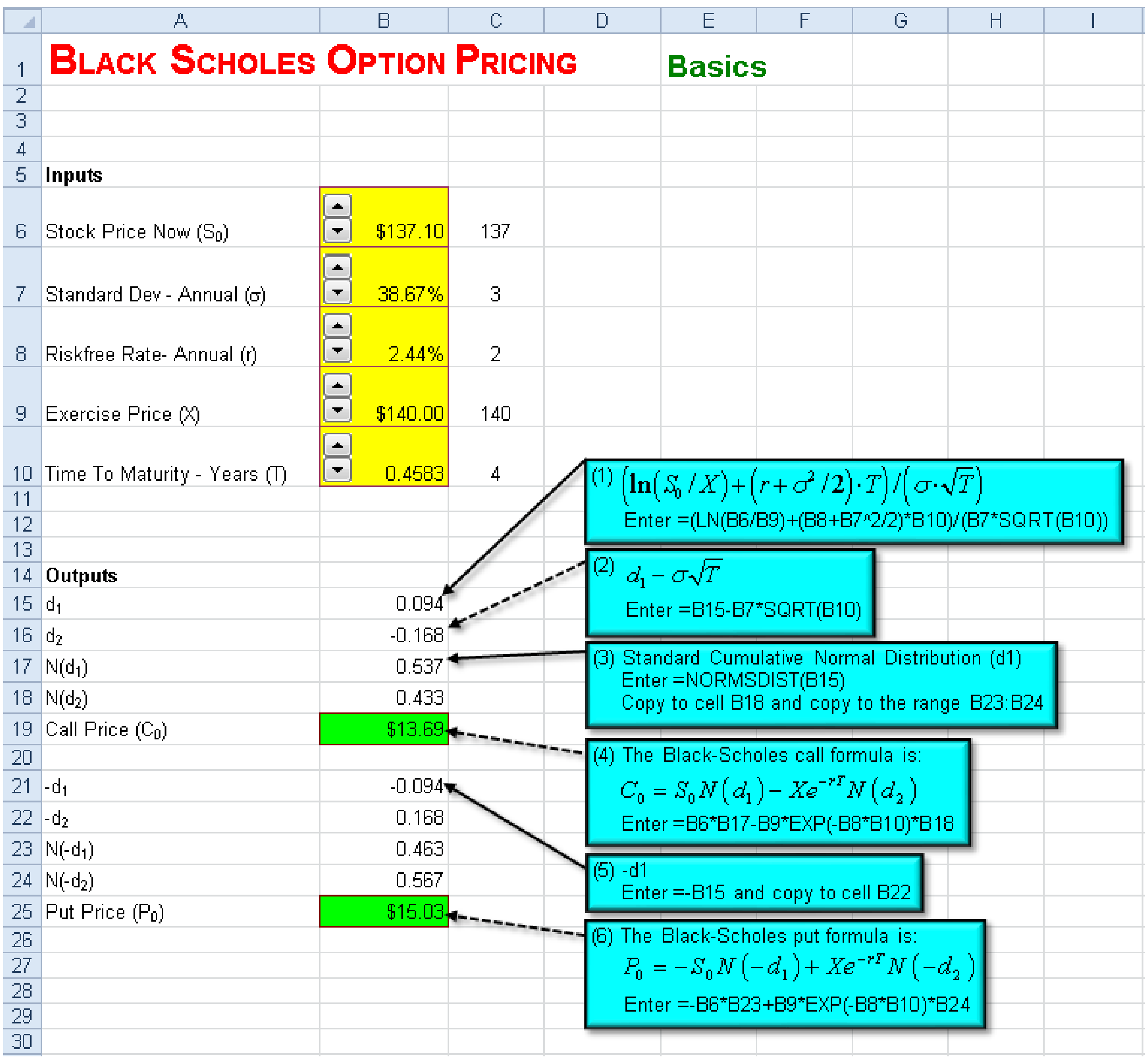
1. You have the opportunity to purchase a piece of land for $0.7 million which has known reserves of 375,000 barrels of oil. The reserves are worth $12.6 million based on the current crude oil price of $33.60 per barrel. The cost of building the plant and equipment to develop the oil is $4.5 million, so it is not profitable to develop these reserves right now. However, development may become profitable in the future if the price of crude oil goes up. For simplicity, assume there is a single date in 1.4 years when you can decide whether to develop the oil or not. Further assume that all of the oil can be produced immediately. Using historical data on crude oil prices, you determine that the mean value of the reserves is $13.4 million based on a mean value of the one-year ahead oil price of $35.73 per barrel and the standard deviation 30.0%. The riskfree rate is 4.7% and cost of capital for a project of this type is 12.15%. What is the project's NPV using the binomial model? What would the NPV be if you committed to develop it today no matter what and thus, (incorrectly) ignored the option to develop the oil only if it is profitable?

Chapter 22 Black-Scholes Option Pricing

22.1 Basics

Problem. At the close of trading on April 30, 2010, the stock price of Amazon.com was \$137.10, the standard deviation of daily returns is 38.67%, the yield on a six-month U.S. Treasury Bill was 2.44%, the exercise price of an October 140 call on Amazon.com was \$140.00, the exercise price of an October 140 put on Amazon.com was \$140.00, and the time to maturity for both October 15, 2010 maturity options was 0.4583 years. What is the price of an October 140 call and an October 140 put on Amazon.com?

FIGURE 22.1 Excel Model for Black-Scholes Option Pricing - Basics.

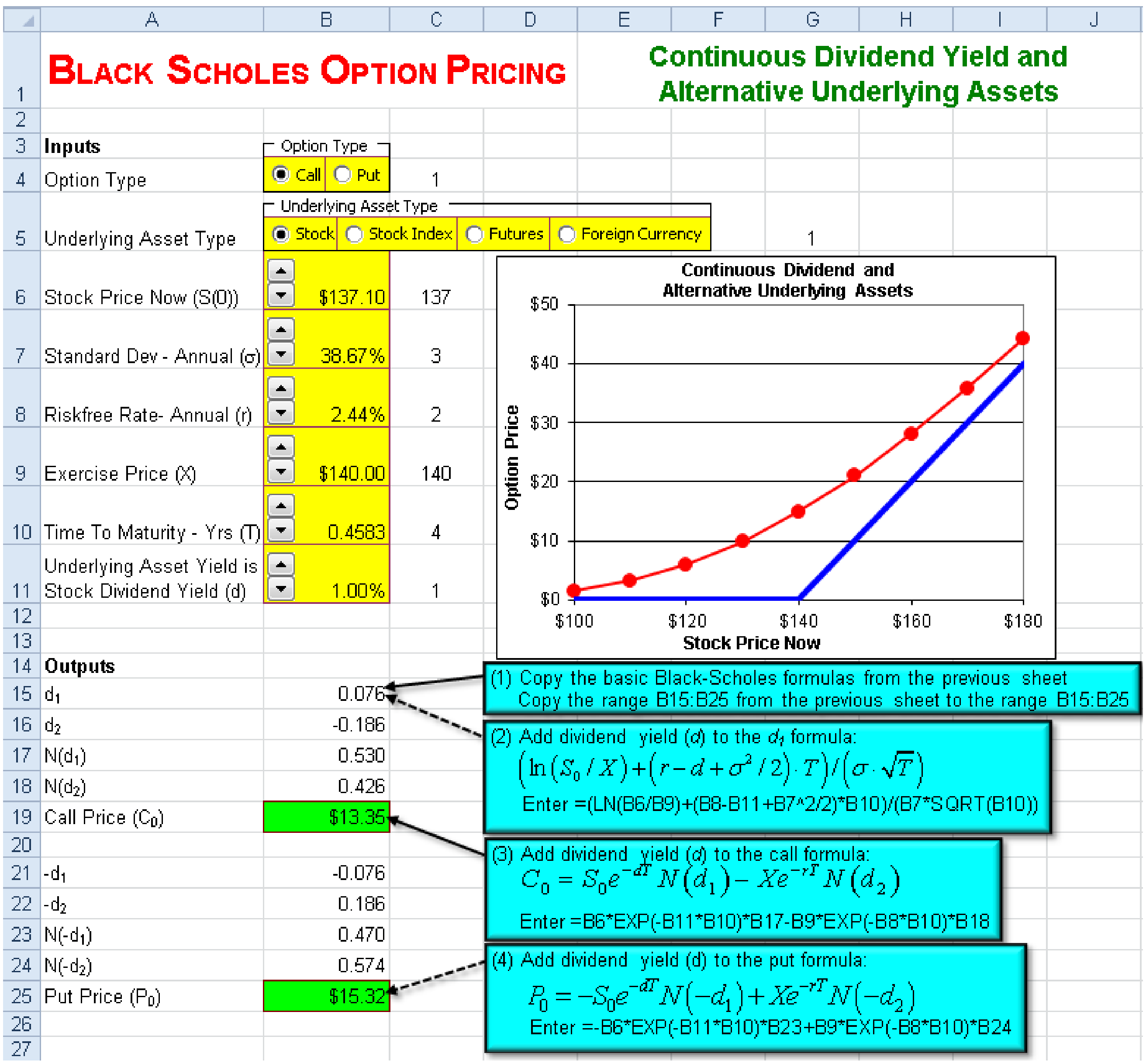


The Black-Scholes model predicts a call price of $13.69. This is four cents different than what the Binominal Option Pricing - Full-Scale Estimation model predicts for a *European* call with identical inputs (including no dividends). The Black-Scholes model predicts a put price of $15.03. This is four cents different than what the Binominal Option Pricing - Full-Scale Estimation model predicts for a *European* put with identical inputs (including no dividends).. The advantage of the Black-Scholes model and its natural analytic extensions is they are quick and easy to calculate. The disadvantage is that they are limited to a narrow range of derivatives (such as *European* options only, etc.).

22.2 Continuous Dividend

Problem. Suppose that Amazon.com paid dividends in tiny amounts on a continuous basis throughout the year at a 1.0% / year rate. What would be the new price of the call and put?

FIGURE 22.2 Black-Scholes – Cont Div Yield and Alt Under Assets – Call



Solution Strategy. Modify the basic Black-Scholes formulas from the previous sheet to include the continuous dividend.

Results. We see that the continuous dividend model predicts a call price of $13.35. This is a drop of 34 cents from the no dividend version. The continuous dividend model predicts a put price of $15.32. This is a rise of 29 cents from the no dividend version. To create a dynamic chart, we have a few more steps.

FIGURE 22.3 Black-Scholes – Cont Div Yield and Alt Under Assets – Call

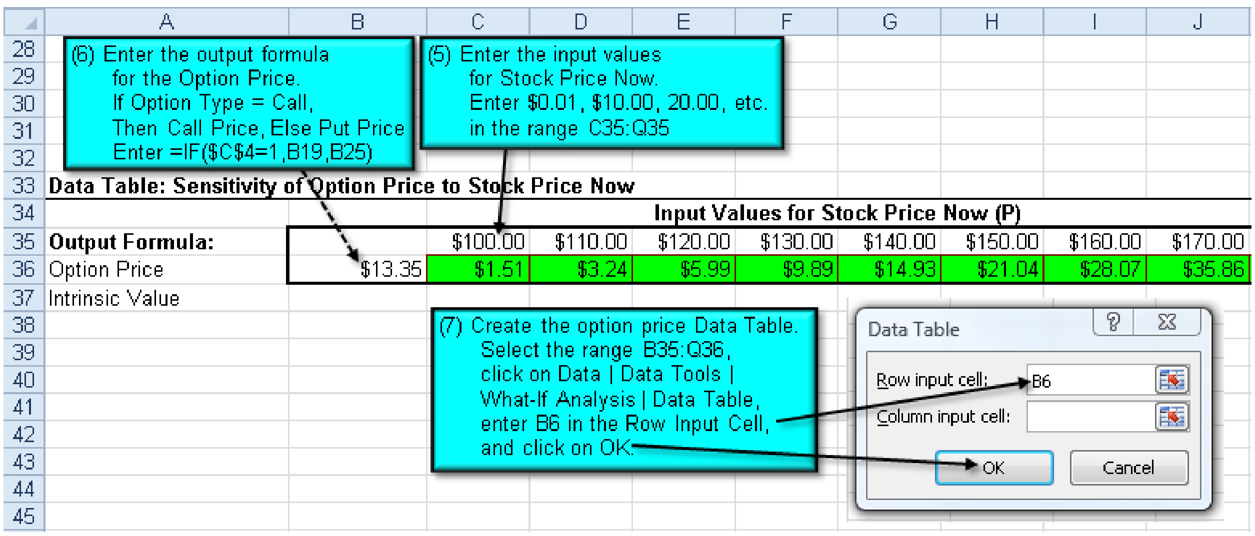
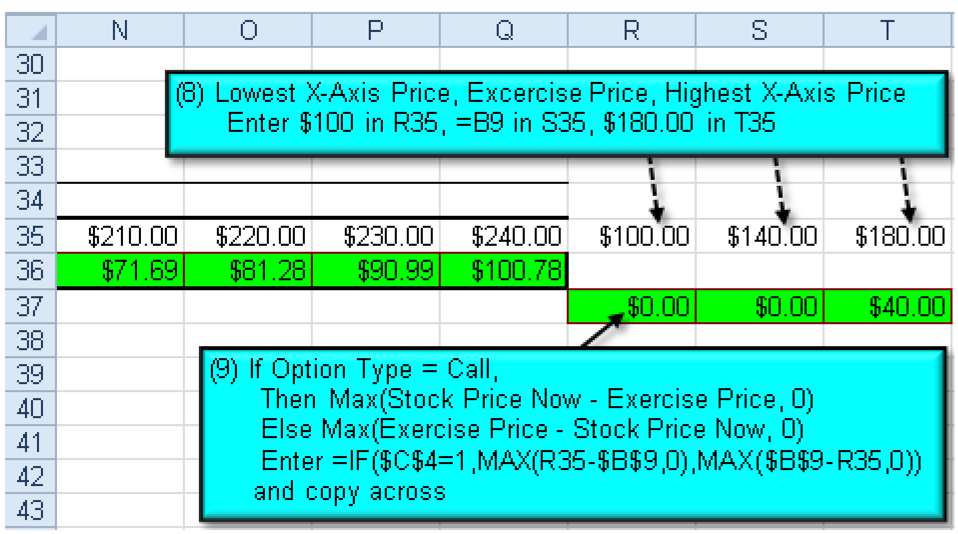


FIGURE 22.4 Black-Scholes – Cont Div Yield and Alt Under Assets – Call

Excel 97-2003 Equivalent
To call up a Data Table in Excel 2003, click on **Data** | **Table**.

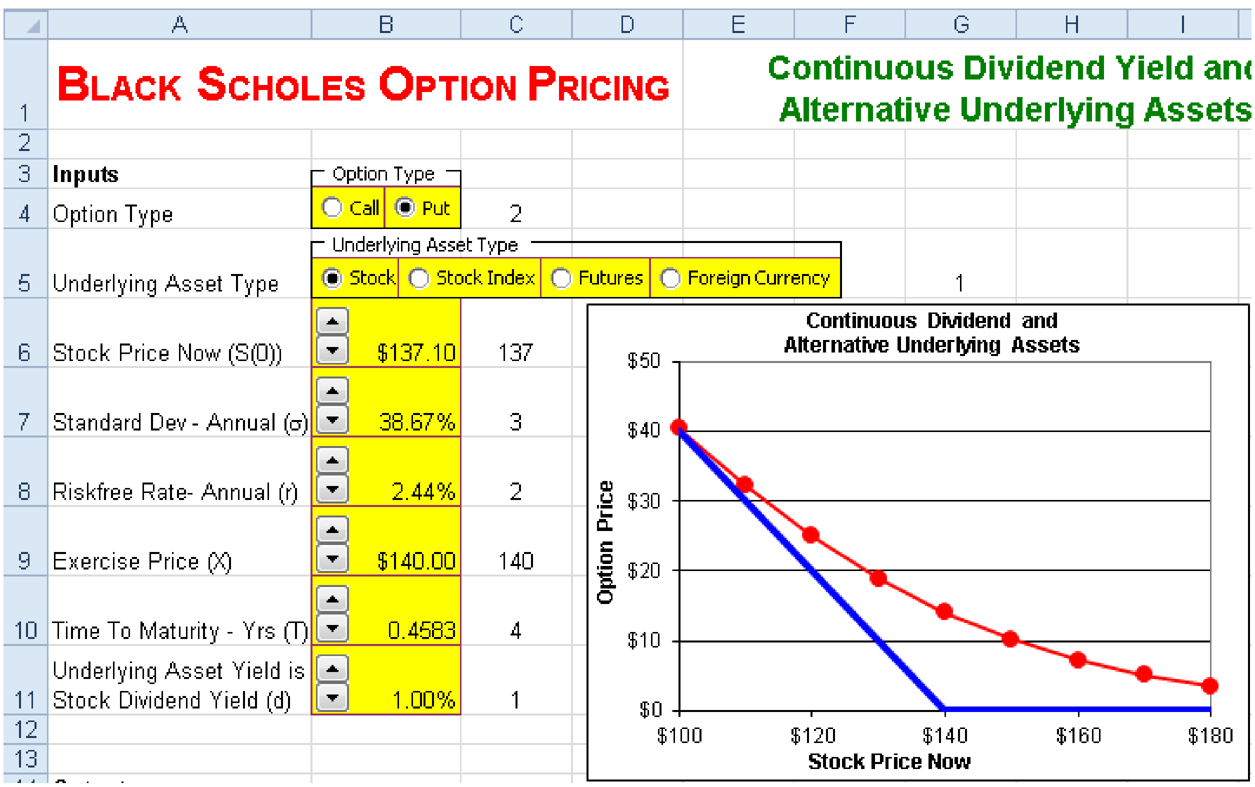


The spin buttons allows you to change Black-Scholes inputs and instantly see the impact on a graph of the option price and intrinsic value. This allows you to perform instant experiments on the Black-Scholes option pricing model. Here is a list of experiments that you might want to perform:

- What happens when the standard deviation is increased?
- What happens when the time to maturity is increased?
- What happens when the exercise price is increased?
- What happens when the riskfree rate is increased?
- What happens when the dividend yield is increased?
- What happens when the standard deviation is really close to zero?
- What happens when the time to maturity is really close to zero?

Notice that the Black-Scholes option price is usually greater than the payoff you would obtain if the option was maturing today (the "intrinsic value"). This extra value is called the "Time Value" of the option. Given your result in the last experiment above, can you explain *why* the extra value is called the "Time Value"? Now let's look at the put option.

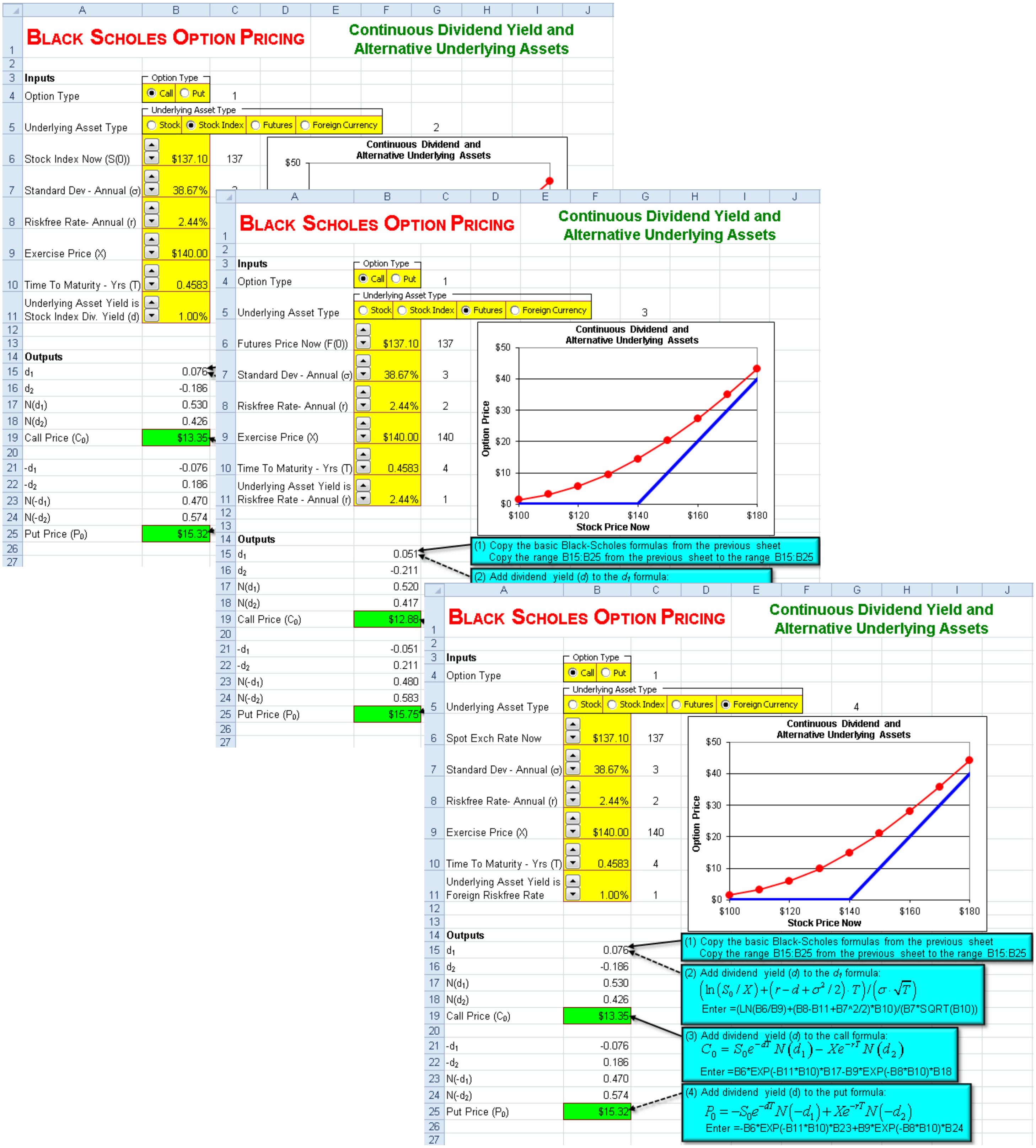
FIGURE 22.5 Black-Scholes – Cont Div Yield and Alt Under Assets – Put



The put option value sometime drops below the intrinsic value. To understand why, try increasing the riskfree rate and see what happens. Then decrease the riskfree rate to zero and see what happens. You can perform many similar experiments on the put option.

The model can handle three additional types of underlying asset (see **row 5**): (1) stock index, (2) futures, and (3) foreign currency. Then the underlying asset yield (see **row 11**) becomes: (1) the stock index dividend yield, (2) the riskfree rate, and (3) the foreign riskfree rate, respectively.

FIGURE 22.6 Black-Scholes – Cont Div Yield and Alt Under Assets – Call



22.3 Implied Volatility

Problem. At the close of trading on April 30, 2010, SPX, a security based on the S&P 500 index, traded at 1,186.69. European call and put options on SPX with the exercise prices shown below traded for the following prices:

Exercise price	1,175	1,195	1,200	1,225	1,250
Call price	$58.50	$47.16	$44.30	$32.41	$22.30
Exercise price	1,100	1,125	1,150	1,195	1,200
Put price	$27.50	$34.10	$38.00	$54.60	$59.10

These call options mature on August 20, 2010, which is in 0.3056 years. The S&P 500 portfolio pays a continuous dividend yield of 1.89% per year and the annual yield on a Treasury Bill which matures on August 15th is 0.16% per year. What is the implied volatility of each of these calls and puts? What pattern do these implied volatilities follow across exercise prices and between calls vs. puts?

Solution Strategy. Calculate the difference between the observed option price and the option price predicted by the continuous dividend yield version of the Black-Scholes model using a dummy value for the stock volatility. Have the Excel Solver tool adjust the stock volatility by trial and error until the difference between the observed price and the model price is equal to zero (within a very small error tolerance).

FIGURE 22.7 Excel Model of Black-Scholes - Implied Volatility.

	A	B	C	D	E	F	G	H	I	J	K
1	BLACK SCHOLES OPTION PRICING				Implied Volatility						
2											
3	**Inputs**										
4	Option Type: 1=Call, 2=Put	1	1	1	1	1	2	2	2	2	2
5	Underlying Asset Type	Underlying Asset Type: ◉ Stock ○ Stock Index ○ Futures ○ Foreign Currency					1				
6	Stock Price Now (S(0))	1,186.69	1,186.69	1,186.69	1,186.69	1,186.69	1,186.69	1,186.69	1,186.69	1,186.69	1,186.69
7	Standard Dev - Annual (σ)	21.48%	20.69%	20.41%	19.50%	18.49%	23.59%	22.69%	20.18%	17.94%	18.57%
8	Riskfree Rate- Annual (r)	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%
9	Exercise Price (X)	1,175	1,195	1,200	1,225	1,250	1,100	1,125	1,150	1,195	1,200
10	Time To Maturity - Years (T)	0.3056	0.3056	0.3056	0.3056	0.3056	0.3056	0.3056	0.3056	0.3056	0.3056
11	Underlying Asset Yield is Stock Dividend Yield (d)	1.89%	1.89%	1.89%	1.89%	1.89%	1.89%	1.89%	1.89%	1.89%	1.89%
12	Observed Option Price	$58.50	$47.16	$44.30	$32.41	$22.30	$27.50	$34.10	$38.00	$54.60	$59.10
13											
14	**Outputs**										
15	d_1	0.098	-0.050	-0.089	-0.290	-0.509	0.606	0.446	0.290	-0.074	-0.109
16	d_2	-0.021	-0.164	-0.202	-0.398	-0.611	0.476	0.321	0.178	-0.173	-0.211
17	$N(d_1)$	0.539	0.480	0.464	0.386	0.305	0.728	0.672	0.614	0.470	0.457
18	$N(d_2)$	0.492	0.435	0.420	0.345	0.270	0.683	0.626	0.571	0.431	0.416
19	Model Call Price (C_0)	$58.50	$47.16	$44.30	$32.41	$22.30	$107.89	$89.51	$68.42	$40.04	$39.54
20											
21	$-d_1$	-0.098	0.050	0.089	0.290	0.509	-0.606	-0.446	-0.290	0.074	0.109
22	$-d_2$	0.021	0.164	0.202	0.398	0.611	-0.476	-0.321	-0.178	0.173	0.211
23	$N(-d_1)$	0.461	0.520	0.536	0.614	0.695	0.272	0.328	0.386	0.530	0.543
24	$N(-d_2)$	0.508	0.565	0.580	0.655	0.730	0.317	0.374	0.429	0.569	0.584
25	Model Put Price (P_0)	$53.07	$61.72	$63.86	$76.96	$91.83	$27.50	$34.10	$38.00	$54.60	$59.10
26											
27	**Solver**										
28	Difference (observed - model)	-3E-08	-1.2E-07	-5E-07	-6.2E-07	1.3E-07	5.4E-08	1.6E-07	3.4E-08	2.0E-08	1.5E-07

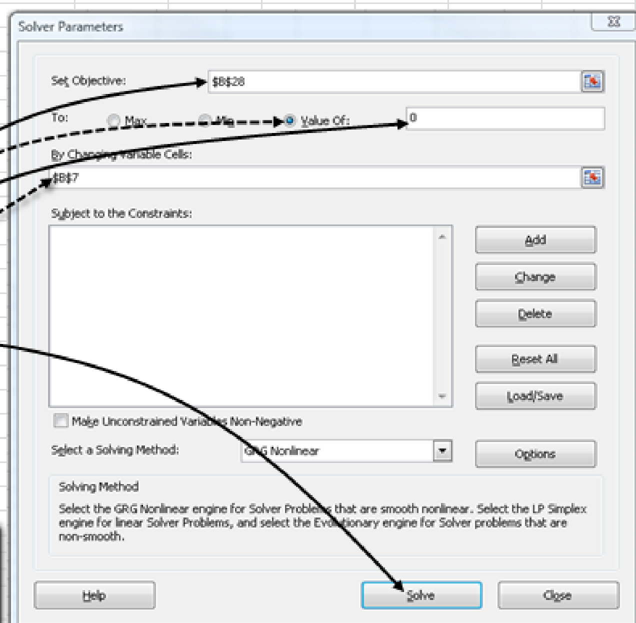
(1) Copy the continuous dividend Black-Scholes formulas from sheet 19.2
Copy the range B15:B25 from sheet 19.2 to the range B15:K25

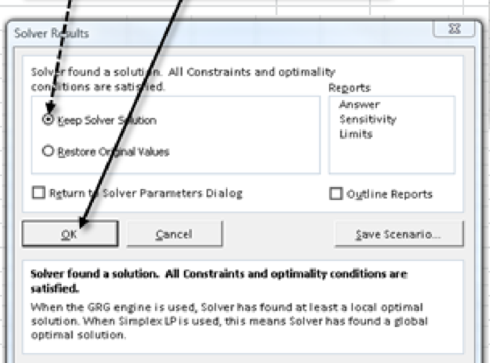
(2) If Option Type = Call,
Then Observed Option Price - Model Call Price
Else Observed Option Price - Model Put Price
Enter =IF(B4=1,B12-B19,B12-B25)

(3) Use Solver to determine the Implied Volatility.
* Click on **Data** | **Analysis** | **Solver**,
* enter **B28** in Set Target Cell,
* click on the **Value Of** button
* enter **0** in the adjacent box,
* enter **B7** in By Changing Cells,
* and click on **Solve**.

When Solver finds a solution,
* click on the **Keep Solver Solution** button
* and click on **OK**.

Repeat using Solver to determine the implied volatility for column C.





Excel 97-2003 Equivalent

To install Solver in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Solver** checkbox on the Add-Ins dialog box, and click on **OK**.

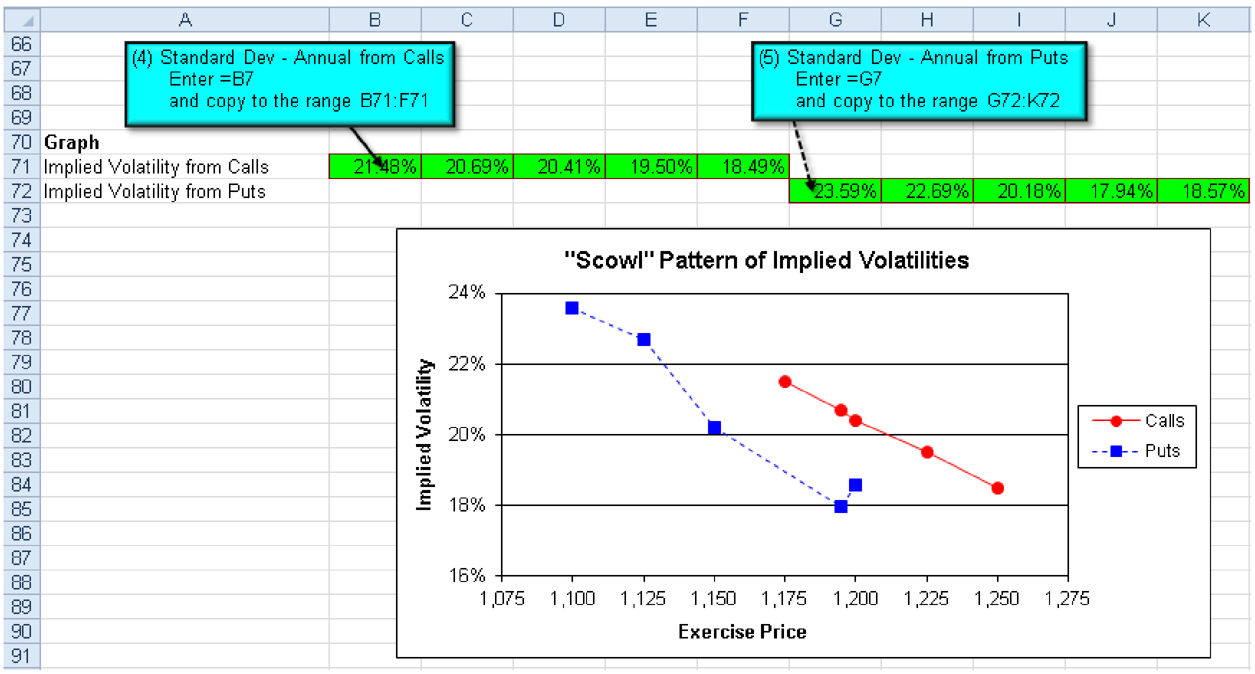
Excel 2007 Equivalent

To install the Analysis ToolPak in Excel 2007, click on , click on Excel Options at the bottom of the drop-down window, click on **Add-Ins**, highlight **Solver** in the list of Inactive Applications, click on **Go**, check the **Solver**, and click on **OK**.

To install the Analysis ToolPak, click on File, click on Options, click on **Add-Ins**, highlight the **Solver** in the list of Inactive Applications, click on **Go**, check the **Solver**, and click on **OK**.

If the market's beliefs about the distribution of returns of the S&P 500 Index matched the theoretical distribution of returns assumed by the Black-Scholes model, then all of the implied volatilities would be the same. From the graph we see this is not the case. The implied volatility pattern declines sharply with the exercise price and puts have lower implied volatilities than calls. In the '70s and '80s, the typical implied volatility pattern was a U-shaped, "Smile" pattern. In the '90s and 2000s, it is more typical to see a downward-sloping, "Scowl" pattern.

FIGURE 22.8 Graph of the "Scowl" Pattern of Implied Volatilities.



Problems

1. Download three months of daily stock price for any stock that has listed options on it and compute the standard deviation of daily returns. Lookup the current stock price of your stock, use the standard deviation of daily returns you just computed, lookup the yield on a six-month U.S. Treasury Bill, lookup the exercise price of a call on your stock that matures in approximately six months, lookup the exercise price of a put on your stock that matures in approximately six months, and compute the time to maturity for both options in fractions of a year. For the call and put that you identified on your stock, determine the price of the call and put using the Black-Scholes basics model.

2. Use the same inputs as problem 1. Forecast the continuous dividend that your stock pays or make an assumption about the continuous dividend that your stock pays. Determine the price of the call and put using the Black-Scholes continuous dividend model.

3. Perform instant experiments on whether changing various inputs causes an increase or decrease in the Call Price and in the Put Price and by how much.

   (a.) What happens when the standard deviation is increased?
   (b.) What happens when the time to maturity is increased?
   (c.) What happens when the exercise price is increased?
   (d.) What happens when the riskfree rate is increased?
   (e.) What happens when the dividend yield is increased?
   (f.) What happens when the standard deviation is really close to zero?
   (g.) What happens when the time to maturity is really close to zero?

4. The S&P 500 index closes at 2000. European call and put options on the S&P 500 index with the exercise prices shown below trade for the following prices:

Exercise price	1,950	1,975	2,000	2,025	2,050
Call price	$88	$66	$47	$33	$21
Put price	$25	$26	$32	$44	$58

   All options mature in 88 days. The S&P 500 portfolio pays a continuous dividend yield of 1.56% per year and the annual yield on a Treasury Bill which matures on the same day as the options is 4.63% per year. Determine what is the implied volatility of each of these calls and puts. What pattern do these implied volatilities follow across exercise prices and between calls vs. puts?

Chapter 23 Debt And Equity Valuation

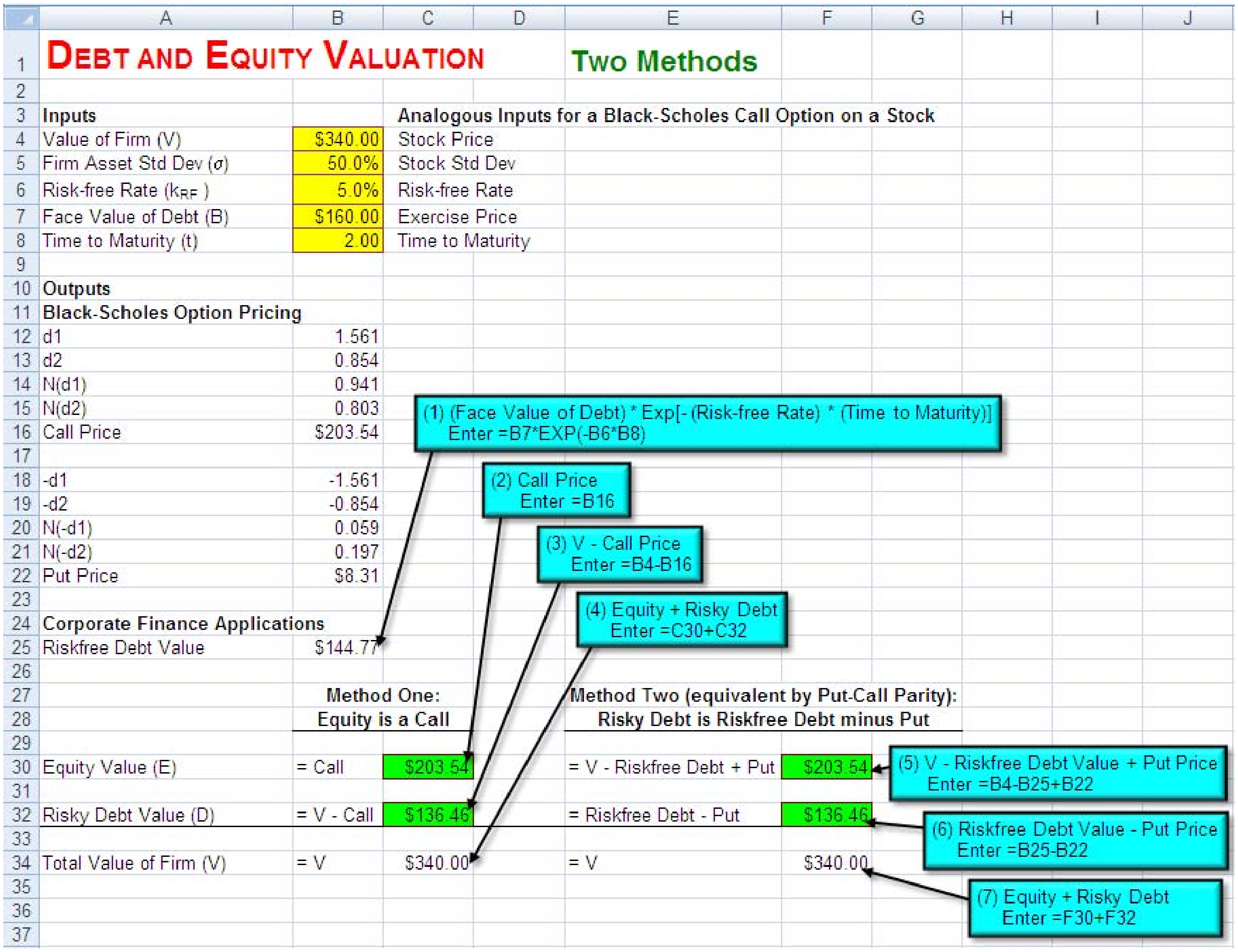
23.1 Two Methods

Problem. The Value of the Firm (V) is $340 million, the Face Value of the Debt (B) is $160 million, the time to maturity of the debt (t) is 2.00 years, the riskfree rate (k_{RF}) is 5.0%, and the standard deviation of the return on the firm's assets (σ) is 50.0%. There are two different methods for valuing the firm's equity and risky debt based in an option pricing framework. Using both methods, what is the firm's Equity Value (E) and Risky Debt Value (D)? Do both methods produce the same result?

Solution Strategy. In the first method, equity is considered to be a call option. Thus, E = Call Price. For this call option, the underlying asset is the Value of the Firm (V) and the exercise price is the face value of the debt (B). Hence, the call price is calculated from the Black-Scholes call formula by substituting V for P and B for X. The rationale is that if V > B, then the equityholders gain the net profit V-B. However, if V < B, then the equityholders avoid the loss by declaring bankruptcy, turning V over to the debtholders, and walking away with zero rather than owing money. Thus, the payoff to equityholders is Max (V - B, 0), which has the same payoff form as a call option. Further, we can use the fact that Debt plus Equity equals Total Value of Firm (D + E = V) and obtain the value of debt D = V - E = V - Call.

In the second method, Risky Debt is considered to be Riskfree Debt minus a Put option. Thus, D = Riskfree Debt - Put. For this put option, the underlying asset is also the Value of the Firm (V) and the exercise price is also the face value of the debt (B). Hence, the put price is calculated from the Black-Scholes put formula by substituting V for P and B for X. The rationale is that the put option is a *Guarantee* against default in repaying the face value of the debt (B). Specifically, if V > B, then the equityholders repay the face value B in full and the value of the guarantee is zero. However, if V < B, then the equityholders only pay V and default on the rest, so the guarantee must pay the balance B - V. Thus, the payoff on the guarantee is Max (B - V, 0), which has the same payoff form as a put option. Further, we can use the fact that Debt plus Equity equals Total Value of Firm (D + E = V) and obtain E = V - Risky Debt = V - (Riskfree Debt - Put).

FIGURE 23.1 Excel Model for Stocks and Risky Bonds.



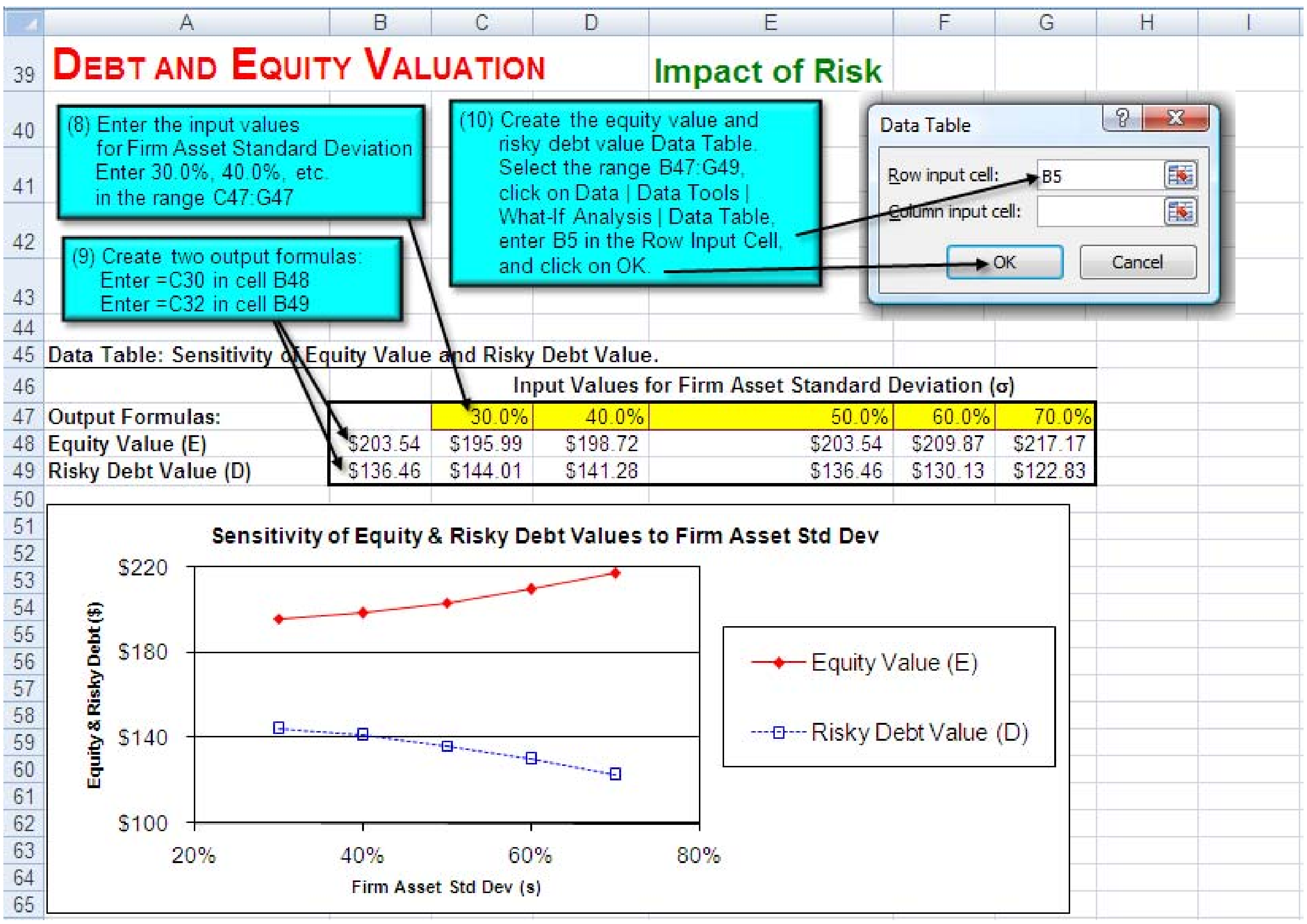
Both methods of doing the calculation find that the Equity Value (E) = $203.54 and the Risky Debt Value (D) = $136.46. We can verify that both methods should always generate the same results. Consider what we get if we equate the Method One and Method Two expressions for the Equity Value (E): **Call Price = V – Riskfree Bond Value + Put Price**. You may recognize this as an alternative version of Put-Call Parity. The standard version of Put-Call Parity is: **Call Price = Stock Price - Bond Price + Put Price**. To get the alternative version, just substitute V for the Stock Price and substitute the Riskfree Bond Value for the Bond Price. Consider what we get if we equate the Method One and Method Two expressions for the Risky Debt Value (D): **V - Call Price = Riskfree Bond - Put Price**. This is simply a rearrangement of the alternative version of Put-Call Parity. Since Put-Call Parity is always true, then both methods of valuing debt and equity will always yield the same result!

23.2 Impact of Risk

Problem. What impact does the firm's risk have upon the firm's Debt and Equity valuation? Specifically, if you increased Firm Asset Standard Deviation, then what would happen to the firm's Equity Value and Risky Debt Value?

Solution Strategy. Create a **Data Table** of Equity Value and Risky Debt Value for different input values for the Firm's Asset Standard Deviation. Then graph the results and interpret it.

FIGURE 23.2 Excel Model of the Sensitivity of Equity Value and Risky Debt Value.



Excel 97-2003 Equivalent

To call up a Data Table in Excel 97-2003, click on **Data** | **Table**.

Looking at the chart, we see that increasing the firm's asset standard deviation causes a wealth transfer from debtholders to equityholders. This may seem surprising, but this is a direct consequence of equity being a call option and debt being V *minus* a call option. We know that increasing the standard deviation makes a call more valuable, so equivalently increasing the firm's asset standard deviation makes the firm's Equity Value more valuable and reduces the Risky Debt Value by the same amount.

The intuitive rationale for this is that an increase in standard deviation allows equityholders to benefit from more frequent and bigger increases in V, while not being hurt by more frequent and bigger decreases in V. In the later case, the equityholders are going to declare bankruptcy anyway so they don't care how much V drops. Debtholders are the mirror image. They do *not* benefit from more frequent and bigger increases in V since repayment is capped at B, but they are *hurt* by more frequent and bigger decreases in V. In the latter case, the size of the repayment default (B – V) increases as V drops more.

The possibility of transferring wealth from debtholders to equityholders (or visa versa) illustrates the potential for conflict between equityholders and debtholders. Equityholders would like the firm to take on riskier projects, but debtholders would like the firm to focus on safer projects. Whether the firm ultimately decides to take on risky or safe projects will determine how wealth is divided between the two groups.

Problems

1. The Value of the Firm (V) is $780 million, the Face Value of the Debt (B) is $410 million, the time to maturity of the debt (t) is 1.37 years, the riskfree rate (k_{RF}) is 3.2%, and the standard deviation of the return on the firm's assets (σ) is 43.0%. Using both methods of debt and equity valuation, what is the firm's Equity Value (E) and Risky Debt Value (D)? Do both methods produce the same result?

2. Determine what impact an increase in the Firm Asset Standard Deviation has on the firm's Equity Value and Risky Debt Value.

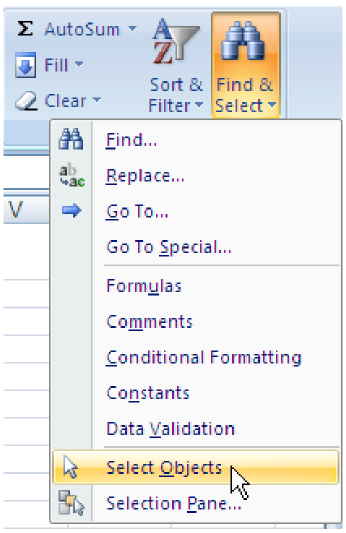
PART 8 EXCEL SKILLS

Chapter 24 Useful Excel Tricks

24.1 Quickly Delete The Instructions and Arrows

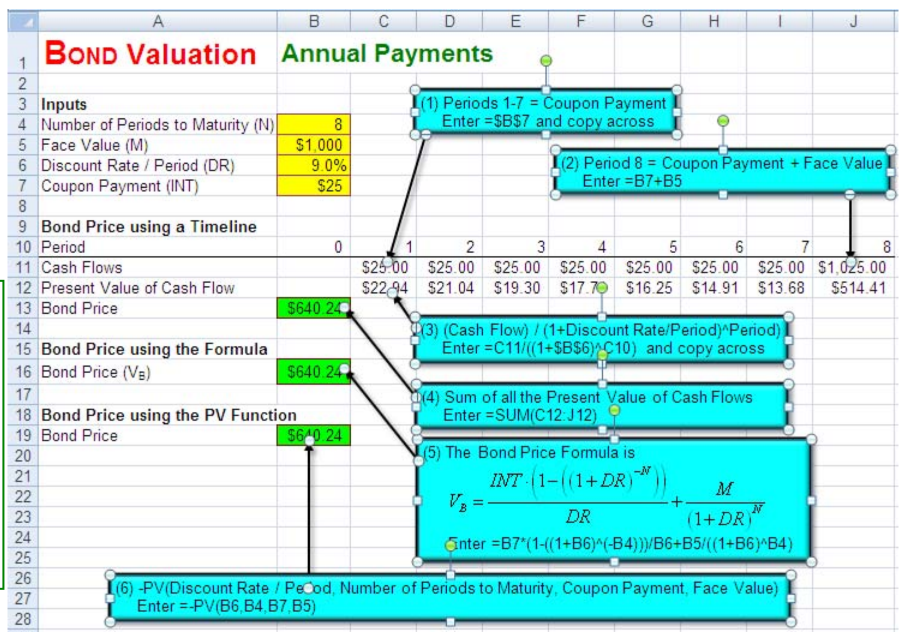
Task. Quickly get rid of all of the instruction boxes and arrows after you are done building the Excel model.

How To. All of the instruction boxes and arrows are *objects* and there is an easy way to select all of them at once. Click on **Home | Editing | Find & Select down-arrow | Select Objects.** This causes the cursor to become a pointer . Then point to a **location above and to the left** of the instruction boxes and arrows, continue to hold down the left mouse button while you drag the pointer to a **location below and to the right** of the instruction boxes and arrows, and then let go of the left mouse button. This selects *all* of the instruction boxes and arrows (see example below). Then just press the **Delete** key and they are all gone!



Excel 97-2003 Equivalent

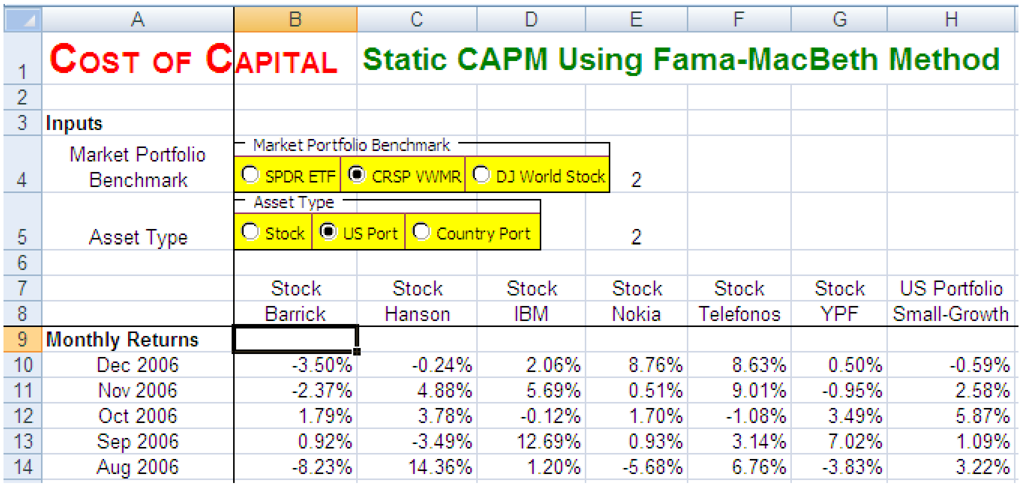
To get the Select Objects cursor in Excel 97-2003, click on the **Drawing** icon on the Standard toolbar and then click on the **Select Objects** icon (which looks like pointer) on the Drawing toolbar in the lower-left corner of the screen.



24.2 Freeze Panes

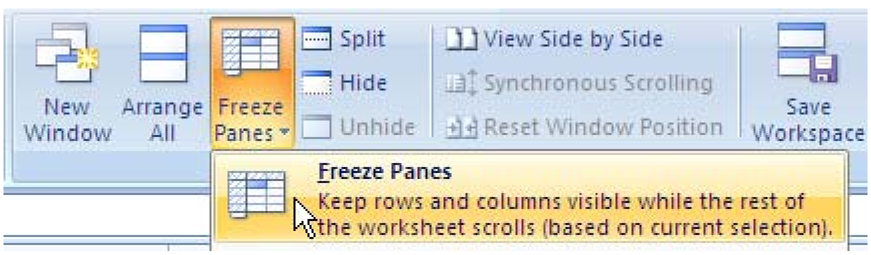
Task. Freeze column titles at the top of the columns and/or freeze row titles on the left side of the rows. This is especially useful for large spreadsheets.

How To. In the example below, suppose you want to freeze the column titles from row 8 and above (freezing Barrick over column B, Hanson over column C, etc.) and you want to freeze the row titles in column A. Select cell **B9** (as shown), because cell **B9** is just below row 8 that you want to freeze and just to the right of column A that you want to freeze.



	A	B	C	D	E	F	G	H
1	COST OF CAPITAL		Static CAPM Using Fama-MacBeth Method					
2								
3	**Inputs**							
4	Market Portfolio Benchmark	Market Portfolio Benchmark: SPDR ETF / CRSP VWMR / DJ World Stock			2			
5	Asset Type	Asset Type: Stock / US Port / Country Port			2			
6								
7		Stock	Stock	Stock	Stock	Stock	Stock	US Portfolio
8		Barrick	Hanson	IBM	Nokia	Telefonos	YPF	Small-Growth
9	**Monthly Returns**							
10	Dec 2006	-3.50%	-0.24%	2.06%	8.76%	8.63%	0.50%	-0.59%
11	Nov 2006	-2.37%	4.88%	5.69%	0.51%	9.01%	-0.95%	2.58%
12	Oct 2006	1.79%	3.78%	-0.12%	1.70%	-1.08%	3.49%	5.87%
13	Sep 2006	0.92%	-3.49%	12.69%	0.93%	3.14%	7.02%	1.09%
14	Aug 2006	-8.23%	14.36%	1.20%	-5.68%	6.76%	-3.83%	3.22%

Then click on **View | Window | Freeze Panes down-arrow | Freeze Panes**.



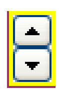
Excel 97-2003 Equivalent

To Freeze Paines in Excel 97-2003, click on **Window | Freeze Panes**.

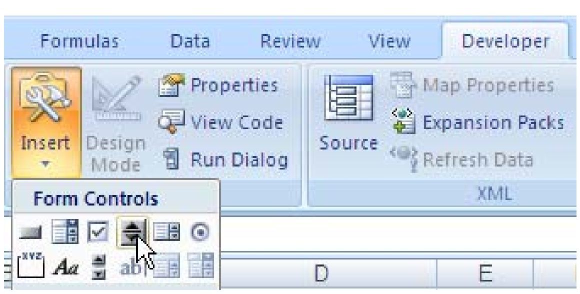
24.3 Spin Buttons and the Developer Tab

Excel 2007 Equivalent

To view the macro in Excel 2007, click on the **Office** button , click on the **Excel Options** button, check the **Show Developer tab in the Ribbon** checkbox, and click **OK**.

Task. Add a spin button  to make an input interactive.

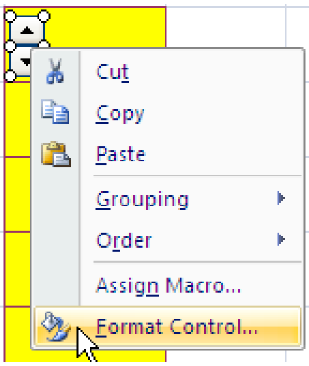
How To. Spin buttons and other so-called "form controls" are located on the Developer tab . If the Developer tab is not visible, you can display it by clicking on , click on , click on **Customize Ribbon**, check the **Developer** checkbox, and click **OK**.

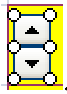


Then click on **Developer | Controls | Insert down-arrow | Form Controls | Spin Button**.

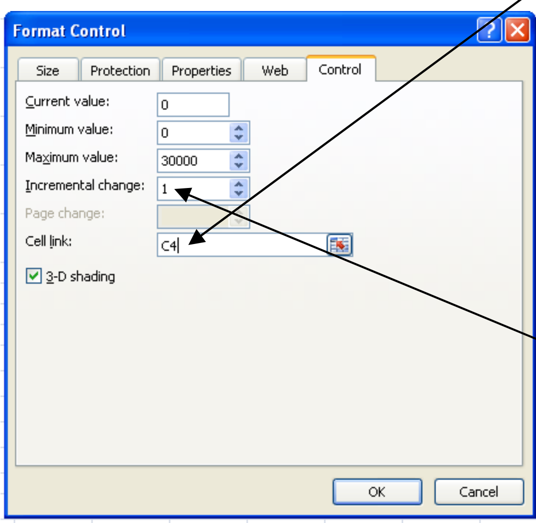
Excel 97-2003 Equivalent

To insert a Spin Button in Excel 97-2003, click on **View | Toolbars | Forms**. Then click on the **Spinner** icon on the Forms Toolbar.



Then point the cursor crosshairs to the upper-left corner of where you want the spin button to be, click and drag to the lower-right corner, and release. You get a spin button . Now place the cursor over the top of the spin button, right-click, and select **Format Control** from the pop-up menu. On the **Control** tab of the **Format Control** dialog box, enter **C4** in the **Cell Link** entry box, and click **OK**.

Now when you click on the spin button, the value in cell **C4** will increase or decrease by 1. For convenience, I scale the spin button output to the appropriate scale of the input. For example, in the spreadsheet below the spin button in cell **B6** is linked to the cell **C6** and creates the integer value **5**. The formula in cell B6 is **=C6/100** and this create the value **5.0%** for the riskfree rate.



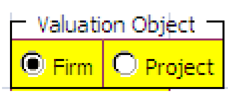
	A	B	C	D
1	BLACK SCHOLES OPTION PRICING			
2				
3	**Inputs**			
4	Stock Price Now (S_0)	$69.00	69	
5	Standard Dev - Annual (σ)	70.1%	7	
6	Riskfree Rate- Annual (r)	5.0%	5	
7	Exercise Price (X)	$70.00	70	
8	Time To Maturity - Years (T)	0.60	6	

Unfortunately, Spin Buttons are only allowed to have **Incremental Changes** that are integers (1, 2, 3, etc.). It would be convenient if they could have **Incremental Changes** of any value, such as .01 or -.0043.

24.4 Option Buttons and Group Boxes

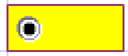
Excel 97-2003 Equivalent

To insert a Option Button in Excel 97-2003, click on **View | Toolbars | Forms**. Then click on the **Option Button** icon on the Forms Toolbar

Task. Add option buttons  to allow input choices.

How To. Option buttons and other so-called "form controls" are located on the Developer tab . If you don't see a Developer tab, then you need to take a simple step to make it visible (see the section above).

Then click on **Developer | Controls | Insert down-arrow | Form Controls | Option Button**.

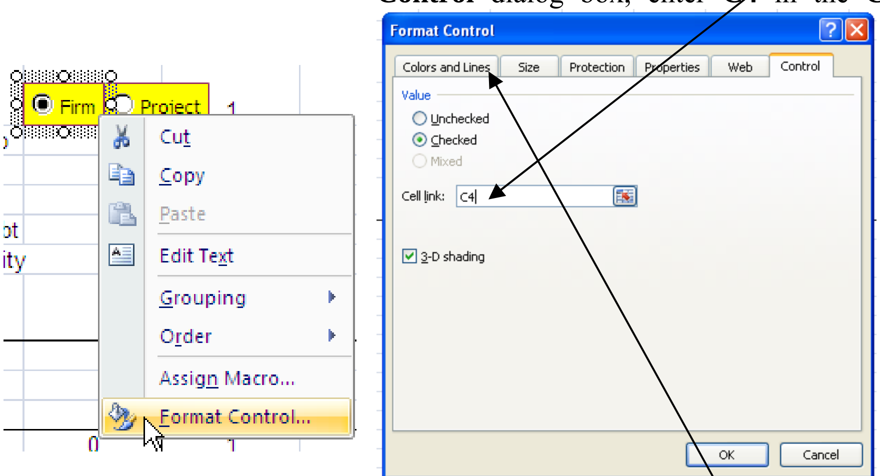
Then point the cursor crosshairs to the upper-left corner of where you want the option button to be, click and drag to the lower-right corner, and release. You get a option button . Repeat this process to get more option buttons.

Now place the cursor over the top of the first option button, right-click, then click over the blank text area, click a second time over the blank text area, delete any unwanted text (e.g., "Option Button1"), enter a text description of the choice (e.g., "Firm"), and then click outside the option button to finish 

. Repeat this process for the other option buttons (e.g., "Project") 

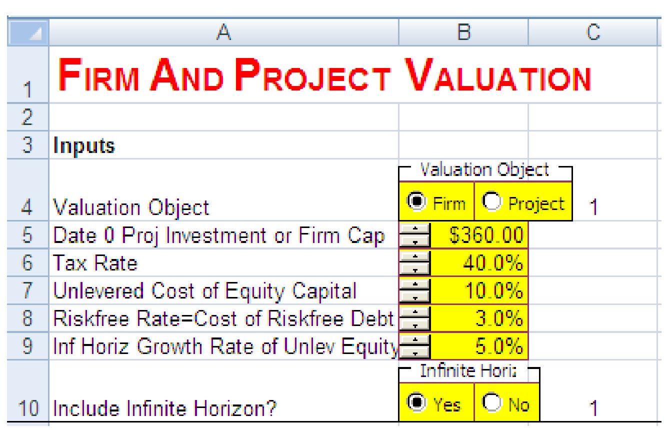
.

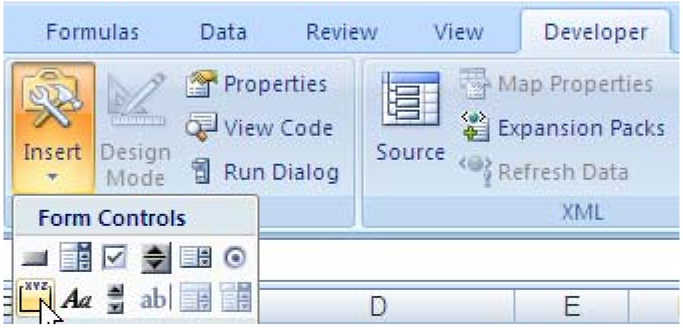
Now place the cursor over the top of the first option button, right-click, and select **Format Control** from the pop-up menu. On the **Control** tab of the **Format Control** dialog box, enter **C4** in the **Cell Link** entry box, and click **OK**.



Now when the first option button is clicked, then the cell **C4** will show a **1**, and when the second option button is clicked, then the cell **C4** will show a **2**. Optionally, you click on the **Colors and Lines** tab of **Format Control** dialog box and specify the option button's fill color, line color, etc.

If you just want to have *one set* of option buttons on a spreadsheet, then you are done. However, if you want to have two or more sets of option buttons (see example below), then you need to use **Group Boxes** to indicate which option buttons belong to which set.





Click on **Developer | Controls | Insert down-arrow | Form Controls | Group Box**.

Then point the cursor crosshairs above and left of the first option button, click and drag to below and right of the second option button (or last option button in the set), and release. A Group Box is created which surrounds the option buttons. Click on the title of the Group Box, delete any unwanted text (e.g., "Group Box 1"), enter a text description (e.g., "Valuation Object"). Now when you click on the Firm or Project option button in cell **B4** of the example above, then the linked cell **C4** changes to 1 or 2. Repeat the process of creating option buttons and surrounding them by group boxes to create all of the sets of option buttons that you want.

Excel 97-2003 Equivalent

To insert a Group Box in Excel 97-2003, click on **View | Toolbars | Forms**. Then click on the **Group Box** icon on the Forms Toolbar.

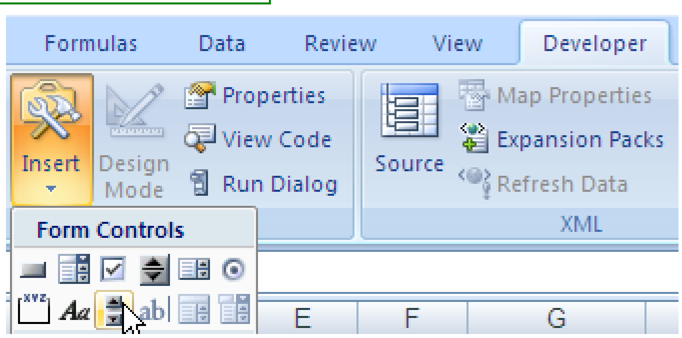
24.5 Scroll Bar

Excel 97-2003 Equivalent

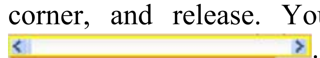
To insert a Scroll Bar in Excel 97-2003, click on **View | Toolbars | Forms**. Then click on the **Scroll Bar** icon on the Forms Toolbar.

Task. Add a scroll bar call option to make big or small changes to an input.

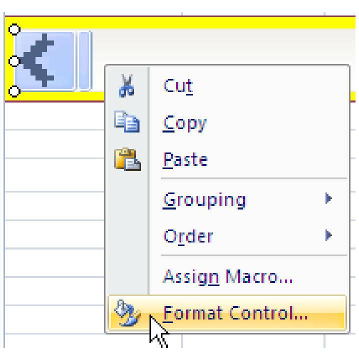
How To. Option buttons and other so-called "form controls" are located on the Developer tab . If you don't see a Developer tab, then you need to take a simple step to make it visible (see two sections above).

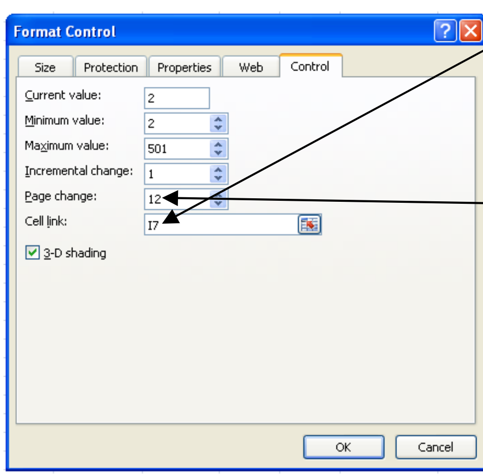


Then click on **Developer | Controls | Insert down-arrow | Form Controls | Scroll Bar**.

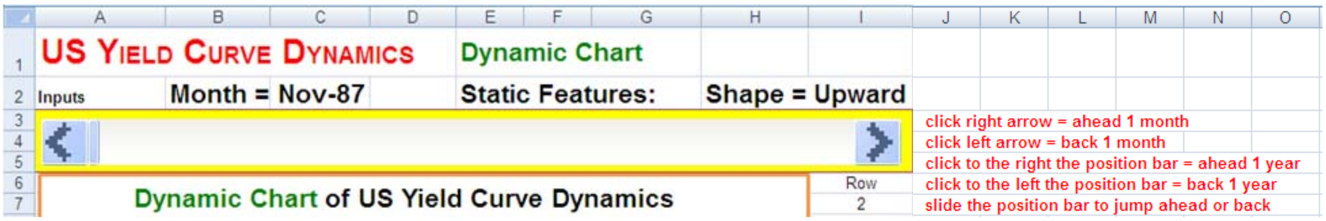
Then point the cursor crosshairs to the upper-left corner of where you want the option button to be, click and drag to the lower-right corner, and release. You get a scroll bar .

Now place the cursor over the top of the scroll bar, right-click, and select **Format Control** from the pop-up menu. On the **Control** tab of the **Format Control** dialog box, enter **I7** in the **Cell Link** entry box, and click **OK**. Optionally, you can specify the **Page Change** amount, which is the change in the cell link when you click on the white space of the scroll bar. In this example, a **Page Change** of **12** months jumps a year ahead.





The advantage of a scroll bar is that you can make big or small changes (see example below). Clicking on the left or right arrow lowers or raises the value in cell **I7** by 1. Clicking on the white space of the scroll bar, lowers or raises the value in cell **I7** by 12 (the Page Change). Sliding the position bar allows you to rapidly scroll through the entire range of values.



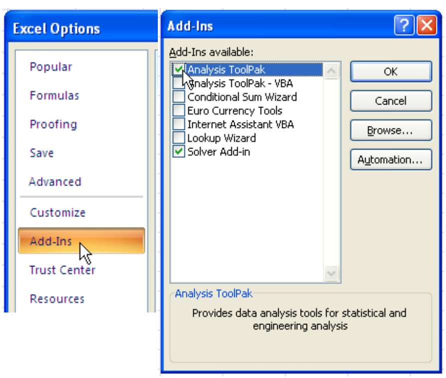
24.6 Install Solver or the Analysis ToolPak

Excel 97-2003 Equivalent

To install the Analysis ToolPak in Excel 97-2003, click on **Tools**, **Add-Ins**, check the **Analysis TookPak** checkbox on the Add-Ins dialog box, and click on **OK**. To install Solver, do the same steps except substitute **Solver** instead.

Task. Install Solver or the Analysis ToolPak.

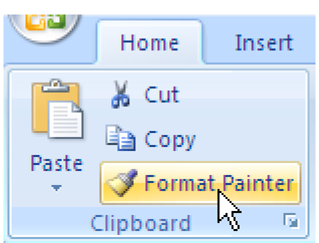
How To. Excel provides several special tools, such as Solver and the Analysis ToolPak, which need to be separately installed. Solver is a sophisticated, yet easy to use optimizer. The Analysis ToolPak contains advanced statistical programs and advanced functions.



To install the Analysis ToolPak, click on the **Office** button , click on the **Excel Options** button at the bottom of the drop-down window, click on **Add-Ins**, highlight the **Analysis ToolPak** Analysis ToolPak in the list of Inactive Applications, click on **Go** Go... near the bottom of the dialog box, check the **Analysis ToolPak**, and click on **OK**.

To install Solver, do the same steps except substitute **Solver** in place of **Analysis ToolPak** along the way.

24.7 Format Painter



Excel 97-2003 Equivalent

To invoke Format Painter in Excel 97-2003, click on the **Format Painter** icon on the Standard Toolbar.

Task. Apply formatting from one cell to other cells.

How To. Select the cell(s) whose format you want to copy (e.g., select **D5:E5** in the example below). Then click on **Home | Clipboard | Format Painter** Format Painter. The cursor now includes a paint brush. Then select the range that you want to apply the formatting to (e.g., range **D6:E17** in the example below). Notice that Format Painter copies all of the formatting, including number type (percentage), number of decimals, background color, and border color.

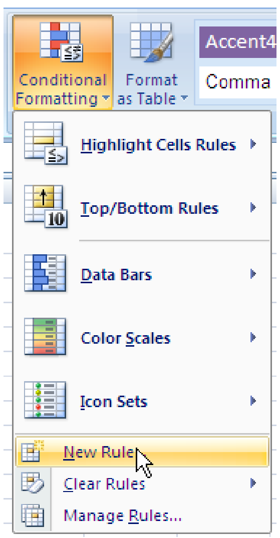
Before

	A	B	C	D	E
1	THE YIELD CURVE	Obtaining and Using It			
2		Maturity	Time To	Yield To	Forward
3	**Yield Curve Inputs**	Date	Maturity	Maturity	Rates
4	Today's Date	5/22/2007			
5	One Month Treasury Bill	6/22/2007	0.08	4.90%	4.90%
6	Three Month Treasury Bill	8/22/2007	0.25	0.0477	0.0471
7	Six Month Treasury Bill	11/22/2007	0.50	0.0481	0.0485
8	One Year Treasury Strip	5/15/2008	0.98	0.0489	0.0497
9	Two Year Treasury Strip	8/15/2009	2.23	0.0482	0.0477
10	Three Year Treasury Strip	8/15/2010	3.23	0.0474	0.0456
11	Four Year Treasury Strip	8/15/2011	4.23	0.0472	0.0466
12	Five Year Treasury Strip	8/15/2012	5.23	0.0471	0.0467
13	Ten Year Treasury Strip	8/15/2017	10.23	0.0493	0.0516
14	Fifteen Year Treasury Bond	8/15/2022	15.23	0.0514	0.0557
15	Twenty Year Treasury Bond	8/15/2027	20.23	0.0511	0.0502
16	Twenty Five Year Treasury Bond	8/15/2032	25.23	0.0497	0.0441
17	Thirty Year Treasury Bond	2/15/2037	29.73	0.0495	0.0484

After

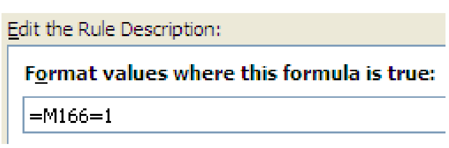
	A	B	C	D	E
1	THE YIELD CURVE	Obtaining and Using It			
2		Maturity	Time To	Yield To	Forward
3	**Yield Curve Inputs**	Date	Maturity	Maturity	Rates
4	Today's Date	5/22/2007			
5	One Month Treasury Bill	6/22/2007	0.08	4.90%	4.90%
6	Three Month Treasury Bill	8/22/2007	0.25	4.77%	4.71%
7	Six Month Treasury Bill	11/22/2007	0.50	4.81%	4.85%
8	One Year Treasury Strip	5/15/2008	0.98	4.89%	4.97%
9	Two Year Treasury Strip	8/15/2009	2.23	4.82%	4.77%
10	Three Year Treasury Strip	8/15/2010	3.23	4.74%	4.56%
11	Four Year Treasury Strip	8/15/2011	4.23	4.72%	4.66%
12	Five Year Treasury Strip	8/15/2012	5.23	4.71%	4.67%
13	Ten Year Treasury Strip	8/15/2017	10.23	4.93%	5.16%
14	Fifteen Year Treasury Bond	8/15/2022	15.23	5.14%	5.57%
15	Twenty Year Treasury Bond	8/15/2027	20.23	5.11%	5.02%
16	Twenty Five Year Treasury Bond	8/15/2032	25.23	4.97%	4.41%
17	Thirty Year Treasury Bond	2/15/2037	29.73	4.95%	4.84%

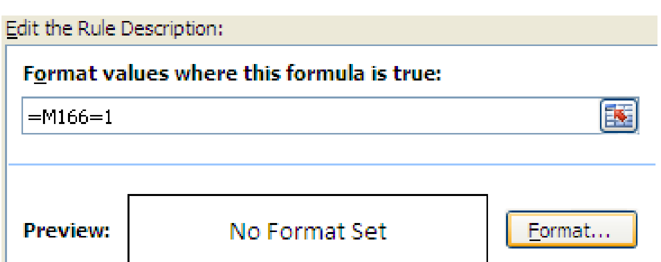
24.8 Conditional Formatting

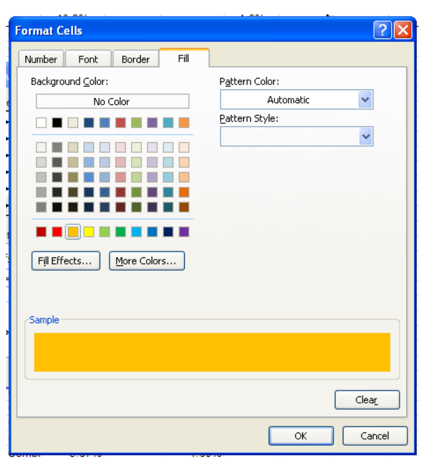


Task. Conditionally format a cell. This allows the displayed format to change based upon the results of a formula calculation.

How To. Suppose you want to use special formatting to highlight the best portfolio in constrained portfolio optimization (see example below). Select cell M166. Click on **Home | Styles | Conditional Formatting down-arrow | New Rule**. Then click on Use a formula to determine which cells to format ► Use a formula to determine which cells to format. In the text entry box, enter **=M166=1**. This checks whether the value of cell M166 is equal to one. Formulas for conditional fomatting must begin with an equal sign, so oddly you end up with two equal signs in the formula. Then click on the **Format** button. In the **Format Cells** dialog box, click on the **Fill** tab, select the **color** you like, click **OK**, and then click **OK** again. Finally, copy this new conditional format down the column using Format Painter. Click on **Home | Clipboard | Format Painter** Format Painter. The cursor now includes a paint brush. Then select the range **M167:M181**. In this example, the cell **M173** turns orange because it is the highest ranking (#1) portfolio. If you changed one of the problem inputs, then a different portfolio might be ranked #1 and the cell corresponding to the new #1 would be highlighted in orange.







	L	M
54	Investor Utility	Portfolio Ranking
166	0.555%	15
167	0.568%	13
168	0.578%	11
169	0.587%	9
170	0.594%	7
171	0.599%	5
172	0.603%	3
173	0.604%	1
174	0.604%	2
175	0.602%	4
176	0.598%	6
177	0.593%	8
178	0.585%	10
179	0.576%	12
180	0.565%	14
181	0.552%	16

Excel 97-2003 Equivalent

To invoke Conditional Formatting in Excel 97-2003, click on the **Format | Conditional Formatting**.

24.9 Fill Handle

Task. Fill in row 10 with integers from 0 to 8 to create the timeline (see example below). This fill technique works for wide range of patterns.

How To. Enter **0** in cell **B10** and **1** in cell **C10**. Select the range **B10:C10**, then hover the cursor over the fill handle (the square in the lower-right corner) of cell **C10** and the cursor turns to a plus symbol. Click, drag the plus symbol to cell **J10**, and release. The range fills up with the rest the pattern from 2 to 8.

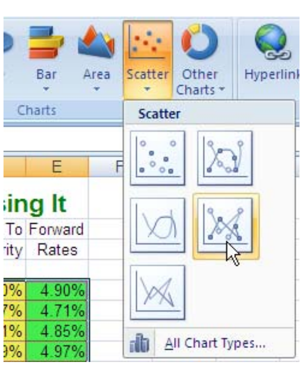
Before

	A	B	C	D	E	F	G	H	I	J
1	Bond Valuation	Annual Payments								
2										
3	**Inputs**									
4	Number of Periods to Maturity (N)	8								
5	Face Value (M)	$1,000								
6	Discount Rate / Period (DR)	9.0%								
7	Coupon Payment (INT)	$25								
8										
9	**Bond Price using a Timeline**									
10	Period	0	1							
11	Cash Flows		$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$1,025.00
12	Present Value of Cash Flow		$22.94	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$1,025.00
13	Bond Price	########								

After

	A	B	C	D	E	F	G	H	I	J
1	Bond Valuation	Annual Payments								
2										
3	**Inputs**									
4	Number of Periods to Maturity (N)	8								
5	Face Value (M)	$1,000								
6	Discount Rate / Period (DR)	9.0%								
7	Coupon Payment (INT)	$25								
8										
9	**Bond Price using a Timeline**									
10	Period	0	1	2	3	4	5	6	7	8
11	Cash Flows		$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$1,025.00
12	Present Value of Cash Flow		$22.94	$21.04	$19.30	$17.71	$16.25	$14.91	$13.68	$514.41
13	Bond Price	$640.24								

24.10 2-D Scatter Chart



Task. Create a two-dimensional Scatter Chart.

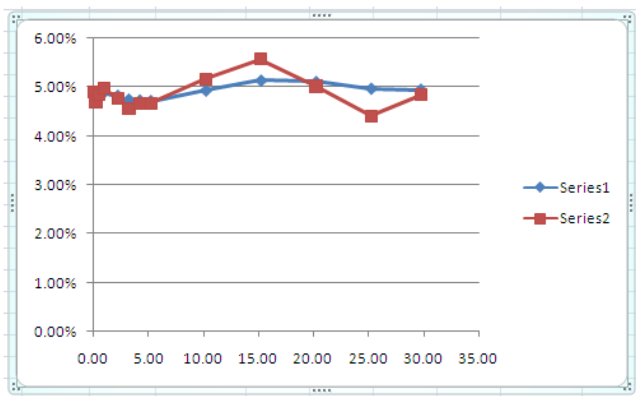
How To. Select the range that has the data you wish to graph (e.g., select **C5:E17** in the example below). Click on **Insert | Charts | Scatter down-arrow | Scatter with Straight Lines and Markers**.

Excel 97-2003 Equivalent

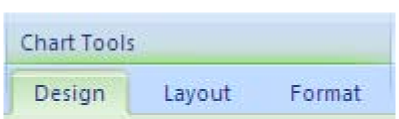
To insert a 2-D Scatter Chart in Excel 97-2003, click on the **Insert | Chart | XY (Scatter) | Scatter with data points connected by lines**.

	A	B	C	D	E
1	THE YIELD CURVE	Obtaining and Using It			
2		Maturity	Time To	Yield To	Forward
3	**Yield Curve Inputs**	Date	Maturity	Maturity	Rates
4	Today's Date	5/22/2007			
5	One Month Treasury Bill	6/22/2007	0.08	4.90%	4.90%
6	Three Month Treasury Bill	8/22/2007	0.25	4.77%	4.71%
7	Six Month Treasury Bill	11/22/2007	0.50	4.81%	4.85%
8	One Year Treasury Strip	5/15/2008	0.98	4.89%	4.97%
9	Two Year Treasury Strip	8/15/2009	2.23	4.82%	4.77%
10	Three Year Treasury Strip	8/15/2010	3.23	4.74%	4.56%
11	Four Year Treasury Strip	8/15/2011	4.23	4.72%	4.66%
12	Five Year Treasury Strip	8/15/2012	5.23	4.71%	4.67%
13	Ten Year Treasury Strip	8/15/2017	10.23	4.93%	5.16%
14	Fifteen Year Treasury Bond	8/15/2022	15.23	5.14%	5.57%
15	Twenty Year Treasury Bond	8/15/2027	20.23	5.11%	5.02%
16	Twenty Five Year Treasury Bond	8/15/2032	25.23	4.97%	4.41%
17	Thirty Year Treasury Bond	2/15/2037	29.73	4.95%	4.84%

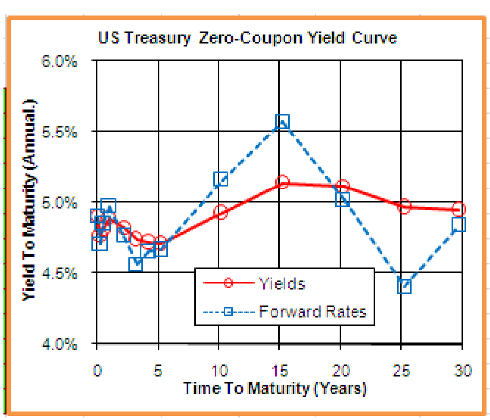
A rough version of the 2-D Scatter Chart appears.



As long as the Chart is selected, three new tabs appear that provide lots of chart options for Design, Layout, and Formatting.



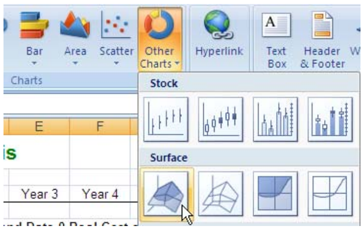
Alternatively, you can right-click on parts of the chart to get pop-up menus with formatting choices. Here is what a fully-formatted 2-D Scatter Chart looks like.



24.11 3-D Surface Chart

Task. Create a three-dimensional Surface Chart.

How To. Select the range that has the data you wish to graph (e.g., select **C94:G98** in the example below). Click on **Insert | Charts | Other Charts down-arrow | Surface | 3-D Surface**.

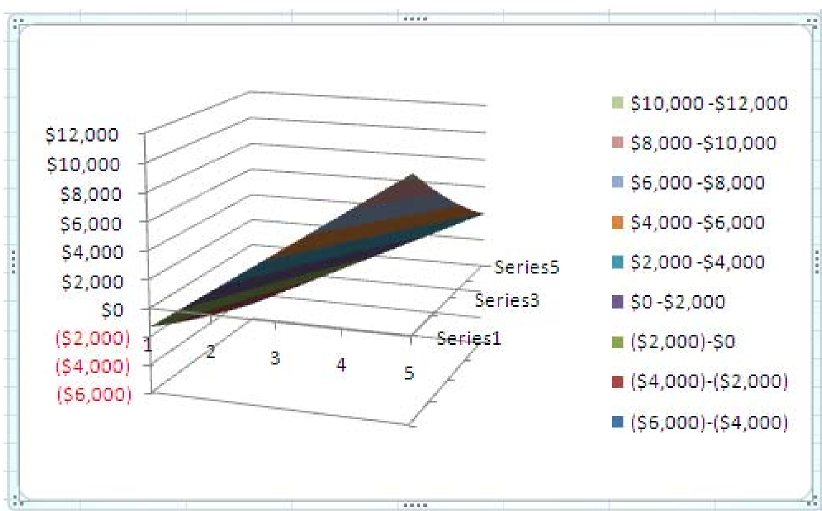


Excel 97-2003 Equivalent

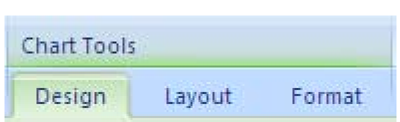
To insert a 3-D Surface Chart in Excel 97-2003, click on the **Insert | Chart | Surface | 3-D Surface**

	A	B	C	D	E	F	G
1	PROJECT NPV	Sensitivity Analysis					
2	(in thousands of $)						
3		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
90							
91	Data Table: Sensitivity of the Net	Present Value to Unit Sales and Date 0 Real Cost of Capital					
92			Input Values for Unit Sales Scale Factor				
93	Out Formula: Net Present Value	$3,180	80%	90%	100%	110%	120%
94		9.0%	($1,324)	$1,667	$4,658	$7,649	$10,640
95	Input Values for	11.0%	($2,336)	$422	$3,180	$5,938	$8,696
96	Date 0 Real Cost of Capital	13.0%	($3,246)	($698)	$1,851	$4,399	$6,947
97		15.0%	($4,065)	($1,706)	$652	$3,010	$5,369
98		17.0%	($4,804)	($2,617)	($431)	$1,755	$3,941

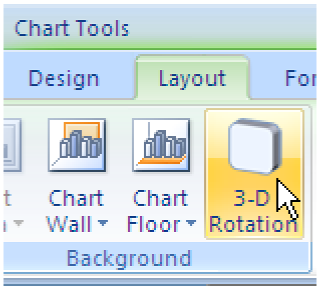
A rough version of the 3-D Surface Chart appears.



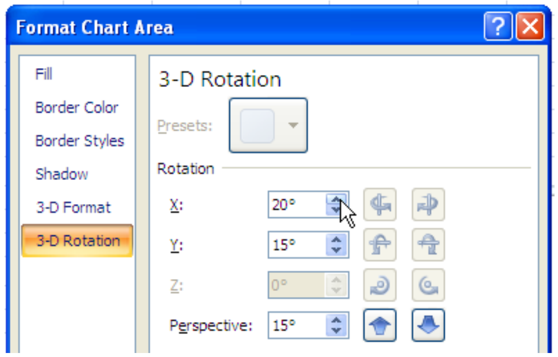
As long as the Chart is selected, three new tabs appear that provide lots of chart options for Design, Layout, and Formatting.



Alternatively, you can right-click on parts of the chart to get pop-up menus with formatting choices.



It is often useful to rotate a 3-D chart. To do this, click on **Layout | Background | 3-D Rotation**. 3-D Rotation provides the ability to rotate the surface in the X-axis direction, Y-axis direction, or Z-axis direction.



Here is what a fully-formatted 3-D Surface Chart looks like.