

# Appendix E: Microsoft Excel 2010 and Tools for Statistical Analysis

Microsoft Excel 2010, part of the Microsoft Office 2010 system, is a spreadsheet program that can be used to organize and analyze data, perform complex calculations, and create a wide variety of graphical displays. We assume that readers are familiar with basic Excel operations such as selecting cells, entering formulas, copying, and so on. But we do not assume readers are familiar with Excel 2010 or the use of Excel for statistical analysis.

The purpose of this appendix is twofold. First, we provide an overview of Excel 2010 and discuss the basic operations needed to work with Excel 2010 workbooks and worksheets. Second, we provide an overview of the tools that are available for conducting statistical analysis with Excel. These include Excel functions and formulas which allow users to conduct their own analyses and add-ins that provide more comprehensive analysis tools.


Excel's Data Analysis add-in, included with the basic Excel system, is a valuable tool for conducting statistical analysis. In the last section of this primer we provide instruction for installing the Data Analysis add-in. Other add-ins have been developed by outside suppliers to supplement the basic statistical capabilities provided by Excel. In the last section we also discuss StatTools, a commercially available add-in developed by Palisade Corporation.


## Overview of Microsoft Excel 2010

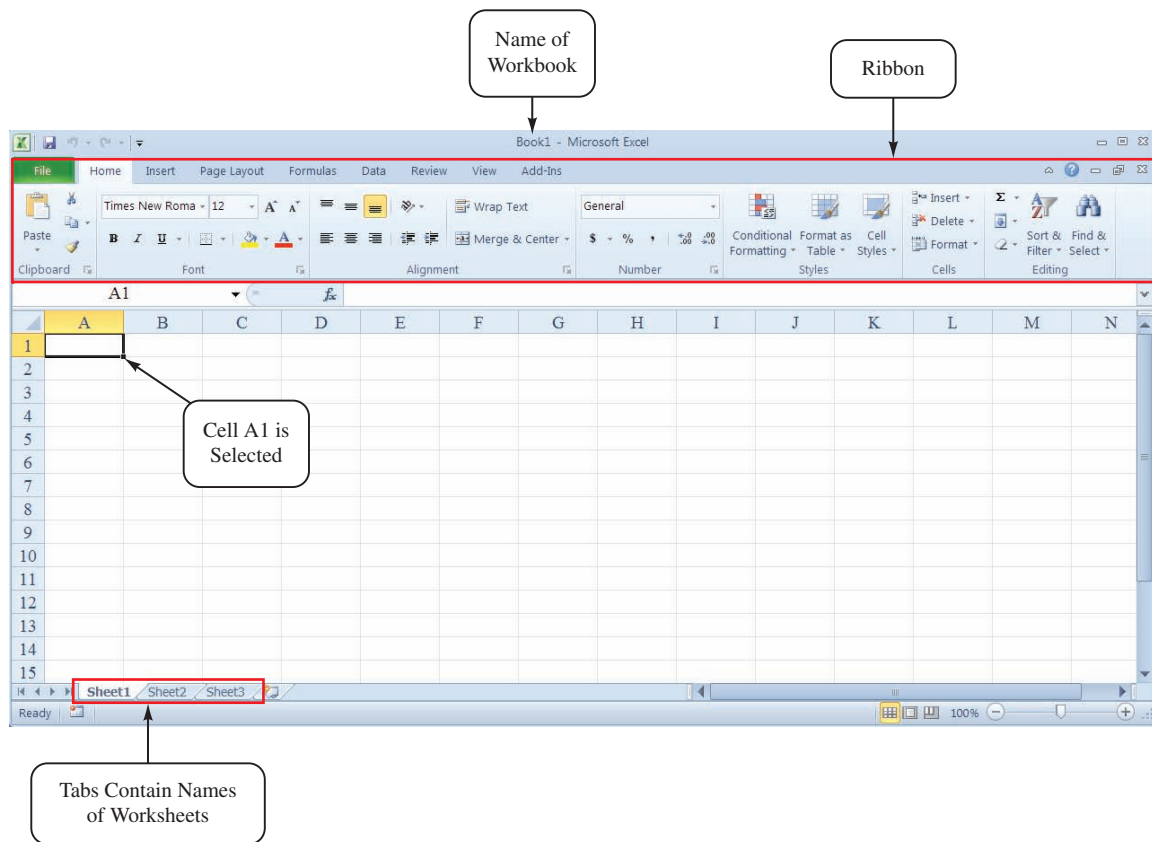
When using Excel for statistical analysis, data is displayed in workbooks, each of which contains a series of worksheets that typically include the original data as well as any resulting analysis, including charts. Figure E.1 shows the layout of a blank workbook created each time Excel is opened. The workbook is named Book1, and consists of three worksheets named Sheet1, Sheet2, and Sheet3. Excel highlights the worksheet currently displayed (Sheet1) by setting the name on the worksheet tab in bold. To select a different worksheet simply click on the corresponding tab. Note that cell A1 is initially selected.

*A workbook is a file containing one or more worksheets.*

The wide bar located across the top of the workbook is referred to as the Ribbon. Tabs, located at the top of the Ribbon, provide quick access to groups of related commands. There are nine tabs shown on the workbook in Figure E.1: File; Home; Insert; Page Layout; Formulas; Data; Review; View; and Add-Ins. Each tab contains a series of groups of related commands. Note that the Home tab is selected when Excel is opened. Figure E.2 displays the groups available when the Home tab is selected. Under the Home tab there are seven groups: Clipboard; Font; Alignment; Number; Styles; Cells; and Editing. Commands are arranged within each group. For example, to change selected text to boldface, click the Home tab and click the Bold button in the Font group.

Figure E.3 illustrates the location of the Quick Access Toolbar and the Formula Bar. The Quick Access Toolbar allows you to quickly access workbook options. To add or remove features on the Quick Access Toolbar click the Customize Quick Access Toolbar button  on the Quick Access Toolbar.

The Formula Bar (see Figure E.3) contains a Name box, the Insert Function button , and a Formula box. In Figure E.3, "A1" appears in the name box because cell A1 is selected. You can select any other cell in the worksheet by using the mouse to move the cursor to another cell and clicking or by typing the new cell location in the Name box. The Formula box is used to display the formula in the currently selected cell. For instance, if you had entered =A1+A2 into cell A3, whenever you select cell A3 the formula =A1+A2 will be

**FIGURE E.1** BLANK WORKBOOK CREATED WHEN EXCEL IS OPENED

shown in the Formula box. This feature makes it very easy to see and edit a formula in a particular cell. The Insert Function button allows you to quickly access all of the functions available in Excel. In Section E.3 we show how to find and use a particular function.

## Basic Workbook Operations

Figure E.4 illustrates the worksheet options that can be performed after right-clicking on a worksheet tab. For instance, to change the name of the current worksheet from “Sheet1” to “Data,” right-click the worksheet tab named “Sheet1” and select the Rename option. The current worksheet name (Sheet1) will be highlighted. Then, simply type the new name (Data) and press the Enter key to rename the worksheet.

Suppose that you wanted to create a copy of “Sheet 1.” After right-clicking the tab named “Sheet1,” select the Move or Copy option. When the Move or Copy dialog box appears, select Create a Copy and click OK. The name of the copied worksheet will appear as “Sheet1 (2).” You can then rename it, if desired.


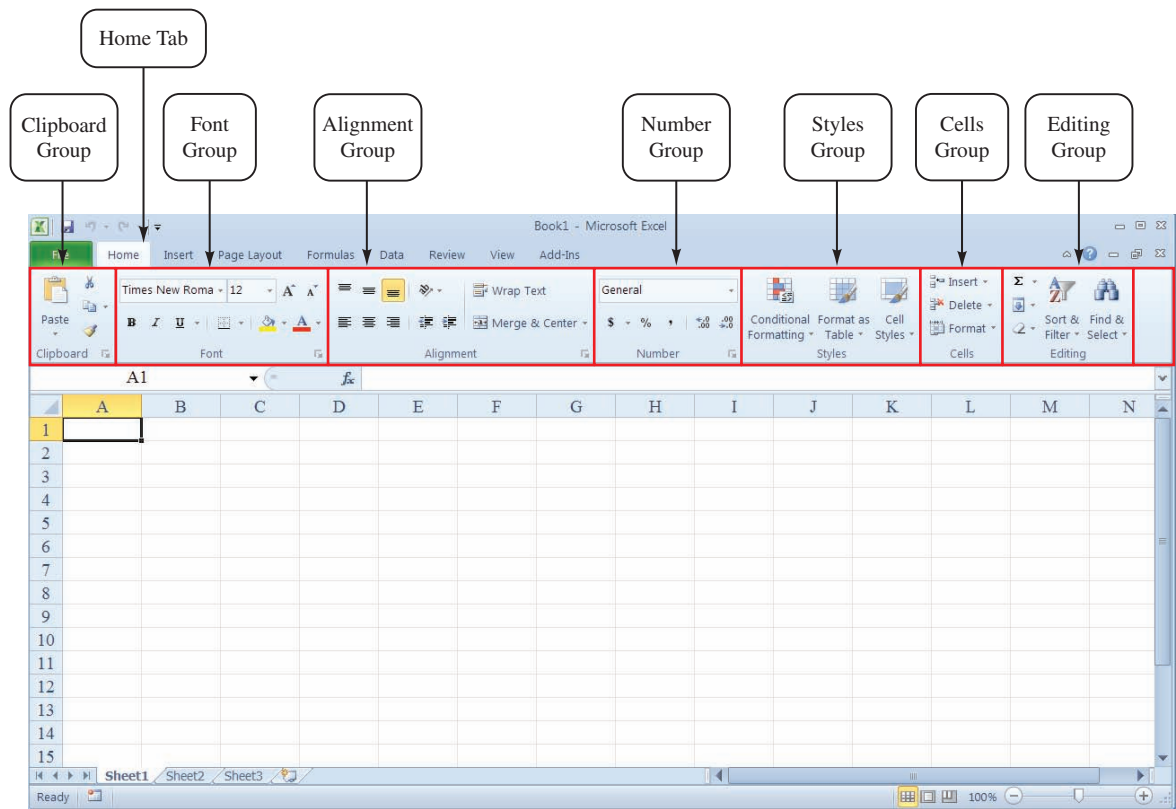
To add a worksheet to the workbook, right-click any worksheet tab and select the Insert option; when the Insert dialog box appears, select Worksheet and click OK. An additional blank worksheet titled “Sheet 4” will appear in the workbook. You can also insert a new worksheet by clicking the Insert Worksheet tab button  that appears to the right of the last worksheet tab displayed. Worksheets can be deleted by right-clicking the worksheet

FIGURE E.2 PORTION OF THE HOME TAB



tab and choosing Delete. After clicking Delete a window will appear warning you that any data appearing in the worksheet will be lost. Click Delete to confirm that you do want to delete the worksheet. Worksheets can also be moved to other workbooks or a different position in the current workbook by using the Move or Copy option.

## Creating, Saving, and Opening Files

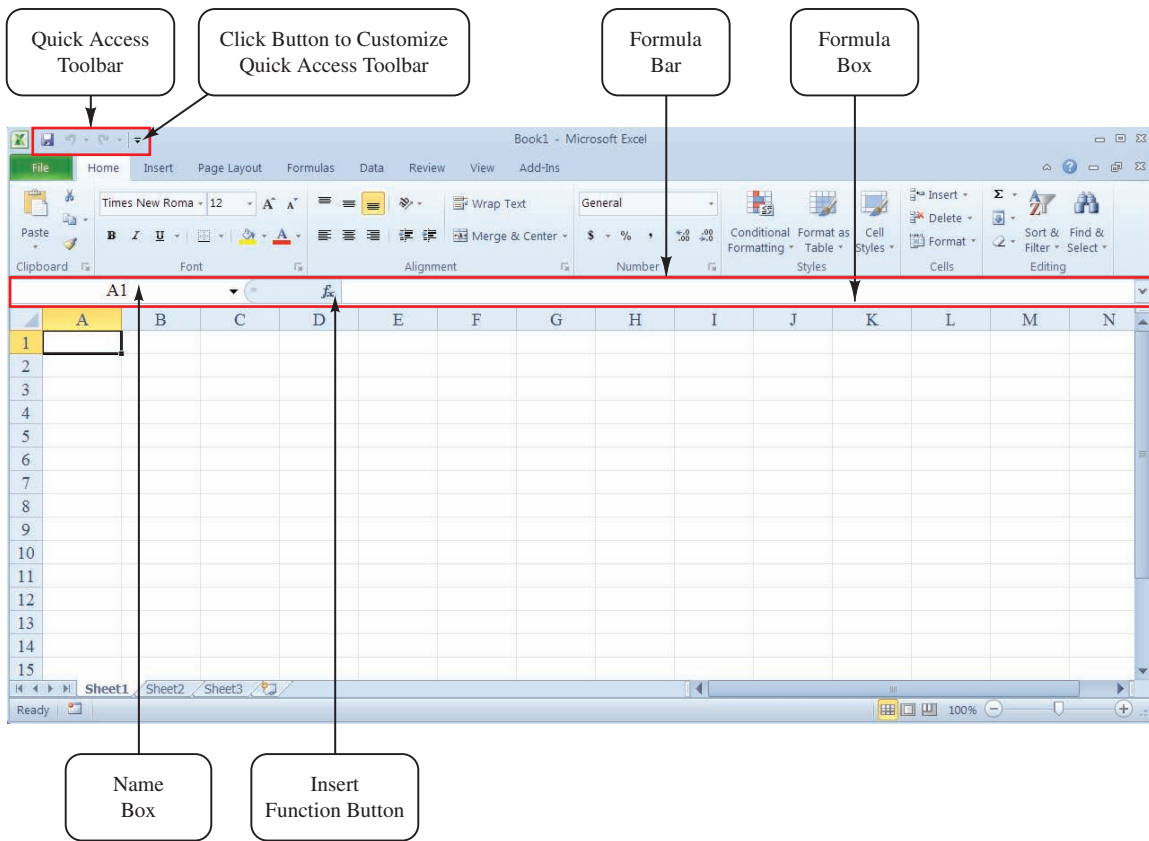
Data can be entered into an Excel worksheet by manually entering the data into the worksheet or by opening another workbook that already contains the data. As an illustration of manually entering, saving, and opening a file we will use the example from Chapter 2 involving data for a sample of 50 soft drink purchases. The original data are shown in Table E.1.

Suppose you just opened Excel and want to work with this data. A blank workbook containing three worksheets will be displayed. The soft drink data can now be entered by simply typing it into one of the worksheets. If Excel is currently running and no blank workbook is displayed, you can create a blank workbook using the following steps:

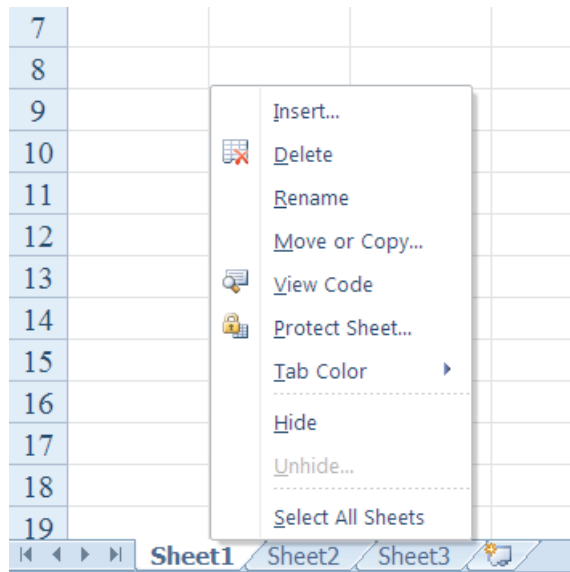
- Step 1.** Click the **File** tab
- Step 2.** Click **New** in the list of options
- Step 3.** When the Available Templates dialog box appears:  
Double click **Blank Workbook**

A new workbook containing three worksheets labeled Sheet1, Sheet2, and Sheet3 will appear.

**FIGURE E.3** EXCEL 2010 QUICK ACCESS TOOLBAR AND FORMULA BAR



**FIGURE E.4** WORKSHEET OPTIONS OBTAINED AFTER RIGHT-CLICKING ON A WORKSHEET TAB



**TABLE E.1** DATA FROM A SAMPLE OF 50 SOFT DRINK PURCHASES

Coke Classic	Sprite	Pepsi
Diet Coke	Coke Classic	Coke Classic
Pepsi	Diet Coke	Coke Classic
Diet Coke	Coke Classic	Coke Classic
Coke Classic	Diet Coke	Pepsi
Coke Classic	Coke Classic	Dr. Pepper
Dr. Pepper	Sprite	Coke Classic
Diet Coke	Pepsi	Diet Coke
Pepsi	Coke Classic	Pepsi
Pepsi	Coke Classic	Pepsi
Coke Classic	Coke Classic	Pepsi
Dr. Pepper	Pepsi	Pepsi
Sprite	Coke Classic	Coke Classic
Coke Classic	Sprite	Dr. Pepper
Diet Coke	Dr. Pepper	Pepsi
Coke Classic	Pepsi	Sprite
Coke Classic	Diet Coke	

Suppose we want to enter the data for the sample of 50 soft drink purchases into Sheet1 of the new workbook. First, we enter the label “Brand Purchased” into cell A1; then, we enter the data for the 50 soft drink purchases into cells A2:A51. As a reminder that this worksheet contains the data, we will change the name of the worksheet from “Sheet1” to “Data” using the procedure described previously. Figure E.5 shows the data worksheet that we just developed.

Before doing any analysis with these data, we recommend that you first save the file; this will prevent you from having to reenter the data in case something happens that causes Excel to close. To save the file as an Excel 2010 workbook using the filename *SoftDrink* we perform the following steps:

- Step 1.** Click the **File** tab
- Step 2.** Click **Save** in the list of options
- Step 3.** When the Save As dialog box appears:  
 Select the location where you want to save the file  
 Type the filename **SoftDrink** in the **File name** box  
 Click **Save**

Excel’s Save command is designed to save the file as an Excel 2010 workbook. As you work with the file to do statistical analysis you should follow the practice of periodically saving the file so you will not lose any statistical analysis you may have performed. Simply click the File tab and select Save in the list of options.

Sometimes you may want to create a copy of an existing file. For instance, suppose you would like to save the soft drink data and any resulting statistical analysis in a new file named “SoftDrink Analysis.” The following steps show how to create a copy of the SoftDrink workbook and analysis with the new filename, “SoftDrink Analysis.”

- Step 1.** Click the **File** tab
- Step 2.** Click **Save As**
- Step 3.** When the Save As dialog box appears:  
 Select the location where you want to save the file


*Keyboard shortcut: To save the file, press CTRL+S.*

**FIGURE E.5** WORKSHEET CONTAINING THE SOFT DRINK DATA

	A	B	C	D	E	F
1	<b>Brand Purchased</b>					
2	Coke Classic					
3	Diet Coke					
4	Pepsi					
5	Diet Coke					
6	Coke Classic					
7	Coke Classic					
8	Dr. Pepper					
9	Diet Coke					
10	Pepsi					
11	Pepsi					
12	Coke Classic					
13	Dr. Pepper					
14	Sprite					
15	Coke Classic					
16	Diet Coke					
17	Coke Classic					
18	Coke Classic					
19	Sprite					
20	Coke Classic					
50	Pepsi					
51	Sprite					
52						
53						
54						
55						

Note: Rows 21–49 are hidden.

Type the filename **SoftDrink Analysis** in the **File name** box  
Click **Save**

Once the workbook has been saved, you can continue to work with the data to perform whatever type of statistical analysis is appropriate. When you are finished working with the file simply click the close window button  located at the top right-hand corner of the Ribbon. To access the SoftDrink Analysis file at another point in time you can open the file by performing the following steps:

- Step 1.** Click the **File** tab
- Step 2.** Click **Open**
- Step 3.** When the Open dialog box appears:  
Select the location where you previously saved the file  
Enter the filename **SoftDrink** in the **File name** box  
Click **Open**

The procedures we showed for saving or opening a workbook begin by clicking File tab to access the Save and Open commands. Once you have used Excel for awhile you will probably find it more convenient to add these commands to the Quick Access Toolbar.

## Using Excel Functions

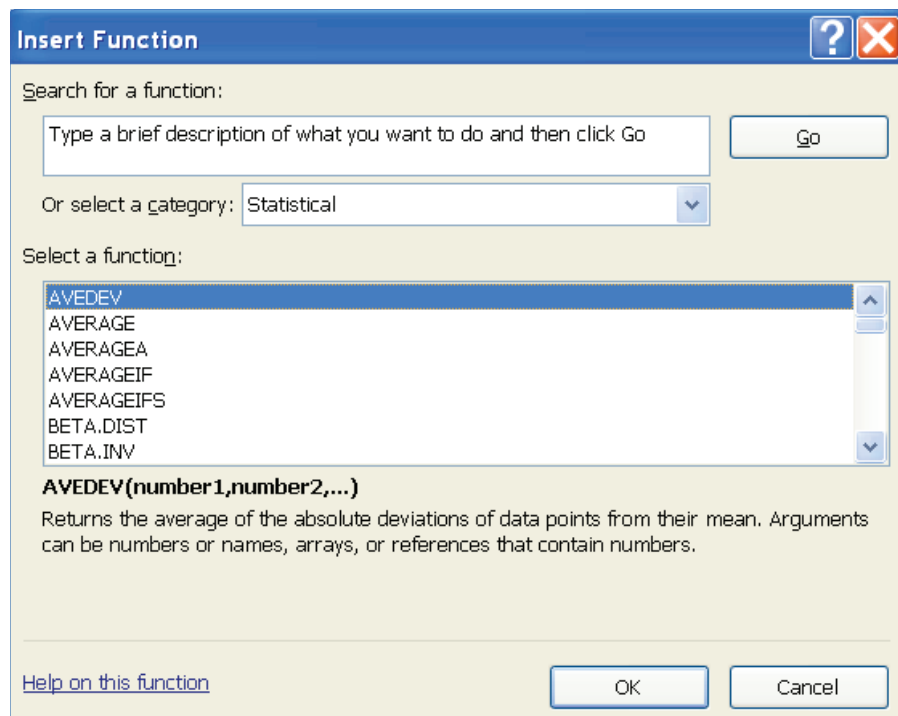
Excel 2010 provides a wealth of functions for data management and statistical analysis. If we know what function is needed, and how to use it, we can simply enter the function into the appropriate worksheet cell. However, if we are not sure what functions are available to accomplish a task or are not sure how to use a particular function, Excel can provide assistance.

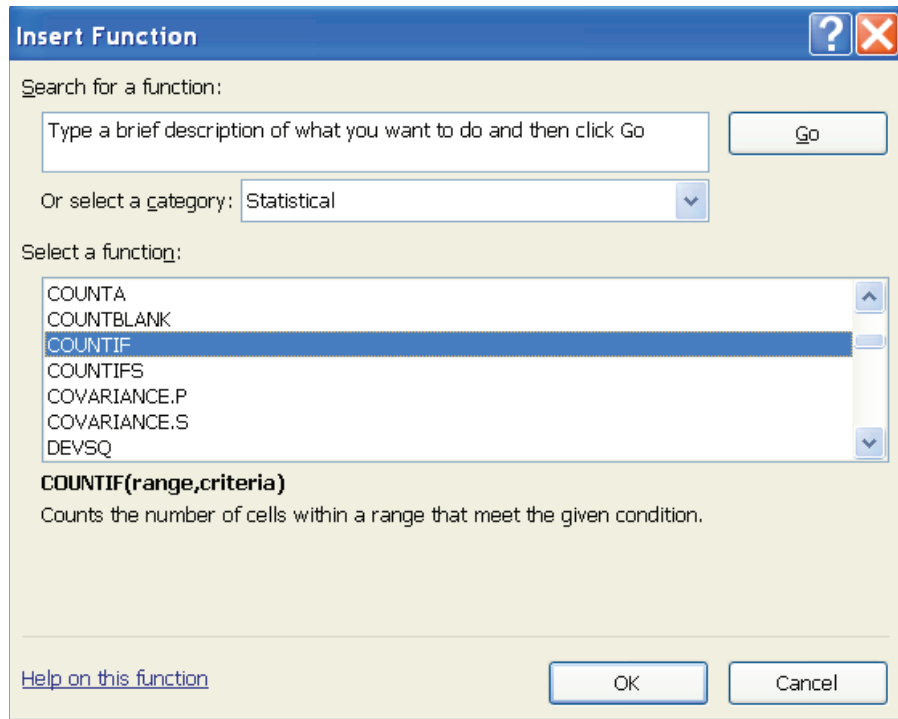
### Finding the Right Excel Function

To identify the functions available in Excel, click the **Formulas** tab on the Ribbon and then click the **Insert Function** button in the **Function Library** group. Alternatively, click the  $f_x$  button on the formula bar. Either approach provides the **Insert Function** dialog box shown in Figure E.6. Many new functions for statistical analysis have been added with Excel 2010.

The **Search for a function** box at the top of the Insert Function dialog box enables us to type a brief description of what we want to do. After doing so and clicking **Go**, Excel will search for and display, in the **Select a function** box, the functions that may accomplish our task. In many situations, however, we may want to browse through an entire category of functions to see what is available. For this task, the **Or select a category** box is helpful. It contains a drop-down list of several categories of functions provided by Excel. Figure E.6 shows that we selected the **Statistical** category. As a result, Excel's statistical functions appear in alphabetic order in the Select a function box. We see the AVEDEV function listed first, followed by the AVERAGE function, and so on.

FIGURE E.6 INSERT FUNCTION DIALOG BOX



**FIGURE E.7** DESCRIPTION OF THE COUNTIF FUNCTION IN THE INSERT FUNCTION DIALOG BOX

The AVEDEV function is highlighted in Figure E.6, indicating it is the function currently selected. The proper syntax for the function and a brief description of the function appear below the Select a function box. We can scroll through the list in the Select a function box to display the syntax and a brief description for each of the statistical functions that are available. For instance, scrolling down farther, we select the COUNTIF function as shown in Figure E.7. Note that COUNTIF is now highlighted, and that immediately below the Select a function box we see **COUNTIF(range,criteria)**, which indicates that the COUNTIF function contains two inputs, range and criteria. In addition, we see that the description of the COUNTIF function is “Counts the number of cells within a range that meet the given condition.”

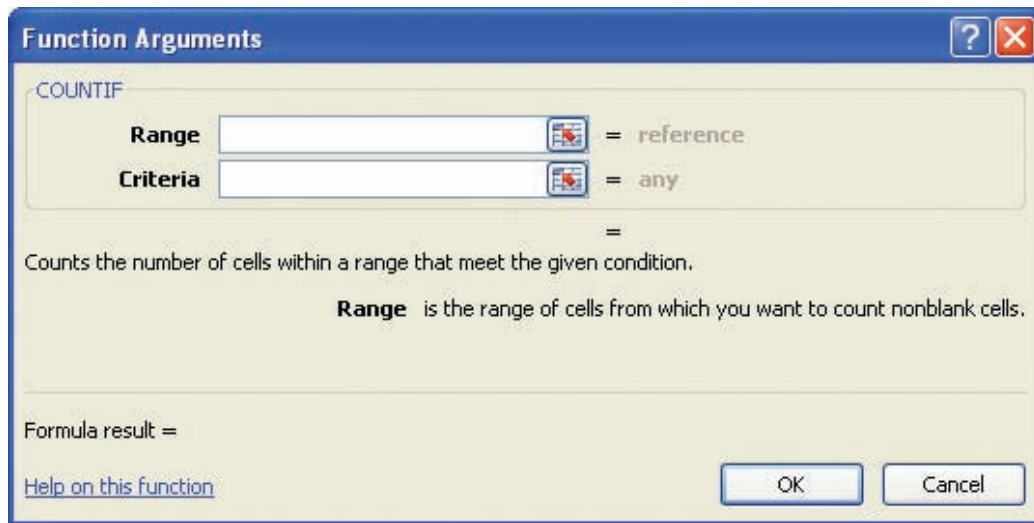
If the function selected (highlighted) is the one we want to use, we click **OK**; the **Function Arguments** dialog box then appears. The Function Arguments dialog box for the COUNTIF function is shown in Figure E.8. This dialog box assists in creating the appropriate arguments for the function selected. When finished entering the arguments, we click **OK**; Excel then inserts the function into a worksheet cell.

## Inserting a Function into a Worksheet Cell

We will now show how to use the Insert Function and Function Arguments dialog boxes to select a function, develop its arguments, and insert the function into a worksheet cell.

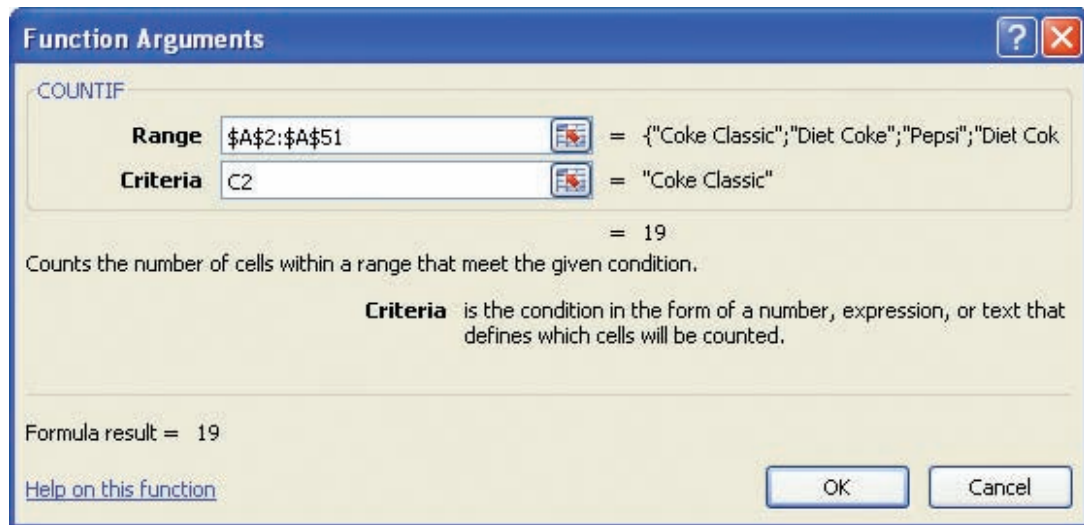
Suppose we want to construct a frequency distribution for the soft drink purchase data in Table E.1. Figure E.9 displays an Excel worksheet containing the soft drink data and labels for the frequency distribution we would like to construct. We see that the frequency of Coke Classic purchases will go into cell D2, the frequency of Diet Coke purchases will go into cell D3, and so on. Suppose we want to use the COUNTIF function to compute the frequencies and would like some assistance from Excel.



**FIGURE E.8** FUNCTION ARGUMENTS DIALOG BOX FOR THE COUNTIF FUNCTION**FIGURE E.9** EXCEL WORKSHEET WITH SOFT DRINK DATA AND LABELS FOR THE FREQUENCY DISTRIBUTION WE WOULD LIKE TO CONSTRUCT

	A	B	C	D	E	F
1	<b>Brand Purchased</b>		<b>Soft Drink</b>	<b>Frequency</b>		
2	Coke Classic		Coke Classic			
3	Diet Coke		Diet Coke			
4	Pepsi		Dr. Pepper			
5	Diet Coke		Pepsi-Cola			
6	Coke Classic		Sprite			
7	Coke Classic					
8	Dr. Pepper					
9	Diet Coke					
10	Pepsi					
45	Pepsi					
46	Pepsi					
47	Pepsi					
48	Coke Classic					
49	Dr. Pepper					
50	Pepsi					
51	Sprite					
52						

- Step 1.** Select cell D2
- Step 2.** Click *fx* on the formula bar
- Step 3.** When the Insert Function dialog box appears:  
 Select **Statistical** in the **Or select a category** box  
 Select **COUNTIF** in the **Select a function** box  
 Click **OK**

**FIGURE E.10** COMPLETED FUNCTION ARGUMENTS DIALOG BOX FOR THE COUNTIF FUNCTION

**Step 4.** When the **Function Arguments** dialog box appears (see Figure E.10):

Enter \$A\$2:\$A\$51 in the **Range** box

Enter C2 in the **Criteria** box (At this point, the value of the function will appear on the next-to-last line of the dialog box. Its value is 19.)

Click **OK**

**Step 5.** Copy cell D2 to cells D3:D6

The worksheet then appears as in Figure E.11. The formula worksheet is in the background; the value worksheet appears in the foreground. The formula worksheet shows that the COUNTIF function was inserted into cells D2:D6. The value worksheet shows the proper class frequencies as computed.

We illustrated the use of Excel's capability to provide assistance in using the COUNTIF function. The procedure is similar for all Excel functions. This capability is especially helpful if you do not know what function to use or forget the proper name and/or inputs required for a function.

## Using Excel Add-Ins

### Excel's Data Analysis Add-In

Excel's Data Analysis add-in, included with the basic Excel package, is a valuable tool for conducting statistical analysis. Before you can use the Data Analysis add-in it must be installed. To see if the Data Analysis add-in has already been installed, click the Data tab on the Ribbon. In the Analysis group you should see the Data Analysis command. If you do not have an Analysis group and/or the Data Analysis command does not appear in the Analysis group, you will need to install the Data Analysis add-in. The steps needed to install the Data Analysis add-in are as follows:

**Step 1.** Click the **File** tab

**Step 2.** Click **Options**

**Step 3.** When the Excel Options dialog box appears:

Select **Add-Ins** from the list of options (on the pane on the left)

**FIGURE E.11** EXCEL WORKSHEET SHOWING THE USE OF EXCEL'S COUNTIF FUNCTION TO CONSTRUCT A FREQUENCY DISTRIBUTION

	A	B	C	D	E
1	<b>Brand Purchased</b>		<b>Soft Drink</b>	<b>Frequency</b>	
2	Coke Classic		Coke Classic	=COUNTIF(\$A\$2:\$A\$51,C2)	
3	Diet Coke		Diet Coke	=COUNTIF(\$A\$2:\$A\$51,C3)	
4	Pepsi		Dr. Pepper	=COUNTIF(\$A\$2:\$A\$51,C4)	
5	Diet Coke		Pepsi-Cola	=COUNTIF(\$A\$2:\$A\$51,C5)	
6	Coke Classic		Sprite	=COUNTIF(\$A\$2:\$A\$51,C6)	
7	Coke Classic				
8	Dr. Pepper				
9	Diet Coke				
10	Pepsi				
45	Pepsi				
46	Pepsi				
47	Pepsi				
48	Coke Classic				
49	Dr. Pepper				
50	Pepsi				
51	Sprite				
52					

	A	B	C	D	E
1	<b>Brand Purchased</b>		<b>Soft Drink</b>	<b>Frequency</b>	
2	Coke Classic		Coke Classic	19	
3	Diet Coke		Diet Coke	8	
4	Pepsi		Dr. Pepper	5	
5	Diet Coke		Pepsi-Cola	13	
6	Coke Classic		Sprite	5	
7	Coke Classic				
8	Dr. Pepper				
9	Diet Coke				
10	Pepsi				
45	Pepsi				
46	Pepsi				
47	Pepsi				
48	Coke Classic				
49	Dr. Pepper				
50	Pepsi				
51	Sprite				
52					

In the **Manage** box, select **Excel Add-Ins**  
Click **Go**

**Step 4.** When the Add-Ins dialog box appears:  
Select **Analysis ToolPak**  
Click **OK**

## Outside Vendor Add-Ins

One of the leading companies in the development of Excel add-ins for statistical analysis is Palisade Corporation. In this text we use StatTools, an Excel add-in developed by Palisade. StatTools provides a powerful statistics toolset that enables users to perform statistical analysis in the familiar Microsoft Office environment.

In the appendix to Chapter 1 we describe how to download and install the StatTools add-in and provide a brief introduction to using the software. In several appendices throughout the text we show how StatTools can be used when no corresponding basic Excel procedure is available or when additional statistical capabilities would be useful.

Typically the add-ins offered with textbooks are designed primarily for classroom use. StatTools, however, was developed for commercial applications. As a result, students who learn how to use StatTools will be able to continue using StatTools throughout their professional career.

# Appendix F: Computing $p$ -Values Using Minitab and Excel

Here we describe how Minitab and Excel can be used to compute  $p$ -values for the  $z$ ,  $t$ ,  $\chi^2$ , and  $F$  statistics that are used in hypothesis tests. As discussed in the text, only approximate  $p$ -values for the  $t$ ,  $\chi^2$ , and  $F$  statistics can be obtained by using tables. This appendix is helpful to a person who has computed the test statistic by hand, or by other means, and wishes to use computer software to compute the exact  $p$ -value.

## Using Minitab

Minitab can be used to provide the cumulative probability associated with the  $z$ ,  $t$ ,  $\chi^2$ , and  $F$  test statistics. So the lower tail  $p$ -value is obtained directly. The upper tail  $p$ -value is computed by subtracting the lower tail  $p$ -value from 1. The two-tailed  $p$ -value is obtained by doubling the smaller of the lower and upper tail  $p$ -values.

**The  $z$  test statistic** We use the Hilltop Coffee lower tail hypothesis test in Section 9.3 as an illustration; the value of the test statistic is  $z = -2.67$ . The Minitab steps used to compute the cumulative probability corresponding to  $z = -2.67$  follow.

- Step 1.** Select the **Calc** menu
- Step 2.** Choose **Probability Distributions**
- Step 3.** Choose **Normal**
- Step 4.** When the Normal Distribution dialog box appears:
  - Select **Cumulative probability**
  - Enter 0 in the **Mean** box
  - Enter 1 in the **Standard deviation** box
  - Select **Input Constant**
  - Enter  $-2.67$  in the **Input Constant** box
  - Click **OK**

Minitab provides the cumulative probability of .0038. This cumulative probability is the lower tail  $p$ -value used for the Hilltop Coffee hypothesis test.

For an upper tail test, the  $p$ -value is computed from the cumulative probability provided by Minitab as follows:

$$p\text{-value} = 1 - \text{cumulative probability}$$

For instance, the upper tail  $p$ -value corresponding to a test statistic of  $z = -2.67$  is  $1 - .0038 = .9962$ . The two-tailed  $p$ -value corresponding to a test statistic of  $z = -2.67$  is 2 times the minimum of the upper and lower tail  $p$ -values; that is, the two-tailed  $p$ -value corresponding to  $z = -2.67$  is  $2(.0038) = .0076$ .

**The  $t$  test statistic** We use the Heathrow Airport example from Section 9.4 as an illustration; the value of the test statistic is  $t = 1.84$  with 59 degrees of freedom. The Minitab steps used to compute the cumulative probability corresponding to  $t = 1.84$  follow.

- Step 1.** Select the **Calc** menu
- Step 2.** Choose **Probability Distributions**

**Step 3.** Choose **t**

**Step 4.** When the **t Distribution** dialog box appears:  
 Select **Cumulative probability**  
 Enter 59 in the **Degrees of freedom** box  
 Select **Input Constant**  
 Enter 1.84 in the **Input Constant** box  
 Click **OK**

Minitab provides a cumulative probability of .9646, and hence the lower tail  $p$ -value = .9646. The Heathrow Airport example is an upper tail test; the upper tail  $p$ -value is  $1 - .9646 = .0354$ . In the case of a two-tailed test, we would use the minimum of .9646 and .0354 to compute  $p$ -value =  $2(.0354) = .0708$ .

**The  $\chi^2$  test statistic** We use the St. Louis Metro Bus example from Section 11.1 as an illustration; the value of the test statistic is  $\chi^2 = 28.18$  with 23 degrees of freedom. The Minitab steps used to compute the cumulative probability corresponding to  $\chi^2 = 28.18$  follow.

**Step 1.** Select the **Calc** menu  
**Step 2.** Choose **Probability Distributions**  
**Step 3.** Choose **Chi-Square**  
**Step 4.** When the **Chi-Square Distribution** dialog box appears:  
 Select **Cumulative probability**  
 Enter 23 in the **Degrees of freedom** box  
 Select **Input Constant**  
 Enter 28.18 in the **Input Constant** box  
 Click **OK**

Minitab provides a cumulative probability of .7909, which is the lower tail  $p$ -value. The upper tail  $p$ -value =  $1 -$  the cumulative probability, or  $1 - .7909 = .2091$ . The two-tailed  $p$ -value is 2 times the minimum of the lower and upper tail  $p$ -values. Thus, the two-tailed  $p$ -value is  $2(.2091) = .4182$ . The St. Louis Metro Bus example involved an upper tail test, so we use  $p$ -value = .2091.

**The  $F$  test statistic** We use the Dullus County Schools example from Section 11.2 as an illustration; the test statistic is  $F = 2.40$  with 25 numerator degrees of freedom and 15 denominator degrees of freedom. The Minitab steps to compute the cumulative probability corresponding to  $F = 2.40$  follow.

**Step 1.** Select the **Calc** menu  
**Step 2.** Choose **Probability Distributions**  
**Step 3.** Choose **F**  
**Step 4.** When the **F Distribution** dialog box appears:  
 Select **Cumulative probability**  
 Enter 25 in the **Numerator degrees of freedom** box  
 Enter 15 in the **Denominator degrees of freedom** box  
 Select **Input Constant**  
 Enter 2.40 in the **Input Constant** box  
 Click **OK**

Minitab provides the cumulative probability and hence a lower tail  $p$ -value = .9594. The upper tail  $p$ -value is  $1 - .9594 = .0406$ . Because the Dullus County Schools example is a two-tailed test, the minimum of .9594 and .0406 is used to compute  $p$ -value =  $2(.0406) = .0812$ .

**WEB file**  
p-Value

## Using Excel

Excel functions and formulas can be used to compute  $p$ -values associated with the  $z$ ,  $t$ ,  $\chi^2$ , and  $F$  test statistics. We provide a template in the data file entitled p-Value for use in computing these  $p$ -values. Using the template, it is only necessary to enter the value of the test statistic and, if necessary, the appropriate degrees of freedom. Refer to Figure F.1 as we describe how the template is used. For users interested in the Excel functions and formulas being used, just click on the appropriate cell in the template.

**The  $z$  test statistic** We use the Hilltop Coffee lower tail hypothesis test in Section 9.3 as an illustration; the value of the test statistic is  $z = -2.67$ . To use the  $p$ -value template for this hypothesis test, simply enter  $-2.67$  into cell B6 (see Figure F.1). After doing so,  $p$ -values for all three types of hypothesis tests will appear. For Hilltop Coffee, we would use the lower tail  $p$ -value = .0038 in cell B9. For an upper tail test, we would use the  $p$ -value in cell B10, and for a two-tailed test we would use the  $p$ -value in cell B11.

**The  $t$  test statistic** We use the Heathrow Airport example from Section 9.4 as an illustration; the value of the test statistic is  $t = 1.84$  with 59 degrees of freedom. To use the  $p$ -value template for this hypothesis test, enter 1.84 into cell E6 and enter 59 into cell E7 (see Figure F.1). After doing so,  $p$ -values for all three types of hypothesis tests will appear.

**FIGURE F.1** EXCEL WORKSHEET FOR COMPUTING  $p$ -VALUES

	A	B	C	D	E
1	Computing $p$ -Values				
2					
3					
4	Using the Test Statistic $z$			Using the Test Statistic $t$	
5					
6	Enter $z$ -->	-2.67		Enter $t$ -->	1.84
7				$df$ -->	59
8					
9	$p$ -value (Lower Tail)	0.0038		$p$ -value (Lower Tail)	0.9646
10	$p$ -value (Upper Tail)	0.9962		$p$ -value (Upper Tail)	0.0354
11	$p$ -value (Two Tail)	0.0076		$p$ -value (Two Tail)	0.0708
12					
13					
14					
15					
16	Using the Test Statistic Chi Square			Using the Test Statistic $F$	
17					
18	Enter Chi Square -->	28.18		Enter $F$ -->	2.40
19	$df$ -->	23		Numerator $df$ -->	25
20				Denominator $df$ -->	15
21					
22	$p$ -value (Lower Tail)	0.7909		$p$ -value (Lower Tail)	0.9594
23	$p$ -value (Upper Tail)	0.2091		$p$ -value (Upper Tail)	0.0406
24	$p$ -value (Two Tail)	0.4181		$p$ -value (Two Tail)	0.0812

The Heathrow Airport example involves an upper tail test, so we would use the upper tail  $p$ -value = .0354 provided in cell E10 for the hypothesis test.

**The  $\chi^2$  test statistic** We use the St. Louis Metro Bus example from Section 11.1 as an illustration; the value of the test statistic is  $\chi^2 = 28.18$  with 23 degrees of freedom. To use the  $p$ -value template for this hypothesis test, enter 28.18 into cell B18 and enter 23 into cell B19 (see Figure F.1). After doing so,  $p$ -values for all three types of hypothesis tests will appear. The St. Louis Metro Bus example involves an upper tail test, so we would use the upper tail  $p$ -value = .2091 provided in cell B23 for the hypothesis test.

**The  $F$  test statistic** We use the Dullus County Schools example from Section 11.2 as an illustration; the test statistic is  $F = 2.40$  with 25 numerator degrees of freedom and 15 denominator degrees of freedom. To use the  $p$ -value template for this hypothesis test, enter 2.40 into cell E18, enter 25 into cell E19, and enter 15 into cell E20 (see Figure F.1). After doing so,  $p$ -values for all three types of hypothesis tests will appear. The Dullus County Schools example involves a two-tailed test, so we would use the two-tailed  $p$ -value = .0812 provided in cell E24 for the hypothesis test.