

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 , χ^2 , and F statistics that are used in hypothesis tests. As discussed in the text, only approximate p -values for the t , χ^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 , χ^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 χ^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 = $2(.0406) = .0812$.



Using Excel

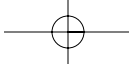
Excel functions and formulas can be used to compute p -values associated with the z , t , χ^2 , and F test statistics. We provide a template in the data file entitled p -Value for use in computing these p -values. Using the template, it is only necessary to enter the value of the test statistic and, 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. The

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



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 χ^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.

