**Step 6:** Make the decision and state the conclusion in terms of the original question.

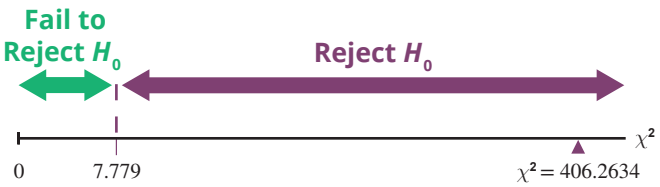



Figure 16.2.4

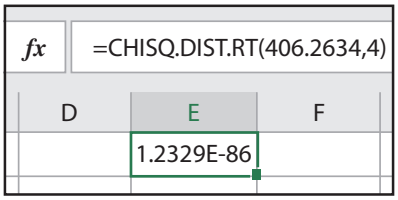
If the null hypothesis is true, the test statistic will be greater than or equal to the critical value of 7.779 only 10% of the time. Since $\chi^2 \approx 406.2634$ is larger than 7.779, we will reject $H_0$. Large values of the test statistic indicate that the proportion of Americans falling into a category changed from January 2017 to January 2021, and the change is too great to be due to ordinary sampling variation.

The *P*-value for a test statistic value of 406.2634 and degrees of freedom equal to 4 is approximately 0. Therefore, we reject the null hypothesis.

*Conclusion and Interpretation:* At the 10% level of significance, there is sufficient evidence to conclude that American sentiment towards support for basic research changed from January 2017 to January 2021. The difference in sentiment over the 4-year period is much too great to be attributed to ordinary sampling variation alone.

### Technology

The *P*-value can be found in Excel using the CHISQ.DIST.RT function. For instructions, please visit stat.hawkeslearning.com and navigate to **Discovering Business Statistics, Second Edition > Technology Instructions > Chi-Square Distribution > Right-Tailed Probability (cdf)**.




## 16.2 Exercises

### Basic Concepts

1. Describe what the test statistic for the chi-square test for goodness of fit measures.
2. What is a multinomial probability distribution? What more familiar probability distribution discussed previously in the text is a multinomial probability distribution related to?
3. List the four requirements for a multinomial experiment.
4. What are the null and alternative hypotheses for a chi-square test for goodness of fit?
5. What is the test statistic for a chi-square test for goodness of fit?
6. How many degrees of freedom does the test statistic for the chi-square test for goodness of fit have?
7. What assumptions are necessary for a chi-square test for goodness of fit?
8. How are the expected values determined in a chi-square test for goodness of fit?

### Exercises

9. A telephone company claims that the service calls they receive are equally distributed among the five working days of the week. A survey of 85 randomly selected service calls produced the following results.

| Service Calls | | | | | |
|---|---|---|---|---|---|
| | Monday | Tuesday | Wednesday | Thursday | Friday |
| Number of Calls | 15 | 20 | 25 | 15 | 10 |

**a.** Is the company's claim refuted by the data at $\alpha = 0.05$?

**b.** What assumptions were made in the test for part **a.**?

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**10.** Suppose a consumer affairs representative for Mars Incorporated claims that M&M's plain chocolate candies are mixed such that each large production batch has "precisely" the following ratios of colored candies: 30% brown, 20% yellow, 20% red, 10% orange, 10% green, and 10% blue. To test this claim, a professor distributed small sample bags of M&M's to students and had them count the number of candies of each color. The counts of the students were then pooled with the following results.

**Candy Colors**

| | Brown | Yellow | Red | Orange | Green | Blue | Total |
|---|---|---|---|---|---|---|---|
| Number of Candies | 84 | 79 | 75 | 49 | 36 | 47 | 370 |

**a.** If the representative's claim is true, what would be the expected number of candies in each of the color categories for 370 candies?

**b.** Is the representative's claim refuted by the data at $\alpha = 0.01$?

**c.** What assumptions were made in performing the test for part **b.**?

**11.** A highway department executive claims that the number of fatal accidents which occur in her state does not vary from month to month. A survey of 170 fatal accidents produced the following results.

**Accidents**

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accidents | 18 | 16 | 7 | 5 | 8 | 12 | 15 | 18 | 15 | 11 | 20 | 25 |

**a.** Is the executive's claim refuted by the data at $\alpha = 0.01$?

**b.** What assumptions were made in the test for part **a.**?

**12.** The market research firm Nielson recently published market share figures for the operating systems in smartphones. The report stated the following results.

**Market Share for Smartphone Operating Systems**

| Operating System | Market Share (%) |
|---|---|
| Android OS | 29 |
| iPhone OS | 27 |
| Blackberry OS | 27 |
| Microsoft Windows Mobile | 10 |
| HP Palm/WebOS | 4 |
| Symbian OS | 2 |
| Other | 1 |

**Source:** Nielson.com

Suppose that a marketing manager for a telecommunications company that uses one of the above operating systems doubts the Nielson findings. He collects his own data by surveying 400 people at a local mall. His findings are given in the following table.

**Survey Results**

| Operating System | Number of People |
|---|---|
| Android OS | 125 |
| iPhone OS | 115 |
| Blackberry OS | 99 |
| Microsoft Windows Mobile | 56 |
| HP Palm/WebOS | 5 |
| Symbian OS | 0 |
| Other | 0 |

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**a.** Compute the expected number of observations for each category for the survey conducted by the telecommunications marketing manager.

**b.** State the null and alternative hypotheses for the chi-square test for goodness of fit.

**c.** Using $\alpha = 0.05$, perform a goodness of fit test to determine if the survey conducted by the marketing manager is evidence that the market shares reported by Nielson have changed.

**d.** What assumptions were made in the test for part **c.**?

**e.** Do you have any concerns about the way in which the marketing manager's survey was conducted? Explain.

**13.** A psychologist conducted an attitude survey of 200 randomly selected individuals several years ago. The individuals were asked to pick the one category which most accurately described their attitudes. The results of the survey were as follows.

| 1st Attitude Survey | |
|---|---|
| **Attitude** | **Percent of Respondents** |
| Optimistic | 15% |
| Slightly Optimistic | 30% |
| Slightly Pessimistic | 30% |
| Pessimistic | 25% |

The psychologist believes that these attitudes have changed over time. To test this theory, he randomly selects 200 individuals and asks them the same questions. The results of the second survey are as follows.

| 2nd Attitude Survey | |
|---|---|
| **Attitude** | **Percent of Respondents** |
| Optimistic | 20% |
| Slightly Optimistic | 40% |
| Slightly Pessimistic | 30% |
| Pessimistic | 10% |

**a.** Can the psychologist conclude that the attitudes have changed over time at $\alpha = 0.01$?

**b.** What assumptions were made in the test for part **a.**?

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