Technology

For instructions on performing an ANOVA test visit stat.hawkeslearning.com and navigate to **Discovering Business Statistics, Second Edition > Technology Instructions > ANOVA > One-Way**.

One way Anova

Summary of Fit

RSquare	0.338598
Adj Rsquare	0.3296
Root Mean Square Error	22.38679
Mean of Response	121.8667
Observations (or Sum Wgts)	150

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob > F
Age Group	2	37715.57	18857.8	37.6276	< 0001*
Error	147	73671.76	501.2		
C. Total	149	111387.33			

Means for One way Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
8-12 Years Old	50	128.000	3.1660	121.74	134.26
13-18 Years Old	50	137.480	3.1660	131.22	143.74
Over 18 Years Old	50	100.120	3.1660	93.86	106.38

Std Error uses a pooled estimate of error variance

Figure 12.1.3

Note that the *P*-value is less than 0.0001 which indicates that we would reject the null hypothesis and conclude that the average viewing time between age groups is significantly different. However, from the results of the one-way ANOVA, we only know that the mean viewing time between age groups is different. We will discuss in Section 12.4 some popular multiple comparison procedures that will let us know specifically which of the group means is significantly different.

12.1 Exercises

Basic Concepts

1. What is the price that is paid when pairing experimental units in a paired difference experiment?
2. Give two examples of business situations in which a manager would be interested in comparing several population means.
3. Give an example of a business situation in which a manager would be interested in the average response of a variable that depends on more than one factor.
4. What are experimental units?
5. What is a treatment?
6. Why does simply comparing the sample means for multiple populations not suffice when determining if there is a significant difference in the population means?
7. Explain how box plots can be useful in analyzing data when comparing population means.
8. How is the total variation in the dependent variable broken down in analysis of variance?
9. What does the total sum of squares describe? What are its degrees of freedom?
10. What is the mathematical expression for the sum of squares for treatments?

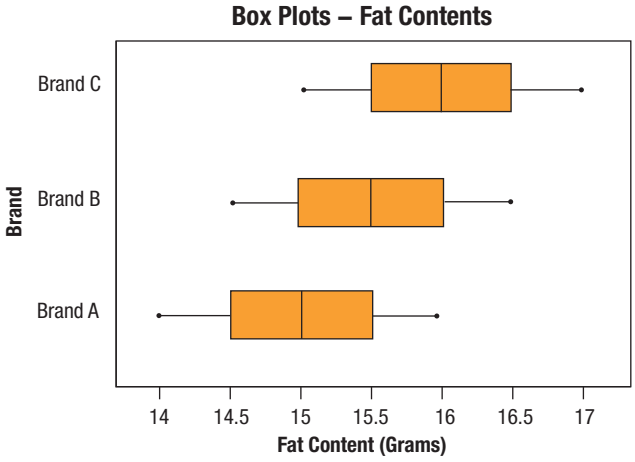
11. What is the grand mean? How is it calculated?

12. What is the mean square for treatments?

13. What is the relationship between TSS, SST, and SSE? Explain why this relationship makes sense.

Exercises

14. Consider the following box plots for data collected to compare the average fat contents (in grams) per serving (2 tablespoons) of three popular brands of peanut butter.



a. Based on the box plots, do you think that there may be a significant difference in the average fat contents per serving of Brand A and Brand B? Explain.

b. Based on the box plots, do you think that there may be a significant difference in the average fat contents per serving of Brand B and Brand C? Explain.

c. Based on the box plots, do you think that there may be a significant difference in the average fat content per serving of Brand A and Brand C? Explain.

15. Consider the following box plots for data collected to compare the average scores achieved on a standardized aptitude test by freshmen, sophomores, juniors, and seniors at a large university.

a. Based on the box plots, do you think that there may be a significant difference in the average scores achieved by freshmen and sophomores on the standardized test? Explain.

b. Based on the box plots, do you think that there may be a significant difference in the average scores achieved by freshmen and juniors on the standardized test? Explain.

c. Based on the box plots, do you think that there may be a significant difference in the average scores achieved by juniors and seniors on the standardized test? Explain.

16. Consider the following table containing yields for mutual funds in different asset classes (small, mid, and large cap).

Fund Yields by Asset Class

Small Cap		Mid Cap		Large Cap	
Fund	**Yield (%)**	**Fund**	**Yield (%)**	**Fund**	**Yield (%)**
Explorer Value	1.13	Capital Value	0.96	Equity Income	3.24
Small-Cap Value Index Admiral	2.46	Mid-Cap Value Index Admiral	2.47	High Dividend Yield Index	3.50
Small-Cap Index Admiral Shares	1.49	Extended Market Index Admiral Shares	1.22	500 Index Admiral Shares	2.35
Strategic Small-Cap Equity	1.10	Mid-Cap Index Admiral Shares	1.52	Diversified Equity	1.23
Explorer	0.17	Mid-Cap Growth	0.10	FTSE Social Index	1.42
Small-Cap Growth Index Admiral	0.21	Mid-Cap Growth Index Admiral	0.32	Growth Equity	0.60

Source: The Vanguard Group, Inc.

a. Identify the experimental units and the treatment in the context of this problem.

b. Compute the mean and median yields for each asset class.

c. Compute the values of the minimum, maximum, first, and third quartiles for each asset class.

d. Construct side-by-side box plots for the three asset classes.

e. Based on the box plots, do you think that there may be a significant difference in the average yields of small-cap and mid-cap funds? Explain.

f. Based on the box plots, do you think that there may be a significant difference in the average yields of mid-cap and large-cap funds? Explain.

g. Based on the box plots, do you think that there may be a significant difference in the average yields of small-cap and large-cap funds? Explain.

h. Based on your analysis, which asset class contains mutual funds with the largest yields, on average? Explain your answer.

17. Consider the following table containing daily production data from a particular week for three different employee shifts.

Items Produced			
	First Shift (7 AM–3 PM)	Second Shift (3 PM–11 PM)	Third Shift (11 PM–7 AM)
Monday	140	168	77
Tuesday	181	224	123
Wednesday	127	162	77
Thursday	172	182	101
Friday	161	219	147
Saturday	152	171	145
Sunday	173	217	111

a. Identify the experimental units and the treatment in the context of this problem.

b. Compute the mean and median numbers of items produced for each shift.

c. Compute the values of the minimum, maximum, first, and third quartiles for each shift.

d. Construct side-by-side box plots for the three shifts.

e. Based on the box plots, do you think that there may be a significant difference in the average numbers of items produced during the first and second shifts? Explain.

f. Based on the box plots, do you think that there may be a significant difference in the average numbers of items produced during the second and third shifts? Explain.

g. Based on the box plots, do you think that there may be a significant difference in the average numbers of items produced during the first and third shifts? Explain.

h. Based on your analysis, which shift would you say is the most productive, on average? Explain your answer.

18. The sales by strategy data given in Table 12.1.1 yield the following statistics.

Sales by Strategy (Millions of Dollars)		
Strategy 1	Strategy 2	Strategy 3
3	2	4
6	5	2
7	5	5
4	3	6
6	7	6
7	8	7
10	6	9
6	4	8
15	10	14
8	6	8
9	9	7
16	12	16

$$SST \approx 18.0556$$

$$SSE = 438.5$$

a. What are the degrees of freedom associated with the total sum of squares?

b. What are the degrees of freedom associated with the sum of squares for treatments?

c. Find the mean square for treatments, MST.

d. Find the mean square for error, MSE.

19. The fund yield data given in Exercise 16 give the following summary statistics.

Fund Yields by Asset Class

Small Cap		Mid Cap		Large Cap	
Fund	Yield (%)	Fund	Yield (%)	Fund	Yield (%)
Explorer Value	1.13	Capital Value	0.96	Equity Income	3.24
Small-Cap Value Index Admiral	2.46	Mid-Cap Value Index Admiral	2.47	High Dividend Yield Index	3.50
Small-Cap Index Admiral Shares	1.49	Extended Market Index Admiral Shares	1.22	500 Index Admiral Shares	2.35
Strategic Small-Cap Equity	1.10	Mid-Cap Index Admiral Shares	1.52	Diversified Equity	1.23
Explorer	0.17	Mid-Cap Growth	0.10	FTSE Social Index	1.42
Small-Cap Growth Index Admiral	0.21	Mid-Cap Growth Index Admiral	0.32	Growth Equity	0.60

Source: The Vanguard Group, Inc.

$$\text{MST} \approx 1.8464$$
$$\text{MSE} \approx 0.9423$$

a. Interpret the value of MST.

b. What are the degrees of freedom associated with the sum of squares for treatments?

c. Find the sum of squares for treatments.

d. What are the degrees of freedom for the sum of squares for error?

e. Find the sum of squares for error.

20. Consider the production data given in Exercise 17.

Items Produced

	First Shift (7 AM–3 PM)	Second Shift (3 PM–11 PM)	Third Shift (11 PM–7 AM)
Monday	140	168	77
Tuesday	181	224	123
Wednesday	127	162	77
Thursday	172	182	101
Friday	161	219	147
Saturday	152	171	145
Sunday	173	217	111

a. What is the value of the grand mean, $\bar{\bar{x}}$?

b. What is the value of n_j?

c. What is the value of k?

d. What is the value of n_T?

e. For these data, identify the degrees of freedom associated with the total sum of squares, the degrees of freedom associated with the sum of squares for treatments, and the degrees of freedom associated with the sum of squares for error. Verify that the relationship between the degrees of freedom (Total = Treatment + Error) holds.