MKTG 352

Principles of Marketing Research

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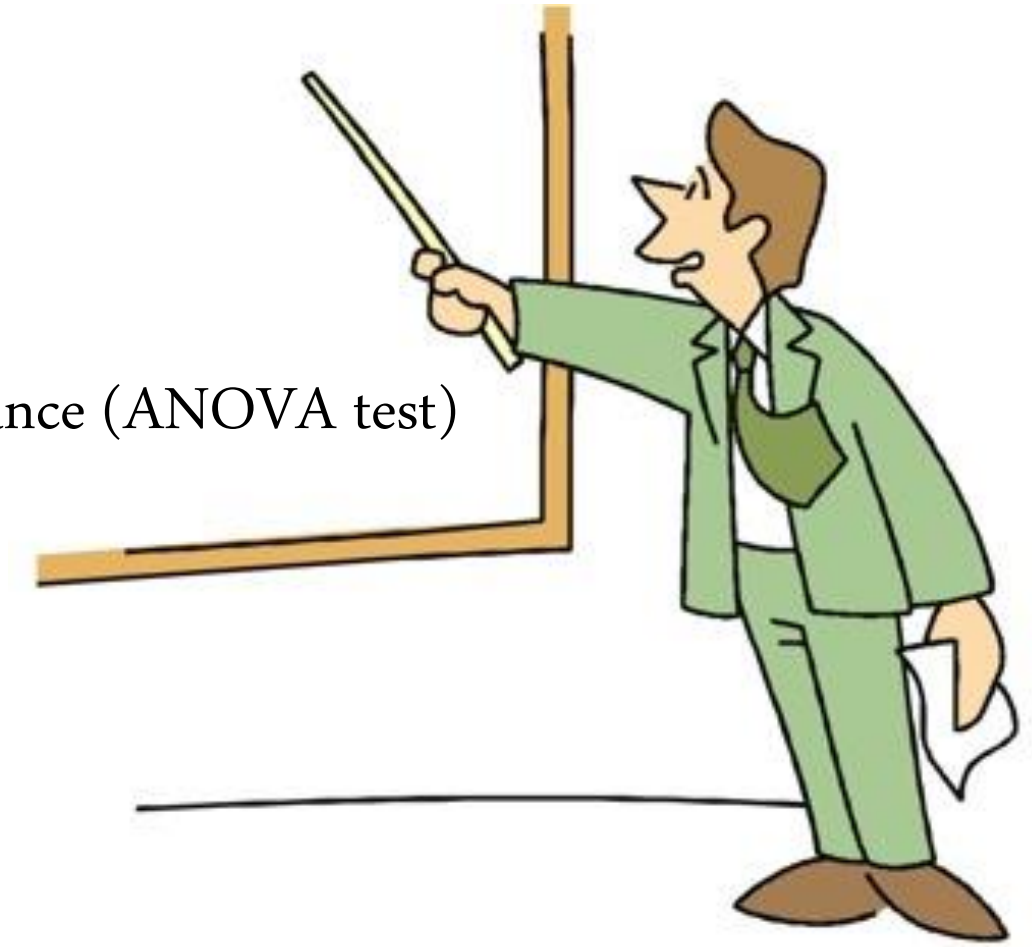
Session #8

Topics for today…

Statistical Tests

- Analysis of Variance (ANOVA test)



Announcement

In-Class assignment #1:

Fri. , Feb. 9th

Question…

Often the marketing analyst wants to determine if varying a **single factor** has a **significant effect** on a marketing outcome such as sales. For example:

- Does a Valentine's Day card sell better on the top, middle, or bottom shelf?
- Do cookies sell more if they are placed on display in the candy aisle, cookie aisle, or cereal aisle?
- Does the sale of a computer book depend on whether the book is placed in the front, back, or middle of the computer section?

Marketing Problem

- A marketing research firm tests the impact of three pricing strategies for a new beverage using a sample of 30 people, divided randomly into three groups of 10 people each.
- Group 1 receives the product with price #1, group 2 receives the product with price #2 and so on. Each person evaluates how fair the price is.

We would like to determine whether there is a significant difference between the three groups in terms of perceived fairness.

Price 1 $8	Price 2 $11	Price 3 $10
13	12	7
17	8	19
19	6	15
11	16	14
20	12	10
15	14	16
18	10	18
9	18	11
12	4	14
16	11	11
AVG=15	AVG=11.1	AVG=13.5

Method: ANOVA

What is ANOVA ?

– Statistical technique specially designed to test whether the **means** of more than **TWO** quantitative populations are equal.

– Is typically used when researches have to determine if there is a statistical difference between **three** or more means.

ANOVA requires:

The dependent variable be metric, i.e. either interval or ratio scaled. Not categorical.

– Perceived enjoyment

The independent variable be non-metric, i.e. categorical.

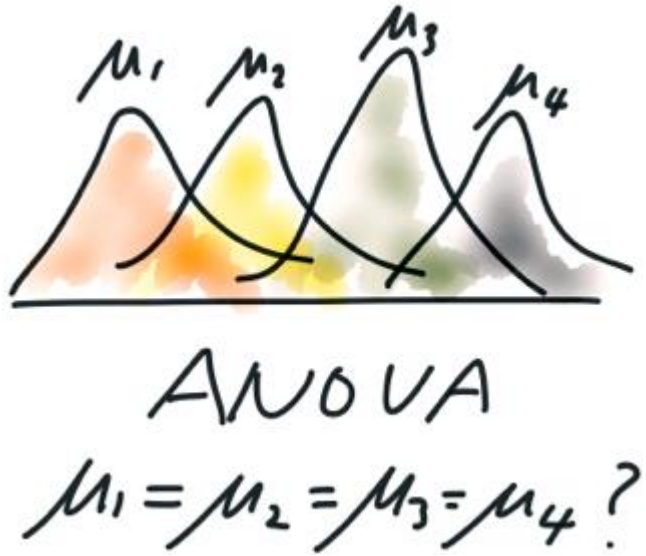
– Flavors

Null & alternative hypothesis

The null hypothesis for an ANOVA assumes that there is no difference between the means.

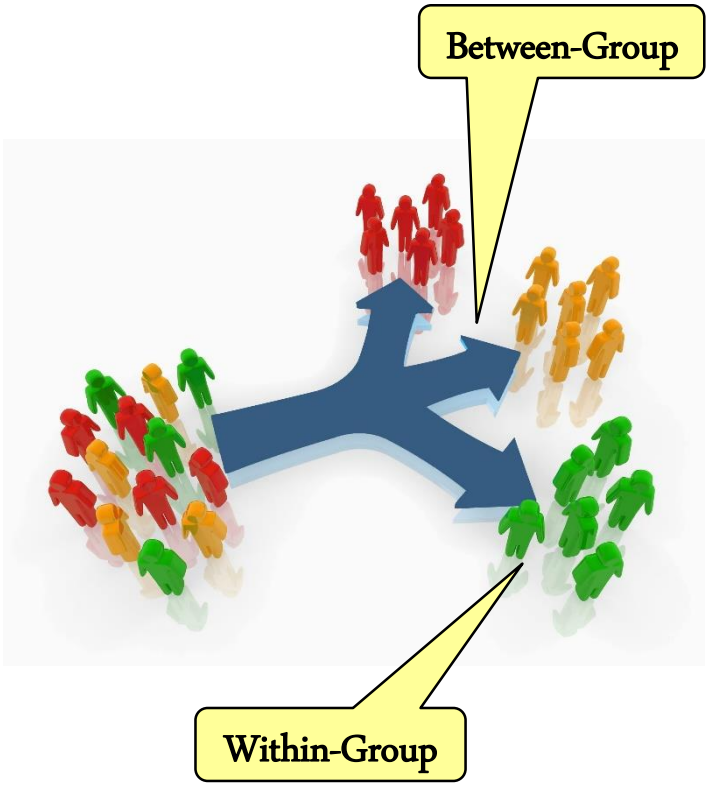
$\mathbf{H_0: mean_1 = mean_2 = mean_3 = \cdots = mean_n}$

$\mathbf{H_a:}$ **not all of the means are equal**



ANOVA

- **The between group variance:**
  - How much the sample means of the group differ from each other.
- **The within group variance:**
  - How much the responses within each group differ from one another.



Calculate F value

Notes

Between Mean Square

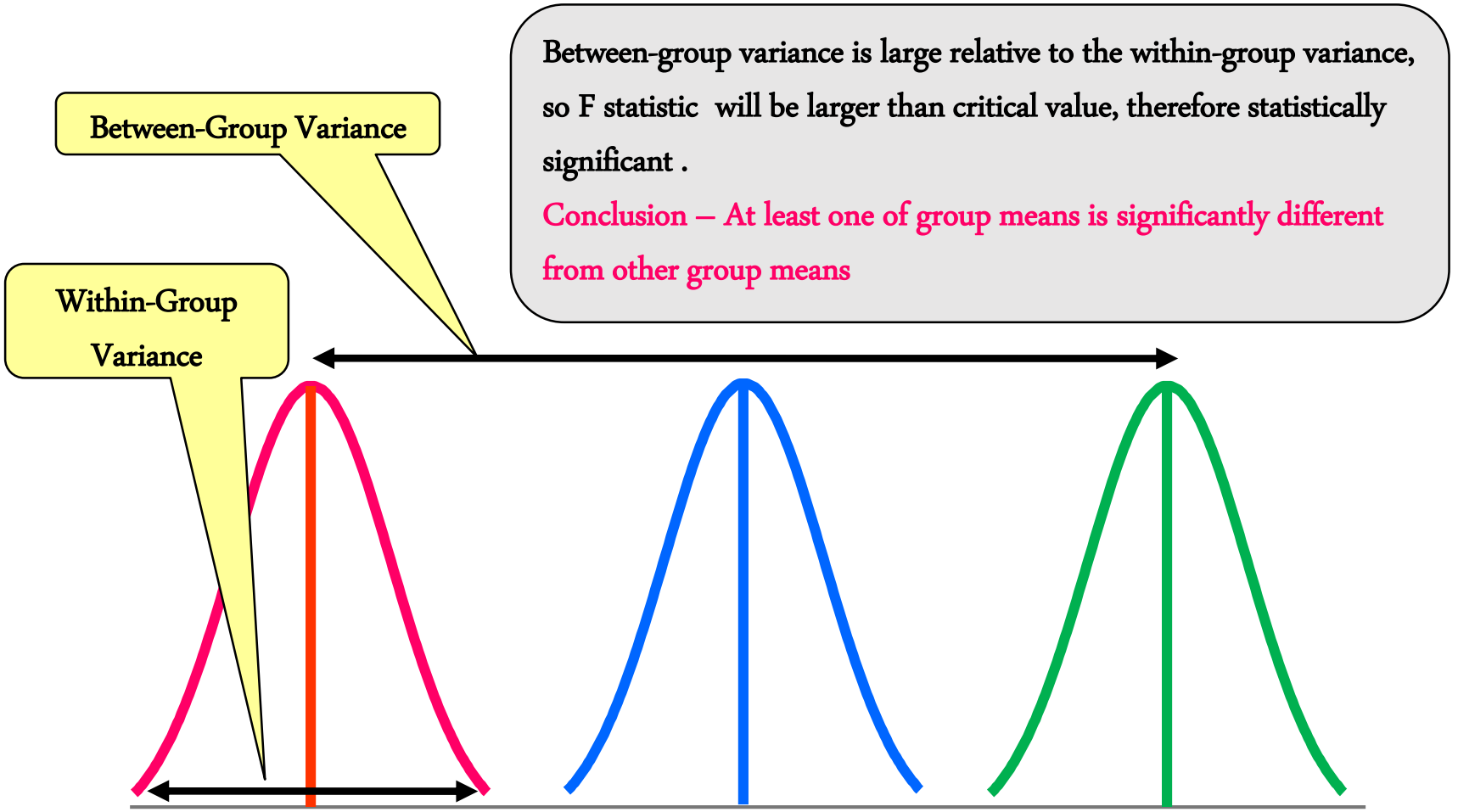
$$F - Value = \frac{\text{Between groups MS variance}}{\text{Within groups MS variance}}$$

Within Mean Square

The F-ratio is used to evaluate whether there is a significant difference between the means or not.

Compare the F-statistic value with F(critical) value which is obtained by looking for it in F distribution tables against degrees of freedom. If the calculated value of F > critical F H null is rejected

Between vs. within group variance



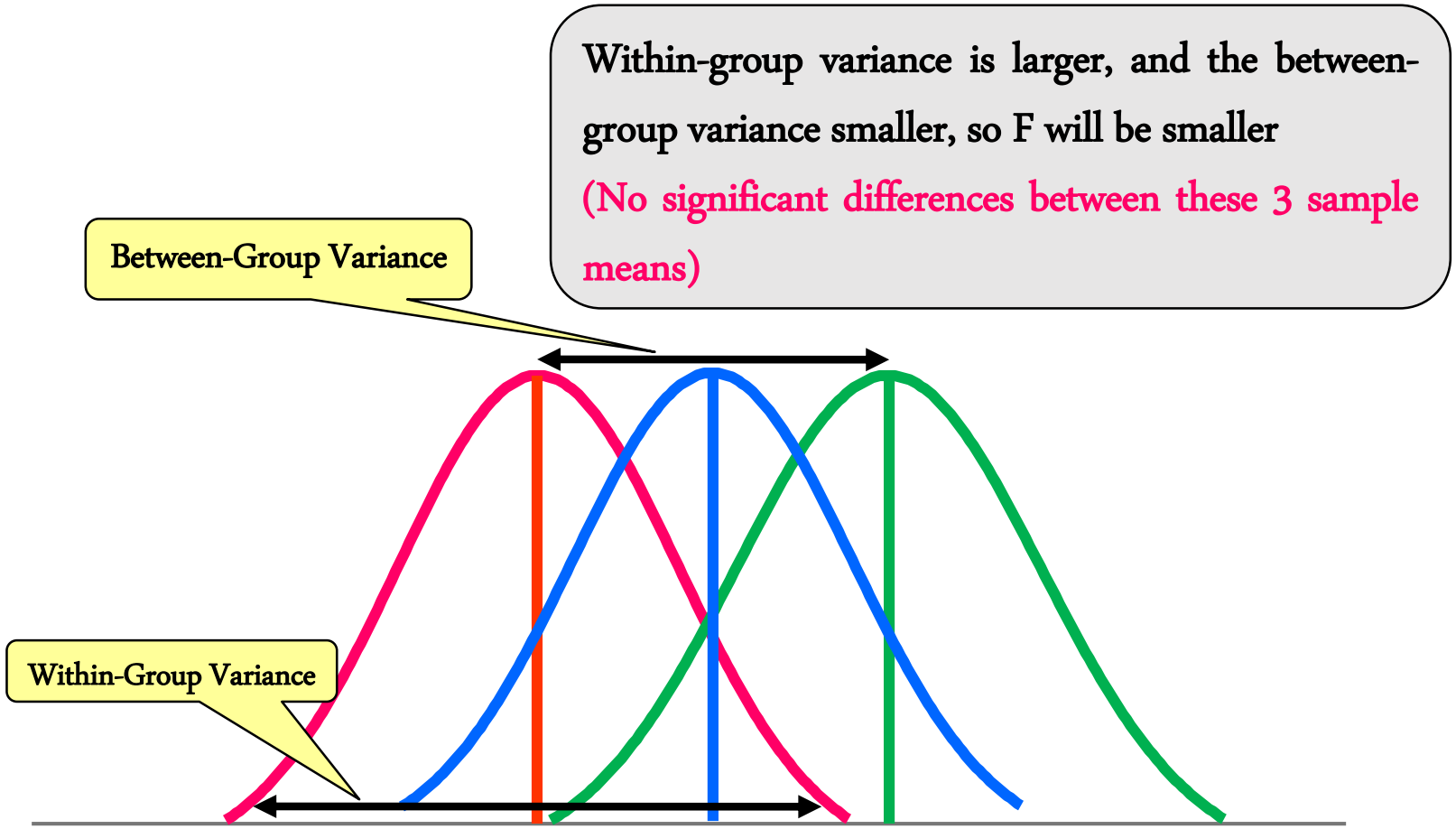
Notes

The larger the between groups variance, the greater the F-ratio.

The greater the F-ratio, the more likely is that there is a significant difference between the means of the groups.

Between vs. within group variance

Notes



The lower the between groups variance, the smaller the F-ratio.

The smaller the F-ratio, the less likely is that there is a significant difference between the means of the groups.

Step #1:Grand Mean

Grand Mean

The grand mean is the average of all the values when the groups are ignored

It is a weighted average of the individual sample means

$$\overline{\overline{x}} = \frac{n_1\overline{x}_1 + n_2\overline{x}_2 + \cdots + n_k\overline{x}_k}{n_1 + n_2 + \cdots + n_k}$$

$$\overline{\overline{x}} = \frac{\sum_{i=1}^{k} n_i\overline{x}_i}{\sum_{i=1}^{k} n_i}$$

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12	4	14
16	11	11

Grand Mean for our example is 13.2

Step #2:Between Group Variation, SS(B)

- The between group variation is the variation between each sample mean and the grand mean
- Each individual variation is weighted by the sample size

$$SS(B) = n_1(\bar{x}_1 - \bar{\bar{x}})^2 + n_2(\bar{x}_2 - \bar{\bar{x}})^2 + \cdots + n_k(\bar{x}_k - \bar{\bar{x}})^2$$

SS(between)

Price 1	Price 2	Price 3
13	12	7
17	8	19
19	6	15
11	16	14
20	12	10
15	14	16
18	10	18
9	18	11
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16	11	11
AVG=15	AVG=11.1	AVG=13.5

$$SS(B) = \sum_{i=1}^{k} n_i(\bar{x}_i - \bar{\bar{x}})^2$$

SS(B) for our example is 77.4

Step #3: Within Group Variation, SS(W)

SS(within)

- The Within Group Variation is the weighted total of the individual variations
- The weighting is done with the degrees of freedom
- The d.f. for each sample is one less than the sample size for that sample.

SS(W) for our example is:

$9\times(13.3)+9\times(18.7)+9\times(14.05)=414.45$

Degree of freedom

Group 1 variance

$$SS(W) = df_1 s_1^2 + df_2 s_2^2 + \cdots + df_k s_k^2$$

$$SS(W) = \sum_{i=1}^{k} df_i s_i^2$$

Step #4: F-Value

Source	SS	d.f.	MS(variance)	F
Between	77.4	2	38.7	2.52
Within	414.45	27	15.35	
Total	492.8	29		

Degree of Freedom

The between group d.f. is one less than the number of groups

We have three groups, so d.f.(B) = 2

The within group d.f. is the sum of the individual d.f's of each group

The sample sizes are 10, 10, and 10

d.f.(W) = 9 + 9 + 9= 27

The total d.f. is one less than the sample size

d.f.(Total) = 30 – 1 = 29

F Table

Table of Probabilities for the F Distribution

Alpha = 0.05

D/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	24	30	40	60	120
1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88	242.98	243.91	244.69	245.36	245.95	248.01	249.05	250.10	251.14	252.20	253.25
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.40	19.41	19.42	19.42	19.43	19.45	19.45	19.46	19.47	19.48	19.49
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74	8.73	8.71	8.70	8.66	8.64	8.62	8.59	8.57	8.55
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91	5.89	5.87	5.86	5.80	5.77	5.75	5.72	5.69	5.66
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68	4.66	4.64	4.62	4.56	4.53	4.50	4.46	4.43	4.40
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.98	3.96	3.94	3.87	3.84	3.81	3.77	3.74	3.70
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57	3.55	3.53	3.51	3.44	3.41	3.38	3.34	3.30	3.27
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28	3.26	3.24	3.22	3.15	3.12	3.08	3.04	3.01	2.97
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07	3.05	3.03	3.01	2.94	2.90	2.86	2.83	2.79	2.75
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91	2.89	2.86	2.85	2.77	2.74	2.70	2.66	2.62	2.58
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.82	2.79	2.76	2.74	2.72	2.65	2.61	2.57	2.53	2.49	2.45
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69	2.66	2.64	2.62	2.54	2.51	2.47	2.43	2.38	2.34
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60	2.58	2.55	2.53	2.46	2.42	2.38	2.34	2.30	2.25
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53	2.51	2.48	2.46	2.39	2.35	2.31	2.27	2.22	2.18
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48	2.45	2.42	2.40	2.33	2.29	2.25	2.20	2.16	2.11
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.45	2.42	2.40	2.37	2.35	2.28	2.24	2.19	2.15	2.11	2.06
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.41	2.38	2.35	2.33	2.31	2.23	2.19	2.15	2.10	2.06	2.01
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.37	2.34	2.31	2.29	2.27	2.19	2.15	2.11	2.06	2.02	1.97
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.34	2.31	2.28	2.26	2.23	2.16	2.11	2.07	2.03	1.98	1.93
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28	2.25	2.22	2.20	2.12	2.08	2.04	1.99	1.95	1.90
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.28	2.25	2.22	2.20	2.18	2.10	2.05	2.01	1.96	1.92	1.87
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.26	2.23	2.20	2.17	2.15	2.07	2.03	1.98	1.94	1.89	1.84
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.24	2.20	2.18	2.15	2.13	2.05	2.01	1.96	1.91	1.86	1.81
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.22	2.18	2.15	2.13	2.11	2.03	1.98	1.94	1.89	1.84	1.79
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.20	2.16	2.14	2.11	2.09	2.01	1.96	1.92	1.87	1.82	1.77
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.18	2.15	2.12	2.09	2.07	1.99	1.95	1.90	1.85	1.80	1.75
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.17	2.13	2.10	2.08	2.06	1.97	1.93	1.88	1.84	1.79	1.73
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.15	2.12	2.09	2.06	2.04	1.96	1.91	1.87	1.82	1.77	1.71
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.14	2.10	2.08	2.05	2.03	1.94	1.90	1.85	1.81	1.75	1.70
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.13	2.09	2.06	2.04	2.01	1.93	1.89	1.84	1.79	1.74	1.68
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.04	2.00	1.97	1.95	1.92	1.84	1.79	1.74	1.69	1.64	1.58
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.95	1.92	1.89	1.86	1.84	1.75	1.70	1.65	1.59	1.53	1.47
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.87	1.83	1.80	1.78	1.75	1.66	1.61	1.55	1.50	1.43	1.35

Within d. f

Between d. f

F=3.35

Right Tailed, D/N = df in denominator = down the rows, df in numerator = across the columns

Note: Table is for an alpha of 0.05

Table of Probabilities for F Distribution

The F value is 2.52, which is less than the critical F, so we cannot reject the null hypothesis.

Conclusion

There is not enough evidence to support the claim that there is a difference in the perceived fairness level of the price1, price2, and price3.

Follow up tests

Follow up tests:

Performed after an ANOVA determines there is a significant difference in the means. Tells us the groups which are significantly different from each other.

Some Comments …

Companies look for people who can bridge the managerial problems to statistics/math/programming!

The hardest part comes after mid-March,

please set the appropriate expectations to

- How much time to study
- How much to comprehend/understand