

Repeated Measures ANOVA

BUS 735: Business Decision Making and Research

1

Goals of this section

Specific goals

- Learn background and implementation of RANOVA: a method to detect the impact of categorical variables measured over the same subjects (dependent samples).
- Learn how to incorporate ideas we have already learned in RANOVA models.

Learning objectives

- LO3: Be able to construct and use analysis of variance and analysis of covariance models to construct and test hypotheses considering complex relationships among multiple variables.
- LO6: Be able to use standard computer packages such as SPSS and Excel to conduct the quantitative analyses described in the learning objectives above.
- LO7: Have a sound familiarity of various statistical and quantitative methods in order to be able to approach a business decision problem and be able to select appropriate methods to answer the question.

Paired Samples T-Test

- Recall paired samples T-test:
 - Involved *repeated measures*: same sampling units were measured twice (eg: before/after treatment, two related variables on same scale)
 - Examined *within-subject variability*: examined differences in dependent variable *within each subject*.
- Repeated Measures ANOVA (RANOVA): extends the analysis of Paired Samples T-tests to two or more groups.
 - In much the same way ANOVA extended the Independent Samples T-test.
 - We call this **Within-Subjects Analysis of Variance**.
 - This is one type of RANOVA. We will examine another type.

Within-Subject ANOVA Examples

- Is there a difference in sales revenue for businesses...
 - before advertising campaign begins,
 - one week into advertising campaign,
 - one month into advertising campaign, and
 - one month after conclusion of advertising campaign?
- Is there a difference in anxiety in torture victims...
 - before undergoing an 8-week treatment,
 - immediately following 8-week treatment, and
 - six months following conclusion of treatment?

Alternative Within-Subjects Variation

- Dependent samples T-Test and RANOVA have dependent samples as the same subjects are in each group.
- **Across Time Variation...** aka **Occasions variation.**
- **Different Conditions Variation:** measure the same dependent variable, among the same subject, but under different conditions:
 - Magnitude of headache pain with no treatment, after taking Advil, after taking Tylenol; each administered at different times.
- **Related Topics Variation:** *Slightly different* dependent variables are measured for the same subjects:
 - ESL proficiency score for writing.
 - ESL proficiency score for reading.
 - ESL proficiency score for speaking.

One-Way and Two-Way ANOVA

Recall One-Way ANOVA

- Involved *independent groups*: different individuals randomly fell or assigned to into different groups.
- Examined *between-subject variability*: examined differences in dependent variable *between different groups of subjects*.
- Example: Is there is difference in sales revenue between businesses that advertise primarily on...

- television,
 - radio, and
 - outdoor advertising?
- Example: Is there a difference in anxiety in torture victims between males and females?

Recall Two-way ANOVA

- Jointly considered two categorical explanatory variables.
- Accounts for one variable while examining significance of the other.
- Can measure interaction effects.

Between-Within-Subjects ANOVA

- **Between-Within-Subjects ANOVA:** Also a type of RANOVA
- Extends the *repeated-measures within subjects ANOVA* to also account for categorical explanatory variables that put subjects into *independent groups*.
- Combines:
 1. *repeated-measures within subjects ANOVA*, and
 2. *One-way ANOVA* (which measures between-effects).

Example: Between-Within-Subjects ANOVA

Example for sales revenue and advertising:

1. Is there a difference in sales revenue for businesses...
 - before advertising campaign begins,
 - one week into advertising campaign,
 - one month into advertising campaign, and
 - one month after conclusion of advertising campaign...
2. while accounting for differences due to advertising on...
 - television,
 - radio, and
 - outdoor advertising?

Example continued...

Hypothesis Tests:

- (Accounting for...) are there differences in sales revenue depending on time into the advertising campaign?
- (Accounting for...) are there differences in sales revenue depending on the type of advertising?
- Is there an interaction effect between type of advertising and time into the advertising campaign?
 - In other words, “Does the effect advertising has on sales revenue across time depend on the type of advertising?”

Example: Between-Within-Subjects ANOVA

- Is there a difference in anxiety in torture victims...
 - before undergoing an 8-week treatment,
 - immediately following 8-week treatment, and
 - six months following conclusion of treatment...
- while accounting for differences due to gender (male or female)?

Example continued...

Hypothesis Tests:

- (Accounting for...) are there differences in anxiety depending on time with respect to administering treatment?
- (Accounting for...) are there differences in anxiety between males and females?
- Is there an interaction effect between gender and time with respect to administering treatment?
 - In other words, “Is effect the treatment has on anxiety across time (immediately following the treatment and 6 months following the treatment) different for men and women?”

Null and Alternative Hypotheses

- Null: Accounting for the other explanatory variables in the model, there is no difference in the mean dependent variable among the categories of the explanatory variable of interest.
- Alternative: Accounting for the other explanatory variables in the model, at least one of the categories of the explanatory variable has a different mean than the other categories.

Hypothesis Example: Within-Subjects

- Dependent variable: Sales revenue.
- Within-subjects explanatory variable: time into advertising campaign (categorical).
- Null: There is no difference in mean sales revenue for business before an advertising campaign begins, one week into advertising, one month into advertising, and one month after conclusion of advertising.
- Alternative: There is a difference in sales revenue...

Hypothesis Example: Within-Between-Subjects

Variables

- Dependent variable: Sales revenue.
- Within-subjects explanatory variable: time into advertising campaign.
- Between-subjects explanatory variable: advertising medium (TV, radio, outdoor).

Null Hypotheses 1

Accounting for advertising medium, there is no difference in mean sales revenue for business before an advertising campaign begins, one week into advertising, one month into advertising, and one month after conclusion of advertising.

Null Hypotheses 2

Accounting for time into advertising campaign, there is no difference in mean sales revenue for businesses advertising on TV, radio, and outdoor.

Null Hypotheses 3

There is no interaction effect on mean sales revenue coming from advertising medium and time into advertising.

Advantages of RANOVA

- RANOVA is more **powerful** than ANOVA: accounting for within-subjects variation reduces unexplained variation.
- Reduces chance of Type I error (rejecting the null hypothesis when it is true).
- Capture interaction effects that Two-Way ANOVA is not capable of.

Assumptions

- Sample size sufficiently large.
 - At least 30 subjects with repeated measures taken.
 - At least 30 subjects in each group for categorical explanatory variables.

- Dependent variable is interval data or above.
- Normally distributed dependent variable is helpful.
- Homogeneity of variance/covariance:
 - Homogeneity across categories for between-groups.
 - Sphericity: across all differences for within-groups categories.
 - Sphericity across categories for between-groups.