BIA 654 Experimental Design

- Instructor: Professor Chihoon Lee, Ph.D.
- Contact Info: clee4@stevens.edu

- Course Web Address: We will use *Canvas*.
- Prerequisite(s): MGT 720 – Statistical Models or Equivalent, See Syllabus, pp. 4-5, for a list of relevant topics and web resource.
- Basic knowledge on statistical packages, such as R, SAS, or Minitab is preferred but not required.
- SAS-JMP (called 'Jump') is powerful and user-friendly (Stevens students: $29.95 license fee, Windows, Mac).

Course Materials

- Lecture notes: uploaded every week
- Textbook: Testing 1-2-3 Experimental Design with Applications in Marketing and Service Operations, Ledolter and Swersey, Stanford Business Books, 2007 (Can be bought from Stevens Bookstore)

Grading

- **Homework** 30%

-- You are encouraged to work with other students on assignments. You should complete the assignments prior to class.

- **Midterm Exam** 30% -- This will be an in-class, pencil & paper style midterm exam. Each individual must take it individually.

Grading

- **Final Exam: Project Report** 20% **and Presentation** 20%

-- Each team (of size 2-4) will a) identify a research topic, b) apply experimental and/or survey design, c) interpret the results, and d) report the research findings.

-- Each team will write a management report and make a brief presentation describing the research question and hypotheses, methods, results, and implications.

Project Example

- Dominating the iPhone Resale Market with *Fractional Factorial Designs*
- Goal: Determine the best Sales Pitch on Craigslist to sell an IPhone 6

Factor	**(-)**	**(+)**
A: Including a Picture in the body	No	Yes
B: Mention screen quality in the body	No	Yes
C: Displaying a fake price	No	Yes
D: Call to Action in the body	Soft Sell	Hard Sell
E: Posting Time	Evening	Morning
F: Displaying the phone's condition in the subject heade	No	Yes
G: Include packaging/ charger/ headphones / case	No	Yes
H: Payment type	Cash	Paypal

Example continued: Best choices?

posting body please enter phone numbers as contact info above, not in posting body below.

Apple iPhone 6 - 64GB Silver Factory Unlocked (Verizon) Smartphone MG4H2LL/A

This phone is in excellent working and cosmetic condition, and there are no major signs of wear.

posting details

make / manufacturer Apple

model name / number iPhone 6

size / dimensions length x width x height

condition like new

mobile OS apple iOS

include "more ads by this user" link

Project Examples

- Experiment on Elevators Waiting Time in Bobbio Center
- Website Optimization for Election Fundraising
- ….

- This course is about the power of statistical experiments.
- We will learn fundamental topics in experimental research designs and data collection strategies.
- These can reduce firms' costs, increase productivity, and improve their quality of services or products.

LEARNING OBJECTIVES

- After successful completion of this course, you will be able to:

  i) Design various statistical experiments

  ii) Analyze the survey or experimental data

  iii) Document and present the research analyses and finding to help make management and business recommendations

Grading Schemes

- 94 or above: A, $90 \leq$ A− < 94
- $87 \leq$ B+ < 90, $83 \leq$ B < 87, $80 \leq$ B− < 83
- etc.

Comments

- Class discussion is encouraged while working and practicing the Homework problems.
- All *late submissions* (assignments) will receive a 10% grade reduction per day, no credit for submissions past one-week deadline, without prior instructor permission.
- Midterm exam work is to be independent, although you can reference your notes and assignments (no laptop or phone use).

Tentative Class Schedule by Week

- Can find this in Syllabus.

Ethics Statement

The following statement is printed in the Stevens Graduate Catalog and applies to all students taking Stevens courses, on and off campus.

"Academic Improprieties

The term academic impropriety is meant to include, but is not limited to, **cheating on homework, during in-class or take home examinations and plagiarism. The Institute has adopted a procedure to deal with such actions**. An instructor of a graduate course may elect to formally charge a student with committing an academic impropriety to the Dean of Graduate Academics or to adjudicate the issue personally."

Consequences of academic impropriety are severe, **ranging from receiving an "F" in a course, to a warning from the Dean of the Graduate School, which becomes a part of the permanent student record, to expulsion.**

Reference: https://www.stevens.edu/provost/graduate-academics/handbook/academic-standing.html#PDG

Simple Rule: Whatever you write on assignments or final report, it should be your OWN words.

Ethics Pledge

Consistent with the above statements, all homework exercises, tests and exams that are designated as individual assignments MUST contain the following signed statement before they can be accepted for grading.

I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination. I further pledge that I have not copied any material from a book, article, the Internet or any other source except where I have expressly cited the source.

Signature _____ Date: _____

Please note that assignments in this class may be submitted to www.turnitin.com, a web-based anti-plagiarism system, for an evaluation of their originality.

Chihoon Lee

- Stevens: 2015 Fall – Associate Professor
- Seoul National University (Korea), Statistics and Mathematics, 2003 BSc
- Univ. of North Carolina – Chapel Hill, Statistics and Operations Research, 2008 PhD
- Colorado State Univ. Department of Statistics, 2008-2015, Assistant/Associate Professor
- Research: Large Scale Service Operations Management (e.g., call centers, hospitals)

About You?

- Your name
- How long have you been at Stevens?
- In what program?
- Your academic/industry background?

Design of Experiment (DOE)?

- Experiment?
- History
  - The agricultural origins (maximize **crop yield**), 1918 – 1940s
    - Optimal combination of fertilizer level, moisture level, light condition, seeding time, etc.
  - R. A. Fisher (U.K.)
  - Profound impact on agricultural science
  - Factorial designs, ANOVA (we will learn these)
- Modern Marketing: Maximize **firms' profit**

"Boost Your Marketing ROI with Experimental Design"

- Published by Eric Almquist and Gordon Wyner (VP's in Mercer Consulting, Boston) in the October 2001, *Harvard Business Review*.
- Find this article in Contents folder and read!
- Biz Ware Example, Experimentation at Crayola company.

Basic Terms and Concepts

- **Treatments**: Different procedures we want to compare (e.g., Crayola's ROI example: 72 treatments)

- **Experimental Units**: Things to which we apply the treatments (e.g., Crayola target customers: parents/teachers)

- **Response**: Outcomes we observe after applying a treatment to an experimental unit (e.g., Parents' response rate)

Basic Terms and Concepts

- **Factors** combine to form treatments. (e.g., subjects, salutations, calls to action, promotions, closings)

- **Levels**: Individual settings for each factor are called levels of the factor. (e.g., salutations: Hi [user name] :-), Greetings, [user name])

- **Experimental** Factors: Experimenter can 'assign' as treatments to the experimental units (e.g., subjects, salutations, promotions, closings).
- **Classification** Factors can't be changed or assigned, these come as labels on the experimental units (e.g., age, sex, ethnicity).

Homework Assignment 1

1. Pick a Website on the Internet. Suppose you were designing an experiment for increasing visitor's response to a product or service offered on the site.
   - What five factors do you think would be most important to test? In each case, specify two levels for each of the factors and tell whether it is experimental or classification factor.
   - Submit the assignment in next class meeting.

Reading Assignment

1. Read "Boost Your Marketing ROI with Experimental Design"
2. Review of Basic Statistical Concepts: from the textbook
    1. Read Section 2.2 (pp. 8-16)
    2. Read Sections 2.5.1 and 2.5.2 (pp.26-27)

Practical Steps for Planning DOE

1. Recognition and statement of the problem
2. Choice of factors, levels
3. Selection of the response variable(s)
4. Choice of design: our focus in this course
5. Conducting the experiment
6. Statistical analysis
7. Drawing conclusions, and making recommendations

Quiz 1

- The central limit theorem looks at what specific values derived from a population?
  - The median of multiple samples
  - The average of multiple samples
  - The standard deviation of multiple samples
  - The variance of multiple samples

Quiz 2

- Suppose an investor is looking to analyze the overall return for a stock index made up of 1,000 stocks (*Population*).
- Take random samples of stocks from the index to get an *estimate* for the return of the total index (*Parameter*).
- Then, the *average* returns from these samples (suppose each sample is of size 50) approximates the return for the whole index and are approximately (?) distributed.

Quiz 3

- David's gasoline station offers 4 cents off per gallon if the customer pays in cash and does not use a credit card. Past evidence indicated that 40% of all customers pay in cash.
- On average, in one-hour period, 15 customers buy gasoline at this station. We are interested in the number of customers pay in cash.
- This station is an example of what type of discrete probability distribution?
- What is the probability that at most 4 customers pay in cash?

The Basic Principles of DOE

- **Randomization, Replication, Blocking**

- **Randomization:** an essential component!
  - The use of a known, understood probabilistic mechanism for the assignment of treatments to units
  - A deliberate process to eliminate potential biases
- **What could go wrong?!**
  - **Consider a new drug treatment for coronary artery disease. Compare this drug treatment with bypass surgery (invasive major surgery). We have 100 patients. Measure five-year survival.**
    - **Weaker vs. stronger patients?**

The Basic Principles of DOE

- **One could** (of course, this is an oversimplification):
  - Toss a coin for every patient; heads—the patient gets the drug, tails—the patient gets surgery
  - Make up a basket with 50 red balls, 50 white well mixed together. Each patient gets a randomly drawn ball, … etc.
- Randomization helps prevent confounding, even for factors we do not know are important (e.g., health status).
- Cochran and Cox (1957): "Randomization is somewhat analogous to *insurance*, …. The experimenter is thus protected against unusual events that upset his expectations."

The Basic Principles of DOE

- **Replication: the heart of all statistics**
  - how precise our estimates are depends on the sample size
  - E.g.) Estimates of the mean become less variable as the sample size increases: Recall standard error of the mean (the square root of the estimate of the variance of the sample mean) is s (sample std. dev.) over square root of n (sample size).

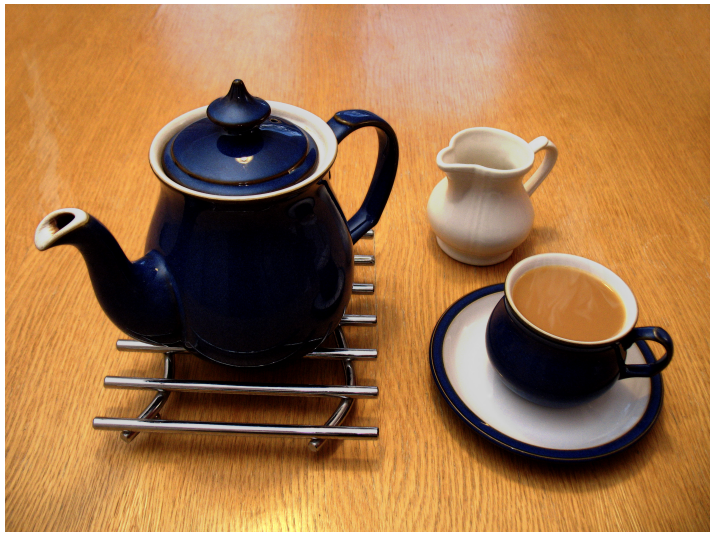
- **Blocking**: Another way of reducing the error variance
  - E.g.) Drug treatment vs. surgery example: Age and gender often considered as nuisance factors which contribute to the variance. Divide 100 patients into 'blocks.'

Review of Basic Statistical Concepts

- Basics of statistical inference
  - Hypothesis tests and Confidence intervals
- Comparative experiments
  - The two sample t-test
  - Sample size determination
  - Power determination

Lady Tasting Tea

- **B. Muriel Bristol-Roach** (1888-1950), Ph.D.
- Claims to be able to tell whether the *milk* or the *tea* was poured into a cup first
- Prompted Ronald Fisher to devise 'Fisher's exact test' to assess the statistical significance of such claims
- Notion of null hypothesis



Fisher's `Null hypothesis'

- "We may speak of this hypothesis as the '*null hypothesis*', and it should be noted that the null hypothesis *is never proved or established, but is possibly disproved, in the course of experimentation*." (**1935** Fisher, The Design of Experiments ii. 19)

- Null Hypothesis: Lady had no such ability.

Fisher's `Experiment'

- Experiment (→ is a 'process'):
  i) Provide the Lady with 8 randomly ordered cups of tea – 4 prepared by first adding milk, 4 prepared by first adding the tea.
  ii) She was to select the 4 cups prepared by one method (e.g., tea first).
- P(The Lady is getting all correct under 'null') would be only 1 in 70 (8 'choose' 4 combination rule = 70), 1/70 ≈ 1.4%.
- Reject the null hypothesis –at a 1.4% *significance level* (simplest Fisher's exact test)

Hypothesis Testing

- You have some claim (*belief*) about the model parameter or response from experiment and you want to see whether the data supports the claim or not.
  - Support (how strong, how significant?)
  - Contradict

Basic Idea of Tests of Significance

Example: Each day Tom and Heather decide who pays for lunch based on a toss of Tom's favorite quarter.

Heads - Tom pays

Tails - Heather pays

Tom claims that heads and tails are equally likely outcomes for this quarter.

Heather thinks she pays more often.

Basic Idea of Tests of Significance

She steals the quarter, tosses it 10 times, gets 7 tails (70% tails). She is furious and claims that the coin is not fair!

There are two possibilities:

1. Tom is telling truth – the chance of tails is 50% and the observed 7 tails out of 10 tosses was only due to sampling variability.

2. Tom is lying – the chance of tails is greater than 50%.

Basic Idea of Tests of Significance

- Suppose they call YOU to decide between 1 and 2. To be fair to both of them, you toss the quarter 25 times. Suppose you get 21 tails.

- What would you conclude? Why?
  - The actual probability of *getting 21 or more tails* in 25 tosses is 0.000455 *if the coin is fair*.
  - This is a concept of P-value!
- Moral of the story: an outcome that would rarely happen *if a claim were true* is good evidence that the claim is not true.