Final Exam Study Guide 209

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The guide is broken into two parts. The "new" stuff and the "old" stuff which reflects the exam's makeup. To be upfront there will be a test of a regression coefficient and I do want you to be able to interpret an ANOVA table.

1 Regression Errors

- Know what an *error* in hypothesis testing it
  - You did NOT do something wrong
  - Your sample was unlucky
  - So you came to the wrong conclusion
  - Type 1 error: Incorrectly claim strong evidence against the null hypothesis even though the null is true
  - Type 2 error: Incorrectly claim you have little/no evidence against the null even though the null is false

- The p-value is uniformly distributed between 0-1
  - So probability of getting a p-value less than .1 (weak evidence) if the null hypothesis is true is 10%
  - Similarly .05 (moderate evidence) would have a 5% probability of randomly happening if the null is true

- Effect size vs p-value
  - An effect size is how strong a change in the response we expect if we change our explanatory variable
    - Increase it by one unit for numeric variables
    - Go from one group to another for categorical data
    - Often described as β in the regression equation

  - A p-value is a statement about detecting statsitical differences
  - Effect size and p-values are not directly related
    * A small p-value can be associated with a meaningless difference between the groups (in real life)
    * Or a large p-value could be associated with a very large $\hat{\beta}$
  - p-values do NOT talk about importance or influence, those are effect sizes
  - Be prepared to comment on whether a large p-value with a large effect is more meaningful than a small p-value with a small effect
    * There is no "correct" answer but I want to make you stretch your thinking
    * And to rationally discuss a position

- Multiple Comparisons and p-hacking
  - What is the multiple comparisons problem?
    * Running multiple tests is more likely to find a small p-value by accident/H_0 is true
    * Raises doubts about how reliable your results are
    * Several ways to deal with this (you don't need to know them)
  - What is p-hacking? Why is it bad?
    * Forcing your model to get small p-values
    * Usually violating assumptions while you do it
    * Or you ignore the multiple comparisons problem
    * Fundamentally violates the point and ideas of science which is to move the football of human knowledge forward and instead is usually seen as a self-serving career move
      · Or it's because they are ignorant of the subject matter which is still worrisome
      · SIDE NOTE: Hanlon's Razor (wiki) states that "never attribute to malice that which is adequately explained by stupidity" and is a personal favorite
    * Originates out of "publish or perish" mentality
    * Strength of evidence in hypothesis testing is (hopefully) going to alleviate this some

2 Testing Regression Coefficients

- Explain why we test coefficients at all
  - What does it imply if our p-value is large?
  - What does it imply if our p-value is small?
- Be able to write out the null and alternative hypothesis

  - Almost always it's H_0: $\beta_{Some\ number} = 0$
- Check the assumptions
  - Same as in the MLR section below
- Interpret R's output on testing regression coefficients.
  - What does a low p-value mean?
  - What does a p-value mean generally?
- Explain when testing regression coefficients can be better than a standard t-test
  - Lurking variables aren't accounted for in t-tests if they exist

3 Multiple Linear Regression (MLR)

- Explain why we use MLR over simple linear regression
  - SLR only allows for one explanatory variable which is too limiting
  - MLR allows us to better understand the system as a whole since we can account for differing effects
- How do we interpret the coefficient of a quantitative (numeric) explanatory variable?
  - When (explanatory variable) increases by 1 unit we expect the mean of (response variable) to increase by $\hat{\beta}_{some\ number}$ holding the other variables constant
- How do we interpret the coefficent of a indicator (eg a nominal/categorical explanatory variable)?
  - When going from (BASELINE CATEGORY) to (INDICATOR'S CATEGORY) we expect the mean of (response variable) to increase by $\hat{\beta}_{some\ number}$ holding the other variables constant
- Make a prediction uisng a MLR
- Assumptions
  - Random
  - Population is normal or n is large
    - The "population" here is the residuals!
  - IID
    - There is where homoskedasticity assumption is (need same spread to be identically distributed)

    - Also where "linear" from SLR went....if the model doesn't fit the reisduals won't have the same scattering around the 0 line
  - NOTE: Both IID and the "pop is normal" reference the residuals!
  - Justify/explain why we color residuals by explanatory variables

4 ANOVA

- You WILL NOT be expected to fill out an ANOVA table
  - You WILL be expected to read an ANOVA table and interpret it's output
- Identify the null and alternative hypothesis
  - Including limitations of what they indicate (doesn't identify which mean is higher/lower/different)

5 Old Stuff

- What is a p-value?
- What is the difference between standard deviation and standard error?
- What does a confidence of 95% mean?
- What are the four main challenges colorblind people face?
- How can we make graphics more accessible?
- Be sure to know how to read the different graphs we have seen early in the semester
- Permutation test basics
- How does a hypothesis test work?
- Read and interpret a confidence interval for some statistic.
- Understand why we use log() in linear modeling and other transformations
  - To help correct failed assumptions
  - Log helps fix the cone shape in residual vs predicted graphs
- Make predictions using SLR, MLR, or log-log models
  - Not as scary as it sounds I promise

- Be comfortable using indicators in regression
  - Eg make a prediction that uses an indicator variable
  - Eg make indicator variables in a data set
- Correlation
  - Pearson vs Spearman
  - Interpretations
- Experiments: Causality or Nah?
  - Be prepared to say whether you believe experiments can show causality or not
  - You don't have to agree with my position but I want intelligent thinking