Univariate and Bivariate Tests

BUS 230: Business and Economics Research and Communication

Goals

- Specific goals:
  - Be able to distinguish different types of data and prescribe appropriate statistical methods.
  - Conduct a number of hypothesis tests using methods appropriate for questions involving only one or two variables.
- Learning objectives:
  - LO2: Interpret data using statistical analysis.
  - LO2.3: Formulate conclusions and recommendations based upon statistical results.

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Statistical Hypotheses

- A **hypothesis** is a claim or statement about a property of a population.
  - Example: The population mean for systolic blood pressure is 120.
- A **hypothesis test** (or **test of significance**) is a standard procedure for testing a claim about a property of a population.
- Recall the example about birth weights with mothers who use drugs.
  - Hypothesis: Using drugs during pregnancy leads to an average birth weight of 7 pounds (the same as with mothers who do not use drugs).

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Null and Alternative Hypotheses

- The **null hypothesis** is a statement that the value of a population parameter (such as the population mean) *is equal to* some claimed value.
  - H_0: $\mu = 7$.
- The **alternative hypothesis** is an alternative to the null hypothesis; a statement that says a parameter differs from the value given in the null hypothesis.
- Pick *only one* of the following for your alternative hypothesis. Which one depends on your research question.
  - H_a: $\mu < 7$.
  - H_a: $\mu > 7$.
  - H_a: $\mu \neq 7$.
- In hypothesis testing, assume the null hypothesis is true until there is strong statistical evidence to suggest the alternative hypothesis.
- Similar to an "innocent until proven guilty" policy.

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Hypothesis tests

- (Many) hypothesis tests are all the same:

$$z \text{ or } t = \frac{\text{sample statistic} - \text{null hypothesis value}}{\text{standard deviation of the sampling distribution}}$$

- Example: hypothesis testing about μ:
  - Sample statistic $= \bar{x}$.
  - Standard deviation of the sampling distribution of $\bar{x}$:

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P-values

- The P-value of the test statistic, is the area of the sampling distribution from the sample result in the direction of the alternative hypothesis.
- Interpretation: If the null hypothesis is correct, than the p-value is the probability of obtaining a sample that yielded your statistic, or a statistic that provides even stronger evidence of the null hypothesis.
- The p-value is therefore a measure of *statistical significance*.
  - If p-values are very small, there is strong statistical evidence in favor of the alternative hypothesis.
  - If p-values are large, there is insignificant statistical evidence. When large, you fail to reject the null hypothesis.
- Best practice is writing research: report the p-value. Different readers may have different opinions about how small a p-value should be before saying your results are statistically significant.

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Types of Data

- Nominal data: consists of categories that cannot be ordered in a meaningful way.
- Ordinal data: order is meaningful, but not the distances between data values.
  - Excellent, Very good, Good, Poor, Very poor.
- Interval data: order is meaningful, *and* distances are meaningful. However, there is *no natural zero*.
  - Examples: temperature, time.
- Ratio data: order, differences, and zero are all meaningful.
  - Examples: weight, prices, speed.

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Types of Tests

- Different types of data require different statistical methods.
- Why? With interval data and below, operations like addition, subtraction, multiplication, and division are *meaningless!*
- Parametric statistics:
  - Typically take advantage of central limit theorem (imposes requirements on probability distributions)
  - Appropriate only for interval and ratio data.
  - More **powerful** than nonparametric methods.
- Nonparametric statistics:
  - Do not require assumptions concerning the probability distribution for the population.
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Single Mean T-Test

- Test whether the population mean is equal or different to some value.
- Uses the sample mean its statistic.
- T-test is used instead of Z-test for reasons you may have learned in a statistics class. Interpretation is the same.
- Parametric test that depends on results from Central Limit Theorem.
- Hypotheses
  - Null: The population mean is equal to some specified value.
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Example Questions

- Suppose we have a dataset of individual schools and the average pay for teachers in each school, and the level of spending as a ratio of the number of students (spending per pupil).
    - Show some descriptive statistics for teacher pay and expenditure per pupil.
    - Is there statistical evidence that teachers make less than $50,000 per year?
    - Is there statistical evidence that expenditure per pupil is more than $7,500?

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Example: Public School Spending

- Dataset: average pay for public school teachers and average public school spending per pupil for each state and the District of Columbia in 1985.
- Download dataset `eduspending.sav`.
- Conduct the following exercises:
  - Show some descriptive statistics for teacher pay and expenditure per pupil.
  - Is there statistical evidence that teachers make less than \$25,000 per year?
  - Is there statistical evidence that expenditure per pupil is more than \$3,500?

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Example: Economic Outlook

- Data from Montana residents in 1992 concerning their outlook for the economy.
- All data is ordinal or nominal:
  - AGE = 1 under 35, 2 35-54, 3 55 and over
  - SEX = 0 male, 1 female
  - INC = yearly income: 1 under \$20K, 2 20-35\$K, 3 over \$35K
  - POL = 1 Democrat, 2 Independent, 3 Republican
  - AREA = 1 Western, 2 Northeastern, 3 Southeastern Montana
  - FIN = Financial status 1 worse, 2 same, 3 better than a year ago
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- Do the majority of Montana residents feel their financial status is the same or better than one year ago?
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- Why?
  - Ordinal data: cannot compute sample means (they are meaningless), only median is meaningful.
  - Small sample size and you are not sure the population is not normal.
- Sign test: can use tests for proportions for testing the median.
  - For a null hypothesized population median...
  - Count how many observations are above the median.
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- Instructor evaluations have an ordinal scale: Excellent, Very Good, Good, Poor, Very Poor.
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- Dataset: 438 students in grades 4 through 6 were sampled from three school districts in Michigan. Students ranked from 1 (most important) to 5 (least important) how important grades, sports, being good looking, and having lots of money were to each of them.
- Open dataset `gradeschools.sav`. Choose second worksheet, titled `Data`.
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- Suppose you want to know whether the mean from one population is larger than the mean for another.
- Independent samples means you have different individuals in your two sample groups.
- Examples:
  - Compare sales volume for stores that advertise versus those that do not.
  - Compare production volume for employees that have completed some type of training versus those who have not.
- Statistic: Difference in the sample means $(\bar{x}_1 - \bar{x}_2)$.
- Hypotheses:
  - Null hypothesis: the difference between the two means is zero.
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- Mann-Whitney U test: nonparametric test to determine difference in *medians*.
- Can you suggest some examples?
- Assumptions:
  - Samples are independent of one another.
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Dependent Samples - Paired Samples

- Use a **paired sampled test** if instead the two samples have the same individuals before and after some treatment.
- Examples:
  - The Biggest Loser: Compare the weight of people on the show before the season begins and one year after the show concludes.
  - Training session: Are workers more productive 6 months after they attended some training session versus before the training session.
- Really simple: for each individual subtract the before treatment measure from the after treatment measure (or vice-versa).
- Treat your new series as a single series.
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Conclusions

- Ideas to keep in mind:
  - What is a sampling distribution? What does it imply about p-values and statistical significance?
  - When it is appropriate to use parametric versus non-parametric methods.
  - Most univariate and bivariate questions have a parametric and non-parametric approach.
- Next class: closed-book, closed note quiz (so study!); and an in-class exercise practicing this stuff in SPSS.
- Next: Statistics to understand the relationship between two variables.

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