Univariate and Bivariate Tests

ECO 230: Business and Economics Research and Communication

Goals

1. Be able to distinguish different types of data and prescribe appropriate statistical methods.
2. Conduct a number of hypothesis tests using methods appropriate for questions involving only one or two variables.

1 Univariate Tests

1.1 Types of Data/Tests

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.

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.
  - There are many methods appropriate for ordinal data, some methods appropriate for nominal data.
  - Computations typically make use of *ranks* instead of actual data.

1.2 Hypothesis Testing about Mean

Single Mean T-Test

- Test whether the population mean is equal or different to some value.
- Uses the sample mean its statistic.
- Parametric test that depends on results from Central Limit Theorem.
- Hypotheses
  - Null: The population mean is equal to some specified value.
  - Alternative: The population mean is [greater/less/different] than the value in the null.

Example: Average Hourly Earnings

Dataset: Current Population Survey from 2004 that includes data on average hourly earnings, marital status, gender, and age for thousands of people.

http://murraylax.org/datasets/cps04.csv

Answer the following questions:

1. Report the mean average hourly earnings in the sample.
2. Construct a 95% confidence interval estimate for the average hourly earnings.
3. Test the hypothesis that average hourly earnings is greater than $16.50.
4. Test the hypothesis that average hourly earnings *is different than* $16.50.

1.3 Nonparametric Testing about Median

Single Median Nonparametric Test

Why not perform a t-test on the mean?

- 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.

Hypothesis test appropriate for medians:

Single-sample Wilcoxon Signed Rank Test

Wilcoxon Signed Rank Test

Hypotheses:

- Null: The population is centered around the null specified value.
- Alternative: The population is centered around a value different from the null specified value.

Sample estimates:

- Sample median (middle number)
- Interpolated median: for ordinal data with limited number of outcomes, this takes into account the percentage of the data that is *strictly below* versus *strictly above* the median.

Example: Attitudes Grade School Kids

- Dataset: 438 students in grades 4 through 6 were sampled from three school districts in Michigan. Students ranked from 1 (most important) to 4 (least important) how important grades, sports, being good looking, and having lots of money were to each of them.
- Dataset http://murraylax.org/datasets/gradschools.csv.
- Answer some of these questions:
  1. Report the median and interpolated median for how important grades are to students.
  2. Report a 95% confidence interval for the median.
  3. Is the median importance for grades is greater than 3?
  4. Is the median importance for money less than 3?

2 Bivariate Tests

2.1 Difference in Populations (Independent Samples)

Difference in Means (Independent Samples)

- Suppose you want to know whether the mean from one population is larger than the mean for another.
- Statistic: Difference in the sample means $(\bar{x}_1 - \bar{x}_2)$.
- Hypotheses:
  - Null: the difference between the two means is zero.
  - Alternative: the difference is [above/below/not equal] to zero.

Example: Average Hourly Earnings

Dataset: Current Population Survey from 2004 that includes data on average hourly earnings, marital status, gender, and age for thousands of people.

http://murraylax.org/datasets/cps04.csv

Answer the following questions:

1. What is the average hourly earnings for males versus females?
2. Estimate a 95% confidence interval for the difference in average hourly earnings between males and females.
3. Test the hypothesis that men and women earn have *different average hourly earnings*
4. Test the hypothesis that men earn on average *more than $2.00* per hour above women.

Nonparametric Tests for Differences in Medians

- Mann-Whitney U test: nonparametric test to determine difference in *medians*.
- Assumptions:
  - Samples are independent
  - The underlying distributions have the same shape (i.e. only the location of the distribution is different). (violating this assumption does not severely change the sampling distribution of the Mann-Whitney U test)
- Null hypothesis: medians for the two populations are the same.
- Alternative hypotheses: medians for the two populations are different.

Example: Grade School Kids' Attitudes

- Dataset: 438 students in grades 4 through 6 were sampled from three school districts in Michigan. Students ranked from 1 (most important) to 4 (least important) how important grades, sports, being good looking, and having lots of money were to each of them.
- Dataset http://murraylax.org/datasets/gradschools.csv.
- Answer these questions:
  1. Report the median and interpolated median for how important grades are for boys versus girls.
  2. Is the median importance for grades different for boys versus girls?

2.2 Paired Samples

Dependent Samples - Paired Samples

- Use a **paired sampled test** if the two samples have the same individuals or sampling units.
- Many examples include before/after tests for differences:
  - 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.
- Examples besides before/after tests for differences:
  - Do students spend more time studying than watching TV?
  - Does the unemployment rate for White/Caucasian differ from the unemployment rate for African Americans (sampling unit = U.S. state).
- These are *dependent samples*, because you have the *same sampling units* in each group.

Parametric and Nonparametric Paired Samples Tests
Paired-samples difference in means t-test

- Appropriate for interval or ratio data
- Appropriate when assumptions of CLT are met

Wilcoxon-Signed Rank Test for Paired-samples

- Tests for a difference in medians (center of distribution)
- Appropriate for ordinal, interval, or ratio data
- Appropriate when assumptions of CLT are met

Paired Samples Means: Motor Vehicle Fatalities

- Centers for Disease Control and Prevention (CDC) state-level data (50 obs) on motor vehicle fatalities by state, age, and sex
- Variables: Motor vehicle occupant fatality rate per 100,000 members of the population
  - Over all age groups
  - Individual age groups: 0-20, 21-34, 35-54, and 55+.
  - Male versus Female

- Dataset: http://murraylax.org/datasets/vehiclefatalities.csv
- Answer the following questions:
  - Report the sample average mortality rate for age groups 21-34 and 35-54.
  - Report the difference in the average mortality rate for age groups 21-34 and 35-54.
  - Report a confidence interval for the difference above.
  - Do age groups 21-34 and 35-54 have different average mortality rates?

Paired-Samples Medians: Grade School Attitudes

- Dataset: 438 students in grades 4 through 6 were sampled from three school districts in Michigan. Students ranked from 1 (most important) to 4 (least important) how important grades, sports, being good looking, and having lots of money were to each of them.
- Dataset http://murraylax.org/datasets/gradschools.csv.
- Answer these questions:
  1. Report the median and interpolated median for how important are grades.
  2. Report the median and interpolated median for how important is sports.
  3. Is the median importance for grades different that the median importance for sports?