Applied Statistical Analysis I

Introduction & stats review

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Today’s Agenda

(2) Lecture recap

(3) Tutorial exercises

Regression analysis

What is a variable? What is regression analysis?

Regression analysis

What is regression analysis?

- Variable: "a characteristic that can vary in value among subjects in a sample or population" (Agresti and Finlay 2009, 11)
- Dependent variable (DV): outcome, response variable, *Y*, phenomenon to be explained.
- Independent variable (IV): input, explanatory variable, covariate, predictor, *X* → Explain variation in DV using the IV.
- What is variation? (Example: Age → Income)

Measurement Scales

How can we measure concepts? And why does it matter?

Measurement Scales

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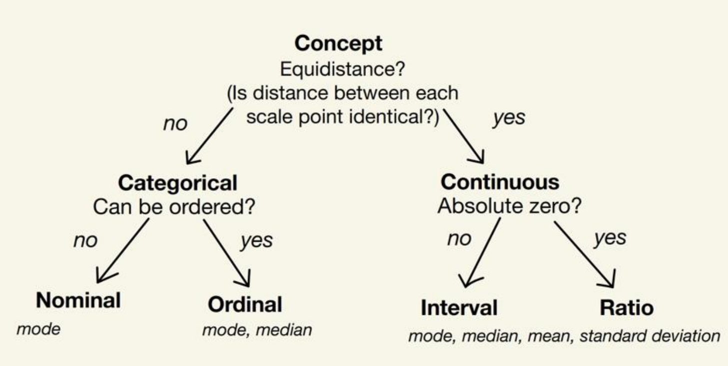


Concept
Equidistance?
(Is distance between each scale point identical?)

no

Categorical
Can be ordered?

no

Nominal
mode

yes

Ordinal
mode, median

yes

Continuous
Absolute zero?

no

Interval

yes

Ratio

mode, median, mean, standard deviation

(Kellstedt and Whitten 2018, Chap. 5)

Discrete: finite set of possible values.
Continuous: infinite set of possible values.

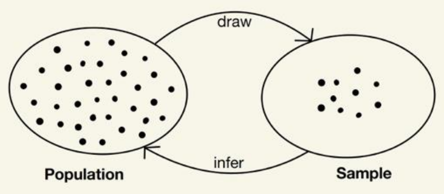
Population, sample, parameter, variable

What is the relationship between population and sample?

Population, sample, parameter, statistic

What is the relationship between population and sample?

- Population: “the total set of subjects of interest in a study” (Agresti and Finlay 2009, 5).
- Parameter: “numerical summary of the population” (Agresti and Finlay 2009, 5).
- Sample: “the subset of the population on which the study collects data” (Agresti and Finlay 2009, 5).
- Statistic: “a numerical summary of the sample data” (Agresti and Finlay 2009, 5).
- Observation: single subject/unit, one row in dataset



Inferential and descriptive statistics

What is the difference between inferential and descriptive statistics?

Inferential and descriptive statistics

What is the difference between inferential and descriptive statistics?

- Descriptive statistics: "summarize the information in a collection of data" (Agresti and Finlay 2009, 4).
- Inferential statistics: "provide predictions about a population, based on data from a sample of that population" (Agresti and Finlay 2009, 4).

Measures of central tendency and variability (dispersion)

How can we describe variables?

Measures of central tendency

How can we describe variables?

- Mean: $\bar{y}$ = Sum of all values divided by the number of observations, $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$

Measures of variability (dispersion)

How can we describe variables?

- Variance: $s^2(y)$ = Sum of squared deviations divided by number of observations (deviation is the difference between observed value and the mean, $y_i - \bar{y}$), $s^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}$
- Standard Deviation: Return original units by taking square root, $s = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}$

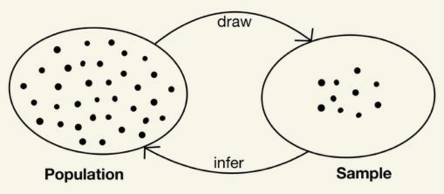
Probability

What is probability? What is a distribution? What is a probability distribution?

Probability

What is probability?

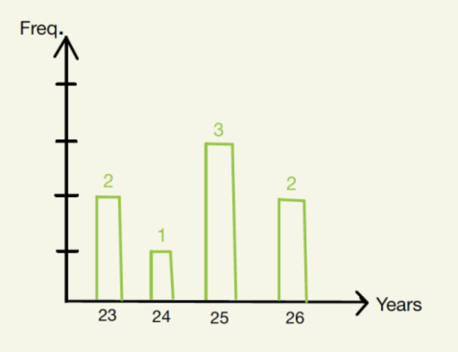
- Probability: “the probability that an observation has a particular outcome is the proportion of times that outcome would occur in a very long sequence of like observations” (Agresti and Finlay 2009, 73). → $P(A) = \frac{\text{Numer of elements in } A}{\text{Number of all elements}}$
- Why do we need probability?



Distributions and probability distributions

What is a distribution?

Example, Age of people in the room.

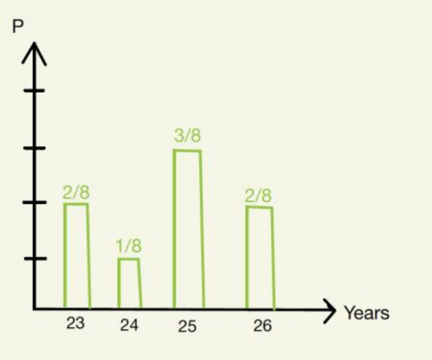


- * Different shapes, for example, binomial distribution, normal distribution, t-distribution...

Distributions and probability distributions

What is a probability distribution?

- Probability distribution "lists the possible outcomes and their probabilities" (Agresti and Finlay 2009, 75).

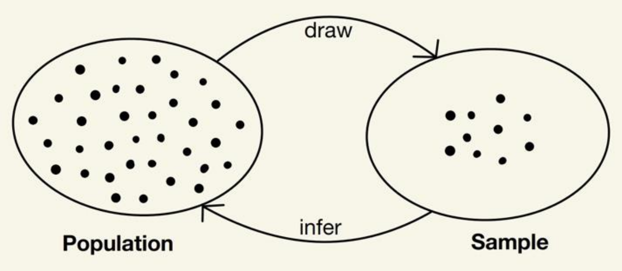


Sampling distribution

What is a sampling distribution? Why is this important?

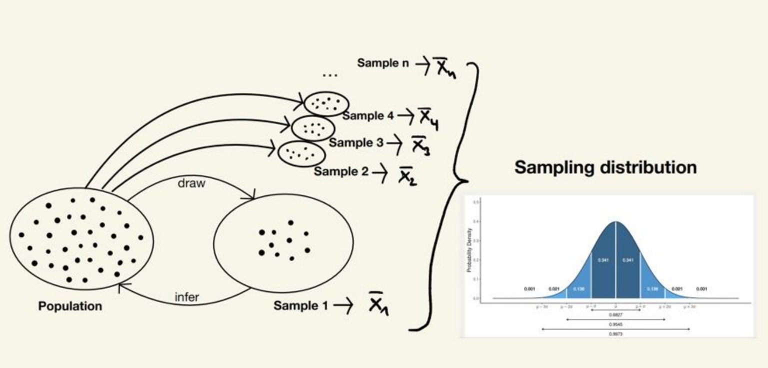
Sampling distribution

Recall the basic idea of empirical research



Sampling distribution

theoretically…



Sampling distribution

What is a sampling distribution?

- Sampling distribution "A sampling distribution of a statistic is the probability distribution that specifies probabilities for the possible values the statistic can take" (Agresti and Finlay 2009, 87).
- In other words, a probability distribution for a statistic rather than values of observations → What is the probability of $\bar{Y} = 0.5$, rather than what is the probability of $Y = 3$?

Sampling distribution

Why is this important?

- The corresponding probability theory "helps us predict how close a statistic falls to the parameter it estimates" (Agresti and Finlay 2009, 87). → how close is $\bar{y}$ to μ?
- Usually only one sample/one estimate → Point estimate: "is a single number that is the best guess for the parameter value" (Agresti and Finlay 2009, 107).

The sampling distribution of the mean, $\bar{y}$

- “If we repeatedly took samples, then in the long run, the mean of the sample means would equal the population mean μ” (Agresti and Finlay 2009, 90). → mean of the sampling distribution of $\bar{y}$ equals the population mean, hence, $\mu = \bar{y}$
- “The standard error describes how much $\bar{y}$ varies from sample to sample” (Agresti and Finlay 2009, 90). → standard error is estimated based on standard deviation, hence, $\sigma_{\bar{y}} = \frac{\sqrt{\sigma}}{n}$
- *Why does this work?*

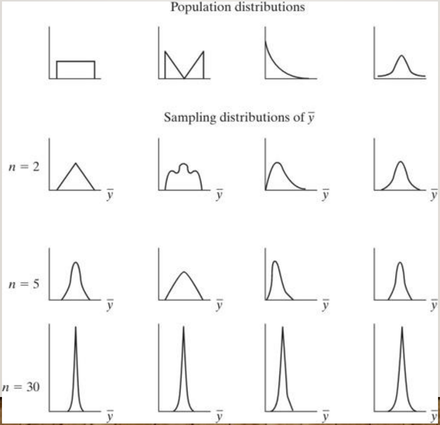
Central Limit Theorem (CLT)

What is the Central Limit Theorem?

Central Limit Theorem

What is the Central Limit Theorem?

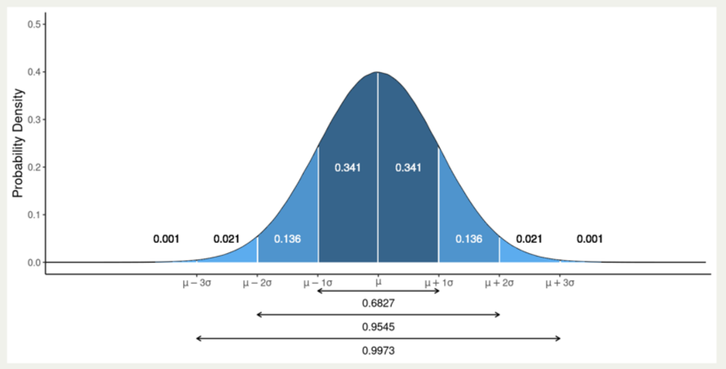
- “For random sampling with a large sample size n, the sampling distribution of the sample mean $\bar{y}$ is approximately a normal distribution” (Agresti and Finlay 2009, 93). → regardless of the population distribution



Central Limit Theorem

What is the Central Limit Theorem?

- "Knowing that the sampling distribution of $\bar{y}$ can be approximated by a normal distribution helps us to find probabilities for possible values of $\bar{y}$ (Agresti and Finlay 2009, 94). → key in inferential statistics



Confidence intervals

What are confidence intervals?

Confidence intervals

What are confidence intervals?

- Confidence interval: “an interval of numbers around the point estimate that we believe contains the parameter value” (Agresti and Finlay 2009, 110). → Point estimate ± Margin of error
- Confidence level:“The probability that this method produces an interval that contains the parameter” (usually 0.95, 0.99) (Agresti and Finlay 2009, 110).
- Margin of error = multiple of the standard error, $\sigma_{\bar{y}} = \frac{\sigma}{\sqrt{n}}$ (Agresti and Finlay 2009, 117).
- For example, for 95% confidence level, the margin of error is $\pm 1.96\sigma_{\bar{y}}$ (have a look at the normal distribution).

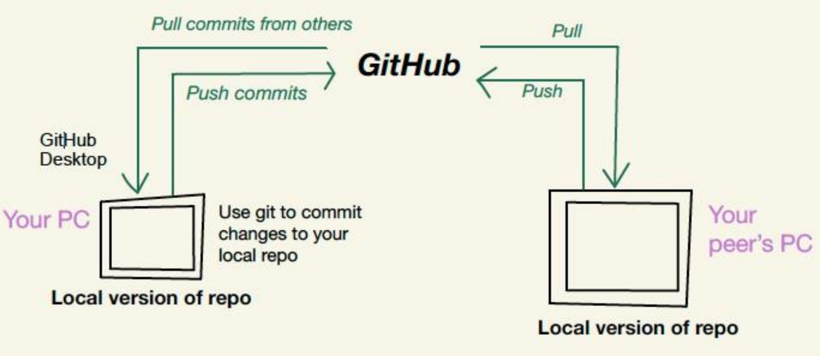
Software check

1. R and RStudio

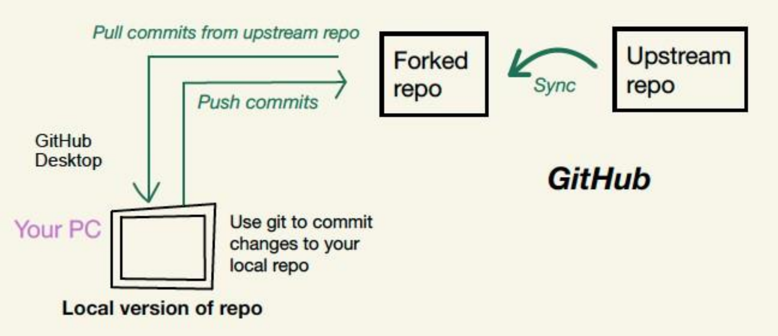
2 LaTeX and TeXstudio/Overleaf

3. git, GitHub account and GitHub Desktop

git, GitHub workflow



git, GitHub workflow



References

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- Agresti, Alan, and Barbara Finlay. 2009. *Statistical methods for the social sciences.* Essex: Pearson Prentice Hall.

- Kellstedt, Paul M., and Guy D. Whitten. 2018. *The fundamentals of political science research.* Cambridge: Cambridge University Press.

Thank you

for your attention!

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