Data Analysis in R

Sampling & Measurement

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Syllabus: Data Analysis in R

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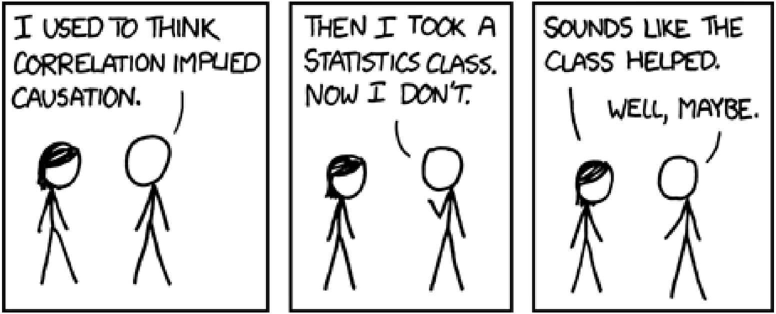
4. Prediction
5. Multivariate Regression
6. Probability & Uncertainty
7. Hypothesis Testing
8. Assumptions & Limits of OLS
9. Interactions & Non-Linear Effects

Recap Causality



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Samples & Populations

- Often when numbers are reported they relate to a sample of a population
  - **Cost:** For elections polls, we could ask all eligible voters
    - The last UK census cost roughly 480 million
    - The 2017 UK election cost more than 140 million
  - **Speed:** It took about 5 years to process all the census data
- Therefore, we use samples to make inferences about a population
- Sample statistics are estimates of population parameters
  - For a statistic to be useful, the sample needs to be representative of the population

'Bad' Example: The 1936 Literary Digest Poll

- Had correctly predicted every US presidential election winner since 1916
- Over 10 million questionnaires sent to subscribers
- Final sample size: over 2.3 million returned.
- Predicted landslide for Landon versus Roosevelt

	FDR's vote share
Literary Digest	43
George Gallup	56
Actual Outcome	62

Basic Sampling

- **Simple random sampling**
  - Every unit has an *equal* selection probability
- **Probability sampling** to ensure representation
  - Every unit in the population has a *known non-zero probability* of being selected

Sampling & Biases

Population	Sample	Potential Bias
Target population		
↓		Frame bias
Frame population →	Sample	Sampling bias
	↓	Unit non-response
	Respondents	
	↓	Item non-response
	Completed items	
		Response bias

Slutions to SRS Problems

- Stratified random sampling
  - Two stages: classify population into groups, then select by SRS *within* groups
  - e.g. 'over-sample' cat owners: divide population by cat ownership, use SRS to select 50 cat-owning and 50 cat-free households
- Cluster random sampling
  - If population members are naturally *clustered*, we can SRS clusters, and then SRS respondents within selected clusters
  - e.g. pupils are naturally grouped by school, so randomly select 5 schools, then randomly pick 10 children from each school

Non-Response Bias

- Unit non-response
  - Certain members of chosen sample may not respond to survey at all
  - Can create bias even if sample is representative
  - This was a problem with the Literary Digest survey (alongside sampling bias)
- Item non-response
  - Respondents may choose not to answer certain questions
  - Can create bias even if sample is representative
  - Sensitive questions $\rightsquigarrow$ non-response
- If those who refuse to answer are **systematically different** from those who answer, resulting inference is likely biased

Example: Item Non-Response

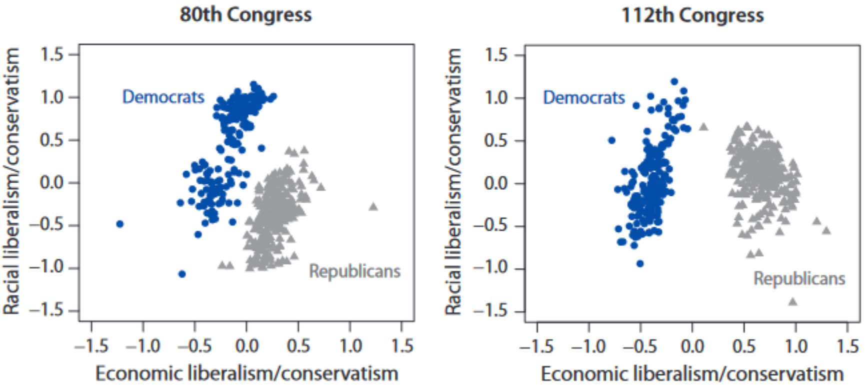
- Civilian Survey in Afghanistan (Lyall, Blair, Imai 2013)
- Can the hearts and minds of civilians be won?
- One question on victimization by Taliban and ISAF
  - More violent areas ⇝ larger share of non-responses

```
afghan <- read.csv("data/afghan.csv")
tapply(afghan$violent.exp.taliban, afghan$province,
       mean, na.rm = TRUE)
## Helmand   Khost   Kunar   Logar Uruzgan
##  0.5042  0.2332  0.3030  0.0802  0.4545
tapply(is.na(afghan$violent.exp.taliban),
afghan$province,
       mean)
## Helmand   Khost   Kunar   Logar Uruzgan
## 0.03041 0.00635 0.00000 0.00000 0.06202
```

Response Bias

- Even when respondents do respond, need to be wary of misreporting
- Responses can be affected by many things, including:
  - Question ordering
  - Interview/Sampling setting
  - Identity of interviewer, etc.
- Sensitive questions $\rightsquigarrow$ social desirability bias
  - e.g. Racial prejudice, corruption, even turnout, income, wealth
  - e.g . "Shy Trump voter"

Example: Measuring Ideology



Source: Imai, p.99

Doing Research is process.
What role does measurement play?

Visualizing Univariate Distributions

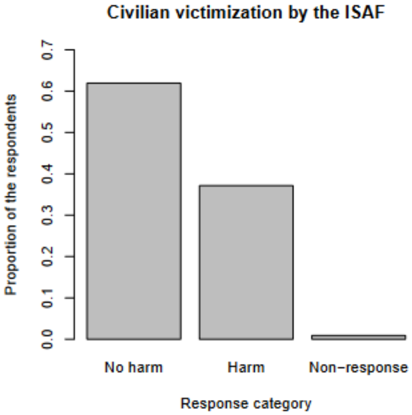
- Descriptive statistics are useful, but sometimes more helpful to visualize the distribution of a variable.
- There are several ways to do this as you have learnt:
  - Barplots
  - Histograms
  - Boxplots[...]
- We'll use the Afghanistan survey data as an example

Barplot

- Visualize the distribution of a categorical (*factor*) variable
  - In this case, whether respondent reported victimization by the coalition of international troops (ISAF)

```
barplot(prop.table(table(ISAF = afghan$violent.exp.ISAF,
                         exclude = NULL)),
        names.arg = c("No harm", "Harm", "Non-response"),
        main = "Civilian victimization by the ISAF",
        xlab = "Response category",
        ylab = "Proportion of the respondents",
        ylim = c(0, 0.7))
```

Barplot II


Civilian victimization by the ISAF
Proportion of the respondents
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
No harm
Harm
Non−response
Response category

Histogram

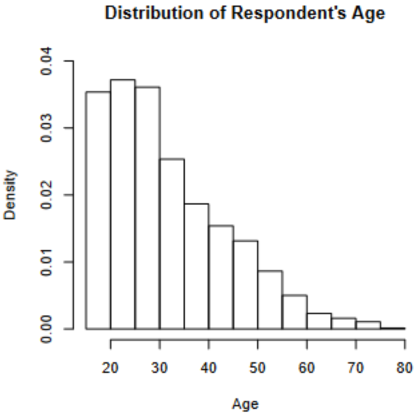
- Visualize the distribution of a continuous variable
- It might help to think about how to create a histogram by hand:
  1. create bins across the variable of interest
  2. count number of observations in each bin
  3. density = bin height

$$\text{density} \;=\; \frac{\text{proportion of observations in bin}}{\text{bin width}}$$

- In R, we use `hist()` with `freq= FALSE`

```
hist(afghan$age, freq = FALSE, ylim = c(0, 0.04),
     xlab = "Age", main =
"Distribution of Respondent's Age")
```

Histogram II

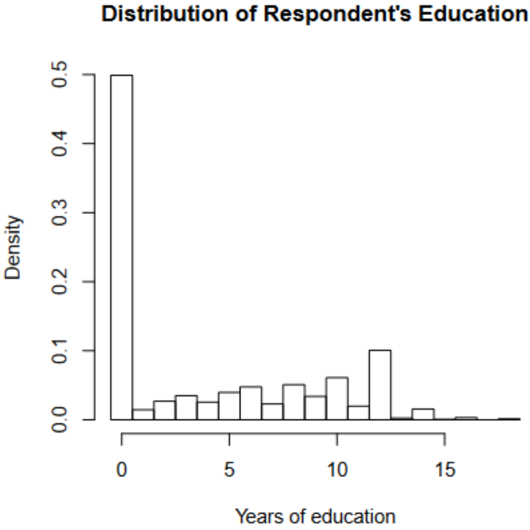


Let's Be Clear About Density

- The areas of the blocks sum to 1 or 100%
- Density $\neq$ Percentage
- The height of the blocks equals the percentage divided by the bin width: in this case, "percent per year"
- More generally, *percentage per horizontal unit*
- We can also choose the bin locations on our own via the `breaks` (locations of bin breaks) or `nclass` (number of bins) arguments

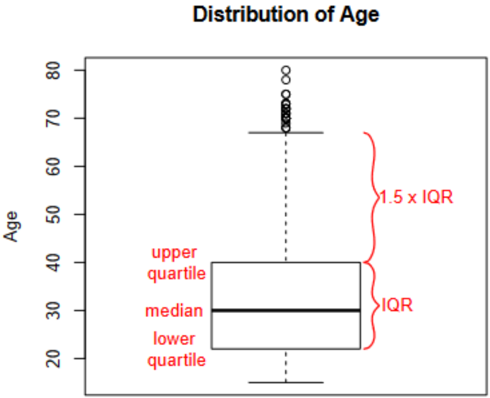
```
hist(afghan$educ.years, freq = FALSE,
     breaks = seq(from = -0.5, to = 18.5, by = 1),
     xlab = "Years of education",
     main = "Distribution of Respondent's Education")
```

Density II


Distribution of Respondent's Education
Density
0.0
0.1
0.2
0.3
0.4
0.5
0
5
10
15
Years of education

Boxplot

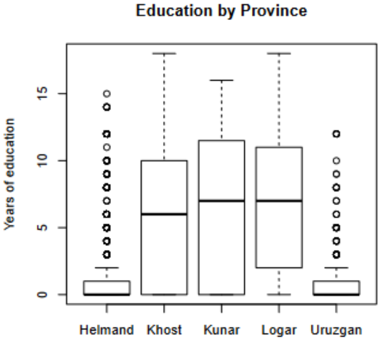
- Characterises the distributions of continuous variables at
- Features:
  - box, whiskers, outliers



Boxplot II

- *Boxplots* also can give you a good overview by groups
- Useful for comparison across multiple categories: `boxplot(y ~ x, data = d)`

```
boxplot(educ.years ~ province, data = afghan,
        main = "Education by Province",
        ylab = "Years of education")
```



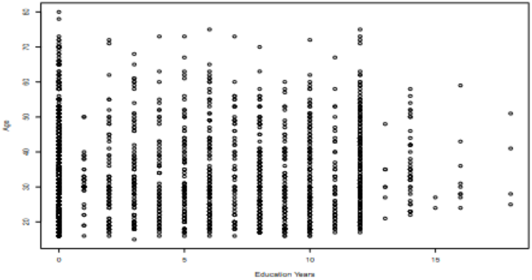
Bivariate Relationships

- More than in univariate distributions, we are often interested in how *two variables relate* to one another
- There, again, are various ways to do this, some of which are:
  - Scatterplots
  - Correlation coefficients
- We'll continue to use the Afghanistan survey data as an example

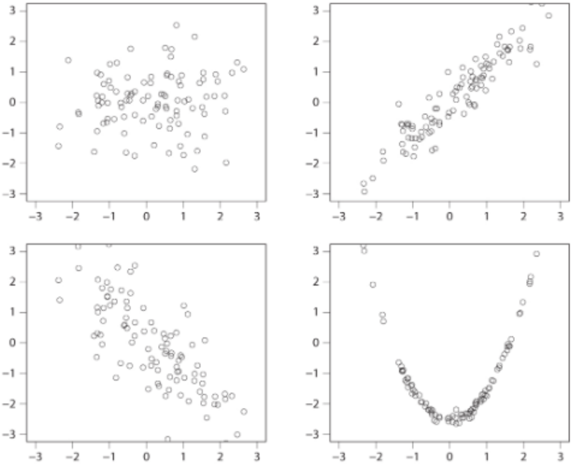
Scatterplot

- Direct graphical comparison of two variables, for same units
- Can simply use `plot()` function

```r
plot(afghan$educ.years, afghan$age,
     xlab = "Education Years", ylab = "Age")
```



Scatterplot II



Correlation

- On average, how do two variables move together?
- Mathematical definition of the correlation coefficient:

$$\frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{x_i - \text{ mean of } x}{\text{standard deviation of } x} \times \frac{y_i - \text{ mean of } y}{\text{standard deviation of } y}\right)$$

$=$ mean of products of z-scores

- As with standard deviation, sometimes $n-1$ is replaced with n

Correlation II

- On average, how do two variables move together?
- Positive correlation: When x is larger than its mean, y is likely to be larger than its mean
- Negative correlation: When x is larger than its mean, y is unlikely to be larger than its mean
- Positive [negative] correlation: data cloud slopes up [down]
- High correlation: data cluster tightly around a line

Example: Correlation of Age and Education

- Compute the correlation in R:

```
cor(afghan$educ.years, afghan$age,
    use = "pairwise")

## [1] 0.04569074
```

- Low correlation! What is low/high?

Properties of the Correlation Coefficient

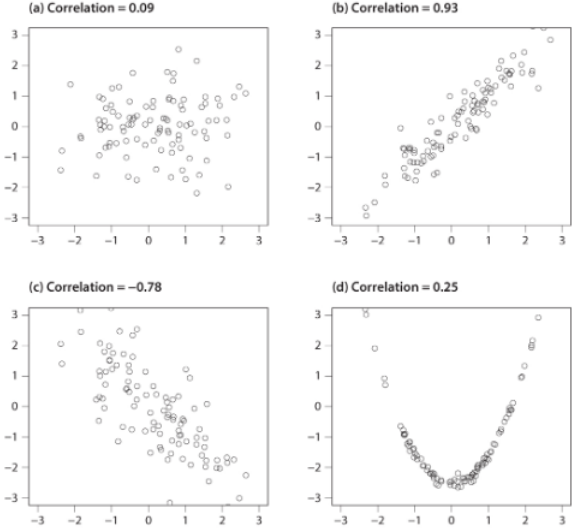
- Correlation is - by design - between -1 and 1
- Order does not matter: $\mathrm{cor}(\mathrm{x}, \mathrm{y}) = \mathrm{cor}(\mathrm{y}, \mathrm{x})$
- Not affected by changes of scale:

$$\mathrm{cor}(x, y) = \mathrm{cor}(ax + b, cy + d)$$

  for any numbers `a`, `b`, `c` and **d**
- Measures don't matter (but ideally do): C v F, cm v inch, e v \$

- Keep in mind: Correlation measures *linear* association!

Correlation III



Wrap Up

- Key points from today:
  - Sampling is necessary; probability sampling the gold standard
  - Multiple sources of bias, even with SRS
  - Visual descriptions and summaries of variables
  - Correlations as useful ways to describe relationships between variables
- Next time we'll be talking about:
  - Bivariate linear regressions

Note: `ggplot` is an ubiquitous package for creating figures in `R` that is more powerful and versatile than base `R` - you'll find some examples on the course page.