

Rotman

INTRO TO R

R Workshop - 1

March 20, 2022 Prepared by Jay Cao / [TDMDAL](https://tdmdal.github.io)

Website: <https://tdmdal.github.io/r-tutorial-202122-winter/>



Rotman School of Management
UNIVERSITY OF TORONTO

Plan for the 4 Sessions

- Overview (Today)
- Data Manipulation (tidyverse)
- Data Visualization (ggplot2)
- Modeling Workflow (tidymodels)
- Time Series & Finance Applications

Plan for Today

- Intro to Overview
 - What is R and what can R do?
 - Setup R
 - Motivation examples
- Overview of R programming and Data Science
 - Basics of R programming
 - Data science with R
- Learning Resources and Road Map

Goal for Today – Answer These Questions

- What's R?
- **What will I use R for?**

- How to Run R code?
- What are the R coding basics?
 - Data and programming structure
 - Data science workflow

- How to learn R (on my own)?
 - with get-started help from this mini-course

What's R?



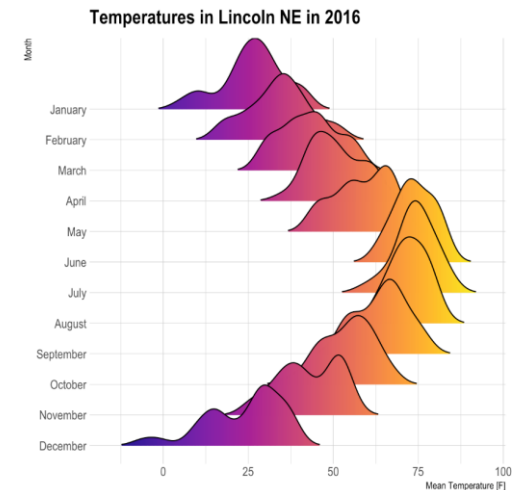
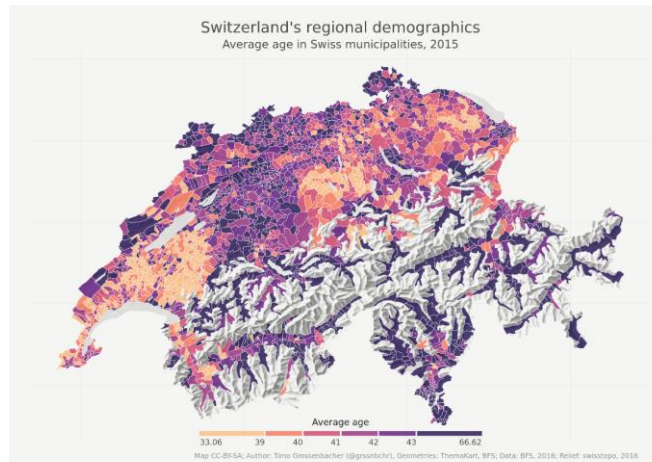
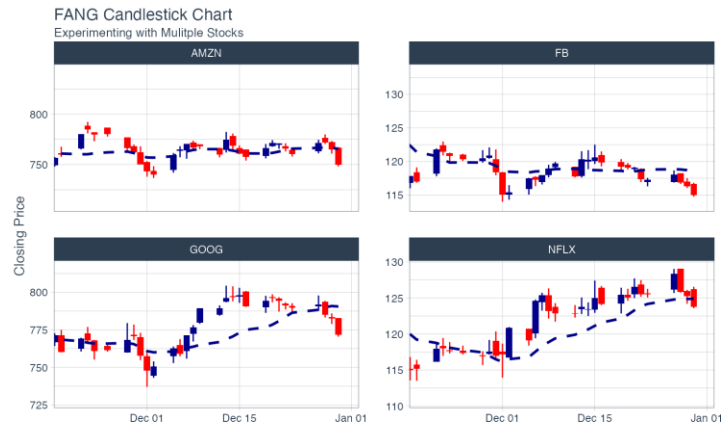
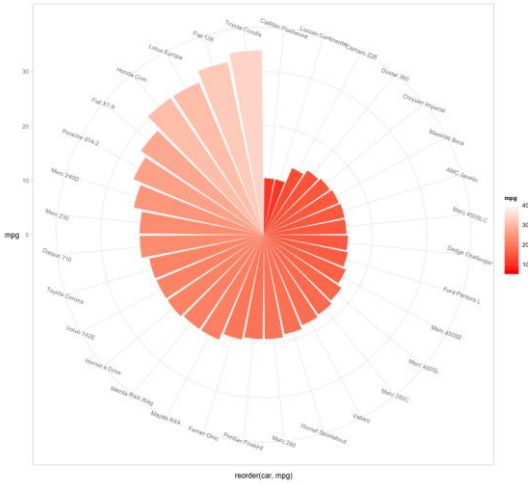
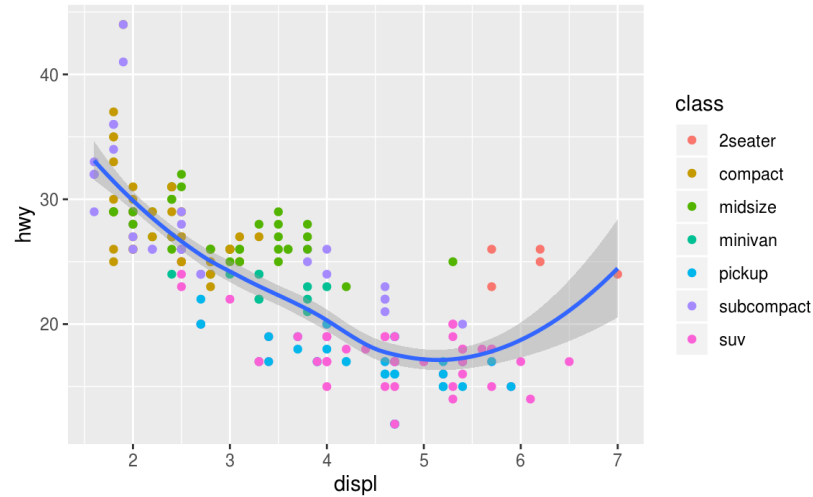
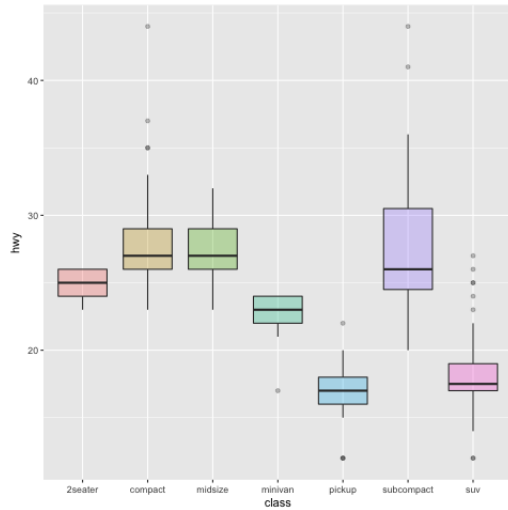
- R = a language + an eco-system
 - A free and open-source programming language
 - An eco-system of many high-quality user-contributed libraries/packages
- In the past R is mostly known for its statistical analysis toolkits
- Nowadays R is capable of (and very good at) many other tasks
 - Tools that cover the whole data analysis workflow
 - Tools for web technology...

What can R do – Statistics & related

- Statistics & Econometrics
 - Regressions
 - Time series analysis
 - Bayesian inference
 - Survival analysis
 - ...
- Numerical Mathematics
 - Optimization
 - Solver
 - Differential equations
 - ...
- Finance
 - Portfolio management
 - Risk management
 - Option pricing
 - ...
- ...

See more R Empirical Finance Packages on [R Task View - Finance](#)

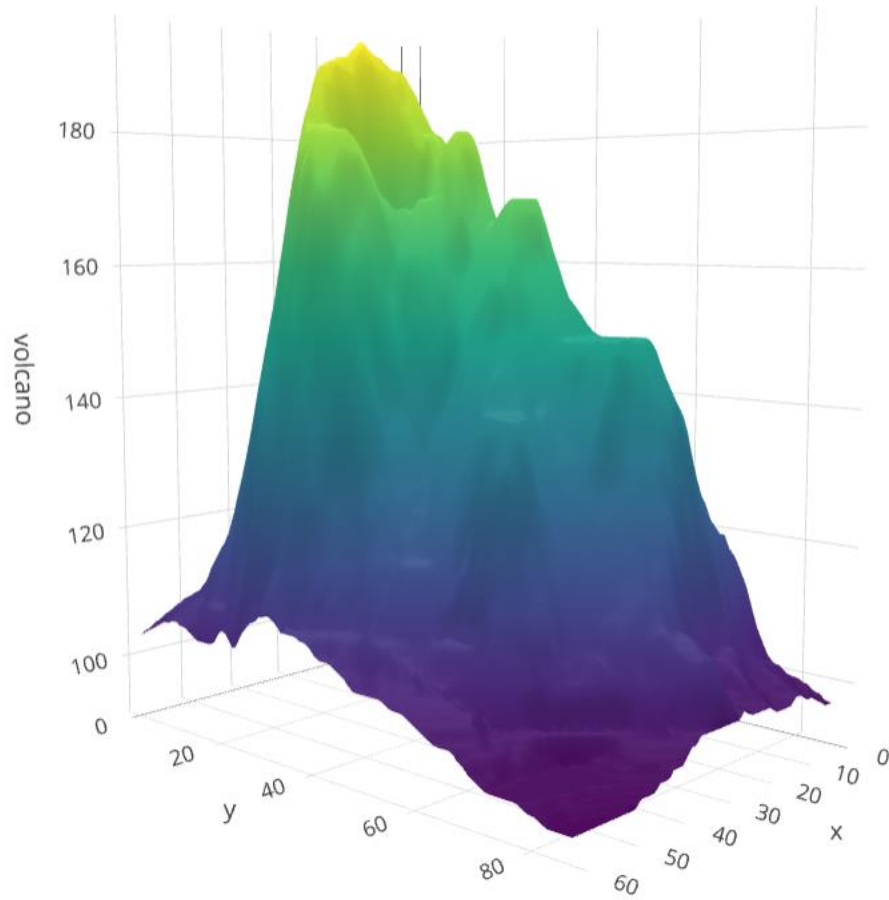
What can R do – Graphics (static ones)



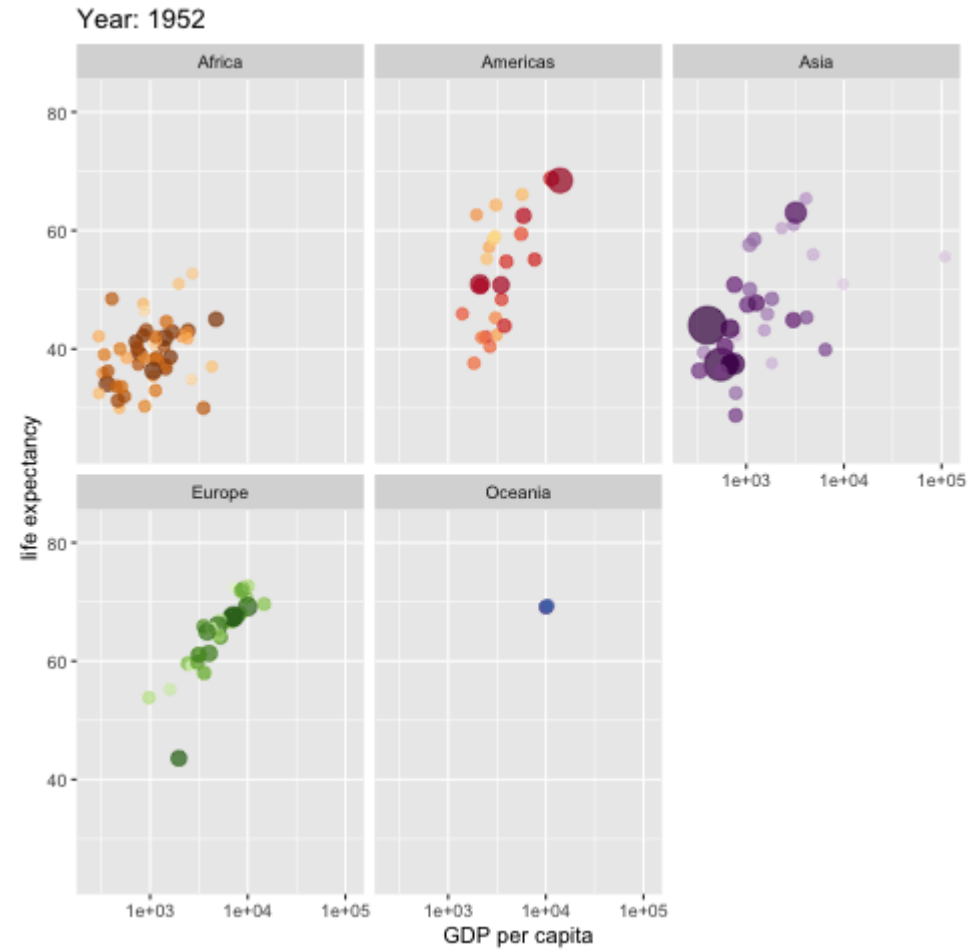
Ref. 1) <https://www.r-graph-gallery.com/>

2) <https://timogrossenbacher.ch/2016/12/beautiful-thematic-maps-with-ggplot2-only/>

What can R do – Graphics (dynamic ones)



<https://plot.ly/r/3d-surface-plots/>;

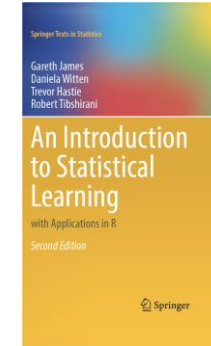


<https://github.com/thomasp85/gganimate>;

What can R do – ML & NLP

- Machine learning

- Statistical learning (clustering, decision tree, etc.)
 - [An Introduction to Statistical Learning \(with Applications in R\)](#)



- Deep learning (neural networks)

- Interface to [Keras](#) and [Tensorflow](#) (via [reticulate](#), an R to Python interface)
- [Torch for R](#) (natively from R; similar as PyTorch in Python)



- Natural language processing (e.g., [tidytext](#), [topicmodels](#))

1. See more R Machine Learning Packages on [R Task View - ML & Statistical Learning](#)
2. See more R Natural Language Processing Packages on [R Task View - NLP](#)

What can R do – Web & Reporting

- Web technology
 - Web scraping (e.g., [rvest](#))
 - API wrapper (e.g., Twitter: [rtweet](#); bigquery: [bigrquery](#); Quandl: [Quandl](#))
 - Shiny web app (<https://shiny.rstudio.com/>)
- Reporting
 - [R Markdown](#) (write reports, slides, blogs, books, etc. See a gallery [here](#).)
- ... (see [R Task View](#) for more)

R vs Excel and BI Tools vs Python



- Excel & Business Intelligence (BI) Tools (e.g., Tableau, Power BI, etc.)
 - 2-D tables as basic data structure
 - Good UI (User Interface) and minimum programming
 - Limited modeling tools
 - Not easy to reproduce an analysis (because it's hard to store UI clicks)
 - Not flexible enough for complicated analysis problems, i.e., problems with
 - Many data cleaning steps/pipelines
 - Many different models to try



Power BI Desktop



- Python
 - Python is more general purpose, R is more specialized in statistical analysis
 - R is much easier to learn (in my opinion)

Why learn R (What can R do for You)?

- Beyond Excel Data Analysis
 - I wish Excel could...
- Automate boring repeating tasks
 - e.g., daily data collection from different sources, weekly dashboard update
- Prototype ideas
 - e.g., a novel trading strategy, a new credit risk model
- Really, find anything that interests you and use R...

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Setup R

- R & RStudio on your computer (most of you should choose this one)
 - Install R (<https://www.r-project.org/>)
 - Install RStudio (<https://rstudio.com/products/rstudio/download/>)
- R & RStudio in the Cloud (run R without installation)
 - RStudio Cloud (<https://rstudio.cloud/>)
 - UofT JupyterHub RStudio (<https://jupyter.utoronto.ca/hub/login>)
- R & **Notebook** in the Cloud (run R without installation)
 - UofT JupyterHub Notebook (<https://jupyter.utoronto.ca/hub/login>)
 - Google Colab (<https://colab.to/r>)

What's RStudio?



The screenshot displays the RStudio interface with the following components:

- Source Editor:** Contains R code for creating a graph. The code uses `tribble` to define a raw data table, then processes it into `node_tb` and `edge_tb` tables, and finally creates a graph object `g` using `create_graph()` and `render_graph()`.
- Environment Pane:** Shows the 'Global Environment' with a 'Data' section containing:

| Object | Description |
|------------|-----------------------|
| edge_tb | 3 obs. of 2 variables |
| g | List of 12 |
| node_tb | 4 obs. of 1 variable |
| node_tb_tp | 2 obs. of 1 variable |
| raw | 4 obs. of 5 variables |
- Viewer Pane:** Displays a directed graph with four nodes (1, 2, 3, 4) and three edges: 1 → 2, 2 → 3, and 2 → 4.
- Console:** Shows the execution of the code from the source editor, including the `render_graph()` command.

RStudio Cloud

The screenshot displays the RStudio Cloud web interface. The browser address bar shows the URL `https://rstudio.cloud/spaces/112457/project/2046604`. The interface includes a left sidebar with navigation options like 'Spaces', 'Your Workspace', 'R Intro', and 'New Space'. The main workspace area is titled 'R Intro / Workshop 1' and features a menu bar with options like 'File', 'Edit', 'Code', 'View', 'Plots', 'Session', 'Build', 'Debug', 'Profile', 'Tools', and 'Help'. The code editor shows a file named 'Untitled1' with a single line of code: `1 |`. The console window at the bottom displays the R startup message: `/cloud/project/` followed by the R license text and help instructions. The file browser on the right shows the project directory with files `.Rhistory` (0 B) and `project.Rproj` (205 B), both modified on Dec 28, 2020, at 4:52 PM. The environment pane shows 'Global Environment' and 'Environment is empty'. The user's name 'Jay Cao' is visible in the top right corner.


RStudio at UofT Jupyterhub

 Jupyter Notebook RStudio JupyterLab'. There is an orange 'Log in to start' button and a link to 'JupyterHelp' for support. At the bottom, there is a welcome message and logos for Jupyter and RStudio."/>

JupyterHub

https://jupyter.utoronto.ca/hub/login

Not syncing



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After logging in, open: Jupyter Notebook RStudio JupyterLab

Log in to start

Use [JupyterHelp](#) to open tickets for support questions.

Welcome to the new University of Toronto **JupyterHub for Teaching** site.

A proof of concept service, developed as a partnership between the [Office of the CIO](#) (Information Technology Services), the Faculty of Arts & Science's new Computational and Data Science



R Notebook in Google Colab

A screenshot of a Google Colab notebook titled "rn1 A Simple Regression". The notebook is open in a browser window with the URL "https://colab.research.google.com/github/tdmdal/r-workshop-researchers/blob/master/docs/rn1_A_Simple_Regression.ipynb". The notebook interface includes a menu bar (File, Edit, View, Insert, Runtime, Tools, Help), a toolbar with options like "+ Code", "+ Text", and "Copy to Drive", and a status bar showing RAM and Disk usage. The main content area is divided into two sections: "1. Data Import and Manipulation" and "2. Modelling".

1. Data Import and Manipulation

We first import a dataset from the workshop website. This is a dataset on married women labor force participation used in [Mroz 1987](#). The dataset is also used throughout Wooldridge's text book: Introductory Econometrics: A Modern Approach. After briefly inspecting the data, we create a new column `lwage` in preparation for a simple regression.

```
[ ] # load data
data_url <- "https://tdmdal.github.io/r-workshop-researchers/data/mroz_1987.csv"
mroz_1987 <- read.csv(data_url)
```

[] # take a look at the structure of the data
`str(mroz_1987)`

See a description of the data columns [here](#).

```
[ ] # print the first few rows of the dataset
head(mroz_1987)
```

```
[ ] # create log wage
mroz_1987["lwage"] <- log(mroz_1987["wage"])
```

2. Modelling

We will run a simple regression to investigate return on education for married women: $\log(wage) = \beta_0 + \beta_1 educ + u$.


```
[ ] # setup a regression model
lr <- lm(formula = lwage ~ educ, data = mroz_1987)
```

R Notebook at UofT Jupyterhub

JupyterHub

https://jupyter.utoronto.ca/hub/login

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A Few Examples

- Analyze portfolio performance
- Look for trends in R community through Twitter
- Recognize handwritten digits - an example of deep learning



**PerformanceAnalytics
Package**



K Keras


TensorFlow

A Few Examples: What to Look For

- Focus on analysis workflow (by reading the code comments)
 - Import and manipulate data
 - Model data
 - Report and visualize results
- Don't focus on R syntax
- Do notice everything is done in a sequential way
 - no conditional branching or looping

Plan for Today

- Intro to Intro
- Overview of R programming and Data Science
 - Basics of R programming
 - Expression & Assignment
 - Data Structure
 - Programming Structure (control flow & function)
 - Turn ideas into code
 - Data science with R
- Learning Road Map and Resources

Expression and Assignment

```
# expression  
2 + sqrt(4) + log(exp(2)) + 2^2  
  
# assignment  
x <- 3  
y <- (pi == 3.14)
```


R Data Structure - Overview

| | Homogeneous | Heterogeneous |
|-----|----------------------|-------------------|
| 1-d | Atomic vector | List |
| 2-d | Matrix | Data frame |
| n-d | Array | |

R Data Structure - Overview

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|-----|------------------------|------------------------|
| 1-d | Atomic vector → | List |
| 2-d | Matrix | ↓ Data frame |
| n-d | Array | |

Atomic Vectors

```
# create R vectors
```

```
vec_character <- c("Hello,", "World!")
```

| | |
|---------------|---------------|
| Hello, | World! |
|---------------|---------------|

```
vec_integer <- c(1L, 2L, 3L)
```

| | | |
|----------|----------|----------|
| 1 | 2 | 3 |
|----------|----------|----------|

```
vec_double <- c(1.1, 2.2, 3.3)
```

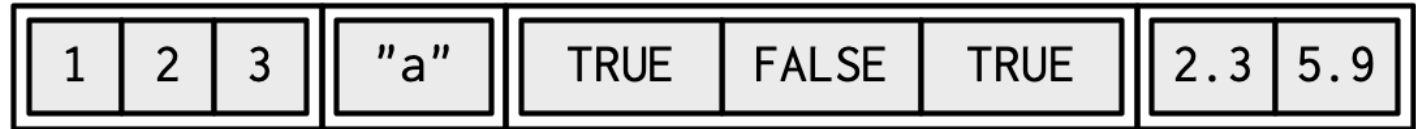
| | | |
|------------|------------|------------|
| 1.1 | 2.2 | 3.3 |
|------------|------------|------------|

```
vec_logical <- c(TRUE, TRUE, FALSE)
```

| | | |
|-------------|-------------|--------------|
| TRUE | TRUE | FALSE |
|-------------|-------------|--------------|

List

```
# create an R list
l1 <- list(
  1:3,
  "a",
  c(TRUE, FALSE, TRUE),
  c(2.3, 5.9)
)
```



Data Frame

```
# create a data frame
df1 <- data.frame(
  x = 1:3,
  y = letters[1:3],
  z = c(1.1, 2.2, 3.3)
)
```

| x | y | z |
|----------|----------|----------|
| 1 | "a" | 1.1 |
| 2 | "b" | 2.2 |
| 3 | "c" | 3.3 |

Data Frame

```
# create a data frame
df1 <- data.frame(
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| x | y | z |
|---|-----|-----|
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Data Frame

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| x | y | z |
|---|-----|-----|
| 1 | "a" | 1.1 |
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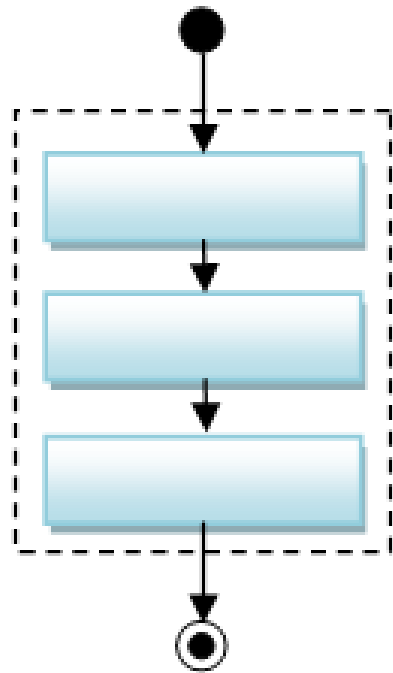
A Cousin to Data Frame - Tibble

```
# load tibble library (part of tidyverse lib)
library(tibble)

# create a tibble
tb1 <- tibble(
  x = 1:3,
  y = letters[1:3],
  z = c(1.1, 2.2, 3.3)
)
```

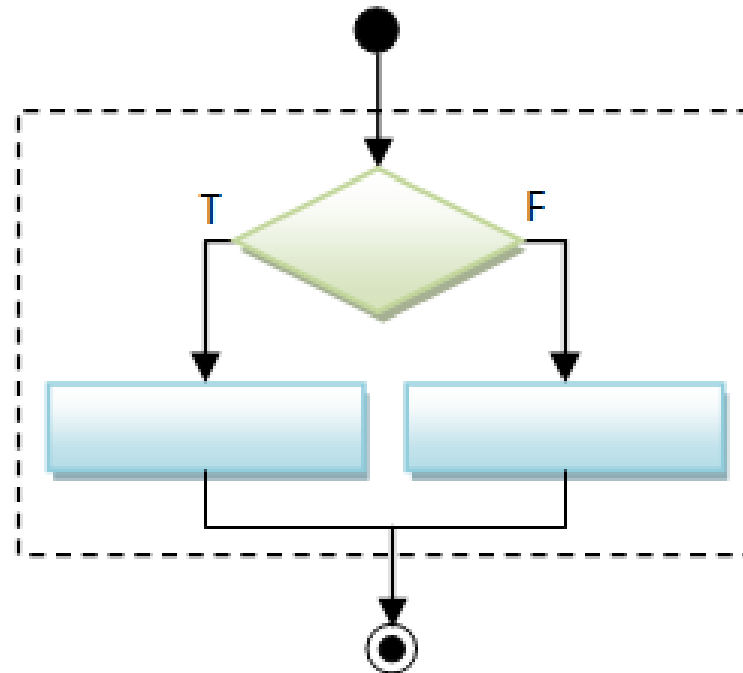
| x | y | z |
|---|-----|-----|
| 1 | "a" | 1.1 |
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Programming Structure: Control Flows



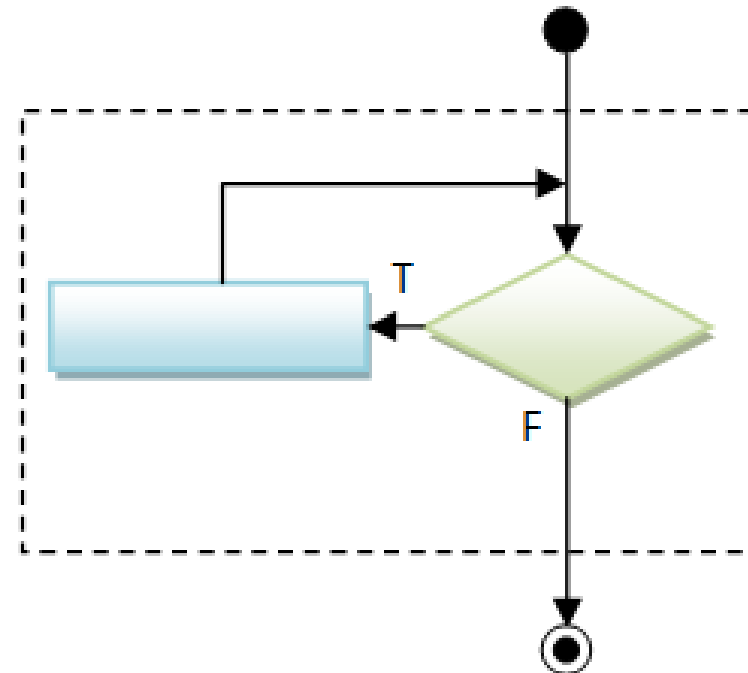
Sequential

Today



Conditional (Decision)

Learn on your own (See Appendix)



Loop (Iteration)

Sequential

- Example: Sum of Squares

$$\sum_{t=1}^3 t^2$$

```
# sum of squares  
t <- 1:3  
y <- sum(t^2)  
print(y)
```

Sequential

- Example: Sum of Squares

$$\sum_{t=1}^3 t^2$$

```
# sum of squares  
t <- 1:3  
y <- sum(t^2)  
print(y)
```

| | | | |
|---|---|---|---|
| t | 1 | 2 | 3 |
|---|---|---|---|

Sequential

- Example: Sum of Squares

$$\sum_{t=1}^3 t^2$$

```
# sum of squares  
t <- 1:3  
y <- sum(t^2)  
print(y)
```

| | | | |
|----------|----|---|---|
| t | 1 | 2 | 3 |
| t^2 | 1 | 4 | 9 |
| sum(t^2) | 14 | | |

Programming Structure: Functions

- What's a function
 - a logical block of code
 - input -> output
- Why write functions
 - Reusability
 - Abstraction
 - Maintainability
- Example: $\sum_{t=1}^n t^2$

```
# sum of squares from 1 to n
ss <- function(n) {
  t <- 1:n
  sum(t^2)
}

# calling the ss() function
print(ss(2))
print(ss(3))
```

Programming Structure: Functions

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Programming Structure: Functions

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- Example: $\sum_{t=1}^n t^2$

```
# sum of squares from 1 to n
ss <- function(n) {
  t <- 1:n
  sum(t^2) # return(sum(t^2))
}

# calling the ss() function
print(ss(2))
print(ss(3))
```

Turn Ideas into Code

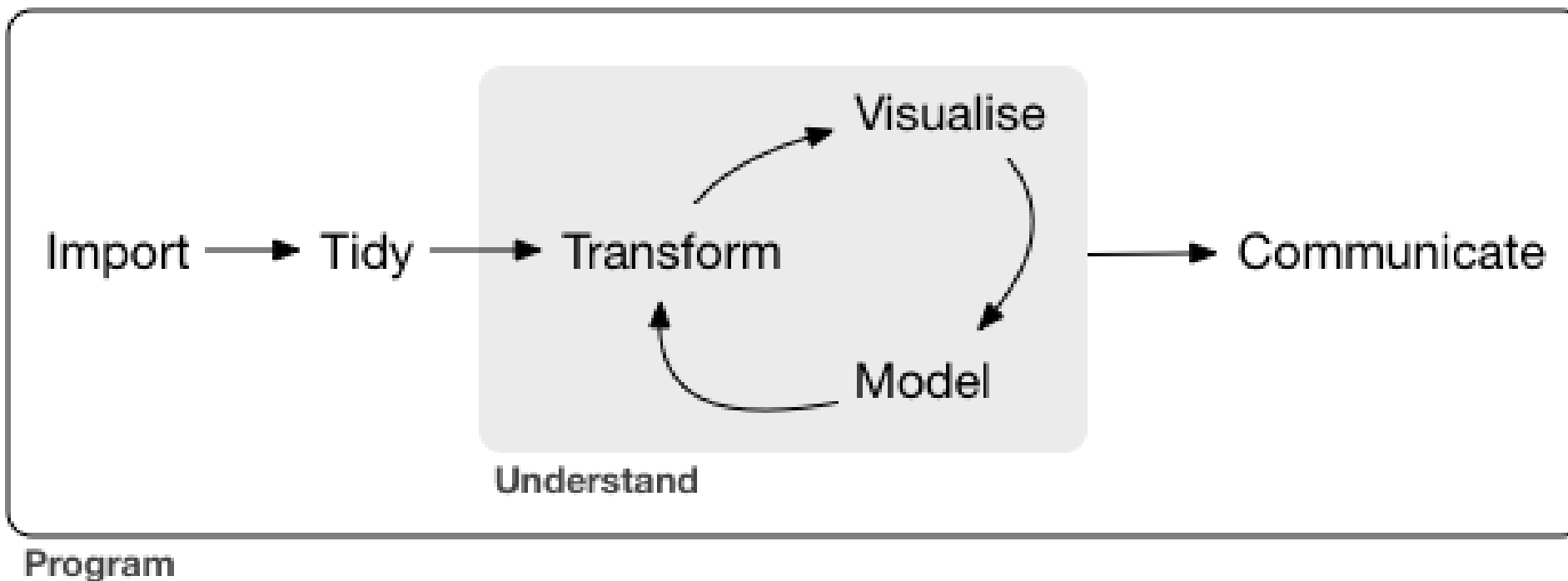
- Solve problems using code: three main ingredients
 - Data Structure + Programming Structure + **Algorithm** (sorting, searching, optimization, etc.)
 - Examples
 - Sort a list of integers
 - Generate and solve Sudoku puzzles
 - Implement and backtest a trading strategy
- For us (data analysis tasks), in most cases, we solve problems by
 - Using algorithm implemented by other peoples (i.e., functions from R packages)
 - Combine algorithms (and data & programming structures) to achieve our goal (still not easy; need practices to write good code.)

Plan for Today

- Intro to Intro
- Overview of R programming and Data Science
 - Basics of R programming
 - Data science with R
 - A Typical data analysis workflow
 - Choice of R packages
 - An example: regression analysis
- Learning Road Map and Resources

Data Science/Analysis Workflow

- Use this workflow to organize your thoughts and code



An Example: Housing Price & Clean Air

Obs: 506

- Manipulate data
 - Load data
 - Create new columns
 - Filter columns and rows
 - Build models
 - Multiple linear regressions
 - Report and graph
 - Build a publication-ready table for regression results
- | | |
|-------------------|-------------------------------------|
| 1. price | median housing price, \$ |
| 2. crime | crimes committed per capita |
| 3. nox | nitrous oxide, parts per 100 mill. |
| 4. rooms | avg number of rooms per house |
| 5. dist | weighted dist. to 5 employ centers |
| 6. radial | accessibiliy index to radial hghwys |
| 7. proptax | property tax per \$1000 |
| 8. stratio | average student-teacher ratio |
| 9. lowstat | % of people 'lower status' |

Many Ways to Achieve the Same Goal

- The “pure” R way if possible
 - Mostly use functions/packages in [R standard library](#) (those shipped with R)
 - for structuring and manipulating data
 - for modeling if possible (e.g. regressions)
 - An example of a simple linear regression
- The “modern” way
 - Use specialized packages to manipulate data and assist modeling tasks
 - Data are stored in improved data structures (in most cases still compatible with base R data structure)
 - What we will focus on

R Packages: Many choices, which one to use

- Often, a task can be achieved using functions in different libraries
 - R is open and extensible!
- Example: load a csv file to a data frame (or its variations)
 - Use [read.csv\(\)](#) function from the `utils` library in Base R
 - Use [read_csv\(\)](#) function from the [readr](#) library
 - Use [fread\(\)](#) function from the [data.table](#) library
 - Use [vroom\(\)](#) from the [vroom](#) library

R Packages: Many choices, which one to use

- Start with the one most people use
- Choose one that is well maintained
 - check document, github, etc. for last update date
 - packages maintained by companies (e.g., RStudio Co.) or academic teams
- Choose one that suits your task

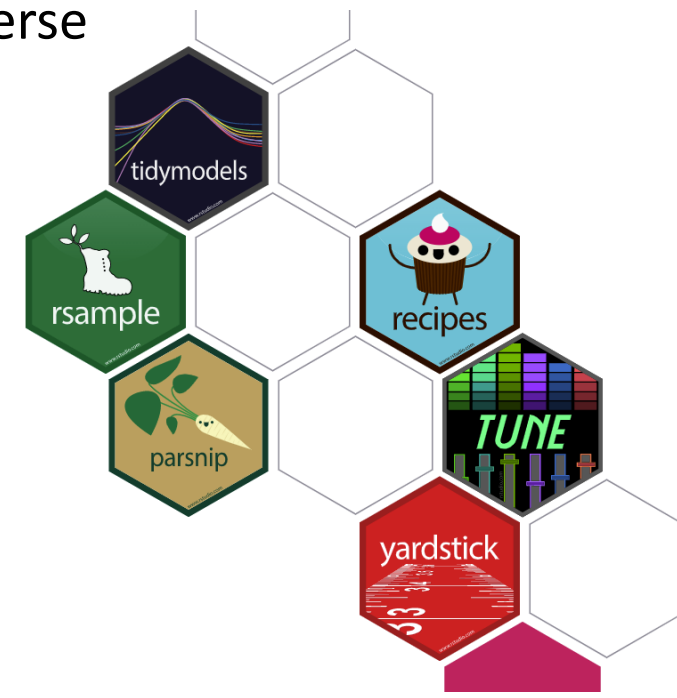
Great Choice for Data Science Work

- Tidyverse

- “an opinionated collection of R packages designed for data science”
- “All packages share an underlying design philosophy, grammar, and data structures.”
- Handle data manipulation, visualization, and much more
- an eco-system: many package developers started to follow tidyverse principles too

- Tidymodels

- “a collection of packages for modeling and machine learning using tidyverse principles”
- Manage modeling process but does not do modeling itself



Our Choice: the Regression Example

- Manipulate data ([tidyverse](#) eco-system)
 - Load data ([read_csv\(\)](#) from the [readr](#))
 - Create new columns ([mutate\(\)](#) from [dplyr](#))
 - Filter columns and rows ([select\(\)](#) and [filter\(\)](#) from [dplyr](#))
- Build models
 - Multiple regression ([lm\(\)](#) from stats library in R base)
- Report and graph
 - Build a publication-ready table ([huxreg\(\)](#) from [huxtable](#) library)

Using R packages/libraries

- Install an R library (only need to install a library once)

```
install.packages("Library_name")
```

- Load an R library (before you use a library)

```
library(Library_name)
```

- [CRAN](#) (The Comprehensive R Archive Network)
 - [CRAN Task Views](#)

Load a CSV file

- [read_csv\(\)](#) from the [readr](#)

```
read_csv(file)
```

```
e.g. hprice <- read_csv("hprice.csv")
```

- More about [read_csv\(\)](#)
- More about [readr](#)

Load Data – Other file formats and sources

- [readxl](#) for Excel sheets
- [haven](#) for SPSS, Stata and SAS data
- [jsonlite](#) for JSON
- [xml2](#) for XML
- [httr](#) for web APIs
- [rvest](#) for web scraping
- [DBI](#) for connecting to DataBase engine
- ...

Load Data – Financial Dataset

- [tq_get\(\)](#) from tidyquant library
 - collect financial and economic data from many online sources
 - Yahoo Finance, FRED, Quandl, Tiingo, Alpha Vantage, Bloomberg
- [simfinapi](#) library
 - download financial statements – balance sheet, cash flow and income statement – and adjusted daily price of stocks through [the simfin project](#)
- a few others (try to look for them yourselves...)

A Quick Detour - Load Data from Web API

- Modern Web API: An example using Yahoo Finance
 - [Yahoo Finance API Specification](#)
 - How does a call look like
 - Apple on Yahoo Finance from the web, <https://finance.yahoo.com/quote/AAPL/history?p=AAPL>
 - An API call for AAPL recommendation trend data, <https://query2.finance.yahoo.com/v11/finance/quoteSummary/AAPL?formatted=true&modules=recommendationTrend&corsDomain=finance.yahoo.com>
 - R packages to get data from Yahoo finance (API call wrappers), [quantmod](#); [tidyquant](#)
- An R package to deal with raw Web API call, [httr](#)
 - You can build your own Yahoo Finance R package using it

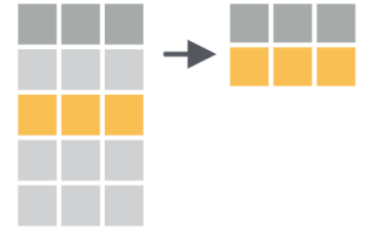
A Quick Detour – Get Data From Bloomberg

- Bloomberg is working hard on its Web APIs
 - <https://www.bloomberg.com/professional/blog/modernizing-capital-markets-tech-with-web-apis/>
- Meanwhile, you can get data using its traditional [server API](#)
 - To connect, need authentication (i.e. hostname, userid, etc.)
- R packages
 - [Rblpai](#) (a wrapper of Bloomberg Server API)
 - Tidyquant's [tq_get\(x, "rblpai"\)](#) (a wrapper of Rblpai package)

Data Manipulation: dplyr basics

- Filter observations (rows): **filter()**

```
filter(my_dataframe, condition1, ...)  
e.g., hprice_reg <- filter(hprice, price > 20000)
```



- Select variables (columns): **select()**

```
select(my_dataframe, var1, ...)  
e.g., hprice_reg <- select(hprice_reg, lprice, rooms)
```



- Create new variables: **mutate()**

```
mutate(my_dataframe, new_var1 = expression1, ...)  
e.g., hprice_reg <- mutate(hprice_reg, lprice = log(price))
```

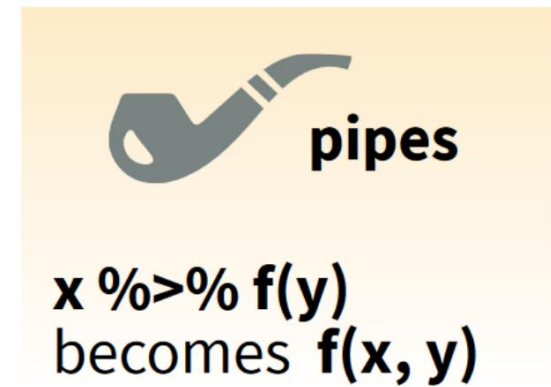


Data Manipulation: Data Pipe (%>%)

```
hprice_reg <- filter(hprice, price > 20000)
hprice_reg <- mutate(hprice_reg, lprice = log(price))
hprice_reg <- select(hprice_reg, lprice, rooms)
```



```
hprice_reg <- hprice %>%
  filter(price > 20000) %>%
  mutate(lprice = log(price)) %>%
  select(lprice, rooms)
```



Regression

- Multiple regressions: [lm\(\)](#) from stats library in base R

```
my_model <- lm(y ~ x1 + x2, data)
```

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon_i$$

```
my_model <- lm(y ~ x1 + x2 + I(x1 * x2), data)
```

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \epsilon_i$$

- Regression result summary: `summary()`

Ref. <https://faculty.chicagobooth.edu/richard.hahn/teaching/FormulaNotation.pdf>

Report

- Summary table
 - [Summary for lm\(\)](#): `summary(my_model)`
- publication-ready table: [huxreg\(\)](#) from [huxtable](#) library

```
huxtable(my_model1, my_model2, ...)
```

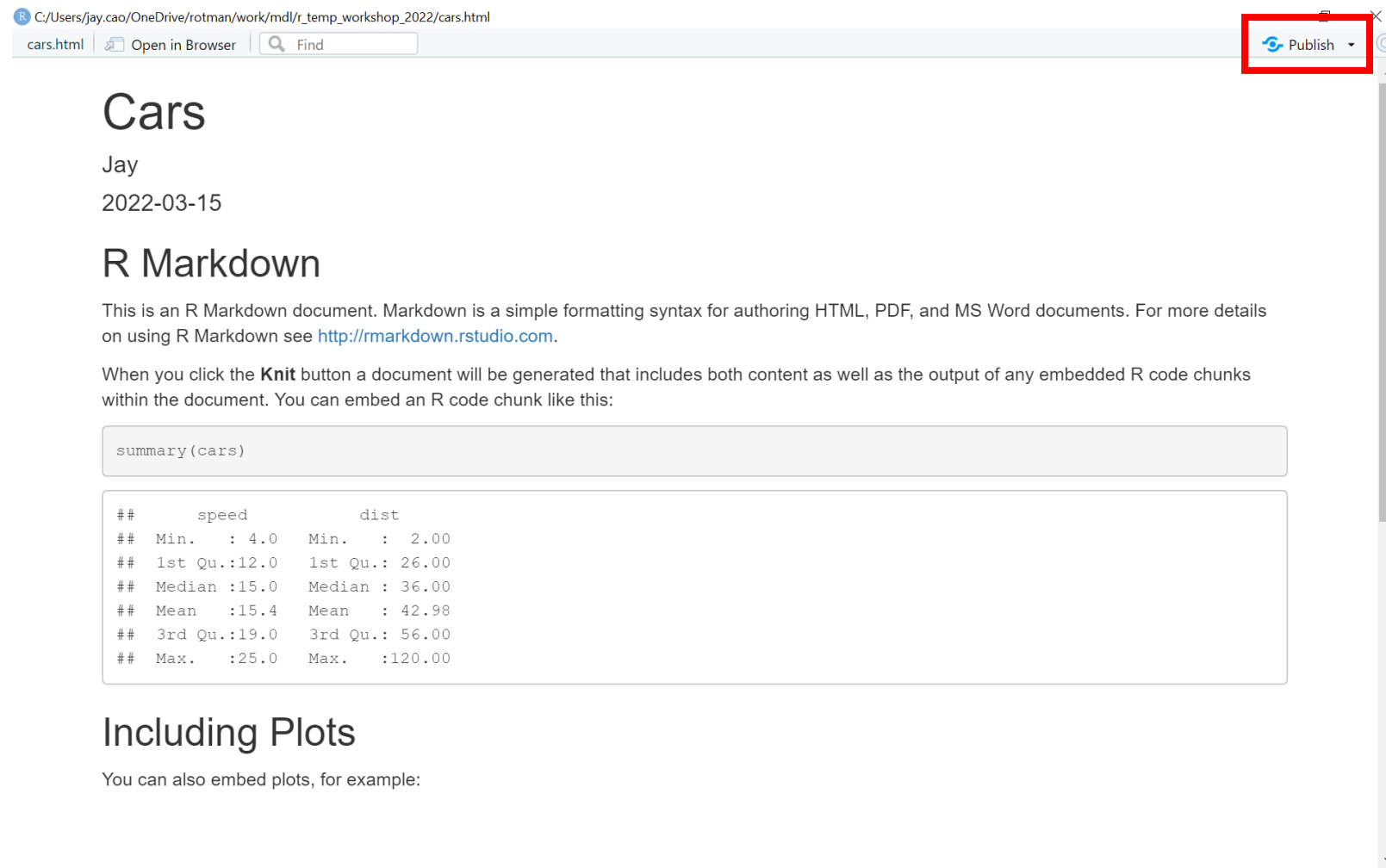
Report - Publish to The Web (1) / R Markdown

```
1 ---
2 title: "cars"
3 author: "Jay"
4 date: '2022-03-15'
5 output: html_document
6 ---
7
8 ```{r setup, include=FALSE}
9 knitr::opts_chunk$set(echo = TRUE)
10 ```
11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a simple formatting syntax for
15 authoring HTML, PDF, and MS word documents. For more details on using R Markdown
16 see <http://rmarkdown.rstudio.com>.
17
18 when you click the Knit button a document will be generated that includes
19 both content as well as the output of any embedded R code chunks within the
20 document. You can embed an R code chunk like this:
21
22 ```{r cars}
23 summary(cars)
24 ```
25
26 ## Including Plots
27
28 You can also embed plots, for example:
```

R Markdown text

Report - Publish to The Web (2) / R Markdown

- Knit button for rendering
 - knitr package



C:/Users/jay.cao/OneDrive/rotman/work/mdl/r_temp_workshop_2022/cars.html

cars.html Open in Browser Find

Publish

Cars

Jay
2022-03-15

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
summary(cars)
```

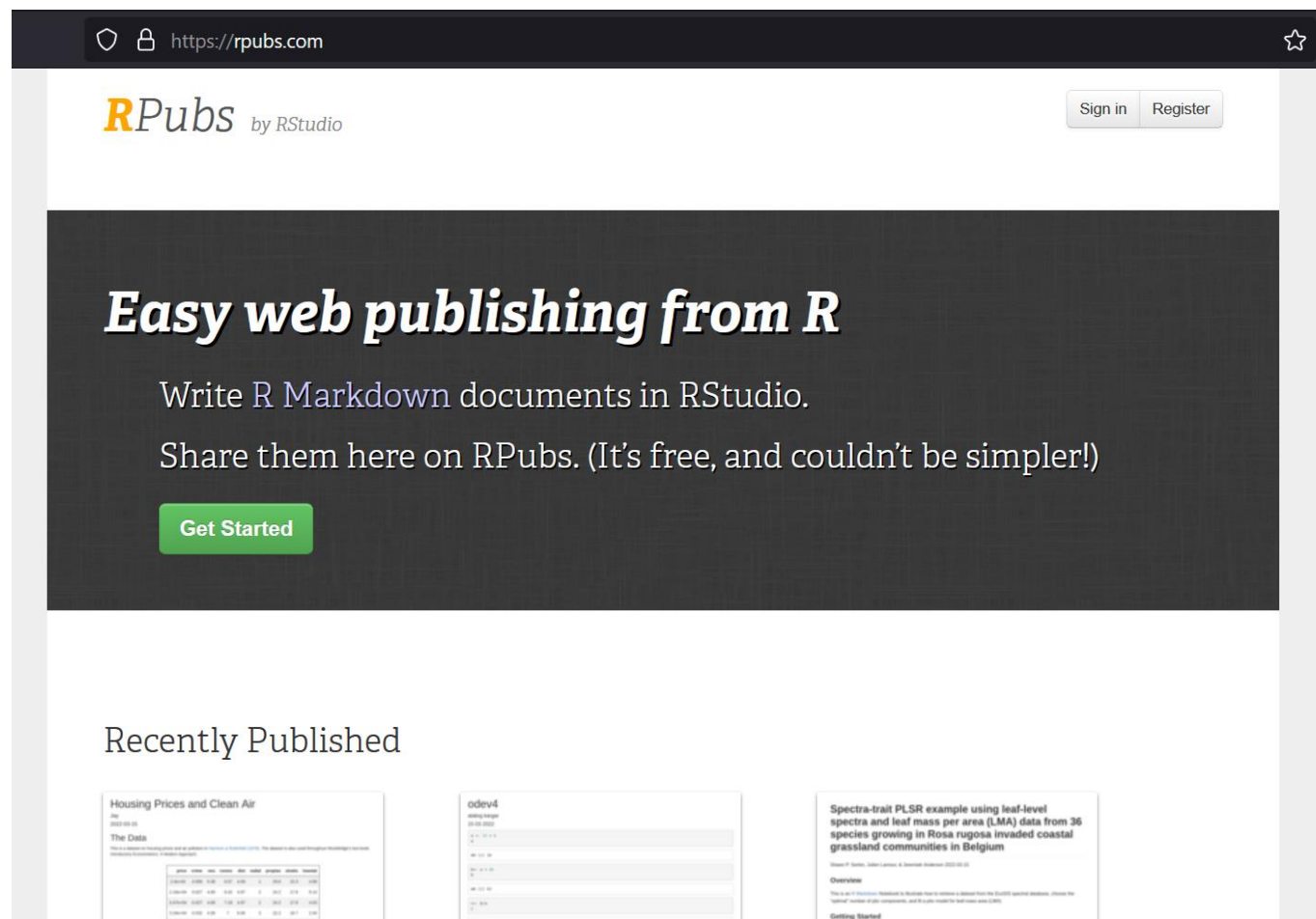
| ## | speed | dist |
|-------------|-------|----------------|
| ## Min. | : 4.0 | Min. : 2.00 |
| ## 1st Qu.: | 12.0 | 1st Qu.: 26.00 |
| ## Median : | 15.0 | Median : 36.00 |
| ## Mean : | 15.4 | Mean : 42.98 |
| ## 3rd Qu.: | 19.0 | 3rd Qu.: 56.00 |
| ## Max. : | 25.0 | Max. : 120.00 |

Including Plots

You can also embed plots, for example:

Report - Publish to The Web (3) / RPubs

- Publish button for publishing
- [RPubs](#)
 - Publish and share your RMarkdown output
- Demo



The screenshot shows the RPubs website homepage. At the top, there is a navigation bar with the RPubs logo (in orange and black) and the text "by RStudio". To the right of the logo are "Sign in" and "Register" buttons. Below the navigation bar is a large dark grey banner with the heading "Easy web publishing from R" in white, bold, italicized font. Underneath the heading, there is a sub-heading "Write R Markdown documents in RStudio." and a paragraph "Share them here on RPubs. (It's free, and couldn't be simpler!)" in white. A green "Get Started" button is positioned at the bottom of the banner. Below the banner, the section "Recently Published" is visible, featuring three preview cards for published reports. The first card is titled "Housing Prices and Clean Air" and shows a table of data. The second card is titled "odev4" and shows a code editor interface. The third card is titled "Spectra-trait PLSR example using leaf-level spectra and leaf mass per area (LMA) data from 36 species growing in Rosa rugosa invaded coastal grassland communities in Belgium" and shows a plot.

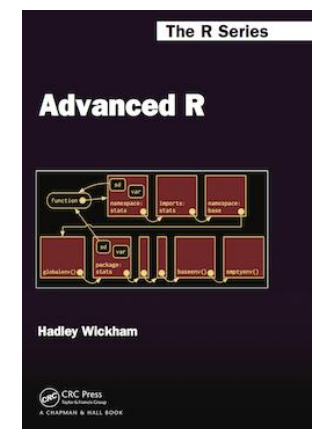
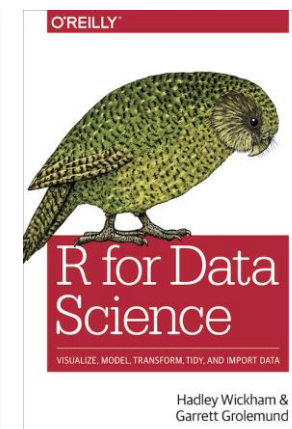
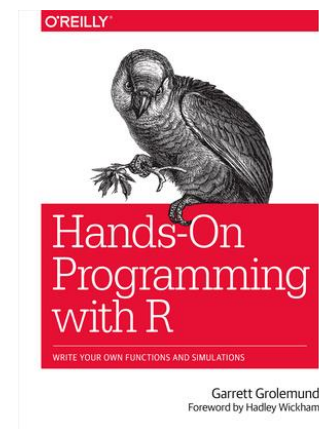
Plan for Today

- Intro to Intro
- Overview of R programming and Data Science
 - Basics of R programming
 - Data science with R
- Learning Resources and Road Map

Learning Road Map (Three Free Books)

- Step 1. Basic R programming skills (Never programmed before? Start here.)
 - Data and programming structure; how to turn an idea into code;
 - Book: [Hands-On Programming with R](#)
- Step 2. R Data Science skills
 - Data wrangling, modeling, and visualization/reporting; Best practice;
 - Book: [R for Data Science](#)
- Step 3. Take your R Skill to the next level
 - Book: [Advanced R](#)

Other free books check bookdown.org often



Learning Approach

- Learn the underlying principles
 - e.g., why organize data in a certain way
- Learn best practices
 - follow a consistent analysis workflow

Free Learning Resource

- [RStudio Education](#)
 - [Choose Your Learning Paths](#)
- [RStudio Video Resources Site](#)
- More free R books? Check bookdown.org often
- Coursera: Search R and learn
 - free for [UofT students](#) (mostly always free if you just audit the courses)
- Twitter (a few seeds: [#rstat](#), [@hadleywickham](#), [@WeAreRLadies](#))

Appendix

- Programming Structure Continued
 - Conditional
 - Iteration

Conditional (if...else...)

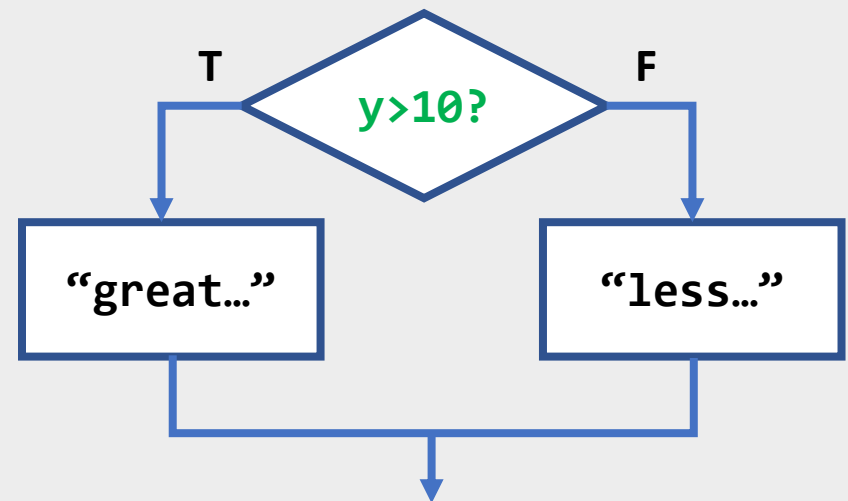
```
if (cond) {  
    # run here if cond is TRUE  
} else {  
    # run here if cond is FALSE  
}
```

```
# y greater than 10?  
if (y > 10) {  
    print("greater than 10")  
} else {  
    print("less or equal to 10")  
}
```

Conditional (if...else...)

```
if (cond) {  
    # run here if cond is TRUE  
} else {  
    # run here if cond is FALSE  
}
```

```
# y greater than 10?  
if (y > 10) {  
    print("greater than 10")  
} else {  
    print("less or equal to 10")  
}
```



Conditional (if...else if...else...)

```
if (cond1) {  
    # run here if cond1 is TRUE  
} else if (cond2) {  
    # run here if cond1 is FALSE but cond2 is TRUE  
} else {  
    # run here if neither cond1 nor cond2 is TRUE  
}
```

Iteration

```
for (var in seq) {  
  do something  
}
```

```
while (cond) {  
  do something if cond is TRUE  
}
```

```
# sum of squares  
t <- 1:3  
y <- 0  
  
for (x in t) {  
  y <- y + x^2  
}  
  
print(y)
```