ACCT 420: R Supplement

R Supplement

Dr. Richard M. Crowley

Vectors

Vectors: What are they?

- Remember back to linear algebra…

Examples:

$$\begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \end{pmatrix} \quad \text{or} \quad \begin{pmatrix} 1 & 2 & 3 & 4 \end{pmatrix}$$

> A row (or column) of data

Vector creation

- Vectors are entered using the `c()` command
- Any data type is fine, but all elements must be the *same type*

```
company <- c("Google", "Microsoft", "Goldman")
company
```

```
## [1] "Google"    "Microsoft" "Goldman"
```

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

```
## [1]  TRUE  TRUE FALSE
```

```
earnings <- c(12662, 21204, 4286)
earnings
```

```
## [1] 12662 21204  4286
```

> A vector in R is a 1 dimensional collection of 1 or more of the *same* data type

Special cases for vectors

- Counting between integers
- `:`, e.g. `1:5` or `22:500`
- `seq()`, e.g. `seq(from=0, to=100, by=5)`

```
1:5
```

```
## [1] 1 2 3 4 5
```

```
seq(from=0, to=100, by=5)
```

```
##  [1]   0   5  10  15  20  25  30
## [18]  85  90  95 100
```

↑ note that [18] means the 18th output

- Repeating something
  - `rep()`, e.g. `rep(1,times=10)` or `rep("hi",times=5)`

```
rep(1,times=10)
```

```
##  [1] 1 1 1 1 1 1 1 1 1 1
```

```
rep("hi",times=5)
```

```
## [1] "hi" "hi" "hi" "hi" "hi"
```

Vector math

> Works the same as scalars, but applies *element-wise*

- First element with first element,
- Second element with second element,
- …

```
earnings  # previously defined
```

```
## [1] 12662 21204  4286
```

```
earnings + earnings  # Add element-wise
```

```
## [1] 25324 42408  8572
```

```
earnings * earnings  # multiply element-wise
```

```
## [1] 160326244 449609616  18369796
```

Vector math

Can also use 1 vector and 1 scalar

- Scalar is applied to all vector elements

```
earnings + 10000  # Adding a scalar to a vector
```

```
## [1] 22662 31204 14286
```

```
10000 + earnings  # Order doesn't matter
```

```
## [1] 22662 31204 14286
```

```
earnings / 1000  # Dividing a vector by a scalar
```

```
## [1] 12.662 21.204  4.286
```

Vector math

- From linear algebra, you might remember multiplication being a bit different, as a dot product. That can be done with `%*%`

```r
# Dot product: sum of product of elements
earnings %*% earnings  # returns a matrix though...
```

```
##           [,1]
## [1,] 628305656
```

```r
drop(earnings %*% earnings)  # Drop drops excess dimensions
```

```
## [1] 628305656
```

- Other useful functions, `length()` and `sum()`:

```r
length(earnings)  # returns the number of elements
```

```
## [1] 3
```

```r
sum(earnings)  # returns the sum of all elements
```

```
## [1] 38152
```

Naming vectors

- Vectors allow us to include a lot of information in one object
  - It isn't easy to read though
- We can make things more readable by assigning `names()`
  - Names provide a way to easily work with and understand the data

Hard to read:

```
earnings
```

```
## [1] 12662 21204  4286
```

Easy to read:

```
names(earnings) <- c("Google",
                     "Microsoft",
                     "Goldman")
earnings
```

```
##    Google Microsoft   Goldman
##     12662     21204      4286
```

```
# Equivalently:
names(earnings) <- company
earnings
```

```
##    Google Microsoft   Goldman
##     12662     21204      4286
```

Selecting and combining vectors

- Selecting can be done a few ways.
  - By index, such as `[1]`
  - By name, such as `["Google"]`

```
earnings[1]
```

```
## Google
##  12662
```

```
earnings["Google"]
```

```
## Google
##  12662
```

- Multiple selection:
  - `earnings[c(1,2)]`
  - `earnings[1:2]`
  - `earnings[c("Google", "Microsoft")]`

```
# Each of the above 3 is equivalent
earnings[1:2]
```

```
##    Google Microsoft
##     12662     21204
```

- Combining is done using `c()`

```
c1 <- c(1,2,3)
c2 <- c(4,5,6)
c3 <- c(c1,c2)
c3
```

```
## [1] 1 2 3 4 5 6
```

Vector example: Profit margin for tech firms

```
# Calculating proit margin for all public US tech firms
# 715 tech firms with >1M sales in 2017
summary(earnings_2017)  # Cleaned data from Compustat, in $M USD
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max. 
## -4307.49    -15.98      1.84    296.84     91.36  48351.00
```

```
summary(revenue_2017)  # Cleaned data from Compustat, in $M USD
```

```
##      Min.    1st Qu.     Median       Mean    3rd Qu.       Max. 
##      1.06     102.62     397.57    3023.78    1531.59  229234.00
```

```
profit_margin <- earnings_2017 / revenue_2017
summary(profit_margin)
```

```
##      Min.    1st Qu.     Median       Mean    3rd Qu.       Max. 
## -13.97960   -0.10253    0.01353   -0.10967    0.09295    1.02655
```

```
# These are the worst, midpoint, and best profit margin firms in 2017. Our names c
profit_margin[order(profit_margin)][c(1,length(profit_margin)/2,length(profit_marg
```

```
## HELIOS AND MATHESON ANALYTIC                       NLIGHT INC 
##                 -13.97960161                       0.01325588 
##            CCUR HOLDINGS INC 
##                   1.02654899
```

Practice: Vectors

- This practice explores the ROA of Goldman Sachs, JPMorgan, and Citigroup in 2017
- Do exercise 2 on the supplementary R practice file:
  - R Practice

Matrices

Matrices: What are they?

- Remember back to linear algebra…

Example:

$$\begin{pmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{pmatrix}$$

> A rows *and* columns of data

Matrix creation

- Matrices are entered using the `matrix()` command
- Any data type is fine, but all elements must be the *same type*

```
columns <- c("Google", "Microsoft", "Goldman")
rows <- c("Earnings","Revenue")

# equivalent: matrix(data=c(12662, 21204, 4286, 110855, 89950, 42254),ncol=3)
firm_data <- matrix(data=c(12662, 21204, 4286, 110855, 89950, 42254),nrow=2)
firm_data
```

```
##       [,1]   [,2]  [,3]
## [1,] 12662   4286 89950
## [2,] 21204 110855 42254
```

Math with matrices

> Everything with matrices works just like vectors

```r
firm_data + firm_data
```

```
##        [,1]   [,2]   [,3]
## [1,] 25324   8572 179900
## [2,] 42408 221710  84508
```

```r
firm_data / 1000
```

```
##        [,1]    [,2]   [,3]
## [1,] 12.662   4.286 89.950
## [2,] 21.204 110.855 42.254
```

Matrix math with matrices

- Matrix transposing, A^T, uses `t()`

```
firm_data_T <- t(firm_data)
firm_data_T
```

```
##        [,1]   [,2]
## [1,] 12662  21204
## [2,]  4286 110855
## [3,] 89950  42254
```

- Matrix multiplication, $A\ B$, uses `%*%`

```
firm_data %*% firm_data_T
```

```
##             [,1]        [,2]
## [1,] 8269698540  4544356878
## [2,] 4544356878 14523841157
```

> We won't use these much, but they can be useful

Matrix naming

- We can name matrix rows and columns, much like we named vector elements
- Use `rownames()` for rows
- Use `colnames()` for columns

```
rownames(firm_data) <- rows
colnames(firm_data) <- columns
firm_data
```

```
##           Google Microsoft Goldman
## Earnings  12662      4286   89950
## Revenue   21204    110855   42254
```

Selecting from matrices

- Select using 2 indexes instead of 1:
  - `matrix_name[rows,columns]`
  - To select all rows or columns, leave that index blanks

```r
firm_data[2,3]
```

```
## [1] 42254
```

```r
firm_data[,c("Google","Microsoft")]
```

```
##          Google Microsoft
## Earnings  12662      4286
## Revenue   21204    110855
```

```r
firm_data[1,]
```

```
##    Google Microsoft   Goldman
##     12662      4286     89950
```

Combining matrices

- Matrices are combined top to bottom as rows with `rbind()`
- Matrices are combined side-by-side as columns with `cbind()`

```
# Preloaded: industry codes as indcode (vector)
#     - GICS codes: 40=Financials, 45=Information Technology
#     - See: https://en.wikipedia.org/wiki/Global_Industry_Classification_Standarc
# Preloaded: JPMorgan data as jpdata (vector)

mat <- rbind(firm_data,indcode)  # Add a row
rownames(mat)[3] <- "Industry"  # Name the new row
mat
```

```
##           Google Microsoft Goldman
## Earnings  12662      4286   89950
## Revenue   21204    110855   42254
## Industry     45        45      40
```

```
mat <- cbind(firm_data,jpdata)  # Add a column
colnames(mat)[4] <- "JPMorgan"  # Name the new column
mat
```

```
##           Google Microsoft Goldman JPMorgan
## Earnings  12662      4286   89950    17370
## Revenue   21204    110855   42254   115475
```

Lists

Lists: What are they?

- Like vectors, but with mixed types
- Generally not something we will create
- Often returned by analysis functions in R
  - Such as the linear models we will look at next week

```r
# Ignore this code for now...
model <- summary(lm(earnings ~ revenue, data=tech_df))
#Note that this function is hiding something...
model
```

```
##
## Call:
## lm(formula = earnings ~ revenue, data = tech_df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -16045.0     20.0    141.6    177.1  12104.6
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.837e+02  4.491e+01  -4.091 4.79e-05 ***
## revenue      1.589e-01  3.564e-03  44.585  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1166 on 713 degrees of freedom
## Multiple R-squared:  0.736,  Adjusted R-squared:  0.7356
## F-statistic:  1988 on 1 and 713 DF,  p-value: < 2.2e-16
```

Looking into lists

- Lists generally use double square brackets, `[[index]]`
  - Used for pulling individual elements out of a list
- `[[c()]]` will drill through lists, as opposed to pulling multiple values
- Single square brackets pull out elements as is
- Double square brackets extract just the element
- For 1 level, we can also use `$`

```
model["r.squared"]
```

```
## $r.squared
## [1] 0.7360059
```

```
model[["r.squared"]]
```

```
## [1] 0.7360059
```

```
model$r.squared
```

```
## [1] 0.7360059
```

```
earnings["Google"]
```

```
## Google
##  12662
```

```
earnings[["Google"]]
```

```
## [1] 12662
```

```
#Can't use $ with vectors
```

Structure of a list

- `str()` will tell us what's in this list

```r
str(model)
```

```
## List of 11
##  $ call         : language lm(formula = earnings ~ revenue, data = tech_df)
##  $ terms        :Classes 'terms', 'formula'  language earnings ~ revenue
##   .. ..- attr(*, "variables")= language list(earnings, revenue)
##   .. ..- attr(*, "factors")= int [1:2, 1] 0 1
##   .. .. ..- attr(*, "dimnames")=List of 2
##   .. .. .. ..$ : chr [1:2] "earnings" "revenue"
##   .. .. .. ..$ : chr "revenue"
##   .. ..- attr(*, "term.labels")= chr "revenue"
##   .. ..- attr(*, "order")= int 1
##   .. ..- attr(*, "intercept")= int 1
##   .. ..- attr(*, "response")= int 1
##   .. ..- attr(*, ".Environment")=<environment: R_GlobalEnv>
##   .. ..- attr(*, "predvars")= language list(earnings, revenue)
##   .. ..- attr(*, "dataClasses")= Named chr [1:2] "numeric" "numeric"
##   .. .. ..- attr(*, "names")= chr [1:2] "earnings" "revenue"
##  $ residuals    : Named num [1:715] -59.7 173.8 -620.2 586.7 613.6 ...
##   ..- attr(*, "names")= chr [1:715] "1" "2" "3" "4" ...
##  $ coefficients : num [1:2, 1:4] -1.84e+02 1.59e-01 4.49e+01 3.56e-03 -4.09 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:2] "(Intercept)" "revenue"
```

Practice: Lists

- In this practice, we will explore lists and how to parse them
- Do exercise 3 on the supplementary R practice file:
  - R Practice

Data frames

What are data frames?

- Data frames are like a hybrid between lists and matrices

Like a matrix:

- 2 dimensional like matrices
- Can access data with `[]`
- All elements in a column must be the same data type

Like a list:

- Can have different data types for different columns
- Can access data with `$`

> Think of columns as variables, rows as observations

Example of a data frame

```r
library(DT)  # This library is great for including larger collections of data in c
datatable(tech_df[1:20,c("conm","tic","margin")], rownames=FALSE)
```

Show 0 entries Search:

conm	tic	margin
AVX CORP	AVX	0.00314245229040611
BK TECHNOLOGIES	BKTI	-0.0920421373270719
ADVANCED MICRO DEVICES	AMD	0.00806905610808782
ASM INTERNATIONAL NV	ASMIY	0.613509486149511
SKYWORKS SOLUTIONS INC	SWKS	0.276661006737142
ANALOG DEVICES	ADI	0.142390322629277
ANDREA ELECTRONICS CORP	ANDR	-0.1661866359447
APPLE INC	AAPL	0.210924208450753
APPLIED MATERIALS INC	AMAT	0.236224805668295
ARROW ELECTRONICS INC	ARW	0.014991585270576

Showing 1 to 10 of 20 entries

Previous 1 2 Next

How to create data frames

1. On import of data, usually you will get a data frame
2. Using the `data.frame()` function

```
df <- data.frame(companyName=company,
                 earnings=earnings,
                 tech_firm=tech_firm,
                 stringsAsFactors=FALSE)
df
```

```
##           companyName earnings tech_firm
## Google         Google    12662      TRUE
## Microsoft   Microsoft    21204      TRUE
## Goldman       Goldman     4286     FALSE
```

> Caution: `stringsAsFactors=FALSE` is needed for R to retain string data!

Selecting from data frames

- Access like a matrix

```
df[,1]
```

```
## [1] "Google"    "Microsoft" "Goldman"
```

- Access like a list

```
df$companyName
```

```
## [1] "Google"    "Microsoft" "Goldman"
```

```
df[[1]]
```

```
## [1] "Google"    "Microsoft" "Goldman"
```

> All are relatively equivalent. Using `$` is generally most natural. Using `[,]` is good for complex references.

Making new columns in a data frame

Suggested method: use `$`

```
df$all_zero <- 0
df$revenue <- c(110855, 89950, 42254)
df$margin <- df$earnings / df$revenue
# Custom function for small tables -- see last slide for code
html_df(df)
```

	companyName	earnings	tech_firm	all_zero	revenue	margin
Google	Google	12662	TRUE	0	110855	0.1142213
Microsoft	Microsoft	21204	TRUE	0	89950	0.2357310
Goldman	Goldman	4286	FALSE	0	42254	0.1014342

Alternative method: use `cbind()` just like with matrices

Sorting data frames

- To sort a *vector*, we could use the `sort()`

```
sort(df$earnings)
```

```
## [1]  4286 12662 21204
```

> THIS CAN'T SORT DATA FRAMES

- A column of a data frame is fine, but it can't sort the whole thing!

Sorting data frames

- To sort a data frame, we use the `order()` function
  - It returns the order of each element in increasing value
    - 1 is the lowest value
  - Then we pass the new order like we are selecting elements

```
ordering <- order(df$earnings)
ordering
```

```
## [1] 3 1 2
```

```
df <- df[ordering,]
df
```

```
##             companyName earnings tech_firm all_zero revenue    margin
## Goldman        Goldman     4286     FALSE        0   42254 0.1014342
## Google          Google    12662      TRUE        0  110855 0.1142213
## Microsoft    Microsoft    21204      TRUE        0   89950 0.2357310
```

Sorting data frames

- Order can sort by multiple levels
  - `order(level1,level2,...)`, where `level_` are vectors or data frame columns

```
# Example of multicolumn sorting:
example <- data.frame(firm=c("Google","Microsoft","Google","Microsoft"),
                      year=c(2017,2017,2016,2016))
example
```

```
##        firm year
## 1    Google 2017
## 2 Microsoft 2017
## 3    Google 2016
## 4 Microsoft 2016
```

```
# with() allows us to avoiding prepending each column with "example$"
ordering <- order(example$firm, example$year)
example <- example[ordering,]
example
```

```
##        firm year
## 3    Google 2016
## 1    Google 2017
## 4 Microsoft 2016
## 2 Microsoft 2017
```

Subsetting data frames

1. We can use the selecting methods from before
2. We can pass a vector of logical values telling R what to keep
   - This is pretty useful!

```
df[df$tech_firm,]  # Remember the comma!
```

```
##           companyName earnings tech_firm all_zero revenue    margin
## Google         Google    12662      TRUE        0  110855 0.1142213
## Microsoft   Microsoft    21204      TRUE        0   89950 0.2357310
```

3. We can use the `subset()` function
   - I don't recommend this function, as it does not always work
     - There are times where it is useful though

```
subset(df,earnings < 20000)
```

```
##         companyName earnings tech_firm all_zero revenue    margin
## Goldman     Goldman     4286     FALSE        0   42254 0.1014342
## Google       Google    12662      TRUE        0  110855 0.1142213
```

Practice: Data frames

- This exercise explores the nature of banks' deposits
  - We will see which of Goldman, JPMorgan, and Citigroup have (since 2010):
    - The least of their assets in deposits
    - The most of their assets in deposits
- Do exercise 4 on the supplementary R practice file:
  - R Practice

Logical expressions

Why use logical expressions?

- We just saw an example in our subsetting function
  - `earnings < 20000`
- Logical expressions give us more control over the data
- They let us easily create logical vectors for subsetting data

```
df$earnings
```

```
## [1]  4286 12662 21204
```

```
df$earnings < 20000
```

```
## [1]  TRUE  TRUE FALSE
```

Logical operators

`==` `!=` `>` `<` `>=` `<=` `!` `|` `&`

- Equals: `==`
  - `2 == 2` → TRUE
  - `2 == 3` → FALSE
  - `'dog'=='dog'` → TRUE
  - `'dog'=='cat'` → FALSE

- Not equals: `!=`
  - The opposite of `==`
  - `2 != 2` → FALSE
  - `2 != 3` → TRUE
  - `'dog'!='cat'` → TRUE

- Comparing strings is done character by character
  - Be very careful with it

Logical operators

`==` `!=` `>` `<` `>=` `<=` `!` `|` `&`

- Greater than: `>`
  - `2 > 1` ⟶ TRUE
  - `2 > 2` ⟶ FALSE
  - `2 > 3` ⟶ FALSE
  - `'dog'>'cat'` ⟶ TRUE

- Less than: `>`
  - `2 < 1` ⟶ FALSE
  - `2 < 2` ⟶ FALSE
  - `2 < 3` ⟶ TRUE
  - `'dog'<'cat'` ⟶ FALSE

- Greater than or equal to: `>`
  - `2 >= 1` ⟶ TRUE
  - `2 >= 2` ⟶ TRUE
  - `2 >= 3` ⟶ FALSE

- Less than or equal to: `>`
  - `2 <= 1` ⟶ FALSE
  - `2 <= 2` ⟶ TRUE
  - `2 <= 3` ⟶ TRUE

Logical operators

- Not: `!`
  - This simply inverts everything
  - `!TRUE` $\rightarrow$ FALSE
  - `!FALSE` $\rightarrow$ TRUE
- And: `&`
  - `TRUE & TRUE` $\rightarrow$ TRUE
  - `TRUE & FALSE` $\rightarrow$ FALSE
  - `FALSE & FALSE` $\rightarrow$ FALSE
- Or: `|` (pipe, same key as '\')
  - Note that `|` is evaluated after all `&`s
  - `TRUE | TRUE` $\rightarrow$ TRUE
  - `TRUE | FALSE` $\rightarrow$ TRUE
  - `FALSE | FALSE` $\rightarrow$ FALSE
- You can mix in parentheses for grouping as needed

Examples for logical operators

- How many tech firms had >$10B in revenue in 2017?

```
sum(tech_df$revenue > 10000)
```

```
## [1] 46
```

- How many tech firms had >$10B in revenue but had negative earnings in 2017?

```
sum(tech_df$revenue > 10000 & tech_df$earnings < 0)
```

```
## [1] 4
```

- Who are those 4 with high revenue and negative earnings?

```
columns <- c("conm","tic","earnings","revenue")
tech_df[tech_df$revenue > 10000 & tech_df$earnings < 0, columns]
```

```
##                              conm   tic  earnings  revenue
## 35                    CORNING INC   GLW  -497.000 10116.00
## 45  TELEFONAKTIEBOLAGET LM ERICS   ERIC -4307.493 24629.64
## 120         DELL TECHNOLOGIES INC 7732B -3728.000 78660.00
## 214                    NOKIA CORP   NOK -1796.087 27917.49
```

Other special values

- We know `TRUE` and `FALSE` already
  - Note that `FALSE` can be represented as 0
  - Note that `TRUE` can be represented as any non-zero number
- There are also:
  - `Inf`: Infinity, often caused by dividing something by 0
  - `NaN`: “Not a number,” likely that the expression 0/0 occurred
  - `NA`: A missing value, usually *not* due to a mathematical error
  - `Null`: Indicates a variable has nothing in it
- We can check for these with:
  - `is.inf()`
  - `is.nan()`
  - `is.na()`
  - `is.null()`

Practice: Subsetting our data frame

- This practice focuses on subsetting out potentially interesting parts of our data frame
  - We will also see which of Goldman, JPMorgan, and Citigroup, in which year, had the lowest earnings since 2010
- Do exercise 5 on the supplementary R practice file:
  - R Practice

Other uses

- Conditional statements (used for programming)

```
# cond1, cond2, etc. can be any logical expression
if(cond1) {
  # Code runs if cond1 is TRUE
} else if (cond2) { # Can repeat 'else if' as needed
  # Code runs if this is the first condition that is TRUE
} else {
  # Code runs if none of the above conditions TRUE
}
```

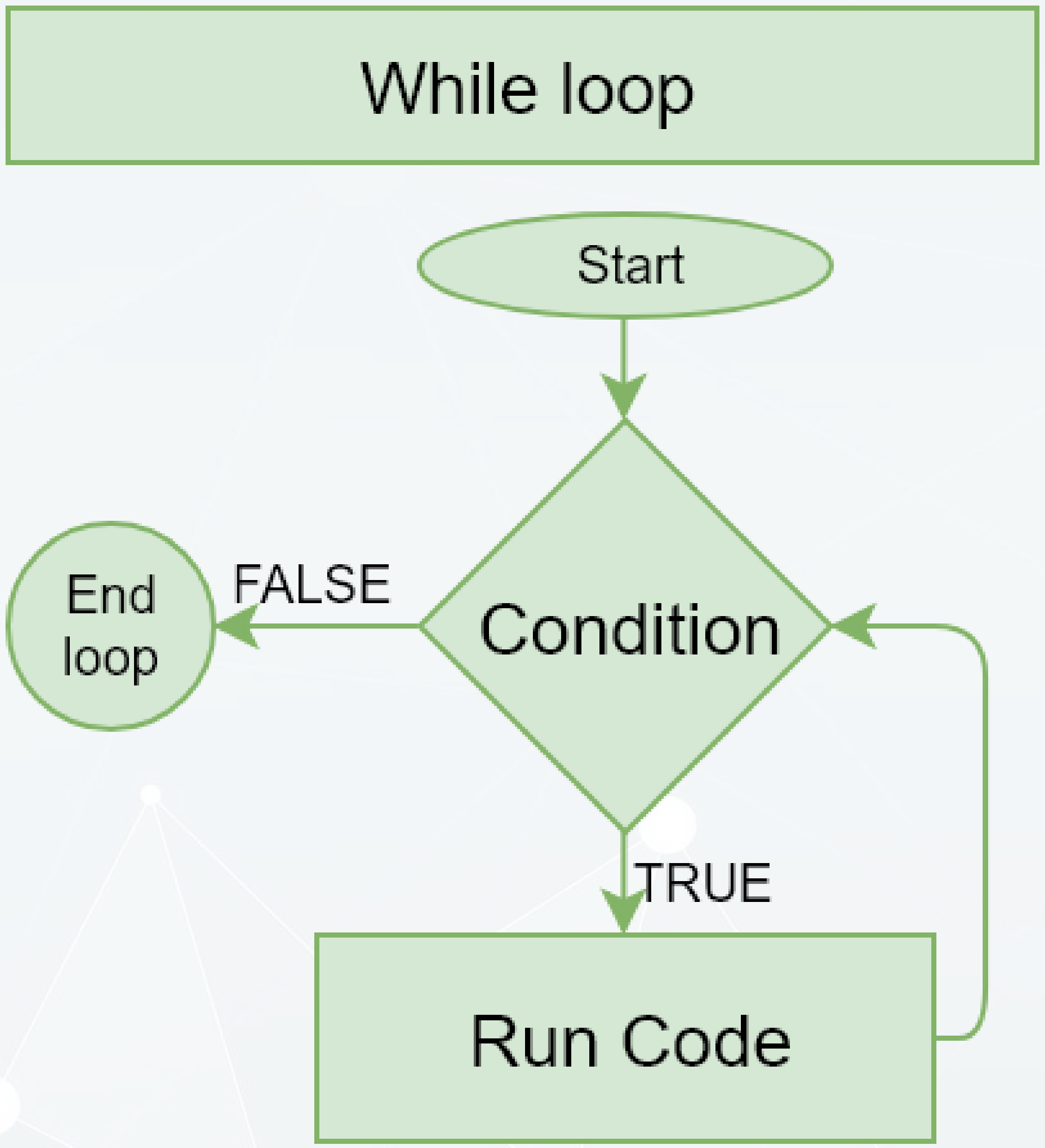
- Vectorized conditional statements using `ifelse()`
  - If else takes 3 vectors and returns 1 vector
    - A vector of `TRUE` or `FALSE`
    - A vector of elements to return from when `TRUE`
    - A vector of elements to return from when `FALSE`

```
# Outputs odd for odd numbers and even for even numbers
even <- rep("even",5)
odd <- rep("odd",5)
numbers <- 1:5
ifelse(numbers %% 2, odd, even)
```

```
## [1] "odd"  "even" "odd"  "even" "odd"
```

Loops and apply

Looping: While loop

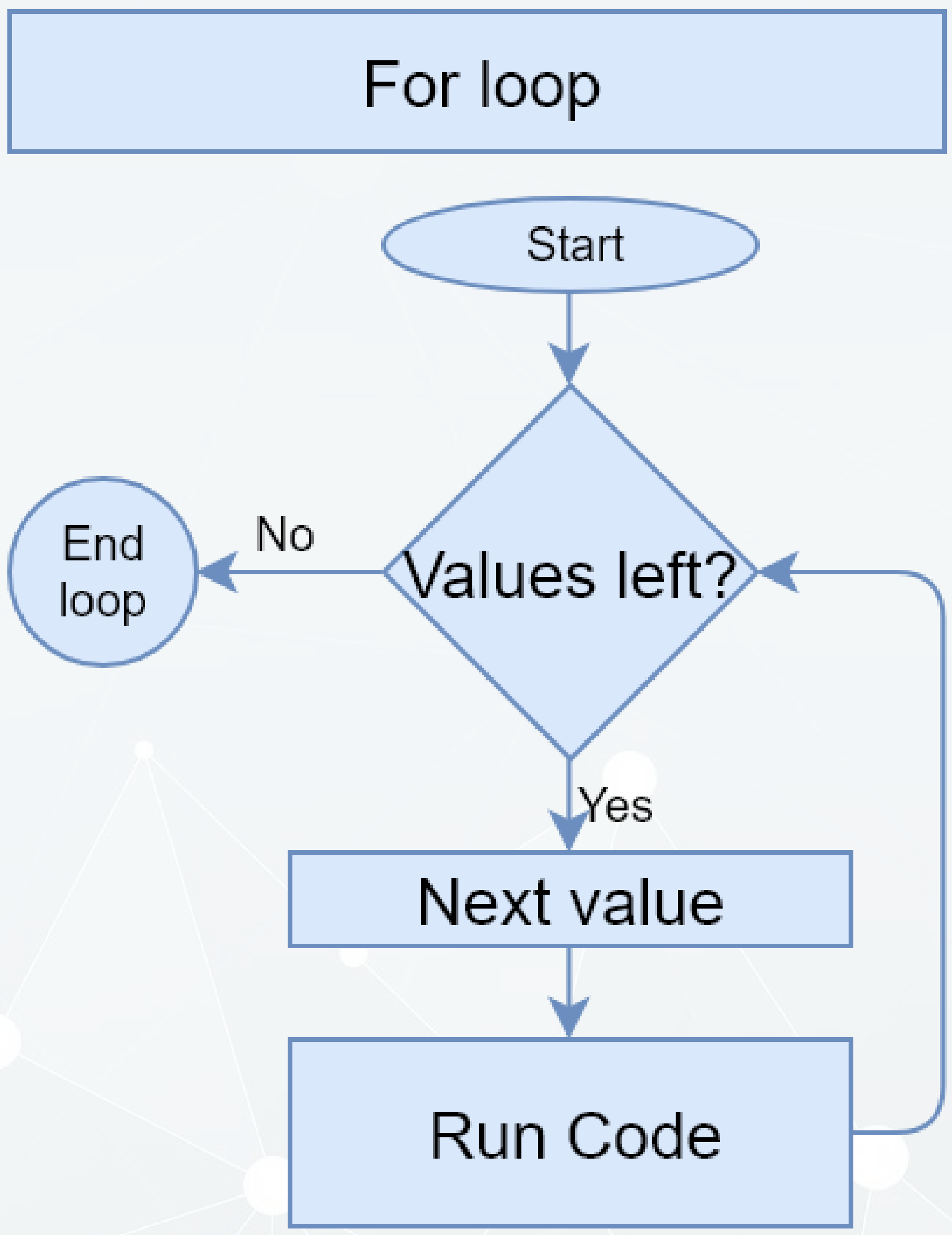


- A `while()` loop executes code repeatedly until a specified condition is `FALSE`

```
i = 0
while(i < 5) {
  print(i)
  i = i + 2
}
```

```
## [1] 0
## [1] 2
## [1] 4
```

Looping: For loop



- A `for()` loop executes code repeatedly until a specified condition is `FALSE`, while incrementing a given variable

```
for(i in c(0,2,4)) {
  print(i)
}
```

```
## [1] 0
## [1] 2
## [1] 4
```

Dangers of looping in R

- Loops in R are very slow – they do one calculation at a time, but R is best for doing many calculations at once

```
# Profit margin, all US tech firms
start <- Sys.time()
margin_1 <- rep(0,length(tech_df$ni))
for(i in seq_along(tech_df$ni)) {
  margin_1[i] <- tech_df$earnings[i] /
               tech_df$revenue[i]
}
end <- Sys.time()
time_1 <- end - start
time_1
```

```
## Time difference of 0.009973049 sec
```

```
# Profit margin, all US tech firms
start <- Sys.time()
margin_2 <- tech_df$earnings /
            tech_df$revenue
end <- Sys.time()
time_2 <- end - start
time_2
```

```
## Time difference of 0.001995087 sec
```

```
identical(margin_1, margin_2)  # Are these calculations identical?  Yes they are.
```

```
## [1] TRUE
```

```
paste(as.numeric(time_1) / as.numeric(time_2), "times") # How much slower is the
```

```
## [1] "4.99880497131931 times"
```

Useful functions

Help functions

- There are two equivalent ways to quickly access help files:
  - `?` and `help()`
  - Usage to get the help file for `data.frame()`:
    - `?data.frame`
    - `help(data.frame)`
- To see the options for a function, use `args()`

```
args(data.frame)
```

```
## function (..., row.names = NULL, check.rows = FALSE, check.names = TRUE,
##     fix.empty.names = TRUE, stringsAsFactors = default.stringsAsFactors())
## NULL
```

A note on using functions

```
args(data.frame)
```

```
## function (..., row.names = NULL, check.rows = FALSE, check.names = TRUE,
##     fix.empty.names = TRUE, stringsAsFactors = default.stringsAsFactors())
## NULL
```

- The `...` represents a series of inputs
  - In this case, inputs like `name=data`, where name is the column name and data is a vector
- The `____ = ____` arguments are options for the function
  - The default is prespecified, but you can overwrite it
    - Recall: `stringsAsFactors = FALSE` from earlier
- Options can be very useful or save us a lot of time!
- You can always find them by:
  - Using the `?` command
  - Checking other documentation like www.rdocumentation.org
  - Using the `args()` function

Installing more functions

- R Provides an easy way to install packages without ever leaving R
  - The `install.packages()` command
  - Can install a single package or a vector of packages

```
# To install the tidyverse package:
install.packages("tidyverse")

# To install ggplot2, dplyr, and magrittr packages:
install.packages(c("ggplot2", "dplyr", "magrittr"))
```

- Load packages using `library()`
  - Need to do this each time you open a new instance of R

```
# Load the tidyverse package
library(tidyverse)
```

Pipe notation

> Pipe notation is never necessary and not built in to R

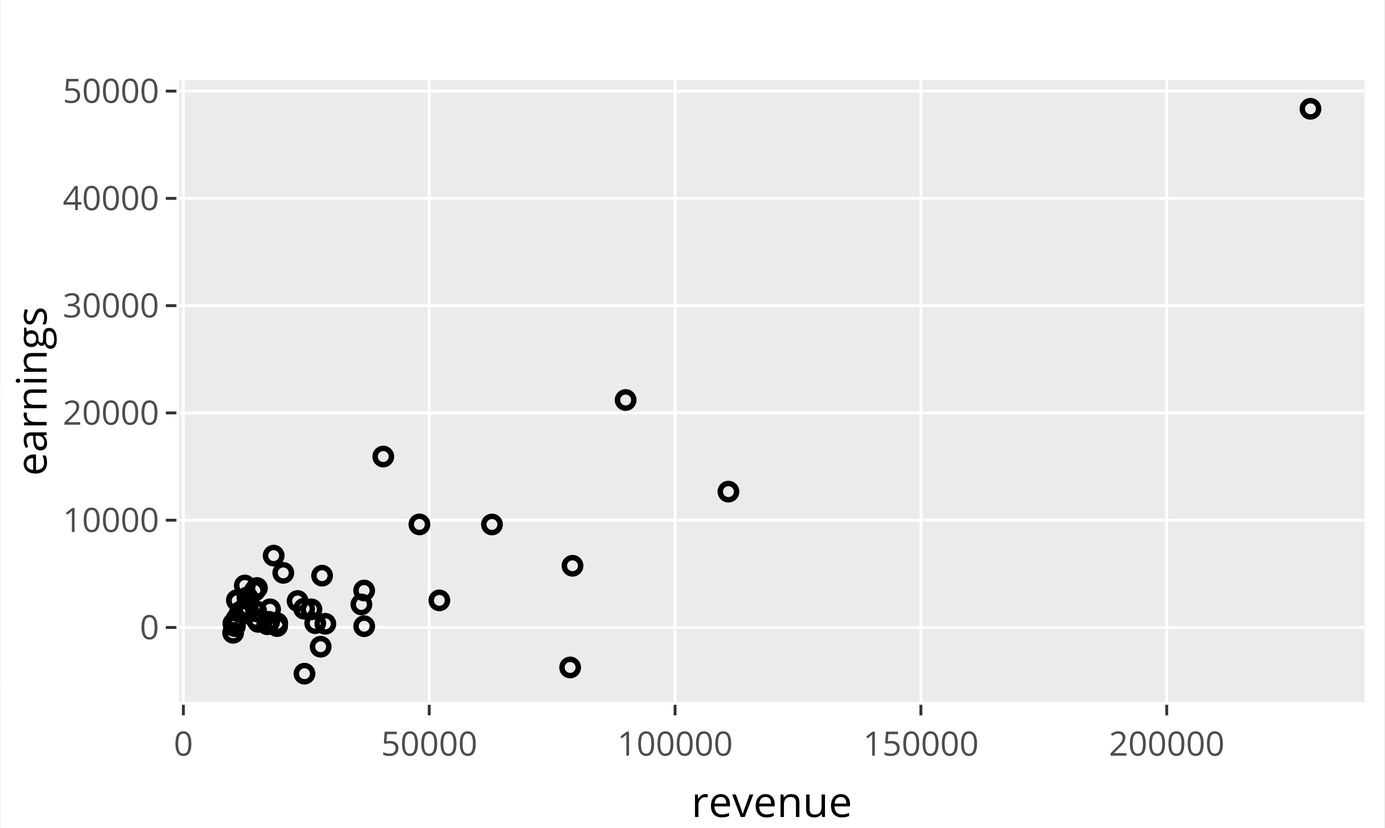
- Pipe notation is provided by the `magrittr` package
  - Part of `tidyverse`, an extremely popular collection of packages
- Pipe notation is done using `%>%`
  - `Left %>% Right(arg2, ...)` is the same as `Right(Left, arg2, ...)`

> Piping can drastically improve code readability

Piping example

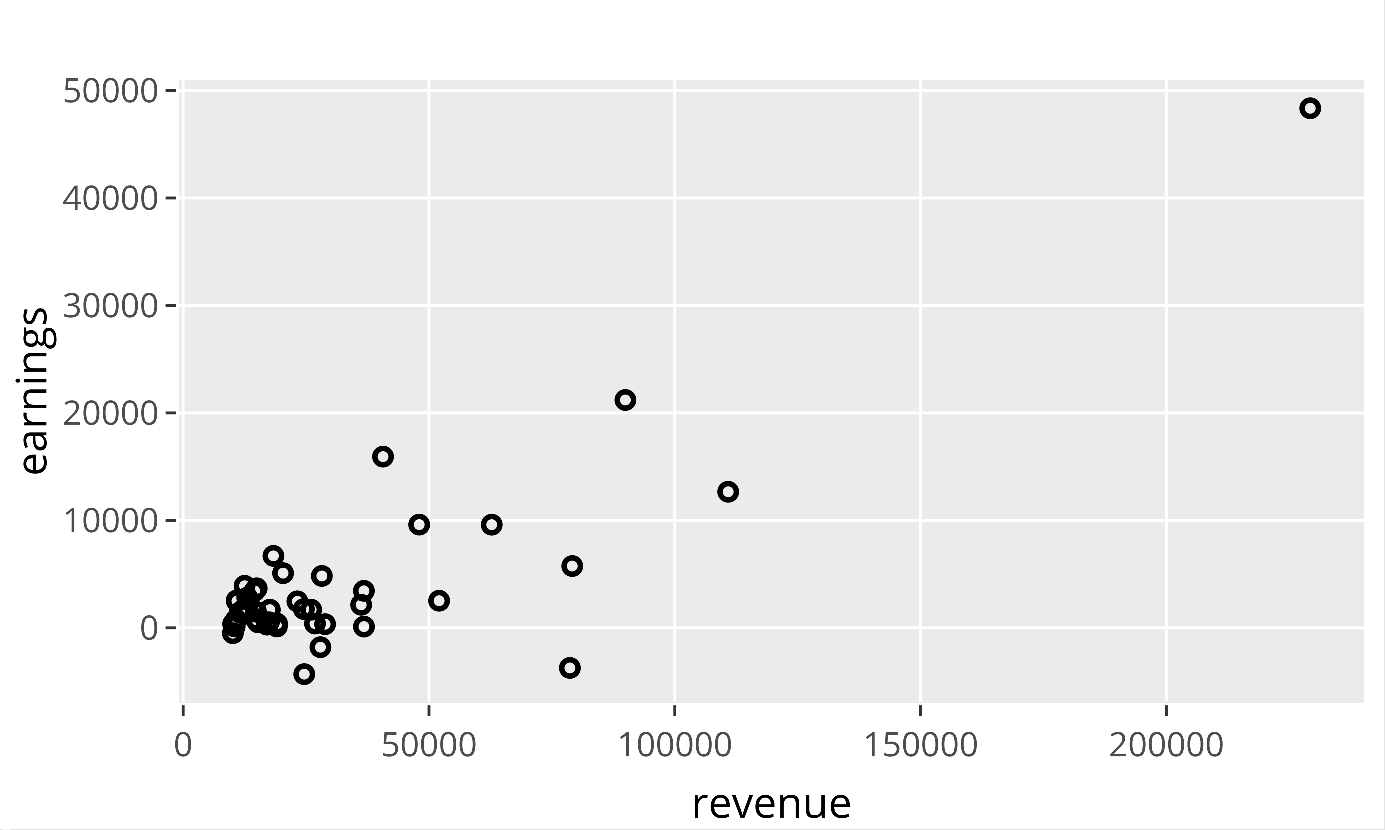
> Plot tech firms' earnings vs revenue, >$10B in revenue

```
library(tidyverse)
library(plotly)

plot <- tech_df %>%
  subset(revenue > 10000) %>%
  ggplot(aes(x=revenue,y=earnings)) + # ggplot comes from ggplot2, part of tidyver
  geom_point(shape=1, aes(text=sprintf("Ticker: %s", tic)))  # Adds point, and tic
ggplotly(plot)  # Makes the plot interactive
```



Piping example: Without piping

```r
library(tidyverse)
library(plotly)

plot <- ggplot(subset(tech_df, revenue > 10000), aes(x=revenue,y=earnings)) +
  geom_point(shape=1, aes(text=sprintf("Ticker: %s", tic)))
ggplotly(plot)  # Makes the plot interactive
```



Practice: External library usage

- This practice focuses on using an external library
  - We will also see which of Goldman, JPMorgan, and Citigroup, in which year, had the lowest earnings since 2010
- Do exercise 6 on the supplementary R practice file:
  - R Practice

> Note: The ~ indicates a formula the left side is the y-axis and the right side is the x-axis

> Note: The | tells lattice to make panels based on the variable(s) to the right

Math functions

- `sum()`: Sum of a vector
- `abs()`: Absolute value
- `sign()`: The sign of a number

```
vector = c(-2,-1,0,1,2)
sum(vector)
```

```
## [1] 0
```

```
abs(vector)
```

```
## [1] 2 1 0 1 2
```

```
sign(vector)
```

```
## [1] -1 -1  0  1  1
```

Stats functions

- `mean()`: Calculates the mean of a vector
- `median()`: Calculates the median of a vector
- `sd()`: Calculates the sample standard deviation of a vector
- `quantile()`: Provides the *quartiles* of a vector
- `range()`: Gives the minimum and maximum of a vector
  - Related: `min()` and `max()`

```r
quantile(tech_df$earnings)
```

```
##          0%         25%         50%         75%        100%
## -4307.4930   -15.9765     1.8370    91.3550  48351.0000
```

```r
range(tech_df$earnings)
```

```
## [1] -4307.493 48351.000
```

Make your own functions!

- Use the `function()` function!
  - `my_func <- function(agruments) {code}`

Simple function: Add 2 to a number

```
add_two <- function(n) {
  n + 2
}

add_two(500)
```

```
## [1] 502
```

Slightly more complex function example

```
mult_together <- function(n1, n2=0, square=FALSE) {
  if (!square) {
    n1 * n2
  } else {
    n1 * n1
  }
}

mult_together(5,6)
```

```
## [1] 30
```

```
mult_together(5,6,square=TRUE)
```

```
## [1] 25
```

```
mult_together(5,square=TRUE)
```

```
## [1] 25
```

Practice: Functions

- This practice focuses on making a custom function
  - Currency conversion between USD and SGD!
    - A web-based example is in the end notes
- Do exercise 7 on the supplementary R practice file:
  - R Practice

Packages used for these slides

- `DT`
- `kableExtra`
- `knitr`
- `plotly`
- `quantmod`
- `revealjs`
- `RColorBrewer`
- `tidyverse`

Custom functions

```
# Custom code for small tables from dataframes
library(knitr)
library(kableExtra)
html_df <- function(text, cols=NULL, col1=FALSE, full=F) {
  if(!length(cols)) {
    cols=colnames(text)
  }
  if(!col1) {
    kable(text, "html", col.names=cols, align=c("l", rep('c',length(cols)-1))) %>%
      kable_styling(bootstrap_options=c("striped","hover","responsive"), full_width=full)
  } else {
    kable(text, "html", col.names=cols, align=c("l", rep('c',length(cols)-1))) %>%
      kable_styling(bootstrap_options=c("striped", "hover","responsive"), full_width=full) %>%
      column_spec(1,bold=T)
  }
}
```

```
# Custom code for pulling 1 day of ForEx data from OANDA
FXRate <- function(from="USD", to="SGD", dt=Sys.Date()) {
  options("getSymbols.warning4.0"=FALSE)
  require(quantmod)
  data <- getSymbols(paste0(from, "/", to), from=dt-1, to=dt, src="oanda", auto.assign=F)
  return(data[[1]])
}
```