What is R?

R is a program. Like any program, it takes inputs from a user and does something.

In this case, the input is your code.

You can input code in two ways:

1. R can read it from a file
2. R can read it "interactively"

We'll focus on using R interactively in this module.

Does Something

What do we want R to do? What is the output?

This will determine how you use R (or any other language).

Communication

If you want to communicate something to someone:

- HTML
- PDF Document
- Jupyter Notebook
- Website
- Pretty Pictures

Plus the code to repeat/modify the above material

ETL

If you want to transform data:

- CSV, JSON, RData, SQL, database entries

Plus the code to repeat/modify the transformation

Your Own Opinion

If you want to learn, ask questions, the output might be:

- Nothing

Plus the code to repeat/modify your question or answer.

You're writing code

No matter what you use R for, the code is always an end in and of itself.

R is functional

You can manage code complexity in R with functions.

1. Write functions that have one responsibility.
2. Assign each responsibility fully to one function.

Learning R

Today we want to use R to do the following:

Test the accuracy of the standard errors in an OLS regression, given input data of different sizes, with Gaussian noise.

Break down the problem

The first step is to break down the task into separate responsibilities:

1. Generate input data with Gaussian noise, of differing sizes.
2. Get standard errors of OLS regression on the above input data.
3. Compare OLS estimate to the true value.

Responsibility

Given our breakdown of the tasks in this problem, we know we need 3 functions.

Let's start with the first one, generating data.

Functions in R

Here is a function that generates zeros:

```
generate_data <- function (howMuchData) {
    output <- rep(0, how_much_data)
    return(output)
}
```

How does variable assignment work? Function arguments? Function calls?

Functions in R

Remember the return statement is optional. This is the same:

```
generate_data <- function (how_much_data) {
    output <- rep(0, how_much_data)
    output
}
```

Functions in R

What if we do this? Is this the same function?

```
how_much_data <- 20

generate_data <- function () {
    output <- rep(0, how_much_data)
    output
}
```

Functions in R

If R doesn’t find a variable inside the function, it will look outside.

Functions in R

What's bad about this?

```
generate_data <- function () {
    output <- rep(0, how_much_data)
    output
}

how_much_data <- 20
data <- generate_data()

how_much_data <- 35
data_2 <- generate_data()
```

Functions in R

Remember the responsibility metaphor. Previously, the function generate_data was completely in charge of generating data.

In this version, the responsibility of generating the data is shared: between the function and whoever is in charge of keeping track of the value of “how_much_data” in the global scope.

Functions in R

That someone is you.

But you shouldn't be sharing the responsiblity. You have enough to do.

Give the responsibility fully to the function. Write a reliable function.

Functions in R

```
generate_data <- function (how_much_data) {
    output <- rep(0, how_much_data)
    output
}


data <- generate_data(20)

data_2 <- generate_data(35)
```

Generating Data

Let's work on generating data according to the data generating process:

$$y = \beta x + \epsilon$$

Where

$$x \sim Normal(0, 1)$$
$$\epsilon \sim Normal(0, \sigma^2)$$

Generating Data

```
generate_data <- function(N, beta, sd) {
    x <- rnorm(N, 0, 1)
    eps <- rnorm(N, 0, sd)
    y <- beta*x + eps
    list(x = x, y = y)
}
```

What are lists in R?

Generating Data

```
generate_data <- function(N, beta, sd) {
    x <- rnorm(N, 0, 1)
    eps <- rnorm(N, 0, sd)
    y <- beta*x + eps
    list(x = x, y = y)
}
```

What is a list?

Running the Regression

```
run_regression <- function(y, x) {
    coef <- ???
    se <- ???
    list(coef=coef, se=se)
}
```

Here again we have two responsibilities:

1. Calculating the coefficient on x.
2. Calculating the standard errors on the coefficients.

Running the Regression

```
calc_coef <- function(y,x) cov(x,y) / var(x)

calc_se <- function(y, x, coef) {
    n <- length(y)
    eps <- y - x*coef
    e_sd <- mean(eps^2)
    se <- sqrt(e_sd / (n*var(x)))
    se
}
```

- Functions can be put on one line!
- var() actually returns the unbiased variance estimate (n-1), but we will just use it to keep things simple.

Running the Regression

```
run_regression <- function(y, x) {
    coef <- calc_coef(y, x)
    se <- calc_se(y, x)
    list(coef=coef, se=se)
}
```

Evaluating the Model

```
eval_model <- function(coef, se, beta, conf = 1.96) {
    up <- coef + se*conf
    down <- coef - se*conf
    beta > down & beta < up
}
```

- Default function values
- Logical operators
- Will this return a scalar or a vector? (depends on coef and beta!)

Evaluating the Model

```
eval_model <- function(coef, se, beta, conf = 1.96) {
    up <- coef + se*conf
    down <- coef - se*conf
    beta > down & beta < up
}
```

Note:

- Default function values
- Logical operators
- Will this return a scalar or a vector?

Making our simulation

```
simulate <- function(N, beta, sd) {
    d <- generate_data(N, beta, sd)
    m <- run_regression(d$y, d$x)
    eval_model(m$coef, m$se, beta)
}

avg_simulations <- function(M, N, beta, sd) {
    inside <- sapply(1:M, function (x) simulate(N, beta, sd
    sum(inside) / M
}
```

- apply family
- Summing boolean vector

Results

Let's see our results:

```
library(ggplot2)

check_N <- function(M, beta, sd) {
    x <- seq(4, 50, 2)
    y <- sapply(x, function(N) avg_simulations(M, N, beta,
    qplot(x, y)
}
```

Results

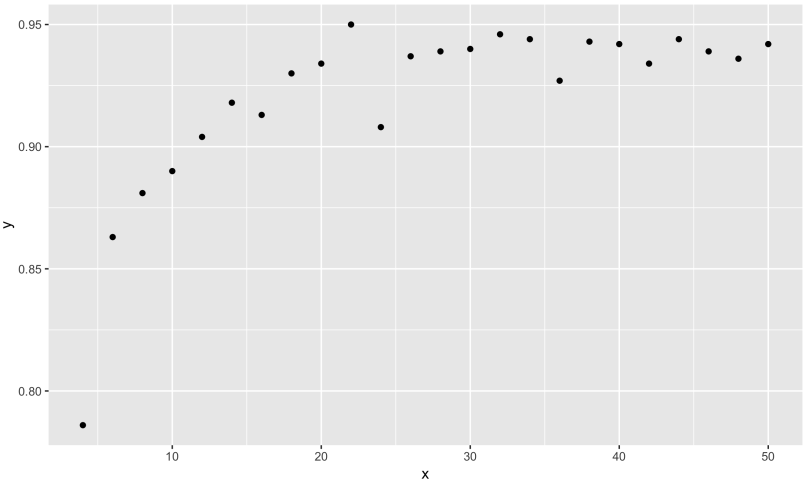

Figure 1: inline