Data Analysis in R

Adam Rawles

Recap

- What is R and RStudio?
- Basic arithmetic operators
- Variable assigment
- Data types
- Data structures (including subsetting)
- Functions

Overview

- Installing packages
- Loading data
- Cleaning data
- Summary statistics
- Graphs and plots

Installing packages

- Installing packages with RStudio is easy to do
- RStudio has a built-in interface for installing packages...
- Or, you can use the R function "install.packages()", and provide the name of the package(s) you want to install to the function

```
install.packages("ggplot2")
install.packages(c("ggplot2", "dplyr"))
```

- Packages must be loaded before they are available, via the library() function

```
library(ggplot2)
```

- Note: if you close RStudio, you'll need to reload your packages

Loading data

- Data can be loaded into R in many formats
- The easiest of which are .xlsx or .csv files
- These can be loaded into R two different ways
  - The first is by using the read.csv()/read.xlsx() functions
    - The read.csv() function takes a string of the file's path as it's only required input argument
      - But there are a number of optional arguments (e.g. header, stringsAsFactor,...)
    - The read.xlsx() function requires both a path, and the index of the sheet you want from the workbook

Loading data

- The second is to use RStudio's built in "Import Dataset" interface
  - This interface essentially just acts as a wrapper to the read.csv()/xlsx() functions

Loading data - example

Loading data - example

```
consdata <- read.csv("consdata.csv", header = TRUE, stringsAsFactors = TRUE)

head(consdata, n = 2)
```

```
##   settlement_date settlement_period metered_entity_type metered_entity
## 1      01/01/2018                1                MPAN       testmpan
## 2      01/01/2018                2                MPAN       testmpan
##   meter_reading actual_estimate avg_temperature_c
## 1        0.8889               E              7.40
## 2        0.8899               E              7.38
```

Loading data - exercise

- Using RStudio's "Import Dataset" or the read.csv() function, load the cons_data dataset

Data cleaning

- After the data is loaded into R, we need to make sure that each column is in the correct format (e.g. character, factor, numeric, etc.)
- This can be done two different ways:
  - You can either click on the dataframe in the Environment pane, which will open the dataframe in the Source pane
    - From here, you can hover over the column headers to see what type the data is stored as
  - Or, you can use the is.xxxxx functions to check from the console.
    - To do this, you choose the appropriate function for the type you want (e.g. is.numeric()), and include the column you want to check as an argument

Data cleaning

```
is.numeric(consdata$meter_reading) ## we could also do is.numeric(consdata[,1]) as per our last session
```

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

```
is.numeric(consdata$actual_estimate)
```

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

```r
is.factor(consdata$actual_estimate)
```

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

Data cleaning

- If you want to get the type of a column without comparing it to other types, you use the is() function
- The first value returned from this function will tell you the data type of the column

```r
is(consdata$meter_reading)
```

```
## [1] "numeric" "vector"
```

```r
is(consdata$actual_estimate)
```

```
## [1] "factor"              "integer"             "oldClass"
## [4] "numeric"             "vector"              "data.frameRowLabels"
```

Data cleaning

- If a column does not have the correct type, we can easily coerce the values into the type that we want
- The exact method is different depending on what you are converting from and to
- Generally speaking however, the method for converting a column type is:

```r
dataframe$column <- as.xxxxx(dataframe$column)
```

Data cleaning - exercise

- Convert the meter reading column into a character, check that it's been converted, and then convert it back to numeric

```r
consdata$meter_reading <- as.character(consdata$meter_reading)

is.character(consdata$meter_reading)
```

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

```r
consdata$meter_reading <- as.numeric(consdata$meter_reading)
```

Data cleaning

- This method works well for:
  - Numeric/integer to character
  - Character to numeric/integer
  - Integer to numeric
  - Numeric to integer

  - Character to factor
  - Factor to character
  - Numeric to factor
- For factor to numeric, there's an extra step:
  - Before the factors levels can be converted, they need to be converted to characters first:

```
dataframe$column <- as.numeric(as.character(dataframe$column))
```

Data cleaning - dates

- Dates in R can be tricky
  - R will not import date values in as dates unless you specify that it should
    - But RStudio's "Import Dataset" feature can be pretty handy here...
  - If you don't, R will import them as characters (which means they'll be converted to factors unless you specify stringsAsFactors = FALSE)
- To convert a character to a date, use the as.Date() function...

Data cleaning - dates (example)

```
datetest <- "12/12/2018"
datetest <- as.Date(datetest, format = "%d/%m/%Y")
is(datetest)
```

```
## [1] "Date"     "oldClass"
```

- To convert from a factor to a date, first convert to a character...

Data cleaning - dates (exercise)

- Our consdata$settlement_date column is currently a factor, convert it to date
- Remeber to convert the column to character first!

```
consdata$settlement_date <- as.character(consdata$settlement_date)
consdata$settlement_date <- as.Date(consdata$settlement_date, format = "%d/%m/%Y")
```

```
consdata$settlement_date <- as.Date(as.character(consdata$settlement_date), format = "%d/%m/%Y")
```

Data cleaning - dates

- Dates can also come in numeric form, calculated as the number of days from a particular origin
- For example, a numeric value of 1, with an origin of 12/12/2018 would correspond to a date value of 13/12/2018
- If your date values are in numeric format, you need to specify the origin in the as.Date() function...

Data cleaning - dates (example)

```
datetest <- 17940
datetest <- as.Date(datetest, origin = as.Date("01/01/1970", format = "%d/%m/%Y"))
datetest
```

```
## [1] "2019-02-13"
```

Data cleaning - dates

- With dates, always specify the format (format codes can be found online and are included in your help sheet)
- There's no is.Date() function in base R
- So to check whether a value is a date, use is()

Data cleaning - conclusion

- To find out the type of a column, use the is() function
- Otherwise, you can (usually) test if a column is a specific type via the is.xxxxx functions
- Converting between datatypes (except from numeric -> factor) is easy with the as.xxxxx functions
- When converting numbers to factors, convert them to characters first
- When converting from characters or numeric to dates, as.Date() requires "format" or "origin" parameters respectively

Summary statistics

- Before doing any in-depth analysis, it's always a good idea to get some descriptive statistics from your data
- This includes the mean, the median, the standard deviation, and the interquartile range, but the statistics you use will depend on your data
- Getting these values for each column is easy using the built-in functions R provides:

```
mean()
median()
sd()
quantile()
```

Summary statistics - exercise

- Find the mean, median, standard deviation, and quantiles for our meter reading column

```
mean(consdata$meter_reading)
```

```
## [1] 0.8383583
```

```
median(consdata$meter_reading)
```

```
## [1] 0.85145
```

```r
sd(consdata$meter_reading)
```

```
## [1] 0.05566309
```

```r
quantile(consdata$meter_reading)
```

```
##      0%     25%     50%     75%    100%
## 0.74840 0.77970 0.85145 0.88915 0.91740
```

Summary statistics

- More often than not however, you'll want summary statistics for more than one column, or maybe broken down by group
- R includes a function that will give you summary statistics for each column (the summary() function):

```r
summary(consdata)
```

```
##  settlement_date      settlement_period metered_entity_type
##  Min.   :2018-01-01   Min.   : 1.00     MPAN:96
##  1st Qu.:2018-01-01   1st Qu.:12.75
##  Median :2018-03-22   Median :24.50
##  Mean   :2018-03-22   Mean   :24.50
##  3rd Qu.:2018-06-10   3rd Qu.:36.25
##  Max.   :2018-06-10   Max.   :48.00
##   metered_entity meter_reading    actual_estimate avg_temperature_c
##  testmpan:96     Min.   :0.7484   A:48            Min.   : 6.670
##                  1st Qu.:0.7797   E:48            1st Qu.: 7.338
##                  Median :0.8515                   Median : 8.280
##                  Mean   :0.8384                   Mean   : 8.929
##                  3rd Qu.:0.8891                   3rd Qu.:10.640
##                  Max.   :0.9174                   Max.   :12.300
```

Summary statistics by group

- Summary statistics by group are a little bit more complicated as they require the "psych" package
- Once the "psych" package is installed, you can use the describeBy() function to give you summary statistics for each level of a factor in your dataset:
- Note: You'll likely get some error messages if one of your columns isn't numeric, but you can ignore them

```r
describeBy(consdata, consdata$actual_estimate)
```

Summary statistics by group - exercise

- Install the "psych" package
- Produce summary statistics by Settlement Date

Summary statistics by group - answer

```
install.packages("psych")
```

```
library(psych)
describeBy(consdata, consdata$settlement_date)
```

Summary statistics by group

```
## Warning in FUN(newX[, i], ...): no non-missing arguments to min; returning
## Inf

## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning
## -Inf

## Warning in FUN(newX[, i], ...): no non-missing arguments to min; returning
## Inf

## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning
## -Inf

##
##  Descriptive statistics by group
## group: A
##                      vars  n  mean    sd median trimmed   mad  min   max
## settlement_date         1 48   NaN    NA     NA     NaN    NA  Inf  -Inf
## settlement_period       2 48 24.50 14.00  24.50   24.50 17.79 1.00 48.00
## metered_entity_type*    3 48  1.00  0.00   1.00    1.00  0.00 1.00  1.00
## metered_entity*         4 48  1.00  0.00   1.00    1.00  0.00 1.00  1.00
## meter_reading           5 48  0.79  0.03   0.78    0.79  0.03 0.75  0.83
## actual_estimate*        6 48  1.00  0.00   1.00    1.00  0.00 1.00  1.00
## avg_temperature_c       7 48 10.58  1.06  10.65   10.60  1.16 8.63 12.30
##                      range  skew kurtosis   se
## settlement_date       -Inf    NA       NA   NA
## settlement_period    47.00  0.00    -1.28 2.02
## metered_entity_type*  0.00   NaN      NaN 0.00
## metered_entity*       0.00   NaN      NaN 0.00
## meter_reading         0.09  0.34    -1.24 0.00
## actual_estimate*      0.00   NaN      NaN 0.00
## avg_temperature_c     3.67 -0.22    -1.17 0.15
## ------------------------------------------------------------
## group: E
##                      vars  n  mean    sd median trimmed   mad  min   max
## settlement_date         1 48   NaN    NA     NA     NaN    NA  Inf  -Inf
## settlement_period       2 48 24.50 14.00  24.50   24.50 17.79 1.00 48.00
## metered_entity_type*    3 48  1.00  0.00   1.00    1.00  0.00 1.00  1.00
## metered_entity*         4 48  1.00  0.00   1.00    1.00  0.00 1.00  1.00
## meter_reading           5 48  0.89  0.01   0.89    0.89  0.01 0.87  0.92
## actual_estimate*        6 48  2.00  0.00   2.00    2.00  0.00 2.00  2.00
## avg_temperature_c       7 48  7.28  0.33   7.30    7.28  0.41 6.67  7.93
```

```
##                       range  skew kurtosis   se
## settlement_date        -Inf    NA       NA   NA
## settlement_period     47.00  0.00    -1.28 2.02
## metered_entity_type*   0.00   NaN      NaN 0.00
## metered_entity*        0.00   NaN      NaN 0.00
## meter_reading          0.05  0.14    -0.82 0.00
## actual_estimate*       0.00   NaN      NaN 0.00
## avg_temperature_c      1.26 -0.03    -1.17 0.05
```

Summary statistics - conclusion

- Producing summary statistics for columns in a dataframe can be done through the mean(), median(), sd(), and quartile() functions
- Producing summary statistics for multiple columns can be done with the summary() function
- Producing summary statistics by group requires the "psych" package, and the describeBy() function

Plotting

- After calculating your summary statistics, it can be useful to visualise the data to better understand any trends or differences
- For example, we may want to see if there's a difference between the meter reading values for estimates vs. actuals
- We could use a plot to visualise that difference
- There are two good ways to create plots
  - The first uses R's built-in plotting functions
  - The second uses a package called "ggplot2"

Plotting

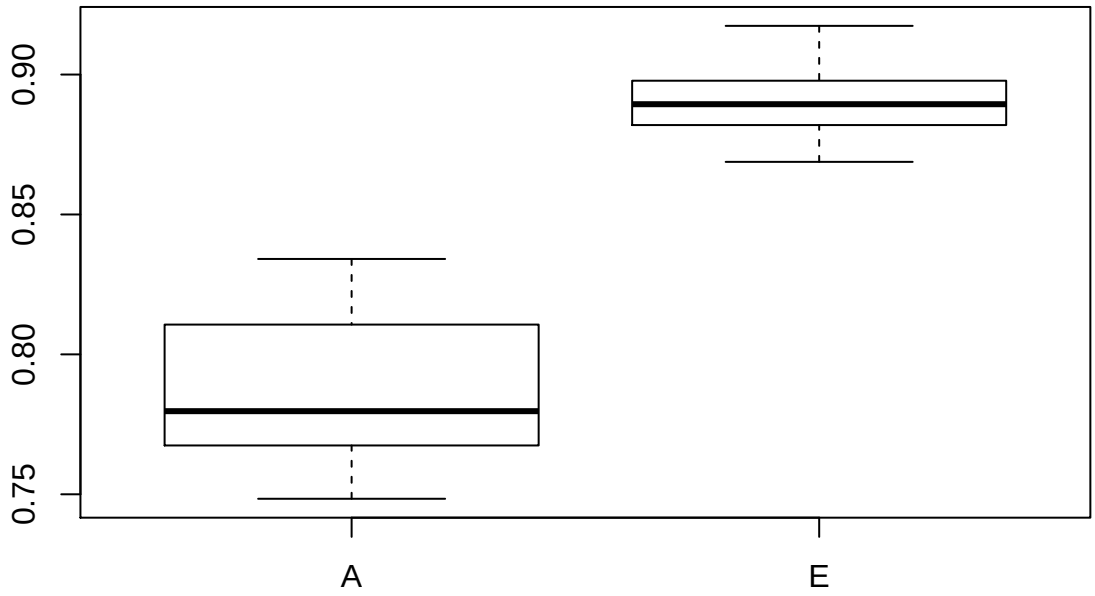
- R's main plotting function is plot()
- This function takes the data you want to visualise as it's only required argument, with optional arguments to specify what kind of plot you want
- If you don't specify what kind of plot you want, plot() tries to guess the most appropriate type of plot for your data, and creates it

Plotting - example

- First off, let's plot the meter reading values of estimates and actuals to see if there's a difference:

```
plot(x = consdata$actual_estimate, y = consdata$meter_reading)
```

Plotting - example



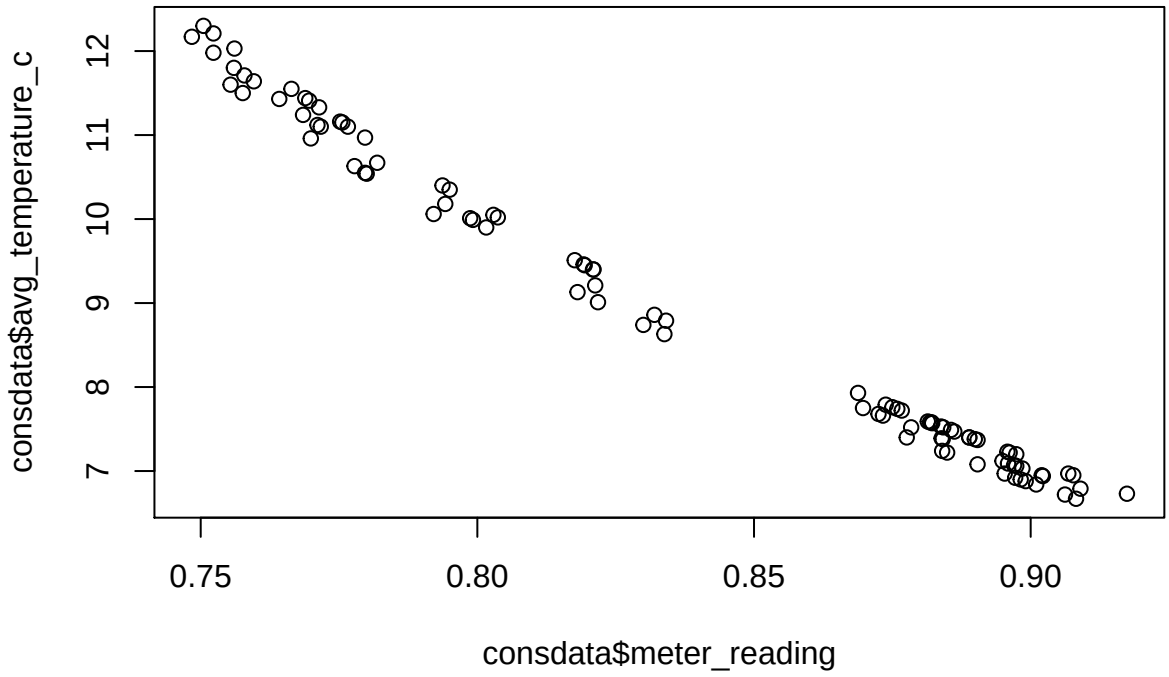
- As you can see, we've specified our x and y axis, but not what type of plot we want
- But the plot() function has guessed that we probably want a boxplot
- Note: you can also force R to create a boxplot using the boxplot() function

Plotting - example

- Next, we might want to see if there's a correlation between the meter reading and the temperature
- Again, we can use the plot function, specify our x and y axis, and R will guess what the best plot is

```
plot(x = consdata$meter_reading, y = consdata$avg_temperature_c)
```

Plotting - example



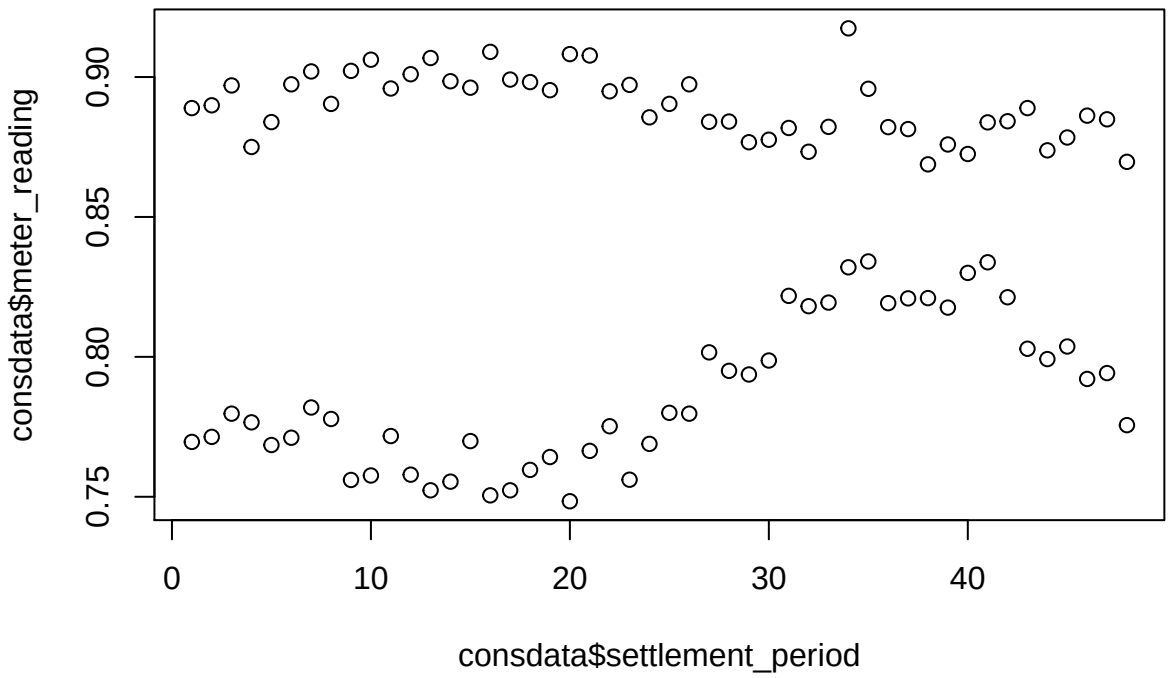
- R has created a scatter plot by default, but we can change the type if we wish using the option "type" argument
- See your help sheet for the different types

Plotting - exercise

- Create a plot of meter readings against Settlement Periods...

Plotting - answer

```
plot(x = consdata$settlement_period, y = consdata$meter_reading)
```

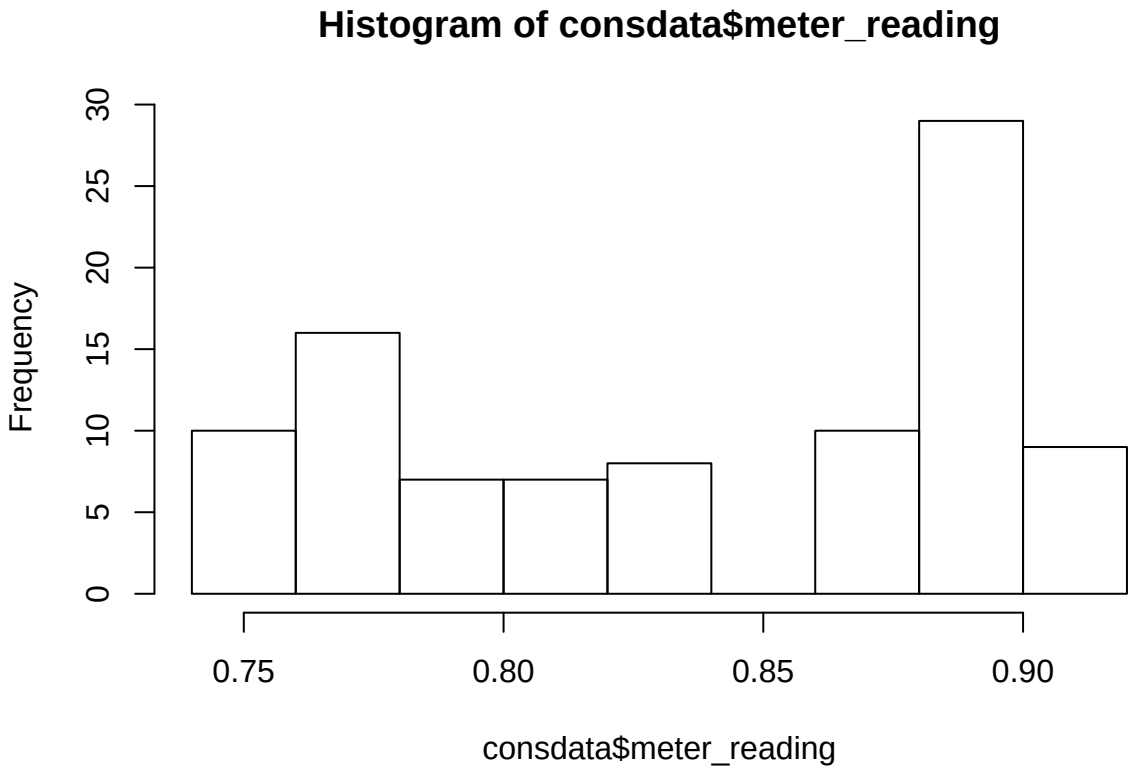


Histograms - example

- One of the best features of the plotting system in R is how easy it is to make histograms
- You can either use the plot() function and specify "h" as the type, or we can use the hist() function and provide one variable to produce a simple histogram...

```
hist(consdata$meter_reading)
```

Histograms - example



Customizing your graphs

- To make your graph easier to understand, you may want to...
  - Change the title
  - Change the axis labels
  - Change the points
  - Change the size of the bins for our histogram
- Note: These are a few of the customization options, but there are many, many more

Customizing your graphs

- Change the title
  - To change the title, all we need to do is specify a "main" parameter in our plot function...

```
plot(consdata$meter_reading, consdata$avg_temperature_c,
     main = "Correlation between temperature and consumption")
```

- Change the axis labels
  - To change the labels on the axes, we use the "xlab"/"ylab"" parameters...

```r
plot(consdata$meter_reading, consdata$avg_temperature_c,
     main = "Correlation between temperature and consumption",
     xlab = "Meter reading (KwH)",
     ylab = "Temperature (degrees Celsius)")
```

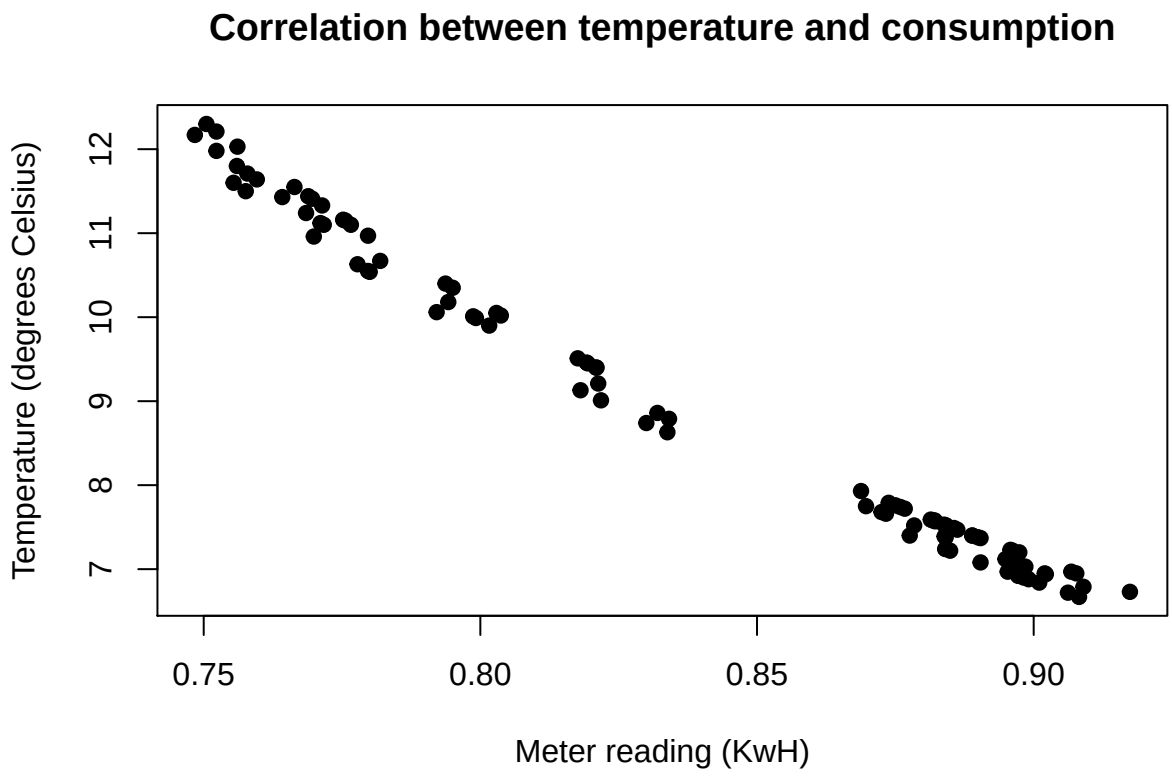
Customizing your graphs

- Changing the graph points
  - To change the points, we use the "pch" paremeter, and specify a value between 0 and 25...

```r
plot(consdata$meter_reading, consdata$avg_temperature_c,
     main = "Correlation between temperature and consumption",
     xlab = "Meter reading (KwH)",
     ylab = "Temperature (degress Celsius)",
     pch = 19)
```

- Putting those all together...

Customizing your graphs

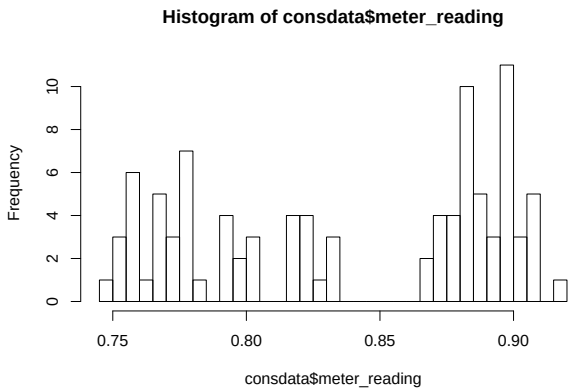


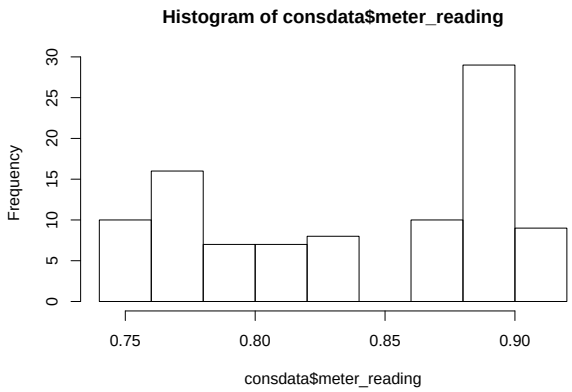
Customizing your graphs (histograms)

- In addition to the previous customization options, for histograms, we can change the size of the bins
  - To do this, we specify the "breaks" parameter in our hist() function
  - This splits up out our data into x number of bins of equal size

```
hist(consdata$meter_reading, breaks = 30)
```

Customizing your graphs (histograms)





Plotting - final exercise

- Create a plot of your choice, and change the title and axis labels.

Plotting - conclusion

- In short, R has lots of in-built tools to make quick, simple graphs and plots
- Most types of graph only require a few input parameters, but there's lots of customization options
- In a later module, we'll look at a package called ggplot2, which we'll use to create more complex and professional graphics

Conclusion

- Installing packages
  - install.packages(), library()
- Loading data
  - read.csv()/read.xlsx()
- Cleaning data
  - Data type checks
  - Data type conversion
    - Look out for dates and factors!
- Plotting

  - plot()/hist()

- Customization
  - “main”, “xlab”, “ylab”, “pch”, “breaks”

- Next time...
  - Creating functions
  - For loops
  - If else statements