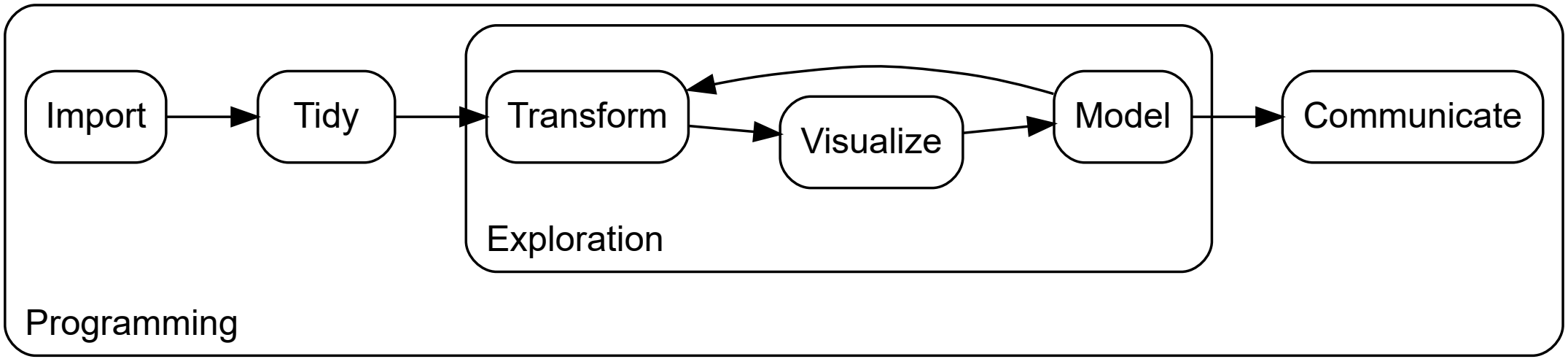
Data Analysis using R

Importing

Sven Werenbeck-Ueding

25.09.2023



Source: Wickham and Grolemund (2016)

Popular file formats

Excel Spreadsheet (.xlsx)

- Format for storing human-readable, rectangular data
- One or more sheets containing rectangular data
- Older spreadsheet file format: .xls

	A	B	C	D	E	F	G	H	I	J	K
1	Encuesta Nacional de Empleo/Encuesta Nacional de Ocupación y Empleo (Q3 2003 to Q3 2013										
2											
3											
4	id	migrate	female	age	municipali	year	quarter	marital_st	empl_stat	educ	income
5	189889	No	Female	50	2004	2004	Q2	Single	Unemploy	12	0
6	189889	No	Female	50	2004	2004	Q3	Single	Unemploy	12	0
7	189889	No	Female	50	2004	2004	Q4	Single	Unemploy	12	0
8	189889	No	Female	50	2004	2005	Q1	Widowed	Unemploy	12	0
9	189890	No	Male	26	2004	2005	Q3	Married	Full-time	10	
10	189890	No	Male	26	2004	2005	Q4	Married	Full-time	10	
11	189890	No	Male	26	2004	2006	Q1	Married	Full-time	10	
12	189890	No	Male	26	2004	2006	Q2	Married	Part-time	10	
13	189891	No	Male	36	2004	2006	Q4	Married	Part-time	6	3440
14	189891	No	Male	36	2004	2007	Q1	Married	Full-time	6	3440
15	189891	No	Male	36	2004	2007	Q2	Married	Full-time	6	3440
16	189891	No	Male	36	2004	2007	Q3	Married	Part-time	6	3440
17	189894	No	Female	33	2004	2010	Q3	Married	Full-time	9	559
18	189894	No	Female	33	2004	2010	Q4	Married	Full-time	9	559
19	189894	No	Female	33	2004	2011	Q1	Married	Part-time	9	559
20	189894	No	Female	33	2004	2011	Q2	Married	Full-time	9	559
21	189895	No	Male	32	2004	2011	Q4	Married	Full-time	9	5590
22	189895	No	Male	32	2004	2012	Q1	Married	Full-time	9	5590
23	189895	No	Male	32	2004	2012	Q2	Married	Full-time	9	5590
24	189895	No	Male	32	2004	2012	Q3	Married	Part-time	9	5590

Popular file formats

Comma Separated Values (.csv)

- Format for storing human-readable, rectangular data
- Values are most commonly separated by , or ;
- Each line corresponds to a row
- First line usually contains column names

```
Encuesta Nacional de Empleo/Encuesta Nacional de Ocupación y Empleo (Q3 2003 to Q3 2013,,,,,,,,,
,,,,,,,,,
,,,,,,,,,
id,migrate,female,age,municipality,year,quarter,marital_status,empl_status,educ,income
189889,No,Female,50,2004,2004,Q2,Single,Unemployed,12,0
189889,No,Female,50,2004,2004,Q3,Single,Unemployed,12,0
189889,No,Female,50,2004,2004,Q4,Single,Unemployed,12,0
189889,No,Female,50,2004,2005,Q1,Widowed,Unemployed,12,0
189890,No,Male,26,2004,2005,Q3,Married,Full-time,10,NA
189890,No,Male,26,2004,2005,Q4,Married,Full-time,10,NA
189890,No,Male,26,2004,2006,Q1,Married,Full-time,10,NA
189890,No,Male,26,2004,2006,Q2,Married,Part-time,10,NA
189891,No,Male,36,2004,2006,Q4,Married,Part-time,6,3440
189891,No,Male,36,2004,2007,Q1,Married,Full-time,6,3440
189891,No,Male,36,2004,2007,Q2,Married,Full-time,6,3440
189891,No,Male,36,2004,2007,Q3,Married,Part-time,6,3440
189894,No,Female,33,2004,2010,Q3,Married,Full-time,9,559
189894,No,Female,33,2004,2010,Q4,Married,Full-time,9,559
189894,No,Female,33,2004,2011,Q1,Married,Part-time,9,559
189894,No,Female,33,2004,2011,Q2,Married,Full-time,9,559
189895,No,Male,32,2004,2011,Q4,Married,Full-time,9,5590
189895,No,Male,32,2004,2012,Q1,Married,Full-time,9,5590
189895,No,Male,32,2004,2012,Q2,Married,Full-time,9,5590
189895,No,Male,32,2004,2012,Q3,Married,Part-time,9,5590
189896,No,Male,51,2004,2013,Q1,Widowed,Full-time,6,2580
189896,No,Male,51,2004,2013,Q2,Single,Full-time,6,2580
```

Example Data

- Mexican survey data used in Feigenberg (2020a) and provided by Feigenberg (2020b)
  - Encuesta Nacional de Ocupación y Empleo (ENOE)
  - Q3 2003 to Q3 2013
  - Quarterly rotating panel: Households included for 5 quarters
  - Records whether any household member leaves to the US
  - Potential migrants are restricted from ages 15 to 65
  - Explanatory variables: age, gender, marital status and education for all household members
- In folder `data/raw/` of the online repository in csv and excel format
- Data was altered to satisfy needs for this course

Importing Data

readxl

> The readxl package makes it easy to get data out of Excel and into R. [...] `readxl` has no external dependencies, so it's easy to install and use on all operating systems. It is designed to work with tabular data. `readxl` supports both the legacy .xls format and the modern xml-based .xlsx format.
>
> Wickham and Bryan (2022)

`readxl` is part of the tidyverse but not part of its core packages!

Load the package to use it:

```
#install.packages("readxl")
library(readxl)
```

read_excel()

```
?read_excel
```

The `read_excel()` function is capable of reading data from .xls and .xlsx files. If the file format is known, it is recommended to directly use `read_xls()` or `read_xlsx()`, respectively, to prevent `R` from guessing.

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`path`

The path to the file you want to read

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`sheet`

String or integer specifying the sheet name or position to read; defaults to the first sheet

Ignored if the sheet is specified via `range`

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`range`

Excel expression for the cell range to read from, e. g. "B3:D87". Can also be used to specify the sheet name like "Budget!B2:G14".

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`col_names`

- Either `TRUE`/`FALSE` or a character vector of column names
- If `TRUE`, the default, the first row is used as column names
- If `FALSE`, column names are generated in this fashion: `X1`, `X2`, \dots

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

col_types

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`na`

Character vector to interpret as missing values; defaults to empty cells, i. e. `""`

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`skip`

Number of rows to skip before reading the data; defaults to 0

Ignored if `range` is given

read_excel()

```
?read_excel
```

Function call and arguments:

```
read_excel(
  path,
  sheet = NULL,
  range = NULL,
  col_names = TRUE,
  col_types = NULL,
  na = "",
  skip = 0,
  n_max = Inf,
  ...
)
```

`n_max`

Sets the maximum number of rows to read; defaults to `Inf`

Ignored if `range` is given

Let's try this out!

Code | Message | Output

- Import raw data on migration choice of Mexicans and their socioeconomic characteristics
- Data sets can be found in the data folder of the repository

```
read_excel("data/raw/enoe/enoe.xlsx")
```

Let's try this out!

Code | Message | Output

```
## New names:
## • `` -> `...2`
## • `` -> `...3`
## • `` -> `...4`
## • `` -> `...5`
## • `` -> `...6`
## • `` -> `...7`
## • `` -> `...8`
## • `` -> `...9`
## • `` -> `...10`
## • `` -> `...11`
## • `` -> `...12`
```

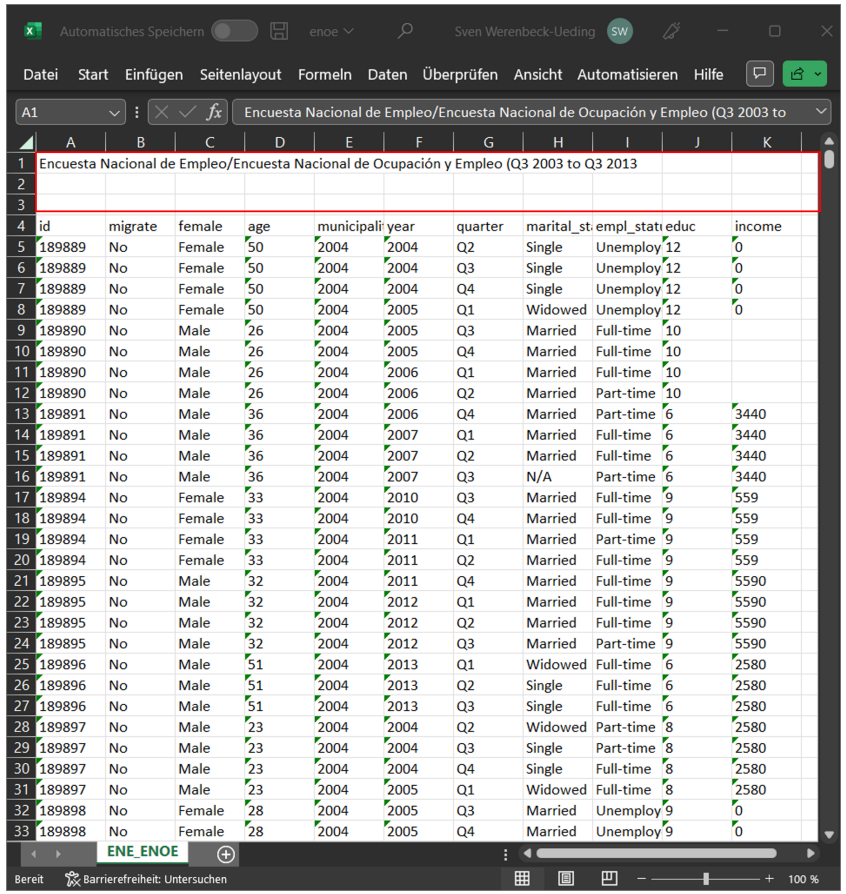
Let's try this out!

Code | Message | **Output**

```
## # A tibble: 165,460 × 12
##    Encuesta …¹ ...2  ...3  ...4  ...5  ...6  ...7  ...8  ...9  ...10 ...11 ...12
##    <chr>       <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr>
##  1 <NA>        <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>
##  2 <NA>        <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>
##  3 id          migr… age   muni… fence year  quar… sex   mari… empl… educ  inco…
##  4 189889      No    50    2004  0     2004  Q3    Fema… Sing… Unem… 12    0
##  5 189889      No    50    2004  0     2004  Q4    Fema… Sing… Unem… 12    0
##  6 189889      No    50    2004  0     2005  Q1    Fema… Sing… Unem… 12    0
##  7 189890      No    26    2004  0     2005  Q4    Male  Marr… Full… 10    <NA>
##  8 189890      No    26    2004  0     2006  Q1    Male  Marr… Full… 10    <NA>
##  9 189890      No    26    2004  0     2006  Q2    Male  N/A   Full… 10    <NA>
## 10 189891      No    36    2004  0     2006  Q4    Male  Marr… Full… 6     3440
## # … with 165,450 more rows, and abbreviated variable name
## #   ¹`Encuesta Nacional de Empleo/Encuesta Nacional de Ocupación y Empleo (Q3 2003 to Q3 2013`
```

What happened?

Let's take a look at the excel file:



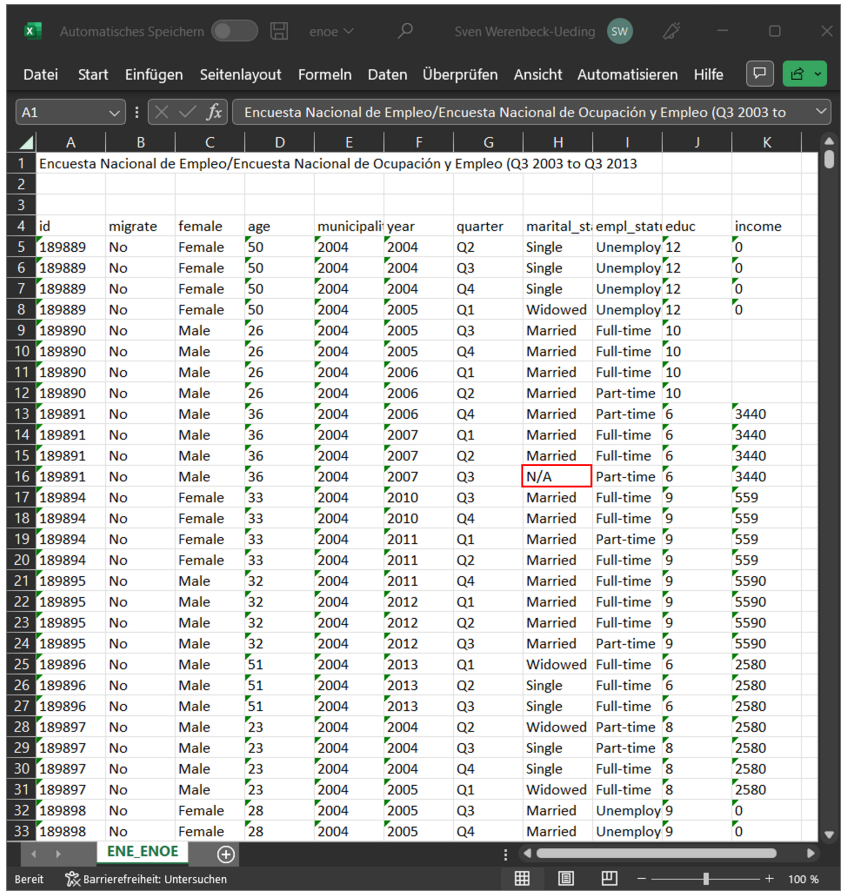
The first few rows contain some information about the spreadsheet itself. This is **very** common with excel files from government authorities!

We can use the `skip` argument to start reading after the third line:

```
read_excel("data/raw/enoe/enoe.xlsx",
           skip = 3)
```

What happened?

Let's take a look at the excel file:



There seems to be some inconsistencies with the naming of missing values...

Use the `na` argument to treat empty cells and `N/A` as missing values (`NA`):

```
read_excel("data/raw/enoe/enoe.xlsx",
           skip = 3,
           na = c("", "N/A"))
```

Another try...

Code | Message | Output

```
read_excel("data/raw/enoe/enoe.xlsx",
           skip = 3, # Skip the first three lines
           na = c("", "N/A")) # Interpret empty cells and cells containing "N/A" as missing
```

Another try...

Code | Message | Output

Another try...

Code | Message | Output

```
## # A tibble: 165,457 × 12
##    id     migrate age   munici…¹ fence year  quarter sex   marit…² empl_…³ educ
##    <chr>  <chr>   <chr> <chr>    <chr> <chr> <chr>   <chr> <chr>   <chr>   <chr>
##  1 189889 No      50    2004     0     2004  Q3      Fema… Single  Unempl… 12
##  2 189889 No      50    2004     0     2004  Q4      Fema… Single  Unempl… 12
##  3 189889 No      50    2004     0     2005  Q1      Fema… Single  Unempl… 12
##  4 189890 No      26    2004     0     2005  Q4      Male  Married Full-t… 10
##  5 189890 No      26    2004     0     2006  Q1      Male  Married Full-t… 10
##  6 189890 No      26    2004     0     2006  Q2      Male  <NA>    Full-t… 10
##  7 189891 No      36    2004     0     2006  Q4      Male  Married Full-t… 6
##  8 189891 No      36    2004     0     2007  Q1      Male  Married Full-t… 6
##  9 189891 No      36    2004     0     2007  Q2      Male  Married Full-t… 6
## 10 189894 No      33    2004     1     2010  Q3      <NA>  Married Full-t… 9
## # … with 165,447 more rows, 1 more variable: income <chr>, and abbreviated
## #   variable names ¹municipality, ²marital_status, ³empl_status
```

readr

> The goal of `readr` is to provide a fast and friendly way to read rectangular data from delimited files, such as comma-separated values (CSV) and tab-separated values (TSV). It is designed to parse many types of data found in the wild, while providing an informative problem report when parsing leads to unexpected results.
>
> Wickham, Hester, and Bryan (2022)

read_csv()

```
?read_csv
```

`read_csv()` function is a special case of `read_delim()` with the **separator set to `,`** used for reading files with comma separated values. The related **`read_csv2()`**, in contrast, **assumes a `;` as separator** for values and interprets `,` as decimal point (which is common in some European countries).

- Considerably faster than the base `R` solution `read.csv()`
- Consistent parameter naming (`col_names` and `col_type` instead of `header` and `colClasses`)
- Automatically parses common date formats, but leaves strings unaltered
- Progression bar for big data sets

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`file`

The path to the file you want to read

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`col_names`

- Either `TRUE`/`FALSE` or a character vector of column names
- If `TRUE`, the default, the first row is used as column names
- If `FALSE`, column names are generated in this fashion: `X1`, `X2`, \dots

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`col_types`

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`col_select`

Character vector containing columns to include in the resulting data set; defaults to `NULL`

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`na`

Character vector to interpret as missing values; defaults to `c("", "NA")`

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`skip`

Number of lines to skip before reading the data; defaults to 0

read_csv()

```
?read_csv
```

Function call and arguments:

```
read_csv(
  file,
  col_names = TRUE,
  col_types = NULL,
  col_select = NULL,
  na = c("", "NA"),
  skip = 0,
  n_max = Inf,
  ...
)
```

`n_max`

Sets the maximum number of lines to read; defaults to `Inf`

Import the ENE/ENOE Data Set from CSV

Code | Message | Output

```
read_csv("data/raw/enoe/enoe.csv")
```

Import the ENE/ENOE Data Set from CSV

Code | Message | Output

```
## New names:
## • `` -> `...2`
## • `` -> `...3`
## • `` -> `...4`
## • `` -> `...5`
## • `` -> `...6`
## • `` -> `...7`
## • `` -> `...8`
## • `` -> `...9`
## • `` -> `...10`
## • `` -> `...11`
## • `` -> `...12`

## Warning: One or more parsing issues, call `problems()` on your data frame for details,
## e.g.:
##   dat <- vroom(...)
##   problems(dat)
```

Import the ENE/ENOE Data Set from CSV

Code | Message | Output

```
## Warning: One or more parsing issues, call `problems()` on your data frame for details,
## e.g.:
##   dat <- vroom(...)
##   problems(dat)

## # A tibble: 165,460 × 12
##    Encuesta …¹ ...2  ...3  ...4  ...5  ...6  ...7  ...8  ...9  ...10 ...11 ...12
##          <dbl> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr> <chr>
##  1          NA <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>
##  2          NA <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>
##  3          NA migr… age   muni… fence year  quar… sex   mari… empl… educ  inco…
##  4      189889 No    50    2004  0     2004  Q3    Fema… Sing… Unem… 12    0
##  5      189889 No    50    2004  0     2004  Q4    Fema… Sing… Unem… 12    0
##  6      189889 No    50    2004  0     2005  Q1    Fema… Sing… Unem… 12    0
##  7      189890 No    26    2004  0     2005  Q4    Male  Marr… Full… 10    <NA>
##  8      189890 No    26    2004  0     2006  Q1    Male  Marr… Full… 10    <NA>
##  9      189890 No    26    2004  0     2006  Q2    Male  N/A   Full  10    <NA>
```

Similar problems as before!

- Skip first three lines
- Set first line (after skipping three lines) as column names
- Interpret `N/A` as missing

Import ENE/ENOE Data with Function Arguments

Code | Message | Output

```
read_csv("data/raw/enoe/enoe.csv",
         skip = 3,
         col_names = TRUE, # The default
         na = c("", "N/A"))
```

Import ENE/ENOE Data with Function Arguments

Code | Message | Output

```
## Rows: 165457 Columns: 12
## ── Column specification ────────────────────────────────────────────────────
## Delimiter: ","
## chr (11): migrate, age, municipality, fence, year, quarter, sex, marital_sta...
## dbl  (1): id
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Import ENE/ENOE Data with Function Arguments

Code | Message | Output

```
## # A tibble: 165,457 × 12
##        id migrate age   munici…¹ fence year  quarter sex   marit…² empl_…³ educ
##     <dbl> <chr>   <chr> <chr>    <chr> <chr> <chr>   <chr> <chr>   <chr>   <chr>
##  1 189889 No      50    2004     0     2004  Q3      Fema… Single  Unempl… 12
##  2 189889 No      50    2004     0     2004  Q4      Fema… Single  Unempl… 12
##  3 189889 No      50    2004     0     2005  Q1      Fema… Single  Unempl… 12
##  4 189890 No      26    2004     0     2005  Q4      Male  Married Full-t… 10
##  5 189890 No      26    2004     0     2006  Q1      Male  Married Full-t… 10
##  6 189890 No      26    2004     0     2006  Q2      Male  <NA>    Full-t… 10
##  7 189891 No      36    2004     0     2006  Q4      Male  Married Full-t… 6
##  8 189891 No      36    2004     0     2007  Q1      Male  Married Full-t… 6
##  9 189891 No      36    2004     0     2007  Q2      Male  Married Full-t… 6
## 10 189894 No      33    2004     1     2010  Q3      NA    Married Full-t… 9
## # … with 165,447 more rows, 1 more variable: income <chr>, and abbreviated
## #   variable names ¹municipality, ²marital_status, ³empl_status
```

Data Types

Vectors in R

- Vectors can be distinguished in atomic vectors and lists
  - Atomic vector: All elements must have the same type
  - Lists: Elements can have different types
- If you are already familiar with R, you probably have encountered vectors on several occasions, e. g. the sequence `1:10` is an atomic vector containing all integers between 1 and 10

```
1:10
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```
typeof(1:10) # Check the type of the integer vector 1:10
```

```
## [1] "integer"
```

Primary Types of Atomic Vectors

Type	Description	How to check
Logical	`TRUE`/`FALSE` or their abbreviations `T`/`F`. Simple calculations can be conducted on vectors of this type, e. g. `sum(T, T, F, T)` gives 3 because `TRUE` is interpreted as 1 and `FALSE` as 0.	`is.logical()`
Character	Strings surrounded by " or '	`is.character()`
Double	Numerical values with decimals. Special values are `Inf`, `-Inf` and `NaN`.	`is.double()`
Integer	Numerical values that cannot contain fractional values. Must be followed by `L`	`is.integer()`

Both, Integers and doubles, are numerical values!

`is.numeric()` returns `TRUE` for values that are either integers *or* doubles.

Factors: Representation of Categorical Data

- Factors contain predefined values only
- Integer vector with attributes `class` ("factor") and `levels` (set of values)

```
# Create a factor vector with two levels c("Employed", "Unemployed")
fct <- factor(c("Employed", "Employed", "Unemployed", "Employed"))

fct
```

```
## [1] Employed   Employed   Unemployed Employed
## Levels: Employed Unemployed
```

```
# Take a look at the vector
str(fct)
```

```
##  Factor w/ 2 levels "Employed","Unemployed": 1 1 2 1
```

Factors: Representation of Categorical Data

```
# Check the vector type
typeof(fct)
```

```
## [1] "integer"
```

```
# Get the vector attributes
attributes(fct)
```

```
## $levels
## [1] "Employed"   "Unemployed"
##
## $class
## [1] "factor"
```

```
# To get the levels of a vector, use the short-hand levels() function instead
levels(fct)
```

```
## [1] "Employed"   "Unemployed"
```

Lists

```
# Construct a list
our_list <- list(1:10, # Integer sequence
                 seq(0, 1, by = 0.25), # Double sequence
                 c("This", "is", "a", "character", "vector"), # Character vector
                 factor(c("Employed", "Employed", "Unemployed", "Employed"))) # Factor vector
```

```
typeof(our_list)
```

```
## [1] "list"
```

```
# Take a look at the list structure
str(our_list)
```

```
## List of 4
##  $ : int [1:10] 1 2 3 4 5 6 7 8 9 10
##  $ : num [1:5] 0 0.25 0.5 0.75 1
##  $ : chr [1:5] "This" "is" "a" "character" ...
##  $ : Factor w/ 2 levels "Employed","Unemployed": 1 1 2 1
```

Lists

Lists may contain more complex objects than atomic vectors, such as lists.

```
list(1:10,
     seq(0, 1, by = 0.25),
     list("a", 1:2))
```

```
## [[1]]
##  [1]  1  2  3  4  5  6  7  8  9 10
##
## [[2]]
## [1] 0.00 0.25 0.50 0.75 1.00
##
## [[3]]
## [[3]][[1]]
## [1] "a"
##
## [[3]][[2]]
## [1] 1 2
```

Data Frames

- Data sets are usually represented as `data.frame` objects in R
- A `data.frame` is essentially a named list of vectors with equal length

```
# Construct a data frame
df <- data.frame(income = c(0, 500, 3000),
                 empl_status = factor(c("Unemployed", "Employed", "Employed")))
```

Data Frames

```
# Check the type
typeof(df)
```

```
## [1] "list"
```

```
# Get the attributes
attributes(df)
```

```
## $names
## [1] "income"      "empl_status"
##
## $class
## [1] "data.frame"
##
## $row.names
## [1] 1 2 3
```

tibble

> A `tibble`, or `tbl_df`, is a modern reimagining of the `data.frame`, keeping what time has proven to be effective, and throwing out what is not. `Tibbles` are `data.frames` that are lazy and surly: they do less (i.e. they don't change variable names or types, and don't do partial matching) and complain more (e.g. when a variable does not exist). This forces you to confront problems earlier, typically leading to cleaner, more expressive code. `Tibbles` also have an enhanced `print()` method which makes them easier to use with large datasets containing complex objects.
>
> Müller and Wickham (2022)

Data Frames vs. Tibbles

Tibbles' enhanced `print()` function shows only the first 10 rows and displays information on the data structure:

```
# Construct a data frame
df <- data.frame(
  income = c(0, 500, 3000),
  empl_status = factor(
    c("Unemployed", "Employed", "Employed")
  )
)

# Print the data frame
df
```

```
##   income empl_status
## 1      0  Unemployed
## 2    500    Employed
## 3   3000    Employed
```

```
# Construct a tibble
tbl <- tibble(
  income = c(0, 500, 3000),
  empl_status = factor(
    c("Unemployed", "Employed", "Employed")
  )
)

# Print the tibble
tbl
```

```
## # A tibble: 3 × 2
##   income empl_status
##    <dbl> <fct>
## 1      0 Unemployed
## 2    500 Employed
## 3   3000 Employed
```

Data Frames vs. Tibbles

When subsetting, `tibble` gives a warning if the column does not exist:

```
df$gender
```

```
## NULL
```

```
tbl$gender
```

```
## Warning: Unknown or uninitialised column: `gender`
```

```
## NULL
```

Importing Data as Tibble

`read_excel()` and `read_csv()` automatically create a `tibble` object:

```
data <- read_csv("data/raw/enoe/enoe.csv", skip = 3, col_names = TRUE, na = c("", "N/A"))

typeof(data)
```

```
## Rows: 165457 Columns: 12
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr (11): migrate, age, municipality, fence, year, quarter, sex, marital_sta...
## dbl  (1): id
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.

## [1] "spec_tbl_df" "tbl_df"      "tbl"         "data.frame"
```

The class of a `tibble` also contains "data.frame". Hence, functions applied to `data.frame` objects can also be applied to `tibbles`.

Further Literature

- Further information on tibbles can be found in chapter 10 of Wickham and Grolemund (2016) and the package documentation (see Müller and Wickham (2022)).
- Chapter 3 of Wickham (2019) discusses the technical properties of vectors in R more deeply.

Exporting Data

write_csv()

```
?write_csv
```

write_csv() function is a special case of `write_delim()` with the **separator set to ,**. Again, there is a related **write_csv2()** which sets the separator to `;`.

- Considerably faster than the base `R` solution `write.csv()`
- Does not include row names as a column in the written file
- Progression bar for big data sets

write_csv()

```
?write_csv
```

Function call and arguments:

```
write_csv(
  x,
  file,
  na = "NA",
  append = FALSE,
  col_names = !append,
  ...
)
```

x

A `data.frame` or `tibble` to write to `.csv`

write_csv()

```
?write_csv
```

Function call and arguments:

```
write_csv(
  x,
  file,
  na = "NA",
  append = FALSE,
  col_names = !append,
  ...
)
```

`file`

File (path) to write to

write_csv()

```
?write_csv
```

Function call and arguments:

```
write_csv(
  x,
  file,
  na = "NA",
  append = FALSE,
  col_names = !append,
  ...
)
```

na

String used for missing values; defaults to "NA"

write_csv()

```
?write_csv
```

Function call and arguments:

```
write_csv(
  x,
  file,
  na = "NA",
  append = FALSE,
  col_names = !append,
  ...
)
```

append

- If FALSE, the default, the existing will be overwritten.
- If TRUE, it will be appended to the existing file.

write_csv()

```
?write_csv
```

Function call and arguments:

```
write_csv(
  x,
  file,
  na = "NA",
  append = FALSE,
  col_names = !append,
  ...
)
```

`col_names`

- If `FALSE`, column names will not be included at the top of the file.
- If `TRUE`, column names will be included.
- The default is to take the opposite value given to argument `append`

Export the ENE/ENOE Data Set to CSV

Code | Output

```
data <- read_csv("data/raw/enoe/enoe.csv", skip = 3, col_names = TRUE, na = c("", "N/A"))

write_csv(data, "data/raw/enoe.csv")
```

Export the ENE/ENOE Data Set to CSV

Code | Output

The exported data is stored in csv format in the raw folder of the data folder:

```
list.files("data/raw/")
```

```
## [1] "enoe"              "enoe.csv"          "fence_construction"
```

References

Feigenberg, B. (2020a). "Fenced Out: The Impact of Border Construction on US-Mexico Migration". In: *American Economic Journal: Applied Economics* 12.3, pp. 106-39. DOI: 10.1257/app.20170231. URL: https://www.aeaweb.org/articles?id=10.1257/app.20170231.

Feigenberg, B. (2020b). *Replication package for: Fenced Out: The Impact of Border Construction on US-Mexico Migration.* American Economic Association. URL: https://www.aeaweb.org/journals/dataset?id=10.1257/app.20170231.

Müller, K. and H. Wickham (2022). *tibble: Simple Data Frames*. https://tibble.tidyverse.org/, https://github.com/tidyverse/tibble.

Wickham, H. (2019). *Advanced R*. 2nd. Chapman & Hall/CRC. URL: http://adv-r.had.co.nz/.

Wickham, H. and J. Bryan (2022). *readxl: Read Excel Files*. https://readxl.tidyverse.org, https://github.com/tidyverse/readxl.

Wickham, H. and G. Grolemund (2016). *R for data science. import, tidy, transform, visualize, and model data*. O'Reilly. URL: https://r4ds.had.co.nz/.

Wickham, H., J. Hester, and J. Bryan (2022). *readr: Read Rectangular Text Data*. https://readr.tidyverse.org, https://github.com/tidyverse/readr.