Data Handling: Import, Cleaning and Visualisation

Lecture 7:

Data Sources, Data Gathering, Data Import

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Welcome back!

Updates

Guest Lecture by Corina Grünenfelder

9 December 2021, “Data Science in Insurance”

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Part II: Data gathering and preparation

Date	Topic
18.11.2021	Data sources, data gathering, data import
25.11.2021	Data preparation and manipulation
25.11.2021	Exercises/Workshop 4: Data import and data preparation/manipulation

Part III: Analysis, visualisation, output

Date	Topic
02.12.2021	Basic statistics and data analysis with R
09.12.2021	Guest Lecture (“Data Science in Insurance”)
09.12.2021	Exercises/Workshop 5: Applied data analysis with R
16.12.2021	Visualisation, dynamic documents
21.12.2021	Exercises/Workshop 6: Visualization, dynamic documents
23.12.2021	Summary, Wrap-Up, Q&A, Feedback
23.12.2021	Exam for Exchange Students

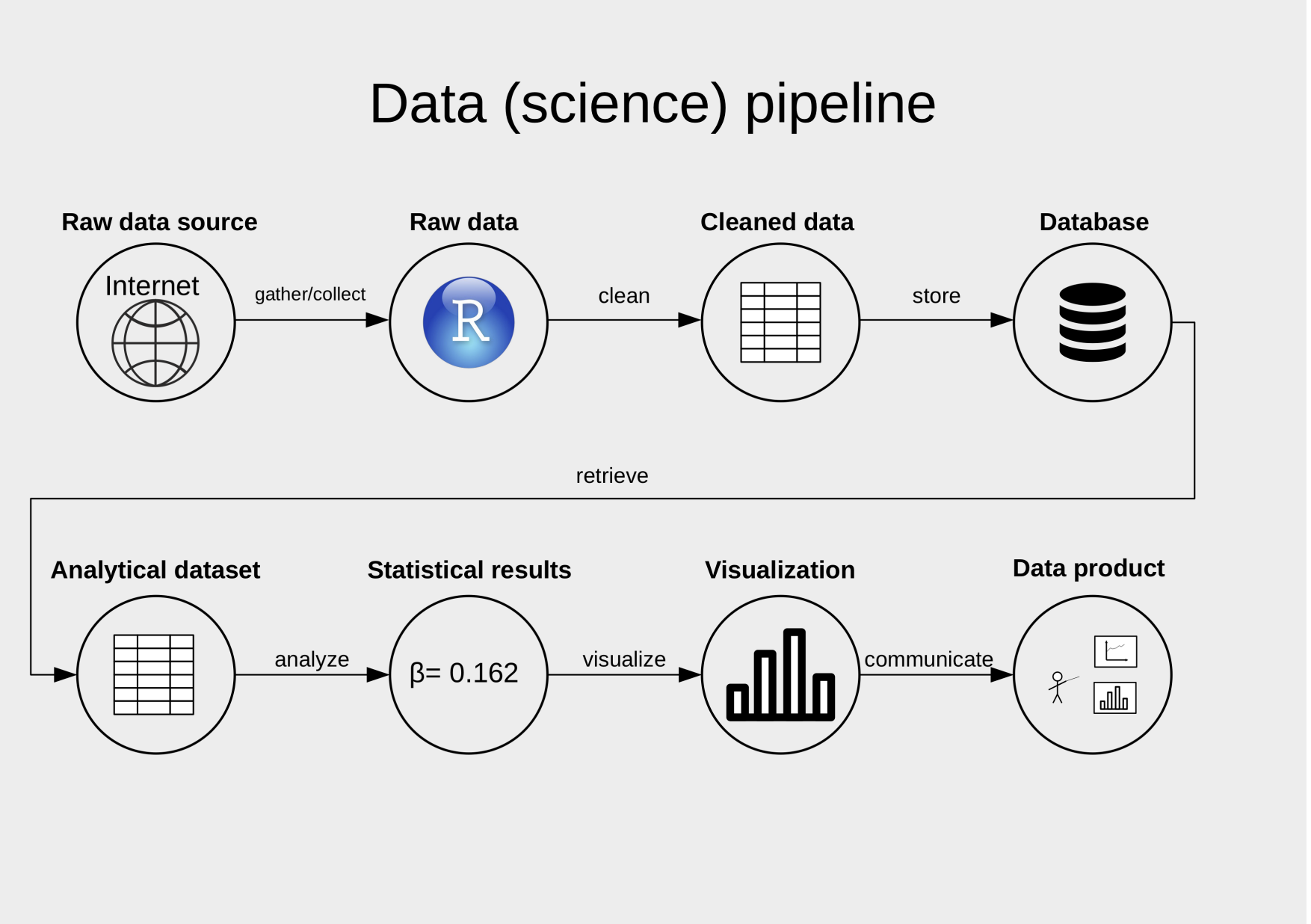
“Putting it all Together”

Putting it all together

- You know what **'data'** is…
- You know how digital data is **stored**…
- You know how to write **computer code**…
- You know the basics of **programming in R**…
- You know the basics of **statistics**…
- You have **basic domain knowledge** (in Econ/Business)…

These are the basics to handle data properly!
This is the basis of data science!

We are ready to start the data science journey



Sources/formats in economics

Sources/formats in economics

- CSV (typical for rectangular/table-like data)
- Variants of CSV (tab-delimited, fix length etc.)
- XML and JSON (useful for complex/high-dimensional data sets)
- HTML (a markup language to define the structure and layout of webpages)
- Unstructured text

Sources/formats in economics

- Excel spreadsheets (`.xls`)
- Formats specific to statistical software packages (SPSS: `.sav`, STATA: `.dat`, etc.)
- Built-in R datasets
- Binary formats

Data Gathering Procedure

Organize your data pipeline!

- One R script to gather/import data.
- The beginning of your data pipeline!

A Template/Blueprint

Tell your future self what this script is all about

```
##############################################################################
# Data Handling Course: Example Script for Data Gathering and Import
#
# Imports data from ...
# Input: links to data sources (data comes in ... format)
# Output: cleaned data as CSV
#
# U. Matter, St. Gallen, 2020
##############################################################################
```

Script sections

- Recall: programming tasks can often be split into smaller tasks.
- Use sections to implement task-by-task and keep order.
- In RStudio: Use `----------` to indicate the beginning of sections.
- Start with a ‘meta’-section.

Script sections

```
##############################################################################
# Data Handling Course: Example Script for Data Gathering and Import
#
# Imports data from ...
# Input: links to data sources (data comes in ... format)
# Output: cleaned data as CSV
#
# U. Matter, St. Gallen, 2018
##############################################################################


# SET UP --------------
# load packages
library(tidyverse)

# set fix variables
INPUT_PATH <- "/rawdata"
OUTPUT_FILE <- "/final_data/datafile.csv"
```

Script sections

Finally we add sections with the actual code (in the case of a data import script, maybe one section per data source)

```
##############################################################################
# Project XY: Data Gathering and Import
#
# This script is the first part of the data pipeline of project XY.
# It imports data from ...
# Input: links to data sources (data comes in ... format)
# Output: cleaned data as CSV
#
# U. Matter, St. Gallen, 2018
##############################################################################


# SET UP --------------
# load packages
library(tidyverse)

# set fix variables
INPUT_PATH <- "/rawdata"
OUTPUT_FILE <- "/final_data/datafile.csv"


# IMPORT RAW DATA FROM CSVs -------------
```

Loading/Importing Rectangular Data

Loading built-in datasets

In order to load such datasets, simply use the `data()`-function:

```
data(swiss)
```

Inspect the data after loading

```
# inspect the structure
str(swiss)
```

```
## 'data.frame':    47 obs. of  6 variables:
##  $ Fertility       : num  80.2 83.1 92.5 85.8 76.9 76.1 83.8 92.4 82.4 82.9 ...
##  $ Agriculture     : num  17 45.1 39.7 36.5 43.5 35.3 70.2 67.8 53.3 45.2 ...
##  $ Examination     : int  15 6 5 12 17 9 16 14 12 16 ...
##  $ Education       : int  12 9 5 7 15 7 7 8 7 13 ...
##  $ Catholic        : num  9.96 84.84 93.4 33.77 5.16 ...
##  $ Infant.Mortality: num  22.2 22.2 20.2 20.3 20.6 26.6 23.6 24.9 21 24.4 ...
```

```
# look at the first few rows
head(swiss)
```

```
##              Fertility Agriculture Examination Education Catholic Infant.Mortalit
## Courtelary        80.2        17.0          15        12     9.96             22.
## Delemont          83.1        45.1           6         9    84.84             22.
## Franches-Mnt      92.5        39.7           5         5    93.40             20.
## Moutier           85.8        36.5          12         7    33.77             20.
## Neuveville        76.9        43.5          17        15     5.16             20.
## Porrentruy        76.1        35.3           9         7    90.57             26.
```

Importing Rectangular Data from Text-Files

Comma Separated Values (CSV)

The `swiss`-dataset would look like this when stored in a CSV:

```
"District","Fertility","Agriculture","Examination","Education","Catholic","Infant.Mo
"Courtelary",80.2,17,15,12,9.96,22.2
```

What do we need to read this format properly?

Parsing CSVs in R

- `read.csv()` (basic R distribution)
- Returns a `data.frame`

```
swiss_imported <- read.csv("data/swiss.csv")
```

Parsing CSVs in R

- Alternative: `read_csv()` (`readr`/`tidyr`-package)
- Returns a `tibble`.
- Used in Wickham and Grolemund (2017).

```
swiss_imported <- read_csv("data/swiss.csv")
```

Import and parsing with **readr**

- Why `readr`?
  - Functions for all common rectangular data formats.
  - Consistent syntax.
  - More robust and faster than similar functions in basic R.
- Alternative: The `data.table`-package (handling large datasets).

Basic usage of readr functions

Parse the first lines of the swiss dataset directly like this…

```
library(readr)

read_csv('"District","Fertility","Agriculture","Examination","Education","Catholic",
"Courtelary",80.2,17,15,12,9.96,22.2')
```

```
## Rows: 1 Columns: 7
```

```
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr (1): District
## dbl (6): Fertility, Agriculture, Examination, Education, Catholic, Infant.Mortali
```

```
##
## 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.
```

```
## # A tibble: 1 × 7
##   District   Fertility Agriculture Examination Education Catholic Infant.Mortalit
##   <chr>          <dbl>       <dbl>       <dbl>     <dbl>    <dbl>           <dbl>
## 1 Courtelary      80.2          17          15        12     9.96            22.2
```

or read the entire `swiss` dataset by pointing to the file

Basic usage of readr functions

In either case, the result is a `tibble`:

```
swiss
```

```
## # A tibble: 47 × 7
##    District     Fertility Agriculture Examination Education Catholic Infant.Morta
##    <chr>            <dbl>       <dbl>       <dbl>     <dbl>    <dbl>          <
##  1 Courtelary        80.2        17            15        12     9.96           
##  2 Delemont          83.1        45.1           6         9    84.8            
##  3 Franches-Mnt      92.5        39.7           5         5    93.4            
##  4 Moutier           85.8        36.5          12         7    33.8            
##  5 Neuveville        76.9        43.5          17        15     5.16           
##  6 Porrentruy        76.1        35.3           9         7    90.6            
##  7 Broye             83.8        70.2          16         7    92.8            
##  8 Glane             92.4        67.8          14         8    97.2            
##  9 Gruyere           82.4        53.3          12         7    97.7            
## 10 Sarine            82.9        45.2          16        13    91.4            
## # … with 37 more rows
```

Basic usage of `readr` functions

- Other `readr` functions have practically the same syntax and behavior.
  - `read_tsv()` (tab-separated)
  - `read_fwf()` (fixed-width)
  - ...

Parsing CSVs

Recognizing columns and rows is one thing…

```
swiss
```

```
## # A tibble: 47 × 7
##    District     Fertility Agriculture Examination Education Catholic Infant.Morta
##    <chr>            <dbl>       <dbl>       <dbl>     <dbl>    <dbl>          <
##  1 Courtelary        80.2        17             15        12     9.96
##  2 Delemont          83.1        45.1            6         9    84.8
##  3 Franches-Mnt      92.5        39.7            5         5    93.4
##  4 Moutier           85.8        36.5           12         7    33.8
##  5 Neuveville        76.9        43.5           17        15     5.16
##  6 Porrentruy        76.1        35.3            9         7    90.6
##  7 Broye             83.8        70.2           16         7    92.8
##  8 Glane             92.4        67.8           14         8    97.2
##  9 Gruyere           82.4        53.3           12         7    97.7
## 10 Sarine            82.9        45.2           16        13    91.4
## # … with 37 more rows
```

What else did `read_csv()` recognize?

Parsing CSVs

- Recall the introduction to data structures and data types in R
- How does R represent data in RAM
  - **Structure**: `data.frame`/`tibble`, etc.
  - **Types**: `character`, `numeric`, etc.
- Parsers in `read_csv()` guess the data **types**.

Parsing CSV-columns

- `"12:00"`: type `character`?

Parsing CSV-columns

- `"12:00"`: type `character`?
- What about `c("12:00", "midnight", "noon")`?

Parsing CSV-columns

- `"12:00"`: type `character`?
- What about `c("12:00", "midnight", "noon")`?
- And now `c("12:00", "14:30", "20:01")`?

Parsing CSV-columns

Let's test it!

```
read_csv('A,B
         12:00, 12:00
         14:30, midnight
         20:01, noon')
```

```
## Rows: 3 Columns: 2
```

```
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr  (1): B
## time (1): A
```

```
##
## 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.
```

```
## # A tibble: 3 × 2
##   A      B
##   <time> <chr>
## 1 12:00  12:00
## 2 14:30  midnight
## 3 20:01  noon
```

Parsing CSV-columns

Let's test it!

```
read_csv('A,B
         12:00, 12:00
         14:30, midnight
         20:01, noon')
```

```
## Rows: 3 Columns: 2
```

```
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr  (1): B
## time (1): A
```

```
##
## 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.
```

```
## # A tibble: 3 × 2
##   A      B
##   <time> <chr>
## 1 12:00  12:00
## 2 14:30  midnight
## 3 20:01  noon
```

Parsing CSV-columns: guess types

Under the hood `read_csv()` used the `guess_parser()`- function to determine which type the two vectors likely contain:

```
guess_parser(c("12:00", "midnight", "noon"))
```

```
## [1] "character"
```

```
guess_parser(c("12:00", "14:30", "20:01"))
```

```
## [1] "time"
```

Other Common Rectangular Formats

Spreadsheets/Excel

Needs additional R-package: `readxl`.

```
# install the package
install.packages("readxl")
```

Spreadsheets/Excel

Then we load this additional package ('library') and use the package's `read_excel()`-function to import data from an excel-sheet.

```
# load the package
library(readxl)

# import data from a spreadsheet
swiss_imported <- read_excel("data/swiss.xlsx")
```

Data from other data analysis software

- STATA, SPSS, etc.
- Additional packages needed:
  - `foreign`
  - `haven`
- Parsers (functions) for many foreign formats.
  - For example, `read_spss()` for SPSS' `.sav`-format.

Data from other data analysis software

```r
# install the package (if not yet installed):
# install.packages("haven")

# load the package
library(haven)

# read the data
swiss_imported <- read_spss("data/swiss.sav")
```

Importing Web Data Formats

XML in R

```
## {xml_document}
## <customers>
## [1] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
## [2] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
```

```
# load packages
library(xml2)

# parse XML, represent XML document as R object
xml_doc <- read_xml("data/customers.xml")
xml_doc
```

XML in R: tree-structure

‘customers’ is the root-node, ‘persons’ are it’s children:

```
# navigate downwards
persons <- xml_children(xml_doc)
persons
```

```
## {xml_nodeset (2)}
## [1] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
## [2] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
```

XML in R: tree-structure

Navigate sidewards and upwards

```
# navigate sidewards
persons[1]
```

```
## {xml_nodeset (1)}
## [1] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
```

```
xml_siblings(persons[[1]])
```

```
## {xml_nodeset (1)}
## [1] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
```

```
# navigate upwards
xml_parents(persons)
```

```
## {xml_nodeset (1)}
## [1] <customers>\n  <person>\n    <name>John Doe</name>\n    <orders>\n      <prod
```

XML in R: tree-structure

Extract specific parts of the data:

```
# find data via XPath
customer_names <- xml_find_all(xml_doc, xpath = ".//name")
# extract the data as text
xml_text(customer_names)
```

```
## [1] "John Doe"  "Peter Pan"
```

JSON in R

```
# load packages
library(jsonlite)

# parse the JSON-document shown in the example above
json_doc <- fromJSON("data/person.json")

# look at the structure of the document
str(json_doc)
```

```
## List of 6
##  $ firstName  : chr "John"
##  $ lastName   : chr "Smith"
##  $ age        : int 25
##  $ address    :List of 4
##   ..$ streetAddress: chr "21 2nd Street"
##   ..$ city         : chr "New York"
##   ..$ state        : chr "NY"
##   ..$ postalCode   : chr "10021"
##  $ phoneNumber:'data.frame': 2 obs. of  2 variables:
##   ..$ type  : chr [1:2] "home" "fax"
##   ..$ number: chr [1:2] "212 555-1234" "646 555-4567"
##  $ gender     :List of 1
##   ..$ type: chr "male"
```

JSON in R

The nesting structure is represented as a **nested list**:

```
# navigate the nested lists, extract data
# extract the address part
json_doc$address
```

```
## $streetAddress
## [1] "21 2nd Street"
##
## $city
## [1] "New York"
##
## $state
## [1] "NY"
##
## $postalCode
## [1] "10021"
```

```
# extract the gender (type)
json_doc$gender$type
```

```
## [1] "male"
```

Tutorial (advanced): Importing data from a HTML table

Q&A

References

Wickham, Hadley, and Garrett Grolemund. 2017. Sebastopol, CA: O'Reilly. http://r4ds.had.co.nz/.