Automated Web Scraping with R

Resul Umit

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Skip intro — To the contents slide.

I can teach this workshop at your institution — Email me.

Who am I?

Resul Umit

- post-doctoral researcher in political science at the University of Oslo
- teaching and studying representation, elections, and parliaments
    - a recent publication: Parliamentary communication allowances do not increase electoral turnout or incumbents' vote share
- teaching workshops, also on
    - writing reproducible research papers
    - version control and collaboration
    - working with Twitter data
    - creating academic websites
- more information available at resulumit.com

The Workshop — Overview

- One and a half day, on how to automate the process of extracting data from websites
  - 160+ slides, 15+ exercises
  - a demonstration website for practice

- Designed for researchers with basic knowledge of R programming language
  - does not cover programming with R
    - e.g., we will use existing functions and packages
  - ability to work with R will be very helpful
    - but not absolutely necessary — this ability can be developed during and after the workshop as well

The Workshop — Motivation

- Data available on websites provide attractive opportunities for academic research
  - e.g., parliamentary websites were the main source of data for my PhD

- Acquiring such data requires
  - either a lot of resources, such as time
  - or a set of skills, such as automated web scraping

- Typically, such skills are not part of academic training
  - for my PhD, I visited close to 3000 webpages to collect data manually
    - on members of ten parliaments
    - multiple times, to update the dataset as needed

The Workshop — Motivation — Aims

- To provide you with an understanding of what is ethically possible
    - we will cover a large breath of issues, not all of it is for long-term memory
        - hence the slides are designed for self study as well
    - awareness of what is ethical and possible, Google, and perseverance are all you need
- To start you with acquiring and practicing the skills needed
    - practice with the demonstration website
        - plenty of data, stable structure, and an ethical playground
    - start working on a real project

The Workshop — Contents

Part 1. Getting the Tools Ready

- e.g., installing software

Part 2. Preliminary Considerations

- e.g., ethics of web scraping

Part 3. HTML Basics

- e.g., elements and attributes

Part 4. CSS Selectors

- e.g., selecting an element

Part 5. Scraping Static Pages

- e.g., getting text from an element

Part 6. Scraping Dynamic Pages

- e.g., clicking to create an element

To the list of references.

The Workshop — Organisation

- I will go through a number of slides…
    - introducing things
    - demonstrating how-to do things

- … and then pause, for you to use/do those things
    - e.g., prepare your computer for the workshop, and/or
    - complete a number of exercises

- We are here to help
    - ask me, other participants
    - consult Google, slides, answer script
        - type, rather than copy and paste, the code you will find on the slides or the script

The Workshop — Organisation — Slides

03:00

Slides with this background colour indicate that your action is required, for

- setting the workshop up
    - e.g., installing R
- completing the exercises
    - e.g., checking website protocols
    - these slides have countdown timers
        - as a guide, not to be followed strictly

The Workshop — Organisation — Slides

- Code and text that go in R console or scripts `appear as such — in a different font, on gray background`
    - long codes and texts will have their own line(s)

```
bow(url = "https://luzpar.netlify.app/members/") %>%
  scrape() %>%
  html_elements(css = "td+ td a") %>%
  html_attr("href") %>%
  url_absolute(base = "https://luzpar.netlify.app/")
```

The Workshop — Organisation — Slides

- Codes and texts that go in R console or scripts `appear as such — in a different font, on gray background`
  - long codes and texts will have their own line(s)

- Results that come out as output appear as such — in the same font, on green background
  - except for some results, such as a browser popping up

- Specific sections are highlighted yellow as such for emphasis
  - these could be for anything — codes and texts in input, results in output, and/or texts on slides

- The slides are designed for self-study as much as for the workshop
  - *accessible*, in substance and form, to go through on your own

Part 1. Getting the Tools Ready

Back to the contents slide.

Workshop Slides — Access on Your Browser

- Having the workshop slides* on your own machine might be helpful
    - flexibility to go back and forward on your own
        - especially while in a breakout room
    - ability to scroll across long codes on some slides

- Access at https://resulumit.com/teaching/scrp_workshop.html
    - will remain accessible after the workshop
    - might crash for some Safari users
        - if using a different browser application is not an option, view the PDF version of the slides on GitHub

* These slides are produced in R, with the `xaringan` package (Xie, 2021).

Demonstration Website — Explore on Your Browser

05:00

- There is a demonstration website for this workshop
    - available at https://luzpar.netlify.app/
    - includes fabricated data on the imaginary Parliament of Luzland
    - provides us with plenty of data, stable structure, and an ethical playground
- Using this demonstration website for practice is recommended
    - tailored to exercises, no ethical concern
    - but not compulsory — use a different one if you prefer so
- Explore the website now
    - click on the links to see an individual page for
        - states, constituencies, members, and documents
    - notice that the documents section is different than the rest
        - it is a page with dynamic frame

Demonstration Website — Explore on Your Browser

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- Explore the website now
  - click on the links to see an individual page for
    - states, constituencies, members, and documents
  - notice that the documents section is different than the rest
    - it is a page with dynamic frame

R — Download from the Internet and Install

- Programming language of this workshop
    - created for data analysis, extending for other purposes
        - e.g., accessing websites
    - allows for all three steps in one environment
        - accessing websites; scraping and processing data
    - an alternative: python

- Download R from https://cloud.r-project.org
    - optional, if you have it already installed — but then consider updating*
        - the `R.version.string` command checks the version of your copy
        - compare with the latest official release at https://cran.r-project.org/sources.html

* The same applies to all software that follows — consider updating if you have them already installed. This ensures everyone works with the latest, exactly the same, tools.

RStudio — Download from the Internet and Install

- Optional, but highly recommended
  - facilitates working with R

- A popular integrated development environment (IDE) for R
  - an alternative: GNU Emacs

- Download RStudio from https://rstudio.com/products/rstudio/download
  - choose the free version
  - to check for any updates, follow from the RStudio menu:

> `Help -> Check for Updates`

RStudio Project — Create from within RStudio

- RStudio allows for dividing your work with R into separate projects
  - each project gets dedicated workspace, history, and source documents
  - this page has more information on why projects are recommended

- Create a new RStudio project for for this workshop, following from the RStudio menu:

> `File -> New Project -> New Directory -> New Project`

- Choose a location for the project with `Browse...`
  - avoid choosing a synced location, e.g., `Dropbox`
    - likely to cause warning and/or error messages
    - if you must, pause syncing, or add an sync exclusion

R Packages — Install from within RStudio[*]

02:00

Install the packages that we need

```r
install.packages(c("rvest", "RSelenium", "robotstxt", "polite", "dplyr"))
```

[*] You may already have a copy of one or more of these packages. In that case, I recommend updating by re-installing them now.

R Packages — Install from within RStudio

Install the packages that we need

```
install.packages(c("rvest", "RSelenium", "robotstxt", "polite", "dplyr"))
```

We will use

- `rvest` (Wickham, 2021), for scraping websites
- `RSelenium` (Harrison, 2020), for browsing the web programmatically
- `robotstxt` (Meissner and Ren, 2020), for checking permissions to scrape websites
- `polite` (Perepolkin, 2019), for compliance with permissions to scrape websites
- `dplyr` (Wickham, François, Henry, et al., 2021), for data manipulation

R Script — Start Your Script

- Check that you are in the newly created project
  - indicated at the upper-right corner of RStudio window
- Create a new R Script, following from the RStudio menu

  > `File -> New File -> R Script`

- Name and save your file
  - to avoid the `Untitled123` problem
  - e.g., `scrape_web.R`
- Load `rvest` and other packages

```r
library(rvest)
library(RSelenium)
library(robotstxt)
library(polite)
library(dplyr)
```

Java — Download from the Internet and Install

- A language and software that `RSelenium` needs
    - for automation scripts

- Download Java from https://www.java.com/en/download/
    - requires restarting any browser that you might have open

Chrome — Download from the Internet and Install

- A browser that facilitates web scraping
  - favoured by `RSelenium` and most programmers

- Download Chrome from https://www.google.com/chrome/

SelectorGadget — Add Extension to Browser

- An extension for Chrome
    - facilitates selecting what to scrape from a webpage
    - optional, but highly recommended
    - open source software

- Add the extension to your browser
    - search for it at https://chrome.google.com/webstore/category/extensions
    - if you cannot use Chrome, drag and drop this link to your bookmarks bar

- ScrapeMate is an alternative extension
    - for both Chrome and Firefox
    - on Firefox, search at https://addons.mozilla.org/

Solutions — Note Where They Are

- Solutions to exercises, or links to them, are available online
    - can be downloaded at https://luzpar.netlify.app/exercises/solutions.R

- I recommend the solutions to be consulted as a last resort
    - after a genuine effort to complete the exercises yourself first

Other Resources*

- `RSelenium` vignettes
  - available at https://cran.r-project.org/web/packages/RSelenium/vignettes/basics.html
- R for Data Science (Wickham and Grolemund, 2021)
  - open access at https://r4ds.had.co.nz
- Text Mining with R: A Tidy Approach (Silge and Robinson, 2017)
  - open access at tidytextmining.com
  - comes with a course website where you can practice

* I recommend these to be consulted not during but after the workshop.

Part 2. Preliminary Considerations

Back to the contents slide.

Considerations — the Law

- Web scraping might be illegal
  - depending on who is scraping what, why, how — and under which jurisdiction
  - reflect, and check, before you scrape

- Web scraping might be more likely to be illegal if, for example,
  - it is harmful to the source commercially and/or physically
    - e.g., scraping a commercial website to create a rival website
    - e.g., scraping a website so hard and fast that it collapses
  - it gathers data that is
    - under copyright
    - not meant for the public to see
    - then used for financial gain

Considerations — the Ethics

- Web scraping might be unethical
  - depending on who is scraping what, why, and how
  - reflect before you scrape

- Web scraping might be more likely to be unethical if, for example,
  - it is — edging towards — being illegal
  - it does not respect the restrictions
    - as defined in `robots.txt` files
  - it harvests data
    - that is otherwise available to download, e.g., through APIs
    - without purpose, at dangerous speed, repeatedly

Considerations — the Ethics — `robots.txt`

- Most websites declare a robots exclusion protocol
    - making their rules known with respect to programmatic access
        - who is (not) allowed to scrape what, and sometimes, at what speed
    - within `robots.txt` files
        - available at, e.g., www.websiteurl.com/robots.txt

- The rules in `robots.txt` cannot not enforced upon scrapers
    - but should be respected for ethical reasons

- The language in `robots.txt` files is specific but intuitive
    - easy to read and understand
    - the `robotstxt` package makes these even easier

Considerations — the Ethics — `robots.txt` — Syntax

- It has pre-defined keys, most importantly
  - `User-agent` indicates who the protocol is for
  - `Allow` indicates which part(s) of the website can be scraped
  - `Disallow` indicates which part(s) must not be scraped
  - `Crawl-delay` indicates how fast the website could be scraped
- In case you write your own protocol one day, note that
  - the keys start with capital letters
  - they are followed by a colon `:`

```
User-agent:
Allow:
Disallow:
Crawl-delay:
```

Considerations — the Ethics — `robots.txt` — Syntax

- Websites define their own values
  - after a colon and a white space

```
User-agent: *
Allow: /
Disallow: /about/
Crawl-delay: 5
```

- Note that
  - * indicates the protocol is for everyone
  - / indicates all sections and pages
  - `/about/` indicates a specific path
  - values for `Crawl-delay` are in seconds

  - this website allows anyone to scrape, provided that
    - `/about/` is left out, and
    - the website is accessed at 5-seconds intervals

Considerations — the Ethics — `robots.txt` — Syntax

Files might include optional comments, written after the number sign #

```
# thank you for respecting our protocol

User-agent: *
Allow: /
Disallow: /about/
Crawl-delay: 5    # please delay for five seconds, to ensure our servers are not overloaded
```

Considerations — the Ethics — `robots.txt` — Syntax

The protocol of this website only applies to Google

- Google is allowed to scrape everything
- there is no defined rule for anyone else

```
User-agent: googlebot
Allow: /
```

Considerations — the Ethics — robots.txt — Syntax

The protocol of this website only applies to Google

- Google is disallowed to scrape two specific paths
  - with no limit on speed
- there is no defined rule for anyone else

```
User-agent: googlebot
Disallow: /about/
Disallow: /history/
```

Considerations — the Ethics — `robots.txt` — Syntax

This website has different protocols for different agents

- Google is allowed to scrape everything, with a 5-second delay
- Bing is not allowed to scrape anything
- everyone else can scrape the section or page located at www.websiteurl/about/

```
User-agent: googlebot
Allow: /
Crawl-delay: 5

User-agent: bing
Disallow: /

User-agent: *
Allow: /about/
```

Considerations — the Ethics — `robotstxt`

- The `robotstxt` packages facilitates checking website protocols
    - from within R — no need to visit websites via browser
    - provides functions to check, among others, the rules for specific paths and/or agents

- There are two main functions
    - `robotstxt`, which gets complete protocols
    - `paths_allowed`, which checks protocols for one or more specific paths

Considerations — the Ethics — `robotstxt`

Use the `robotstxt` function to get a protocol

- supply a base URL with the `domain` argument
    - as a string
    - probably the only argument that you will need

```
robotstxt(
  domain = NULL,
  ...
)
```

Considerations — the Ethics — `robotstxt`

```r
robotstxt(domain = "https://luzpar.netlify.app")
```

```
## $domain
## [1] "https://luzpar.netlify.app"
##
## $text
## [robots.txt]
## --------------------------------------
##
## User-agent: googlebot
## Disallow: /states/
##
## User-agent: *
## Disallow: /exercises/
##
## User-agent: *
## Allow: /
## Crawl-delay: 2
##
##
##
```

Considerations — the Ethics — robotstxt

Check the list of permissions for the most relevant part in the output

```
robotstxt(domain = "https://luzpar.netlify.app")$permissions
```

```
##      field useragent       value
## 1 Disallow googlebot    /states/
## 2 Disallow         * /exercises/
## 3    Allow         *           /
```

Considerations — the Ethics — `robotstxt`

Use the `paths_allowed` function to check protocols for one or more specific paths

- supply a base URL with the `domain` argument
- `path` and `bot` are the other important arguments
    - notice the default values

- leads to either `TRUE` (allowed to scrape) or `FALSE` (not allowed)

```
paths_allowed(
  domain = "auto",
  paths = "/",
  bot = "*",
  ...
)
```

Considerations — the Ethics — `robotstxt`

```
paths_allowed(domain = "https://luzpar.netlify.app")
```

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

```
paths_allowed(domain = "https://luzpar.netlify.app",
              paths = c("/states/", "/constituencies/"))
```

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

```
paths_allowed(domain = "https://luzpar.netlify.app",
              paths = c("/states/", "/constituencies/"), bot = "googlebot")
```

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

Exercises

07:30

1) Check the protocols for https://www.theguardian.com

- via (a) your browser and (b) with the `robotstxt` function in R
- compare what you see

2) Check a path with the `paths_allowed` function

- such that it will return `FALSE`
- taking the information from Exercise 1 into account
- hint: try looking at the list of permissions first

3) Check the protocols for any website that you might wish to scrape

- with the `robotstxt` function
- reflect on the ethics of scraping that website

Considerations — the Ethics — Speed

- Websites are designed for visitors with human-speed in mind
    - computer-speed visits can overload servers, depending on bandwidth
        - popular websites might have more bandwidth
        - but, they might attract multiple scrapers at the same time

- Waiting a little between two visits makes scraping more ethical
    - waiting time may or may not be defined in the protocol
        - lookout for, and respect, the `Crawl-delay` key in `robots.txt`
    - Part 5 and Part 6 covers how to wait

- Not waiting enough might lead to a ban
    - by site owners, administrators
    - for IP addresses with undesirably high number of visits in a short period of time

Considerations — the Ethics — Purpose

Ideally, we scrape for a purpose

- e.g., for academics, to answer one or more research questions, test hypotheses
    - developed prior to data collection, analysis
        - based on, e.g., theory, claims, observations
    - perhaps, even pre-registered
        - e.g., at OSF Registries

Considerations — Data Storage

Scraped data frequently requires

- large amounts of digital storage space
    - internet data is typically big data

- private, safe storage spaces
    - due to local rules, institutional requirements

Part 3. HTML Basics

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HTML — Overview

- Webpages include more than what is immediately visible to visitors
    - not only text, images, links
    - but also code for structure, style, and functionality — interpreted by browsers first
        - HTML provides the structure
        - CSS provides the style
        - JavaScript provides functionality, if any

- Web scraping requires working with the source code
    - even when scraping only what is already visible
    - to choose one or more desired parts of the visible
        - e.g., text in table and/or bold only

- Source code also offers more, invisible, data to be scraped
    - e.g., URLs hidden under text

HTML — Webpage Source

The `Ctrl` + `U` shortcut is to display source code — alternatively, right click and `View Page Source`

HTML — DOM

Browsers also offer putting source codes in a structure

- known as DOM (document object model), initiated by the `F12` key on Chrome

Exercises

05:00

4) View the source code of a page

- as plain code and as in DOM
- compare the look of the two

5) Search for a word or a phrase in source code

- copy from the front-end page
- search in plain text code or in DOM
  - using the `Ctrl` + `F` shortcut

- compare the look of the front- and back-end

HTML — Overview

- HTML stands for hypertext markup language
  - it gives the structure to what is visible to visitors
    - text, images, links
  - would a piece of text appear in a paragraph or a list?
    - depends on the HTML code around that text

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

HTML documents

- start with a declaration
    - so that browsers know what they are

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
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  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

HTML documents

- start with a declaration
  - so that browsers know what they are

- consist of elements
  - written in between opening and closing tags

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Root

html is the root element

- it is also the parent to all other elements
- its important children are the head and body elements

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Head

head contains metadata, such as

- titles, which appear in browser bars and tabs
- style elements

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

body contains the elements in the main body of pages, such as

- headers, paragraphs, lists, tables, images

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Syntax — Elements — Tags

Most elements have opening and closing tags

```
<p>This is a one sentence paragraph.</p>
```

This is a one sentence paragraph.

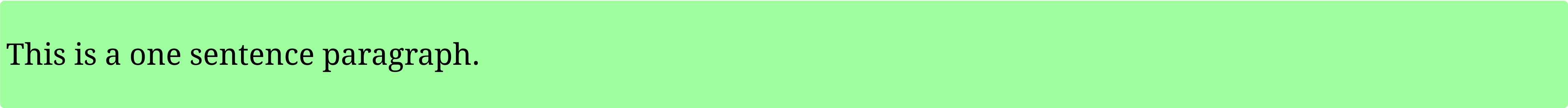
Note that

- tag name, in this case p, defines the structure of the element
- the closing tag has a forward slash / before the element name

HTML — Syntax — Elements — Content

Most elements have some content

```
<p>This is a one sentence paragraph.</p>
```



This is a one sentence paragraph.

HTML — Syntax — Elements — Attributes

Elements can have attributes

```
<p>This is a <strong id="sentence-count">one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Note that

- the `id` attribute is not visible to the visitors
- attribute string sentence-count could have been anything I could come up with
  - unlike the tag and attribute names — e.g., `strong`, `id` as they are pre-defined

- some other attributes, such as `style`, can have visible effects

HTML — Syntax — Elements — Attributes

There could be more than one attribute in a single element

```
<p>This is a <strong class="count" id="sentence-count">one</strong> sentence paragraph.</p>

<p>There are now <strong class="count" id="paragraph-count">two</strong> paragraphs.</p>
```

This is a **one** sentence paragraph.

There are now **two** paragraphs.

Note that

- there could be more than one attribute in an element
  - with a white space in between them
- the same `class` attribute (e.i., `count`) can apply to multiple elements
  - while the `id` attribute must be unique on a page

HTML — Important Elements — Links

Links are provided with the `a` (anchor) element

```
<p>Click <a href="https://www.google.com/">here</a> to google things.</p>
```

Click here to google things.

Note that

- `href` (hypertext reference) is a required attribute for this element
- most attributes are optional, but some are required

HTML — Important Elements — Links

Links can have titles

```
<p>Click <a title="This text appears when visitors hover over the link"
            href="https://www.google.com/">here</a> to google things.</p>
```

Click here to google things.

Note that

- the `title` attribute is one of the optional attributes
- it becomes visible when hovered over with mouse

HTML — Important Elements — Lists

The `<ul>` tag introduces un-ordered lists, while the `<li>` tag defines lists items

```
<ul>
  <li>books</li>
  <li>journal articles</li>
  <li>reports</li>
</ul>
```

- books
- journal articles
- reports

Note that

- Ordered lists are introduced with the the `<ol>` tag instead

HTML — Syntax — Notes

Elements can be nested

```
<p>This is a <strong>one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Note that

- there are two elements above, a paragraph and a strong emphasis
- strong is said to be the child of the paragraph element
    - there could be more than one child
    - in that case, children are numbered from the left
- paragraph is said to be the parent of the strong element

HTML — Syntax — Notes

By default, multiple spaces and/or lines breaks are ignored by browsers

```
<ul><li>books</li><li>journal                     articles</li><li>reports
</li>


</ul>
```

- books
- journal articles
- reports

Note that

- plain source code may or may not be written in a readable manner
- this is one reason why DOM is helpful

Exercises

10:00

6) Re-create the page at https://luzpar.netlify.app/states/ in R

- start an HTML file, following from the RStudio menu:

  > `File -> New File -> HTML File`

- copy the text from the website, paste in the HTML file
- add the structure with HTML code
- click `Preview` to view the result

7) Add at least one extra tag and/or attribute

- with a visible effect on how the page looks at the front end
  - hints:
    - google if you need to
    - www.w3schools.com has a lot resources
- save this document as we will continue working on it

Part 3. CSS Selectors

Back to the contents slide.

CSS — Overview

- CSS stands for cascading stylesheets
    - it gives the style to what is visible to visitors
        - text, images, links
    - would a piece of text appear in black or blue?
        - depends on the CSS for that text

- CSS can be defined
    - inline, as an attribute of an element
    - internally, as a child element of the `head` element
    - externally, but then linked in the `head` element

CSS — Syntax

- CSS is written in rules

```
p {font-size:12px;}

.count {background-color:yellow;}

#sentence-count {color:red;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
  - one or more selectors, matching one or more HTML elements and/or attributes

- Note that
  - the syntax changes with the selector type
    - elements and attributes
    - among attributes, classes and ids

```
p {font-size:14px;}

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
  - one or more selectors, matching one or more HTML elements and/or attributes
  - a declaration

- Note that

  - declarations are written in between two curly brackets

```
p {font-size:14px;}

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
    - one or more selectors, matching one or more HTML elements and/or attributes
    - a declaration, with one or more properties

```
p {font-size:14px;}

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;
```

- Note that
    - properties are followed by a colon

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
  - one or more selectors
  - a declaration, with one or more properties and values

```
p {font-size:14px;}

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;
```

- Note that
  - values are followed by a semicolon
  - `property:value;` pairs are separated by a white space

CSS — Internal

- CSS rules can be defined internally
    - within the `style` element
    - as a child of the `head` element
- Internally defined rules apply to all matching selectors
    - on the same page

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color:blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

CSS — External

- CSS rules can be defined externally
    - saved somewhere linkable
    - defined with the the `linked` element
    - as a child of the `head` element
- Externally defined rules
    - are saved in a file with .css extension
    - apply to all matching selectors
        - on any page linked

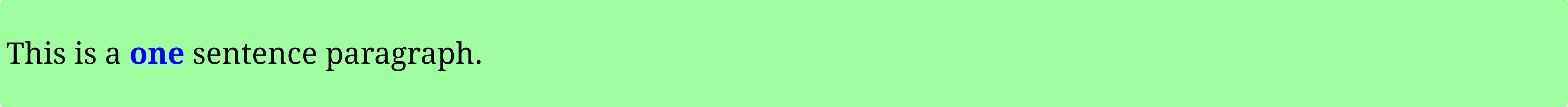
```
<!DOCTYPE html>
<html>
  <head>
    <link rel="styles" href="simple.css">
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
       <li>This</li>
       <li>is a</li>
       <li>list</li>
    </ul>
  </body>
</html>
```

CSS — Inline

CSS rules can also be defined inline

- with the `style` attribute
- does not require selector
- applies only to that element

```
<p>This is a <strong style="color:blue;">one</strong> sentence paragraph.</p>
```



This is a **one** sentence paragraph.

Exercise

05:00

8) Provide some simple style to your HTML document

- one that you created during the previous exercise
- using internal or external style, but not inline
  - so that you can practice selecting elements

- no idea what to do? try
  - increasing the font size of the text in paragraph
  - change the colour of the second item in the list to red
  - get more ideas from www.w3schools.com/css

Part 5. Scraping Static Pages

Back to the contents slide.

Static Pages — Overview

- We will collect data from static pages with the `rvest` package
    - static pages are those that display the same source code to all visitors
        - including the content — it does not change
    - every visitor sees the same page at a given URL
    - each page has a different URL
    - https://luzpar.netlify.app/ is a static page

- Scraping static pages involves two main tasks
    - download the source code from one or more pages to R
        - typically, the only interaction with the page itself
    - select the exact information needed from the source code
        - takes place locally, on your machine
        - the main functionality that `rvest` offers
            - with the help from selectors

Static Pages — `rvest` — Overview

- A relative small R package for web scraping
  - created by Hadley Wickham
  - popular — used by many for web scraping
    - downloaded 557,181 times last month
    - some of it must be thanks to being a part of the `tidyverse` family
  - last major revision was in March 2021
    - better alignment with `tidyverse`

- A lot has already been written on this package
  - you will find solutions to, or help for, any issues online
  - see first the package documentation, numerous tutorials — such as this, this, and this

- Comes with the recommendation to combine it with the `polite` package
  - for ethical web scraping

Static Pages — `rvest` — Get Source Code

Use the `read_html` function to get the source code of a webpage into R

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">\n<meta ch ...
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="p ...
```

Static Pages — `rvest` — Get Source Code

You may wish to check the protocol first, for ethical scraping

```
paths_allowed(domain = "https://luzpar.netlify.app/")
```

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

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">\n<meta ch ...
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="p ...
```

Static Pages — `rvest` — Get Source Code — `polite`

- The `polite` package facilitates ethical scraping
  - recommended by `rvest`

- It divides the process of getting source code into two
  - check the protocol
  - get the source only if allowed

- It also
  - waits for a period of time
    - minimum by what is specified in the protocol
  - allows you to introduce yourself to website administrators while scraping

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the `bow` function to check the protocol
  - for a specific URL

```
bow(url,
  user_agent = "polite R package - https://gi
  delay = 5,
  ...
  )
```

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol
    - for a specific URL
    - for a specific agent

```
bow(url,
  user_agent = "polite R package - https://gi
  delay = 5,
  force = FALSE,
  ...
  )
```

- Note that
    - the user_agent argument can communicate information to website administrators
        - e.g., your name and contact details

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the `bow` function to check the protocol
  - for a specific URL
  - for a specific agent
  - for any crawl-delay directives

```
bow(url,
  user_agent = "polite R package - https://gi
  delay = 5,
  force = FALSE,
  ...
  )
```

- Note that
  - the `delay` argument cannot be set to a number smaller than in the directive
    - if there is one

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the bow function to check the protocol
  - for a specific URL
  - for a specific agent
  - for crawl-delay directives

```
bow(url,
  user_agent = "polite R package - https://gi
  delay = 5,
  force = FALSE,
  ...
  )
```

- Note that
  - the `delay` argument cannot be set to a number smaller than in the directive
    - if there is one
  - the `force` argument is set to `FALSE` by default
    - avoids repeated, unnecessary interactions with web page
    - by caching, and re-using, previously downloaded sources

Static Pages — `rvest` — Get Source Code — `polite`

- Second, use the `scrape` function get source code
  - for an object created with the `bow` function

```
scrape(bow,
       ...
       )
```

- Note that
  - `scrape` will only work if the results from `bow` are positive
    - creating a safety valve for ethical scraping
  - by piping, `bow` into `scrape`, you can avoid creating objects

Static Pages — `rvest` — Get Source Code

These two pieces of code lead to the same outcome, as there is no protocol against the access

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type
## [2] <body id="top" data-spy="scroll" data-
```

```
bow(url = "https://luzpar.netlify.app/") %>%
    scrape()
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type
## [2] <body id="top" data-spy="scroll" data-
```

Static Pages — `rvest` — Get Source Code

The difference occurs when there is a protocol against the access

```
read_html("https://luzpar.netlify.app/exercis
```

```
## {html_document}
## <html>
## [1] <head>\n<meta http-equiv="Content-Type
## [2] <body>\r\n\r\n<h1>States of Luzland</h
```

```
bow(url = "https://luzpar.netlify.app/exercis
    scrape()
```

```
## NULL
```

Static Pages — `rvest` — `html_elements`

- Get one or more HTML elements
  - specified with a selector
    - CSS or XPATH
  - we will work with CSS in this workshop
    - facilitated by Chrome and SelectorGagdet

```
html_element(x,
             css,
             xpath)

html_elements(x,
              css,
              xpath)
```

- Note that
  - there are two versions of the same function
    - singular one gets the first instance of an element
    - plural one gets all instances

Static Pages — rvest — html_elements

Get the a (anchor) elements on the homepage

```
bow(url = "https://luzpar.netlify.app") %>%
  scrape() %>%
  html_elements(css = "a")
```

```
## {xml_nodeset (24)}
##  [1] <a class="js-search" href="#" aria-label="Close"><i class="fas fa-times-circle text- ...
##  [2] <a class="navbar-brand" href="/">Parliament of Luzland</a>
##  [3] <a class="navbar-brand" href="/">Parliament of Luzland</a>
##  [4] <a class="nav-link active" href="/"><span>Home</span></a>
##  [5] <a class="nav-link" href="/states/"><span>States</span></a>
##  [6] <a class="nav-link" href="/constituencies/"><span>Constituencies</span></a>
##  [7] <a class="nav-link" href="/members/"><span>Members</span></a>
##  [8] <a class="nav-link" href="/documents/"><span>Documents</span></a>
##  [9] <a class="nav-link js-search" href="#" aria-label="Search"><i class="fas fa-search"  ...
## [10] <a href="#" class="nav-link" data-toggle="dropdown" aria-haspopup="true" aria-label= ...
## [11] <a href="#" class="dropdown-item js-set-theme-light"><span>Light</span></a>
## [12] <a href="#" class="dropdown-item js-set-theme-dark"><span>Dark</span></a>
## [13] <a href="#" class="dropdown-item js-set-theme-auto"><span>Automatic</span></a>
## [14] <a href="https://github.com/resulumit/scrp_workshop" target="_blank" rel="noopener"> ...
## [15] <a href="https://resulumit.com/" target="_blank" rel="noopener">Resul Umit</a>
```

Static Pages — `rvest` — `html_elements`

I would like to get only the URLs on the main body of the page

- SelectorGadget tells me the correct selector is `#title a`

```
bow(url = "https://luzpar.netlify.app") %>%
  scrape() %>%
  html_elements(css = "#title a")
```

```
## {xml_nodeset (9)}
## [1] <a href="https://github.com/resulumit/scrp_workshop" target="_blank" rel="noopener">a ...
## [2] <a href="https://resulumit.com/" target="_blank" rel="noopener">Resul Umit</a>
## [3] <a href="/documents/">documents</a>
## [4] <a href="/constituencies/">constituencies</a>
## [5] <a href="/members/">members</a>
## [6] <a href="/states/">states</a>
## [7] <a href="https://github.com/rstudio/blogdown" target="_blank" rel="noopener">Blogdown ...
## [8] <a href="https://gohugo.io/" target="_blank" rel="noopener">Hugo</a>
## [9] <a href="https://github.com/wowchemy" target="_blank" rel="noopener">Wowchemy</a>
```

Static Pages — `rvest` — `html_text`

- Get the text content of one or more HTML elements
  - for the elements already chosen
    - with the `html_elements` function
  - this returns what is already visible to visitors

- Note that
  - there are two versions of the same function
    - `html_text` returns text with any space or line breaks around it
    - `html_text2` returns plain text

```
html_text(x, trim = FALSE)

html_text2(x, preserve_nbsp = FALSE)
```

Static Pages — `rvest` — `html_text`

```r
bow(url = "https://luzpar.netlify.app") %>%
  scrape() %>%
  html_elements(css = "#title a") %>%
  html_text()
```

```
## [1] "a workshop on automated web scraping" "Resul Umit"
## [3] "documents"                            "constituencies"
## [5] "members"                              "states"
## [7] "Blogdown"                             "Hugo"
## [9] "Wowchemy"
```

Static Pages — `rvest` — `html_attr`

- Get one or more attributes of one or more HTML elements
  - for the elements already chosen
    - with the `html_elements` function
  - attributes are specified with their name
    - not CSS or XPATH

- Note that
  - there are two versions of the same function
    - singular one gets a specified attribute
    - plural one gets all available attributes

```
html_attr(x, name, default = NA_character_)

html_attrs(x)
```

Static Pages — rvest — html_attrs

```
bow(url = "https://luzpar.netlify.app") %>%
  scrape() %>%
  html_elements(css = "#title a") %>%
  html_attrs()
```

```
## [[1]]
##                                          href                                       target
## "https://github.com/resulumit/scrp_workshop"                                     "_blank"
##                                           rel
##                                    "noopener"
##
## [[2]]
##                      href                   target                      rel
## "https://resulumit.com/"                 "_blank"               "noopener"
##
## [[3]]
##           href
## "/documents/"
##
## [[4]]
##                href
```

Static Pages — `rvest` — `html_attr`

```
bow(url = "https://luzpar.netlify.app") %>%
  scrape() %>%
  html_elements(css = "#title a") %>%
  html_attr(name = "href")
```

```
## [1] "https://github.com/resulumit/scrp_workshop"
## [2] "https://resulumit.com/"
## [3] "/documents/"
## [4] "/constituencies/"
## [5] "/members/"
## [6] "/states/"
## [7] "https://github.com/rstudio/blogdown"
## [8] "https://gohugo.io/"
## [9] "https://github.com/wowchemy"
```

Note that

- some URLs are given relative to the base URL
    - e.g., `/states/`, which is actually https://luzpar.netlify.app/states/
    - you can complete them with the `url_absolute` function

Static Pages — rvest — url_absolute

Complete the relative URLs with the `url_absolute` function

```
bow(url = "https://luzpar.netlify.app") %>%
  scrape() %>%
  html_elements(css = "#title a") %>%
  html_attr(name = "href") %>%
  url_absolute(base = "https://luzpar.netlify.app")
```

```
## [1] "https://github.com/resulumit/scrp_workshop"
## [2] "https://resulumit.com/"
## [3] "https://luzpar.netlify.app/documents/"
## [4] "https://luzpar.netlify.app/constituencies/"
## [5] "https://luzpar.netlify.app/members/"
## [6] "https://luzpar.netlify.app/states/"
## [7] "https://github.com/rstudio/blogdown"
## [8] "https://gohugo.io/"
## [9] "https://github.com/wowchemy"
```

Static Pages — rvest — html_table

Use the html_table() function to get the text content of table elements

```
bow(url = "https://luzpar.netlify.app/members/") %>%
  scrape() %>%
  html_elements(css = "table") %>%
  html_table()
```

```
## [[1]]
## # A tibble: 100 x 3
##    Member           Constituency  Party
##    <chr>            <chr>         <chr>
##  1 Arthur Ali        Mühlshafen    Liberal
##  2 Chris Antony      Benwerder     Labour
##  3 Chloë Bakker      Steffisfelden Labour
##  4 Rose Barnes       Dillon        Liberal
##  5 Emilia Bauer      Kilnard       Green
##  6 Wilma Baumann     Granderry     Green
##  7 Matteo Becker     Enkmelo       Labour
##  8 Patricia Bernard Gänsernten    Labour
##  9 Lina Booth        Leonrau       Liberal
```

Static Pages — `rvest`

We can create the same tibble with `html_text`, which requires getting each variable separately to be merged

```r
tibble(

"Member" = bow(url = "https://luzpar.netlify.app/members/") %>%
        scrape() %>%
        html_elements(css = "td:nth-child(1) a") %>%
        html_text(),

"Constituency" = bow(url = "https://luzpar.netlify.app/members/") %>%
        scrape() %>%
        html_elements(css = "td:nth-child(2) a") %>%
        html_text(),

"Party" = bow(url = "https://luzpar.netlify.app/members/") %>%
        scrape() %>%
        html_elements(css = "td:nth-child(3)") %>%
        html_text()

)
```

Static Pages — rvest

Keep the number of interactions with websites to minimum

- by saving the source code as an object, which could be used repeatedly

```r
the_page <- bow(url = "https://luzpar.netlify.app/members/") %>%
            scrape()

tibble(

"Member" = the_page %>%
        html_elements(css = "td:nth-child(1)") %>%
        html_text(),

"Constituency" = the_page %>%
        html_elements(css = "td:nth-child(2)") %>%
        html_text(),

"Party" = the_page %>%
        html_elements(css = "td:nth-child(3)") %>%
        html_text()

)
```

Exercise

15:00

9) Create a dataframe out of the table at https://luzpar.netlify.app/members/

- with as many variables as possible
- hints:
  - start with the code in the previous slide, and add new variables from attributes
  - the first two columns have important attributes
    - e.g., URLs for the pages for members and their constituencies
    - make these URLs absolute
    - see what other attributes are there to collect

Static Pages — Crawling — Overview

- Rarely a single page includes all variables that we need
    - instead, they are often scattered across different pages of a website
    - e.g., we might need data on election results — in addition to constituency names

- Web scraping then requires crawling across pages
    - using information found on one page, to go to the next
    - website design may or may not facilitate crawling

- We can write for loops to crawl
    - the speed of our code matters the most when we crawl
    - ethical concerns are higher

Static Pages — Crawling — Example

Task:

- I need data on the name and vote share of parties that came second in each constituency
- This data is available on constituency pages, but
  - there are too many such pages
    - e.g., https://luzpar.netlify.app/constituencies/arford/
  - I do not have the URL to these pages

Plan:

- Scrape https://luzpar.netlify.app/members/ for URLs
- Write a for loop to
  - visit these pages one by one
  - collect and save the variables needed
  - write these variables into a list
  - turn the list into a dataframe

Static Pages — Crawling — Example

Scrape the page that has all URLs, for absolute URLs

```
the_links <- bow(url = "https://luzpar.netlify.app/members/") %>%
        scrape() %>%
        html_elements(css = "td+ td a") %>%
        html_attr("href") %>%
        url_absolute(base = "https://luzpar.netlify.app/")

# check if it worked
head(the_links)
```

```
## [1] "https://luzpar.netlify.app/constituencies/muhlshafen/"
## [2] "https://luzpar.netlify.app/constituencies/benwerder/"
## [3] "https://luzpar.netlify.app/constituencies/steffisfelden/"
## [4] "https://luzpar.netlify.app/constituencies/dillon/"
## [5] "https://luzpar.netlify.app/constituencies/kilnard/"
## [6] "https://luzpar.netlify.app/constituencies/granderry/"
```

Static Pages — Crawling — Example

Create an empty list

```
temp_list <- list()

for (i in 1:length(the_links)) {

the_page <- bow(the_links[i]) %>% scrape()

temp_tibble <- tibble(

"constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

"second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
        html_text(),

"vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
        html_text()

)

temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Start a for loop to iterate over the links one by one

```r
temp_list <- list()

for (i in 1:length(the_links)) {

the_page <- bow(the_links[i]) %>% scrape()

temp_tibble <- tibble(

"constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

"second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
        html_text(),

"vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
        html_text()

)

temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Get the source code for the next link

```
temp_list <- list()

for (i in 1:length(the_links)) {

the_page <- bow(the_links[i]) %>% scrape()

temp_tibble <- tibble(

"constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

"second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
        html_text(),

"vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
        html_text()

)

temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Get the variables needed, put them in a tibble

```r
temp_list <- list()

for (i in 1:length(the_links)) {

the_page <- bow(the_links[i]) %>% scrape()

temp_tibble <- tibble(

"constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

"second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
        html_text(),

"vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
        html_text()

)

temp_list[[i]] <- temp_tibble

}
```

Static Pages — Crawling — Example

Add each tibble into the previously-created list

```r
temp_list <- list()

for (i in 1:length(the_links)) {

the_page <- bow(the_links[i]) %>% scrape()

temp_tibble <- tibble(

"constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

"second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
        html_text(),

"vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
        html_text()

)

temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Turn the list into a tibble

```r
temp_list <- list()

for (i in 1:length(the_links)) {

the_page <- bow(the_links[i]) %>% scrape()

temp_tibble <- tibble(

"constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

"second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
        html_text(),

"vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
        html_text()

)

temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Check the resulting dataset

```
head(df, 10)
```

```
## # A tibble: 100 x 3
##    constituency  second_party vote_share
##    <chr>         <chr>        <chr>
##  1 Mühlshafen    Green        26.1%
##  2 Benwerder     Conservative 24.8%
##  3 Steffisfelden Green        25.7%
##  4 Dillon        Conservative 27%
##  5 Kilnard       Conservative 28.8%
##  6 Granderry     Labour       26.1%
##  7 Enkmelo       Liberal      26.8%
##  8 Gänsernten    Green        26.6%
##  9 Leonrau       Conservative 25%
## 10 Zotburg       Conservative 28.4%
## # ... with 90 more rows
```

Exercise

45:00

10) Crawl into members' personal pages to create a rich dataset

- with members being the unit of observation

Hints:

- see an example dataset at https://luzpar.netlify.app/files/exercises/static_data.csv
- start with the related code in the previous slides, and adopt it to your needs
- practice with 3 members until you are ready to run the loop for all
    - e.g., by replacing `1:length(the_links)` with `1:3` for the loop

Part 6. Scraping Dynamic Pages

Back to the contents slide.

Dynamic Pages — Overview

- Dynamic pages are ones that display custom content
  - different visitors might see different content on the same page
    - while the URL remains the same
  - depending on, for example, their own input
    - e.g., clicks, scrolls
  - https://luzpar.netlify.app/documents/ is a page with a dynamic part

- Dynamic pages are more difficult than static pages to scrape
  - it involves three, instead of two, steps
  - we will have a new package, `RSelenium`, for the additional step

Dynamic Pages — Three Steps to Scrape

Scraping dynamic pages involves three main tasks

- Create the desired instance of the dynamic page
  - with the `RSelenium` package
  - e.g., by clicking, scrolling, filling in forms, from within R

- Get the source code into R
  - `RSelenium` downloads XML
  - `rvest` turns it into HTML

- Extract the exact information needed from the source code
  - as for static pages
  - with the the `rvest` package

Dynamic Pages — `Rselenium` — Overview

- A package that integrates Selenium 2.0 WebDriver into R
    - created by John Harrison
    - downloaded 4,785 times last month
    - last updated in February 2020

- A lot has already been written on this package
    - you will find solutions to, or help for, any issues online
    - see the package documentation and the vignettes for basic functionality
    - Google searches return code and tutorials in various languages
        - not only R but also Python, Java

Dynamic Pages — `Rselenium` — Overview

- The package involves more methods than functions
    - code look slightly unusual for R
    - as it follows the logic behind Selenium

- It allows interacting with two things — and it is crucial that we are aware of the difference
    - browsers on your computer
        - e.g., opening a browser and navigating to a page
    - elements on a webpage
        - e.g., opening and clicking on a drop-down menu

Interacting with Browsers

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
    - so that you can control a web browser from within R

```
rsDriver(port = 4567L,
         browser = "chrome",
         version = "latest",
         chromever = "latest",
         ...
         )
```

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
    - so that you can control a web browser from within R

- Note that the defaults can cause errors, such as
    - tying to start two servers from the same port

```
rsDriver(port = 4567L,
         browser = "chrome",
         version = "latest",
         chromever = "latest",
         ...
         )
```

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
  - so that you can control a web browser from within R

- Note that the defaults can cause errors, such as
  - trying to start two servers from the same port
  - any mismatch between the version and driver numbers

```
rsDriver(port = 4567L,
         browser = "chrome",
         version = "latest",
         chromever = "latest",
         ...
         )
```

Dynamic Pages — Browsers — Starting a Server

- The latest version of the driver is too new for my browser
  - I have to use an older version to make it work
  - after checking the available versions with the following code

```
binman::list_versions("chromedriver")
```

```
## $win32
## [1] "89.0.4389.23" "90.0.4430.24" "91.0.4472.19"
```

- Note that

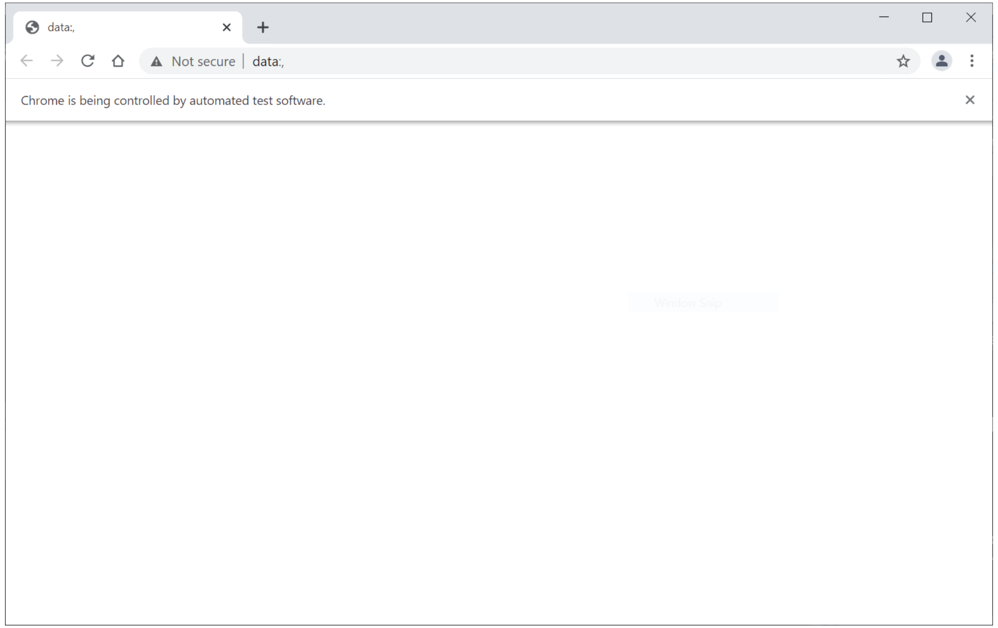
  - you can only use the version that *you* have
  - you might have a different the version than the ones on this slide

Dynamic Pages — Browsers — Starting a Server

- Then the function works
  - a web browser opens as a result
  - an R object named driver is created

- Note that
  - the browser says "Chrome is being controlled by automated test software."
  - you should avoid controlling this browser manually
  - you should also avoid creating multiple servers

```
driver <- rsDriver(chromever = "98.0.4758.102
```



Chrome is being controlled by automated test software.

Dynamic Pages — Browsers — Starting a Server

Separate the client and server as different objects

```
browser <- driver$client
server <- driver$server
```

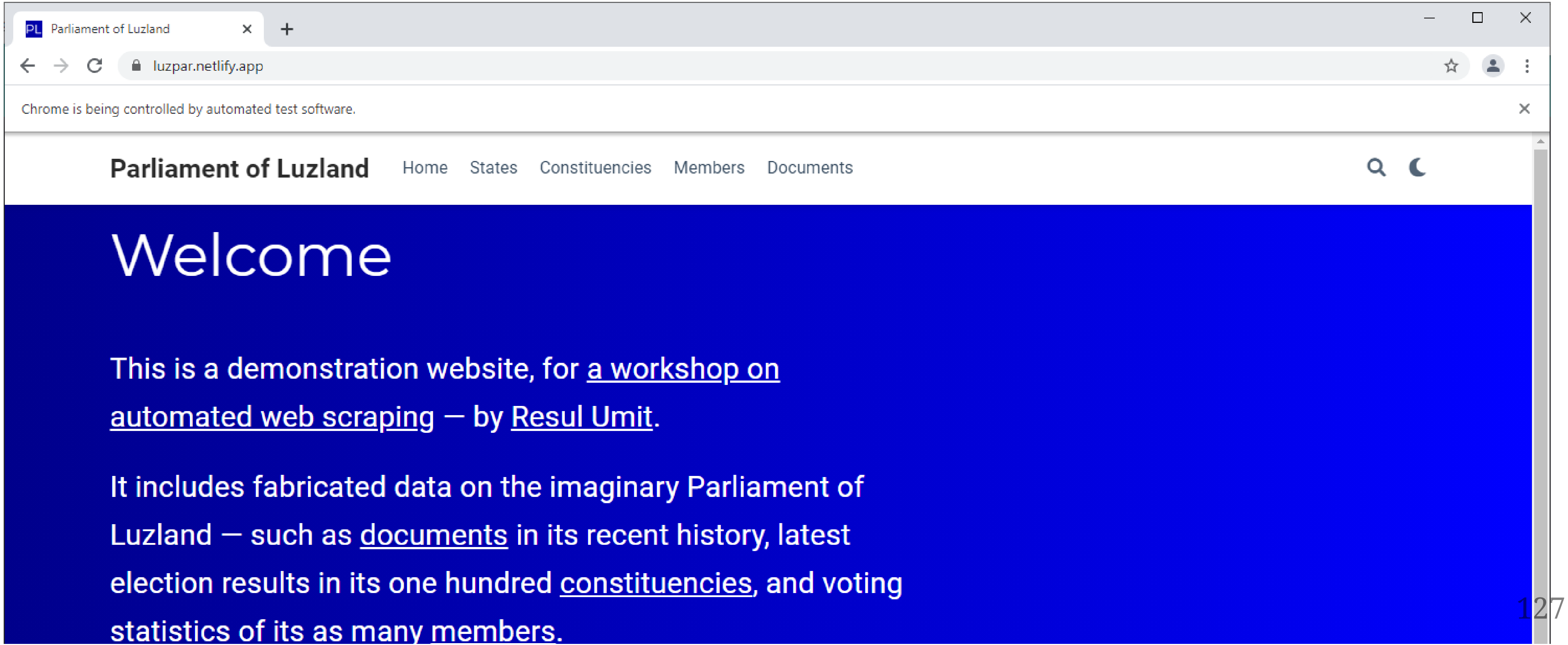
Note that

- `rsDriver()` creates a client and a server
    - the code above singles out the client, with which our code will interact
    - client is best thought as the browser itself
        - it has the class of `remoteDriver`

Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser$navigate(url = "https://luzpar.netlify.app")
```



Chrome is being controlled by automated test software.

Parliament of Luzland   Home   States   Constituencies   Members   Documents

Welcome

This is a demonstration website, for a workshop on automated web scraping — by Resul Umit.

It includes fabricated data on the imaginary Parliament of Luzland — such as documents in its recent history, latest election results in its one hundred constituencies, and voting statistics of its as many members.

Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser$navigate("https://luzpar.netlify.app")
```

Note that

- `navigate` is called a method, not a function
    - it cannot be piped into `browser`
    - use the dollar sign `$` notation instead
    - it is not necessary to type the name of the `url` argument

Dynamic Pages — Browsers — Navigate

Check the description of any method as follows

- with no parentheses after the method name

```
browser$navigate
```

```
Class method definition for method navigate()
function (url)
{
    "Navigate to a given url."
    qpath <- sprintf("%s/session/%s/url", serverURL, sessionInfo[["id"]])
    queryRD(qpath, "POST", qdata = list(url = url))
}
<environment: 0x00000173db9035a8>

Methods used:
     "queryRD"
```

Dynamic Pages — Browsers — Navigate

Go back to the previous URL

```
browser$goBack()
```

Go forward

```
browser$goForward()
```

Refresh the page

```
browser$refresh()
```

Dynamic Pages — Browsers — Navigate

Get the URL of the current page

```
browser$CurrentUrl()
```

Get the title of the current page

```
browser$getTitle()
```

Dynamic Pages — Browsers — Close and Open

Close the browser

- which will not close the session on the server
    - recall that we have singled the client out

```
browser$close()
```

Open a new browser

- which does not require the `rsDriver` function
    - because the server is still running

```
browser$open()
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

```
browser$getPageSource()[[1]]
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

```
browser$getPageSource()[[1]]
```

Note that

- this method returns a list
  - XML source is in the first item
  - this is why we need the `[[1]]` bit

- this is akin to `read_html()` for static pages
  - or `bow() %>% scrape()`

- `rvest` usually takes over after this step

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by combining the two package

```
browser$getPageSource()[[1]] %>%
        read_html() %>%
        html_elements("#title a") %>%
        html_attr("href")
```

```
[1] "https://github.com/resulumit/scrp_workshop"
[2] "https://resulumit.com/"
[3] "https://parliament-luzland.netlify.app/documents/"
[4] "https://parliament-luzland.netlify.app/constituencies/"
[5] "https://parliament-luzland.netlify.app/members/"
[6] "https://parliament-luzland.netlify.app/states/"
[7] "https://github.com/rstudio/blogdown"
[8] "https://gohugo.io/"
[9] "https://github.com/wowchemy"
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by using both packages

```
browser$getPageSource()[[1]] %>%
        read_html() %>%
        html_elements("#title a") %>%
        html_attr("href")
```

Note that

- this method gets the source for only what is physically visible on the browser
- window size and position might become important
  - you may wish to maximise the window

```
browser$browser$maxWindowSize()
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by using both packages

```
browser$getPageSource()[[1]] %>%
        read_html() %>%
        html_elements("#title a") %>%
        html_attr("href")
```

Note that

- we still need the `read_html()` function
    - to turn XML into HTML

Exercises

15:00

11) Navigate to and get the source code of a page

- e.g., https://luzpar.netlify.app/constituencies/
- by using both packages

12) See what other methods are available to interact with browsers

- by typing the object name for your client into R console
  - followed by the dollar sign
  - and hitting the tab key on your keyboard if necessary
- read the description for one or more of them

13) Try one or more new methods

- e.g., take a screenshot of your browser
  - and view it in R

Interacting with Elements

Dynamic Pages — Elements — Find

- Locate an element on the open browser
    - to be interacted later on
        - e.g., clicking on the element

```
findElement(using = "xpath",
               value
               )
```

- Note that
    - the default selector is `xpath`
    - requires entering the `xpath` value

Dynamic Pages — Elements — Find

- Locate an element on the open browser
    - using CSS selectors

```
findElement(using = "css selector",
            value
            )
```

- Note that
    - typing "css", instead of "css selector", also works
    - there are other selector schemes as well, including
        - id
        - name
        - link text

Dynamic Pages — Elements — Find — Selectors

If there were a button on a page with the following DOM...

```
<button class="big-button" id="only-button" name="clickable">Click Me</button>
```

Any of the following would find it

```
browser$findElement(using = "xpath", value = '//*[(@id = "only-button")]')

browser$findElement(using = "css selector", value = ".big-button")

browser$findElement(using = "css", value = "#only-button")

browser$findElement(using = "id", value = "only-button")

browser$findElement(using = "name", value = "clickable")
```

Dynamic Pages — Elements — Objects

Save elements as R objects to be interacted later on

```
button <- browser$findElement(using = ..., value = ...)
```

Note the difference between the classes of clients and elements

```
class(browser)
```

```
[1] "remoteDriver"
attr(,"package")
[1] "RSelenium"
```

```
class(button)
```

```
[1] "webElement"
attr(,"package")
[1] "RSelenium"
```

Dynamic Pages — Elements — Highlight

Highlight the element found in the previous step, with the `highlightElement` method

```
# navigate to a page
browser$navigate("http://luzpar.netlify.app/")

# find the element
menu_states <- browser$findElement(using = "link text", value = "States")

# highlight it to see if we found the correct element
menu_states$highlightElement()
```

Note that

- the highlighted element fill flash for a second or two on the browser
    - helpful to check if selection worked as intended

Dynamic Pages — Elements — Highlight

Highlight the element found in the previous step, with the `highlightElement` method

```
# navigate to a page
browser$navigate("http://luzpar.netlify.app/")

# find the element
menu_states <- browser$findElement(using = "link text", value = "States")

# highlight it to see if we found the correct element
`menu_states$`highlightElement()
```

Note that

- the highlighted element fill flash for a second or two on the browser
  - helpful to check if selection worked as intended
- the highlight method is applied to the element (`menu_states`), not to the client (`browser`)
  - compare it to the find method

Dynamic Pages — Elements — Click

Click on the element found in the previous step, with the `clickElement` method

```
# navigate to a page
browser$navigate("http://luzpar.netlify.app/")

# find an element
search_icon <- browser$findElement(using = "css", value = ".fa-search")

# click on it
search_icon$clickElement()
```

Dynamic Pages — Elements — Input

- Provide input to elements, such as
  - text, with the value argument

```
sendKeysToElement(list(value,
                       key
                       )
                  )
```

Dynamic Pages — Elements — Input

- Provide input to elements, such as
  - text, with the value argument
  - keyboard presses or mouse gestures, with the key argument

```
sendKeysToElement(list(value,
                       key
                       )
                  )
```

- Note that
  - user provides values while the selenium keys are pre-defined

Dynamic Pages — Elements — Input — Selenium Keys

View the list of Selenium keys

```
as_tibble(selKeys) %>% names()
```

```
##  [1] "null"          "cancel"        "help"          "backspace"     "tab"
##  [6] "clear"         "return"        "enter"         "shift"         "control"
## [11] "alt"           "pause"         "escape"        "space"         "page_up"
## [16] "page_down"     "end"           "home"          "left_arrow"    "up_arrow"
## [21] "right_arrow"   "down_arrow"    "insert"        "delete"        "semicolon"
## [26] "equals"        "numpad_0"      "numpad_1"      "numpad_2"      "numpad_3"
## [31] "numpad_4"      "numpad_5"      "numpad_6"      "numpad_7"      "numpad_8"
## [36] "numpad_9"      "multiply"      "add"           "separator"     "subtract"
## [41] "decimal"       "divide"        "f1"            "f2"            "f3"
## [46] "f4"            "f5"            "f6"            "f7"            "f8"
## [51] "f9"            "f10"           "f11"           "f12"           "command_meta"
```

Dynamic Pages — Elements — Input — Selenium Keys — Note

Choosing the body element, you can scroll up and down a page

```
body <- broswer$findElement(using = "css", value = "body")
body$sendKeysToElement(list(key = "page_down"))
```

Dynamic Pages — Elements — Input — Example

Search the demonstration site

```r
# navigate to the home page
browser$navigate("http://luzpar.netlify.app/")

# find the search icon and click on it
search_icon <- browser$findElement(using = "css", value = ".fa-search")
search_icon$clickElement()

# find the search bar on the new page and click on it
search_bar <- browser$findElement(using = "css", value = "#search-query")
search_bar$clickElement()

# search for the keyword "Law" and click enter
search_bar$sendKeysToElement(list(value = "Law", key = "enter"))
```

Dynamic Pages — Elements — Input — Example

Slow down the code where necessary, with the `Sys.sleep`

- for ethical reasons
- because R might be faster than the browser

```r
# navigate to the home page
browser$navigate("http://luzpar.netlify.app/")

# find the search icon and click on it
search_icon <- browser$findElement(using = "css", value = ".fa-search")
search_icon$clickElement()

# sleep for 2 seconds
Sys.sleep(2)

# find the search bar on the new page and click on it
search_bar <- browser$findElement(using = "css", value = "#search-query")
search_bar$clickElement()

# search for the keyword "Law" and click enter
search_bar$sendKeysToElement(list(value = "Law", key = "enter"))
```

Dynamic Pages — Elements — Input — Clear

Clear text, or a value, from an element

```
search_bar$clearElement()
```

Exercise

10:00

14) Conduct an internet search programatically

- navigate to https://duckduckgo.com/
  - just to keep it simple as Google would require you to scroll down and accept a policy
- find, highlight, and fill in the search bar
  - hit enter

15) Scroll down programatically, and up

- to see all results

Dynamic Pages — Elements — Switch Frames

```
switchToFrame(Id
             )
```

- Switch to a different frame on a page
  - some pages have multiple frames
  - you can think of them as browsers within browsers
  - while in one frame, we cannot work with the page source of another frame

- Note that
  - there is one such page on the demonstration website
    - https://luzpar.netlify.app/documents/
    - featuring a shiny app that lives originally lives at https://resulumit.shinyapps.io/luzpar/
  - the `Id` argument takes an element object, unquoted
    - setting it to `NULL` returns to the default frame

Dynamic Pages — Elements — Switch Frames

Switch to a non-default frame

```r
# navigate to a page and wait for the frame to load
browser$navigate("https://luzpar.netlify.app/documents/")
Sys.sleep(4)

# find the frame, which is an element
app_frame <- browser$findElement("css", "iframe")

# switch to it
browser$switchToFrame(Id = app_frame)

#switch back to the default frame
browser$switchToFrame(Id = NULL)
```

Dynamic Pages — Scraping — Example

Task:

- I need to download specific documents published by the parliament
    - e.g., proposals and reports
- The related section of the website is a dynamic page
    - initially it is empty, and clicking on things do not change the URL

Plan:

- Interact with the page until it displays the desired list of documents
- Get the page source and separate the links
- Write a for loop to
    - visit the related pages one by one
    - download the documents

Dynamic Pages — Scraping — Example

Interact with the page until it displays the desired list of documents

```r
# navigate to the desired page and wait a little
browser$navigate("https://luzpar.netlify.app/documents/")
Sys.sleep(4)

# switch to the frame with the app
app_frame <- browser$findElement("css", "iframe")
browser$switchToFrame(Id = app_frame)

# find and open the drop down menu
drop_down <- browser$findElement(using = "css", value = ".bs-placeholder")
drop_down$clickElement()

# choose proposals
proposal <- browser$findElement(using = 'css', "[id='bs-select-1-1']")
proposal$clickElement()

# choose reports
report <- browser$findElement(using = 'css', "[id='bs-select-1-2']")
report$clickElement()

# close the drop down menu
drop_down$clickElement()
```

Dynamic Pages — Scraping — Example

Get the page source and separate the links

```
the_links <- browser$getPageSource()[[1]] %>%
        read_html() %>%
        html_elements("td a") %>%
        html_attr("href")

print(the_links)
```

```
## [1] "https://luzpar.netlify.app/documents/human-rights-2021/"
## [2] "https://luzpar.netlify.app/documents/greenhouse-gas-emissions-2021/"
## [3] "https://luzpar.netlify.app/documents/tax-reform-2020/"
## [4] "https://luzpar.netlify.app/documents/parliamentary-staff-2020/"
## [5] "https://luzpar.netlify.app/documents/cyber-security-2019/"
## [6] "https://luzpar.netlify.app/documents/electronic-cigarettes-2019/"
```

Dynamic Pages — Scraping — Example

Write a for loop to download PDFs

```
for (i in 1:length(the_links)) {

pdf_link <- bow(url = the_links[i]) %>%
        scrape() %>%
        html_elements(css = ".btn-page-header") %>%
        html_attr("href") %>%
        url_absolute(base = "https://luzpar.netlify.app/")

download.file(url = pdf_link, destfile = basename(pdf_link))

}
```

Exercise

30:00

17) Collect data on a subset of documents

- article tags and image credits
- for documents within the Law and Proposal categories
- published after 2019

Hint

- start with the related code in the previous slides, and adopt it to your needs

References

Back to the contents slide.

References

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The workshop ends here.

Congradulations for making it this far, and

thank you for joining me!

Back to the contents slide.