

Data Science for Public Policy

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Reproducible Research with R Markdown

Motivation

There are many problems worth avoiding in an analysis:

- Copying-and-pasting or transposing
- Manual repetition
- Out-of-sequence documents
- Parallel documents (a script and a narrative Word doc)
- Code written for computers that is tough to parse by humans

Literate (Statistical) Programming



Literate Programming and LaTeX

Let us change our traditional attitude to the construction of programs: Instead of imagining that our main task is to instruct a computer what to do, let us concentrate rather on explaining to human beings what we want a computer to do. ~Literate Programming (1984)

R Markdown

R Markdown is a framework for creating reproducible documents. It combines narrative text with styles, code, and the output of code and can be used to create many types of

documents including PDFs, html websites, slides, and more.

According to [Wickham and Grolemund](#), there are three main reasons to use R Markdown:

1. For communicating to decision makers, who want to focus on the conclusions, not the code behind the analysis.
2. For collaborating with other data scientists (including future you!), who are interested in both your conclusions, and how you reached them (i.e. the code).
3. As an environment in which to do data science, as a modern day lab notebook where you can capture not only what you did, but also what you were thinking.

R Markdown uses

- plain text files ending in `.Rmd` that are similar to `.R` files.
- `library(rmarkdown)` and `library(knitr)`.
- [pandoc](#).

`library(rmarkdown)` “knits” `.Rmd` (R Markdown files) into `.md` (Markdown files), which Pandoc then converts into any specified output type. `library(rmarkdown)` doesn’t need to be loaded and the entire process is handled by clicking the “knit” button in RStudio.



Clicking the “knit” button starts this process.



Source: [R for Data Science](#) by Hadley Wickham and Garrett Grolemund

`library(rmarkdown)`, `library(knitr)`, and `pandoc` are all installed with RStudio. The only additional software you will need is a LaTeX distribution. Follow [these instructions](#) to install `library(tinytex)` if you want to make PDF documents.

This workflow has a few advantages:

1. All code is rerun in a clean environment when “knitting”. This ensures that the code runs in order and is reproducible.
2. It is easier to document code than with inline comments.
3. The output types are really appealing. By creating publishable documents with code, there is no need to copy-and-paste or transpose results.
4. The process is iterable and scalable.

Three Ingredients in a .Rmd

1. YAML header
2. Markdown text
3. Code chunks

1. YAML header

YAML stands for “yet another markup language”. The YAML header contains meta information about the document including output type, document settings, and parameters that can be passed to the document. The YAML header starts with `---` and ends with `---`.

Here is the simplest YAML header for a PDF document:

```
---
output: pdf_document
---
```

YAML headers can contain many output specific settings. This YAML header creates an HTML document with code folding and a floating table of contents:

```
---
output:
  html_document:
    code_folding: hide
    toc: true
    toc_float: TRUE
---
```

Parameters can be specified as follows

```
---
output: pdf_document
params:
  state: "Virginia"
---
```

Now state can be referred to anywhere in R code as `params$state`.

2. Markdown text

Markdown is a shortcut for HyperText Markup Language (HTML). Essentially, simple meta characters corresponding to formatting are added to plain text.

Titles and subtitles

Title 1

Title 2

Title 3

Text formatting

italic

****bold****

``code``

Lists

- * Bulleted list item 1
- * Item 2
 - * Item 2a
 - * Item 2b

1. Item 1
2. Item 2

Links and images

[text](http://link.com)

3. Code chunks

Code is added to R Markdown documents inline with ``r 2 + 2``.

More frequently, code is added in code chunks:

```
```${r chunk-name, echo = FALSE}
2 + 2
```
```

The first argument inline or in a code chunk is the language engine. Most commonly, this will just be a lower case `r`. `knitr` allows for many different language engines:

- R
- Python
- SQL
- Bash
- Rcpp
- Stan
- Javascript
- CSS

The second argument inside brackets in code chunks is the chunk name. Always name code chunks. Other chunk-specific settings can be added inside the brackets. Here are the most important options:

| Option | Effect |
|-------------------------------|-------------------------------|
| <code>echo = FALSE</code> | Hides code in output |
| <code>eval = FALSE</code> | Turns off evaluation of chunk |
| <code>fig.height = 8in</code> | Changes figure width |
| <code>fig.width = 8in</code> | Changes figure height |

Default setting for the entire document can be changes with R code such as the following:

```
knitr::opts_chunk$set(echo = FALSE)
```

The table added above was typed as Markdown code. But sometimes it is easier to use a code chunk to create and print a table. Pipe any data frame into `knitr::kable()` to create a table that will be formatted in the output of a knitted R Markdown document.

Exercise 1

1. Click the new script button and add a “Text File”.
2. Save the document as “README.md”.
3. Add some Markdown text from the above selections.
4. Click the preview button.

...

Exercise 2

1. Click the new script button and add an R Markdown script.

2. Select the HTML option.
3. Save the script as “html-example.Rmd”.
4. Add a code chunk and some R code.
5. Click the “knit” button.

...

Applications

PDF documents

```
---  
output: pdf_document  
---
```

html documents (single-page website)

```
---  
output: html_document  
---
```

GitHub README

```
---  
output: github_document  
---
```

Bookdown

[Bookdown](#) is an R package by Yihui Xie for authoring books in R Markdown. Many books, including R for Data Science ([GitHub](#)) by Hadley Wickham and Garrett Grolemund, have been written in R Markdown.

Blogdown

[Blogdown](#) is an R package by Yihui Xie for creating and managing a blog in R Markdown. [Up & Running with blogdown](#) by Alison Hill is a great tutorial for getting started with Blogdown.

Microsoft Word and Microsoft PowerPoint

It is possible to write to Word and PowerPoint. In general, I’ve found the functionality to be limiting and it is difficult to match institutional branding standards.

Slides

```
---
output:
  revealjs::revealjs_presentation:
    css: styles.css
    incremental: true
    reveal_options:
      slideNumber: true
      previewLinks: true
---
```

Fact sheets

An alternative to knitting an R Markdown document with the `knit` button is to use the `rmarkdown::render()` function. This allows for rendering documents to be iterated. By passing different parameters to each rendering, it's possible to create documents for different geographies, organizations, people, or periods of time.

At the Urban Institute, we regularly iterate fact sheets at the state and county level.

Examples:

- [Expanding the EITC for Workers without Resident Children](#)

[Data@Urban](#) includes an outline.

Fact pages

It's also possible to iterate websites with `rmarkdown::render()`. The Urban Institute State and Local Finance Initiative creates [State Fiscal Briefs](#) by iterating R Markdown documents.

[Data@Urban](#)

Exercise 3

1. Click the new script button and add an R Markdown script.
2. Select the PDF option.
3. Save the script as “pdf-example.Rmd”.
4. Add a code chunk and a `ggplot2` visualization of `storms`.
5. Click the “knit” button.

...

Resources

- [R4DS R Markdown chapter](#)
- [RStudio R Markdown intro](#)
- [RStudio R Markdown gallery](#)
- [Happy Git R Markdown tutorial](#)
- [RMarkdown cheat sheet](#)