Dynamic Documents using R: Hands-On

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Slides at
https://github.com/BITSS/RT2_remote_2020

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Dynamic Documents For Computational Reproducibility

One Type of Dynamic Document: R Markdown

Practical Excercise #1

Practical Excercise #2

Bonus Practical Excercise

Final Remarks & More Resources

Dynamic Documents For Computational Reproducibility

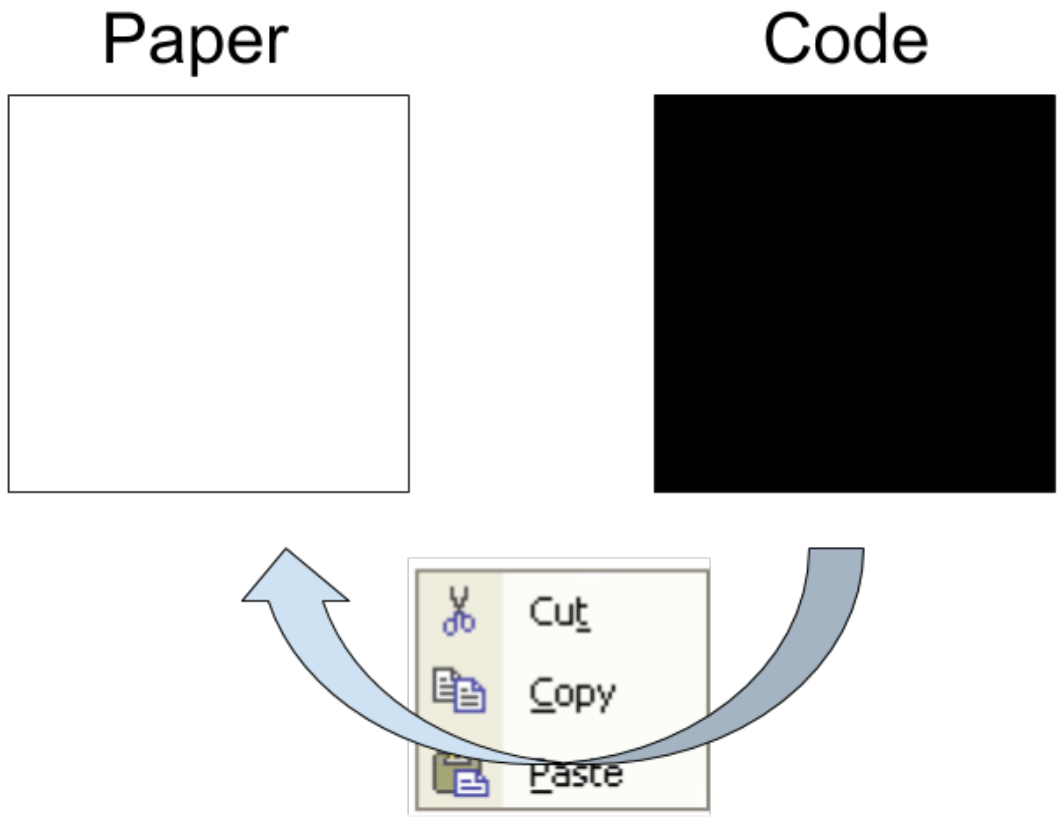
Before we start:

- Have the latest version of R and RStudio installed
- Please clone the following repo to your computer: github.com/BITSS/RT2_DC_2020

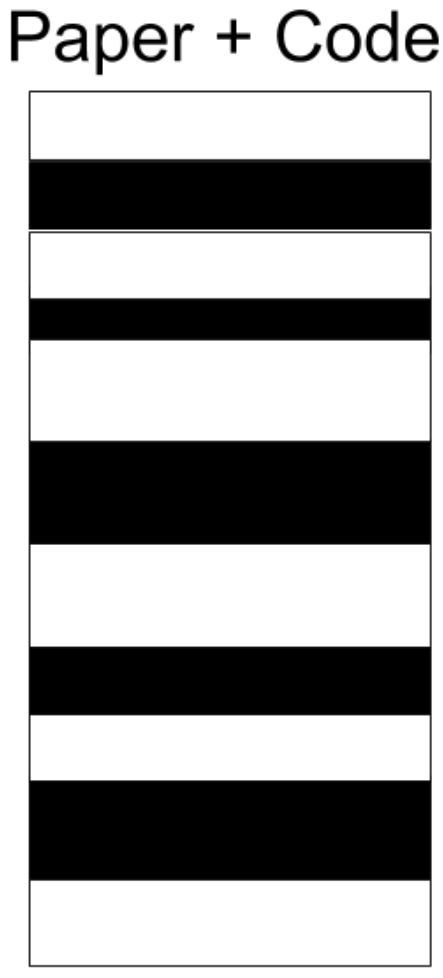
Dynamic Documents For Computational Reproducibility

- Based on principles of *literate programming* aims at combining code and paper in one single document
- Best framework to achieve the holy grail of **one-click reproducible workflow**
- Best two current implementations: `RMarkdown (R)` & `Jupyter (Python)`. `Stata` is catching up (dyndocs release here and reviews here and here)

Currently code and narrative components live in separate universes



Dynamic Documents: integrate the two universes!



Dynamic Documents: A Recipe

- 1 simple language that can combine text and code: `Markdown`
- 1 statistical package to do the analysis (`R`, `Python`, `3S's?`)
- 1 machinery to combine analysis and text to create a single output: `Pandoc`
- [Optional-but-not-really] 1 program to bring all the elements together: RStudio/RMarkdown, Jupyter

Markdown laguange/syntax in 60 seconds

syntax

```
Plain text
End a line with two spaces to start a new paragraph.
*italics* and _italics_
**bold** and __bold__
superscript^2^
~~strikethrough~~
[link](www.rstudio.com)

# Header 1

## Header 2

### Header 3

#### Header 4

##### Header 5

###### Header 6

endash: --
emdash: ---
ellipsis: ...
inline equation: $A = \pi*r^{2}$
image: ![](path/to/smallorb.png)

horizontal rule (or slide break):
```

becomes

Plain text
End a line with two spaces to start a new para
italics and *italics*
bold and **bold**
superscript^2
~~strikethrough~~
link

Header 1

Header 2

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Header 6

endash: –
emdash: —
ellipsis: …
inline equation: $A = \pi * r^2$
image: 

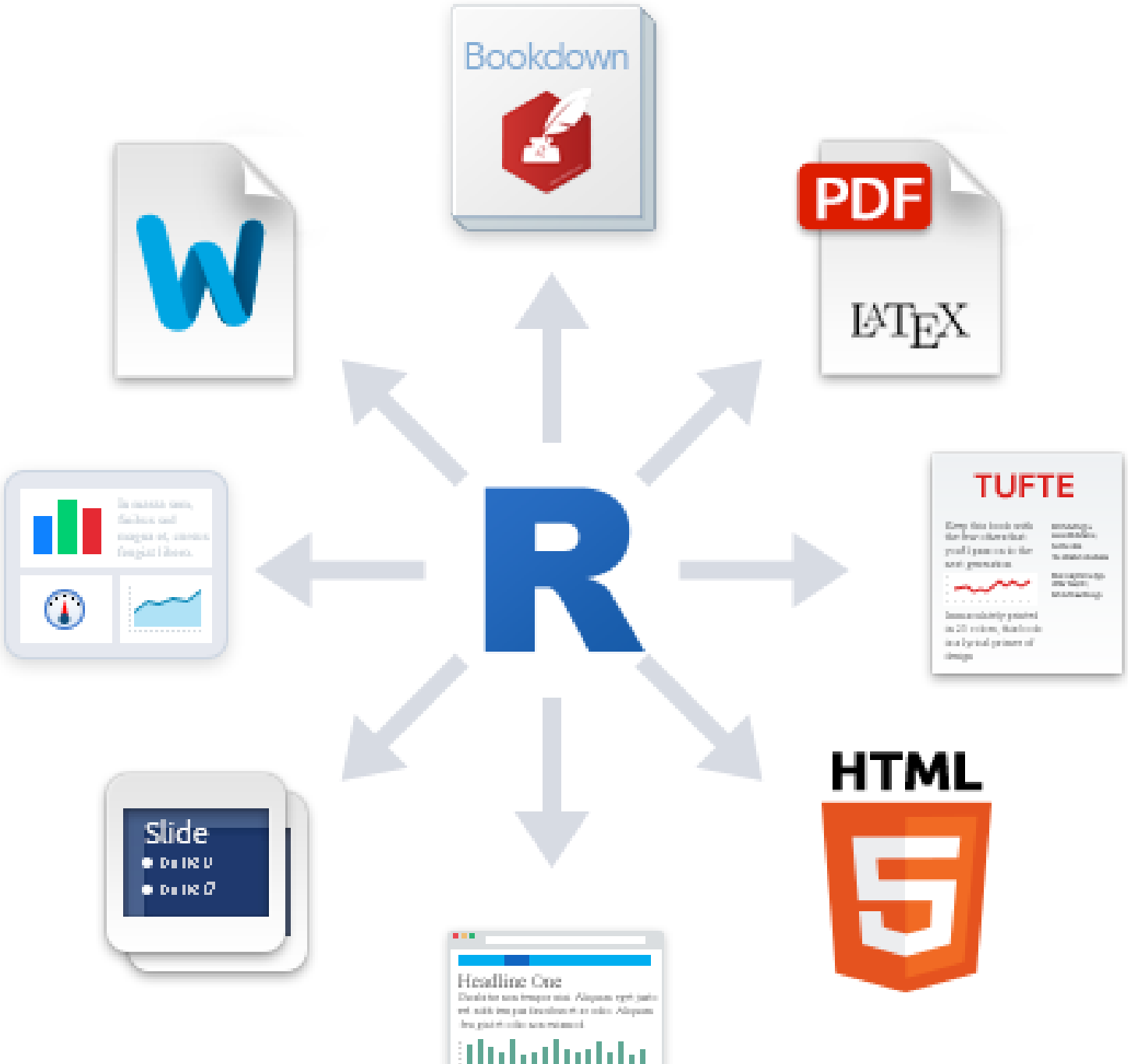
google: "online markdown editor"

One Type of Dynamic Document: R Markdown

For our excercise: R Markdown

- R: **open source** programming language design for statistical analysis.
- RStudio: free software that provides and Integrated Development Environment (IDE)
- RStudio combines all together: R + Markdown + Pandoc to produce multiple outputs

R Markdown



Basic Structure

- A header
- Text
- Code: inline and chunks

Basic Structure: Header

```
---
title: "Sample Paper"
author: "Fernando Hoces"
output: html_document
---
```

Basic Structure: Body of Text

```
---
header
---
```

This is where you write your paper. Nothing much to add. You can check Markdown syntax here. And it can use can type equations using LaTex syntax!

Basic Structure: Code Chunks and Inline

```
---
header
---
```

Body of text.

To begin a piece of code ("code chunk"). Enclose them in the following expression (Ctrl/Cmd + shift/optn + i)

````
```{r, eval=TRUE}
here goes the code
```
````

To write inline use only one Back-tick to open followed by an "r" and one to close `` `r 1+1` `` in the output.

Practical Excercise #1

Hands-on excercise: the birthday problem!

As an illustration lets write a report using the participants in this workshop to illustrate the famous birthday problem.

What is the probability that at least two people this room share the same birthday?

There are 11 in this room.
Is it something like $\frac{1}{365} \times 11 = 0.03$*?*

Goals for excercise #1

Primary Goals:

1 - Become familiar with your first DD.

2 - Compile an empty (or default) DD into multiple formats.

3 - Edit a DD with some narrative, some code (in R) and some math (optional).

4 - Present all the results dynamically into multiple outputs.

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Secondary Goal:

1 - Expose you to some R programming.

2 - Entertain you with a fun problem.

Create a new RMarkdown File

1 - In RStudio: `File-> New File -> RMarkdown...`
2 - Name it, and save it as `/2-dynamicdocs/first_dd.Rmd`.
3 - Review/edit the header, and delete all the default body of text except for one code chunk.
4 - In that chunk define a seed (`set.seed(1234)` and number of people in the room (`n.pers = ?`).
5 - Below the first chunk, write down a title (using #) and a brief description.

The birthday problem: the math

Actually the math says otherwise:

$$
\begin{aligned}
1 - p(n) &= 1 \times \left(1 - \frac{1}{365}\right) \times \left(1 - \frac{2}{365}\right) \times \cdots \times \left(1 - \frac{n-1}{365}\right) \\
&= \frac{365 \times 364 \times \cdots \times (365 - n + 1)}{365^n} \\
&= \frac{365!}{365^n (365 - n)!} = \frac{n! \cdot \binom{365}{n}}{365^n} \qquad (1) \\
p(n = 11) &= 0.141
\end{aligned}
$$

Code for the math (/2-dynamicdocs/first_dd_solution.Rmd)

Not relevant to look at: just copy and paste lines 23-30 from the solutions into your dynamic document.

```
\begin{align}
 1 - \bar p(n) &= 1 \times \left(1-\frac{1}{365}
                                    \right)
 \times ...
 A lot of equations using LateX syntax!
\end{align}
```

Don't like math? Let's run a simple simulation!

1 - Simulate 1,000 rooms with $n = 11$ random birthdays, and store the results in matrix where each row represents a room.
2 - For each room (row) compute the number of unique birthdays.
3 - Compute the average number of times a room has 11 unique birthdays, across 1,000 simulations, and report the complement.

Code for the simulation (/first_dd_solution.Rmd)

```
birthday.prob = function(n.pers, n.sims) {
  # simulate birthdays
  birthdays = matrix(round(runif(n.pers * n.sims,
                                 1, 365)),
                     nrow = n.sims, ncol = n.pers)
  # for each room (row) get unique birthdays
  unique.birthdays = apply(birthdays, 1,
                           function(x) length(unique(x)) )
  # Indicator with 1 if all are unique birthdays
  all.different = 1 * (unique.birthdays==n.pers)
  # Compute average time all have different birthdays
  result = 1 - mean(all.different)
return(result)
}
n.pers.param = n.pers
sim.prob <- birthday.prob(n.pers.param,n.sims.param); sim.p
```

```
## [1] 0.13
```

Results

- Many people originally think of a prob $\sim \frac{1}{365} \times N = 0.03$
- However the true probability is of $p(n = 11) = 0.141$
- And the simulated probability is of 0.13

Practical Excercise #2

Hands-on excercise #2: Mostly Harmless Econometrics!

There is a fantastic Github repo that is reproducing results from MHE

Lets use the of examples Figure 5.2.4 to show how dynamic docs can be used in data analysis.

Figure to reproduce

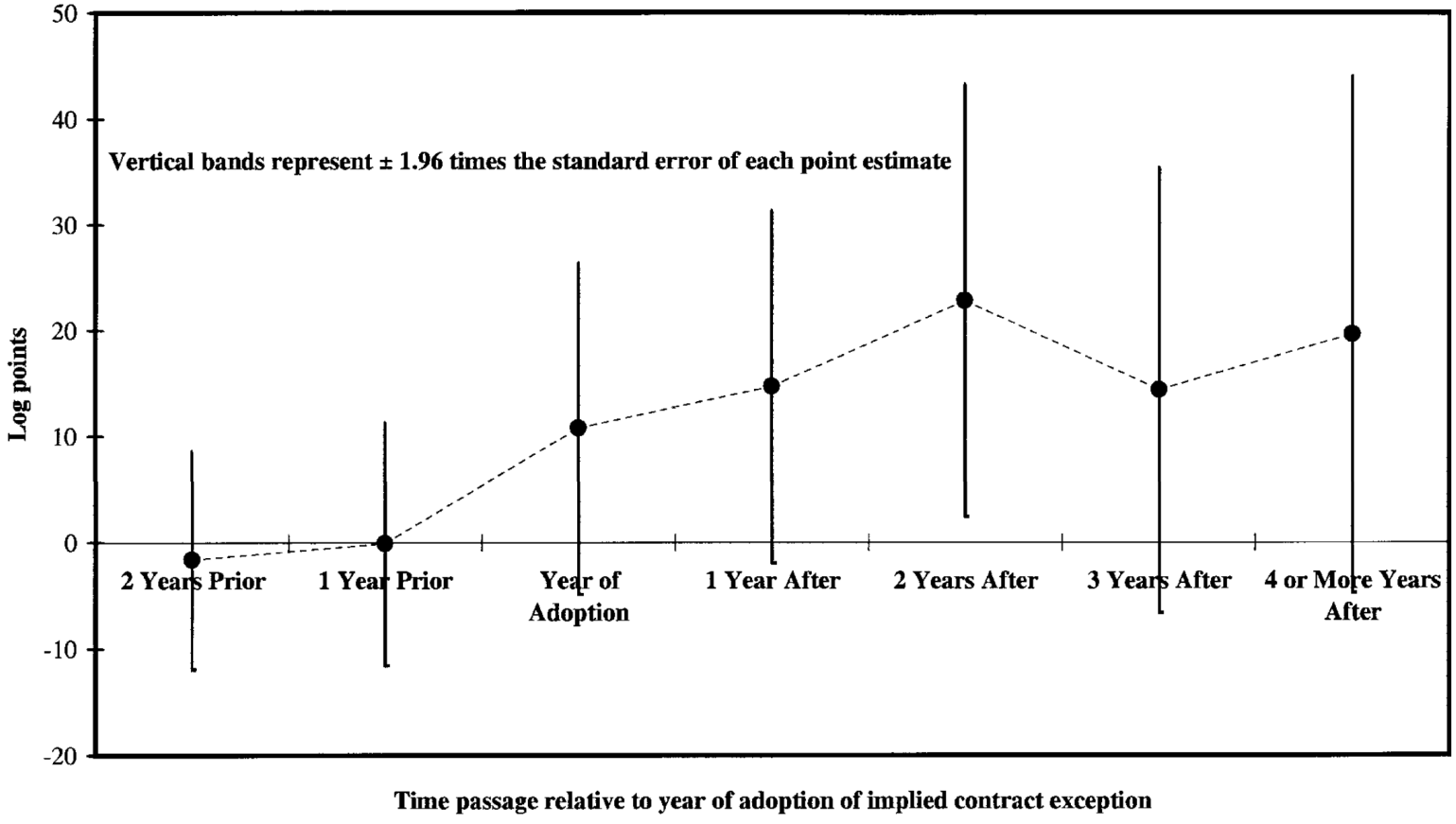

FIG. 3.—Estimated impact of implied contract exception on log state temporary help supply industry employment for years before, during, and after adoption, 1979–95.

Goals for excercise #2

Primary Goals:

1 - Demonstrate how the **entire workflow** of a study can fit into a DD.

2 - Show how to add options to the header.

3 - Demonstrate how a DD make code readable to non-coders.

Goals for excercise #2

Primary Goals:

1 - Demonstrate how the **entire workflow** of a study can fit into a DD.

2 - Show how to add options to the header.

3 - Demonstrate how a DD make code readable to non-coders.

Secondary Goal:

1 - Expose you to some R programming.

Instructions to get started with excercise #2:

1 - Create a new blank `.Rmd` file (steps 1 - 3 in from previous ex.) 2 - Save it as `/2-dynamicdocs/Figure 5-2-4.Rmd`
3 - Look at this code behind figure 5.2.4.
4 - Start building your own DD to describe what this code does.

We will go step by step using `/2-dynamicdocs/Figure 5-2-4_solutions.Rmd` as back-up.

Description

- Begin a new section (##), titled “Description”
- Write a brief description of our goal in the DD.
- You might want to insert a reference to the paper: link here.
- Specific content not so relevant, just refer to “a treatment” and “a outcome”.

Getting the raw data

- Begin a new section (##), titled "Raw Data".
- Describe what you will do.
- Create two code chunks:

````
```{r download data, eval=FALSE, echo=TRUE,
warning=FALSE, results='hide', message=FALSE}
# Download the data and unzip it
download.file(
'http://economics.mit.edu/~dautor/outsourcingatwill_table7
'outsourcingatwill_table7.zip'
)
unzip('outsourcingatwill_table7.zip')
```
````

Code chunk #2

```
```{r load data, echo=TRUE, warning=FALSE,
results='hide', message=FALSE}
# Load the data
autor <- read.dta('table7/autor-jole-2003.dta')
```
```

Cleaning the data

- Begin a new section (##), titled "Data Cleaning".
- Describe what you will do:
  - Restrict sample to years between 1979 and 1995 (inclusive)
  - Remove Guam from the sample (state = 98).
- Create one code chunk:

````
```{r data cleaning, echo=TRUE}
# Restrict sample
autor <- autor[which(autor$year >= 79 & autor$year <= 95),
autor <- autor[which(autor$state != 98), ]
```
````

- Add some description on the data (using dynamic reporting). See solutions (Figure `5-2-4_solutions.Rmd` line 58) for examples.

Build the analytic file

- Begin a new section (##), titled "Build analytic file".
- Describe what you will do.
- We need to construct the following variables:
  - Log of total employment
  - Normalize the year variable to 1978
- Insert a new code chunk:

```
```{r analytic file, echo=TRUE}
# Log total employment: from BLS employment & earnings
autor$lnemp <- log(autor$annemp)

# Normalize year to 1978
autor$t  <- autor$year - 78

# Create state and year factors (required format for fe reg
autor$state <- factor(autor$state)
autor$year  <- factor(autor$year)
```
```

Describe the model to estimate (optional)

- Begin a new section (##), titled “Define model to estimate”.
- One line describing what we want to estimate (i.e. “We want to estimate a fixed effect model with lead and lag treatment variables”).
- A mathematical model that represents the equation to be estimated (look at solutions).

Vizualize the results (optional)

- Begin a new section (##), titled “Vizualize the results”.
- One line describing what we want to estimate (i.e. “This estimates are then used to create figure 3 of the original paper, which is figure 5.2.4 in MHE.”).

````
```{r viz}
here goes the code
```
````

Practical Excercise #2

- Run your version into multiple outputs.
- Run the solutions version into multiple outputs.
- Compare document with original version of the code.

Bonus Practical Excercise

Goals for excercise #3

Primary Goals:

1 - Map the concepts of DD into Stata `dyndoc`.

2 - Demonstrate how to execute a DD in Stata.

Bonus hands-on excercise #3: Stata and TIER

1- Go to github.com and search `dyndoc tier` or click here: github.com/dvorakt/TIER_exercises.
2- Download or clone the repo.
3- Unzip it.
4- Open Stata (15), set working directory, and type `dyndoc "filepath/dyndoc_debt_growth/debt and growth stata dyndoc.do", replace`
5- Go to the folder and click in `debt and growth stata dyndoc.html`

Bonus truck: NBER Working Papers!

- Remeber the example from yesterday on the half bake analysis of NBER papers in github?
- Fork and clone the repo one more time: github.com/fhoces/nber_trends
- Now run the `.Rmd` file instead.

Final Remarks & More Resources

Final Remarks & More Resources

- With DD we can achieve a one-click reproducible workflow.
- This is particularly helpful to understand/present results that are hard to digest.
- More great examples in the workshop repo (`x-moredynamicdocs`).
- Want to learn more: great free books (can you guess how they were written?)
- One final cool example: Ed Rubin's materials for econometrics course. Example here.