Software and Workflow for Reproducible Research

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Outline

Reproducibility & Transparency

- What are problems associated with reproducibility?
- What are solutions to these problems?
- **What are practical tools to implement these solutions?**

Problems

- Publication bias (see previous talk)
- Specification Searching (see previous talk)
- Data not available
- Code not available/unintelligible
- Code and data cannot reproduce original results

Irreproducible Workflow

- Even with the original authors' help, you can't get the data to reproduce the published results. Or you just can't find the data to begin with.
- *Journal of Money, Credit, and Banking* Project. (Dewald et al., AER 1986)
- Martin Feldstein on Social Security and private savings, Reinhart and Rogoff on debt and GDP growth.

Solutions

- Study Registry (see previous talk)
- Pre-Analysis Plan (see previous talk)
- Reproducible Workflow

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Reproducible Workflow

- Literate Programing
- Version control with Github or OSF.
- R Markdown and R Studio to write dynamic documents.
- Data Sharing
  - Harvard's Dataverse

Literate Programming

- First, *programming* is key to reproducibility. Working in Excel is not reproducible.
- See Reinhart and Rogoff "Growth in a Time of Debt" controversy:
  - Original Paper, *AER P & P* 2010
  - Herndon et. al (2013) finding.
  - *New Yorker* summary.
- Random number generation in Excel–set seed with Data Analysis Toolpak.

Literate Programming

- If you are using SPSS, use of 'syntax' to record all the commands you run is simple. (See UCLA tutorial.) Similarly in Stata, 'commandlog'.
- Better is to write scripts. R, Stata, SAS, Python, or whatever you please.
- Open source has some advantages (being free, for one) but you're going to use what everyone in your field uses.

Literate Programming

- Second, *literate programming* is key to reproducibility. Write code to be read by a human being, with the code for the computer secondary.

Literate Programming

> *"I believe that the time is ripe for significantly better documentation of programs, and that we can best achieve this by considering programs to be works of literature. Hence, my title: "Literate Programming."*
> *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.*

(cont.)

Literate Programming

> *"The practitioner of literate programming can be regarded as an essayist, whose main concern is with exposition and excellence of style. Such an author, with thesaurus in hand, chooses the names of variables carefully and explains what each variable means. He or she strives for a program that is comprehensible because its concepts have been introduced in an order that is best for human understanding, using a mixture of formal and informal methods that reinforce each other."*

–Donald Knuth *The Computer Journal*, 1984 Quotes Original

Organizing and Recording Workflow

"Reproducibility is just collaboration with people you don't know, including yourself next week"

—Philip Stark, UC Berkeley Statistics

Organizing and Recording Workflow

Practical coding and organizational suggestions

- Long (2008) *The Workflow of Data Analysis Using Stata*
- Making any changes to a file that has been posted/shared means it gets a new name.
- Use version commands to ensure others get same results.
- Keep a daily research log.
- Take the tiem

Version Control

- Using version control (AKA revision control) can help to make your work more reproducible.
- What is version control?

> *Version control is a system that records changes to a file or set of files over time so that you can recall specific versions later. For the examples in this book you will use software source code as the files being version controlled, though in reality you can do this with nearly any type of file on a computer.*
>
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Version Control

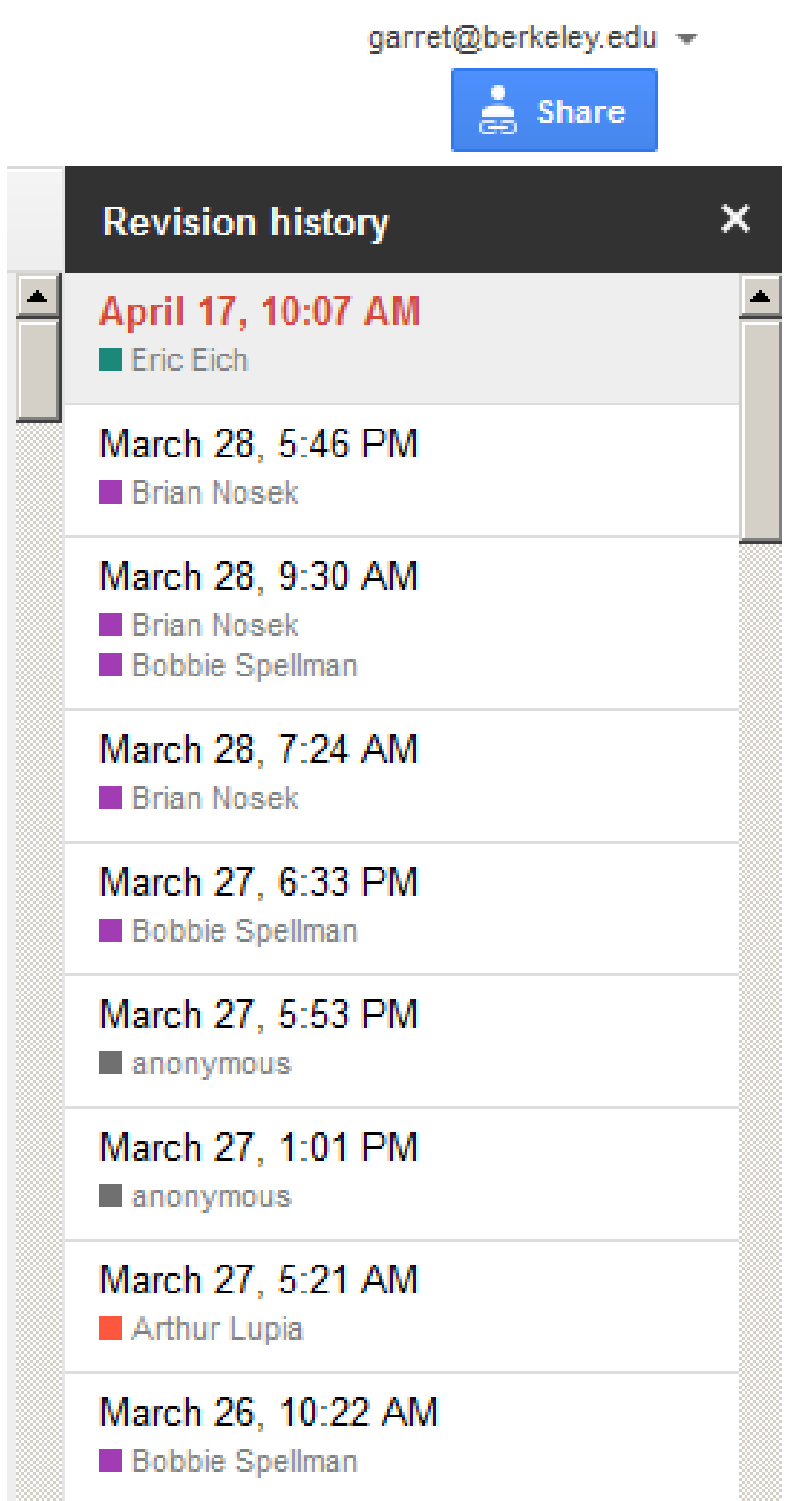
With version control you can:

- Collaborate
- Track who made every change
- Easily switch between versions of files
- Compare versions of files
- Backup
- Work with the same files on different machines
- Experiment with a new version of code without breaking things

Link1 Link2 Link3

Version Control

Places you're already using version control without knowing it:


garret@berkeley.edu
Share
Revision history
April 17, 10:07 AM
Eric Eich
March 28, 5:46 PM
Brian Nosek
March 28, 9:30 AM
Brian Nosek
Bobbie Spellman
March 28, 7:24 AM
Brian Nosek
March 27, 6:33 PM
Bobbie Spellman
March 27, 5:53 PM
anonymous
March 27, 1:01 PM
anonymous
March 27, 5:21 AM
Arthur Lupia
March 26, 10:22 AM
Bobbie Spellman

Elephant: Revision history

View logs for this page

Browse history

From year (and earlier): 2015 From month (and earlier): all Tag filter: Go

For any version listed below, click on its date to view it. For more help, see Help:Page history and Help:Edit summary.

External tools: Revision history statistics · Revision history search · Edits by user · Number of watchers · Page view statistics

(cur) = difference from current version, (prev) = difference from preceding version, **m** = minor edit, → = section edit, ← = automatic edit summary

(newest | oldest) View (newer 50 | older 50) (20 | 50 | 100 | 250 | 500)

Compare selected revisions

- (cur | prev) 03:57, 1 August 2006 Stevenj (talk | contribs) . . (53,894 bytes) (-1) . . *(vprotected is the correct tag, I believe)*
- (cur | prev) 03:55, 1 August 2006 SlimVirgin (talk | contribs) **m** . . (53,895 bytes) (0) . . *(Protected Elephant: isn't actually protected; as requested [edit=autoconfirmed:move=autoconfirmed])*
- (cur | prev) 03:55, 1 August 2006 SlimVirgin (talk | contribs) **m** . . (53,895 bytes) (0) . . *(Protected Elephant: wasn't actually protected; as requested [edit=autoconfirmed:move=autoconfirmed])*
- (cur | prev) 03:54, 1 August 2006 SlimVirgin (talk | contribs) **m** . . (53,895 bytes) (0) . . *(Protected Elephant: wasn't actually protected; as requested [edit=autoconfirmed:move=autoconfirmed])*
- (cur | prev) 03:54, 1 August 2006 SlimVirgin (talk | contribs) **m** . . (53,895 bytes) (0) . . *(Protected Elephant: wasn't actually protected; as requested [edit=autoconfirmed:move=autoconfirmed])*
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- (cur | prev) 03:53, 1 August 2006 SlimVirgin (talk | contribs) **m** . . (53,895 bytes) (0) . . *(Protected Elephant: wasn't actually protected; as requested [edit=autoconfirmed:move=autoconfirmed])*
- (cur | prev) 03:51, 1 August 2006 RasputinAXP (talk | contribs) . . (53,895 bytes) (+14) . . *(protecting from vandalism)*
- (cur | prev) 03:47, 1 August 2006 Stevenj (talk | contribs) . . (53,881 bytes) (-15) . . *(whoops, unrevert; I accidentally re-added the vandalism instead of removing it, sorry)*
- (cur | prev) 03:46, 1 August 2006 Crzrussian (talk | contribs) . . (53,896 bytes) (-46) . . *({{protected}})*
- (cur | prev) 03:41, 1 August 2006 Stevenj (talk | contribs) **m** . . (53,942 bytes) (+61) . . *(Reverted edits by Xaosflux (talk) to last version by Fire Star)*
- (cur | prev) 03:40, 1 August 2006 Xaosflux (talk | contribs) . . (53,881 bytes) (-61) . . *(-THE NUMBER OF ELEPHANTS HAS TRIPLED IN THE LAST SIX MONTHS!)*

Version Control

Places you're already using version control without knowing it:

- Google Docs
- Wikipedia
- Every piece of software you use.

Version Control

Isn't this just a complicated version of the "date and initial" method?

- regressions2015.08.24.do
- regressions2015.08.25.do
- regressions2015.08.25GC.do
- Hassle
- Confusion

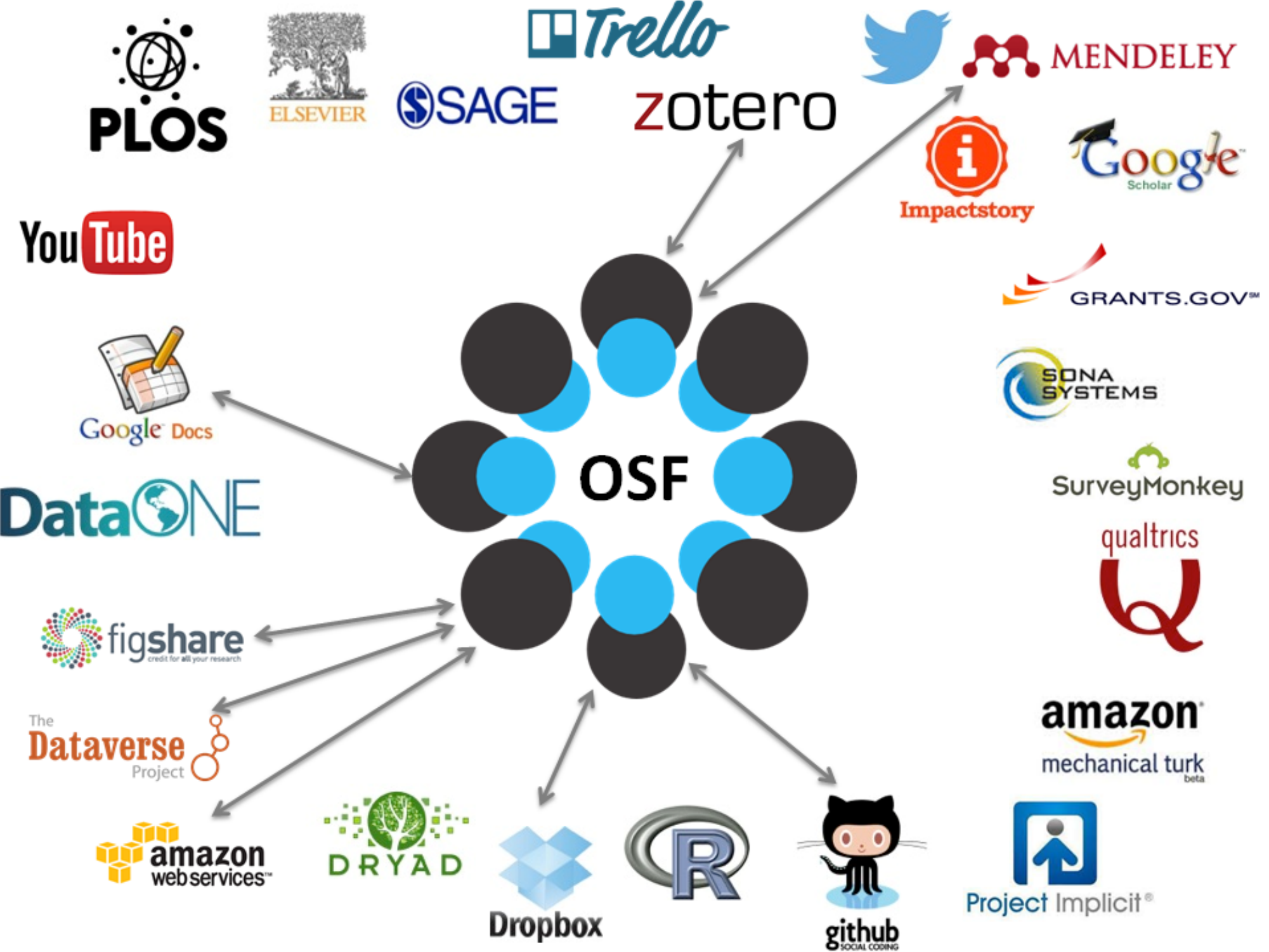
Version Control

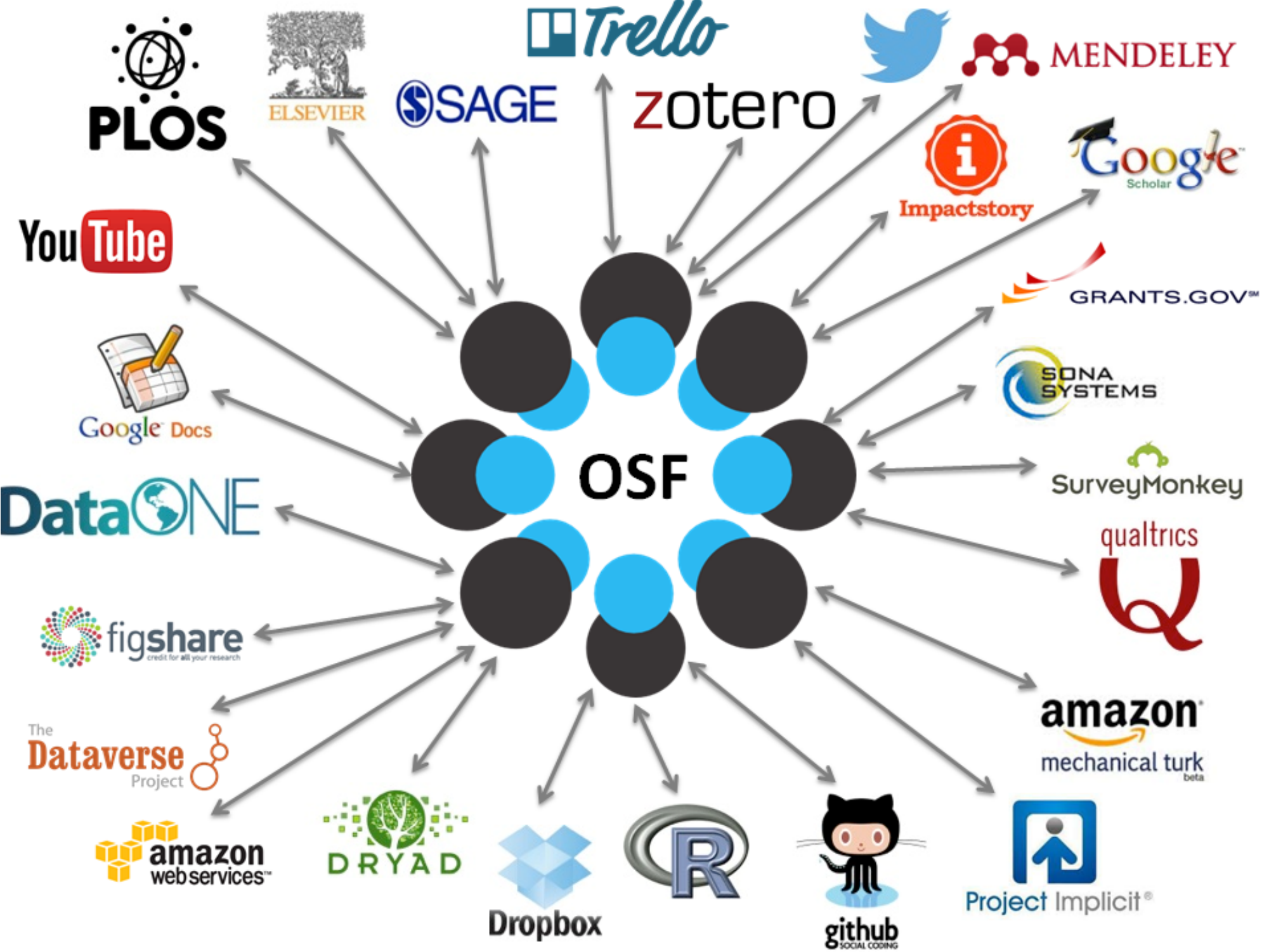
Here is a good rule of thumb: If you are trying to solve a problem, and there are multi-billion dollar firms whose entire business model depends on solving the same problem, and there are whole courses at your university devoted to how to solve that problem, you might want to figure out what the experts do and see if you can't learn something from it.

...

Not one piece of commercial software you have on your PC, your phone, your tablet, your car, or any other modern computing device was written with the "date and initial" method.

–Matthew Gentzkow and Jesse M. Shapiro "Code and Data for the Social Sciences: A Practitioner's Guide"


PLOS
ELSEVIER
Trello
SAGE
zotero
MENDELEY
Impactstory
Google Scholar
YouTube
GRANTS.GOV
Google Docs
SONA SYSTEMS
OSF
DataONE
SurveyMonkey
qualtrics
figshare
credit for all your research
The Dataverse Project
amazon mechanical turk beta
amazon web services
DRYAD
Dropbox
github SOCIAL CODING
Project Implicit


PLOS
ELSEVIER
Trello
SAGE
zotero
MENDELEY
Impactstory
Google Scholar
YouTube
GRANTS.GOV
Google Docs
SONA SYSTEMS
OSF
DataONE
SurveyMonkey
qualtrics
figshare
credit for all your research
amazon mechanical turk beta
The Dataverse Project
amazon web services
DRYAD
Dropbox
github SOCIAL CODING
Project Implicit

Examples

GitHub and OSF Examples:

- Slides for this workshop on Github.com
- `http://www.github.com/bitss/aphrc`
- Slides also available on the Open Science Framework
- `https://osf.io/m5ey4/`

Dynamic Documents

- Even if you write perfect (version controlled) code, you can still run into problems going from your code to paper. This is where *dynamic documents* come in.
- A dynamic document includes your data, code, analysis, and output all in one place. Fully automated, you can guarantee no mistakes from copying and pasting.
- Do this with R Markdown in R Studio or Ketchup in Stata.

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Dynamic Documents

- Include tables by linking to a file, instead of a static image.
- Include number by linking to a value calculated by an analysis file, instead of a static number typed manually.
- Automatically update tables and numbers.
- Produce entire paper with one or two clicks.

Examples

- R Studio Example
- Stata Example

Conclusion

Simple tools exist to help you transparently and reproducibly take your research from beginning to end.

- Trial Registries (previous slides)
- Pre-Analysis Plans (previous slides)
- Version Control
- Open Science Framework
- Dynamic Documents
- Trusted Public Data Archive (next slides)

Read more in my *Manual of Best Practices in Transparent Social Science Research* on GitHub.