'revisit': an R Package for Taming the Reproducibility Problem

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University of California at Davis

with Laurel Beckett, Tiffany Chen, Reed Davis, Paul Thompson and Emily Watkins

Stanford R Group, 7 November, 2017

These slides will be available at
`http://heather.cs.ucdavis.edu/StanfordR.pdf`

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If You Are Curious

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If You Are Curious

Why is a CS professor interested in this?

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If You Are Curious

Why is a CS professor interested in this?

- PhD in pure math, abstract probability theory.
- Joined UCD, working on statistical methodology.
- Was one of the founders of the UCD Stat Dept.
- Moved to CS Dept. long ago, but "Once a statistician, always a statistician."

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Reinhart and Rogoff Case

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Reinhart and Rogoff (2010) found that high government debt $\Longrightarrow$ weaker/negative economic growth.

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- After correction, -0.1% growth becomes +2.2%

Eichengreen Comment

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Eichengreen Comment

The brouhaha over Carmen Reinhart and Kenneth Rogoffs article "Growth in a Time of Debt" has raised troubling questions not only about the efficacy of [fiscal] austerity, but also about the reliability of economic analysis. If a flawed study could appear in a prestigious working-paper series, why should anyone trust economic research?

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Who's Right?

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- Reinhart and Rogoff defended their basic findings.

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  - In this case, e.g. "What if a different time frame had been used?" "What if a different weighting had been used?"

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Goals of 'revisit': Part 1

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- A "statistical audit."

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  - Allows users to ask the "What if?" questions, in nested manners. E.g. asking 3 binary What Ifs forms 8 scenarios, which in **revisit** we call *branches* after GitHub.
- Enable the original research team itself to do the above *during the research project*.

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Potti Case

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- Cancer, genomics research.

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- Clinical trials patients sued.

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- Sloppiness, apparent fraud.

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Potti Case

- Cancer, genomics research.
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- Sloppiness, apparent fraud.
- But also *poor use of statistical methods*.

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The Statistical Methodology Aspect

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Nature reported on a survey of scientists about the reproducibility problem (emphasis added),

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> *More than 60% of respondents [cited]...pressure to publish and* **selective reporting***...More than half pointed to insufficient replication in the lab, poor oversight or* **low statistical power***.*
> *Respondents were asked to rate 11 different approaches to improving reproducibility...Nearly 90% — more than 1,000 people — ticked* **"More robust experimental design," "better statistics"...**

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ASA Statement on P-Values

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- The problems have been known all along, e.g. Meehl, "Ronald [Fisher] has befuddled us, mesmerized us, and led us down the primrose path."

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- "The ASA releases this guidance on p-values to improve the conduct and interpretation of quantitative science and inform the growing emphasis on reproducibility of science research."

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Multiple Inference Methods

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Lack of use of multiple/simultaneous inference procedures, a severe problem:

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Lack of use of multiple/simultaneous inference procedures, a severe problem:

- Even if there are no underlying interesting effects, if one performs enough tests, some "significant" ones will be found.

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- One of the problems cited in the Potti case was "overfitting," here meaning the above.

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Goals of 'revisit': Part 2

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Encourage statistical best practices.

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- The **revisit** package aims to wean users away from relying much on p-values.

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- E.g. log-linear model.

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- Solution: Apply the "Poisson trick" and use **glm()**.

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Goals, Part 2, cont'd.

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Goals, Part 2, cont'd.

Dealing with the multiple inference issue:

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- The package attempts to count how many tests/confidence intervals the user has (directly or indirectly) performed.

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- Currently only Bonferroni offered, more coming.

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Wrapper Functions

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- Users call **revisit** functions, as wrappers to standard R functions.

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- Among other things, **lm.rv()** will run, say, **qr()** from the **quantreg** package, then display for the user the two sets of estimated regression coefficients. If they differ much, some outlier hunting/deletion might be warranted.

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- Among other things, **lm.rv()** will run, say, **qr()** from the **quantreg** package, then display for the user the two sets of estimated regression coefficients. If they differ much, some outlier hunting/deletion might be warranted.
- In addition, some plots from my **regtools** package will be run (on CRAN, coordinated with my new book).

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Structure of the revisit Package

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- Case studies.
- GitHub-inspired branch structure. Each "What if?" scenario is saved as a separate file.

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- GitHub-inspired branch structure. Each "What if?" scenario is saved as a separate file.
- Example scenario: Delete outliers x, y and z; choose predictor variables u and v; use Bonferroni adjustments.
- A scientist who has explored several scenarios can package these branches and send them to others for further exploration.

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GUI Example

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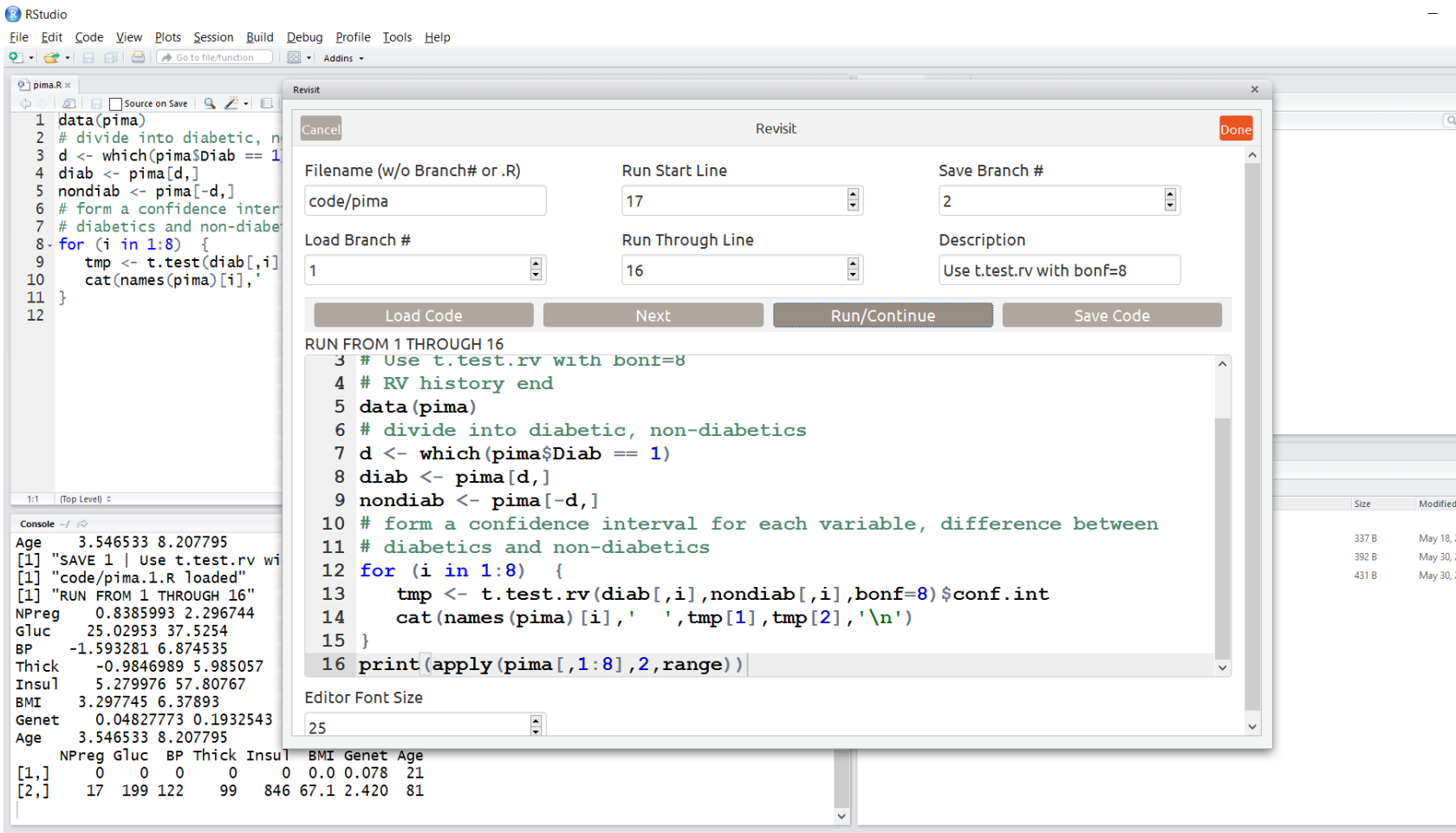
GUI Example



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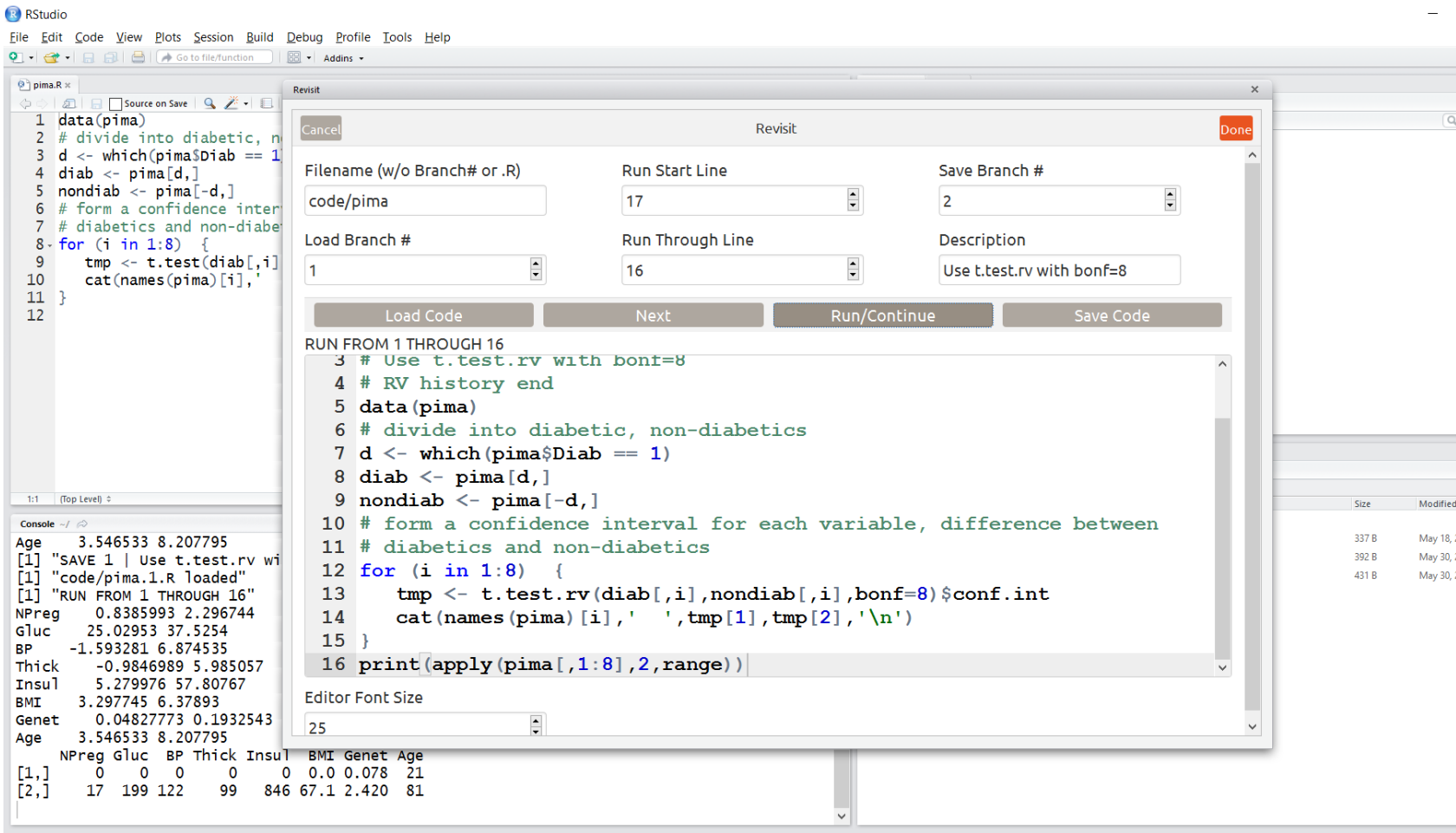

But it will be clearer to display text here.

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Case Study: Zavodny

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- Zavodny study, commissioned by an advocacy group in 2011, of impact of H-1B work visa program on U.S. workers.

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- Highly controversial, much criticism of the visa by Clinton, Sanders, Trump etc. in 2016 election.

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- Zavodny found that each visa worker creates 2.62 new jobs for Americans. Peri (2014), also funded by an advocacy group, had similar findings. Gelber *et al* found the opposite, a crowding-out of U.S. workers.

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- Dr. Zavodny kindly shared her code and data with Reed Davis, one of the **revisit** authors.

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Zavodny, cont'd.

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Zavodny, cont'd.

```
> library(revisit)
> rvinit()  # required initialization
> loadb('ols262.R')  # load the branch
> lcc()  # list the code
...
...
4 data(zav)
5 zav = zav[zav$year < 2008,] # 2008-2010 removed
...
...
```

Again, this is R code converted from Stata. Does it reproduce Zavodny's results? Yes:

```
> runb()
[1] "Slope   = 0.00446438147988468"
[1] "P-value = 0.0140870195483076"
[1] "Jobs    = 262.985782017836"
```

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Zavodny, cont'd.

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Zavodny, cont'd.

But Zavodny omitted 2008-2010. What if...?

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Zavodny, cont'd.

But Zavodny omitted 2008-2010. What if...?

We call **revisit** function **edt()** to edit the code (visual editor in GUI),

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Zavodny, cont'd.

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We call **revisit** function **edt()** to edit the code (visual editor in GUI), commenting out line 5. Then:

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Zavodny, cont'd.

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We call **revisit** function **edt()** to edit the code (visual editor in GUI), commenting out line 5. Then:

```
> runb()
[1] "Slope    = 0.00180848722715659"
[1] "P-value = 0.33637275201986"
[1] "Jobs     = 124.352299406043"
```

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Now, the result is no longer significant [sic], and the point estimate has been cut in half.

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Zavodny, cont'd.

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Zavodny, cont'd.

Some other What Ifs:

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Zavodny, cont'd.

Some other What Ifs:

Adj. R^2 is 0.91, quite high.

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Zavodny, cont'd.

Some other What Ifs:

Adj. R^2 is 0.91, quite high. The author's model include dummies for state effects. What if we remove them?

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Zavodny, cont'd.

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```
...

Coefficients:
                                  Estimate  Std. Error
(Intercept)                      4.1780416   0.0106922
lnimmshare_emp_stem_e_grad      -0.0130295   0.0036493
lnimmshare_emp_stem_n_grad       0.0005722   0.0040274
fyear2001                       -0.0098670   0.0104854
...
Multiple R-squared:  0.372,  Adj. R-squared:  0.3517
```

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Zavodny, cont'd.

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...
Multiple R-squared:  0.372,  Adj. R-squared:  0.3517
```

Using only immigrant share and time effects, R^2 drops a lot.

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Zavodny, cont'd.

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Zavodny, cont'd.

Very complex topic, many assumptions etc.
But clearly Zavodny's "2.62 jobs created by each H-1B" figure – very widely cited in the press — cannot be taken as definitive.

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Who Might Use revisit?

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- Good for coordination within a research team, during a project, asking a lot pf What If questions.

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- Voluntary publication of the data and **revisit** files by a research team, in the spirit of open intellectual inquiry and reproducibility.

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- Possible adoption by journals and funding agencies, as a requirement for publication/funding?
- Use as a teaching tool, especially with the case studies.