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Motivation 1: "Reproducibility Crisis"

Replication in Social Sciences (same method, different sample)	**Reproduction in Economics (same data and methods)**
OSC (2015): 30%-60%	Chang & Li (2015): 43%
Camerer et. al. (2016): ~60%	Gertler et. al. (2017): 14%
Nosek & Camerer et. al. (2018): ~60%	Kingi et. al. (2018): 43%
Klein et. al. (2018): 50%	Wood et. al. (2018): 25%

M2: More Inclusive Concept Scholarly Output

> Clarebout Principle:
>
> "An article about computational science in a scientific publication is not the scholarship itself, it's merely scholarship advertisement. The actual scholarship is the complete software development environment and the complete set of instructions which generated the figures."
>
> *Buckheit and D.L. Donoho (1995, 2009)*

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M2: More Inclusive Concept Scholarly Output

Potential benefits of following the Clarebout Principle

Well discussed potential positive effects on:

- Pedagogy
- Incremental generation of knowledge

Under discussed:

- Possible positive effect on diversity, equity and inclusion: no connections or language skills ("appropriate politeness") required to obtain materials

M3: Prevent Loss of Knowledge

Every semester, graduate students around **the world** take an Empirical/Applied [...] Economics course. A typical assignment consists of reproducing the results of a paper and, possibly, testing the robustness of its results.

Stage	New Knowledge
Scope (select and verify)	Data and code exist?
Assess	Degree of reproducibility for specific part of the paper
Improve	E.g. fixed paths, libraries, added missing files, etc.
Test robustness	Results are robust to additional specifications

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Context for ACRE

- American Economics Association (AEA) creates first data policy in 2006.
  - Must publish some data (waivers available)
- AEA updates policy in 2019.
  - Must post all data and code. Publication is conditional on verifying reproducibility (if confidential: must document extensively)
  - A new requirement is to post all cleaning code, even for data that is not public
  - See the AEA Data Editor Website for more information
- We should expect high levels of computational reproducibility after 2019 (AEA Journals).
- We should not demand 100% reproducibility before, but we could identify the gaps and try to improve some.

Beyond Binary Judgments

Reproductions can easily gravitate towards adversarial exchanges.

- Early career researcher (ECR) have incentives to emphasize unsuccessful reproductions
- Original authors have a more senior position and can use it to deter in-depth reproductions from ECRs.
- The media also focuses on eye-catching headlines

Our approach:

We do not want to say

> "Paper X is (ir)reproducible"

We do want to say

> "Result Y in paper X has a high/low **level** of reproducibility according to **several** reproduction attempts. Moreover, **improvements** have been made to the original reproduction package, **increasing** its reproducibility to a higher level"

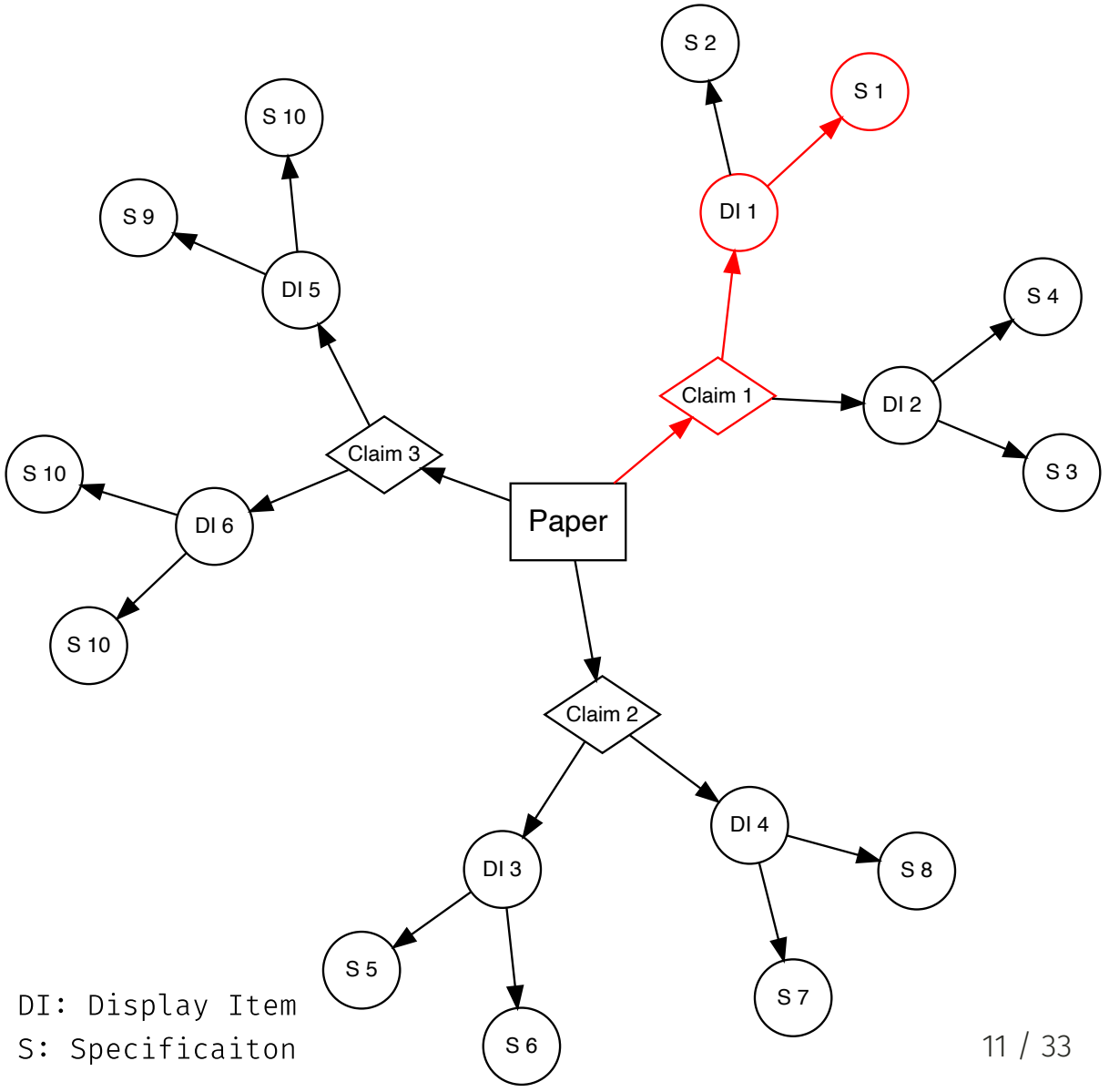
Our Framework

Each **reproduction attempt** is centered around scientific **claims**

One paper can contain several claims.

Each claim may be supported by various **display items**: tables, figures & inline results.

A reproduction attempt is at the claim level, and reproducers must record their **specifications** of interest.

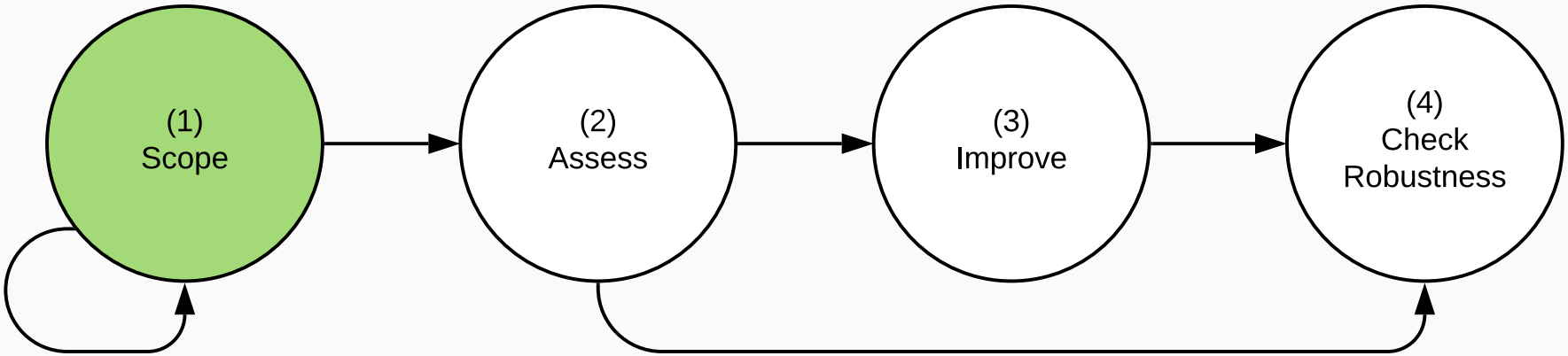


DI: Display Item
S: Specificaiton

Large part of this exercise is about standardization

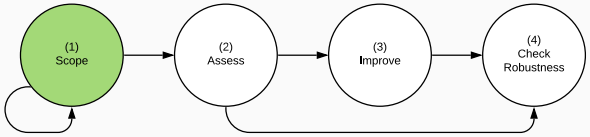
- **Computational Reproduction (or Reproduction)**
- **Replication (will not mention this term again!)**
- Reproduction attempt
- **Reproduction package**
- Claim
- Display item
- Specification
- Preferred specification
- **Raw data**
- **Analysis data**
- **Candidate paper**
- **Declared paper**
- Reproduction tree
- Complete Workflow
- Computationally Reproducible from Analytic data (CRA)
- Computationally Reproducible from Raw data (CRR)
- Reasonable test
- Feasible test
- Minimal effort

Stages



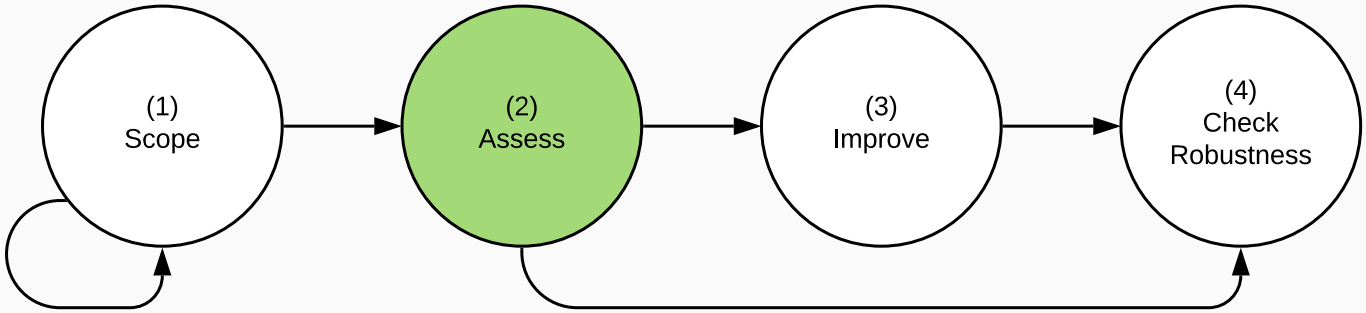
Scoping

1. Select or be assigned a candidate paper
2. Check ACRE Platform for previous entries and verify availability of reproduction package (RP)
3. If no RP, leave a short record, and repeat with a different candidate paper
4. Once RP is found then candidate becomes declared paper
5. Only then: read the paper and select claim(s), display items and specification to reproduce



> **Box 1:** Summary Report Card for ACRE Paper Entry
> **Title:** Sample Title
> **Authors:** Jane Doe & John Doe
> **Original Reproduction Package Available:** URL/No
> [If "Yes"]
> **Additional Reproduction Packages:** Number (eg., 2)
> [If "No"]
> **Contacted Authors?:** Yes/No
> [If "Yes(contacted)"]
> **Type of Response:** Categories (6).
> **Authors Available for Further Questions for ACRE Reproductions:** Yes/No/Unknown

Assessment



Two main parts for assessment:

1. Find all the elements behind a display item
2. Score the reproducibility of that display item

Identify All the Elements Behind a Display Item

Reproducers will be asked to draw a clear connection to the raw data sources mentioned in the paper and the display item under reproduction.

Data sources

Connect the data sources in the paper's text with specific raw data files.

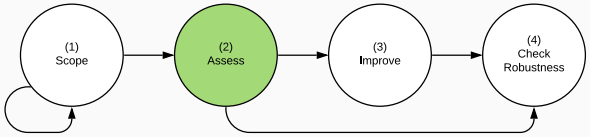
Analytic data sets

Describe each analytic data file.

Code files

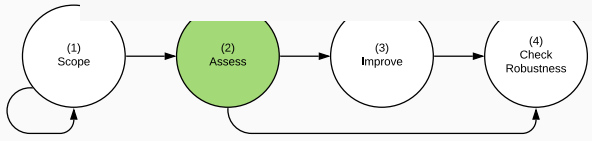
Inspect all code files and record all their inputs and outputs.

With all the information recorded above, reproducers can use the **ACRE Diagram Builder** to generate a **reproduction tree**.



Reproduction Tree

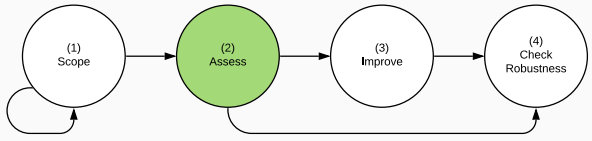
```
table1.tex
    |___[code] analysis.R
        |___analysis_data.dta
            |___[code] final_merge.do
                |___cleaned_1_2.dta
                |   |___[code] clean_merged_1_2.do
                |       |___merged_1_2.dta
                |           |___[code] merge_1_2.do
                |               |___cleaned_1.dta
                |               |   |___[code] clean_raw_1.py
                |               |       |___raw_1.dta
                |               |___cleaned_2.dta
                |                   |___[code] clean_raw_2.py
                |                       |___raw_2.dta
                |___cleaned_3_4.dta
                    |___[code] clean_merged_3_4.do
                        |___merged_3_4.dta
                            |___[code] merge_3_4.do
                                |___cleaned_3.dta
                                |   |___[code] clean_raw_3.py
                                |       |___raw_3.dta
                                |___cleaned_4.dta
                                    |___[code] clean_raw_4.py
                                        |___raw_4.dta
```



Levels

Levels of Computational Reproducibility
(P denotes "partial", C denotes "complete")

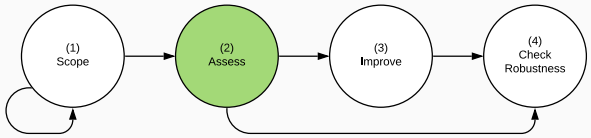
	Availability of materials, and reproducibility									
	Analysis Code		Analysis Data			Cleaning Code		Raw Data		
	P	C	P	C	CRA	P	C	P	C	CRR
L1: No materials	-	-	-	-	-	-	-	-	-	-
L2: Only code	✔	✔	-	-	-	-	-	-	-	-
L3: Partial analysis data & code	✔	✔	✔	-	-	-	-	-	-	-
L4: All analysis data & code	✔	✔	✔	✔	-	-	-	-	-	-
L5: Reproducible from analysis	✔	✔	✔	✔	✔	-	-	-	-	-
L6: Some cleaning code	✔	✔	✔	✔	✔	✔	-	-	-	-
L7: All cleaning code	✔	✔	✔	✔	✔	✔	✔	-	-	-
L8: Some raw data	✔	✔	✔	✔	✔	✔	✔	✔	-	-
L9: All raw data	✔	✔	✔	✔	✔	✔	✔	✔	✔	-
L10:Reproducible from raw data	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔



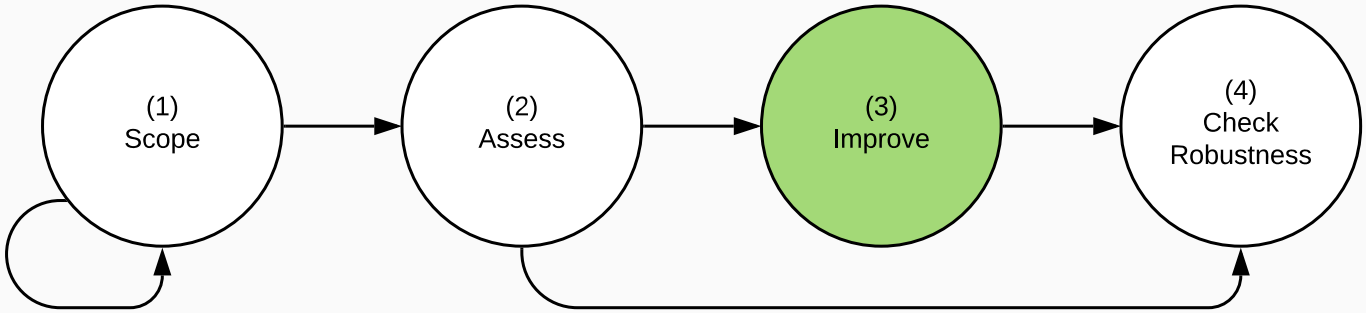
Levels: Proprietary/Confidential Data

Levels of Computational Reproducibility
with Proprietary/Confidential Data
(P denotes "partial", C denotes "complete")

	Availability of materials, and reproducibility									
	Analysis Code		Instr. Analysis Data		CRA	Cleaning Code		Instr. Raw Data		CRR
	P	C	P	C		P	C	P	C	
L1: No materials	-	-	-	-	-	-	-	-	-	-
L2: Only code	✔	✔	-	-	-	-	-	-	-	-
L3*: Partial analysis data & code	✔	✔	✔	-	-	-	-	-	-	-
L4*: All analysis data & code	✔	✔	✔	✔	-	-	-	-	-	-
L5*: Proof of third party CRA	✔	✔	✔	✔	✔	-	-	-	-	-
L6: Some cleaning code	✔	✔	✔	✔	✔	✔	-	-	-	-
L7: All cleaning code	✔	✔	✔	✔	✔	✔	✔	-	-	-
L8*: Some instr. for raw data	✔	✔	✔	✔	✔	✔	✔	✔	-	-
L9*: All instr. for raw data	✔	✔	✔	✔	✔	✔	✔	✔	✔	-
L10*:Proof of third party CRR	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔



Improvements

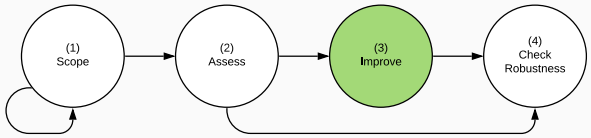


Three types of improvements:

1. Improvements at the paper level
2. Improvements at the display-item level
3. Specific future improvements

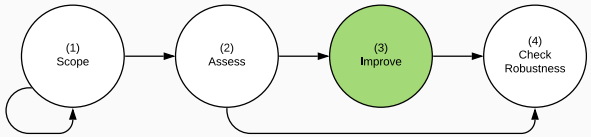
Improvements: Paper-level

- Use version control software (Git/Github).
- Improve documentation: comments, indentations, object names, etc.
- Re-organize the reproduction package into a set of folders and sub-folders that follow standardized best practices, and add a master script that executes all the code in order, with no further modifications. See AEA's reproduction template.
- Literate programming environment (e.g., Jupyter notebooks, RMarkdown)
- Re-write code using a differenet statistical software (ideally open source, like R, Python, or Julia).
- Set up a computing capsule (e.g., Binder and Code Ocean).

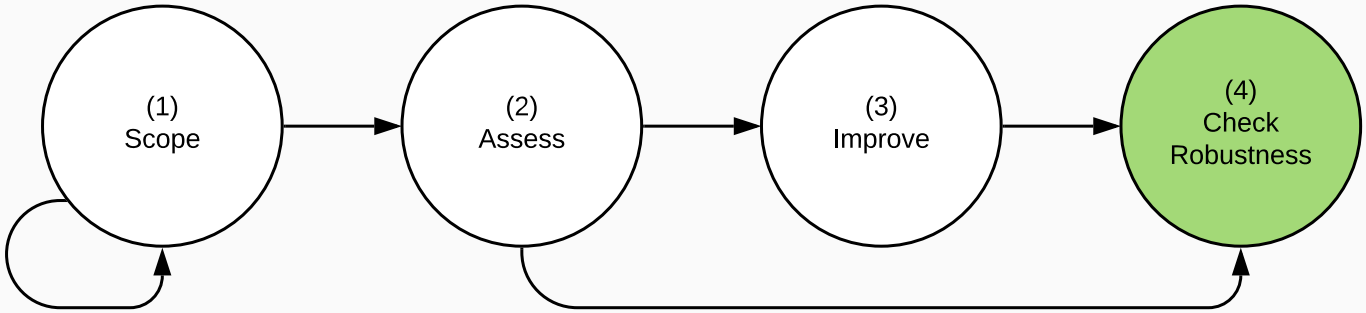


Improvements: Display item-level

- Adding missing raw data: files or meta-data
  - Example: "Add raw temperature and relative humidity data"
- Adding missing analytic data files
  - Example: "Copy the row files from Data folder into new `Analysis\trade cost\Input`"
- Adding missing analysis or cleaning code
  - Example: "Replaced broken Wald bootstrap code with updated code/command"
- Debugging code
  - Example: "was counting each group 4 times in round 1, so fixed that"



Robustness Checks



Two main parts for robustness:

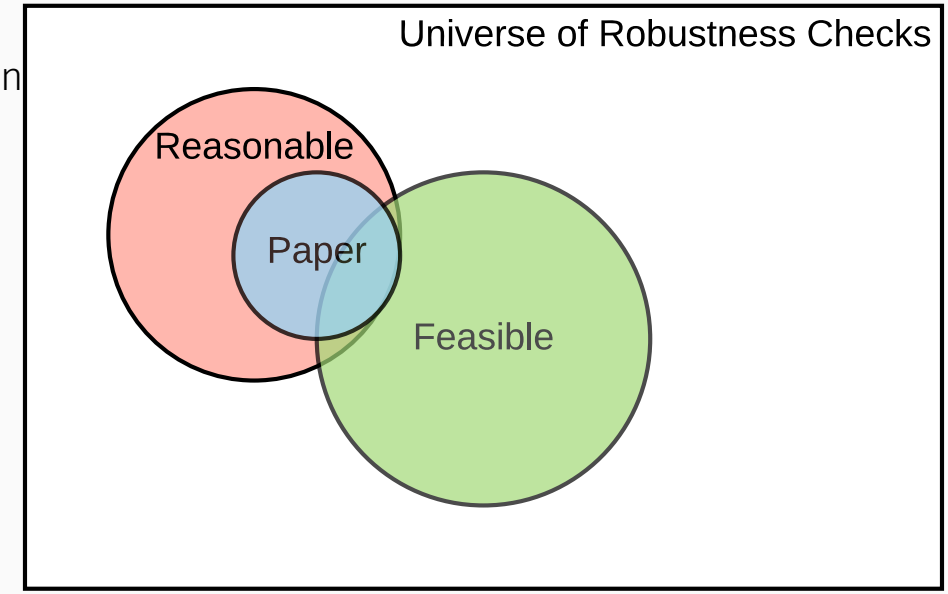
1. Increase the number of possible robustness checks
2. Justify the appropriateness of a specific test

Robustness

Robustness checks: any possible change in a computational choice, both in data analysis and data cleaning

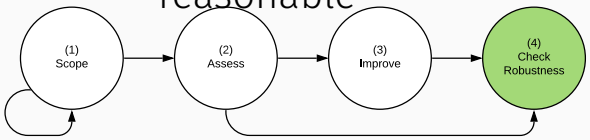
Reasonable specifications (Simonsohn et. al., 2018):

1. Sensible tests of the research question
2. Expected to be statistically valid, and
3. Not redundant with other specifications in the set.



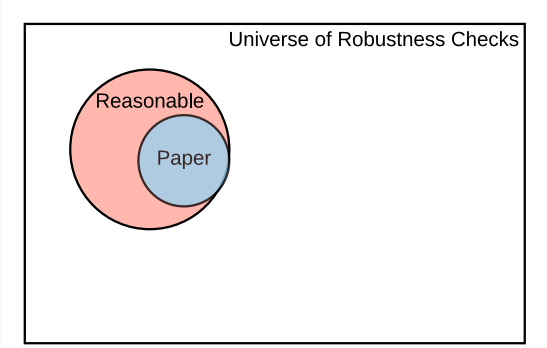
Reproducers will be able to record two types of contributions:

- Mapping the universe of robustness checks
- Justify a specific robustness check as reasonable

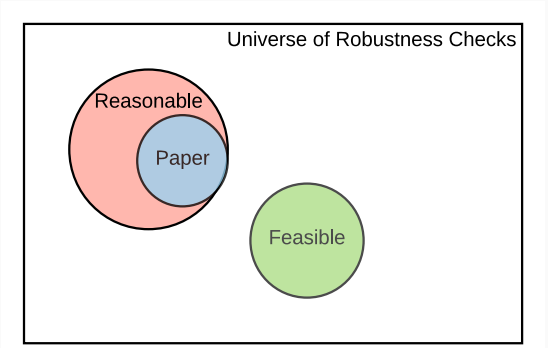


Robustness & Reproducibility

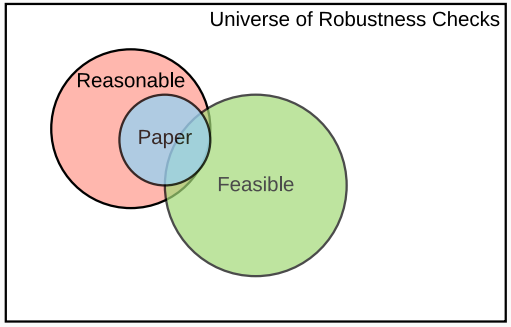
Robustness with level 1



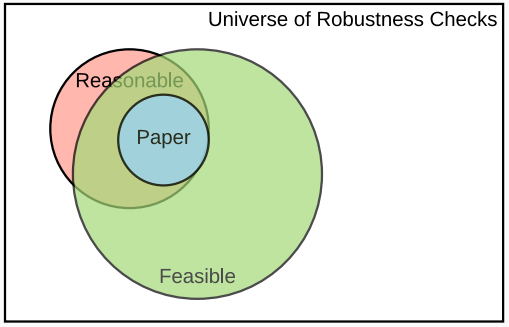
Robustness with levels 2-4

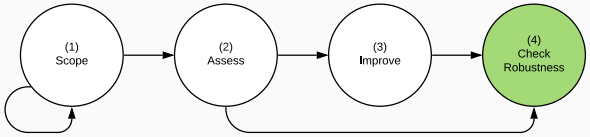


Robustness with levels 5-9



Robustness with level 10





Promoting a Constructive Exchange

1 - Contacting the original author(s) when there is no reproduction package

2 - Contacting the original author(s) to request specific missing items of a reproduction package

3 - Asking for additional guidance when some materials have been shared

4 - Response when the original author has refused to share due to *undisclosed reasons*

5 - Response when the original author has refused to share due to legal or ethical restrictions of the data

6 - Contacting the original author to share the results of your reproduction exercise

7 - Responding to hostile responses from original authors

Under development: sample responses form authors to reproducers

Example 1: Following up on additional materials

Template email:

> **Subject:** Clarification for reproduction materials for `["Title of the paper"]`
>
> Dear Dr. `[Lastname of Corresponding Author]`,
>
> Thank you for sharing the materials. They have been immensely helpful for my work.
>
> Unfortunately, I ran into a few issues as I delved into the reproduction exercise, and I think your guidance would be helpful in resolving them. **`[Describe the issues and how you have tried to resolve them. Describe whatever files or parts of the data or code are missing. Refer to examples 1 and 2 below for more details]`**.
>
> Thank you in advance for your help.
>
> Best regards,
> `[Reproducer]`

An example of well described issues:

> Specifically, I am attempting to reproduce [`display item X (e.g., table 1, figure 3)`]. I found that the following components are required to reproduce to reproduce [`display item X`]:

```
display_item_X
   └──[code] formatting_table1.R
       ├──output1_part1.txt
       |   └──[code] output_table1.do
       |       └──[data] analysis_data01.csv
       |           └──[code] data_cleaning01.R*
       |              └──[data] UNKNOWN
       └──output1_part2.txt
           └──[code] output_table2.do
               └──[data] analysis_data02.csv
                   └──[code] data_cleaning02.R
                      └──[data] admin_01raw.csv*
```

> I have marked with an asterisk (*) the items that I could not find in the reproduction materials: **data_cleaning01.R** and **admin_01raw.csv**. After accessing these files, I will also be able to identify the name of the raw data set required to obtain output1_part1.txt. This is to let you know that I may need to contact you again if I cannot find this file (labeled as **UNKNOWN** above) in the reproduction materials.
>
> I understand that this request will require some work for you or somebody in your research group, but I want to assure you that I will add these missing files to the reproduction package for your paper on the ACRE platform. **Doing this will ensure that you will not be asked twice for the same missing file.**

Easy to grade: report 1

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Easy to grade: report 1

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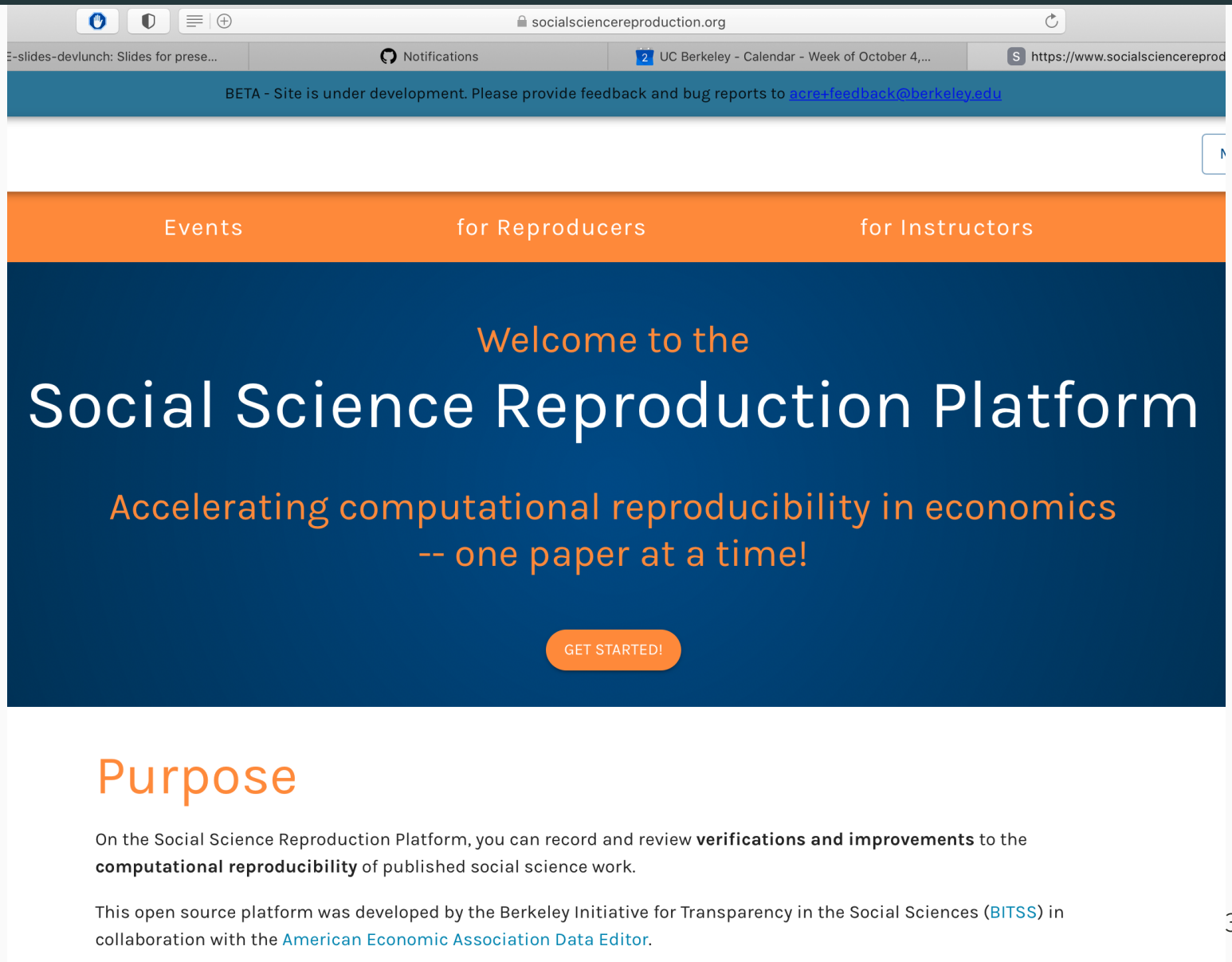

Acknowledgements

Arnold Ventures

Everybody who has participated in the pilots so far:

Ted Miguel's Graduate Development Economic Course (2019, 2020) - UC Berkeley

Dina Pomeranz undergraduate thesis for Marc Richter - University of Zurich

Slides template: Grant McDermott.