Overview

The code in this replication package replicates all tables, figures and in-text results from the paper, as well as the supplementary material. There are two main files. The first main file carries out all computations using Julia and saves intermediate output required to assemble the figures and tables. The second main file uses R to create LaTeX files for the tables and PDF files for the figures. The replicator should expect the code to run for about 96 hours (on a 32 vCPU, 64GB memory AWS EC2 c6g.8xlarge instance or an equivalent desktop machine) to reproduce all results. Alternatively, the main script carrying out the computations offers options for skipping some of the computationally intensive calculations. With the corresponding flags enabled, the replicator should expect the code to run for about 36 hours.

Data Availability and Provenance Statements

Statement about Rights

- [x] I certify that the author(s) of the manuscript have legitimate access to and permission to use the data used in this manuscript.
- [x] I certify that the author(s) of the manuscript have documented permission to redistribute/publish the data contained within this replication package. Appropriate permissions are documented in the `LICENSE.txt` file in the `raw_data` folder.

Summary of Availability

- [x] All data **are** publicly available.
- [ ] Some data **cannot be made** publicly available.
- [ ] **No data can be made** publicly available.

Details on each Data Source

Data.Name	Data.Files	Location	Provided	Citation
"Baumeister & Hamilton (2015) Dataset"	BH15-dataset.csv	raw_data/	TRUE	Baumeister and Hamilton (2015)
"Zhou (2020) Dataset"	Zhou20-dataset1.txt	raw_data/	TRUE	Zhou (2020)

The data from Baumeister & Hamilton (2015) was obtained from the replication code for the paper which can be downloaded from Christiane Baumeister's website at https://sites.google.com/site/cjsbaumeister/research. Scroll down to "Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information (with James D. Hamilton), Econometrica, 83(5), September 2015, 1963-199" and download the file `BHcode.zip` from the link titled `Matlab codes`. The file is called `labor_data.csv` and its content is identical to the file `BH15-dataset.csv` supplied in the `raw_data` folder.

The data from Zhou (2020) can be downloaded from the *Journal of Applied Econometrics Data Archive* at http://qed.econ.queensu.ca/jae/datasets/zhou001/. Download the file `data-xz.zip` and extract the zip file. The dataset file is called `dataset1.txt` and is identical to the file `Zhou20-dataset1.txt` supplied in the `raw_data` folder.

Computational requirements

Software Requirements

- [x] The replication package contains one or more programs to install all dependencies and set up the necessary directory structure.

The codes were last run on *December 12th 2023* using the specified versions of Julia and R with the packages/libraries listed below.

- **Julia 1.9.4** with the following packages
  - `DelimitedFiles`
  - `SpecialFunctions`
  - `StaticArrays`
  - `SparseArrays`
  - `Statistics`
  - `LinearAlgebra`
  - `StatsBase`
  - `StatsFuns`
  - `Distributions`,
  - `ForwardDiff`
  - `NLopt`

    - `DataFrames`
    - `CSV`
    - `ProgressMeter`
    - `LaTeXStrings`

The first main file `01_run_computations.sh` contains code to install the required Julia packages, if they are not already installed on the system.

- **R 4.3.2** with the following libraries
    - `tidyverse`
    - `kableExtra`
    - `latex2exp`
    - `cowplot`
    - `gridExtra`

The second main file `02_make_figures_tables.R` contains code to install the required R libraries, if they are not already installed on the system.

Note: In certain circumstances (e.g. missing write permissions of the user running the script for the directory used to store installed packages/libraries or missing dependencies on Linux required to compile the R libraries), the automatic installation of the packages/libraries might fail. In this case, please install the packages/libraries listed above manually.

Controlled Randomness

- [x] A random seed is set in line 9 of `include/Settings.jl`. This seed is used for all simulation studies.

Memory, Runtime, Storage Requirements

Summary

Approximate time needed to reproduce the analyses on a standard (2023) desktop machine:

- [ ] <10 minutes
- [ ] 10-60 minutes
- [ ] 1-2 hours
- [ ] 2-8 hours
- [ ] 8-24 hours
- [ ] 1-3 days
- [x] 3-14 days
- [ ] > 14 days

Approximate storage space needed:

- [ ] < 25 MBytes
- [ ] 25 MB - 250 MB
- [x] 250 MB - 2 GB
- [ ] 2 GB - 25 GB
- [ ] 25 GB - 250 GB
- [ ] > 250 GB

Details

The code was last run on an **AWS Elastic Compute Cloud (EC2)** `c6g.8xlarge` instance with 32 vCPUs, 64 GB memory and 32 GB storage space. The replication took approximately **96 hours** in total.

Description of programs/code

- The first main file `01_run_computations.sh` is a bash script which runs the computations required to replicate the results of the paper and supplementary material using **Julia**. The script produces intermediate output for all figures and tables in the paper and supplementary material and saves them into the folder `output`. Before running the computations, the script verifies that Julia and all required packages are installed. Linux and macOS users can execute the script after adding execution permissions using `chmod +x 01_run_computations.sh` by calling the script as `./01_run_computations.sh`. Windows users are not able to run the bash script directly, but should be able to execute the script via the Windows Subsystem for Linux (WSL), which is

available from Windows 10 onwards, using the command `wsl -e ./01_run_computations.sh` (after installing and setting up WSL).

  - This main file calls the scripts in the folder `scripts` which carry out the required computations. The scripts are clearly labelled with names corresponding to the figures and tables in the paper and supplementary material. For example, the script `scripts/Figure4_5_S6.jl` carries out all computations required to reproduce Figures 4, 5 and S6. All helper functions required to run these computations are located in the `include` directory.

  - **Replication scope:** The main file `01_run_computations.sh` offers customization options that can be changed by the replicator in order to limit the scope of the replication. For example, to skip the computationally intensive alternative tests (Pseudo-Maximum Likelihood, GMM and Bootstrap-based tests), set the environment variable `SKIP_ALTERNATIVE_TESTS` from `0` to `1`. Similarly, the bash variables `SKIP_SUPPLEMENT` and `SKIP_PAPER` can be changed by the replicator from `0` to `1` in order to skip the computations for the supplementary material and main paper, respectively.

  - **Parallelization:** The main file `01_run_computations.sh` offers the possibility to carry out some of the computations in parallel using multi-threading. The bash variable `N_WORKERS` allows changing the number of threads that are used to carry out the computations. If `N_WORKERS=1`, all simulations will be carried out without parallelization. If `N_WORKERS>1`, the simulation scripts will launch `N_WORKERS` additional julia threads which collect the computing jobs from a job channel and write the results to a results channel, both stored in the main thread. If your system uses a parallel version of LAPACK/BLAS routines, it is recommended to set the number of workers considerably lower than the number of available (virtual) cores, to avoid an over-provisioning of threads.

  - **Important:** When changing the value of the bash variables at the top of the `01_run_computations.sh` file, make sure not to introduce any white-spaces.

- The second main file `02_make_figures_tables.R` is an R script which produces the `.tex` files for all tables and `.pdf` files for all figures, loading the intermediate output saved to `output`. The script can be run directly from the Terminal via the `R` or `Rscript` commands or can be run using an IDE such as RStudio.

  - **Important:** If you have changed the replication scope in the first main file `01_run_computations.sh`, make sure that you adjust the variables of the same names in the script `02_make_figures_tables.R` such that the values match the ones you used in the first main file.

Instructions to Replicators

1. Make sure Julia (at least 1.9.0) and R (at least 4.3.0) are installed on the system.

2. Unzip the replication code, open a terminal and navigate to the root directory of the replication code.

3. Edit the file `01_run_computations.sh` and change the values of `N_WORKERS`, `SKIP_SUPPLEMENT`, `SKIP_PAPER` and `SKIP_ALTERNATIVE_TESTS` as desired (see the previous section for further explanation). At default values, the computations will be carried out in serial (`N_WORKERS=1`) and all results are replicated (`SKIP_SUPPLEMENT=0`, `SKIP_PAPER=0`, `SKIP_ALTERNATIVE_TESTS=0`).

4. Make the bash script executable by running the command `chmod +x 01_run_computations.sh` and launch the computations by calling the bash script using `./01_run_computations.sh`.

5. After the script has finished successfully, verify that the `output` directory contains the intermediate output files (`.csv` format) for the figures and tables.

6. Open the script `02_make_figures_tables.R` and adjust the values of `SKIP_SUPPLEMENT` and `SKIP_PAPER` to match the values you picked in step 3. Then, run the script using R (e.g. by sourcing it from the R command line, using the `Rscript` command from the Terminal or opening the file in RStudio and clicking `Source`).

7. After the script has finished successfully, the `output` directory will contain the `.tex` and `.pdf` files for all tables and figures.

List of tables and programs

The provided code reproduces:

- [x] All numbers provided in text in the paper
- [x] All tables and figures in the paper

The following table lists all tables, figures and in-text results contained in the paper and supplementary material, together with the scripts that generate them. Intermediate results produced by the scripts in the `scripts/` folder (which are called by the `01_run_computations.sh` main file) are saved to the `output` folder (in `.csv` format). Final `.tex` and `.pdf` files generated by the second main file `02_make_figures_tables.R` are similarly saved to the `output` folder. The results are listed in order of appearance in the paper and supplementary material, respectively. The script names and output file names for results which can be found in the supplementary material are prefixed with the letter `S`.

Figure/Table #	Program	Output file
Table 2	scripts/Table2.jl	output/Table2.csv
	02_make_figures_tables.R	output/Table2.tex
Table 3	scripts/Table3.jl	output/Table3.csv
	02_make_figures_tables.R	output/Table3.tex
Figure 1	scripts/Figure1.jl	output/Figure1.csv
	02_make_figures_tables.R	output/Figure1.pdf
p-values (Section 8.1)	scripts/Figure2_3_S5.jl	console output
Figure 2	scripts/Figure2_3_S5.jl	output/Figure2.csv
	02_make_figures_tables.R	output/Figure2.pdf
Figure 3	scripts/Figure2_3_S5.jl	output/Figure3.csv
	02_make_figures_tables.R	output/Figure3.pdf
p-values (Section 8.2)	scripts/Figure4_5_S6.jl	console output
Figure 4	scripts/Figure4_5_S6.jl	output/Figure4.csv
	02_make_figures_tables.R	output/Figure4.pdf
Figure 5	scripts/Figure4_5_S6.jl	output/Figure5.csv
	02_make_figures_tables.R	output/Figure5.pdf
Table S1	scripts/TableS1.jl	output/TableS1.csv
	02_make_figures_tables.R	output/TableS1.tex
Table S2	scripts/TableS2.jl	output/TableS2.csv
	02_make_figures_tables.R	output/TableS2.tex
Table S3	scripts/TableS3.jl	output/TableS3.csv
	02_make_figures_tables.R	output/TableS3.tex
Table S4	scripts/TableS4.jl	output/TableS4.csv
	02_make_figures_tables.R	output/TableS4.tex
Table S5	scripts/TableS5.jl	output/TableS5.csv
	02_make_figures_tables.R	output/TableS5.tex
Figure S1	scripts/FigureS1_S2.jl	output/FigureS1_S2.csv
	02_make_figures_tables.R	output/FigureS1.pdf
Figure S2	scripts/FigureS1_S2.jl	output/FigureS1_S2.csv

Figure/Table #	Program	Output file
	02_make_figures_tables.R	output/FigureS2.pdf
Figure S3	scripts/FigureS3_S4.jl	output/FigureS3.csv
	02_make_figures_tables.R	output/FigureS3.pdf
Figure S4	scripts/FigureS3_S4.jl	output/FigureS4.csv
	02_make_figures_tables.R	output/FigureS4.pdf
Figure S5	scripts/Figure2_3_S5.jl	output/FigureS5.csv
	02_make_figures_tables.R	output/FigureS5.pdf
Figure S6	scripts/Figure4_5_S6.jl	output/FigureS6.csv
	02_make_figures_tables.R	output/FigureS6.pdf

References

Baumeister, C., & Hamilton, J. D. (2015). "Sign restrictions, structural vector autoregressions, and useful prior information." *Econometrica, 83(5), 1963-1999*. https://doi.org/10.3982/ECTA12356

Zhou, X. (2020). Refining the workhorse oil market model. *Journal of Applied Econometrics, 35(1), 130-140*. https://doi.org/10.1002/jae.2743