Financial Frictions
Micro vs Macro Volatility

Data and code replication package

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Note on this version

This version corrects numerical implementation issues, notably an unintended overwriting of household-dependent Jacobian entries by `update_model`. Derivatives computed in the full equilibrium system (`Fsys`) were replaced by aggregate-block derivatives (`Fsys_agg`), including for aggregates such as the MPC. We thank Simone De Vito, PhD Student in Economics at University of Rome Tor Vergata, for finding this error. This affected model dynamics. Investment adjustment costs and aggregate shock sizes were recalibrated to match the original targets for consumption volatility relative to output and output volatility. The quantitative results have been updated, while the paper's main conclusions remain unchanged.

The empirical part has also been revised to make the aggregate results reproducible from the public package. Required aggregate inputs and non-confidential exports are now included, together with the code for the quarterly bank-spread moments. Sample definitions have been aligned with those used for the published Table 5, and data-source, vintage and execution documentation has been corrected and expanded. The aggregate figures, Table 5 data moments and income-process and TFP parameters can be reproduced from the supplied files. Replication of the underlying household and bank-level analyses continues to require authorized access to confidential microdata.

Package overview

The package follows the original release layout: empirical files are in replication_data and recalibrated model files in replication_model. Their internal folder names are retained.

The shared Bash launcher runs the analyses supported by the supplied aggregate data and exported moments, followed by the complete model workflow. Confidential-data preparation runs separately in the authorized secure environment.

```
README.pdf / README.docx       Combined instructions
run_data_and_model.sh          Shared launcher
replication_data/              Empirical code and supplied inputs
  analysis/  prepare/  income-process/  exported/  Codebooks/
replication_model/             Recalibrated model package
  README.pdf / README.docx     Detailed model instructions
  replication_model.sh        Full model launcher
  Project.toml  Manifest.toml  Julia package environment
  models/  scripts/           Model variants and helpers
```

Each component keeps its own output directories. The model launcher creates figures/, tables/, tempfigures/, temptables/ and models/terminaloutput/ inside replication_model. The empirical scripts write to their existing out/ and temp/ subfolders inside replication_data.

Software and setup

Julia 1.9.3 was used for the updated model server runs. The supplied model Manifest.toml records Julia 1.9.2 from the original environment. Project.toml and Manifest.toml specify package dependencies; install the Julia executable separately and ensure it is on PATH.

Stata 19.5 was used for the updated model-based regressions. The empirical master file specifies Stata 18; the public empirical scripts require collect, available in Stata 17 and later. Use a licensed Stata installation with the commands required by the selected workflow.

The empirical income-process estimation uses Python 3 with numpy, pandas and scipy. Rebuilding the restricted household data additionally requires SAS 9.4. The supplied master_run_file.ps1 describes the Windows PowerShell workflow and the separate SAS, Stata and Python instances used in the Statistics Denmark environment.

Install dependencies once

From the package root, install the model Julia dependencies:

```
julia --project=replication_model -e 'using Pkg; Pkg.instantiate()'
```

In Stata, use ssc install followed by each required package name: gtools, ftools, require, reghdfe, coefplot, estout and winsor2. The model Stata graph scheme spartan is included in the model folders. The public empirical route uses built-in Stata commands with the supplied exports; the add-ons are needed by the model regressions and restricted empirical preparation and analysis.

For the Python environment used by the empirical estimation:

```
python3 -m pip install numpy pandas scipy
```

Run the combined package

Open a terminal in the package root. The default runs the public empirical analyses, then all model stages, including second order, welfare, Monte Carlo simulations and model-based Stata regressions:

```
bash run_data_and_model.sh
```

The components can also be run separately:

```
bash run_data_and_model.sh data
bash run_data_and_model.sh model
bash run_data_and_model.sh --help
```

If Stata is outside PATH, set STATA_BIN to its executable. PYTHON_BIN selects the Python executable when needed. For example:

```
STATA_BIN=/path/to/stata PYTHON_BIN=python3 bash run_data_and_model.sh
```

Model jobs run sequentially, with multiple Julia threads within each job. A complete model run can take several days. HANK2 second-order jobs use a 300 GB heap-size hint and require a machine with sufficient physical RAM; the hint is not a hard memory limit. Detailed model settings and result mappings are in replication_model/README.pdf.

Empirical data sources and access

We confirm that we have the rights or permissions to use all data referenced in this package for this research under the access conditions described below, and permission to publish the data included in the package. Only non-confidential materials are included in the public deposit. Confidential Statistics Denmark and MFI microdata are not distributed.

Household and bank microdata

Familiedata contains annual household balance sheets and imputed consumption. Danmarks Nationalbank constructs it from Statistics Denmark registers covering household membership, assets, liabilities and income; consumption is imputed as income less the change in net assets. The underlying registers are BEF, BOL, EJER, FAIK, FAM, FIDA, FORMAND, FORMBIL, FORMEJER, IDAN, IDAP, IND, INHP, INPI, LON, SYHB, REAL and UDDA.

URTEPERS and IRTEPERS contain end-of-year loan and deposit balances with person and bank identifiers. Together with BEF, the firm register FIRM and the firm-identifier crosswalk E_CVR_SE, they link household balance sheets to banks. The MFI microdata contain bank-level deposit and lending rates reported to Danmarks Nationalbank. The included Codebooks/mfi_codebook.pdf describes these variables.

Statistics Denmark registers are available to approved researchers through secure remote workstations. MFI access is granted by Danmarks Nationalbank on a case-by-case basis, with Statistics Denmark handling the link to household records. Approved researchers may contact the authors for assistance in obtaining copies of the final Familiedata and MFI datasets in their authorized Statistics Denmark project folder.

Statistics Denmark research data access and security rules

Danmarks Nationalbank balance sheet and interest rate statistics

Aggregate sources and preservation

The public aggregate inputs come from Statistics Denmark national accounts and Danmarks Nationalbank banking statistics. NA.xlsx and DN.xlsx contain data and source instructions for calibration targets; TFP_DK.xlsx supplies the TFP series. Codebooks/aggregate_codebook.pdf documents the aggregate series and exported coefficients, spreads and income moments. The quarterly national accounts use the 2022Q3, Revised vintage. The annual CPI input required for confidential-data preparation is not included.

We commit to preserving the data and code, including fixed copies of the restricted datasets in the authorized environments, for at least five years after publication and to providing reasonable assistance with clarification and replication requests.

Empirical computing environment

The empirical replication used SAS 9, Stata 18 and Python 3.12.3. The reported Python package versions are numpy 2.4.6, pandas 3.1.1 and scipy 1.17.1; reported Stata add-on versions are reghdfe 6.12.5, gtools 1.11.6, coefplot 1.8.4 and estout 3.31. A complete empirical run on Statistics Denmark servers takes approximately two weeks.

Empirical data and execution

Analyses using the supplied inputs

replication_data/run_public.sh runs run_public.do in Stata and then income-process/estimate_data.py in Python. The Stata entry point runs macro_data.do, including its quarterly spread calculations, followed by TFP_Denmark_estimates.do. It uses the shipped aggregate exports even when confidential intermediate files are also present.

Required supplied inputs are the three files in exported/ (spread.dta, averagempc.dta and spread_quarterly.dta), the four CSV files in prepare/0_macrodata/in/, TFP_DK.xlsx and income-process/moments_diff_resid_ypre.csv. Keep these files in their supplied locations. DN.xlsx, NA.xlsx and the codebooks are also retained from the empirical package.

The exported spread series, annual regression coefficients and income moments were produced from confidential source data. The public route reproduces the subsequent calculations using those exports; it does not reconstruct the underlying household regressions.

For Table 5, the consumption-output and investment-output correlations use 1991Q1–2019Q4; the annual output-volatility denominator for the relative volatility of DCDY uses 1991–2021. The spread row reports the volatility of the HP-filtered quarterly spread relative to output volatility and the correlation of the unfiltered spread with the output cycle.

Full replication with restricted data access

The confidential household and bank-level raw data are not distributed in this package. Authorized users must configure the institution-specific data libraries and executable paths before running the preparation scripts. See Codebooks/aggregate_codebook.pdf and Codebooks/mfi_codebook.pdf for the supplied variable documentation.

Follow the sequence in replication_data/master_run_file.ps1. Where the secure environment uses separate software instances, run the stages in the corresponding instances:

1. SAS: configure the libname paths and %include paths in prepare/0_familiedata_sas/0 Run all SAS.sas. Run it to produce familiedata.sas7bdat in that folder's out/ directory.
2. Stata: place the required CPI input dst_PRIS9.xlsx in prepare/0_macrodata/in/. This file is not included; inflation.do expects the annual input in cells A4:B25. Configure other confidential source paths, set the working directory to replication_data and run do run.do.
3. Python: run estimate_data.py from income-process after generating and transferring the income moments. The supplied moments file supports the public route; replace it with the newly generated moments only when intentionally rebuilding the complete empirical results.

The confidential quarterly bank-spread export is generated separately by prepare/2_prepare_spreads_irte_urte/gen_quarterly_spread.do in the Nationalbank environment. Configure that script's source paths to regenerate exported/spread_quarterly.dta. The supplied export is used by the public route.

The full restricted-data workflow must run where the required confidential inputs are available. The shared Bash launcher does not attempt that preparation stage. Restricted-source library settings remain specific to the secure environment.

Empirical results and output locations

Paths in this table are relative to replication_data. Public-run diagnostics and printed estimates are recorded in the timestamped directory reported by run_public.sh.

Result	Producing script	Output or availability
Figure 1; Figure 4b	analysis/macro_data.do	analysis/out/spread_cons_t5.pdf; cyclical_mpc.pdf
Table 5 data moments	analysis/macro_data.do; quarterly_spread_cyclicality.do	Printed in the public Stata log, including quarterly spread moments
Tables 2 and E1 TFP persistence	analysis/TFP_Denmark_estimates.do	Quarterly persistence printed in the public Stata log
Table 2 income process	income-process/estimate_data.py	Annual persistence and shock standard deviations in the income-process log
Table 3 aggregate calibration targets	NA.xlsx; DN.xlsx	Capital/output, government debt/output and government spending/output in NA.xlsx; banking leverage in DN.xlsx
Figures 2, 3, 4a and A.1	analysis/analysis.do	Requires restricted household data; PDFs in analysis/out/
Tables 1, A.1, A.2, A.3	analysis/analysis.do	Requires restricted household data; reg_baseline.tex, descriptives.tex, reg_robust_cars.tex, reg_robust_spec.tex in analysis/out/
Table 3 borrower fractions and borrowing spread	analysis/analysis.do	Requires restricted household data; printed in the empirical analysis log
Table 4 wealth shares	analysis/analysis.do	Requires restricted household data; analysis/out/wealth_shares.csv

Model results

The complete model workflow is replication_model/replication_model.sh. It solves all included first-order variants, the baseline and low-leverage second-order models, and the partial-equilibrium policy functions; then it generates model tables, figures, welfare results and model-based Stata regressions. Model output is copied to replication_model/figures and replication_model/tables. Table 8 is generated by the second-order welfare scripts.

The detailed figure/table-to-script mapping is retained in replication_model/README.pdf. The separate replication_sops.sh, replication_stata.sh and replication_stata_resume.sh remain available inside replication_model for targeted reruns and recovery. They are not additional steps after a successful complete model run.

Original release

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