README

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Replication Code: Estimating HANK for Central Banks

NOTE: There are still a few more updates to come.

The code in this repository replicates "Estimating HANK for Central Banks" by Sushant Acharya, William Chen, Marco Del Negro, Keshav Dogra, Aidan Gleich, Shlok Goyal, Ethan Matlin, Donggyu Lee, Reca Sarfati, Sikata Sengupta.

The code is primarily designed to replicate figures and tables in the "Estimating HANK" paper. If you are interested in using SMC for your own models, check out our independent software package SMC.jl.

First, make sure you are using the following version of our packages:

- `ClusterManagers.jl` v0.4.5
- `DSGE.jl` v1.3.0
- `ModelConstructors.jl` v0.2.5
- `SMC.jl` v0.1.15
- `StateSpaceRoutines.jl` v0.4.3

To add all packages you need, enter the following into the Julia REPL, in the indicated order (Julia syntax is `]add PACKAGENAME`):

1.]add DSGE@1.3.0
2.]add ClusterManagers@0.4.5
3.]add ModelConstructors@0.2.5
4.]add SMC@0.1.15
5.]add StateSpaceRoutines@0.4.3
6.]add CSV CategoricalArrays DataFrames DataStructures Debugger Distributions FileIO HDF5 IterTools JLD2 JSON MAT MCMCDiagnostics Nullables OrderedCollections Plots StatsBase StatsPlots XLSX
7. At this point, you will also need to also follow the instructions here for setting up a FRED API key.

Introduction

This documentation details how to reproduce the results of the HANK project using the provided code. This document does not include technical details about the models or methods used. For that, please see the paper.

Note that many of these estimations and forecasts are very memory-intensive. There are places in the code where you can add additional workers – if you do not allocate enough memory you will likely see the code fail to run after a certain amount of time and a TaskFailedException error. Add your workers to the variable "myprocs" (or "my_procs" depending on the file). These will be added further in the code by using the Julia built in addprocs() function.

One other detail to note is that the forecast, rmse, plotting, and table code are all sensitive to choosing the right output files and file identifier strings from the step before, so being careful about this will preempt a lot of errors.

Finally, for more context, each of the folders in the folder `/dsge_version` is a separate version of the DSGE.jl. This abstraction from github was done mostly because of changes to the codebase since COVID that rendered a lot of our private branches of DSGE.jl un-publishable by NY Federal Reserve Bank guidelines. An update to DSGE.jl is in the pipeline to account for this but for the sake of the replication code for this paper, the three folders `SW`, `BBL_MH_SMC`, and `BBL_7var` will suffice.

If you need assistance with running the code, reach out to the current NY Fed DSGE RAs (currently Pranay Gundam: Pranay.Gundam@ny.frb.org and Brian Pacula: Brian.Pacula@ny.frb.org).

Data:

Within the data folder, there are many subfolders. * `/data/input_data/raw` gives paths to inputs required for estimation, where ... (not sure if necessary so not gonna flush out) * `/data/input_data/data` contains necessary inputs to the full 11 variable and 7 variable hank models. DSID 01 corresponds to the 7 Variable HANK model, and DSID 1793 corresponds to the full 11 Variable HANK model. * `/data/output_data/` has various JLD2 files (dataf, save1, save4, scov, seven_rmse_final) - which support estimations and forecasts. * `/data/output_data/bayer_born_luetticke/ss1/estimate/raw` contains all raw estimation output files from Hank 7 Variable estimations. * `/data/output_data/hank_full/estimate/` contains all raw estimation output files from the primary HANK models * `/data/output_data/smets_wouters/ss0/estimate/raw` contains all raw estimation output files from SW estimations. * `/data/output_data/smets_wouters/ss0/estimate/work` contains () not really sure yet * `/data/output_data/smets_wouters/ss0/forecast/raw` contains output files from the Smets and Wouters forecasts * `/data/output_data/smets_wouters/ss0/forecast/work` contains MeansBand objects as outputs of SW forecasts that contain forecasted and historical data of observations, as well as their irfs.

Estimations

There are three separate models estimated: the primary HANK model, the 7-variable HANK model, and the Smets and Wouters (SW) model. We start with the primary model.

HANK Estimation

We run two sets of estimations for the HANK model, one from scratch using SMC and one using BBL's original MH estimation as a prior. We start with the SMC estimations.

1. Run estim/hank/fullsmc.jl, ensuring that run_estimate is set to true and use_bridge_cloud is set to false.
2. When this run completes, run estim/hank/fullsmc.jl again, this time with use_bridge_cloud = true (and run_estimate = true). Ensure that the load paths in the loop (lines 212 & 215) match the output estimation files.

   There may be points in which the estimation stops due to running out of memory. When this happens, do the following:

   1. Note the latest stage increment which was saved (it will save every `intermediate_stage_increment` interval)
   2. set `intermed_stage` to that stage increment in the file
   3. Set `use_intermed_start = true`
   4. Save the loop file, and rebatch the estimation

The first step will produce the estimation using data up to 2019Q4. The next step produces estimations starting with data at 2019Q3 and iterating backwards to 2000Q1. Each file will take a significant amount of time to run. Note that the keyword argument filestring_addl changes the name of the outputted estimation

file. This can be useful to avoid overwriting previously existing estimation files (you do not need to worry about this if you are only running the code once for reproducing results). However, because the estimation loop uses the name of the previously outputted estimation file, you will need to update the load paths in lines 211 and 214 accordingly if you change filestring_addl.

Now, we run the estimations starting from BBL's MH results:

1. Run estim/hank/mhcloud.jl with first_run = true and use_bridge_cloud = true. If you want to use a different cloud for this estimation, update that accordingly in line 194
2. Run estim/hank/mhcloud.jl for a second time with first_run = false and use_bridge_cloud = true, changing line 211 to load in the bridge cloud to past estimation.

The notes and recommendations for the full SMC runs above apply to the MH runs as well.

7-Var HANK.

We need to repeat the above for the 7-variable HANK model. However, we do not have access to MH draws from the BBL paper, so we will only be running the SMC estimations. All notes above on filestrings still apply here.

1. Navigate to the file path `estim/hank_7var/` and open `estimloop_7var.jl` to ensure that the setting `run_estimate = true` (line 11) and `use_intermed_start = false` (line 25)
2. Run `estimloop_7var.jl`, making sure the setting run_estimate is set to true.
3. Once that has completed, set `use_intermed_start = true` and `intermed_stage` to the latest stage completed in the first run.
4. Rerun `estimloop_7var.jl`. This should produce the backwards estimations. – Really really unclear as of now
5. As with previously, if the estimation stops prematurely for any reason you can resume estimation by changing `intermed_stage` to the latest intermediate stage. (Unclear if we really need this

SW estimations

The last step of the estimation process is to run the Smets-Wouter model, and again we need to repeat the process above. Once again, all notes on filestrings apply here and keeping track of the filestring_addl variable is important for further steps in the process.

1. Navigate to the file path `estim/sw/` and open `demeaned_sw_loop.jl`.
2. On your first run of this file, ensure that you have set the appropriate `filestring_addl` variable value, `estimate_firststep = true`, and `estimate_loop = true`.
3. Once the previous estimation has successfully ran, set `estimate_firststep = false`, and `estimate_loop = true`.

Forecasts

In order to create the RMSEs tables and plots, you need to run the corresponding forecasts. Keep in mind that the forecasts reference the estimation output files created from the step above, so make sure you double check that the names of the output files being loaded match.

You can located the files you need to run in order to create the forecasts in the '/forecasts/**Model**' folder. To create some of the plots and tables in the paper you will need to run the files: hank_fullsmc_forecasts.jl, mhcloud_forecasts.jl, sevenvar_forecasts.jl, and dm_sw_for_loop.jl in their respective folders. Running each of the forecasting files are very simple and similar.

SW forecasts

The dm_sw_for_loop.jl file doesn't have many boolean toggles or settings to worry about. Before running, ensure: 1. You have set the appropriate value for 'filestring_addl' 2. run_forecasts is set to true 3. You have set the appropriate parallel processing 4. run the file

HANK forecasts

There are two files you will need to worry about. Follow the instructions above for both mhcloud_forecasts.jl and hank_fullsmc_forecasts.jl.

7-Var HANK forecasts

Follow the instructions above for the sevenvar_forecasts.jl file.

RMSEs and Plots

The RMSE calculations and plots are just a matter of pulling from the correct forecast files: matching the appropriate output filepaths and forecast strings is very important. Ensure that you run each script in the rmse folder, taking note of where the files are being saved. Then run the appropriate files in the plots folder, making sure you are pulling from the correct jld2s. Note that the input datafiles for the RMSE calculations must be the meansbands output jld2 data files that you get from running a forecast.

To generate RMSE calculations: - **HANK Model**: You will first need to load the model that you used to create the corresponding forecasts. The easiest way to do this is to run mhcloud_forecasts.jl from the forecast instructions above but make sure to set `run_forecast = false`. After doing do, run the mhcloud_rmse.jl file taking note of the input data file. Follow the same instructions for smc_rmse.jl. - **7-Var Model**: You will first need to load the model that you used to create the corresponding forecasts. The easiest way to do this is to run sevenvar_forecasts.jl from the forecast instructions above but make sure to set `run_forecast = false`. After doing do, run the seven_rmse.jl file taking note of the input data file. - **SW**: Run the dm_sw_rmse_loop.jl file taking note of the input data file.

Making Tables and Plots:

As a reminder, loading in the correct datafiles is the most important step of running this code. To replicate Prior and Posterior Tables in Section 4:

- Run `/tables/hank_7var/7var_tables.jl` , adding file path references where needed and `includeall.jl` file at the top.

To replicate RMSE Plots in Section 4, Figure 1:

- Open `gen_plots_bblsmc_sw.jl`, change the input file path at the top of the file, and change the output file paths in lines 82-85 if you would like to save the figures in a different file directory.
- Run `/plots/gen_plots_bblsmc_sw.jl`
- Note that each result is generated in a separate PDF.

To replicate RSME Plots in Section 4, Figure 2:

- Open `/plots/gen_plots_bbl_sw.jl`, change input file paths at the top of the file, and change the output file paths in lines 82-85 if you would like to save the figures in a different file directory.
- Run `/plots/gen_plots_bbl_sw.jl`
- Note that each result is generated in a separate PDF.

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