Data and Program Documentation for "Bank Market Power and Central Bank Digital Currency: Theory and Quantitative Assessment"

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Overview

This file describes the data and codes used to obtain the results in the paper. Data and codes along with this readme file can be downloaded here. After downloading the file, first unzip it and put all the files in the same folder. The majority of the files are matlab codes written in Matlab 2020a in MacOS. They end with the extension ".m". Files end with the extension ".do" are STATA files. The codes sometimes need to access directories that are different from the current working directory. The current directory format is valid in MacOS but in order to run the codes in Windows, one may need to change "/" in the directory information to "\". For a detailed description of every file, please see the next section below.

To start using the codes, please first run "initializing.m". This file constructs the correct folder structure and rename the files properly. It creates two folders under the main directory: "benchmark" and "entry". Files in the folder "benchmark" are used to obtain results for the benchmark model of the paper, which features perfect competitive lending market and fixed number of banks. Files in the folder "entry" are used to obtain results for the extension with imperfectly competitive loan market and free bank entry.

To get the results in the paper, please first go to the folder "benchmark". One can run "money_demand_graph.m" to obtain Figure 5a in the paper. "Cournot_solution_CBDC.m" generates Figure 5b and Figure 6 in the paper. It reports the CBDC interest rate that maximizes bank lending and output and the resulting increases in lending and output. It also reports ranges of CBDC interest rates that promote bank lending and output.

"Cournot_solution_CBDC_cashless.m" generates Figure 7 in the paper. It also reports the minimum fraction of type 3 sellers that need to stop accepting cash before a non-interest-bearing CBDC becomes effective. The folder named "entry" contains files with exactly the same names as the aforementioned files. They also have the same functionality but reports results for the model with imperfectly competitive lending market and free bank entry.

This paper uses Call Reports data downloaded from Wharton Research Data Services (WRDS). Because accessing data requires prescription and the data file is also very large, we do not include the data. However, one can use the SAS code (item 29 in the following file list) to download the data from WRDS.

File Description

We now describe the file list after running initializing.m. Files in folders "benchmark" and "entry" have identical names and identical functionality. The difference, as mentioned above, is that codes in the folder "benchmark" are for the benchmark model with a perfectly competitive lending market and a fixed number of banks, while codes in "entry" are for the extension with an imperfectly competitive lending market and endogenous bank entry. Therefore, we only describe codes in the folder "benchmark".[1]

File list (filenames and brief description of all files):

1. initializing.m
   Format: Matlab
   Brief description: Initialize the folder structure and rename files properly.

2. deinitializing.m
   Format: Matlab
   Brief description: Undo initializing.m and translate the structured folder into an unstructured one.

3. Filename: benchmark/calibration_main.m

[1]Notice that we have already stored the calibrated parameter values. Therefore, one can directly obtain the results in the paper by running "money_demand_graph.m"m "Cournot_solution_CBDC.m", and "Cournot_solution_CBDC_cashless.m". But in the following, we also describe the files and steps needed to obtain the calibrated parameters. Also in all the Matlab codes, the parameter B is defined to be two times the value of the parameter B in the paper.

Format: Matlab

Brief description: Calibrate (θ, B, σ) given the value of DM trading probability, Ω, which is provided by the file "benchmark/tradep.txt" described below. See also Online Appendix H. It generates a file named output.txt, which contains the nonlinear least square criterion of the money demand curve given the DM trading probability. One need to run the code for DM meeting probabilities 0.05., 0.06,..., 0.9 and then save the corresponding output files in "benchmark/intermediate_results" with names "output5.txt", "output6.txt",..., "outuput90.txt". To do so, one can use a HTCondor system to run calibration_main.m many times with different values input in "benchmark/tradep.txt". And then rename and save all the output files in "benchmark/intermediate_results" or one can run the file "benchmark/calibration_md_loop.m" described below. The output files will later be used by "benchmark/calibration_main_all.m" to obtain the final calibration results. See below.

4. Filename: benchmark/tradep.txt

   Format: text file

   Brief description: Feed in the DM meeting probability to calibration_main.m. For example, if we need to set the DM meeting probability in calibration to be 0.5, then we need to input 0.5 in "tradep.txt".

5. Filename: benchmark/calibration_md_loop.m

   Format: Matlab

   Brief description: It runs calibration_main.m for DM meeting probabilities 0.05, 0.06, ..., 1 in a loop and save corresponding output files in the folder "intermediate_results" under the names "output1.txt", "output2.txt",..., "outuput90.txt". After running this file, we can run "benchmark/calibration_main_all.m", described below, to obtain the calibrated parameters shown in the paper. It is time-consuming to run this file.

6. Filename: benchmark/calibration_main_all.m

   Format: Matlab

   Brief description: Read all the output files in folder "intermediate_results" generated by the aforementioned files and find the DM meeting probability, Ω, that fits the money demand curve best. This leads to the final calibrated parameter shown in Section 4.1. For the calibration algorithm, please see Online Appendix H. The

calibrated parameters are saved in the file "pars_post_LN87_08_final.mat". We have stored "pars_post_LN87_08_final.mat" from the final calibration but not all the intermediate output files to reduce the number of files.

7. Filename: benchmark/omega.txt
   Format: text file
   Brief description: Feed calibrated values of ω_1, ω_2 and ω_3 to "calibration_main.m" and "calibration_main_all.m".

8. Filename: benchmark/ssopt.txt
   Format: text file
   Brief description: Option file for benchmark/calibration_main.m. It inputs options such as the years of data to use and the initial value for θ.

9. Filename: benchmark/money_demand_graph.m
   Format: Matlab
   Brief description: Generate figure 5a in the paper, i.e, the data and model money demand curve.

10. Filename: benchmark/Cournot_solution_CBDC.m
    Format: Matlab
    Brief description: It plots the loan demand and loan supply curves, and shows the effects of a CBDC with different interest rates under the calibrated parameters. It generates Figure 5b and Figure 6 in the paper. It also reports the CBDC interest rates that maximize output and lending and the resulting changes in output and lending. Moreover, it reports the range of CBDC rates that lead to more lending or more output.

11. Filename: benchmark/Cournot_solution_CBDC_cashless.m
    Format: Matlab
    Brief description: Assess the effect of a zero-interest CBDC under the calibrated parameters as the use of cash declines. It generates Figure 7 in the paper. It also reports the minimum fraction of type 3 sellers who need to reject cash before the zero-interest CBDC becomes effective.

12. Filename: benchmark/pass_variables.m
    Format: Matlab

Brief description: Define variables passed to functions. It is used in "benchmark/Cournot_solution_CBDC.m" and
"benchmark/Cournot_solution_CBDC_cashless.m"

13. Filename: benchmark/calibration_money_demand_func.m
    Format: Matlab
    Brief description: Given DM trading probability Ω and bargaining power θ, find the set of parameters that best fit the money demand curve in the data. It is used in "benchmark/calibration_main.m".

14. Filename: benchmark/cal_MD_v2.m
    Format: Matlab
    Brief description: Given $(\theta, B, \sigma, \Omega)$, deposit and loan rates, calculate the money demand from the model. It also calculate the mean squared error between the model money demand and the data money demand. It is used in "benchmark/calibration_main.m".

15. Filename: benchmark/calibration_func_v3.m
    Format: Matlab
    Brief description: Given the all parameters, calculate the number of banks that rationalizes the spread in the data and the differences between model predicted deposit rate and data. It is used in "benchmark/calibration_main_all.m" to calibrate the productivity parameter A.

16. Filename: benchmark/calibration_money_demand_func1.m
    Format: Matlab
    Brief description: Given the calibrated parameters and interest rates, calculate the model predicted money demand. It is in "benchmark/money_demand_graph.m" to generate Figure 5a.

17. Filename: benchmark/SS_eq.m
    Format: Matlab
    Brief description: Calculate equilibrium balances of cash and electronic balances given the preference parameters and CBDC rate. It is used in "benchmark\Cournot_solution_CBDC.m" and
    "benchmark\Cournot_solution_CBDC_cashless.m".

18. Filename: benchmark/SS_eq_noCBDC.m
    Format: Matlab
    Brief description: Calculate the equilibrium without a CBDC given the inverse demand for deposits. It is used in "benchmark\Cournot_solution_CBDC.m" and "benchmark\Cournot_solution_CBDC_cashless.m".

19. Filename: benchmark/SS_eq_noCBDC_fast.m
    Format: Matlab
    Brief description: Calculate the equilibrium without a CBDC given the values of the αs. It is designed to compute the equilibrium fast when the αs vary. It is used in "benchmark/Cournot_solution_CBDC_cashless.m"

20. Filename: benchmark/SS_eq_CBDCR.m
    Format: Matlab
    Brief description: Calculate the equilibrium where a CBDC serves as a reserve. It is use in "benchmark/Cournot_solution_CBDC.m". Results not reported in the paper.

21. Filename: benchmark/pass_variables_calibration.m
    Format: Matlab
    Brief description: Define the variables passed to functions. It is used in "benchmark/calibration.m" and "benchmark/calibration_main_all.m".

22. Filename: benchmark/D_inv_demand.m
    Format: Matlab
    Brief description: Obtain the inverse demand for deposits without a CBDC as a function of deposit rate. It is used in "benchmark/Cournot_solution_CBDC.m" and its output is an input to "benchmark/SS_eq_noCBDC.m".

23. Filename: benchmark/eq_func.m
    Format: Matlab
    Brief description: Given real values of deposits, cash and the loan rate, calculate how far the equilibrium conditions without a CBDC are from being satisfied. It is used in "benchmark/CBDC_eq_noCBDC_fast.m"

24. Filename: benchmark/eq_func_con.m
    Format: Matlab

Brief description: Given real values of deposits, cash and the loan rate, calculate how far the equilibrium conditions without a CBDC are from being satisfied. It is the same as "benchmark/eq_func.m" except that it is written in a format that can be taken as nonlinear constraints by fmincon. It is used in "benchmark/CBDC_eq_noCBDC_fast.m"

25. Filename: benchmark/eqZD_func_con.m
    Format: Matlab
    Brief description: Given the real values of deposits, cash and interests, calculate how far the buyers' first-order conditions are from being satisfied. It is used in "benchmark/cal_MD_v2.m" to calculate the money demand.

26. Filename: benchmark/LSLD.m
    Format: Matlab
    Brief description: Calculate the loan demand and loan supply functions. It is used in "benchmark/Cournot_solution_CBDC.m" to plot Figure 5b in the paper.

27. Filename: benchmark/figure_halfpage
    Format: Matlab
    Brief description: Format pictures. It is used in "benchmark/Cournot_solution_CBDC.m".

28. Filename: benchmark/pars_post_LN87_08_final.mat
    Format: Matlab matrix file
    Brief description: Store the calibrated parameter values.

29. Filename: CBDC_banking_1987-2019.do
    Format: stata do file
    Brief description: Apply to call reports data and generate "deposit_rates.csv", average deposit handling costs and total transaction balances. Need to download call reports data using WRDS_data_code.txt and save it as dta file. One also need to change the working directory at the beginning of the do file according to where the call report data is located.

30. Filename: WRDS_data_code.txt
    Format: SAS file
    Brief description: SAS code for downloading call reports data from WRDS. It is

based on the SAS code provided by Philipp Schnabl on his website. The data dictionary can also be download from his website or by clicking here.

31. Filename: eta.xlsx
    Format: Excel file
    Brief description: It regresses real commercial lending (on the Y-axis of the graph in the excel file) and real prime rate (on the X-axis) for monthly data from 1995m1-2018m11 using BUSLOANS, MPRIME, CPIAUCSL, all from FRED. Denote the slope by γ, then η is calculated by $1 + 1/\gamma$.

32. Filename: Lucas_nicolini.csv
    Format: csv file
    Brief descrption: The new money demand data from "On the stability of money demand" by Lucas and Nicolini, Journal of Monetary Economics 2015, vol 73 (c), 48-65. This file is also copied to the folders “benchmark” and “entry”.

33. Filename: RESBALREQ.xls
    Format: Excel file
    Brief description: Reserve data from FRED and total transaction balances calculated from call reports data by summing up RCON2215 across all banks. These data are used to calculate the required reserve ratios.

34. Filename: deposit_rates.csv
    Format: csv file
    Brief description: Interest rates on transaction deposits and loans generated from call reports data using code “CBDC_banking_1987-2019.do”. For details on how the series are constructed, see Online Appendix H. This file is also copied to the folders “benchmark” and “entry”.