Readme: Code and Data for "The Reversal Interest Rate"

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Contents

1 General overview

This project contains the code necessary to replicate the results in "The Reversal Interest Rate," by Joseph Abadi, Markus Brunnermeier, and Yann Koby, to be published at the *American Economic Review*. Section 2 of this document describes the datasets used in the analysis (data is used only in the Online Appendix of the paper). All of the code can be run using Matlab and Dynare, as described in Section 3.

Section 5 provides instructions for replicators to reproduce the figures in the paper. The code used for this project is split into several sub-folders. For each sub-folder, there is an additional subsection of this readme containing instructions on how to run the code to reproduce the corresponding results. Here we summarize the contents of each sub-folder.

1. `theory` sub-folder: The files in this folder produce Figure 1 in Section II.D.

2. `main_results` sub-folder: This folder includes a Dynare file that runs the benchmark model. The files in this sub-folder produce the main estimates of the reversal rate (for investment and bank lending). They also produce Figures 2-5 in Section III.

3. `forward_guidance` sub-folder: This folder contains Dynare files that compute the economy's response to forward guidance. The files in this sub-folder produce Figure 6 in Section III.E of the paper and Figures C.12-C.13 in Online Appendix C.6.

4. `discussion` sub-folder: This folder contains code that produces the results discussed in Section IV.A (Figure 7 and the discussion of the response of ROE to interest rate shocks) and in Section IV.E (the results related to held-to-maturity bonds). It also produces supporting figures in the Online Appendix (Figure C.1 in Online Appendix C.1 and Figure C.9 in Online Appendix C.4). **This is the only subfolder that contains data, and the corresponding results are used only in Online Appendix C.1**.

5. `sensitivity_analysis` sub-folder: The code in this folder runs the sensitivity analysis. It produces Figure 8 in Section IV.B of the paper as well as Figures C.3-C.7 in Online Appendix C.2.

6. `robustness` sub-folder: The code in this folder finds the reversal rate in response to productivity and discount factor shocks, as discussed in Section IV.D of the paper. This code produces Figure C.8 in Online Appendix C.3.

7. `apx_C` sub-folder: The code in this folder performs comparisons between impulse responses in the benchmark model and those in more standard DSGE models (a modified version of the Christiano, Eichenbaum, and Evans (2005) model and a "frictionless"

version of the benchmark model). It produces Figures C.10-C.11 in Online Appendix C.5.

Section 4 provides a list of tables and figures as well as the code that reproduces each.

2 Data availability and provenance

Data are not used in the body of the paper. Section C.1 of the Online Appendix (referenced in Section 4 of the paper) uses publicly available data on interbank and deposit rates in the Euro area.

2.1 Statement of rights

All of the data referenced in Section 2.2 are publicly available. We certify that we have the right to access and distribute the data.

2.2 Details on the data

Data provenance: The data used in Online Appendix C.1 come from the European Central Bank's publicly available Statistical Data Warehouse (`https://sdw.ecb.europa.eu`). The EONIA rate data come from the "Eonia rate - Historical close, average of observations through period" in the Financial Markets (FM) database (series key FM.M.U2.EUR.4F.MM.EONIA.HSTA), available at `https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=143.FM.M.U2.EUR.4F.MM.EONIA.HSTA`. The data on deposit spreads are the "Bank interest rates - overnight deposits from households - euro area" item in the MIR database (series key MIR.M.U2.B.L21.A.R.A.2250.EUR.N), available at `https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=124.MIR.M.U2.B.L21.A.R.A.2250.EUR.N`.

Datasets in the replication package: The file `overnight_deposits_master.csv` (contained in the `discussion` subfolder) contains data on the EONIA rate (column "EONIA") and the average deposit rate (column "Euro area") among Euro area banks from 1/31/2003 to 12/31/2021 (monthly). The sources of these series are listed above. **This is the only file in the replication package that contains data**. We use the data on the EONIA rate and to compute the deposit spread in the data (column "Spread"), the deposit rate predicted by the model (column "Model rate"), and the deposit spread predicted by the model (column "Model spread"). The procedure for computing model-predicted deposit rates and spreads is described in Online Appendix C.1.

3 Computational requirements

3.1 Software requirements

The code in this folder was run using Matlab R2023a and Dynare 5.4. Matlab R2023a can be purchased from Mathworks at `https://www.mathworks.com/pricing-licensing.html?prodcode=ML`. Dynare is a free, open-source package for Matlab. The latest version can be downloaded at `https://www.dynare.org`. Once a newer version of Dynare is available, version 5.4 will no longer be the most current one that is listed by default at that URL. Instead, it can be found in the release archives at `https://www.dynare.org/release/`. In order to properly run the Dynare files in this project, it is necessary to add Dynare to the Matlab path. After installing, this can usually be done via the Matlab command `addpath c:\dynare\5.4\matlab`.

3.2 Memory and runtime requirements

The code in this replication package was last run on a laptop with 16GB of RAM and 512GB of disk space (running Windows 11). With the exception of the code in subfolder `sensitivity_analysis`, all files were run in under 2 hours on this laptop. The code in subfolder `sensitivity_analysis` took about 20 hours to run. After running all of the code as described in Section 5, the replication folder takes up roughly 8MB of storage.

4 List of figures

Name of figure	File that produces figure	Output files
Figure 1	supply_demand_RIR.m	supply_demand_1.png, supply_demand_2.png
Figure 2	Dyn_RIR_commented.mod	loan_irf.png, invest_irf.png
Figure 3	Dyn_RIR_commented.mod	y_irf.png
Figure 4	Dyn_RIR_commented.mod	loanrate_irf.png, dRL_irf.png
Figure 5	Dyn_RIR_commented.mod	invest_bd_irf.png, invest_nbd_irf.png
Figure 6	forward_guidance_figures_RIR.m	fg_8quarter.png, fg_8quarter_Y.png
Figure 7	nii_figures_RIR.m, diffdiff_figures_RIR.m	nii_response.png, dd_vs_rate.png
Figure 8	sensitivity_figures_RIR.m	sensitivity_lvg_elastivityV.png, sensitivity_Y_bd_shV.png
Figure C.1	deposit_spread_fit_RIR.m	deposit_spread_ts.png
Figure C.2	nii_figures_RIR.m	roe_irf.png
Figure C.3	sensitivity_figures_appendix_RIR.m	Several (see Section 5.5)
Figure C.4	sensitivity_figures_appendix_RIR.m	Several (see Section 5.5)
Figure C.5	sensitivity_figures_RIR.m	Several (see Section 5.5)
Figure C.6	sensitivity_figures_RIR.m	Several (see Section 5.5)
Figure C.7	sensitivity_figures_appendix_RIR.m	Several (see Section 5.5)
Figure C.8	reversal_rate_finder_a_RIR.m, reversal_rate_finder_beta_RIR.m	reversal_irf_a.png, reversal_irf_beta.png
Figure C.9	reversal_rate_finder_htm_RIR.m	rr_htm_investment.png, rr_htm_lending.png
Figure C.10	cee_comparison_plots_RIR.m	cee_comparison.png
Figure C.11	nk_comparison_plots_RIR.m	nk_comparison.png
Figure C.12	forward_guidance_figures_RIR.m	fg_8quarter_L.png, fg_8quarter_Pi.png, fg_8quarter_C.png
Figure C.13	forward_guidance_figures_small_RIR.m	fg_8quarter_L_small.png, fg_8quarter_Pi_small.png, fg_8quarter_C_small.png

5 Description of code and instructions for replicators

5.1 Subfolder `theory`

What this code does: The files in this folder produce Figure 1 in Section II.D.
List of code files:

1. `supply_demand_RIR.m`: This file produces Figure 1. In order to compute loan demand and supply curves, it calls `loan_demand.m` and `eps_l.m`.

2. `loan_demand.m`: This function computes the loan demand curve (given a loan quantity, it returns a loan rate).

3. `eps_l.m`: This function computes the elasticity of loan demand at a particular interest rate. This elasticity is necessary to compute the loan supply curve under imperfect competition.

How to use this code: Run `supply_demand_RIR.m`. This produces two figures (`supply_demand_1.png` and `supply_demand_2.png`) that are the left and right panels of Figure 1 in Section II.D of the paper.

5.2 Subfolder `main_results`

What this code does: This folder includes a Dynare file that runs the benchmark model. The files in this sub-folder produce the main estimates of the reversal rate (for investment and bank lending). They also produce Figures 2-5 in Section III.
List of code files:

1. `Dyn_RIR_commented.mod`: This is the main Dynare file (with comments that apply to most of the variations of the model in the other sub-folders). It runs the benchmark model under the main parametrization reported in Tables 1 and 2 in the paper. It also computes all of the main impulse responses and produces figures.

2. `Dyn_RIR_finder.mod`: A Dynare file that runs the benchmark model but allows the size of the "large" monetary shock to be loaded from an external file `shock_value_mp.mat` (so that the size of the shock can be varied to find the reversal rate).

3. `reversal_rate_finder_RIR.m`: A Matlab file that loops over the size of the initial "large" monetary shock, saves it in `shock_value_mp.mat`, and then runs `Dyn_RIR_finder.mod` to compute the marginal impulse response to an additional -10bp Taylor rule innovation. This file is used to compute the reversal rates for investment and bank lending reported in the paper.

How to use this code:

1. Run `dynare Dyn_RIR_commented`. This generates Figures 2-5 in Section III of the paper. The panels of Figure 2 are saved as `loan_irf.png` and `invest_irf.png`, respectively. Figure 3 is `y_irf.png`. The panels of Figure 4 are `loanrate_irf.png` and `dRL_irf.png`, respectively. The panels of Figure 5 are `invest_bd_irf.png` and `invest_nbd_irf.png`, respectively.

2. Run `reversal_rate_finder_RIR.m`. This produces two figures, `rr_investment.png` and `rr_lending.png`, that can be read to find the reversal rate (at the impact of the shock) for investment and bank lending, respectively.

5.3 Subfolder `forward_guidance`

What this code does: This folder contains Dynare files that compute the economy's response to forward guidance. The files in this sub-folder produce Figure 6 in Section III.E of the paper and Figures C.12-C.13 in Online Appendix C.6.

List of code files:

1. `Dyn_RIR_fg.mod`: Dynare file that contains the benchmark model with forward guidance shocks. It can be run to compute the benchmark economy's impulse response to forward guidance at several horizons.

2. `Dyn_RIR_NK.mod`: Dynare file that contains a "frictionless" version of the model without banking frictions and computes impulse responses to forward guidance at several horizons.

3. `forward_guidance_figures_RIR.m`: Matlab file that produces figures with impulse responses to forward guidance that holds rates at -1% for eight quarters, both in the benchmark economy and in the frictionless economy.

4. `forward_guidance_figures_small_RIR.m`: Matlab file that produces figures with impulse responses to forward guidance that holds rates at 1.5% for eight quarters, both in the benchmark economy and in the frictionless economy.

How to use this code:

1. Run `dynare Dyn_RIR_fg`. This saves the impulse responses to forward guidance in the benchmark model (in `fg_RIR.mat` and `fg_RIR_small.mat`).

2. Run `dynare Dyn_RIR_NK`. This saves the impulse responses to forward guidance in the frictionless model (in `fg_NK.mat` and `fg_NK_small.mat`).

3. Run `forward_guidance_figures_RIR.m`. This loads the IRFs stored in `fg_RIR.mat` and `fg_NK.mat` and plots them. The panels of Figure 6 in Section III.E of the paper are saved as `fg_8quarter.png` and `fg_8quarter_Y.png`, respectively. The panels of Figure C.12 in Online Appendix C.6 are saved as `fg_8quarter_L.png`, `fg_8quarter_Pi.png`, and `fg_8quarter_C.png`, respectively.

4. Run `forward_guidance_figures_small_RIR.m`. This loads the IRFs stored in `fg_RIR_small.mat` and `fg_NK_small.mat`. The panels of Figure C.13 in Online Appendix C.6 are saved as `fg_8quarter_L_small.png`, `fg_8quarter_Pi_small.png`, and `fg_8quarter_C_small.png`, respectively.

5.4 Subfolder `discussion`

What this code does: This folder contains code that produces the results discussed in Section IV.A (Figure 7 and the discussion of the response of ROE to interest rate shocks) and in Section IV.E (the results related to held-to-maturity bonds). It also produces supporting figures in the Online Appendix (Figure C.1 in Online Appendix C.1 and Figure C.9 in Online Appendix C.4). **This is the only subfolder that contains data**.

List of code files:

1. `Dyn_RIR_lending.mod`: Dynare file that contains the modified model with "non-deposit-dependent" banks used for the difference-in-difference experiment in Section IV.A. This code computes the impulse response of lending for both the benchmark model's banks and non-deposit-dependent banks.

2. `Dyn_RIR_nii.mod`: Dynare file that computes the impulse response of NII and returns on accounting equity (ROE) to interest rate shocks in the benchmark model. These results are discussed in Section IV.A of the paper.

3. `Dyn_RIR_htm.mod`: Dynare file containing a modified version of the model in which some of banks' bonds are marked as "held-to-maturity" for accounting purposes. This is discussed briefly in Section IV.E of the paper and then more extensively in Online Appendix C.4.

4. `Dyn_RIR_deposits.mod`: Dynare file containing a modified version of the model in which the pass-through of interest rates to deposit spreads is non-zero even when rates are positive. This is used to estimate the reversal rate in the modified model, which is discussed in Online Appendix C.1.

5. `diffdiff_figures_RIR.m`: Matlab file that produces figures related to the "diff-in-diff" experiment with non-deposit-dependent banks described in Section IV.A.

6. `nii_figures_RIR.m`: Matlab file that produces figures related to the impulse responses of NII and ROE to monetary shocks.

7. `reversal_rate_finder_htm_RIR.m`: Matlab file that computes the reversal rate in the modified version of the model with held-to-maturity bonds.

8. `reversal_rate_finder_deposits_RIR.m`: Matlab file that computes the reversal rate in the modified version of the model with non-zero pass-through from interest rates to deposit spreads in positive territory.

9. `deposit_spread_fit_RIR.m`: Matlab file that calibrates the pass-through from the policy rate to deposit spreads in the modified model discussed in Online Appendix C.1. Uses the dataset `overnight_deposits_master.csv`. **This is the only file that uses data**.

How to use this code:

1. Run `diffdiff_figures_RIR.mod`. This generates the right panel of Figure 7 in Section IV.A (saved as `dd_vs_rate.png`).

2. Run `nii_figures_RIR.m`. This generates the left panel of Figure 7 in Section IV.A (saved as `nii_response.png`) and Figure C.2 in Online Appendix C.1.

3. Run `reversal_rate_finder_htm_RIR.m`. This generates figures displaying the reversal rate for investment and bank lending as a function of the fraction of held-to-maturity bonds on bank balance sheets (saved as `rr_htm_investment.png` and `rr_htm_lending.png`, respectively).

4. Run `deposit_spread_fit_RIR.m`. This creates Figure C.1 in Online Appendix C.1.

5. Run `reversal_rate_finder_deposits_RIR.m`. This creates two figures (`reversal_rate_deposits.png` and `reversal_rate_L_deposits.png`) that can be used to find the reversal rate in the modified model for investment and bank lending, respectively.

5.5 Subfolder `sensitivity_analysis`

What this code does: The code in this folder runs the sensitivity analysis. It produces Figure 8 in Section IV.B of the paper as well as Figures C.3-C.7 in Online Appendix C.2.

List of code files:

1. `Dyn_RIR_a_search.mod`: Dynare file that runs the benchmark model with a custom parametrization (loaded by `parameter_grid_sensitivity_RIR.m`, also in this folder). Computes marginal impulse response to a -10bp Taylor rule innovation given some initial level of interest rates (loaded from `shock_value_mp.mat`).

2. `parametrization.m`: Matlab file that loads the model's benchmark parametrization (i.e., the parameters/targets reported in Tables 1 and 2 in the paper).

3. `parameter_grid_sensitivity_RIR.m`: Matlab file that loops through possible parametrizations of the model and computes the reversal rate for each parametrization. In each case, the file first loads the benchmark parametrization by running parametrization.m and then changes the value of a single parameter.

4. `sensitivity_figures_RIR.m`: Matlab file that loads the results of `parameter_grid_sensitivity.m` and creates the main sensitivity analysis figures in the paper, Section IV.B (as well as some that are in Online Appendix C.2).

5. `sensitivity_figures_appendix_RIR.m`: Matlab file that loads the results of `parameter_grid_sensitivity` and creates the remaining sensitivity analysis figures in Online Appendix C.2.

How to use this code:

1. Run `parameter_grid_sensitivity_RIR.m` (as detailed in the file). For each parameter x, this generates two files `x0_rr_mpshock.mat` and `x1_rr_mpshock.mat` containing the investment reversal rate for the possible values of x.

2. Run `sensitivity_figures_RIR.m`. This creates Figure 8 in Section IV.B of the paper (with the panels named `sensitivity_lvg_elasticityV.png` and `sensitivity_Y_bd_shV.png`), Figure C.5 in Online Appendix C.2 (`sensitivity_elast_investV.png` and `sensitivity_tau_SV.png`), and Figure C.6 in Online Appendix C.2 (`sensitivity_eps_LV.png` and `sensitivity_eps_DV.png`).

3. Run `sensitivity_figures_appendix_RIR.m`. This creates Figures C.3, C.4, and C.7 in Online Appendix C.2 (`sensitivity_standard1_apx.png`, `sensitivity_standard2_apx.png`, and `sensitivity_calib_apx.png`).

5.6 Subfolder `robustness`

What this code does: The code in this folder finds the reversal rate in response to productivity and discount factor shocks, as discussed in Section IV.D of the paper. This code produces Figure C.8 in Online Appendix C.3.

List of code files:

1. `Dyn_RIR_finder_a.mod`: Dynare file containing a modificiation of the model with productivity shocks.

2. `Dyn_RIR_finder_beta.mod`: Dynare file containing a modification of the model with discount factor shocks.

3. `reversal_rate_finder_a_RIR.m`: Matlab file that computes the reversal rate for productivity shocks.

4. `reversal_rate_finder_beta_RIR.m`: Matlab file that computes the reversal rate for discount factor shocks.

How to use this code:

1. Run `reversal_rate_finder_a_RIR.m`. This produces a figure that plots the marginal response of investment to an additional -10bp Taylor rule shock, as a function of the initial interest rate (`reversal_irf_a.png`). The shock that initially displaces the interest rate is a productivity shock.

2. Run `reversal_rate_finder_beta_RIR.m`. This produces a figure that plots the marginal response of investment to an additional -10bp Taylor rule shock, as a function of the initial interest rate (`reversal_irf_beta.png`). The shock that initially displaces the interest rate is a discount factor shock.

5.7 Subfolder `apx_C`

What this code does: The code in this folder performs comparisons between impulse responses in the benchmark model and those in more standard DSGE models (a modified version of the Christiano, Eichenbaum, and Evans (2005) model and a "frictionless" version of the benchmark model). It produces Figures C.10-C.11 in Online Appendix C.5.

List of code files:

1. `Dyn_RIR_benchmark.mod`: Dynare file containing the benchmark model. It computes impulse responses for small monetary shocks near the steady state in order to facilitate comparisons with standard DSGE models.

2. `Dyn_RIR_NK.mod`: Dynare file containing a modified "frictionless" version of the benchmark model without banking frictions. It computes impulse responses to small monetary shocks near the steady state.

3. `Dyn_RIR_CEE.mod`: Dynare file containing a modified version of the Christiano, Eichenbaum, and Evans (2005) model without wage stickiness or variable utilization. It computes impulse responses to small monetary shocks near the steady state.

4. `nk_comparison_plots_RIR.m`: Matlab file that produces plots comparing the impulse responses in the benchmark model and in the "frictionless" model.

5. `cee_comparison_plots_RIR.m`: Matlab file that produces plots comparing the impulse responses in the benchmark model and in the CEE model.

How to use this code:

1. Run `nk_comparison_plots_RIR.m`. This calls `Dyn_RIR_benchmark.mod` and `Dyn_RIR_NK.mod` to compute impulse responses and produce Figure C.11 in Online Appendix C.5.

2. Run `cee_comparison_plots_RIR.m`. This calls `Dyn_RIR_benchmark.mod` and `Dyn_RIR_CEE.mod` to compute impulse responses and produce Figure C.10 in Online Appendix C.5.

References

European Central Bank, "Statistical Data Warehouse," 2021. https://sdw.ecb.europa.eu/ (accessed 4/11/2023).