Read Me

This manuscript describes how to replicate estimation results and draw graphs in our paper as well as the content of Matlab files (M-files) stored in this folder.

## 1. Structure of files

There are four main folders: [1] **Model_Benchmark**, [2] **Model_Const_Linear**, [3] **Model_Gap_GDP,** and [4] **Model_Gap_Growth**.

- In [1] **Model_Benchmark**, we store Matlab codes for solving and estimating benchmark models, say nonlinear New-Keynesian (NK) model with the ZLB constraint or without it.
- In [2] **Model_Const_Linear,** we store Matlab codes for doing "linear" version of above NK models constrained by the ZLB or not.
- In [3] **Model_Gap_GDP**, we store Matlab codes for doing nonlinear version using data with "real GDP gap", insteat of the first difference of GDP data.
- In [4] **Model_Gap_Growth**, we store Matlab codes for doing nonlinear version using data with both of "real GDP gap" and the first difference of GDP data.

The structure of Matlab codes and adopted methods of solving and estimating, except files setting underlying models or loading data, are same in above four main folders. In the four main folders, we store six common functions as follows.

- A sub-folder "**Toolbox**" are inherent and selected from "Toolbox" provided by Rickter, Throckmorton and Walker (2014). Functions of this folder are mainly used to solving a nonlinear model by Time Iteration with Liner Interpolation (TL).
- A sub-folder "**fun_projection**" is a set of functions for solving our NK model using above "**Toolbox**".
- Three sub-folders such as "**fun_smc**", "**fun_particle**" and "**fun_prior**" are a set of functions used for conducting methods of SMC2, particle filter for estimating endogenous variables, and sampling parameters from prior distributions, respectively.
- A sub-folder "**fun_hist_decomp**" is a set of functions for calculating contribution to endogenous variables by structural shocks shown in Figure 6.

In a sub-folder "**data**" of above four main folders, we have data files and prior setting files as follows.

- "**data_jpn_1_def.csv**" as for data including first difference of GDP per capita
- "**data_jpn_1.csv**" as for data including GDP gap in terms of per capita.
- "**prior_setting_2_I0.csv**" as for setting values of prior distributions and calibrations of parameters. **Tables 1** summarizes these values.
- An M-file: "load_data.m", of the sub-folder: "fun_smc", loads above data files, while an M-file: "fun_prior_setting.m", of the sub-folder: "fun_prior", loads above prior stetting file.

## 2. How to Run Matlab Codes

Main programs of estimation are **"model_0_I0.m", model_1_I0.m"** and **"model_2_I0.m"** corresponding to three models, i.e., model_0_I0.m represents the NK model without ZLB constraint, while model_1_I0.m and model_2_I0.m represent both of them constrained by the ZLB but classified by adoption of monetary policy rules 1 and 2, respectively. . These three programs call an M-file, say **"main_smc2_I0_def.m"**, which execute procedure of SMC2, after setting the following models and estimation options.

- In Line 23 through 29 of above three M-files, we set options of models such as ZLB (zlbflag = 0 or 1) and monetary policy rule (policy_flag = 1 or 2), as well as estimation option such as numbers of particle of parameters (nsim), stage of SMC (nstage) and particle of shocks (nparticles).

- In Line 29, the option of measurement errors are as follows: when m_err_flag = 1, then we set m_error = [0.005 0.005 0.0025] (the sizes of standard deviations of output, inflation and interest rate are 0.5%, 0.5% and 0.25%, respectively). And when m_err_flag = 2, then we set m_error = [0.001 0.001 0.0005] in similar manner.

- Matlab codes of model definition as below are in a sub-folder: "**fun_projection**", of the four main folders.
  - **"eqm_TL.m"** describes a nonlinear NK model.
  - **"eqm_TL_CL.m"** describes a linear NK model constrained with ZLB or not.

  Each M-file of model definition is called by "**solve_model.m**" or "**solve_model_CL.m**" in folder '**fun_smc**' of the four main folders.

- Posterior estimations of parameters sampled by the SMC method are saved in the following Mat-files.
  '/output/save_para_I0_def_(zlbflag)_(policy_flag)_nsim)_(nparticles).mat'

## 3. Reporting Tables and Drawing Graphs

As for **Tables 2, 4 and 5**.

Using outputs of sampling of parameters, posterior estimation of parameters and policy functions are calculated by an M-file: "main_plot_result.m". Similar to the outputs of sampling of parameters, outputs of summary of posterior parameters are saved as text files in a sub-folder "**output**".

- Tables 2, 4 and 5 in our paper are reported from above text files.
- Policy functions derived from posterior means of parameters, as well as filtered endogenous variables, are saved as a Mat file put on as the name of a corresponding model (e.g., model_0_state.mat) in the folder: "**data_sample**" of "**Plot_Fig**" of the main folder "**Model_ Benchmark**".
- An M-file, "cal_particle " called by "main_plot_result.m" implements particle filters and calculates endogenous variables, which are saved as a Mat-file, **'output / [model_name]_state.mat'**, using the posterior means of parameters.
- An M-file, "cal_hist_IRF_2" called by "main_plot_result.m" calculates impulse response functions to a monetary shock, which are saved as a Mat-file, **'output / IRF_[model_name].mat'**, using the posterior means of parameters.
- M-files, "plot_pf.m" (3-dimension version) and "plot_pf2.m" (contour version) draw policy functions derived from the posterior means of parameters.

**As for Tables 3**.

Calculation of probabilities of duration of interest rate and inflation are executed by M-files, "Cal_prob_duration_r.m" and "Cal_prob_duration_pi.m", respectively. By doing the calculations, they read policy functions saved as one Mat-file in folder "**data_sample**" of "Plot_Fig" of the folder "**Model_Benchmark**". Table 3 reports values from output of these codes.

As for making **Figures 2 thorough 10**, Matlab codes are in the sub-folder "**Plot_Fig**" of main folder: "**Model_ Benchmark**". Each code corresponding to figures is put on name including figure number (e.g., plot_Fig_2.m). Just executing an M-file in the folder makes the corresponding graph soon. To this end, each code reads data, and estimation results such like policy functions and filtered endogenous variable saved in the sub-folder "**data_sample**" of a sub-folder "**Plot_Fig**".