Readme for Code Packet for "Really Uncertain Business Cycles"

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This file contains an overview of the code packet for the solution, simulation, and estimation of the RUBC model, outlining the purpose of each file. The individual files are liberally documented. However, the code packet can be broken into five main groups. The purposes of each are:

1. Solution and simulation of the baseline general equilibrium model.
2. Solution and simulation of the partial equilibrium model.
3. Solution and simulation of the general equilibrium model with extended forecast rules.
4. Implementation of the structural estimation of the general equilibrium model.
5. Solution and simulation of the Brock-Mirman model.
6. Simulation of the baseline general equilibrium model to compute impulse responses according to the Koop, et al. (1996) simulation differencing approach.

A more detailed discussion of each group of files follows below.

Group #1: Solution and Simulation of the Baseline General Equilibrium Model

These files can be found in the subfolder *1_BASELINE_GE*. The use of these files requires a Fortran compiler as well as R.

RUBC_ge.f90: This file contains the main body of the code, solving and simulating the model unconditionally. Depending on flags set at the top of the code, a simulated impulse response to an uncertainty shock can also be computed from this file. The code here depends upon *base_lib.f90*, and outputs a number of text files with simulation and solution data for external processing. It is written in Fortran.

base_lib.f90: This file contains a number of utility functions and subroutines called in *RUBC_ge.f90*. It is written in Fortran.

compile_script.sh: This Bash script compiles the *base_lib.f90* and *RUBC_ge.f90* files, producing the 64-bit parallelized executable *RUBC_ge.exe*. The details of the compilation procedure will vary from configuration to configuration, so this file is purely illustrative.

read_RUBC_ge.R: This file reads in text files generated by RUBC_ge.exe with simulation data and generates PDF figures summarizing the model unconditional simulation. Depending on the flags set at the top of the code, this file also processes the simulated data to compute a simulated impulse response to an uncertainty shock. It is written in R.

FIRST_MOMENT: This subfolder contains four files. They are labelled identically to the four files listed above and play almost identical roles. The single distinction is that the simulated impulse responses involve a first-moment or levels shock to aggregate productivity rather than an uncertainty shock or second-moment shock. Performance of this impulse response simulation, and selection of a first-moment or a first-moment + second-moment shock, is controlled via flags at the top of the code in RUBC_ge.f90.

Group #2: Solution and Simulation of the Partial Equilibrium Model

These files can be found in the subfolder *2_BASELINE_PE*. The use of these files requires a Fortran compiler as well as MATLAB.

RUBC_pe.f90: This file contains the main body of the code, solving and simulating the model. Both unconditional simulations and simulation of an impulse response to an uncertainty shock are computed. The code here depends upon *base_lib.f90*, and outputs a number of text files with simulation and solution data for external processing. It is written in Fortran.

base_lib.f90: This file contains a number of utility functions and subroutines called in *RUBC_pe.f90*. It is written in Fortran.

compile_script.sh: This Bash script compiles the *base_lib.f90* and *RUBC_pe.f90* files, producing the 64-bit parallelized executable *RUBC_pe.exe*. The details of the compilation procedure will vary from configuration to configuration, so this file is purely illustrative.

read_RUBC_pe.R: This file reads in text files generated by *RUBC_pe.exe* with simulation data and generates PDF figures summarizing the model unconditional simulation and the simulated impulse response to an uncertainty shock. It is written in MATLAB.

Group #3: Solution and simulation of the general equilibrium model with extended forecast rules.

These files can be found in the subfolder *3_EXTENDED_FORECASTS_GE*. The use of these files requires a Fortran compiler as well as R. There are two subfolders, *ADDITIONAL_FCST_MOMENT* and *ADDITIONAL_UNC_LAGS*. Within each subfolder, each file serves an almost identical role and is labelled in the same manner as those files in Group #1 above. The difference is that the files in *ADDITIONAL_FCST_MOMENT* solve a version of the baseline general equilibrium model with an additional moment in the forecast rule, while files in *ADDITIONAL_UNC_LAGS* solve a version of the baseline general equilibrium model with additional exogenous lags of uncertainty in the forecast rule.

Group #4: Estimation of the General Equilibrium Model

These files can be found in the subfolder *4_GE_ESTIMATION*. The use of these files requires a Fortran compiler, R, and MATLAB.

RUBC_wrapper.f90: This file contains the main body of the code. The program *RUBC_wrapper* implements particle swarm optimization based on the SMM objective function, and it primarily involves bookkeeping and program setup commands. However, the function *RUBC_func* called by *RUBC_wrapper* and written in the same file implements the evaluation of the SMM objective for a given set of parameters, i.e. it solves and simulates the general equilibrium model given those parameters, computes moments based on the simulated data, and then computes the SMM objective based on these moments. The file *RUBC_wrapper.f90* relies on *base_lib.f90* for utility functions and outputs a wide range of text files, needed for moment calculation which is completed externally in the MATLAB files *MACROMOM.m* and *MICROMOM.m*. It is written in Fortran.

base_lib.f90: This file contains a number of utility functions and subroutines called in RUBC_ge.f90. It is written in Fortran.

compile_script.sh: This Bash script compiles the *base_lib.f90* and *RUBC_wrapper.f90* files, producing the 64-bit parallelized executable *RUBC_wrapper.exe*. The details of the compilation procedure will vary from configuration to configuration, so this file is purely illustrative.

MACROMOM.m: This file contains a function called from *RUBC_func* in the file *RUBC_wrapper.f90*. The function takes as inputs simulation dimension parameters as well as simulated aggregate TFP data, estimates a GARCH(1,1) model based on the change in aggregate TFP, and computes time series moments of the resulting estimated conditional heteroskedasticity series. This file outputs both the estimated conditional heteroskedasticity series as well as the time series macro moments in text files. The function is written in MATLAB.

MICROMOM.m: This file contains a function called from RUBC_func in the file *RUBC_wrapper.f90*. The function takes as inputs simulation dimension parameters as well as simulated firm-level TFP data, estimates measurement error-adjusted panel regressions based on this micro data, and computes time series moments based on the cross-sectional estimated interquartile range of the innovations of these regressions. The file outputs both the resulting cross-sectional uncertainty time series as well as the times series micro moments in text files. The function is written in MATLAB.

MOMENT_CALCS: This subfolder contains files used to compute the estimates and covariance matrix of the time series moments of the micro and macro uncertainty proxies in the data.

MOMENT_CALCS/moments_data.m: This files reads in macro TFP change data from John Fernald's website as well as the micro uncertainty proxy computed from Census data. The file processes these series to produce the micro and macro uncertainty series in output text files for moment calculation and moment covariance matrix estimation. It is written in MATLAB.

MOMENT_CALCS/dTFP.xls and *MOMENT_CALCS/IQR.xls:* These Excel files contains the macro TFP change data from John Fernald's website as well as the micro uncertainty proxy from Census data.

MOMENT_CALCS/boot.R: This file reads the data produced by *moments_data.m* and computes the time series moments of the micro and macro uncertainty series. It also applies a stationary time series bootstrap procedure to compute an estimate of the covariance matrix of these moments. The moment estimates and covariance matrix estimate are output in text files. It is written in R.

*SE_CALCS***:** This subfolder contains files used in the calculation of the standard errors of the SMM point estimates.

SE_CALCS/RUBC_SMM_SE.f90: This file contains code very similar to the code in *RUBC_wrapper.f90*. However, instead of point estimation as the goal, this code starts with point estimates and uses forward approximation to numerically differentiate the moment function with respect to the estimated parameters, by repeated solution and simulation of the model at points in parameter space nearby the estimated parameters. The code relies upon utility functions in base_lib.f90 as well as the moment calculation functions *MICROMOM.m* and *MACROMOM.m.* This code outputs a number of text files with simulated data, and it also outputs the estimated derivative matrix in a text file for use by other files. It is written in Fortran.

SE_CALCS/base_lib.f90: This file contains a number of utility functions and subroutines called in *RUBC_ge.f90*. It is written in Fortran.

SE_CALCS/compile_script.sh: This Bash script compiles the *base_lib.f90* and *RUBC_SMM_SE.f90* files, producing the 64-bit parallelized executable *RUBC_SMM_SE.exe*. The details of the compilation procedure will vary from configuration to configuration, so this file is purely illustrative.

SE_CALCS/MACROMOM.m: This file contains a function called from RUBC_func in the file *RUBC_SMM_SE.f90*. The function takes as inputs simulation dimension parameters as well as simulated aggregate TFP data, estimates a GARCH(1,1) model based on the change in aggregate TFP, and computes time series moments of the resulting estimated conditional heteroskedasticity series. This file outputs both the estimated conditional heteroskedasticity series as well as the time series macro moments in text files. The function is written in MATLAB.

SE_CALCS/MICROMOM.m: This file contains a function called from RUBC_func in the file RUBC_SMM_SE.f90. The function takes as inputs simulation dimension parameters as well as simulated firm-level TFP data, estimates measurement error-adjusted panel regressions based on this micro data, and computes time series moments based on the cross-sectional estimated interquartile range of the

innovations of these regressions. The file outputs both the resulting cross-sectional uncertainty time series as well as the times series micro moments in text files. The function is written in MATLAB.

SE_CALCS/SE_compute.m: This file takes as inputs the estimated numerical derivatives of the moment function as well as the covariance matrix of the targeted moments from the data. Then, the file computes the asymptotic covariance matrix and standard errors of the estimated parameters from the SMM procedure. The function is written in MATLAB.

IRF: This subfolder contains files identical in purpose and labelling as the files in Group #1, but these versions solve a version of the general equilibrium model based on clearing a nonconvexified excess demand function.

Group #5: Solution and Simulation of the Brock-Mirman Model

These files can be found in the subfolder *5_BROCK_MIRMAN*. The use of these files requires a Fortran compiler as well as MATLAB.

RUBC_Brock_Mirman.f90: This file contains the main body of the code, solving and unconditionally simulating a version of the Brock and Mirman (1972) model. Depending on flags set at the top of the code, the program also simulates the impulse response to an aggregate productivity shock or a capital destruction shock. The code relies upon utility functions from *base_lib.f90* and outputs a number of text files with simulation data. It is written in Fortran.

base_lib.f90: This file contains a number of utility functions and subroutines called in RUBC_pe.f90. It is written in Fortran.

compile_script.sh: This Bash script compiles the *base_lib.f90* and *RUBC_Brock_Mirman.f90* files, producing the 64-bit parallelized executable *RUBC_Brock_Mirman.exe*. The details of the compilation procedure will vary from configuration to configuration, so this file is purely illustrative.

read_Brock_Mirman.m: This file reads the raw text file simulation data produced by *RUBC_Brock_Mirman.exe*, computes the implied impulse response functions, and saves this data. It is written in MATLAB.

Group #6: Simulation of the baseline general equilibrium model to compute impulse responses according to the Koop, et al. (1996) simulation differencing approach.

These files can be found in the subfolder 6_SIMULATION_DIFFERENCING_IRF. The use of these files requires a Fortran compiler as well as R.

RUBC_ge.f90: This file contains the main body of the code, which solves and simulates the baseline GE version of the model while simulating conditional responses or impulse responses according to the procedure outlined in Koop, et al. (1996).

base_lib.f90: This file contains a number of utility functions and subroutines called in RUBC_pe.f90. It is written in Fortran.

compile_script.sh: This Bash script compiles the *base_lib.f90* and *RUBC_ge.f90* files, producing the 64-bit parallelized executable *RUBC_ge.exe*. The details of the compilation procedure will vary from configuration to configuration, so this file is purely illustrative.

read_RUBC_ge.R: This file reads in text files generated by RUBC_ge.exe with simulation data and generates PDF figures summarizing the model unconditional simulation. Depending on the flags set at the top of the code, this file also processes the simulated data to compute a simulated impulse response to an uncertainty shock. It is written in R.