The CMR Model

The DSGE in “Risk Shocks” by Christiano, Motto, and Rostagno
Code Reference Manual
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1 Introduction

This package is a collection of routines that implement the CMR model. The source code is distributed under the GNU General Public License, a copy of which is included in this document (see [GNU General Public License], page 15). The manual is distribted under the (see [GNU Free Documentation License], page 22). The code makes extensive use of the Dynare software package for solving and estimating DSGE models. The choice of license is for practical and required reasons. The code is meant to be as freely available as possible. Additionally, the model requires several files from Dynare, which are licensed under the GNU General Public License. In order to comply with the terms of that license, all code released here is also licensed to any user under the GNU General Public License.

You should know that the code provided has no warranty. The code is provided “as is.”

Any system with Matlab (version 7.0 or above) or GNU Octave (versions 3.0 or above) and Dynare (version 4.3.2) should be able to use the code. Matlab must be purchased from MathWorks `http://www.mathworks.com/products/matlab/`. GNU Octave is free software and can be downloaded from `http://www.gnu.org/software/octave/`. Dynare is also free software and can be downloaded from `http://www.dynare.org/`.

1.1 Installation

The model code must be in the current working directory of Matlab or Octave. To see the name of the current working directory, issue the command

```
>> pwd
```

To see the names of the files in the current working directory, issue the command

```
>> ls
```

To change directories, use the `cd` command.

1.2 Using Dynare

The library requires that the Dynare be installed and available to Matlab or Octave. Use the `addpath` command to add the path to the installation of Dynare. To ensure that Matlab or Octave can find `dynare`, issue the command

```
>> which dynare
```

If you see `'dynare' not found.`, the path to Dynare has not been added.

1.3 A Note on Dynare Versions

The code distributed here is compatible with dynare 4.3.2. Unfortunately, several of the changes made in Dynare 4.3.3 affected the files needed to implement the Weibull distribution, which is used in the prior for the measurement error of equity. With minor modification, the user should be able to use any version of Dynare in the future. However, to replicate the results using the code provided here, the user should use dynare 4.3.2.

2 Using the Code

The analysis in the paper is done in several subdirectories. In order to reduce the possibility of error, the model files and other files that are constant accross different versions of the analysis are stored in the top-level directory. Additionally, several files from Dynare had to be changed in order to accommodate the model. Before starting to use the code, make sure that `/path/to/cmrfiles` is on the Matlab search path, where `/path/to` is a stand in for the directory structure leading to the `cmrfiles` directory. This can be done with an `addpath` command. This ensures that the custom Dynare files and the steady state file will be found by Dynare. In this section of the reference manual, we document the model files and the custom Dynare files.

2.1 Model Files

This section describes files specific to the CMR model. These files are located in the top directory of the zip file that contains the code. These files are used by the code that does the analysis and graphing in each of the subdirectories.

2.1.1 cmr_declarations.mod

The file `cmr_declarations.mod` declares variables using the `var`, `varexo`, and `parameters` commands. More information about these commands can be found at http://www.dynare.org/manual/index_12.html. This file is included in `cmr.mod` using the `@# include` command.

2.1.2 cmr_estimated_params.mod

The file `cmr_estimated_params.mod` declares priors for the estimated parameters in the `estimated_params` block. More information about the `estimated_params` block can be found at http://www.dynare.org/manual/index_24.html#index-estimated_005fparams. This file is included in `cmr.mod` using the `@# include` command.

2.1.3 cmr_estimated_params_init.mod

The file `cmr_estimated_params_init.mod` declares initial values of the estimated parameters in the `estimated_params_init` block. More information about the `estimated_params_init` block can be found at http://www.dynare.org/manual/index_24.html#index-estimated_005fparams_005finit. This file is included in `cmr.mod` using the `@# include` command.

2.1.4 cmr_model.mod

The file `cmr_model.mod` contains the model equations. Extensive use is made of model-local variables in order to reduce the size of the linearized economy. More information about the `model` block can be found at http://www.dynare.org/manual/index_15.html. This file is included in `cmr.mod` using the `@# include` command.

2.1.5 cmr_parameters.mod

The file `cmr_parameters.mod` calibrates initial values of the parameters. This file is included in `cmr.mod` using the `@# include` command.

2.1.6 cmr_shocks.mod

The file `cmr_shocks.mod` declares the shocks in the `shocks` block. More information about the `estimated_params_init` block can be found at `http://www.dynare.org/manual/index_18.html`. This file is included in `cmr.mod` using the `@# include` command.

2.1.7 cmr_steadystate.m

The file `cmr_steadystate.m` computes the steady state of the model. This is called by numerous Dynare routines.

2.1.8 data_BAAoverTB.mat

The file `data_BAAoverTB.mat` contains the observation data. The names must be the same as those used in the `varobs` command.

2.2 Custom Dynare Files

This package includes a directory named `dynare_code` that contains several custom dynare files. The files are listed below with a brief description of the reason they are included. Please note that the copyright of these files remains with the Dynare Team. As permited by the Dynare Team, these files are distributed under version 3 of the GNU General Public License (see [GNU General Public License], page 15).

2.2.1 disp_th_moments.m

The file `disp_th_moments.m` is modified to allow several variables of interest to be returned as return values.

2.2.2 draw_prior_density.m

The file `draw_prior_density.m` is modified to allow the Weibull prior when `options_.weibull = 1`.

2.2.3 prior_bounds.m

The file `prior_bounds.m` is modified to allow the Weibull prior when `options_.weibull = 1`.

2.2.4 priordens.m

The file `priordens.m` is modified to allow the Weibull prior when `options_.weibull = 1`.

2.2.5 set_prior.m

The file `set_prior.m` is modified to allow the Weibull prior when `options_.weibull = 1`.

3 Producing the Graphs

The graphs are produced in subdirectories that are named to correspond to the numbering in the manuscript. Instructions for producing each graph follows. It is important that the working directory of Matlab or Octave be the directory in which the graphing files are located, e.g. `/path/to/cmrfiles/figure2`.

3.1 Figure 1

In the directory `figure1` is a file named `cmr.mod`. To generate Figure 1, all you need to do is run dynare with this file. That is,

```
>> dynare cmr
```

3.2 Figure 2

In the directory `figure2` is a file named `cmr.mod`. This code can be used to generate impulse responses from the model shown in Figure 2. You have to run dynare twice. On the first run, set the Taylor rule inflation parameter to 1.5 by setting taylor1p5 = 1. There is a line near the beginning of the file that may be modified to reflect this setting. It should look like

```
@# define taylor1p5 = 1
```

After making sure that this is the case, run dynare

```
>> dynare cmr
```

In addition to the files generated by Dynare, the code will produce a file named `results_taylor1p5.mat` that will be used on the next run of dynare. After running Dynare the first time, change taylor1p5 to be zero. That is, in the `cmr.mod` file, make sure

```
@# define taylor1p5 = 0
```

Run dynare again,

```
>> dynare cmr
```

and the graph will be produced and appear in a separate window.

3.3 Figure 3

In the directory `figure3` are files named `cmr.mod`, `correlate.m`, `difftrans.m`, `hpfast.m`, `se.m` `corr_.m`, `cross_corr.m`, `do_plot.m`, and `pltt.m`. This code can be used to generate correlograms shown in Figure 3. You have to run dynare twice. On the first run, turn off the non-risk shocks by setting stopshock to 1. There is a line near the beginning of the file that may be modified to reflect this setting. It should look like

```
@# define stopshock = 1
```

After making sure that this is the case, run dynare

```
>> dynare cmr
```

In addition to the files generated by Dynare, the code will produce several mat files that will be used on the next run of dynare. After running Dynare the first time, change stopshock to be 0. That is, in the `cmr.mod` file, make sure

```
@# define stopshock = 0
```

Run dynare again,

```
>> dynare cmr
```

and the graph will be produced and appear in a separate window.

3.4 Figure 4

In the directory `figure4` is a file named `cmr.mod`. To generate Figure 4, all you need to do is run dynare with this file. That is,

```
>> dynare cmr
```

3.5 Figure 5

In the directory `figure5` are files named `cmr.mod`, `cmr_mode.mat`, and `cmr_mode_cee.mat`. This code can be used to generate Figure 5. The `.mat` file is required by the `estimation` command in Dynare, which is used to recover the smoothed variables without actually doing the estimation. You have to run dynare twice. On the first run, you restrict the model to be a version of the model in Christiano, Evans, and Eichenbaum by setting the macro variable cee to 1. There is a line near the beginning of the file that may be modified to reflect this setting. It should look like

```
@# define cee = 1
```

After making sure that this is the case, run dynare

```
>> dynare cmr
```

In addition to the files generated by Dynare, the code will produce a mat file that will be used on the next run of dynare. After running Dynare the first time, change cee to be 0. That is, in the `cmr.mod` file, make sure

```
@# define cee = 0
```

Run dynare again,

```
>> dynare cmr
```

and the graph will be produced and appear in a separate window.

3.6 Figure 7

In the directory `figure7` are files named `cmr.mod`, `hpfast.m` and `cmr_mode.mat`. The `.mat` file is required by the `estimation` command in Dynare, which is used to recover the smoothed variables without actually doing the estimation. To generate Figure 7, all you need to do is run dynare with the `cmr.mod` file. That is,

```
>> dynare cmr
```

3.7 Figure 8

In the directory `figure8` is a file named `cmr.mod` and a file named `cmr_mode.mat`. The `.mat` file is required by the `estimation` command in Dynare, which is used to recover the smoothed variables without actually doing the estimation. To generate Figure 8, all you need to do is run dynare with the `cmr.mod` file. That is,

```
>> dynare cmr
```

4 Producing the Tables

The results that are shown in the tables are produced in subdirectories that are named to correspond to the numbering in the manuscript. Instructions for producing the data in Table 2, Table 3, and Table 4 follow. It is important that the working directory of Matlab or Octave be the directory in which the graphing files are located, e.g. `/path/to/cmrfiles/table2`.

4.1 Table 2

In the directory `table` is a file named `cmr.mod` and a file named `cmr_mode.mat`. To generate the data in Table 2, all you need to do is run dynare with this file. That is,

```
>> dynare cmr
```

The relevant information is printed to the screen by Dynare.

4.2 Table 3

In the directory `table3` are files named `cmr.mod`, `cmr_mode.mat`, `find_ss_4table.m`, and `model_ss_table.m`. To generate the data in Table 2, all you need to do is run dynare with this file. That is,

```
>> dynare cmr
```

The relevant information is printed to the screen after the default Dynare output.

4.3 Table 4

In the directory `table4` are subdirectories that include the code required to replicate the MCMC results reported in Table 4. NOTE: the log files from the MCMC runs is also included in this file, meaning that you can see the output without actually running the code. This is potentially important because Dynare takes about one week to complete the computation in each subdirectory. There are many different configurations of the signals in Table 4. For example, there are runs with signals on the risk shock (the baseline case), signals on technology, signals on monetary policy, etecetera. The subdirectories are named to correspond to the various runs. All that the user should need to do is make sure that the home directory (`cmrfiles`) is on the Matlab path and then run `dynare cmr`.

5 Coding Standards

Though none of these coding standards are required to implement the model, they are intended to improve readability and maintainability of the code. The standards are described here to help the reader understand the naming conventions as well as other decisions made with regard to the code's style.

5.1 Declarations

Declarations of variables and parameters using the `var`, `varexo`, and `parameters` commands should occur on separate lines for each parameter or variable. Additionally, parameter and variables names should be alphebatized in the declaration. For example,

```
var
x,
y,
z;
```

5.2 Names

For continuity, distinctions are made regarding the way objects are named.

5.2.1 Variables

Variables declared in the `var` command should have names consisting only of letters and numbers. Additionally, the names should be reflective of the symbols used for the same concept in the manuscript. Underscores are explicitly omitted. This keeps the length of variable names from getting so long that the model block becomes unwieldy. It also gives the underscore particular meaning when naming other objects.

5.2.2 Parameters

Parameters declared in the `parameters` command should have names that consist of letters and numbers followed by an `_p`. The `_p` makes parameters explicit when defining model equations.

5.2.3 Exogenous Variables

Exogenous variables declared in the `varexo` command should have names that begin with `e_` and then consist of only letters and numbers. The `e_` makes exogenous variables explicit when defining model equations.

5.2.4 Observable Variables

Observable variables declared in the `varobs` command should be appended with `_obs`. This makes clear the observation equations in the model.

5.3 Model-Local Variables

When model-local variables are defined in the model block with the `#` command, use the same conventions as for other names. However, because these expressions are pasted as text strings into the model file, the variables cannot be indexed by time and it is often necessary to define a one-step-ahead or one-step-behind version of the variable. In that case, append a `p1` to the end to indicate one step ahead or `m1` to indicate one step behind. Additionally, when defining a model-local variable, the entire expression on the right-hand-side of the equals sign should be enclosed in a set of parentheses. This ensures that the entire block of code will be multiplied, exponentiated, etc. when pasted in to the model block by the preprocessor.

5.4 Spacing of Model Equations

The arithmetic expressions `+`, `-`, `*`, `/`, and `=` should be preceeded and followed by one space. It is occasionally acceptable add additional spaces before or after these operators in order to align similar equations. Additionally, for expressions within exponents it is acceptable to omit the spaces for ease of readability. Left parentheses should not be followed by a space. Similarly, right parentheses should not be preceeded by a space. The expression `^` should not be preceeded by or followed by a space.

5.5 Line Length

Code should be limited to 75 characters per line. The lone exception is in the model block, where equations are often more readable when allowed to exceed this limit. If more than one line is used for a single equation in the model block, new lines should begin with a `+`, `-`, `*`, or `/`.

6 Name Index

Names used in the code are here matched to their concepts in the manuscript.

6.1 Endogenous Variable Names

`c` $c_t \equiv C_t/z_t^*$, scaled aggregate consumption

`epsil` ϵ_t, technology shock

`Fp` $F_{p,t}$, convenience variable for price evolution

`Fw` $F_{w,t}$, convenience variable for wage evolution

`g` $g_t \equiv G_t/z_t^*$, scaled government purchases

`gamma` γ_t, equity shock

`h` h_t, hours

`i` $i_t \equiv I_t/z_t^* \Upsilon^t$, scaled investment

`kbar` $\bar{k}_{t+1} \equiv \bar{K}_{t+1}/z_t^*$, scaled entrepreneurial capital

`lambdaf` $\lambda_{f,t}$, intermediate goods shock

`lambdaz` $\lambda_{z,t}$, marginal utility of consumption

`muup` $\mu_{\Upsilon,t}$, investment goods technology shock

`muzstar` $\mu_{z^*,t}$, growth rate of z_t^*

`n` n_{t+1}, entrepreneurial net worth

`omegabar` $\bar{\omega}_t$, the ω separating bankrupt and non-bankrupt entrepreneurs

`phi` ϕ, fixed cost that ensures zero profits

`pi` $\pi_t \equiv P_t/P_{t-1}$, inflation

`pitarget` π_t^{target}, inflation rate in the monetary authority's policy rule

`pstar` p_t^*, useful variable in pricing equations

`q` $q_t \equiv \Upsilon^t Q_{\bar{K}',t}/P_t$, scaled market price of capital

`Re` R_t, risk-free rate of interest

`rL` real-risk-free-10-year rate of interst

`rk` r_t^k, rental rate of capital

`Rk` R_t^k, return on capital

`RL` nominal-risk-free-rate-10-year rate of interest

`s` s_t, marginal cost

`sigma` σ_t, risk shock

`term` term structure of interest rates

u u_t, utilization rate of capital

wtilde $\tilde{w}_t$, scaled real wage

wstar w_t^*, useful variable in wage equations

xi0, xi1, xi2, xi3, xi4, xi5, xi6, xi7, xi8
$\xi_{0,t}, \xi_{1,t}, \xi_{2,t}, \xi_{3,t}, \xi_{4,t}, \xi_{5,t}, \xi_{6,t}, \xi_{7,t}, \xi_{8,t}$, news shocks

zetac $\zeta_{c,t}$, preference shock on consumption

zetai $\zeta_{I,t}$, maginal efficiency of investment

6.2 Observable Variable Names

consumption_obs
$c_t \mu_{z^*,t}/(c_{t-1}\mu_{z^*})$,

credit_obs
$(q_t * \bar{k}_t - n_t)/(q_{t-1}\bar{k}_{t-1} - n_{t-1})\mu_{z^*,t}/\mu_{z^*}$

gdp_obs $(c_t + i_t/\mu_{\Upsilon,t} + g_t)\mu_{z^*,t}/(c_{t-1} + i_{t-1}/\mu_{\Upsilon,t-1} + g_{t-1})/\mu_{z^*}$

hours_obs
h_t/h

inflation_obs
π_t/π

investment_obs
$i_t \mu_{z^*,t}/(i_{t-1}\mu_{z^*})$

networth_obs
$n_t \mu_{z^*,t}/(n_{t-1}\mu_{z^*})$

pinvest_obs
$\mu_{\Upsilon,t-1}/\mu_{\Upsilon,t}$

premium_obs
Re_obs $\exp(Re - Re_p)$

RealRe_obs
$((1 + R_t)/\pi_{t+1})/((1 + R)/\pi)$

Spread1_obs
$1 + RL_t - R_t$

wage_obs $\tilde{w}_t \mu_{z^*,t}/(\tilde{w}_{t-1}\mu_{z^*})$

6.3 Exogenous Variable Names

The endogenous variables ϵ_t, g_t, γ_t, $\lambda_{f,t}$, $\mu_{\Upsilon,t}$, $\mu_{z^*,t}$, π_t^{target}, σ_t, $term_t$, $\zeta_{c,t}$, and $\zeta_{i,t}$ have an AR(1) representation. When an exogenous variable is the shock to one of those variables in the AR(1) representation, we will call it a shock to that variable.

e_epsil shock to ϵ_t

e_g shock to g_t

e_gamma shock to γ_t

e_lambdaf
shock to $\lambda_{f,t}$

e_muup shock to $\mu_{\Upsilon,t}$

e_muzstar
shock to $\mu_{z^*,t}$

e_pitarget
shock to π_t^{target}

e_sigma shock to σ_t

e_xi1, e_xi2, e_xi3, e_xi4, e_xi5, e_xi6, e_xi7, e_xi8
shocks to $\xi_{0,t}, \xi_{1,t}, \xi_{2,t}, \xi_{3,t}, \xi_{4,t}, \xi_{5,t}, \xi_{6,t}, \xi_{7,t}, \xi_{8,t}$

e_term shock to $term_t$

e_xp monetary policy shock

e_zetac shock to $\zeta_{c,t}$

e_zetai shock to $\zeta_{i,t}$

6.4 Parameter Names

actil_p, parameter in generalized monetary policy rule

adptil_p parameter in generalized monetary policy rule

adytil_p parameter in generalized monetary policy rule

alpha_p α in Cobb-Douglas production technology

aptil_p $\tilde{a}_\pi$ in monetary policy rule

aytil_p $\tilde{a}_y$ in monetary policy rule

b_p b habit parameter in utility

beta_p β time-discounting parameter in utility

bigtheta_p
Θ determines resources used for state-verification in resource constraint

c_p parameter in generalized monetary policy rule

delta_p δ depreciation parameter

etag_p η_g determines the percentage of output consumed by the government in steady state

epsil_p mean of the process for ϵ_t

g_p parameter in generalized monetary policy rule

gamma_p mean of the process for γ_t

i_p parameter in generalized monetary policy rule `iota_p` ι in definition of $\tilde{\pi}_t$

`iotaw_p` ι_w in definition of $\tilde{\pi}_{w,t}$

`iotamu_p` ι_μ in equation for $W_{i,t}$

`lambdaf_p`
mean of process for $\lambda_{f,t}$

`lambdaw_p`
λ_w in the wage aggregation technology

`mu_p` μ growth rate

`muup_p` mean of process for $\mu_{\Upsilon,t}$

`muzstar_p`
mean of process for $\mu^*_{z,t}$

`pi_p` π mean inflation

`pibar_p` $\bar{\pi}$ indexation parameter

`pitarget_p`
mean of target inflation

`psiL_p` Ψ_L wage bill financing

`Re_p` mean risk free rate

`rhoepsil_p`
AR(1) parameter for the process ϵ_t

`rhog_p` AR(1) parameter for the process g_t

`rhogamma_p`
AR(1) parameter for the process γ_t

`rholambdaf_p`
AR(1) parameter for the process $\lambda_{f,t}$

`rhomuup_p`
AR(1) parameter for the process $\mu_{\Upsilon,t}$

`rhomuzstar_p`
AR(1) parameter for the process $\mu^*_{z,t}$

`rhopitarget_p`
AR(1) parameter for the process π^*_t

`rhosigma_p`
AR(1) parameter for the process σ_t

`rhoterm_p`
AR(1) parameter for the process $term_t$, which is the term structure variable

`rhotil_p` $\tilde{\rho}$ persistence in the monetary policy equation

`rhozetac_p`
AR(1) parameter for the process $\zeta_{c,t}$

`rhozetai_p`
AR(1) parameter for the process $\zeta_{i,t}$

`rk_p` Used to determine utilization cost for output

`Sdoupr_p` S' in definition of adjustment costs

`signal_corr_p`
governs correlation among news signals

`sigmaa_p` σ_a utilization cost function

`sigmaL_p` σ_L preference parameter for labor

`stdepsil_p`
standard deviation of the inovation to the process ϵ_t

`stdg_p` standard deviation of the inovation to the process g_t

`stdgamma_p`
standard deviation of the inovation to the process γ_t

`stdlambdaf_p`
standard deviation of the inovation to the process $\lambda_{f,t}$

`stdmuup_p`
standard deviation of the inovation to the process $\mu_{\Upsilon,t}$

`stdmuzstar_p`
standard deviation of the inovation to the process $\mu^*_{z,t}$

`stdpitarget_p`
standard deviation of the inovation to the process π^*_t

`stdsigma1_p`
standard deviation of contemporaneous component of the signals

`stdsigma2_p`
standard deviation of news component of the signals

`stdterm_p`
standard deviation of the inovation to the process $term_t$, which is the term structure

`stdzetac_p`
standard deviation of the inovation to the process $\zeta_{c,t}$

`stdzetai_p`
standard deviation of the inovation to the process $\zeta_{i,t}$

`tauc_p` τ^c consumption tax rate

`taud_p` τ^d bond tax rate

`tauk_p` τ^k capital tax rate

`taul_p` τ^l wage tax rate

`term_p` mean of the process $term_t$ which governs the term structure `tauo_p` τ^o appears in efficiency condition for capital utilization

`upsil_p` Υ growth parameter

`we_p` w^e lump-sum transfer to entrepreneurs

`zeta_p` ζ_t in equation 6

`zetac_p` mean of the process $\zeta_{c,t}$

`zetai_p` mean of the process $\zeta_{i,t}$

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