User Guide for Replication of the Results in McKnight, Mihailov and Pompa Rangel, *Journal of Macroeconomics*, Volume 63, March 2020, Article 103188

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Contents

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1 The Model in Its MMP/IAM and KLL/CAM Versions

The model in McKnight, Mihailov and Pompa Rangel, MMP (2020: JoM) features a medium-scale small open economy (SOE) New Keynesian (NK) model with incomplete (IAM) versus complete international asset markets (CAM), incomplete exchange rate pass-through, 9 shock processes and 9 observables. It complements and extends the similar model in Kam, Lees and Liu, KLL (2009: JMCB), which assumes CAM. Note, however, that the two model versions are not nested, and the IAM version contains a debt-elastic interest-rate premium and a related additional parameter, which is not the case for the CAM version.

Following KLL (and adapting their MATLAB codes) MMP is estimated using Bayesian techniques in its log-linearized equilibrium where the foreign economy (the US) is assumed to be represented by a simple reduced-form 3VAR(1) in CPI inflation, the output gap and the nominal (policy) interest rate. Using quarterly data (with annualized inflation and interest rates), KLL estimate for 3 advanced SOEs, Australia, Canada and New Zealand over the inflation targeting period interpreted as constrained discretion in monetary policy, where the focus is on the relative weights in the central bank objective function (for the targets of output gap, μ_y, and real exchange rate, μ_q, stabilization as well as interest rate smoothing, μ_r, once that for inflation stabilization is normalized to 1,) where two of the key parameters are calibrated at the same value for the three countries: the discount factor, $\beta = 0.99$, and the share of imports in consumption, $\alpha = 0.45$. MMP do the same for all five Latin American inflation targeting (LAIT) SOEs operating a flexible exchange-rate regime, Brazil, Chile, Colombia, Mexico and Peru, but replacing the common calibration of α by a country-specific one (as measured in the sample) and adding another commonly calibrated parameter arising from the extension to incomplete asset markets (and closing the SOE by an equation for the debt-elastic interest rate premium), $\chi = 0.05$.

The matrix representation of the log-linearized model equilibrium conditions (which include the first-order necessary conditions for optimal behavior of all agents, the market clearing conditions for each individual and aggregate market, and accounting identities or definitions) writes down the model in state space (SS) system form, to solve and estimate it via (Bayesian) maximum likelihood.

$$
\begin{aligned}
\underset{(ny\times ny)}{\mathbf{A}_0}\underset{(ny\times 1)}{y_t} &= \underset{(ny\times ny)}{\mathbf{A}_1}\underset{(ny\times 1)}{y_{t-1}} + \underset{(ny\times ny)}{\mathbf{A}_2}\underset{(ny\times 1)}{\mathbb{E}_t y_{t+1}} \\
&+ \underset{(ny\times nx)}{\mathbf{A}_3}\underset{(nx\times 1)}{x_t} + \underset{(ny\times nx)}{\mathbf{A}_4}\underset{(nx\times 1)}{\mathbb{E}_t x_{t+1}} + \underset{(ny\times nz)}{\mathbf{A}_5}\underset{(nz\times 1)}{z_t} \qquad (1)
\end{aligned}
$$

The short-term (policy) interest rate is both an endogenous state variable, and so enters the vector y_t, and a control (instrument) variable (the only one such variable), and so enters the vector x_t too. Each equation in the matrix notation of the SS system (1) is numbered in the code according to the row and selects the respective variables that enter it according to the column. That is, if $\mathbf{A}(\text{row}, \text{col})$ denotes a generic matrix that can be any of the subscripted ones in (1): $\mathbf{A}_0(1, 5)$, for example, selects the (nonzero) coefficient of the $5th$ variable in vector y_t to enter the $1st$ equation in the SS form, and so forth.

The MATLAB code implements the Bayesian estimation procedure described in the JoM article. Most of the code was run in MATLAB R2014a, but some of it was also run on MATLAB R2017b, in Windows 7 OS (not in Windows 10 OS or Mac OS). Note that on a usual desktop or laptop, a single run of the code for one country and one model version takes about 48-72 hours to complete! All equations in (1) enter the code in model_solve.m, the program that solves the linear rational expectations model (LREM) under optimal discretion, discretion.m (or commitment, commitment.m, not in the paper) and writes the solution in SS form. Then, model_likelihood.m evaluates the likelihood function by running the Kalman filter.

In both MMP (or, `_mmp9` in the code), which denotes the IAM version, and KLL (or `_kll` in the code), which denotes the CAM version: $ny = 22$, $nx = 1$, $nz = ny^{obs} = 9$.

2 Structure of the KLL-MMP MATLAB Codes

We illustrate the structure of the code taking Mexico as a first, or baseline, country case.

2.1 Main Program for Bayesian Estimation

Let us consider the MMP/IAM version; then the main program is:

`mex_est_qifspq_099_044_005_mh025_rng0twister_Gpv05_mmp9.m`

when $\mu_q > 0$; or

`mex_est_qifspq_099_044_005_mh025_rng0twister_Gpv05_mmp9_muq0.m`

when $\mu_q = 0$.

Note that in the corresponding KLL/CAM version, the main program is:

`mex_est_qifspq_099_044_005_mh025_rng0twister_kll.m`

when $\mu_q > 0$; or

`mex_est_qifspq_099_044_005_mh025_rng0twister_kll_muq0.m`

when $\mu_q = 0$.

Note that the maximum length for a file name in MATLAB is 63 characters!

Let us now explain the meaning of the components in the name of the main program:

`mex_est_qifspq_099_044_005_mh025_rng0twister_Gpv05_mmp9.m`

This program estimates optimal policy models under discretion (in the codes, option `POLICY=1`) or commitment (option `POLICY=0`) and is based on Kam, Lees and Liu (2009: JMCB) original codes. It implements Bayesian estimation using the Random Walk Metropolis-Hastings Markov Chain Monte Carlo (RWMH-MCMC) algorithm to simulate draws from the posterior densities of the parameter vector (`Theta`).

The mnemonics in the file name of the program above means:

`mex`: Mexico;

`_est:` (Bayesian) estimation;

`_qifspq:` based on quarterly (`q`) IMF-IFS (`ifs`) data accessed online and transformed and reformatted conveniently as an Excel input file, stored in `\data\mexdata_qifspq.xlsx` (itself contained as a final adaptation with single worksheet in values rather than formulas of a richer database with multiple worksheets, `\data\mexdata_qifsall.xlsx`), where all variables measured as % (inflation and interest rates) are expressed in % quarter-on-quarter, that is, in per quarter (`pq`) terms, and all other variables (nominal and real exchange rates, terms of trade, GDP, final consumption expenditure, and – only in the working paper version of 2016, cited in the JoM article, where a larger model version of MMP was estimated, with an additional 10th observable, international reserves in home currency, and an additional 10th shock, a preference shock) are converted to natural logarithms of the original quarterly data;

`_099:` common (for all LAIT countries) calibration of $\beta = 0.99$;

`_044:` country-specific calibration for Mexico of $\alpha = 0.44$ (much more digits after the decimal are used in the code);

`_005:` common (for all LAIT countries) calibration of $\chi = 0.05$ in the IAM version (absent in the CAM version);

`_mh025:` country-specific calibration for Mexico of the scaling constant in the RWMH-MCMC algorithm to target a reasonable acceptance rate (of, broadly, $20 - 40\%$);

`_Gpv05:` Geweke (`G`) convergence statistics probability value (`pv`) calculated with a sample split in halves (`05`);

`_rng0twister:` country-specific choice for Mexico of the seed (`0,` possibly, after some trials, as in the other country cases where this is a number higher than 0) of the Mersenne twister (`twister`, kept the same for all countires) function pseudo-random number generator (`rng`) used in the RWMH-MCMC simulation;

Any of the last 5 indicators in the file name for the main program should be changed accordingly when its value has been changed.

2.2 Embedded Function Calls

2.2.1 Manipulating and Plotting the Raw and Doctored Data

`mex_datadoc_qifspq.m`

It calls further the following functions:

`multiplot2Draw.m`: plots the raw data for ANY country (since the raw data sample is identical);

`mex_multiplot2Ddoc.m`: plots the doctored data for Mexico (since the doctored data sample is country-specific);

`suptitle2.m`: places a common title for all subplots presenting the raw or doctored data for ANY country;

`hpfilter.m`: extracts the Hodrick-Prescott trend and cycle for ANY country.

2.2.2 Computing the Model Likelihood after Picking the Observables

`model_likelihood_mmp9.m`

```
function [ L, PROBLEM1,PROBLEM2,PROBLEM3 ]
= model_likelihood_mmp9(Theta,dy,ny,nx,POLICY,nlp)
```

This function computes the likelihood function of a model described by (Theta,policy) with respect to the dataset `dy` of dimension $T \times Ny$.

`ny`: number of state variables, endogenous predetermined and jump variables as well as shock processes, assumed of AR(1) type.

`dy`: number of observed variables (data) as a subset of the state vector

`nlp`: number of lagged policy instruments (1, in our case) in the state vector y_t.

input:

`dy` = data

`Theta` = vector of parameters (some calibrated)

`ny` = number of endogenous variables

output:

`L` = the `likelihood(dy, Theta)`

2.2.3 Solving the LREM and Writing the Solution in SS Form

`model_likelihood_mmp9.m` further calls:

`model_solve_mmp9.m`: solves the RE model with optimal commitment or discretion policy and writes the solution in SS form;

`doublek.m`: to find the stationary Kalman gain and MSE matrix of a matrix Riccati equation.

2.2.4 List of Named Parameters

`model_solve_mmp9.m:` further calls: [...]

`para_latex_mmp9.m:` creates a matrix of parameter names to be printed in a LaTeX table output; however, more importantly, serves to count the number of parameters in the Theta vector, that is, its length, using `npara = rows(paraname)` (including ALL parameters, those that will be calibrated and those that will be assumed away to simplify, for example, the zero cross-correlations in the reduced-form 3VAR(1) representing the F/RoW economy).

2.2.5 Initialization for the Parameter Vector

`mh_init0.mat:` was used by MPP9, and has 38 parameters (vector length of Theta); keeps the same name as in KLL, for smooth integration into the rest of the codes, and therefore needs replacement when one switches from MMP9 (or MMP10, with 40 parameters, in the WP version) to KLL estimation and vice versa.

`mh_init0_kll.mat:` was used by KLL, as `mh_init0.mat`, and has 37 parameters (vector length); it was renamed as `mh_init0_kll.mat`, to distinguish from MMP9, as above (or MMP10, in the WP version); if the KLL codes are run, this `.mat` file has to be renamed back to `mh_init0.mat`, and the MMP9 38 vector needs to be then renamed to `mh_init0_mmp9.mat`.

2.2.6 Convergence Diagnostics

`splitter.m:` allows alternative split of the MH-RW draws to compute the Geweke (1992) chi squared test p-value.

3 How to Change the MATLAB Codes When Estimating Another Country

Say, after estimating for Mexico, we next want to estimate the SAME model (set of codes) for Colombia. Then the main program

`mex_est_qifspq_099_044_005_mh025_rng0twister_Gpv05_mmp9.m`

should be saved as

`col_est_qifspq_099_029_005_mh015_rng3twister_Gpv05_mmp9.m`

where the changes in the name reflect changes in the values of the program parameters captured by the bits between the lower-bars.

Starting from compiling and transforming appropriately the Excel data and then through the sequence of embedded functions called by the main program, one would have to check and change, as follows.

1. `\data\mexdata_qifspq.xlsx` → `\data\coldata_qifspq.xlsx;`

2. `mex_datadoc_qifspq.m` → `col_datadoc_qifspq.m;`

3. `mex_multiplot2Ddoc.m` → `col_multiplot2Ddoc.m;`

4. The indication of the estimated sample in the above two files should correspond to the commands defining the sample in the main program;

5. `genTheta_mex099_044_005.m` → `genTheta_col099_029_005.m.`

In practice, once a tested program, say for Mexico, is opened in MATLAB, and then saved for another country, say Colombia, all ingredients of its file name should be correspondingly changed using "Save As", that is:

`mex_est_qifspq_099_044_005_mh025_rng0twister_Gpv05_mmp9.m`
becomes
`col_est_qifspq_099_029_005_mh015_rng3twister_Gpv05_mmp9.m`

which is implemented quickly by "Find/Replace" using the following steps (tick the box of "Match case"):

1. Find what: `mex_` Replace with: `col_`

2. Find what: `_mex` Replace with: `_col` (5 occasions, of which 3 effective; this affects the `genTheta_mex099....m` file, converting it to `genTheta_col099....m`)

3. Find what: `mex` Replace with: `col` (this is a single but important replacement in the code, as it affects the dataset that is called: `[data,datadate,raw] = xlsread('data/mexdata_qifspq.xlsx');` becomes `[data,datadate,raw] = xlsread('data/coldata_qifspq.xlsx');`

4. Find what: `MEX` Replace with: `COL` (4 occasions: in the naming of the LaTeX tables printed out as output with the estimation results and diagnostics)

5. Find what: `Mexican` Replace with: `Colombian` (a single occasion)

6. Find what: `Mexico` Replace with: `Colombia`

7. Find what: `_044` Replace with: `_029` (this is the country-specific share of imports of goods and services in consumption calculated as sample average)

8. Find what: `_mh025` Replace with: `_mh015` (this is the MH-scale parameter that tunes the acceptance rate) *and do not forget* to enter as well this change in the program, (about) line 74: `mh_scale = 0.25 -> mh_scale = 0.15;`

9. Find what: `rng0twister` Replace with: `rng3twister` (this is the pseudo-random number generator seed (`0->3`) and function `Mersenne twister` (kept the same) *and do not forget* to enter as well this change *twice* in the program, (about) lines 92 and 104: `rng0twister -> rng3twister;`

10. Next come *two amendments* in the program, that *copy/paste and replace*:

    (a) the two lines determining the sample, (about) lines 114-115, `sampldate = 1999` and `startdate = 2003` (in fact, all LAIT countries have the same `sampldate = 1999`, so only `startdate = ????` could be adjusted to the respective country-specific values);

    (b) the country-specific value of the share of import in consumption entered as a calibrated parameter in the mean of the prior, (about) line 153: 0.4432335207 -> 0.2893647135.

4 How to Change the MATLAB Codes When Estimating Alternative Model Versions

Change in a model-specific – but not country-specific – way (appending an extension that identifies a particular model version, here below the original KLL):

1. `para_latex_kll.m;`
2. `model_solve_kll.m;`
3. `model_likelihood_kll.m.`

Then change in a country-specific way:

1. `genTheta_mex099_044_kll.m;`
2. `mex_est_qifspq_099_044_005_mh025_rng0twister_kll.m`

When moving from model version $\mu_q > 0$ to model version $\mu_q = 0$ ONLY the latter two changes need to be made, and the corresponding files saved with appropriate names, e.g., country-specific changes reflected in two files:

1. `genTheta_mex099_044_kll_muq0.m;`
2. `mex_est_qifspq_099_044_005_mh025_rng0twister_kll_muq0.m`

Finally, repeat the steps in the preceding section, by checking and changing (Find/Replace is helpful) all ingredients of the program identified by the lower-bar separated bits in its (long) name.