

Overview and Organization of the LINVER Package

June 2022

Overview

The LINVER package is a self-contained set of programs, equation code, and documentation for running stochastic simulations of a linearized version of the FRB/US model subject to an effective lower bound (ELB) on nominal interest rates, if desired. Users can choose among a range of options for running the simulations, including how agents in different sectors of the economy form their expectations, the monetary policy rule, the neutral level of the federal funds rate, whether threshold conditions are imposed on the timing of liftoff from the ELB, and the sampling procedure used to generate random shocks to the economy that are consistent with historical experience.

Users have the option of running stochastic simulations using three different software languages—Matlab, Octave and EViews—with the proviso that the capabilities of the EViews routines are much more limited than the other two.¹ To this end, the LINVER package is organized into separate, self-contained Matlab, Octave, and EViews directories of programs and other files. Users should be aware that the full range of stochastic simulation routines run appreciably faster in Matlab than they do in Octave.

Users who wish to run stochastic simulations using the programs and files in one of the three directories are assumed to have some familiarity with the programming environment of the relevant software language. In the case of the Matlab and Octave routines, users should also have some familiarity with the Dynare software package, which is called to compute the reduced-form “decision rule” representation of the specific version of the LINVER model to be simulated. Information on Dynare, including the user manual and the Dynare code that needs to be downloaded prior to running stochastic simulations in Matlab and Octave, is available at www.dynare.org.

Prior to running stochastic simulations in either Matlab or Octave, users should review the *User’s Manual*. Among other things, the manual provides an overview of the solution methodology used for these software languages as well as a comprehensive listing of the many simulation options available to users. Users are also encouraged to read the background paper which documents the properties and capabilities of LINVER, and in addition reports results from stochastic simulations run under different assumption for agents’ expectations, monetary policy, and the neutral federal funds rate. This background paper is available at www.federalreserve.gov/econres/feds/linver-the-linear-version-of-frbus.htm. The text file *linver_variable_definitions* lists the model’s variables and their definitions. Finally, users interested in the structure and properties of the nonlinear FRB/US model from which LINVER is derived should consult the material posted on the Federal Reserve Board’s website at www.federalreserve.gov/econres/us-models-about.htm.

¹ In stochastic simulations run using the EViews programs, all agents are assumed to base their expectations for future economic conditions on forecasts derived from small-scale VAR models. In the case of the Matlab and Octave programs, however, some or all agents can have expectations that are model consistent (that is, based on the predictions of LINVER itself).

Organization of the MATLAB directory

To run stochastic simulations using the programs and files in this directory, users must have access to Matlab and its statistics and machine learning toolbox and its optimization toolbox. In addition, users must download the Dynare package and in Matlab set the path to the directory in which the Dynare routines are stored. Finally, users should review the *User's Manual*, which provides a comprehensive list of the available simulation options.

Users run stochastic simulations by executing the script *stochsims*. In the top portion of the script, users must select the expectational version of the model, the monetary policy rule, and whether the ELB will be imposed on the actual federal funds rate and its future path as expected by agents with model-consistent expectations. If the ELB is imposed, users must also set the lower limit on the nominal federal funds rate in simulations.² Users also have the option of overriding the default settings of various other simulation assumptions; see the *User's Manual* for details.

The lower portion of *stochsims* calls a sequence of programs to run the actual stochastic simulations, as follows:

1. *make_parameters* — a script that verifies that the user-supplied simulation parameters are valid, and then sets the remaining unspecified parameters to their default settings.
2. *make_runmod* — a script that constructs the specific version of the model to be simulated and then calls Dynare to compute its VAR representation.
3. *make_matrices* — a script that retrieves the Dynare-generated VAR-representation matrices and namelists, and then constructs additional matrices and other information needed to run stochastic simulations of the linear model subject to the ELB, thresholds, and any other nonlinear constraints if imposed by the user.
4. *make_shocks* — a script that retrieves the historical residuals of the FRB/US behavioral equations from a text file and then randomly samples from this historical set to generate the matrix of shocks that are applied in the stochastic simulations.
5. *stochloop* — a script that simulates N1 separate stochastic paths for the economy, each of N2 length, where N1 and N2 are user-selected parameters. In these simulations, the ELB and any other nonlinear constraints on the expected future path of the federal funds rate are imposed by applying current and anticipated future shocks to the federal funds rate as necessary. These latter shocks are computed by calling the script *addscalc* if no threshold conditions for unemployment and/or inflation must be satisfied prior to liftoff from the ELB. If the user instead chooses to impose threshold conditions for liftoff, then the script *addscalc_thresh* is called.
6. *summarize_results* — a script that provides summary information on the stochastic simulation results and, if desired, saves the results.

² Because the baseline paths of all variables in LINVER are zero, the lower limit on the nominal federal funds rate in simulations implicitly equals the negative of the real-world value of the neutral nominal interest rate if the real-world lower limit on the nominal federal funds rate is zero.

The Matlab directory also contains four text files that serve as inputs to the simulation programs. These files contain the equations and other model information that define the expectational versions of the model provided for users, as follows:

- *expvers_mceall* — all agents have model-consistent (MC) expectations
- *expvers_var* — all agents have expectations based on the predictions of small-scale VAR models
- *expvers_mcap* — financial market participants have MC expectations while agents in other sectors have VAR-based expectations
- *expvers_mcapwp* — financial market participants and wage and price setters have MC expectations while other agents have VAR-based expectations

Finally, this directory contains the *hist_residuals* text file of historical residuals of the main FRB/US behavioral equations from 1970Q1 to 2019Q4. In addition, the file includes a series that indexes whether the economy was in one of the seven recessions that occurred during this period. This recession index is used by the default state-contingent sampling procedure to generate random shocks but is ignored by the other available sampling options.

Organization of the OCTAVE directory

The instructions for running stochastic simulations with Octave are largely the same as those for Matlab, as described in the previous section and in the *User's Manual*, including the need to download the Dynare package and in Octave set the path to the directory in which the Dynare code is stored. Differences between the Octave and Matlab implementations are minor. The names of many of the Octave files have an "_octave" suffix to avoid confusion. Thus, users run stochastic simulations by executing the script *stochsims_octave*. Unlike Matlab, the Octave code does not require any toolboxes. In addition, Dynare's design is such that each of its versions is compatible with only a single specific version of Octave. For example, Dynare 5.0 requires Octave 6.4, while Dynare 4.6 requires Octave 5.2. The Octave implementation of LINVER has been tested with these two software combinations. Simulation execution time is slower with Octave than Matlab, with speed differing by a factor of three or four. Because of differences random number generators, the outcomes of Octave and Matlab stochastic experiments with identical designs will differ a bit, though the discrepancies will diminish as the number of stochastic replications increases.

Organization of the EViews directory

To run stochastic simulations with the *stochsims_eviews* program in this directory, users must have access to EViews version 8 or later and install the *read_xml_model* add-in. The *LINVER in EViews* document provides instructions for installing the add-in and information about the options available in the simulation program.

Although agents in LINVER can have expectations of future economic conditions that are either based projections of small-scale VAR models or consistent with the predictions of LINVER itself, only the VAR option is available in the EViews stochastic simulation program. Because EViews cannot access the reduced-form representation of LINVER that the Matlab

and Octave routines use Dynare to construct, EViews solutions of stochastic simulation experiments are impractically slow when agents have model-consistent expectations.