

Replication files for:
“Volatile Hiring: Uncertainty in Search and Matching Models”^{*}

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This document describes how to replicate the numerical results in the article “Volatile Hiring: Uncertainty in Search and Matching Models.” The accompanying replication codes can be downloaded under [this link](#).¹ The folder structure there and the sections in this document match in an obvious way, hence we do not always indicate the full path for every file we refer to.

Any references to figures or sections that are not preceded by a capital letter refer to the main article, whereas those that are refer to the online appendix.

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¹Please note that these replication codes were written for Matlab 2019b and Dynare 4.4.3. Compatibility with different versions, notably Dynare 4.6 and above, is not guaranteed.

I Benchmark search-and-matching model (Section 3)

As described in the main text, the policy functions of the benchmark search-and-matching model with stochastic volatility are approximated using higher-order perturbation methods, relying on the Dynare package for Matlab ([Adjemian et al. \(2018\)](#)). The master file is `main_SaMBaseline.m`. In this file, the user specifies the main settings, including structural parameter values. This file calls the Dynare mod file `dynareSaMBaseline.mod` and plots the relevant IRFs.² Here and elsewhere, structural parameters and steady-state values are stored in the structure `sPar`. Generic, design-related settings are stored in the structure `sSettings`.

To elaborate, the model equations are in `dynareSaMBaseline.mod`, with an exact solution for the deterministic steady-state passed on through `dynareSaMBaseline_steadystate.m`. The IRF computations are likewise performed in `dynareSaMBaseline.mod`. In particular, pure uncertainty shocks are computed using a manual, simulations-based approach that involves the following three main steps: (i.) compute the ergodic mean in the absence of shocks (EMAS) by simulating the economy using the policy functions provided by Dynare, starting at the deterministic steady-state, and taking the first point after the burn-in period (during which the economy transitions to the EMAS); (ii.) simulate with an added innovation to the volatility of productivity shocks after the burn-in period; (iii.) compute the IRF as the deviation of variables in that simulation with added innovation from the EMAS.³ On the other hand, 'traditional' GIRFs are computed using the package provided by [Andreasen et al. \(2018\)](#). Note that the resulting "total volatility" IRFs – which represent the agents' rational expectations for the path of variables in the period in which the shock hits – could *also* be obtained by explicitly including in the mod file the expectations for the variables in question.⁴

Exact replication of figures in the paper.

Figure 1. In `dynareSaMBaseline.mod`, set `@#defineOptionWNash=1` (line 20). In `main_SaMBaseline.m`, set `sPar.alpha=0.5` (line 37). Then run `main_SaMBaseline.m`. To also get the formatting exactly right, adjust the vertical axis limits for subplots 4 and 6, respectively, by commenting in and out the prepared specifications in lines 210-212 and 237-238.

Figure 2. In `dynareSaMBaseline.mod`, set `@#defineOptionWNash=0` (line 20). In `main_SaMBaseline.m`, set `sPar.alpha=0.5`. Then run `main_SaMBaseline.m`. To also get the formatting exactly right, adjust the vertical axis limits for subplots 4 and 6, respectively, by commenting in

² Notice that section `Manualplotting` of the code pre-selects the variables to be plotted. Commented out at the bottom is an alternative approach that allows the user to select which variables they want to be shown.

³For further descriptions, also see [Born and Pfeifer \(2014\)](#) and [this blog post](#). I have benefited from Johannes Pfeifer's extensive and excellent collection of replication codes, notably his [implementation](#) of [Basu and Bundick \(2017\)](#).

⁴Please email for further details.

and out the prepared specifications in lines 210-212 and 237-238.

Figure 3. In `dynareSaMBaseline.mod`, set `@#defineOptionWNash=0` (line 20). In `main_SaMBaseline.m`, set `sPar.alpha=0.2`. Then run `main_SaMBaseline.m`. To also get the formatting exactly right, adjust the vertical axis limits for subplots 4 and 6, respectively, by commenting in and out the prepared specifications in lines 210-212 and 237-238.

II Alternative search-and-matching model (Section 4)

Conveniently, our proposed search-and-matching model with a finite mass of entrepreneurs that are heterogeneous in terms of their idiosyncratic productivity levels can still be solved using perturbation methods. The folder `Master_Baseline` provides all codes needed to solve the model and plot the IRFs for an uncertainty shock. The master file is `main_SaMOptionValue.m` and the Dynare file is `dynareSAMOptionValue.mod`.

The Dynare implementation is a straightforward extension of the code for the standard search-and-matching model, the primary modifications being as follows: The free-entry condition is replaced by an indifference condition; the value of an unmatched entrepreneur is not necessarily zero but positive in steady state and time-varying in the presence of aggregate uncertainty; the match value (i.e., the value of an entrepreneur) is affected by idiosyncratic productivity; and we have an additional equation for vacancy creation as a function of the entry probability of unmatched entrepreneurs. Notice, furthermore, that given our assumption of a uniform distribution, the entry probability, p , and the conditional expected value of a productivity draw, a^* , are straightforward to characterize analytically.⁵

The computation of the steady state now required solving for the cutoff productivity level and the hiring rate using the indifference equation. This step is implemented in the auxiliary function `fn_Cutoff`. The master file includes an option, `optionRecalibration`, for the user to specify whether or not the recommended recalibration procedure described in Section 4.2 is implemented. If it is not, then the steady state will not match the targeted calibration moments, such as the unemployment rate. The recalibration procedure ensures not only that this is the case, but also picks the strike value χ and worker bargaining power ω such that the steady-state elasticity of labor market tightness matches a targeted value (i.e., the same one used to calibrate the standard model). The auxiliary function `fn_omega_chi.m` serves this function, and it in turn calls the function `fn_Elasticity`. The uniform distribution assumption for idiosyncratic productivity draws makes it possible to solve for that elasticity using Matlab's symbolic toolbox. For users without access to that toolbox, we provide an alternative solution relying on a numerical approximation (`fn_Elasticity_Numerical`).⁶

To characterize some of the model properties – both in steady state and after hitting the economy with a shock – it proved interesting to loop over a range of values for the standard deviation of idiosyncratic productivity, σ_a . The folder `Master_VersionWithLoops`, and in particular the file `main_SaMOptionValue_WithLoop.m`, therefore provides an extension of the baseline code which makes it easy to store and plot outcomes as a function of σ_a . For the user, the primary choices

⁵As described below, it is also possible without much difficulty to use a normal distribution instead.

⁶To use this option, replace calls of `fn_Elasticity` with calls of `fn_Elasticity_Numerical`.

relate to the parameters `sigma_a_num`, `sigma_a_low` and `sigma_a_high`, which together specify the range of σ_a over which the loop is run. The code automatically plots the impact effect of an uncertainty shock on selected variables, but additional results (such as steady-state values or the steady-state elasticity of labor market tightness with respect to aggregate productivity) can be accessed via the structure `sResults`.

Exact replication of figures in the paper.

Figure 4. In folder `Figure_Loop_ComparisonToNash`, run `plot_SaM_OptionValue_CrossSectionalDispersionProperties.m`. The file uses pre-computed inputs `resultsOptionValue_p05_NoRecalib_sigmaa0To001_Fine.mat` and `resultsOptionValue_p05_NoRecalib_sigmaa00005To001_FixedH_Fine.mat` (again, these are provided already), which were obtained using the master version allowing for loops. Notice that to keep the hiring rate fixed, comment out line 123 and comment in line 124 in the Dynare file `dynareSAMOptionValue.mod`.

Figure 5. In folder `Master_Baseline`, run `main_SaMOptionValue.m` for `optionRecalibration='yes'` and `sPar.sigma_a=0.001`.

Figure 6. In folder `Figure_Loop_ComparisonToNash`, run `plot_SaMOptionValue_LoopFigureWithNash.m`. Again, we draw on pre-computed inputs using the Dynare implementations contained in the folders `Main_Section4_NewModel\Master_VersionWithLoops` and `Main_Section3_BaselineModel`.

III Online appendices

Risk aversion

There are two different main codes relevant to this section. The file `main_SaM_RiskAversion.m` is structured similar to the ones already discussed in the context of the canonical SaM model; it sets various options (e.g., structural parameter values), calls a Dynare file (`dynareSaM_riskAversion.mod`), and plots the IRFs for a single model. The user can choose which variables to show.

The figures used in the paper often display IRFs from multiple different models. The file `plot_SaM_RiskAversion.m` may be used to this end. Its code relies on having previously run `main_SaM_RiskAversion.m` several times; this has already been done for the reader, so that the replication package comes with all the relevant inputs (stored in `Output\IRFs`).

Exact replication of figures in the paper.

Figure OB .1. In `plot_SaM_RiskAversion.m`, set `figureName` as `'fig_SaM_RiskAversion_WageLin'` and run. The two input IRFs are generated by running `main_SaM_RiskAversion.m` given a linear wage – which the user can select in `dynareSaM_riskAversion.mod` by setting `@#defineOptionWNash=1` – with either a linear equity pricing equation, equivalent to setting `sPar.xi=0` (line 44) or log utility, using `sPar.xi=1`.

Figure OB .2. In `plot_SaM_RiskAversion.m`, set `figureName` as `'fig_SaM_RiskAversion_WageComparison'` and run. There are four input IRFs (see lines 57-72), each generated using `main_SaM_RiskAversion.m` and assuming log utility. `IRFs_LogU_WageLin_Baseline` is the case with a linear wage rule; `IRFs_LogU_WageNash_Baseline` is the case with a standard Nash-bargained wage; `IRFs_LogU_WageNash_RiskNeutralWage` requires setting both `@#defineOptionNashSDFConstant=1` and `@#defineOptionNashMUConstant=1` in the Dynare file `dynareSaM_riskAversion.mod`; finally, `IRFs_LogU_WageNash_MUConstantInNash` only has `@#defineOptionNashMUConstant=1` but `@#defineOptionNashSDFConstant=0`.

A two-period model with heterogeneity

All figures relating to the two-period model are created using straightforward computations, hence no further documentation is provided beyond the comments in the Matlab codes. All the figures essentially rely on the same steps, but separate codes are provided, because the positioning of various annotations is specific to each figure.

Exact replication of figures in the paper.

Figure OC .1a. Run `main_2Period_ValueOfWaiting_FixedHiring.m`

Figure OC .1b. Run `main_2Period_Cutoff_FixedHiring.m`

Figure OC .1c. Run `main_2Period_ValueOfWaiting_VariableHiring.m`

Figure OC .1d. Run `main_2Period_ValueOfWaiting_VariableHiring.m`

Robustness exercises

Stochastic vs. non-stochastic hiring specification

As described in Footnote OD.2, implementing the non-stochastic instead of the baseline, stochastic hiring specification requires adjustments to both the dynamic and the steady state equations. This replication code folder therefore includes suitably adjusted versions of the Dynare files, functions used in the recalibration, etc. The main file, `mainSaMOptionValue.m`, is structured analogous to the master code and can be used to solve the model once and compute IRFs or, instead, run a loop over different values of σ_a .

Exact replication of figures in the paper.

Figures OD.1a and OD.1b. The code for this figure is stored together with the other codes for the two-period version. The relevant file is `main_2Period_ValueOfWaiting_VariableHiring.m`.

Figure OD.1c. `plotting_SaMWithOptionValue_NonStochasticHiring.m` calls on results created using both the standard/master code and the adjusted version. They are stored in the folder Inputs.

Different degree of cross-sectional dispersion

This figure is straightforward to create, just as Figure ??, that is, using the master code.

Exact replication of figures in the paper.

Figure OD.3. In folder Master_Baseline, run `main_SaMOptionValue.m` for `optionRecalibration='yes'` and `sPar.sigma_a=0.003`.

Normal distribution

Assuming a normal instead of a uniform distribution for idiosyncratic productivity implies two main changes in terms of the numerical implementation. First, we draw on Matlab's internal `normcdf` function to compute the entry probability instead of being able to rely on analytical expressions. This affects both the steady state computation and the expressions used in the Dynare file. Second, in our recalibration procedure, we now need to compute the elasticity of labor market tightness with respect to aggregate productivity numerically (see file `fnElasticity.m`). This replication code folder therefore includes suitably adjusted versions of the Dynare files, functions used in the recalibration, etc. The master code is `main_SaMOptionValue_Normal.m`.

Exact replication of figures in the paper.

Figure OD.2. `plot_SaMOptionValue_Normal.m` calls on results created using the master code, and stored in the folder `Inputs`. In particular, the standard IRFs are computed given $\sigma_a = 0.001$ and using either a normal distribution for a (using the master code in this folder) or the uniform specification (using the baseline code).

Different steady-state entry probability

Changing the targeted steady-state entry probability can simply be done in the master code.

Exact replication of figures in the paper.

Figure OD.4. `plot_SaMWithOptionValue_LowerEntryProbability.m` calls on results created using the master code, and stored in the folder `Inputs`. In particular, the standard IRFs are computed given $\sigma_a = 0.001$ and targeting a steady-state entry probability of either 0.2 or 0.5. Throughout, the recalibration procedure is employed.

References for documentation

- Adjemian, S., Bastani, H., Juillard, M., Karamé, F., Maih, J., Mihoubi, F., Perendia, G., Pfeifer, J., Ratto, M., and Villemot, S. (2018). Dynare: Reference Manual Version 4. Technical Report 1, CEPREMAP.
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- Basu, S. and Bundick, B. (2017). Uncertainty Shocks in a Model of Effective Demand. *Econometrica*, **85**(3), 937–958.
- Born, B. and Pfeifer, J. (2014). Risk Matters: The Real Effects of Volatility Shocks: Comment. *American Economic Review*, **104**(12), 4231–4239.