# FF_VFI_AZ_LOOP Savings Loop Grid Examples

**back to Fan's Intro Math for Econ, Matlab Examples, or Dynamic Asset Repositories**

This is the example vignette for function: **ff_vfi_az_loop** from the **MEconTools Package.** This function solves the dynamic programming problem for a (a,z) model. Households can save a, and face AR(1) shock z. The problem is solved over the infinite horizon.

This is the **looped** code, it is slow for larger state-space problems. The code uses **common grid**, with the same state space and choice space grids.

**Links to Other Code:**

Core Savings/Borrowing Dynamic Programming Solution Functions that are functions in the **MEconTools Package.** :

- Common Choice and States Grid ***Loop***: **ff_vfi_az_loop**
- Common Choice and States Grid ***Vectorized***: **ff_vfi_az_vec**
- States Grid + Continuous Exact Savings as Share of Cash-on-Hand, rely on FOC, ***Loop***: **ff_vfi_az_bisec_loop**
- States Grid + Continuous Exact Savings as Share of Cash-on-Hand, rely on FOC ***Vectorized***: **ff_vfi_az_bisec_vec**
- States Grid + Continuous Exact Savings as Share of Cash-on-Hand, VALUE comparison, ***Loop***: **ff_vfi_az_mzoom_loop**
- States Grid + Continuous Exact Savings as Share of Cash-on-Hand, VALUE comparison, ***Vectorized***: **ff_vfi_az_mzoom_vec**

The sample codes are written for the standard dynamic savings problem. The code can be adapted for multiple assets, savings and borrowing, discrete and continuous choice, etc. A large proportion of dynamic economic models are based on the underlying structure of solving a model with endogenous states and exogenous shocks, and that is what the (a,z) model does. In general, one can write looped code first to make sure the economics is correct, then vectorized code can be adopted to increase speed.

## Test FF_VFI_AZ_LOOP Defaults

Call the function with defaults. By default, shows the asset policy function summary. Model parameters can be changed by the mp_params.

```
%mp_params
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('fl_crra') = 1.5;
mp_params('fl_beta') = 0.94;
% call function
ff_vfi_az_loop(mp_params);
```

```
Elapsed time is 2.378952 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
          i    idx    ndim    numel    rowN    colN     sum       mean      std      coefvari    min    max
```

```
          _    ___    ____    _____    ___    ___    ______    ______    ______    ________    ___    ___
    ap    1     1      2       700      100      7      9855.1    14.079    14.408     1.0234       0      50

xxx TABLE:ap xxxxxxxxxxxxxxxxx
              c1         c2         c3          c4          c5          c6          c7
            _______    _______    _______    _________    _______    _______    _______

    r1            0          0          0     0.045213     0.25576     0.61095     1.0362
    r2            0          0          0     0.045213     0.25576     0.61095     1.0362
    r3            0          0          0     0.045213     0.25576     0.61095     1.0362
    r4            0          0          0      0.06647     0.25576     0.61095     1.0362
    r5            0          0          0      0.06647     0.25576     0.61095      1.164
    r96      43.924     43.924     43.924       43.924      43.924      45.102     45.102
    r97      45.102     45.102     45.102       45.102      45.102      46.298     46.298
    r98      46.298     46.298     46.298       46.298      46.298      47.513     47.513
    r99      47.513     47.513     47.513       47.513      47.513      48.747     48.747
    r100     48.747     48.747     48.747       48.747      48.747          50         50
```

## Test FF_VFI_AZ_BISEC_VEC Speed Tests

Call the function with different a and z grid size, print out speed:

```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_timer') = true;
mp_support('ls_ffcmd') = {};
% A grid 50, shock grid 5:
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 50;
mp_params('it_z_n') = 5;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.715890 seconds.
```

```
% A grid 750, shock grid 15:
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 750;
mp_params('it_z_n') = 15;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 300.576571 seconds.
```

```
% A grid 600, shock grid 45:
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 600;
mp_params('it_z_n') = 45;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 910.111661 seconds.
```

## Test FF_VFI_AZ_LOOP Control Outputs

Run the function first without any outputs, but only the timer.

```
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 50;
mp_params('it_z_n') = 5;
```

```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_timer') = true;
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
mp_support('ls_ffcmd') = {};
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.400105 seconds.
```

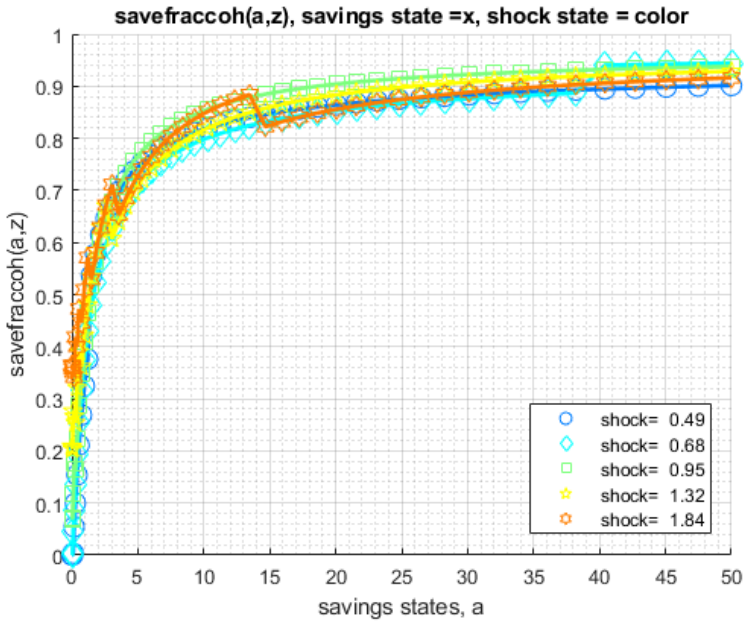
Run the function and show policy function for savings choice. For ls_ffcmd, ls_ffsna, ls_ffgrh, can include these: 'v', 'ap', 'c', 'y', 'coh', 'savefraccoh'. These are value, aprime savings choice, consumption, income, cash on hand, and savings fraction as cash-on-hand.

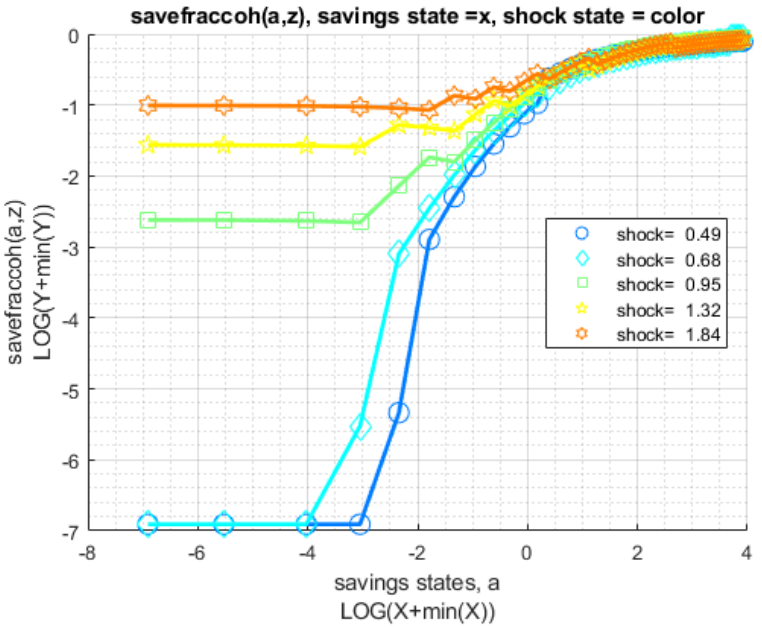
```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
% ls_ffcmd: summary print which outcomes
mp_support('ls_ffcmd') = {};
% ls_ffsna: detail print which outcomes
mp_support('ls_ffsna') = {'savefraccoh'};
% ls_ffgrh: graphical print which outcomes
mp_support('ls_ffgrh') = {'savefraccoh'};
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.410866 seconds.
xxx  ff_vfi_az_vec, outcome=savefraccoh  xxxxxxxxxxxxxxxxxxxxxxxxxx
```

| group | a | mean_z_0_4858 | mean_z_0_67798 | mean_z_0_9462 | mean_z_1_3205 | mean_z_1_8429 |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0.071865 | 0.20862 | 0.36462 |
| 2 | 0.002975 | 0 | 0 | 0.071698 | 0.20827 | 0.36418 |
| 3 | 0.016829 | 0 | 0 | 0.070928 | 0.20666 | 0.36216 |
| 4 | 0.046375 | 0 | 0.0029827 | 0.069341 | 0.20331 | 0.35793 |
| 5 | 0.095198 | 0.0038183 | 0.044243 | 0.11681 | 0.27649 | 0.35114 |
| 6 | 0.1663 | 0.054362 | 0.084837 | 0.17517 | 0.26637 | 0.34171 |
| 7 | 0.26234 | 0.099899 | 0.13609 | 0.16422 | 0.25383 | 0.41847 |
| 8 | 0.38568 | 0.15381 | 0.19428 | 0.22348 | 0.32132 | 0.40047 |
| 9 | 0.53852 | 0.21153 | 0.25554 | 0.28573 | 0.39055 | 0.47258 |
| 10 | 0.72291 | 0.26934 | 0.31659 | 0.34814 | 0.36175 | 0.44538 |
| 11 | 0.94076 | 0.3247 | 0.37504 | 0.40848 | 0.42229 | 0.50941 |
| 12 | 1.1939 | 0.37617 | 0.42941 | 0.46521 | 0.4802 | 0.57087 |
| 13 | 1.484 | 0.53695 | 0.47898 | 0.51743 | 0.5344 | 0.5291 |
| 14 | 1.8128 | 0.57847 | 0.52356 | 0.56473 | 0.58429 | 0.58056 |
| 15 | 2.1817 | 0.61468 | 0.56329 | 0.6071 | 0.62958 | 0.62823 |
| 16 | 2.5924 | 0.6462 | 0.5985 | 0.64475 | 0.67028 | 0.67186 |
| 17 | 3.0463 | 0.67365 | 0.62963 | 0.67804 | 0.60721 | 0.71141 |
| 18 | 3.5449 | 0.69762 | 0.65713 | 0.70737 | 0.6404 | 0.65255 |
| 19 | 4.0894 | 0.71859 | 0.68142 | 0.73318 | 0.67021 | 0.68509 |
| 20 | 4.6813 | 0.73701 | 0.70293 | 0.75587 | 0.6969 | 0.71446 |
| 21 | 5.3218 | 0.75325 | 0.722 | 0.77584 | 0.72078 | 0.74089 |
| 22 | 6.0121 | 0.76763 | 0.73895 | 0.79344 | 0.74211 | 0.76461 |
| 23 | 6.7536 | 0.7804 | 0.75407 | 0.80897 | 0.76119 | 0.78587 |
| 24 | 7.5474 | 0.7918 | 0.76759 | 0.8227 | 0.77824 | 0.80491 |
| 25 | 8.3948 | 0.80201 | 0.77972 | 0.83486 | 0.79351 | 0.82194 |
| 26 | 9.2967 | 0.81119 | 0.79063 | 0.84567 | 0.80719 | 0.83719 |
| 27 | 10.254 | 0.81947 | 0.80049 | 0.8553 | 0.81948 | 0.85083 |
| 28 | 11.269 | 0.82697 | 0.80941 | 0.86389 | 0.83053 | 0.86306 |
| 29 | 12.342 | 0.83379 | 0.81752 | 0.87159 | 0.84048 | 0.87401 |
| 30 | 13.473 | 0.84001 | 0.8249 | 0.87849 | 0.84946 | 0.88384 |
| 31 | 14.665 | 0.84569 | 0.83165 | 0.8847 | 0.85759 | 0.82241 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 32 | 15.918 | 0.8509 | 0.83782 | 0.8903 | 0.86495 | 0.83188 |
| 33 | 17.233 | 0.8557 | 0.8435 | 0.89536 | 0.87163 | 0.84053 |
| 34 | 18.611 | 0.86012 | 0.84872 | 0.89995 | 0.8777 | 0.84844 |
| 35 | 20.053 | 0.86421 | 0.85354 | 0.90411 | 0.88324 | 0.85568 |
| 36 | 21.56 | 0.86799 | 0.858 | 0.9079 | 0.8883 | 0.86231 |
| 37 | 23.133 | 0.87151 | 0.86214 | 0.91136 | 0.89292 | 0.86841 |
| 38 | 24.773 | 0.87479 | 0.86598 | 0.91452 | 0.89716 | 0.87401 |
| 39 | 26.481 | 0.87784 | 0.86955 | 0.91741 | 0.90105 | 0.87917 |
| 40 | 28.258 | 0.8807 | 0.87289 | 0.92007 | 0.90463 | 0.88393 |
| 41 | 30.104 | 0.88337 | 0.87601 | 0.92251 | 0.90793 | 0.88833 |
| 42 | 32.021 | 0.88588 | 0.87893 | 0.92475 | 0.91097 | 0.8924 |
| 43 | 34.01 | 0.88824 | 0.88166 | 0.92683 | 0.91378 | 0.89617 |
| 44 | 36.07 | 0.89046 | 0.88423 | 0.92874 | 0.91638 | 0.89966 |
| 45 | 38.204 | 0.89256 | 0.88665 | 0.93052 | 0.91879 | 0.90291 |
| 46 | 40.412 | 0.89453 | 0.9403 | 0.93216 | 0.92102 | 0.90592 |
| 47 | 42.695 | 0.8964 | 0.94141 | 0.93368 | 0.9231 | 0.90873 |
| 48 | 45.053 | 0.89817 | 0.94245 | 0.9351 | 0.92504 | 0.91135 |
| 49 | 47.488 | 0.89985 | 0.94341 | 0.93642 | 0.92684 | 0.9138 |
| 50 | 50 | 0.90144 | 0.9443 | 0.93765 | 0.92853 | 0.91608 |



Run the function and show summaries for savings and fraction of coh saved:

```
mp_params('it_a_n') = 100;
mp_params('it_z_n') = 9;
mp_support('ls_ffcmd') = {'ap', 'savefraccoh'};
mp_support('ls_ffsna') = {};
mp_support('ls_ffgrh') = {};
mp_support('bl_vfi_store_all') = true; % store c(a,z), y(a,z)
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 3.281815 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ap** | 1 | 1 | 2 | 900 | 100 | 9 | 12904 | 14.338 | 14.524 | 1.013 | 0 |
| **savefraccoh** | 2 | 2 | 2 | 900 | 100 | 9 | 619.51 | 0.68834 | 0.26953 | 0.39157 | 0 |

xxx TABLE:ap xxxxxxxxxxxxxxxxxx

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 | c9 |
|---|---|---|---|---|---|---|---|---|---|
| **r1** | 0 | 0 | 0 | 0 | 0.092813 | 0.25576 | 0.61095 | 1.0362 | 1.6023 |
| **r2** | 0 | 0 | 0 | 0 | 0.092813 | 0.25576 | 0.61095 | 1.0362 | 1.6023 |
| **r3** | 0 | 0 | 0 | 0 | 0.092813 | 0.25576 | 0.61095 | 1.0362 | 1.6023 |
| **r4** | 0 | 0 | 0 | 0.00051272 | 0.092813 | 0.25576 | 0.61095 | 1.0362 | 1.6023 |
| **r5** | 0 | 0 | 0 | 0.0029004 | 0.092813 | 0.25576 | 0.61095 | 1.0362 | 1.6023 |
| **r96** | 43.924 | 43.924 | 43.924 | 43.924 | 43.924 | 45.102 | 45.102 | 45.102 | 46.298 |
| **r97** | 45.102 | 45.102 | 45.102 | 45.102 | 45.102 | 46.298 | 46.298 | 46.298 | 47.513 |
| **r98** | 46.298 | 46.298 | 46.298 | 46.298 | 46.298 | 47.513 | 47.513 | 47.513 | 48.747 |
| **r99** | 47.513 | 47.513 | 47.513 | 47.513 | 47.513 | 48.747 | 48.747 | 48.747 | 50 |
| **r100** | 48.747 | 48.747 | 48.747 | 48.747 | 48.747 | 50 | 50 | 50 | 50 |

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 | c9 |
|---|---|---|---|---|---|---|---|---|---|
| **r1** | 0 | 0 | 0 | 0 | 0.070073 | 0.15255 | 0.28789 | 0.38573 | 0.47121 |
| **r2** | 0 | 0 | 0 | 0 | 0.070045 | 0.1525 | 0.28781 | 0.38565 | 0.47114 |
| **r3** | 0 | 0 | 0 | 0 | 0.069914 | 0.15228 | 0.28748 | 0.3853 | 0.4708 |
| **r4** | 0 | 0 | 0 | 0.00048613 | 0.069636 | 0.1518 | 0.28676 | 0.38454 | 0.47007 |
| **r5** | 0 | 0 | 0 | 0.0027273 | 0.069182 | 0.15101 | 0.28559 | 0.38329 | 0.46886 |
| **r96** | 0.92625 | 0.92358 | 0.92022 | 0.916 | 0.91072 | 0.92836 | 0.91992 | 0.90945 | 0.92033 |
| **r97** | 0.92676 | 0.92416 | 0.92088 | 0.91677 | 0.91162 | 0.92918 | 0.92095 | 0.91073 | 0.92169 |
| **r98** | 0.92727 | 0.92473 | 0.92153 | 0.91752 | 0.91249 | 0.92998 | 0.92194 | 0.91196 | 0.923 |
| **r99** | 0.92776 | 0.92528 | 0.92216 | 0.91824 | 0.91333 | 0.93076 | 0.92291 | 0.91315 | 0.92426 |
| **r100** | 0.92823 | 0.92581 | 0.92277 | 0.91895 | 0.91416 | 0.93151 | 0.92384 | 0.91431 | 0.90252 |

## Test FF_VFI_AZ_LOOP Change Interest Rate and Discount

Show only save fraction of cash on hand:

```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
mp_support('ls_ffcmd') = {'savefraccoh'};
```

```
mp_support('ls_ffsna') = {};
mp_support('ls_ffgrh') = {};
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 100;
mp_params('it_z_n') = 7;
mp_params('fl_a_max') = 50;
mp_params('st_grid_type') = 'grid_powerspace';
```

Solve the model with several different interest rates and discount factor:

```
% Lower Savings Incentives
mp_params('fl_beta') = 0.80;
mp_params('fl_r') = 0.01;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.825240 seconds.
---------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
                  i    idx    ndim    numel    rowN    colN    sum      mean      std      coefvari    min      m
                  _    ___    ____    _____    ____    ____    _____    ______    _____    ________    ___    ___

    savefraccoh   1    1      2       700      100     7       357.49   0.5107    0.2755   0.53945     0      0.8

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
             c1         c2         c3         c4         c5          c6          c7
          _______    _______    _______    _______    _______    _________    ________

    r1          0          0          0          0          0     0.0002246    0.041573
    r2          0          0          0          0          0    0.00022455    0.041566
    r3          0          0          0          0          0     0.0012689    0.041533
    r4          0          0          0          0          0      0.001266    0.041462
    r5          0          0          0          0          0     0.0034759    0.041345
    r96   0.78455    0.78145    0.79995    0.79456     0.7876       0.77865     0.76719
    r97   0.78669    0.78366    0.77972    0.79679    0.78998       0.78122     0.77001
    r98   0.78878    0.78582    0.78197    0.79897    0.79231       0.78374     0.77276
    r99   0.79084    0.78794    0.78417    0.77927    0.79459        0.7862     0.77545
    r100  0.79285    0.79001    0.78633    0.78154    0.79682        0.7886     0.77808
```

```
% Higher Savings Incentives
mp_params('fl_beta') = 0.95;
mp_params('fl_r') = 0.04;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 2.386791 seconds.
---------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
                  i    idx    ndim    numel    rowN    colN    sum      mean       std      coefvari    min
                  _    ___    ____    _____    ____    ____    _____    _______    _____    ________    ___

    savefraccoh   1    1      2       700      100     7       479.94   0.68563    0.27152  0.39602     0

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
             c1         c2          c3          c4          c5          c6          c7
          _______    _______    _________    ________    _______    _______    _______

    r1          0          0            0     0.07007    0.17967    0.30874    0.43404
    r2          0          0            0    0.070042    0.17961    0.30866    0.43396
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **r3** | 0 | 0 | 0 | 0.069911 | 0.17935 | 0.30833 | 0.4336 |
| **r4** | 0 | 0 | 0 | 0.069633 | 0.17881 | 0.30762 | 0.43284 |
| **r5** | 0 | 0 | 0.00049972 | 0.069179 | 0.17792 | 0.30645 | 0.43158 |
| **r96** | 0.92489 | 0.92134 | 0.91672 | 0.91072 | 0.92717 | 0.91691 | 0.92776 |
| **r97** | 0.92544 | 0.92198 | 0.91747 | 0.91162 | 0.92802 | 0.91801 | 0.92895 |
| **r98** | 0.92598 | 0.9226 | 0.9182 | 0.91249 | 0.92885 | 0.91908 | 0.9301 |
| **r99** | 0.9265 | 0.9232 | 0.91891 | 0.91333 | 0.92965 | 0.92011 | 0.93121 |
| **r100** | 0.927 | 0.92379 | 0.9196 | 0.91416 | 0.93042 | 0.9211 | 0.90914 |

## Test FF_VFI_AZ_LOOP Changing Risk Aversion

Here, again, show fraction of coh saved in summary tabular form, but also show it graphically.

```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
mp_support('ls_ffcmd') = {'savefraccoh'};
mp_support('ls_ffsna') = {};
mp_support('ls_ffgrh') = {'savefraccoh'};
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 100;
mp_params('it_z_n') = 7;
mp_params('fl_a_max') = 50;
mp_params('st_grid_type') = 'grid_powerspace';
```

Solve the model with different risk aversion levels, higher preferences for risk:

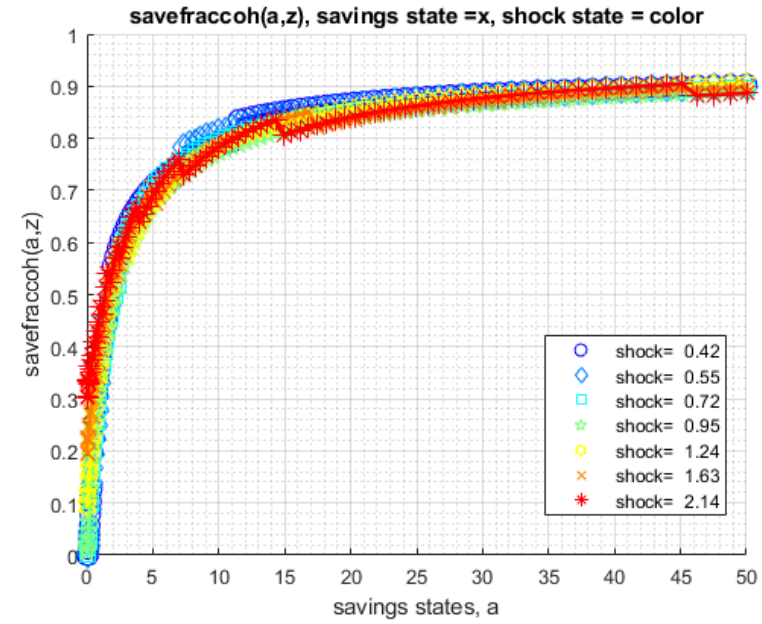
```
% Lower Risk Aversion
mp_params('fl_crra') = 0.5;
ff_vfi_az_loop(mp_params, mp_support);
```

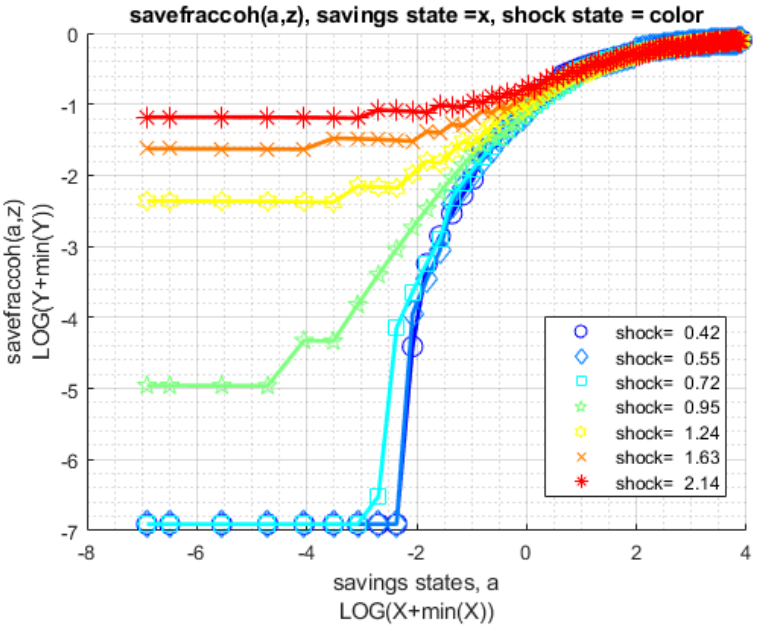
```
Elapsed time is 1.327261 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | _ | ___ | ____ | _____ | ____ | ____ | _____ | _____ | _____ | _____ | ___ | _ |
| **savefraccoh** | 1 | 1 | 2 | 700 | 100 | 7 | 450.35 | 0.64336 | 0.2803 | 0.43568 | 0 | 0. |

```
xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
```

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|---|---|---|---|---|---|---|---|
| | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **r1** | 0 | 0 | 0 | 0.0060341 | 0.093241 | 0.19572 | 0.30604 |
| **r2** | 0 | 0 | 0 | 0.0060316 | 0.093213 | 0.19567 | 0.30599 |
| **r3** | 0 | 0 | 0 | 0.0060204 | 0.09308 | 0.19546 | 0.30574 |
| **r4** | 0 | 0 | 0 | 0.0059964 | 0.092798 | 0.19501 | 0.3052 |
| **r5** | 0 | 0 | 0 | 0.012229 | 0.092335 | 0.19427 | 0.30431 |
| **r96** | 0.90049 | 0.89703 | 0.89253 | 0.88669 | 0.90296 | 0.89297 | 0.90379 |
| **r97** | 0.90128 | 0.89791 | 0.89351 | 0.88781 | 0.90404 | 0.89429 | 0.88181 |
| **r98** | 0.90205 | 0.89876 | 0.89447 | 0.88891 | 0.9051 | 0.89557 | 0.88337 |
| **r99** | 0.9028 | 0.89959 | 0.89541 | 0.88998 | 0.90612 | 0.89681 | 0.88489 |
| **r100** | 0.90354 | 0.9004 | 0.89632 | 0.89101 | 0.90711 | 0.89802 | 0.88636 |




When risk aversion increases, at every state-space point, the household wants to save more.

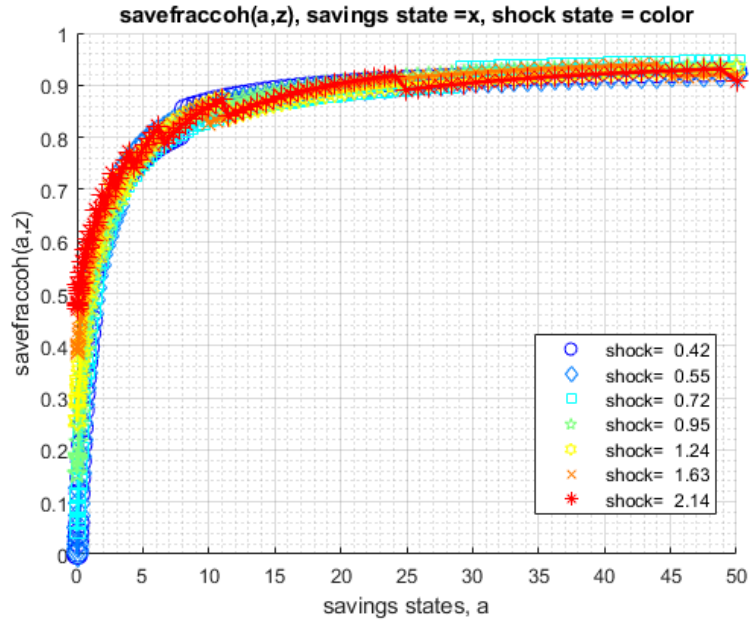
```
% Higher Risk Aversion
mp_params('fl_crra') = 5;
ff_vfi_az_loop(mp_params, mp_support);
```

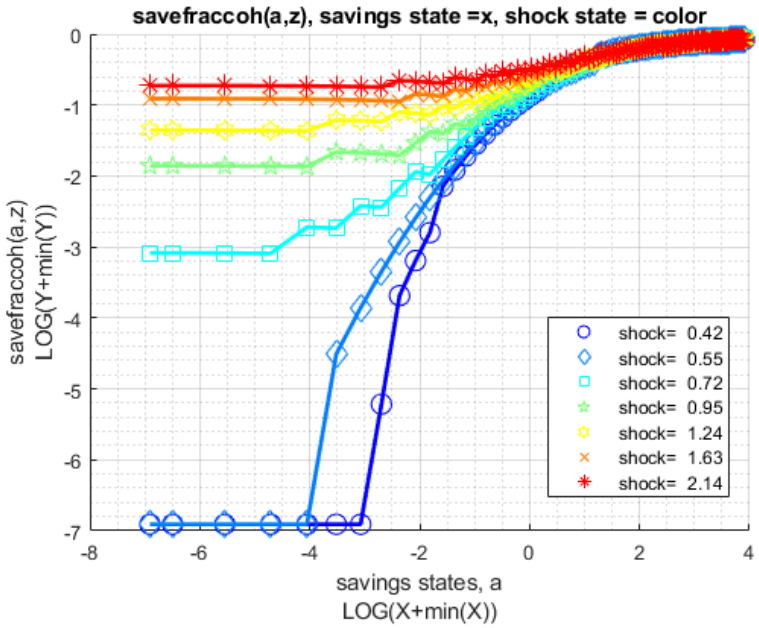
```
Elapsed time is 2.680109 seconds.
---------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
                  i    idx    ndim    numel    rowN    colN     sum       mean       std       coefvari     min
                  _    ___    ____    _____    ____    ____    ______    _______    _______    ________    ___

    savefraccoh   1      1       2      700      100       7     500.59    0.71513    0.25488    0.35641      0
```

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxx

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|---|---|---|---|---|---|---|---|
| r1 | 0 | 0 | 0.044811 | 0.15534 | 0.25694 | 0.40177 | 0.48276 |
| r2 | 0 | 0 | 0.044787 | 0.15528 | 0.25686 | 0.40168 | 0.48268 |
| r3 | 0 | 0 | 0.044678 | 0.15499 | 0.2565 | 0.40124 | 0.48228 |
| r4 | 0 | 0 | 0.044445 | 0.15437 | 0.25572 | 0.40032 | 0.48143 |
| r5 | 0 | 0 | 0.064784 | 0.15337 | 0.25445 | 0.39879 | 0.48003 |
| r96 | 0.92489 | 0.92134 | 0.94129 | 0.93513 | 0.92717 | 0.91691 | 0.92776 |
| r97 | 0.92544 | 0.92198 | 0.9418 | 0.9358 | 0.92802 | 0.91801 | 0.92895 |
| r98 | 0.92598 | 0.9226 | 0.9423 | 0.93644 | 0.92885 | 0.91908 | 0.9301 |
| r99 | 0.9265 | 0.9232 | 0.94278 | 0.93706 | 0.92965 | 0.92011 | 0.93121 |
| r100 | 0.927 | 0.92379 | 0.94324 | 0.93765 | 0.93042 | 0.9211 | 0.90914 |




## Test FF_VFI_AZ_LOOP with Higher Uncertainty

Increase the standard deviation of the Shock.

```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
mp_support('ls_ffcmd') = {'savefraccoh'};
mp_support('ls_ffsna') = {};
mp_support('ls_ffgrh') = {};
mp_params = containers.Map('KeyType','char', 'ValueType','any');
mp_params('it_a_n') = 150;
mp_params('it_z_n') = 15;
mp_params('fl_a_max') = 50;
mp_params('st_grid_type') = 'grid_powerspace';
% graph color spectrum
mp_params('cl_colors') = 'copper';
```

Lower standard deviation of shock:

```
% Lower Risk Aversion
mp_params('fl_shk_std') = 0.10;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 13.492999 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
                  i    idx    ndim    numel    rowN    colN     sum      mean       std      coefvari    min
                  _    ___    ____    _____    ____    ____    ______    _______    _______    ________    ___

    savefraccoh   1     1      2       2250     150      15     1506.3    0.66947    0.28673     0.4283      0
```

```
xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
              c1          c2          c3          c4          c5          c11         c12         c13         c14         c15
            _______     _______     _______     _______     _______     _______     _______     _______     _______     _____

    r1            0           0           0           0           0     0.14061      0.1891     0.24154      0.2699     0.324
    r2            0           0           0           0           0      0.1406     0.18908     0.24152     0.26988     0.324
    r3            0           0           0           0           0     0.14053       0.189     0.24142     0.26977     0.324
    r4            0           0           0           0           0     0.14038     0.18881      0.2412     0.26956     0.324
    r5            0           0           0           0           0     0.14013     0.18851     0.24085      0.2692     0.323
    r146    0.93087     0.92957     0.92815     0.92661     0.92492     0.92712     0.92403     0.92069     0.91706     0.913
    r147    0.93121     0.92994     0.92854     0.92702     0.92537     0.92768     0.92465     0.92135     0.91778     0.913
    r148    0.93156      0.9303     0.92893     0.92743     0.92581     0.92823     0.92525     0.92201     0.91849     0.914
    r149    0.93189     0.93065      0.9293     0.92783     0.92623     0.92878     0.92584     0.92264     0.91918     0.915
    r150    0.93222       0.931     0.92967     0.92823     0.92665      0.9293     0.92641     0.92327     0.91986     0.916
```

Higher shock standard deviation: low shock high asset save more, high shock more asset save less, high shock low asset save more:

```
% Higher Risk Aversion
mp_params('fl_shk_std') = 0.40;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 18.680264 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **savefraccoh** | 1 | 1 | 2 | 2250 | 150 | 15 | 1678.8 | 0.74614 | 0.22779 | 0.30529 | 0 | 0 |

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxx

| | c1 | c2 | c3 | c4 | c5 | c11 | c12 | c13 | c14 | c15 |
|---|---|---|---|---|---|---|---|---|---|---|
| **r1** | 0 | 0 | 0 | 0 | 0 | 0.53612 | 0.59853 | 0.67884 | 0.73891 | 0.776 |
| **r2** | 0 | 0 | 0 | 0 | 0 | 0.53609 | 0.5985 | 0.67882 | 0.73889 | 0.776 |
| **r3** | 0 | 0 | 0 | 0 | 0 | 0.53594 | 0.59839 | 0.67873 | 0.73883 | 0.776 |
| **r4** | 0 | 0 | 0 | 0 | 0 | 0.53563 | 0.59814 | 0.67853 | 0.73868 | 0.776 |
| **r5** | 0 | 0 | 0 | 0 | 0 | 0.53511 | 0.59774 | 0.67821 | 0.73843 | 0.77 |
| **r146** | 0.92696 | 0.9262 | 0.92513 | 0.92359 | 0.92142 | 0.91653 | 0.9078 | 0.88992 | 0.86057 | 0.804 |
| **r147** | 0.92721 | 0.92647 | 0.92541 | 0.9239 | 0.92176 | 0.91741 | 0.90895 | 0.89144 | 0.84828 | 0.793 |
| **r148** | 0.92746 | 0.92673 | 0.92569 | 0.92421 | 0.9221 | 0.91827 | 0.91007 | 0.87813 | 0.83621 | 0.782 |
| **r149** | 0.9277 | 0.92698 | 0.92596 | 0.9245 | 0.92243 | 0.9191 | 0.89605 | 0.86507 | 0.82436 | 0.772 |
| **r150** | 0.92794 | 0.92724 | 0.92623 | 0.9248 | 0.92276 | 0.90467 | 0.88233 | 0.85227 | 0.81273 | 0.762 |