

FF_VFI_AZ_BISEC_LOOP Savings Loop Exact (FOC) 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_bisec_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 **continuous** choices, solved with bisection. The state-space is on a grid, but choice grids are in terms of **percentage of resources** to save and solved exactly.

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](#)

Test FF_VFI_AZ_BISEC_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_bisec_loop(mp_params);
```

Elapsed time is 33.158577 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 | 9863.4 | 14.091 | 14.388 | 1.0211 | 0 | 50.117 |

xxx TABLE:ap xxxxxxxxxxxxxxxxxxxx

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|--|----|----|----|----|----|----|----|
|--|----|----|----|----|----|----|----|

| | | | | | | | |
|------|--------|--------|--------|----------|---------|---------|--------|
| r1 | 0 | 0 | 0 | 0.053491 | 0.25574 | 0.60604 | 1.1157 |
| r2 | 0 | 0 | 0 | 0.053998 | 0.25571 | 0.6066 | 1.1163 |
| r3 | 0 | 0 | 0 | 0.056449 | 0.25576 | 0.60907 | 1.1187 |
| r4 | 0 | 0 | 0 | 0.061799 | 0.26016 | 0.6109 | 1.1239 |
| r5 | 0 | 0 | 0 | 0.066463 | 0.26897 | 0.61141 | 1.1327 |
| r96 | 43.388 | 43.52 | 43.701 | 43.925 | 44.222 | 44.68 | 45.228 |
| r97 | 44.566 | 44.695 | 44.878 | 45.103 | 45.398 | 45.856 | 46.403 |
| r98 | 45.761 | 45.892 | 46.072 | 46.298 | 46.592 | 47.05 | 47.597 |
| r99 | 46.973 | 47.107 | 47.286 | 47.514 | 47.806 | 48.263 | 48.815 |
| r100 | 48.206 | 48.338 | 48.519 | 48.746 | 49.037 | 49.497 | 50.117 |

Test FF_VFI_AZ_BISEC_LOOP Speed Tests

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

```
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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 14.819629 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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 783.169420 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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 1955.142516 seconds.

Test FF_VFI_AZ_BISEC_LOOP Control Outputs

Run the function first without any outputs;

```
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_vec(mp_params, mp_support);
```

Elapsed time is 0.122166 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.

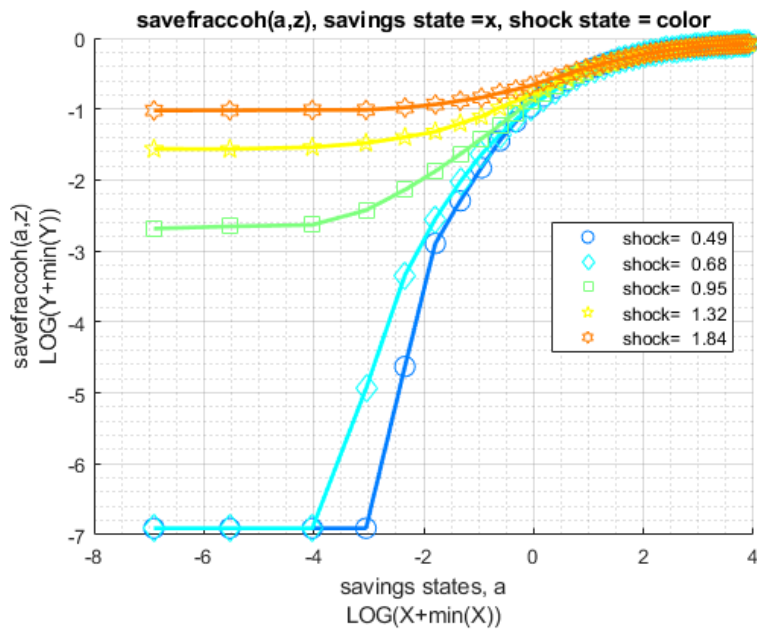
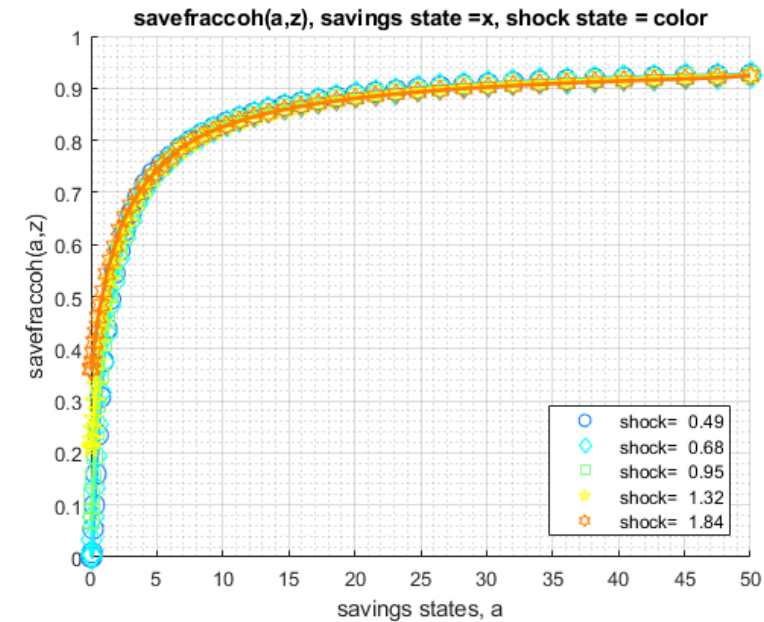
```
mp_support = containers.Map('KeyType','char','ValueType','any');
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
% ls_ffcmd: summary print which outcomes
mp_support('ls_ffcmd') = {};
% ls_ffsna: detail print which outcomes
mp_support('ls_ffsna') = {'savefraccoh'};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

Elapsed time is 20.812511 seconds.

```
xxx ff_vfi_az_vec, outcome=savefraccoh xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

| 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 | 0.067239 | 0.20859 | 0.35953 |
| 2 | 0.002975 | 0 | 0 | 0.069375 | 0.20829 | 0.36032 |
| 3 | 0.016829 | 0 | 0 | 0.070901 | 0.2139 | 0.36215 |
| 4 | 0.046375 | 0 | 0.0061439 | 0.087319 | 0.2266 | 0.36264 |
| 5 | 0.095198 | 0.0087684 | 0.034403 | 0.1168 | 0.2468 | 0.37473 |
| 6 | 0.1663 | 0.054361 | 0.077248 | 0.1522 | 0.26639 | 0.39151 |
| 7 | 0.26234 | 0.099892 | 0.13132 | 0.19388 | 0.29929 | 0.41281 |
| 8 | 0.38568 | 0.15958 | 0.19309 | 0.24112 | 0.33017 | 0.43088 |
| 9 | 0.53852 | 0.23417 | 0.25553 | 0.29215 | 0.37436 | 0.45969 |
| 10 | 0.72291 | 0.3071 | 0.31656 | 0.34812 | 0.41153 | 0.48386 |
| 11 | 0.94076 | 0.37595 | 0.37503 | 0.40842 | 0.44925 | 0.50992 |
| 12 | 1.1939 | 0.43881 | 0.42941 | 0.45755 | 0.48697 | 0.54367 |
| 13 | 1.484 | 0.49509 | 0.48129 | 0.50381 | 0.53262 | 0.56979 |
| 14 | 1.8128 | 0.54489 | 0.53018 | 0.54642 | 0.56778 | 0.59634 |
| 15 | 2.1817 | 0.58871 | 0.57382 | 0.58548 | 0.60055 | 0.6282 |
| 16 | 2.5924 | 0.62716 | 0.61258 | 0.62076 | 0.63101 | 0.65249 |
| 17 | 3.0463 | 0.66079 | 0.64682 | 0.65243 | 0.65884 | 0.6752 |
| 18 | 3.5449 | 0.69027 | 0.67709 | 0.68069 | 0.68423 | 0.69638 |
| 19 | 4.0894 | 0.71621 | 0.70376 | 0.70596 | 0.70724 | 0.71591 |
| 20 | 4.6813 | 0.73703 | 0.72732 | 0.72848 | 0.72799 | 0.73385 |
| 21 | 5.3218 | 0.75326 | 0.74813 | 0.7485 | 0.74673 | 0.75021 |
| 22 | 6.0121 | 0.76913 | 0.76657 | 0.76632 | 0.76364 | 0.76535 |
| 23 | 6.7536 | 0.78536 | 0.78286 | 0.78231 | 0.77889 | 0.7842 |
| 24 | 7.5474 | 0.79983 | 0.79745 | 0.79653 | 0.79269 | 0.79678 |
| 25 | 8.3948 | 0.81271 | 0.81039 | 0.80929 | 0.80514 | 0.80831 |
| 26 | 9.2967 | 0.82418 | 0.82198 | 0.82076 | 0.81637 | 0.81875 |
| 27 | 10.254 | 0.8345 | 0.83242 | 0.83114 | 0.82656 | 0.82833 |
| 28 | 11.269 | 0.84377 | 0.84176 | 0.84042 | 0.83584 | 0.83706 |
| 29 | 12.342 | 0.85214 | 0.85024 | 0.84884 | 0.8442 | 0.84499 |
| 30 | 13.473 | 0.85964 | 0.85781 | 0.85647 | 0.85183 | 0.85232 |
| 31 | 14.665 | 0.86648 | 0.86471 | 0.86337 | 0.85879 | 0.85897 |
| 32 | 15.918 | 0.87264 | 0.87099 | 0.86965 | 0.86507 | 0.86507 |
| 33 | 17.233 | 0.87826 | 0.87667 | 0.87533 | 0.87161 | 0.87063 |
| 34 | 18.611 | 0.88338 | 0.88186 | 0.88052 | 0.87771 | 0.87582 |
| 35 | 20.053 | 0.88802 | 0.88656 | 0.88528 | 0.88326 | 0.88052 |
| 36 | 21.56 | 0.8923 | 0.89089 | 0.88967 | 0.88833 | 0.88485 |

| | | | | | | |
|----|--------|---------|---------|---------|---------|---------|
| 37 | 23.133 | 0.89614 | 0.89486 | 0.89364 | 0.8926 | 0.88888 |
| 38 | 24.773 | 0.89974 | 0.89852 | 0.8973 | 0.89626 | 0.8926 |
| 39 | 26.481 | 0.90304 | 0.90182 | 0.90072 | 0.89968 | 0.89608 |
| 40 | 28.258 | 0.90603 | 0.90493 | 0.90383 | 0.90279 | 0.89925 |
| 41 | 30.104 | 0.90884 | 0.90774 | 0.9067 | 0.90572 | 0.90218 |
| 42 | 32.021 | 0.9114 | 0.91036 | 0.90932 | 0.90841 | 0.90493 |
| 43 | 34.01 | 0.91378 | 0.9128 | 0.91183 | 0.91091 | 0.90749 |
| 44 | 36.07 | 0.91598 | 0.91506 | 0.91408 | 0.91317 | 0.90987 |
| 45 | 38.204 | 0.91805 | 0.91714 | 0.91622 | 0.91537 | 0.91207 |
| 46 | 40.412 | 0.91994 | 0.91909 | 0.91817 | 0.91732 | 0.91415 |
| 47 | 42.695 | 0.92171 | 0.92086 | 0.92001 | 0.91921 | 0.9161 |
| 48 | 45.053 | 0.92336 | 0.92257 | 0.92171 | 0.92092 | 0.91799 |
| 49 | 47.488 | 0.92489 | 0.92409 | 0.92336 | 0.92257 | 0.92025 |
| 50 | 50 | 0.92629 | 0.92562 | 0.92489 | 0.92428 | 0.92403 |



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_bisec_loop(mp_params, mp_support);

```

Elapsed time is 57.010652 seconds.

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CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min |
|-------------|---|-----|------|-------|------|------|--------|---------|---------|----------|-----|
| ap | 1 | 1 | 2 | 900 | 100 | 9 | 12926 | 14.362 | 14.544 | 1.0127 | 0 |
| savefraccoh | 2 | 2 | 2 | 900 | 100 | 9 | 621.24 | 0.69027 | 0.26896 | 0.38965 | 0 |

xxx TABLE:ap XXXXXXXXXXXXXXXXXXXXXXX

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 | c9 |
|------|--------|--------|--------|------------|----------|---------|---------|--------|--------|
| r1 | 0 | 0 | 0 | 0 | 0.087442 | 0.27778 | 0.58243 | 1.0038 | 1.5724 |
| r2 | 0 | 0 | 0 | 0 | 0.087962 | 0.27828 | 0.58297 | 1.0044 | 1.5731 |
| r3 | 0 | 0 | 0 | 0 | 0.090477 | 0.28074 | 0.58547 | 1.0069 | 1.5755 |
| r4 | 0 | 0 | 0 | 0.00055771 | 0.09279 | 0.28605 | 0.5907 | 1.0122 | 1.5808 |
| r5 | 0 | 0 | 0 | 0.0059496 | 0.09602 | 0.29477 | 0.59952 | 1.0209 | 1.5895 |
| r96 | 43.845 | 43.923 | 44.022 | 44.198 | 44.428 | 44.722 | 45.103 | 45.546 | 46.186 |
| r97 | 45.031 | 45.101 | 45.208 | 45.384 | 45.613 | 45.91 | 46.293 | 46.735 | 47.382 |
| r98 | 46.237 | 46.297 | 46.411 | 46.59 | 46.818 | 47.115 | 47.501 | 47.948 | 48.605 |
| r99 | 47.46 | 47.512 | 47.635 | 47.812 | 48.041 | 48.34 | 48.726 | 49.191 | 49.869 |
| r100 | 48.703 | 48.746 | 48.878 | 49.055 | 49.283 | 49.586 | 49.978 | 50.495 | 51.171 |

xxx TABLE:savefraccoh XXXXXXXXXXXXXXXXXXXXXXX

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 | c9 |
|------|---------|---------|---------|------------|----------|---------|---------|---------|---------|
| r1 | 0 | 0 | 0 | 0 | 0.066018 | 0.16569 | 0.27445 | 0.37369 | 0.46243 |
| r2 | 0 | 0 | 0 | 0 | 0.066384 | 0.16593 | 0.27463 | 0.37381 | 0.46256 |
| r3 | 0 | 0 | 0 | 0 | 0.068154 | 0.16715 | 0.27549 | 0.37442 | 0.46292 |
| r4 | 0 | 0 | 0 | 0.00052879 | 0.069619 | 0.16978 | 0.27726 | 0.37564 | 0.46378 |
| r5 | 0 | 0 | 0 | 0.0055946 | 0.071572 | 0.17405 | 0.28025 | 0.37766 | 0.46512 |
| r96 | 0.92458 | 0.92354 | 0.92226 | 0.92171 | 0.92116 | 0.92055 | 0.91994 | 0.91842 | 0.91811 |
| r97 | 0.92531 | 0.92416 | 0.92306 | 0.92251 | 0.92196 | 0.92141 | 0.92086 | 0.91933 | 0.91915 |
| r98 | 0.92605 | 0.9247 | 0.92379 | 0.9233 | 0.92275 | 0.9222 | 0.92171 | 0.92031 | 0.92031 |
| r99 | 0.92672 | 0.92525 | 0.92452 | 0.92403 | 0.92348 | 0.923 | 0.92251 | 0.92147 | 0.92184 |
| r100 | 0.92739 | 0.9258 | 0.92525 | 0.92477 | 0.92422 | 0.92379 | 0.92342 | 0.92336 | 0.92367 |

Test FF_VFI_AZ_BISEC_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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 10.824225 seconds.

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CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min |
|-------------|---|-----|------|-------|------|------|--------|---------|---------|----------|-----|
| | — | — | — | — | — | — | — | — | — | — | — |
| savefraccoh | 1 | 1 | 2 | 700 | 100 | 7 | 357.85 | 0.51122 | 0.27528 | 0.53848 | 0 |

xxx TABLE:savefraccoh XXXXXXXXXXXXXXXXXXXXXXX

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|------|---------|---------|---------|---------|---------|------------|----------|
| | — | — | — | — | — | — | — |
| r1 | 0 | 0 | 0 | 0 | 0 | 0.00022362 | 0.041544 |
| r2 | 0 | 0 | 0 | 0 | 0 | 0.00022362 | 0.041544 |
| r3 | 0 | 0 | 0 | 0 | 0 | 0.0011391 | 0.041544 |
| r4 | 0 | 0 | 0 | 0 | 0 | 0.0016884 | 0.041483 |
| r5 | 0 | 0 | 0 | 0 | 0 | 0.0034584 | 0.04136 |
| r96 | 0.79586 | 0.79275 | 0.78945 | 0.78591 | 0.78225 | 0.77853 | 0.77059 |
| r97 | 0.79684 | 0.79379 | 0.79055 | 0.78713 | 0.78359 | 0.77993 | 0.77212 |
| r98 | 0.79782 | 0.79482 | 0.79171 | 0.78835 | 0.78488 | 0.78127 | 0.77365 |
| r99 | 0.79873 | 0.79586 | 0.79275 | 0.78951 | 0.7861 | 0.78262 | 0.77548 |
| r100 | 0.79965 | 0.79684 | 0.79385 | 0.79061 | 0.78732 | 0.7839 | 0.7781 |

```
% Higher Savings Incentives
```

```
mp_params('fl_beta') = 0.95;
mp_params('fl_r') = 0.04;
ff_vfi_az_bisec_loop(mp_params, mp_support);
```

Elapsed time is 53.369195 seconds.

XX

CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min |
|-------------|---|-----|------|-------|------|------|--------|---------|---------|----------|-----|
| | — | — | — | — | — | — | — | — | — | — | — |
| savefraccoh | 1 | 1 | 2 | 700 | 100 | 7 | 481.37 | 0.68768 | 0.27118 | 0.39435 | 0 |

xxx TABLE:savefraccoh XXXXXXXXXXXXXXXXXXXXXXX

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|-----|---------|---------|---------|----------|---------|---------|---------|
| | — | — | — | — | — | — | — |
| r1 | 0 | 0 | 0 | 0.065774 | 0.18076 | 0.30655 | 0.41654 |
| r2 | 0 | 0 | 0 | 0.066201 | 0.18101 | 0.30674 | 0.4166 |
| r3 | 0 | 0 | 0 | 0.06791 | 0.18223 | 0.30747 | 0.41709 |
| r4 | 0 | 0 | 0 | 0.069619 | 0.18467 | 0.30759 | 0.41812 |
| r5 | 0 | 0 | 0 | 0.071694 | 0.18876 | 0.30838 | 0.41983 |
| r96 | 0.92428 | 0.92245 | 0.92178 | 0.92116 | 0.92049 | 0.91872 | 0.91824 |
| r97 | 0.92501 | 0.92324 | 0.92257 | 0.92196 | 0.92129 | 0.91958 | 0.91921 |
| r98 | 0.92574 | 0.92397 | 0.92336 | 0.92275 | 0.92208 | 0.92049 | 0.92025 |

| | | | | | | | |
|------|---------|---------|---------|---------|---------|---------|---------|
| r99 | 0.92647 | 0.9247 | 0.92409 | 0.92348 | 0.92287 | 0.92147 | 0.92159 |
| r100 | 0.92702 | 0.92544 | 0.92483 | 0.92422 | 0.92373 | 0.92336 | 0.92348 |

Test FF_VFI_AZ_BISEC_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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 47.635241 seconds.

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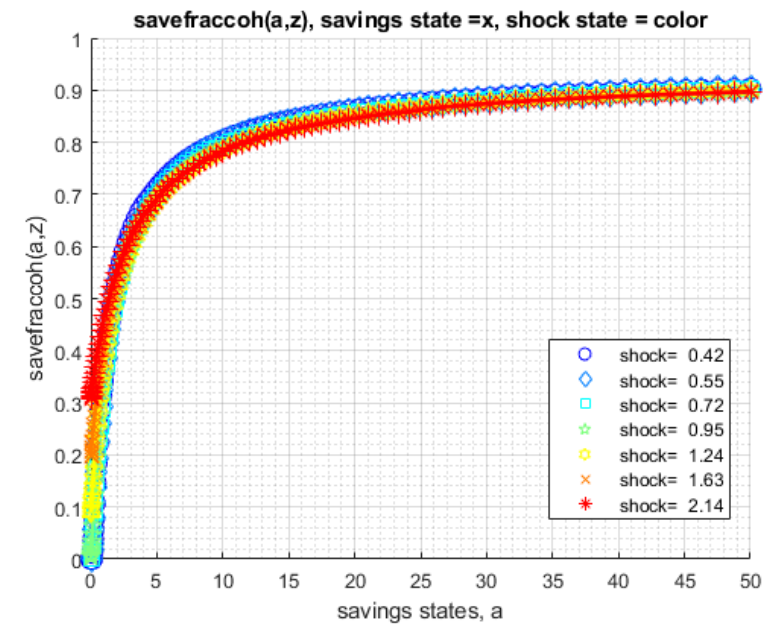
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min | max |
|-------------|---|-----|------|-------|------|------|--------|--------|---------|----------|-----|---------|
| | — | — | — | — | — | — | — | — | — | — | — | — |
| savefraccoh | 1 | 1 | 2 | 700 | 100 | 7 | 452.13 | 0.6459 | 0.28031 | 0.43398 | 0 | 0.92348 |

xxx TABLE:savefraccoh XXXXXXXXXXXXXXXXXXXXXXX

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|------|---------|---------|---------|-----------|----------|---------|---------|
| | — | — | — | — | — | — | — |
| r1 | 0 | 0 | 0 | 0.0047401 | 0.089089 | 0.19822 | 0.30783 |
| r2 | 0 | 0 | 0 | 0.0051674 | 0.089394 | 0.1984 | 0.30796 |
| r3 | 0 | 0 | 0 | 0.0060218 | 0.090676 | 0.19926 | 0.30851 |
| r4 | 0 | 0 | 0 | 0.0082801 | 0.092812 | 0.20115 | 0.30973 |
| r5 | 0 | 0 | 0 | 0.012247 | 0.092995 | 0.2042 | 0.31174 |
| r96 | 0.90047 | 0.89925 | 0.89828 | 0.8973 | 0.89632 | 0.89376 | 0.89297 |
| r97 | 0.90127 | 0.90017 | 0.89919 | 0.89828 | 0.8973 | 0.8948 | 0.89394 |
| r98 | 0.90206 | 0.90102 | 0.90011 | 0.89919 | 0.89828 | 0.89577 | 0.89498 |
| r99 | 0.90279 | 0.90188 | 0.90102 | 0.90011 | 0.89919 | 0.89681 | 0.8959 |
| r100 | 0.90359 | 0.90273 | 0.90188 | 0.90096 | 0.90011 | 0.89803 | 0.89687 |



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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 46.937845 seconds.

XX

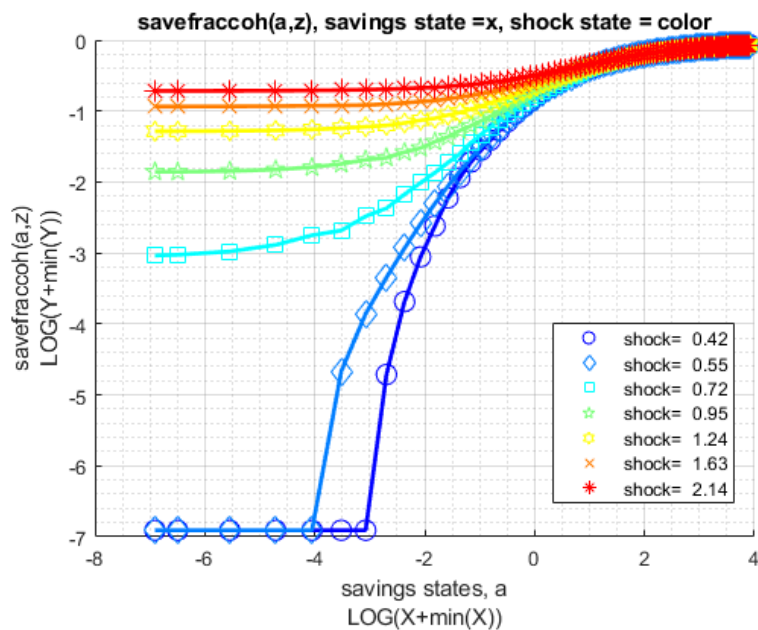
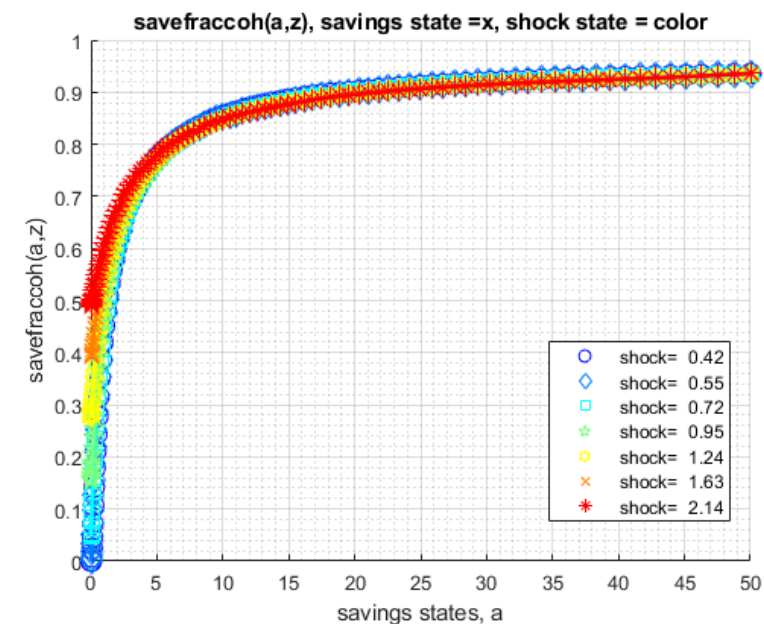
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min | max |
|-------------|---|-----|------|-------|------|------|--------|---------|---------|----------|-----|-----|
| savefraccoh | 1 | 1 | 2 | 700 | 100 | 7 | 502.71 | 0.71816 | 0.25437 | 0.3542 | 0 | 0 |

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxxxx

| | c1 | c2 | c3 | c4 | c5 | c6 | c7 |
|------|---------|---------|----------|---------|---------|---------|---------|
| r1 | 0 | 0 | 0.047037 | 0.15537 | 0.27573 | 0.3909 | 0.48782 |
| r2 | 0 | 0 | 0.047525 | 0.15531 | 0.27591 | 0.39102 | 0.48795 |
| r3 | 0 | 0 | 0.049844 | 0.1569 | 0.27695 | 0.3917 | 0.48837 |
| r4 | 0 | 0 | 0.054788 | 0.16025 | 0.27915 | 0.3931 | 0.48929 |
| r5 | 0 | 0 | 0.062905 | 0.16569 | 0.28275 | 0.39542 | 0.49075 |
| r96 | 0.93307 | 0.93258 | 0.93203 | 0.93154 | 0.9302 | 0.92995 | 0.92971 |
| r97 | 0.93374 | 0.93325 | 0.93276 | 0.93227 | 0.93111 | 0.93105 | 0.93117 |
| r98 | 0.93441 | 0.93398 | 0.93349 | 0.93307 | 0.93209 | 0.93227 | 0.9327 |
| r99 | 0.93508 | 0.93465 | 0.93423 | 0.93392 | 0.93331 | 0.93368 | 0.93435 |
| r100 | 0.93575 | 0.93539 | 0.93508 | 0.9349 | 0.93496 | 0.93526 | 0.93587 |



Test FF_VFI_AZ_BISEC_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_bisec_loop(mp_params, mp_support);
```

Elapsed time is 150.979328 seconds.

XX

CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min | max |
|-------------|---|-----|------|-------|------|------|--------|---------|---------|----------|-----|-----|
| | — | — | — | — | — | — | — | — | — | — | — | — |
| savefraccoh | 1 | 1 | 2 | 2250 | 150 | 15 | 1507.5 | 0.67001 | 0.28668 | 0.42788 | 0 | 0 |

```
xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxxxxxxxx
```

| | c1 | c2 | c3 | c4 | c5 | c11 | c12 | c13 | c14 | c15 |
|------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| r1 | 0 | 0 | 0 | 0 | 0 | 0.13847 | 0.18485 | 0.23026 | 0.27378 | 0.31111 |
| r2 | 0 | 0 | 0 | 0 | 0 | 0.13853 | 0.18491 | 0.23032 | 0.27384 | 0.31111 |
| r3 | 0 | 0 | 0 | 0 | 0 | 0.13895 | 0.18528 | 0.23063 | 0.27408 | 0.31111 |
| r4 | 0 | 0 | 0 | 0 | 0 | 0.13987 | 0.18607 | 0.2313 | 0.27469 | 0.31111 |
| r5 | 0 | 0 | 0 | 0 | 0 | 0.14011 | 0.18735 | 0.2324 | 0.27567 | 0.31111 |
| r146 | 0.92373 | 0.92354 | 0.9233 | 0.92312 | 0.92287 | 0.92086 | 0.92068 | 0.92049 | 0.91952 | 0.91911 |
| r147 | 0.92422 | 0.92403 | 0.92385 | 0.92361 | 0.92342 | 0.92141 | 0.92123 | 0.92098 | 0.92007 | 0.91911 |
| r148 | 0.9247 | 0.92452 | 0.92434 | 0.92409 | 0.92391 | 0.9219 | 0.92171 | 0.92153 | 0.92062 | 0.92007 |
| r149 | 0.92519 | 0.92501 | 0.92483 | 0.92458 | 0.9244 | 0.92245 | 0.92226 | 0.92208 | 0.92116 | 0.92007 |
| r150 | 0.92568 | 0.9255 | 0.92531 | 0.92507 | 0.92489 | 0.92293 | 0.92275 | 0.92257 | 0.92245 | 0.92207 |

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 bisec_loop(mp_params, mp_support);
```

Elapsed time is 136.803951 seconds.

XX

```
CONTAINER NAME: mp ffcmd ND Array (Matrix etc)
```

XX

| | i | idx | ndim | numel | rowN | colN | sum | mean | std | coefvari | min | |
|---|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|-----|---|
| | — | — | — | — | — | — | — | — | — | — | — | — |
| savefraccoh | 1 | 1 | 2 | 2250 | 150 | 15 | 1685.6 | 0.74914 | 0.22909 | 0.3058 | 0 | 0 |
| xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxxxxx | | | | | | | | | | | | |
| | c1 | c2 | c3 | c4 | c5 | c11 | c12 | c13 | c14 | c15 | | |
| | — | — | — | — | — | — | — | — | — | — | | |
| r1 | 0 | 0 | 0 | 0 | 0 | 0.5264 | 0.61264 | 0.68271 | 0.73922 | 0.784 | | |
| r2 | 0 | 0 | 0 | 0 | 0 | 0.52646 | 0.61264 | 0.68271 | 0.73922 | 0.784 | | |
| r3 | 0 | 0 | 0 | 0 | 0 | 0.52658 | 0.6127 | 0.68271 | 0.73922 | 0.784 | | |
| r4 | 0 | 0 | 0 | 0 | 0 | 0.52682 | 0.61288 | 0.68283 | 0.73928 | 0.784 | | |
| r5 | 0 | 0 | 0 | 0 | 0 | 0.52731 | 0.61313 | 0.68295 | 0.73934 | 0.784 | | |
| r146 | 0.92983 | 0.92928 | 0.92873 | 0.92806 | 0.92739 | 0.92269 | 0.92354 | 0.9258 | 0.92904 | 0.93001 | | |
| r147 | 0.9302 | 0.92971 | 0.9291 | 0.92849 | 0.92788 | 0.92361 | 0.92477 | 0.9269 | 0.93001 | 0.93001 | | |
| r148 | 0.93056 | 0.93008 | 0.92953 | 0.92892 | 0.92831 | 0.92458 | 0.92593 | 0.928 | 0.93105 | 0.93105 | | |
| r149 | 0.93093 | 0.93044 | 0.92995 | 0.92934 | 0.92873 | 0.9258 | 0.92702 | 0.9291 | 0.93203 | 0.93203 | | |
| r150 | 0.9313 | 0.93087 | 0.93032 | 0.92977 | 0.92916 | 0.92696 | 0.92818 | 0.93014 | 0.93294 | 0.93294 | | |