FF_VFI_AZ_LOOP Dynamic Programming Asset Problem with Shocks Loop

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 dynamica 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 extremely slow for larger state-space problems.

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 0.446290 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       350      50      7      8427.6    24.079    14.27    0.59263      0     50

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

    r1          0         0         0         0         0         0    2.0408
    r2          0         0         0    1.0204    1.0204    1.0204    3.0612
    r3     1.0204    1.0204    1.0204    2.0408    2.0408    2.0408    4.0816
    r4     2.0408    2.0408    2.0408    2.0408    3.0612    3.0612     5.102
    r5     3.0612    3.0612    3.0612    3.0612    4.0816    4.0816    6.1224
    r46    43.878    43.878    43.878    43.878    43.878    44.898    45.918
    r47    44.898    44.898    44.898    44.898    44.898    45.918    46.939
    r48    45.918    45.918    45.918    45.918    45.918    46.939    47.959
    r49    46.939    46.939    46.939    46.939    46.939    47.959     48.98
    r50    47.959    47.959    47.959    47.959    47.959     48.98        50
```

Test FF_VFI_AZ_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') = false;
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
```

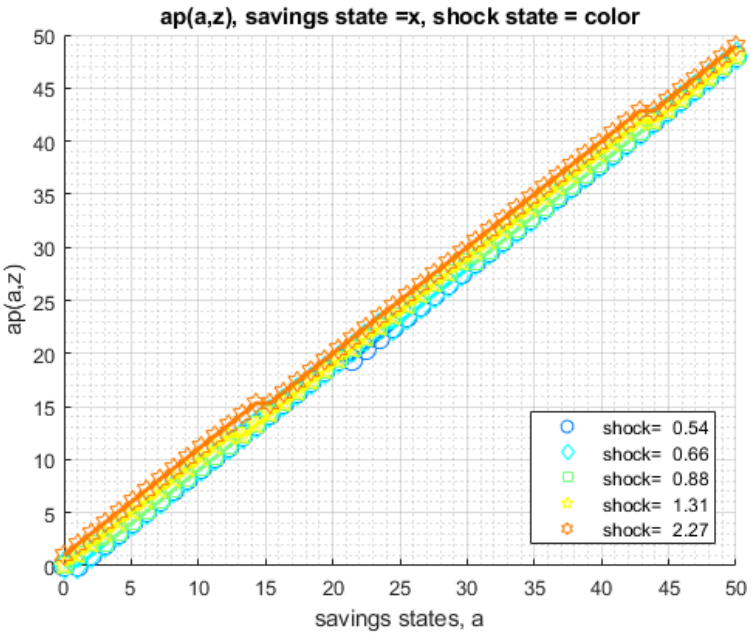
Run the function and show policy function for savings choice. For ls_ffcmd, ls_ffsna, ls_ffgrh, can include these: 'v', 'ap', 'c', 'y', 'coh', 'savefraccoh'. These are value, aprime savings choice, consumption, income, cash on hand, and savings fraction as cash-on-hand.

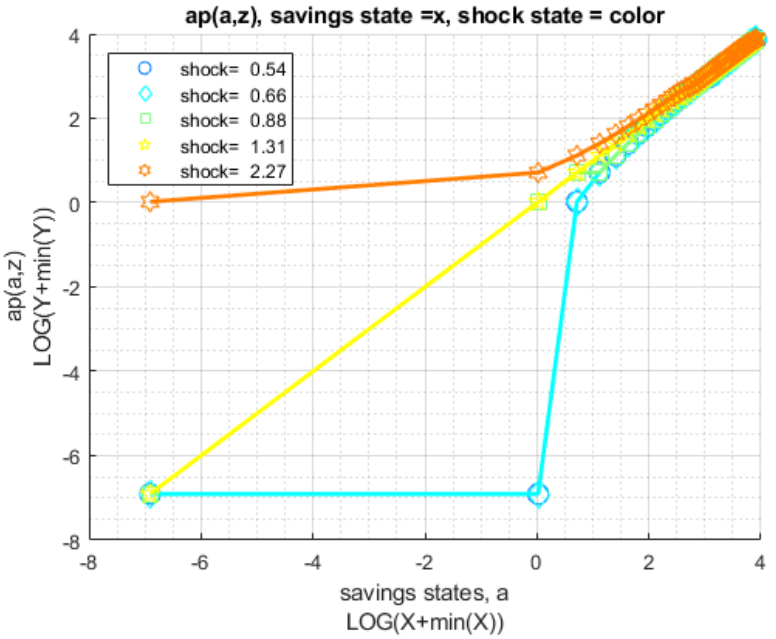
```
mp_support = containers.Map('KeyType','char', 'ValueType','any');
mp_support('bl_print_params') = false;
mp_support('bl_print_iterinfo') = false;
% ls_ffcmd: summary print which outcomes
mp_support('ls_ffcmd') = {};
% ls_ffsna: detail print which outcomes
mp_support('ls_ffsna') = {'ap'};
% ls_ffgrh: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

```
Elapsed time is 0.252449 seconds.
xxx  ff_vfi_az_vec, outcome=ap  xxxxxxxxxxxxxxxxxxxxxxxxxx
```

group	a	mean_z_0_54195	mean_z_0_66401	mean_z_0_88162	mean_z_1_3095	mean_z_2_2745
1	0	0	0	0	0	1.0204
2	1.0204	0	0	1.0204	1.0204	2.0408
3	2.0408	1.0204	1.0204	2.0408	2.0408	3.0612
4	3.0612	2.0408	2.0408	2.0408	3.0612	4.0816
5	4.0816	3.0612	3.0612	3.0612	4.0816	5.102
6	5.102	4.0816	4.0816	4.0816	5.102	6.1224
7	6.1224	5.102	5.102	5.102	6.1224	7.1429
8	7.1429	6.1224	6.1224	6.1224	7.1429	8.1633
9	8.1633	7.1429	7.1429	7.1429	8.1633	9.1837
10	9.1837	8.1633	8.1633	8.1633	9.1837	10.204
11	10.204	9.1837	9.1837	9.1837	10.204	11.224
12	11.224	10.204	10.204	10.204	11.224	12.245
13	12.245	11.224	11.224	11.224	12.245	13.265
14	13.265	12.245	12.245	12.245	12.245	14.286
15	14.286	13.265	13.265	13.265	13.265	15.306
16	15.306	14.286	14.286	14.286	14.286	15.306
17	16.327	15.306	15.306	15.306	15.306	16.327
18	17.347	16.327	16.327	16.327	16.327	17.347
19	18.367	17.347	17.347	17.347	17.347	18.367
20	19.388	18.367	18.367	18.367	18.367	19.388
21	20.408	19.388	19.388	19.388	19.388	20.408
22	21.429	19.388	20.408	20.408	20.408	21.429
23	22.449	20.408	21.429	21.429	21.429	22.449
24	23.469	21.429	22.449	22.449	22.449	23.469
25	24.49	22.449	22.449	23.469	23.469	24.49
26	25.51	23.469	23.469	24.49	24.49	25.51
27	26.531	24.49	24.49	25.51	25.51	26.531
28	27.551	25.51	25.51	26.531	26.531	27.551
29	28.571	26.531	26.531	27.551	27.551	28.571
30	29.592	27.551	27.551	28.571	28.571	29.592
31	30.612	28.571	28.571	28.571	29.592	30.612
32	31.633	29.592	29.592	29.592	30.612	31.633
33	32.653	30.612	30.612	30.612	31.633	32.653
34	33.673	31.633	31.633	31.633	32.653	33.673
35	34.694	32.653	32.653	32.653	33.673	34.694
36	35.714	33.673	33.673	33.673	34.694	35.714
37	36.735	34.694	34.694	34.694	35.714	36.735

38	37.755	35.714	35.714	35.714	36.735	37.755
39	38.776	36.735	36.735	36.735	37.755	38.776
40	39.796	37.755	37.755	37.755	38.776	39.796
41	40.816	38.776	38.776	38.776	39.796	40.816
42	41.837	39.796	39.796	39.796	40.816	41.837
43	42.857	40.816	40.816	40.816	41.837	42.857
44	43.878	41.837	41.837	41.837	41.837	42.857
45	44.898	42.857	42.857	42.857	42.857	43.878
46	45.918	43.878	43.878	43.878	43.878	44.898
47	46.939	44.898	44.898	44.898	44.898	45.918
48	47.959	45.918	45.918	45.918	45.918	46.939
49	48.98	46.939	46.939	46.939	46.939	47.959
50	50	47.959	47.959	47.959	47.959	48.98





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 1.625022 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

	i	idx	ndim	numel	rowN	colN	sum	mean	std	coefvari	min	m
ap	1	1	2	900	100	9	21825	24.25	14.089	0.581	0	
savefraccoh	2	2	2	900	100	9	411.21	0.4569	0.2651	0.58022	0	0.9

```
xxx TABLE:ap xxxxxxxxxxxxxxxxx
```

	c1	c2	c3	c4	c5	c6	c7	c8	c9
r1	0	0	0	0	0	0	0.50505	1.5152	3.0303
r2	0	0	0	0	0.50505	0.50505	1.0101	1.5152	3.5354
r3	0.50505	0.50505	0.50505	0.50505	0.50505	1.0101	1.5152	2.0202	4.0404
r4	1.0101	1.0101	1.0101	1.0101	1.0101	1.5152	2.0202	2.5253	4.5455
r5	1.5152	1.5152	1.5152	1.5152	1.5152	2.0202	2.5253	3.0303	5.0505
r96	45.455	45.455	45.455	45.96	45.96	45.96	46.465	47.475	49.495
r97	45.96	45.96	45.96	46.465	46.465	46.465	46.97	47.98	49.495
r98	46.465	46.465	46.465	46.465	46.97	46.97	47.475	48.485	50
r99	46.97	46.97	46.97	46.97	47.475	47.475	47.98	48.99	50
r100	47.475	47.475	47.475	47.475	47.98	47.98	48.485	49.495	50

```
xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
```

	c1	c2	c3	c4	c5	c6	c7	c8	
r1	0	0	0	0	0	0	0.0094749	0.027855	
r2	0	0	0	0	0.009643	0.0095804	0.01895	0.027855	0.
r3	0.0097386	0.0097261	0.0097083	0.0096824	0.009643	0.019161	0.028425	0.03714	0.
r4	0.019477	0.019452	0.019417	0.019365	0.019286	0.028741	0.0379	0.046425	0
r5	0.029216	0.029178	0.029125	0.029047	0.028929	0.038321	0.047374	0.05571	0.
r96	0.87647	0.87535	0.87375	0.8811	0.87751	0.87181	0.87169	0.87278	0
r97	0.88621	0.88507	0.88346	0.89078	0.88716	0.88139	0.88116	0.88207	0
r98	0.89595	0.8948	0.89317	0.89078	0.8968	0.89097	0.89064	0.89135	0
r99	0.90569	0.90452	0.90287	0.90046	0.90644	0.90055	0.90011	0.90064	0
r100	0.91543	0.91425	0.91258	0.91014	0.91609	0.91013	0.90959	0.90992	0

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') = 50;
mp_params('it_z_n') = 5;
```

```
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;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.068015 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       250      50      5       48.774    0.1951    0.23298     1.1942     0

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

    r1          0          0          0          0    0.0058555
    r2          0          0          0          0    0.0058555
    r3          0          0          0          0    0.0058555
    r4          0          0          0          0    0.0058555
    r5          0          0          0          0    0.0058555
    r46   0.62112    0.61921    0.61584    0.60931      0.59509
    r47   0.66655     0.6645    0.66088    0.65388      0.63861
    r48   0.71414    0.71195    0.70807    0.70057      0.68421
    r49   0.76395     0.7616    0.75745    0.74943      0.73193
    r50   0.81602    0.81351    0.80908    0.80051      0.78182
```

```
% 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 0.291535 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       250      50      5       59.526    0.2381    0.27148     1.1402     0

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

    r1          0          0    0.00051196     0.005772    0.021238
    r2          0          0    0.00051196     0.005772    0.021238
    r3          0          0    0.00051196     0.005772    0.021238
    r4          0          0    0.00099992     0.005772    0.021238
    r5          0          0    0.00099992    0.0079177    0.021238
    r46   0.73495    0.73278       0.72894       0.7215     0.70527
    r47   0.78505    0.78273       0.77862      0.77068     0.75334
    r48   0.83737    0.83489       0.83052      0.82204     0.80355
```

r49	0.89196	0.88933	0.88466	0.87564	0.85594
r50	0.94888	0.94608	0.94111	0.93151	0.91056

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') = 5;
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:

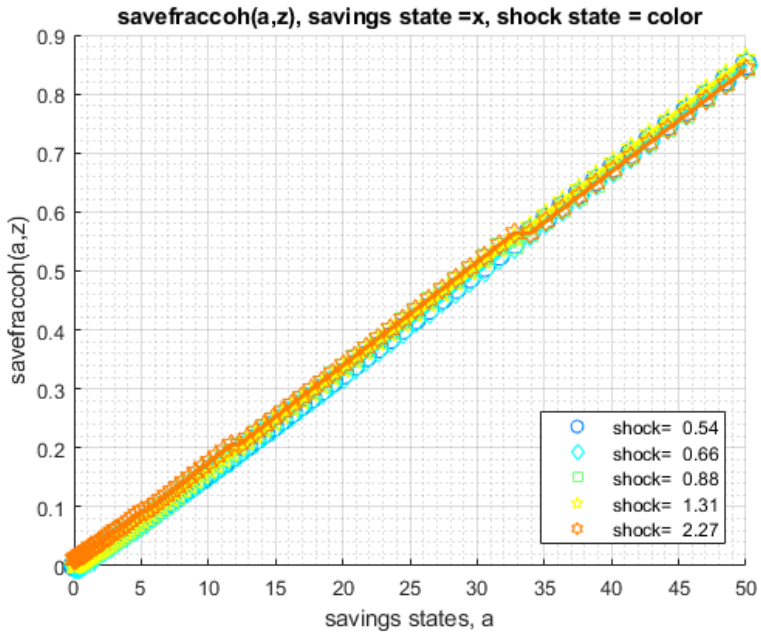
```
% Lower Risk Aversion
mp_params('fl_crra') = 0.5;
ff_vfi_az_loop(mp_params, mp_support);
```

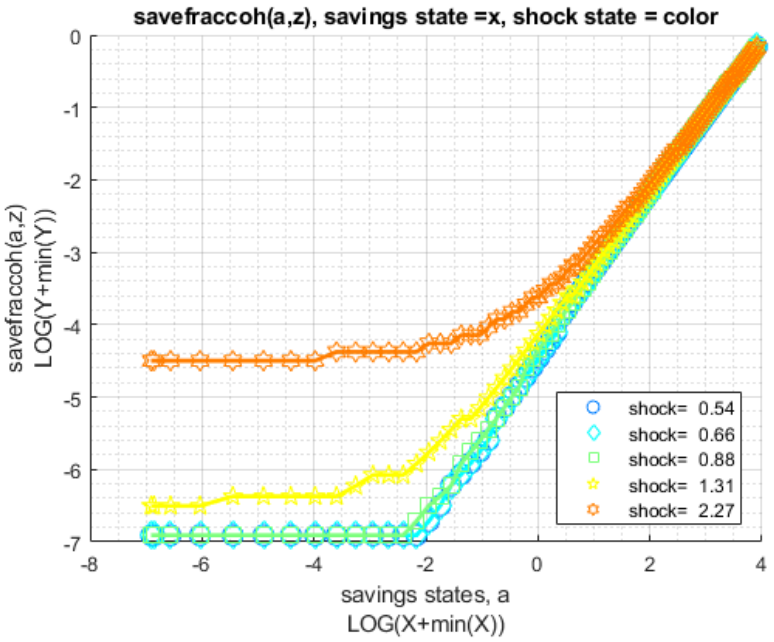
```
Elapsed time is 0.546316 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

	i	idx	ndim	numel	rowN	colN	sum	mean	std	coefvari	min	
savefraccoh	1	1	2	500	100	5	104.98	0.20996	0.24341	1.1593	0	0

```
xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
```

	c1	c2	c3	c4	c5
r1	0	0	0	0.0004985	0.010131
r2	0	0	0	0.0004985	0.010131
r3	0	0	0	0.0004985	0.010131
r4	0	0	0	0.0004985	0.010131
r5	0	0	0	0.00070978	0.010131
r96	0.74758	0.74533	0.74137	0.75815	0.74086
r97	0.77249	0.77018	0.76608	0.78315	0.76529
r98	0.79796	0.79557	0.79134	0.80868	0.79024
r99	0.82398	0.82151	0.81714	0.83477	0.81573
r100	0.85055	0.848	0.84349	0.86141	0.84176





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

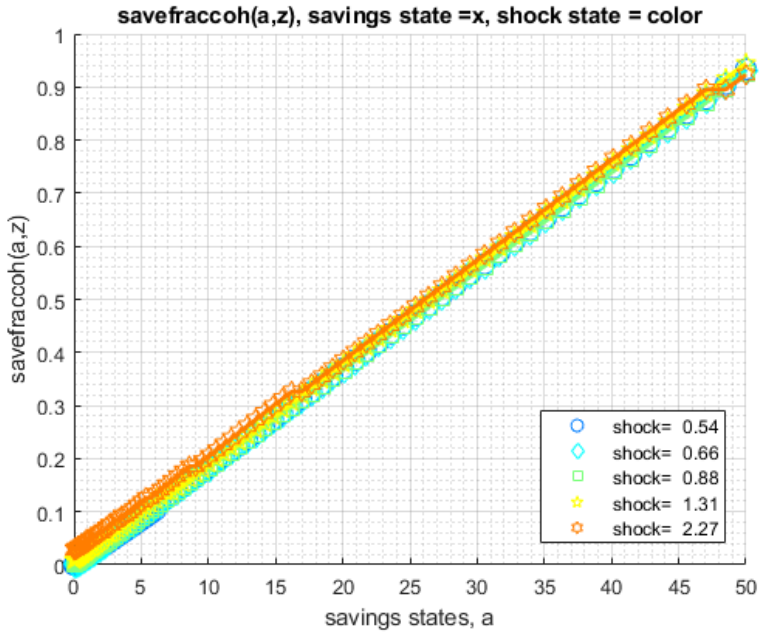
```
% Higher Risk Aversion
mp_params('fl_crra') = 5;
ff_vfi_az_loop(mp_params, mp_support);
```

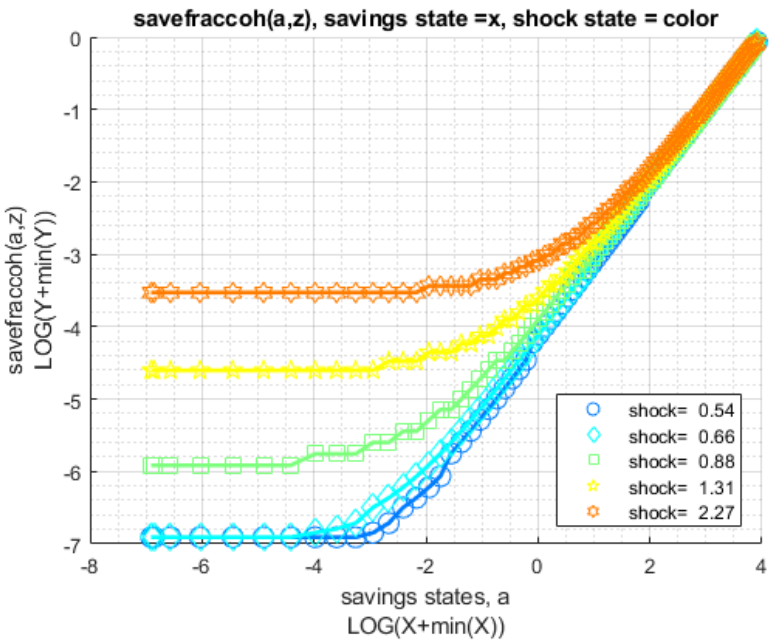
```
Elapsed time is 0.925980 seconds.
----------------------------------------
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CONTAINER NAME: mp_ffcmd ND Array (Matrix etc)
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

	i	idx	ndim	numel	rowN	colN	sum	mean	std	coefvari	min	
savefraccoh	1	1	2	500	100	5	119.58	0.23916	0.26719	1.1172	0	0

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxx

	c1	c2	c3	c4	c5
r1	0	0	0.0017	0.0090168	0.028344
r2	0	0	0.0017	0.0090168	0.028344
r3	0	0	0.0017	0.0090168	0.028344
r4	0	0	0.0017	0.0090168	0.028344
r5	0	0	0.0017	0.0090168	0.028344
r96	0.82398	0.82151	0.81714	0.83477	0.84176
r97	0.85055	0.848	0.84349	0.86141	0.86834
r98	0.8777	0.87507	0.87041	0.88861	0.89548
r99	0.90541	0.9027	0.8979	0.91637	0.89548
r100	0.93371	0.93091	0.92595	0.94471	0.92317





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') = 100;
mp_params('it_z_n') = 5;
mp_params('fl_a_max') = 50;
mp_params('st_grid_type') = 'grid_powerspace';
```

Lower standard deviation of shock:

```
% Lower Risk Aversion
mp_params('fl_shk_std') = 0.05;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.933647 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       500      100      5      112.7    0.22539    0.26207     1.1627      0
```

```
xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxxx
              c1         c2         c3         c4          c5
            _______    _______    _______    _______    _________

    r1            0          0          0          0    0.00049994
    r2            0          0          0          0    0.00049994
    r3            0          0          0          0    0.00049994
    r4            0          0          0          0    0.00049994
    r5            0          0          0          0    0.00049994
    r96     0.79191    0.79066    0.81492    0.81313       0.81102
    r97     0.81774    0.81644     0.8412    0.83936       0.83718
    r98     0.84411    0.84277    0.86805    0.86615       0.86389
    r99     0.87105    0.86967    0.89546     0.8935       0.89117
    r100    0.89855    0.89713    0.92344    0.92142       0.91902
```

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') = 0.25;
ff_vfi_az_loop(mp_params, mp_support);
```

```
Elapsed time is 0.894904 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	500	100	5	115.6	0.23119	0.25857	1.1184	0	0.

xxx TABLE:savefraccoh xxxxxxxxxxxxxxxxx

	c1	c2	c3	c4	c5
r1	0	0	0.00021288	0.0066707	0.033639
r2	0	0	0.00021288	0.0066707	0.033639
r3	0	0	0.00021288	0.0066707	0.033639
r4	0	0	0.00021288	0.0066707	0.033639
r5	0	0	0.00021288	0.0066707	0.033639
r96	0.79959	0.79731	0.79275	0.80778	0.80256
r97	0.82566	0.82331	0.8186	0.83384	0.82817
r98	0.85229	0.84986	0.84501	0.86045	0.85432
r99	0.87949	0.87699	0.87197	0.88762	0.88101
r100	0.90726	0.90468	0.89951	0.91536	0.90826