Distribution Grid Search

This is the example vignette for function: **snw_ds_main_grid_search** from the **PrjOptiSNW Package.** This function solves for vfi and gets distribution induced by policy functions and exogenous distributions. **Grid Search** for VFI and **Grid Search** also for Distribution. The results are illustrative of the differences between using grid search and exact solution. The grid search solution here is not fully vectorized but loops over the state-space.

Test SNW_DS_MAIN_GRID_SEARCH Defaults More Dense

Due to the speed of running this, the example below only uses dense grid

```
mp_params = snw_mp_param('default_moredense');
mp_controls = snw_mp_control('default_test');
mp_controls('bl_print_vfi') = false;
mp_controls('bl_print_ds') = false;
mp_controls('bl_print_ds_verbose') = false;
[Phi_true,Phi_adj,A_agg,Y_inc_agg,it,mp_dsvfi_results] = snw_ds_main_grid_search(mp_params, mp_
```

```
Elapsed time is 6514.834013 seconds.
Completed SNW_VFI_MAIN_GRID_SEARCH;SNW_MP_PARAM=default_moredense;SNW_MP_CONTROL=default_test
Elapsed time is 8310.394598 seconds.
Completed SNW_DS_MAIN;SNW_MP_PARAM=;default_moredense;SNW_MP_CONTROL=;default_test
```

```
Phi_true = Phi_true/sum(Phi_true(:));
```

Show All Info in mp_dsvfi_results More Dense

```
mp_cl_mt_xyz_of_s = mp_dsvfi_results('mp_cl_mt_xyz_of_s');
disp(mp_cl_mt_xyz_of_s('tb_outcomes'))
```

```
                         mean          sd   coefofvar         min         max       pYis0       pYls0       pYgr0  p
                     ________    ________   _________    ________    ________    ________    ________    ________  _

    a_ss               3.6126      6.4914      1.7969           0         135     0.17087           0     0.82913
    ap_ss              12.366       8.591     0.69474           1          55           0           0           1
    cons_ss            1.1622     0.80935     0.69639    0.036857      140.65           0           0           1  1
    v_ss              -15.043      17.999     -1.1965      -597.7      23.892           0      0.8378      0.1622  1.
    n_ss               2.3554      1.4375     0.61029           1           6           0           0           1
    y_all              1.5684      1.4453     0.92149    0.038325      47.427           0           0           1  1
    y_head_inc         1.2411      1.1553      0.9309    0.038325      31.844           0           0           1  1.
    y_head_earn        1.0444      1.0725      1.0269           0      26.444      0.2016           0      0.7984
    y_spouse_inc      0.32734     0.73631      2.2494           0      15.702     0.52499           0     0.47501
    yshr_interest    0.096139     0.15385      1.6002           0     0.99295     0.17087           0     0.82913
    yshr_wage         0.79228     0.33742     0.42588           0           1     0.10584           0     0.89416
    yshr_SS           0.11158     0.25418       2.278           0           1      0.7984           0      0.2016
    yshr_tax          0.18447    0.034469     0.18686    0.038299     0.25519           0           0           1  1
    yshr_nttxss      0.072887     0.27591      3.7854    -0.88844     0.25519           0     0.18437     0.81563
```

More Dense Param Results Define Frames

Define the matrix dimensions names and dimension vector values. Probability mass matrixes, Policy and Value Functions share the same ND dimensional structure.

```
% Grids:
```

```
age_grid = 18:100;
agrid = mp_params('agrid')';
eta_H_grid = mp_params('eta_H_grid')';
eta_S_grid = mp_params('eta_S_grid')';
ar_st_eta_HS_grid = string(cellstr([num2str(eta_H_grid', 'hz=%3.2f;'), num2str(eta_S_grid', 'wz
edu_grid = [0,1];
marry_grid = [0,1];
kids_grid = (1:1:mp_params('n_kidsgrid'))';
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
cl_mp_datasetdesc = {};
cl_mp_datasetdesc{1} = containers.Map({'name', 'labval'}, {'age', age_grid});
cl_mp_datasetdesc{2} = containers.Map({'name', 'labval'}, {'savings', agrid});
cl_mp_datasetdesc{3} = containers.Map({'name', 'labval'}, {'eta', 1:length(eta_H_grid)});
cl_mp_datasetdesc{4} = containers.Map({'name', 'labval'}, {'edu', edu_grid});
cl_mp_datasetdesc{5} = containers.Map({'name', 'labval'}, {'marry', marry_grid});
cl_mp_datasetdesc{6} = containers.Map({'name', 'labval'}, {'kids', kids_grid});
```

Analyze Probability Mass Along Age Dimensions

Where are the mass at? Analyze mass given state space components.

```
% Get the Joint distribution over all states
% Define Graph Inputs
mp_support_graph = containers.Map('KeyType', 'char', 'ValueType', 'any');
mp_support_graph('st_legend_loc') = 'best';
mp_support_graph('bl_graph_logy') = false; % do not log
```

Exogenous Permanent States Mass: Life Cycle, Edu and Marraige

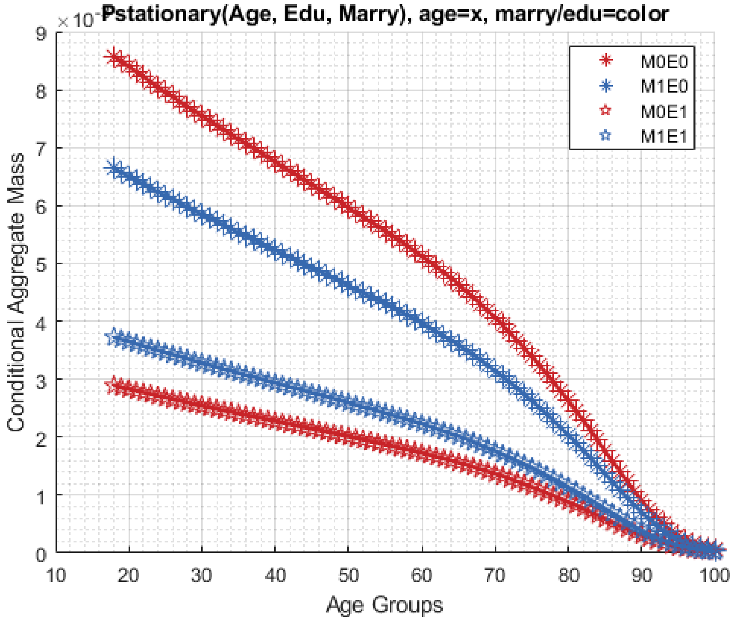
Tabulate value and policies along savings and shocks:

```
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
ar_permute = [2,3,6,1,5,4];
% Value Function
tb_prob_aem = ff_summ_nd_array("P(Age, EDU, MARRY))", Phi_true, true, ["sum"], 3, 1, cl_mp_data
```

```
xxx  P(Age, EDU, MARRY))  xxxxxxxxxxxxxxxxxxxxxxxxxxx
    group     marry     edu     sum_age_18    sum_age_19    sum_age_20    sum_age_21    sum_age_22    sum_age_23    sum
    _____     _____     ___     __________    __________    __________    __________    __________    __________    ___

      1         0        0      0.0085768     0.0084866     0.0083969     0.0083078     0.0082194     0.0081317     0.
      2         1        0      0.0066438     0.0065739     0.0065044     0.0064354     0.0063669      0.006299     0.0
      3         0        1      0.0028875     0.0028571      0.002827      0.002797     0.0027672     0.0027377     0.0
      4         1        1      0.0037292     0.0036899     0.0036509     0.0036122     0.0035738     0.0035356     0.0
```

```
mp_support_graph('cl_st_graph_title') = {'Pstationary(Age, Edu, Marry), age=x, marry/edu=color'
mp_support_graph('cl_st_ytitle') = {'Conditional Aggregate Mass'};
ar_row_grid = ["M0E0", "M1E0", "M0E1", "M1E1"];
mp_support_graph('cl_st_xtitle') = {'Age Groups'};
mp_support_graph('cl_scatter_shapes') = {'*', '*', 'p', 'p' };
mp_support_graph('cl_colors') = {'red', 'blue', 'red', 'blue'};
ff_graph_grid((tb_prob_aem{1:end, 4:end}), ar_row_grid, age_grid, mp_support_graph);
```



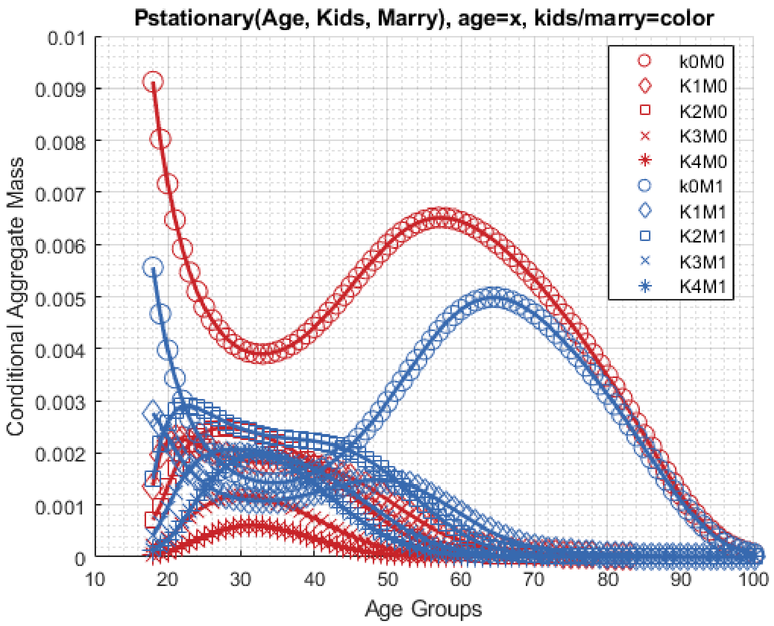
Kids and Marry By Age Mass

```
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
ar_permute = [2,3,4,1,6,5];
% Value Function
tb_prob_amarrykids = ff_summ_nd_array("P(Age, Kids, Marry))", Phi_true, true, ["sum"], 3, 1, cl
```

```
xxx  P(Age, Kids, Marry))  xxxxxxxxxxxxxxxxxxxxxxxxxx
    group    kids    marry     sum_age_18     sum_age_19     sum_age_20     sum_age_21     sum_age_22     sum_age_23     su
    _____    ____    _____    __________    __________    __________    __________    __________    __________    __

      1        1       0       0.0091249      0.0080278      0.0071652      0.0064765      0.0059205      0.0054683     0
      2        2       0       0.0013699      0.0019743      0.0022187      0.0022858      0.0022687      0.0022149     0
      3        3       0      0.00071266     0.00098425      0.0013537      0.0016929      0.0019639      0.0021645     0
      4        4       0      0.00020622     0.00027865     0.00037326     0.00049476     0.00062818     0.00075864    0.
      5        5       0      5.0761e-05     7.8715e-05       0.000113     0.00015485     0.00020534     0.00026306    0.
      6        1       1       0.0055624      0.0046679      0.0039774      0.0034368      0.0030088      0.0026667     0
      7        2       1       0.0027682      0.0025539      0.0023005      0.0020611      0.0018525      0.0016773
      8        3       1       0.0014982      0.0021823      0.0025943      0.0028096       0.002896      0.0029031     0
      9        4       1      0.00041197     0.00064648     0.00095224      0.0012491      0.0015009      0.0016975     0
     10        5       1      0.00013221      0.0002132     0.00033097     0.00049097     0.00068255      0.0008901     0
```

```
mp_support_graph('cl_st_graph_title') = {'Pstationary(Age, Kids, Marry), age=x, kids/marry=colo
mp_support_graph('cl_st_ytitle') = {'Conditional Aggregate Mass'};
ar_row_grid = [...
    "k0M0", "K1M0", "K2M0", "K3M0", "K4M0", ...
    "k0M1", "K1M1", "K2M1", "K3M1", "K4M1"];
mp_support_graph('cl_scatter_shapes') = {...
    'o', 'd' ,'s', 'x', '*', ...
    'o', 'd', 's', 'x', '*'};
mp_support_graph('cl_colors') = {...
    'red', 'red', 'red', 'red', 'red'...
    'blue', 'blue', 'blue', 'blue', 'blue'};
mp_support_graph('cl_st_xtitle') = {'Age Groups'};
ff_graph_grid((tb_prob_amarrykids{1:end, 4:end}), ar_row_grid, age_grid, mp_support_graph);
```



Analyze Probability Mass Asset and Shock Dimensions

Where are the mass at?

```
% Define Graph Inputs
mp_support_graph = containers.Map('KeyType', 'char', 'ValueType', 'any');
mp_support_graph('st_legend_loc') = 'best';
mp_support_graph('bl_graph_logy') = false; % do not log
```

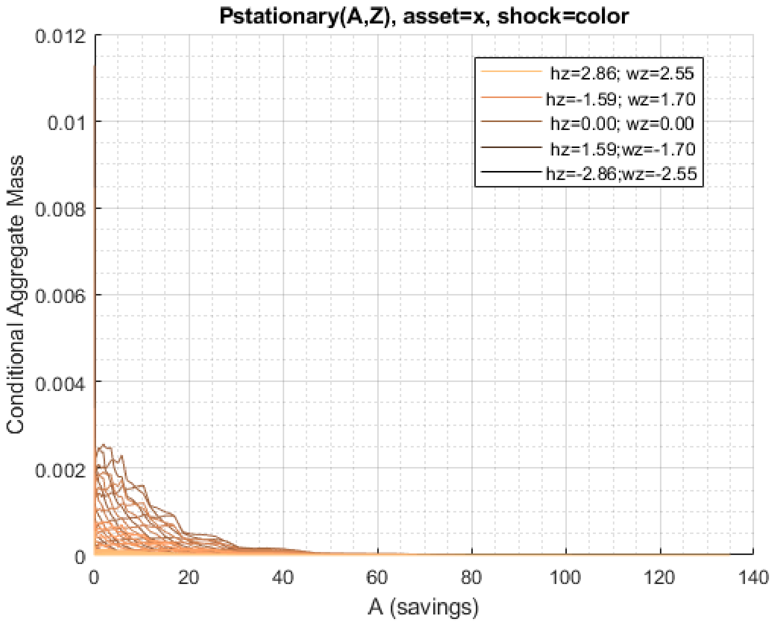
Asset and Shock Mass

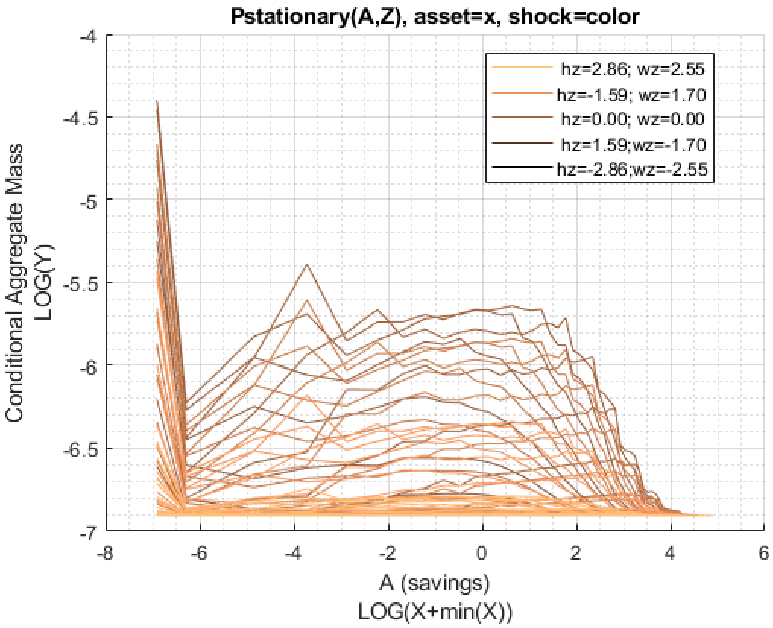
```
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
ar_permute = [1,4,5,6,3,2];
% Value Function
tb_prob_az = ff_summ_nd_array("P(A,Z))", Phi_true, true, ["sum"], 4, 1, cl_mp_datasetdesc, ar_p
```

```
xxx  P(A,Z))  xxxxxxxxxxxxxxxxxxxxxxxxxxx
    group     savings      sum_eta_1     sum_eta_2     sum_eta_3     sum_eta_4     sum_eta_5     sum_eta_6     sum_e
    _____    __________    __________    __________    __________    __________    __________    __________    _____

      1               0    3.3248e-08     5.983e-07    5.0468e-06    2.6071e-05    8.9773e-05    0.00021314    0.000
      2      0.00085734    1.0185e-10    1.5738e-09    3.3484e-08    6.0665e-07    5.2814e-06    1.7889e-05     2.91
      3       0.0068587    3.5085e-10    6.5198e-09    4.9979e-08    3.1065e-07    2.0919e-06    1.2505e-05    4.680
      4        0.023148    9.1216e-10     1.727e-08    1.5853e-07    9.1924e-07     4.228e-06    1.6829e-05    3.770
      5         0.05487    1.4512e-09    2.6722e-08    2.3417e-07    1.3076e-06    5.2407e-06    1.8046e-05    4.133
      6         0.10717    1.6379e-09    2.9149e-08    2.4125e-07    1.2884e-06    5.1297e-06    1.7682e-05    4.637
      7         0.18519     2.294e-09    4.0502e-08    3.4422e-07    1.7987e-06    6.7964e-06    2.0952e-05    5.119
      8         0.29407    2.7467e-09    4.5812e-08    3.5554e-07    1.8118e-06    6.8723e-06    2.0892e-05    5.259
      9         0.43896    2.8104e-09    4.8243e-08    3.9121e-07    1.9756e-06    7.1951e-06    2.0818e-05    4.920
     10           0.625    2.7355e-09    4.7422e-08    3.8625e-07    1.9709e-06    7.2487e-06    2.0707e-05    4.875
     11         0.85734    2.6045e-09    4.5648e-08    3.7801e-07    1.9446e-06    7.1135e-06    2.0218e-05    4.541
     12          1.1411    2.3091e-09     4.118e-08     3.427e-07    1.7857e-06    6.6881e-06    1.9205e-05    4.374
     13          1.4815    1.8391e-09    3.3807e-08    2.9225e-07    1.5886e-06    6.0926e-06    1.7531e-05     3.97
     14          1.8836    1.4638e-09    2.7339e-08    2.4063e-07    1.3481e-06    5.3035e-06    1.5351e-05     3.61
     15          2.3525    1.0398e-09     2.042e-08    1.9039e-07    1.1046e-06    4.5148e-06    1.3541e-05    3.112
     16          2.8935    7.6831e-10    1.5168e-08    1.4306e-07    8.5678e-07    3.6129e-06    1.1466e-05    2.787
     17          3.5117    5.0779e-10    1.0306e-08    1.0222e-07    6.4935e-07    2.7868e-06    9.0469e-06    2.307
     18          4.2121    3.3725e-10    7.1325e-09    7.2301e-08    4.5701e-07    2.0605e-06     7.049e-06    1.869
     19               5    2.0339e-10    4.5055e-09    4.7886e-08    3.1798e-07    1.4784e-06    5.2954e-06    1.510
     20          5.8805    1.1697e-10    2.6614e-09     2.899e-08      2.04e-07    1.0085e-06    3.8316e-06    1.176
     21          6.8587    6.4191e-11    1.5386e-09    1.7458e-08    1.2852e-07    6.6971e-07    2.7498e-06    9.305
     22          7.9398     3.223e-11    8.2009e-10     1.023e-08     7.992e-08    4.4241e-07    1.8723e-06    6.916
     23          9.1289    1.5935e-11    4.2547e-10    5.5799e-09    4.7148e-08    2.8701e-07    1.3269e-06    5.095
     24          10.431    7.6602e-12    2.1449e-10     3.021e-09    2.7923e-08    1.8511e-07    9.7387e-07      3.8
     25          11.852    3.4707e-12    1.1014e-10    1.6503e-09    1.6439e-08    1.1882e-07    6.7833e-07    2.801
     26          13.396    1.5171e-12    5.0241e-11    8.4768e-10    9.2919e-09    7.4842e-08       4.48e-07    1.925
     27          15.069    6.5407e-13    2.3567e-11     4.244e-10    4.9998e-09    4.3238e-08    2.8358e-07    1.235
```

```
mp_support_graph('cl_st_graph_title') = {'Pstationary(A,Z), asset=x, shock=color'};
mp_support_graph('cl_st_ytitle') = {'Conditional Aggregate Mass'};
mp_support_graph('cl_st_xtitle') = {'A (savings)'};
mp_support_graph('st_rowvar_name') = 'z=';
mp_support_graph('it_legend_select') = 5;
mp_support_graph('st_rounding') = '6.2f';
mp_support_graph('bl_graph_logy') = true;
mp_support_graph('cl_colors') = 'copper';
ff_graph_grid((tb_prob_az{1:end, 3:end})', ar_st_eta_HS_grid, agrid, mp_support_graph);% Consum
```





Asset Mass by Age

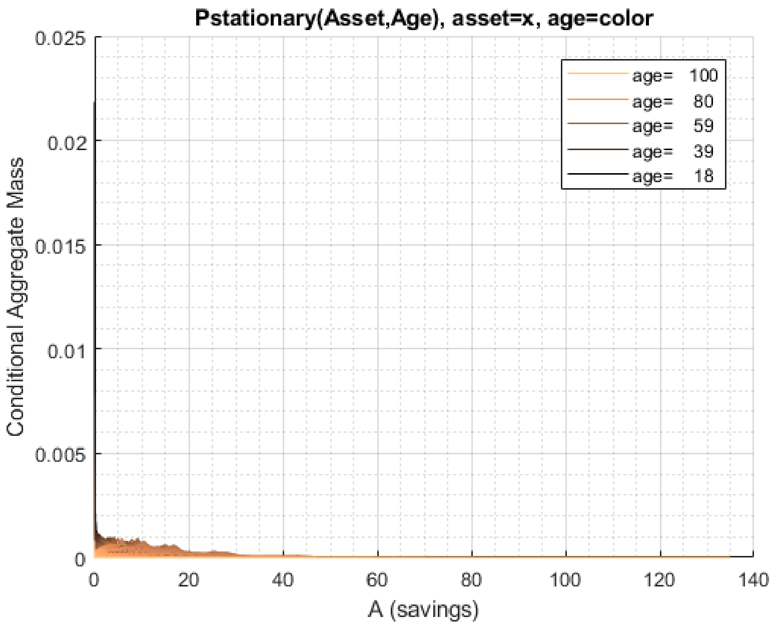
```
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
ar_permute = [3,4,5,6,1,2];
% Value Function
tb_prob_aage = ff_summ_nd_array("P(A,Z))", Phi_true, true, ["sum"], 4, 1, cl_mp_datasetdesc, ar
```

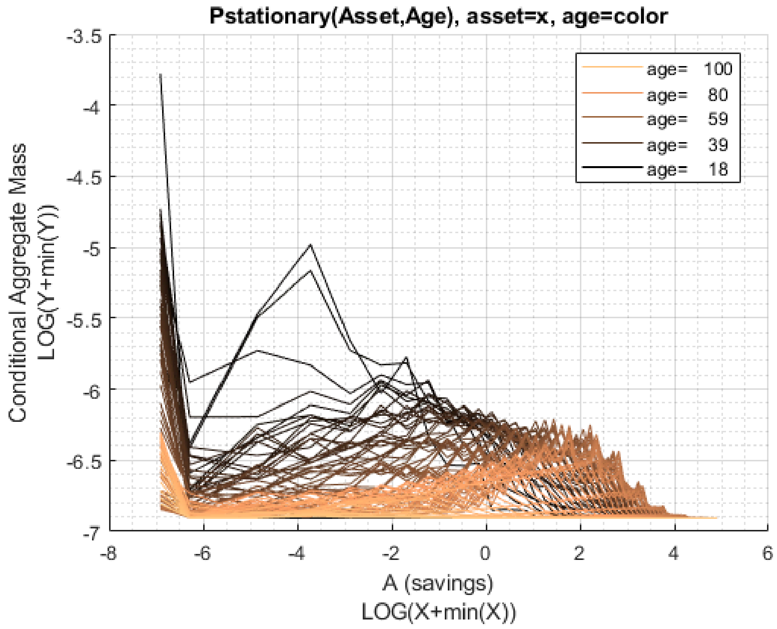
```
xxx   P(A,Z))   xxxxxxxxxxxxxxxxxxxxxxxxxxx
    group      savings      sum_age_18    sum_age_19    sum_age_20    sum_age_21    sum_age_22    sum_age_23    sum_a
    _____    __________    __________    __________    __________    __________    __________    __________    _____

      1               0     0.021837      0.0034489     0.0022777     0.0051619     0.0070701     0.0078351     0.00
      2      0.00085734            0     0.00068848    0.00063521     0.0016036     0.0010378    0.00037256    0.000
      3       0.0068587            0      0.0032017     0.0031082     0.0022491     0.0010432    0.00076245    0.000
      4        0.023148            0      0.0058625     0.0047177     0.0019351     0.0014397     0.0012162     0.00
      5         0.05487            0      0.0024915     0.0022549     0.0014027      0.001227     0.0010924    0.000
      6         0.10717            0      0.0014086     0.0019373     0.0017422     0.0016421       0.00161     0.00
      7         0.18519            0      0.0021091     0.0019779     0.0015628     0.0013724     0.0012726     0.00
      8         0.29407            0     0.00077614     0.0012753     0.0015936     0.0016414     0.0013435     0.00
      9         0.43896            0     0.00045252      0.001062     0.0009547    0.00098397     0.0013165     0.00
     10           0.625            0     0.00044667     0.0006628     0.0010416    0.00096275    0.00093205     0.00
     11         0.85734            0     0.00047477    0.00074294     0.0006549    0.00088876    0.00086767    0.000
     12          1.1411            0     5.5654e-05    0.00024727    0.00052409    0.00050156    0.00070796    0.000
     13          1.4815            0     6.2855e-05    0.00019563    0.00024402    0.00047382    0.00041139    0.000
     14          1.8836            0     5.9284e-05    0.00012121    0.00019477    0.00022476    0.00042115    0.000
     15          2.3525            0     5.4786e-05    9.1062e-05    0.00015255     0.0001713     0.0001937    0.000
     16          2.8935            0     1.2562e-05    5.2495e-05    7.1526e-05    0.00013824    0.00013812    0.000
     17          3.5117            0     1.3674e-06    1.1359e-05    3.0456e-05    4.9417e-05    0.00011344    0.000
     18          4.2121            0     1.7163e-07     5.944e-06    2.1633e-05    2.4249e-05    3.9771e-05    9.192
     19               5            0     7.8629e-08      1.35e-06    5.2915e-06    1.3252e-05    2.1725e-05    3.396
     20          5.8805            0     6.0581e-09    7.6218e-07    4.4269e-06    1.3802e-05    1.2238e-05    1.981
     21          6.8587            0     4.4396e-10    9.1165e-08    6.9508e-07    3.4569e-06     1.388e-05    1.258
     22          7.9398            0              0    3.4291e-08    4.1481e-07    2.9624e-06    4.2114e-06    1.324
     23          9.1289            0              0    2.5522e-08    3.1203e-07    5.0602e-07    2.4977e-06    3.850
     24          10.431            0              0    6.5868e-10    4.3387e-08    3.9922e-07    1.8125e-06    3.032
     25          11.852            0              0    2.4326e-10    1.8803e-08    2.6275e-07    4.5097e-07    1.296
     26          13.396            0              0    4.8838e-12    1.8589e-08     3.869e-08    2.8292e-07    1.489
     27          15.069            0              0     1.813e-12    4.7634e-10    2.1906e-08    2.1902e-07    2.796
     28          16.875            0              0             0    6.2066e-11    1.9079e-08    3.5513e-08    2.221
```

```
29           18.82            0              0             0      6.42e-12    6.8737e-10    2.0331e-08    1.702
30           20.91            0              0             0    1.6411e-13     9.995e-11    1.6987e-08    2.834
31          23.148            0              0             0    1.9878e-14    1.2652e-11    7.6143e-10    2.048
32          25.541            0              0             0             0     7.895e-13    1.3318e-10    1.173
33          28.093            0              0             0             0    1.2464e-14      1.45e-11    7.138
34           30.81            0              0             0             0    2.5551e-16     5.986e-13    1.196
35          33.697            0              0             0             0             0    1.2701e-14    9.134
36          36.758            0              0             0             0             0    2.0518e-16    3.324
37              40            0              0             0             0             0    2.4829e-18    9.849
38          43.427            0              0             0             0             0             0    1.426
39          47.044            0              0             0             0             0             0    2.188
40          50.856            0              0             0             0             0             0
41           54.87            0              0             0             0             0             0
42          59.089            0              0             0             0             0             0
43          63.519            0              0             0             0             0             0
44          68.164            0              0             0             0             0             0
45          73.032            0              0             0             0             0             0
46          78.125            0              0             0             0             0             0
47           83.45            0              0             0             0           ...
```

```
mp_support_graph('cl_st_graph_title') = {'Pstationary(Asset,Age), asset=x, age=color'};
mp_support_graph('cl_st_ytitle') = {'Conditional Aggregate Mass'};
mp_support_graph('cl_st_xtitle') = {'A (savings)'};
mp_support_graph('st_rowvar_name') = 'age=';
mp_support_graph('it_legend_select') = 5;
mp_support_graph('st_rounding') = '6.0f';
mp_support_graph('bl_graph_logy') = true;
mp_support_graph('cl_colors') = 'copper';
ff_graph_grid((tb_prob_aage{1:end, 3:end})', age_grid, agrid, mp_support_graph);% Consumption C
```





Probability Statistics A, C and V Conditional on Ages

Where are the mass at?

```
ap_ss = mp_dsvfi_results('ap_ss');
c_ss = mp_dsvfi_results('cons_ss');
v_ss = mp_dsvfi_results('v_ss');
n_ss = mp_dsvfi_results('n_ss');

y_head_inc = mp_dsvfi_results('y_head_inc_ss');
y_spouse_inc = mp_dsvfi_results('y_spouse_inc_ss');

yshr_wage = mp_dsvfi_results('yshr_wage_ss');
yshr_SS = mp_dsvfi_results('yshr_SS_ss');
yshr_nttxss = mp_dsvfi_results('yshr_nttxss_ss');

for it_ctr=1:size(ap_ss, 1)
    if (ismember(it_ctr, round(linspace(1, size(ap_ss, 1), 3))))
        display(['age =' num2str(age_grid(it_ctr))]);

        % construct input data
        Phi_true_age = Phi_true(it_ctr, :, :, : ,: ,:);
        ap_ss_age = ap_ss(it_ctr, :, :, : ,: ,:);
        c_ss_age = c_ss(it_ctr, :, :, : ,: ,:);
        v_ss_age = v_ss(it_ctr, :, :, : ,: ,:);
        n_ss_age = n_ss(it_ctr, :, :, : ,: ,:);

        y_head_inc_age = y_head_inc(it_ctr, :, :, : ,: ,:);
        y_spouse_inc_age = y_spouse_inc(it_ctr, :, :, : ,: ,:);
        yshr_wage_age = yshr_wage(it_ctr, :, :, : ,: ,:);
        yshr_SS_age = yshr_SS(it_ctr, :, :, : ,: ,:);
        yshr_nttxss_age = yshr_nttxss(it_ctr, :, :, : ,: ,:);

        mp_cl_ar_xyz_of_s = containers.Map('KeyType','char', 'ValueType','any');
    mp_cl_ar_xyz_of_s('ap_ss') = {ap_ss_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('c_ss') = {c_ss_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('v_ss') = {v_ss_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('n_ss') = {n_ss_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('y_head_inc') = {y_head_inc_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('y_spouse') = {y_spouse_inc_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('yshr_wage') = {yshr_wage_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('yshr_SS') = {yshr_SS_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('yshr_nttxss') = {yshr_nttxss_age(:), zeros(1)};
    mp_cl_ar_xyz_of_s('ar_st_y_name') = ["ap_ss", "c_ss", "v_ss", "n_ss",...
      "y_head_inc", "y_spouse", "yshr_wage", "yshr_SS", "yshr_nttxss"];

    % controls
    mp_support = containers.Map('KeyType','char', 'ValueType','any');
    mp_support('ar_fl_percentiles') = [0.01 10 25 50 75 90 99.99];
    mp_support('bl_display_final') = true;
    mp_support('bl_display_detail') = false;
    mp_support('bl_display_drvm2outcomes') = false;
    mp_support('bl_display_drvstats') = false;
    mp_support('bl_display_drvm2covcor') = false;

    % Call Function
    mp_cl_mt_xyz_of_s = ff_simu_stats(Phi_true_age(:)/sum(Phi_true_age,'all'), mp_cl_ar_xyz
  end
end
```

```
age =18
xxx tb_outcomes: all stats xxx
    OriginalVariableNames        ap_ss          c_ss           v_ss          n_ss        y_head_inc      y_spouse
    ______________________    ___________    ___________    __________    ___________    ___________    ___________

    {'mean'              }         4.4841        0.73608       -24.737         1.9854        0.83951        0.20898
    {'sd'                }         2.5942        0.43457        24.426         1.0848        0.62548        0.43796
    {'coefofvar'         }        0.57854        0.59038      -0.98745        0.54639        0.74505         2.0956
    {'min'               }              1       0.036857        -597.7              1       0.038325              0
    {'max'               }             55          17.35        23.892              6         17.095         6.1141
    {'pYis0'             }              0              0             0              0              0        0.52499
    {'pYls0'             }              0              0       0.91009              0              0              0
    {'pYgr0'             }              1              1      0.089914              1              1        0.47501
    {'pYisMINY'          }        0.15961     2.0027e-06    8.8672e-09        0.41786     3.8147e-06        0.52499
    {'pYisMAXY'          }              0              0             0      0.0060544              0     7.6694e-09
    {'p0_01'             }              1         0.0682        -251.7              1       0.072367              0
    {'p10'               }              1        0.30119       -51.639              1        0.25802              0
    {'p25'               }              3        0.40819       -36.859              1         0.4872              0
    {'p50'               }              4        0.65163       -19.949              2        0.66948              0
    {'p75'               }              6        0.91178       -7.7939              3        0.91995        0.24381
    {'p90'               }              8         1.2709       -1.1471              4         1.7371        0.61906
    {'p99_99'            }             16         4.1437        17.666              6         6.1934         4.7312
    {'fl_cov_ap_ss'      }           6.73        0.61926        25.315      -0.086009        0.71874        0.77387
    {'fl_cor_ap_ss'      }              1         0.5493        0.3995      -0.030562        0.44295        0.68113
    {'fl_cov_c_ss'       }        0.61926        0.18885        7.7987        0.07295        0.25218       0.060176
    {'fl_cor_c_ss'       }         0.5493              1        0.7347        0.15474        0.92778        0.31618
    {'fl_cov_v_ss'       }         25.315         7.7987        596.64        -1.0333         10.003         2.2091
    {'fl_cor_v_ss'       }         0.3995         0.7347             1      -0.038995        0.65476        0.20651
    {'fl_cov_n_ss'       }      -0.086009        0.07295       -1.0333         1.1768     2.5745e-18        0.12195
    {'fl_cor_n_ss'       }      -0.030562        0.15474     -0.038995              1     3.7942e-18        0.25667
    {'fl_cov_y_head_inc' }        0.71874        0.25218        10.003     2.5745e-18        0.39122       0.010942
    {'fl_cor_y_head_inc' }        0.44295        0.92778       0.65476     3.7942e-18              1       0.039945
    {'fl_cov_y_spouse'   }        0.77387       0.060176        2.2091        0.12195       0.010942        0.19181
    {'fl_cor_y_spouse'   }        0.68113        0.31618       0.20651        0.25667       0.039945              1
    {'fl_cov_yshr_wage'  }    -1.9999e-30    -3.1429e-31    1.1155e-29    -5.0228e-31    -4.8634e-31    -1.3325e-31
    {'fl_cor_yshr_wage'  }    -1.7359e-15    -1.6286e-15    1.0284e-15    -1.0426e-15    -1.7509e-15    -6.8512e-16
    {'fl_cov_yshr_SS'    }              0              0             0              0              0              0
    {'fl_cor_yshr_SS'    }            NaN            NaN           NaN            NaN            NaN            NaN
    {'fl_cov_yshr_nttxss'}        0.05377       0.011984       0.67106      0.0063843       0.014635      0.0061572
    {'fl_cor_yshr_nttxss'}        0.65501        0.87148        0.8682        0.18598        0.73941         0.4443
    {'fracByP0_01'       }       0.035596     3.1006e-05     0.0014244        0.21046     5.4793e-05              0
    {'fracByP10'         }       0.035596       0.046234       0.31706        0.21046       0.031399              0
    {'fracByP25'         }        0.14894        0.11395       0.58865        0.21046        0.17954              0
    {'fracByP50'         }        0.39097        0.28419       0.84937        0.53024        0.32745              0
    {'fracByP75'         }        0.60677        0.54782       0.99563        0.77109        0.51036        0.13407
    {'fracByP90'         }        0.82323        0.77805        1.0163        0.92834         0.8397        0.41115
    {'fracByP99_99'      }        0.99971        0.99944             1              1        0.99925        0.99766

age =59
xxx tb_outcomes: all stats xxx
    OriginalVariableNames       ap_ss          c_ss          v_ss          n_ss       y_head_inc     y_spouse      ys
    _____________________    __________    __________    __________    __________    __________    __________    __

    {'mean'              }       19.816         1.359       -12.596        1.7239        1.7902       0.41115
    {'sd'                }       7.5997       0.94263        14.529       0.90777        1.4384       0.85562
    {'coefofvar'         }       0.3835       0.69362       -1.1534       0.52659       0.80349        2.0811
    {'min'               }            1      0.056816       -211.91             1       0.05988             0
    {'max'               }           55        31.643        14.416             6        30.606         11.86
    {'pYis0'             }            0             0             0             0             0       0.52499
    {'pYls0'             }            0             0       0.80596             0             0             0
    {'pYgr0'             }            1             1       0.19404             1             1       0.47501
    {'pYisMINY'          }    0.0097508    1.4955e-06    4.4767e-10       0.48835    1.5128e-06       0.52499    3.
    {'pYisMAXY'          }   3.9575e-05    3.6923e-09      2.35e-07     0.0036816    5.7591e-07    7.0076e-09
    {'p0_01'             }            1        0.1046       -83.156             1       0.11307             0
    {'p10'               }           10        0.4435       -33.387             1       0.56354             0
    {'p25'               }           15       0.68544       -20.857             1       0.82346             0
    {'p50'               }           20        1.1501       -9.5768             2        1.4112             0
    {'p75'               }           25        1.7983       -1.8874             2        2.3004       0.49169
    {'p90'               }           29        2.5653        3.2283             3        3.3891        1.2002
    {'p99_99'            }           52        10.514        13.528             6        17.142        9.1776
    {'fl_cov_ap_ss'      }       57.755        5.9089        102.91         0.833        8.8962        1.5795
    {'fl_cor_ap_ss'      }            1       0.82483       0.93205       0.12075       0.81382       0.24292
    {'fl_cov_c_ss'       }       5.9089       0.88856        10.148       0.19066        1.1168       0.19114     -
    {'fl_cor_c_ss'       }      0.82483             1       0.74094       0.22282       0.82371       0.23699
    {'fl_cov_v_ss'       }       102.91        10.148         211.1        2.8206          14.8        3.2552
    {'fl_cor_v_ss'       }      0.93205       0.74094             1       0.21386       0.70816       0.26185
    {'fl_cov_n_ss'       }        0.833       0.19066        2.8206       0.82404      0.051157       0.25285    -0
    {'fl_cor_n_ss'       }      0.12075       0.22282       0.21386             1      0.039179       0.32555     -
    {'fl_cov_y_head_inc' }       8.8962        1.1168          14.8      0.051157         2.069       0.10701     -
    {'fl_cor_y_head_inc' }      0.81382       0.82371       0.70816      0.039179             1       0.08695
    {'fl_cov_y_spouse'   }       1.5795       0.19114        3.2552       0.25285       0.10701       0.73208     0
    {'fl_cor_y_spouse'   }      0.24292       0.23699       0.26185       0.32555       0.08695             1
    {'fl_cov_yshr_wage'  }     -0.49211     -0.043084      -0.82571    -0.0010612     -0.051178     0.0085014
    {'fl_cor_yshr_wage'  }     -0.75357      -0.53189      -0.66137     -0.013605      -0.41406       0.11563
    {'fl_cov_yshr_SS'    }            0             0             0             0             0             0
    {'fl_cor_yshr_SS'    }          NaN           NaN           NaN           NaN           NaN           NaN
    {'fl_cov_yshr_nttxss'}      0.18595      0.018907       0.38617     0.0064928      0.028554     0.0098282     -
    {'fl_cor_yshr_nttxss'}      0.86513       0.70922       0.93979        0.2529        0.7019       0.40615
    {'fracByP0_01'       }   0.00049206    1.8935e-05     0.0018764       0.28329    1.6223e-05             0    4.
    {'fracByP10'         }     0.038429      0.027522       0.35161       0.28329      0.022756             0
    {'fracByP25'         }      0.15239      0.088557       0.65681       0.28329      0.081638             0
    {'fracByP50'         }      0.38532       0.25604       0.94508       0.72028       0.23879             0
    {'fracByP75'         }      0.65807       0.51752        1.0572       0.72028        0.4917       0.14854
    {'fracByP90'         }      0.83502       0.75552        1.0505       0.85389       0.71833       0.42533
    {'fracByP99_99'      }      0.99977       0.99911        1.0001             1         0.999        0.9979

age =100
xxx tb_outcomes: all stats xxx
    OriginalVariableNames        ap_ss           c_ss           v_ss           n_ss        y_head_inc       y_spouse
    ______________________    ___________    ___________    __________    ___________    ___________    ___________

    {'mean'              }              1        0.32267       -3.1409         1.4797        0.25976       0.090594
    {'sd'                }     3.5527e-15        0.17242       0.94302        0.50567       0.022536        0.18604
    {'coefofvar'         }     3.5527e-15        0.53435      -0.30024        0.34173       0.086757         2.0536
    {'min'               }              1        0.21707       -9.9745              1        0.24433              0
    {'max'               }              1         140.65       0.99282              6         5.6926         1.7565
    {'pYis0'             }              0              0             0              0              0        0.52499
    {'pYls0'             }              0              0       0.99701              0              0              0
    {'pYgr0'             }              1              1     0.0029896              1              1        0.47501
    {'pYisMINY'          }              1        0.38656    2.0113e-10         0.5232        0.55431        0.52499
    {'pYisMAXY'          }              1              0             0     4.2206e-08              0      1.321e-08
    {'p0_01'             }              1        0.21707       -6.4374              1        0.24433              0
    {'p10'               }              1        0.21707       -3.6791              1        0.24433              0
    {'p25'               }              1        0.21707       -3.6067              1        0.24433              0
    {'p50'               }              1        0.25723       -3.6067              1        0.24433              0
    {'p75'               }              1        0.36309       -2.8876              2        0.29263        0.10311
    {'p90'               }              1        0.50168        -1.819              2        0.29263        0.24116
    {'p99_99'            }              1         1.8447       0.23336              4        0.31763         1.6611
    {'fl_cov_ap_ss'      }     1.2622e-29    -6.2617e-30    6.0422e-29    -2.5736e-29    -5.0486e-30    -1.4744e-30
    {'fl_cor_ap_ss'      }              1    -1.0222e-14    1.8035e-14    -1.4326e-14    -6.3058e-14    -2.2307e-15
    {'fl_cov_c_ss'       }    -6.2617e-30       0.029727        0.1377       0.049528      0.0011258       0.029696
    {'fl_cor_c_ss'       }    -1.0222e-14              1        0.8469        0.56809        0.28973        0.92578
    {'fl_cov_v_ss'       }     6.0422e-29         0.1377       0.88928        0.13864      0.0090605        0.12887
    {'fl_cor_v_ss'       }     1.8035e-14         0.8469             1        0.29075        0.42634        0.73454
    {'fl_cov_n_ss'       }    -2.5736e-29       0.049528       0.13864         0.2557      0.0016977       0.047692
    {'fl_cor_n_ss'       }    -1.4326e-14        0.56809       0.29075              1        0.14898        0.50696
    {'fl_cov_y_head_inc' }    -5.0486e-30      0.0011258     0.0090605      0.0016977     0.00050787      0.0005624
    {'fl_cor_y_head_inc' }    -6.3058e-14        0.28973       0.42634        0.14898              1        0.13414
    {'fl_cov_y_spouse'   }    -1.4744e-30       0.029696       0.12887       0.047692      0.0005624       0.034611
    {'fl_cor_y_spouse'   }    -2.2307e-15        0.92578       0.73454        0.50696        0.13414              1
    {'fl_cov_yshr_wage'  }    -2.8197e-30       0.031233       0.14436        0.08326     0.00060599       0.034569
    {'fl_cor_yshr_wage'  }    -3.6954e-15        0.84344       0.71277        0.76664         0.1252        0.86517
    {'fl_cov_yshr_SS'    }    -1.9134e-29       -0.03166      -0.14677      -0.084206    -0.00062745       -0.03464
    {'fl_cor_yshr_SS'    }     -2.496e-14       -0.85097      -0.72129       -0.77173       -0.12903       -0.86288
    {'fl_cov_yshr_nttxss'}     1.3054e-29       0.034596       0.16109       0.090587     0.00077099       0.037835
    {'fl_cor_yshr_nttxss'}     1.5717e-14         0.8583        0.7307        0.76628        0.14634         0.8699
    {'fracByP0_01'       }              1        0.26006    0.00032592        0.35357        0.52138              0
    {'fracByP10'         }              1        0.26006       0.20378        0.35357        0.52138              0
    {'fracByP25'         }              1        0.26006       0.67085        0.35357        0.52138              0
    {'fracByP50'         }              1        0.41437       0.67085        0.35357        0.52138              0
    {'fracByP75'         }              1        0.59565       0.86725        0.99419        0.90276        0.17769
    {'fracByP90'         }              1        0.77472       0.96654        0.99419        0.90276        0.44354
    {'fracByP99_99'      }              1        0.99967             1        0.99999        0.99992        0.99968
```