Value and Consumption Low vs Higher Interest Rates Results Comparison

This is the example vignette for function: **snw_vfi_main_bisec_vec** from the **PrjOptiSNW Package.** This function solves for the V(states) for individuals at lower and higher savings interest rates. Note that welfare improves for all when interest rates go up for savings in a model where borrowing is not allowed. However, a change in the interest rate generates an income effect (higher resources) and changes the relative price of consumption today vs. tomorrow. The change in income increases the incentive to consume, but the change in relative price depresses incentives to consume today. The combined effect of rising interest rate on savings on consumption/savings differs by the state-space; households might overall consume more or less depending on their state-space.

Solve Model at 4 Percent Interest Rate

Solve the benchmark model at 4 percent savings interest rate.

```
% mp_params = snw_mp_param('default_dense');
mp_params = snw_mp_param('default_docdense');
mp_params('beta') = 0.95;
fl_higher_r = 0.04;
fl_lower_r = 0.02;
mp_params('r') = fl_higher_r;
mp_controls = snw_mp_control('default_test');
mp_controls('bl_print_vfi') = false;
mp_controls('bl_print_vfi_verbose') = false;
mp_controls('bl_timer') = true;
[V_ss_r04,~,cons_ss_r04,~] = snw_vfi_main_bisec_vec(mp_params, mp_controls);
```

```
Completed SNW_VFI_MAIN_BISEC_VEC;SNW_MP_PARAM=default_docdense;SNW_MP_CONTROL=default_test;time=496.1817
```

Solve Model at 2 Percent Interest Rate

Solve the benchmark model at 2 percent savings interest rate.

```
mp_params('r') = fl_lower_r;
mp_controls = snw_mp_control('default_test');
mp_controls('bl_print_vfi') = false;
mp_controls('bl_print_vfi_verbose') = false;
mp_controls('bl_timer') = true;
[V_ss_r02,~,cons_ss_r02,~] = snw_vfi_main_bisec_vec(mp_params, mp_controls);
```

```
Completed SNW_VFI_MAIN_BISEC_VEC;SNW_MP_PARAM=default_docdense;SNW_MP_CONTROL=default_test;time=495.0637
```

Generate Interest Rate Comparison Matrixes

Take the difference between 4 percent and 2 percent savings interest rate results. When interest rates are higher, greater incentive to save, but leads to heterogeneous responses by income and other characteristics, note that this changes both relative prices as well as total resource/budget, so there is both income and price effects that differ in magnitudes depending on the individual's statespace. Welfare does improve for all higher higher r. Welfare is converted to units in fixed life-time consumption.

```
gamma = mp_params('gamma');
mn_V_gain_r = snw_hh_welfare(V_ss_r04, gamma) - snw_hh_welfare(V_ss_r02, gamma);
mn_C_gain_r = cons_ss_r04 - cons_ss_r02;
fl_r_gap = fl_higher_r - fl_lower_r;
```

Dense Param Results Define Frames

Define the matrix dimensions names and dimension vector values. 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 Difference in V and C with Higher and Lower Savings Interest Rate

The difference between V and C with higher and lower r.

```
% Generate some Data
mp_support_graph = containers.Map('KeyType', 'char', 'ValueType', 'any');
mp_support_graph('cl_st_xtitle') = {'Savings States, a'};
mp_support_graph('st_legend_loc') = 'eastoutside';
mp_support_graph('bl_graph_logy') = true; % do not log
mp_support_graph('it_legend_select') = 21; % how many shock legends to show
mp_support_graph('cl_colors') = 'jet';
```

MEAN(MN_V_GAIN(A,Z))

Tabulate value and policies along savings and shocks:

```
% Set
ar_permute = [1,4,5,6,3,2];
% Value Function
st_title = ['MEAN(MN_V_Gain(A,Z)), r_gap=' num2str(fl_r_gap) ];
tb_az_v = ff_summ_nd_array(st_title, mn_V_gain_r, true, ["mean"], 4, 1, cl_mp_datasetdesc, ar_p
```

xxx MEAN(MN_V_Gain(A,Z)), r_gap=0.02 xxxxxxxxxxxxxxxxxxxxxxxxxxx

group	savings	mean_eta_1	mean_eta_2	mean_eta_3	mean_eta_4	mean_eta_5	mean_eta_6	mean_
1	0	4.6652e-05	4.802e-05	4.9487e-05	5.1045e-05	5.2688e-05	5.4417e-05	5.623
2	0.00051498	4.725e-05	4.8601e-05	5.0052e-05	5.1595e-05	5.3225e-05	5.4941e-05	5.674
3	0.0041199	5.1273e-05	5.2516e-05	5.3868e-05	5.532e-05	5.6863e-05	5.8496e-05	6.022
4	0.013905	6.118e-05	6.2221e-05	6.3373e-05	6.4635e-05	6.5996e-05	6.7452e-05	6.900
5	0.032959	7.7395e-05	7.8196e-05	7.9136e-05	8.0192e-05	8.1347e-05	8.2598e-05	8.394
6	0.064373	9.9291e-05	9.9974e-05	0.00010079	0.00010171	0.00010271	0.00010381	0.000

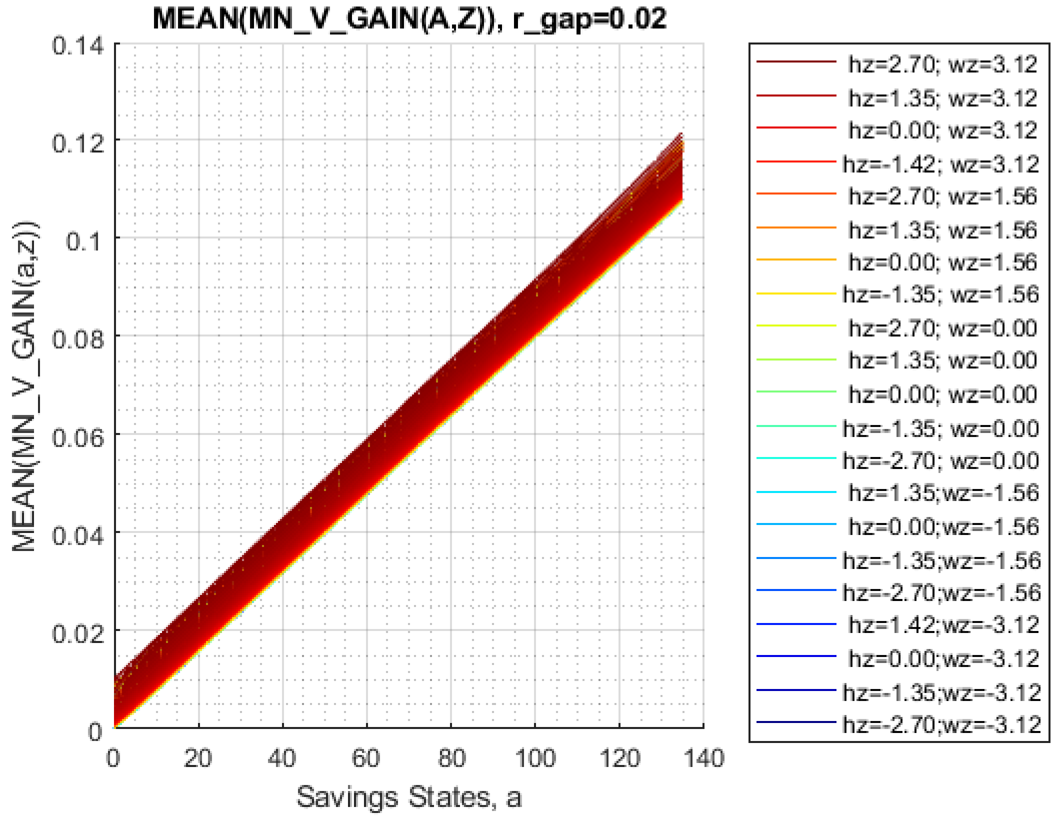
```
% Consumption
st_title = ['MEAN(MN_C_Gain(A,Z)), r_gap=' num2str(fl_r_gap) ];
tb_az_c = ff_summ_nd_array(st_title, mn_C_gain_r, true, ["mean"], 4, 1, cl_mp_datasetdesc, ar_p
```

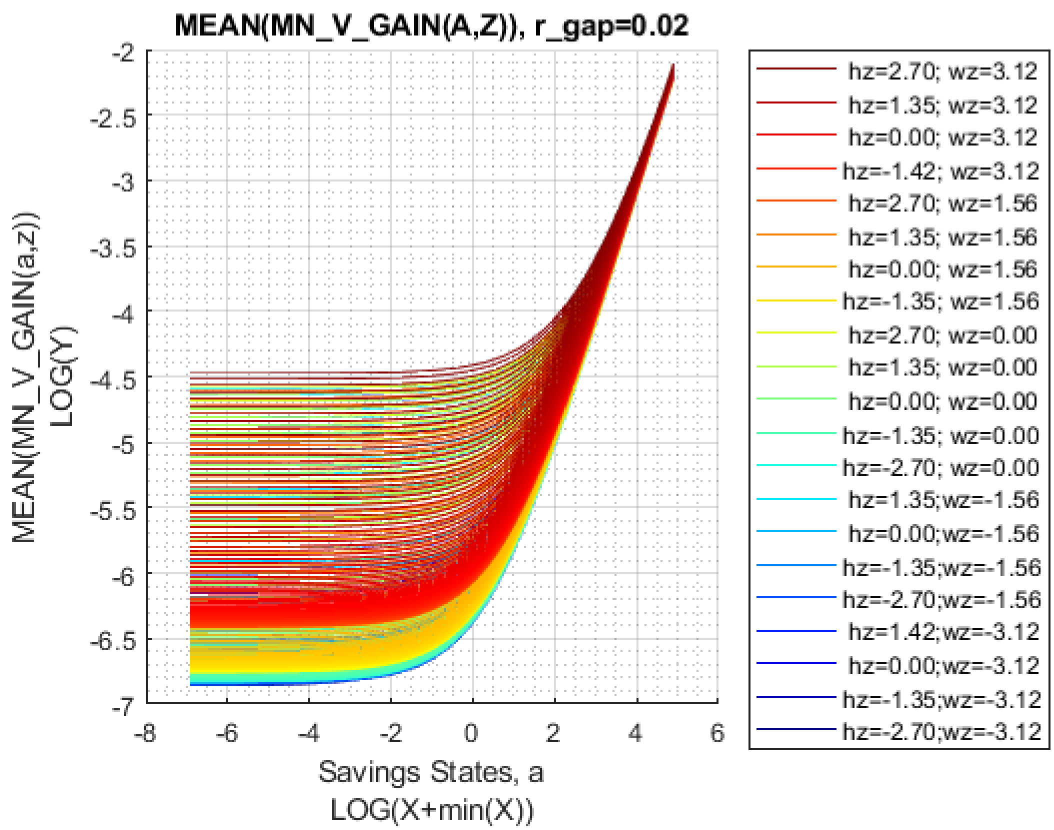
xxx MEAN(MN_C_Gain(A,Z)), r_gap=0.02 xxxxxxxxxxxxxxxxxxxxxxxxxxx

group	savings	mean_eta_1	mean_eta_2	mean_eta_3	mean_eta_4	mean_eta_5	mean_eta_6
1	0	0	0	0	0	0	0
2	0.00051498	9.0758e-06	9.0577e-06	9.0392e-06	9.0202e-06	9.0007e-06	8.9809e-06
3	0.0041199	6.9258e-05	5.9037e-05	5.5968e-05	5.437e-05	5.3887e-05	5.3137e-05
4	0.013905	0.0001131	0.00016511	0.00017196	0.00016519	0.00015748	0.0001458
5	0.032959	0.00026095	0.00020294	0.0001617	0.00014482	0.00014062	0.00014373
6	0.064373	0.00022015	0.00011898	5.4936e-05	2.3556e-05	1.5431e-05	2.7756e-05

Graph Mean Values:

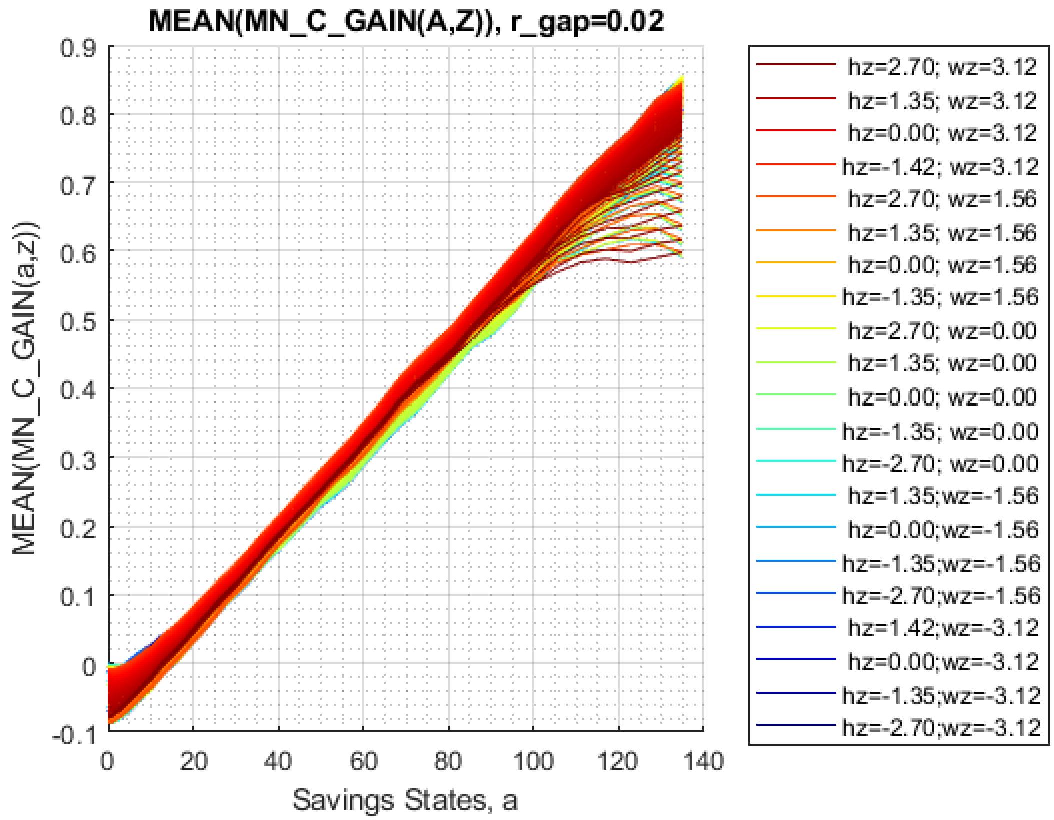
```
st_title = ['MEAN(MN\_V\_GAIN(A,Z)), r\_gap=' num2str(fl_r_gap)  ''];
mp_support_graph('cl_st_graph_title') = {st_title};
mp_support_graph('cl_st_ytitle') = {'MEAN(MN\_V\_GAIN(a,z))'};
ff_graph_grid((tb_az_v{1:end, 3:end})', ar_st_eta_HS_grid, agrid, mp_support_graph);
```

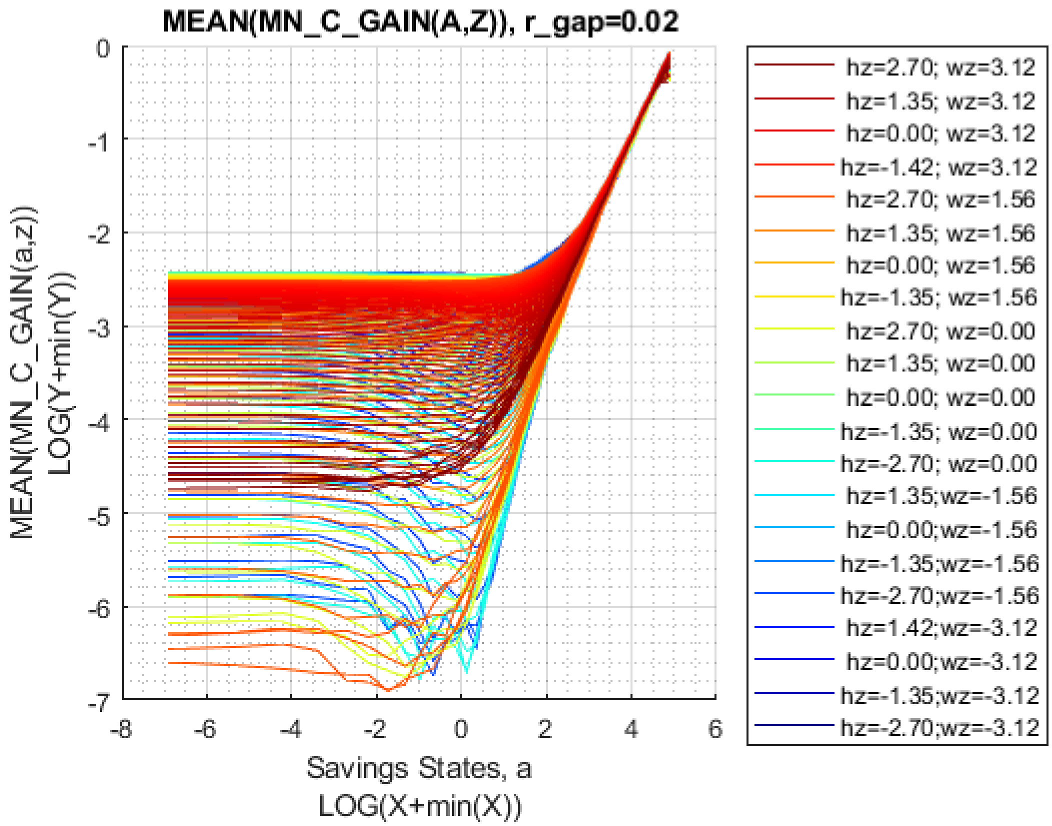




Graph Mean Consumption:

```
st_title = ['MEAN(MN\_C\_GAIN(A,Z)), r\_gap=' num2str(fl_r_gap)  ''];
mp_support_graph('cl_st_graph_title') = {st_title};
mp_support_graph('cl_st_ytitle') = {'MEAN(MN\_C\_GAIN(a,z))'};
ff_graph_grid((tb_az_c{1:end, 3:end})', ar_st_eta_HS_grid, agrid, mp_support_graph);
```





Analyze Kids and Marriage and Age

Aggregating over education, savings, and shocks, what are the differential effects of Marriage and Age.

```
% Generate some Data
mp_support_graph = containers.Map('KeyType', 'char', 'ValueType', 'any');
ar_row_grid = [...
    "k0M0", "K1M0", "K2M0", "K3M0", "K4M0", ...
    "k0M1", "K1M1", "K2M1", "K3M1", "K4M1"];
mp_support_graph('cl_st_xtitle') = {'Age'};
mp_support_graph('st_legend_loc') = 'best';
mp_support_graph('bl_graph_logy') = true; % do not log
mp_support_graph('st_rounding') = '6.2f'; % format shock legend
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'};
```

MEAN(VAL(KM,J)), MEAN(AP(KM,J)), MEAN(C(KM,J))

Tabulate value and policies:

```
% Set
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
ar_permute = [2,3,4,1,6,5];
% Value Function
```

```
st_title = ['MEAN(MN_V_Gain(KM,J)), r_gap=' num2str(fl_r_gap) ];
tb_az_v = ff_summ_nd_array(st_title, mn_V_gain_r, true, ["mean"], 3, 1, cl_mp_datasetdesc, ar_p
```

```
xxx  MEAN(MN_V_Gain(KM,J)), r_gap=0.02  xxxxxxxxxxxxxxxxxxxxxxxxxxx
```

group	kids	marry	mean_age_18	mean_age_19	mean_age_20	mean_age_21	mean_age_22	mean_age_23
1	1	0	0.015087	0.015546	0.016026	0.01653	0.017025	0.017508
2	2	0	0.011707	0.012061	0.012444	0.012858	0.013278	0.013703
3	3	0	0.010499	0.010777	0.011081	0.011412	0.011749	0.012091
4	4	0	0.0094894	0.0097107	0.0099547	0.010224	0.0105	0.010781
5	5	0	0.00886	0.0090319	0.0092234	0.0094371	0.0096558	0.0098787
6	1	1	0.010229	0.010593	0.010984	0.011405	0.011831	0.012259
7	2	1	0.008528	0.0087978	0.0090932	0.0094182	0.0097531	0.010096
8	3	1	0.0079012	0.0081252	0.0083716	0.0086439	0.0089244	0.0092117
9	4	1	0.0073246	0.0075062	0.0077075	0.0079319	0.0081637	0.0084017
10	5	1	0.00696	0.0071075	0.0072717	0.0074553	0.007644	0.0078372

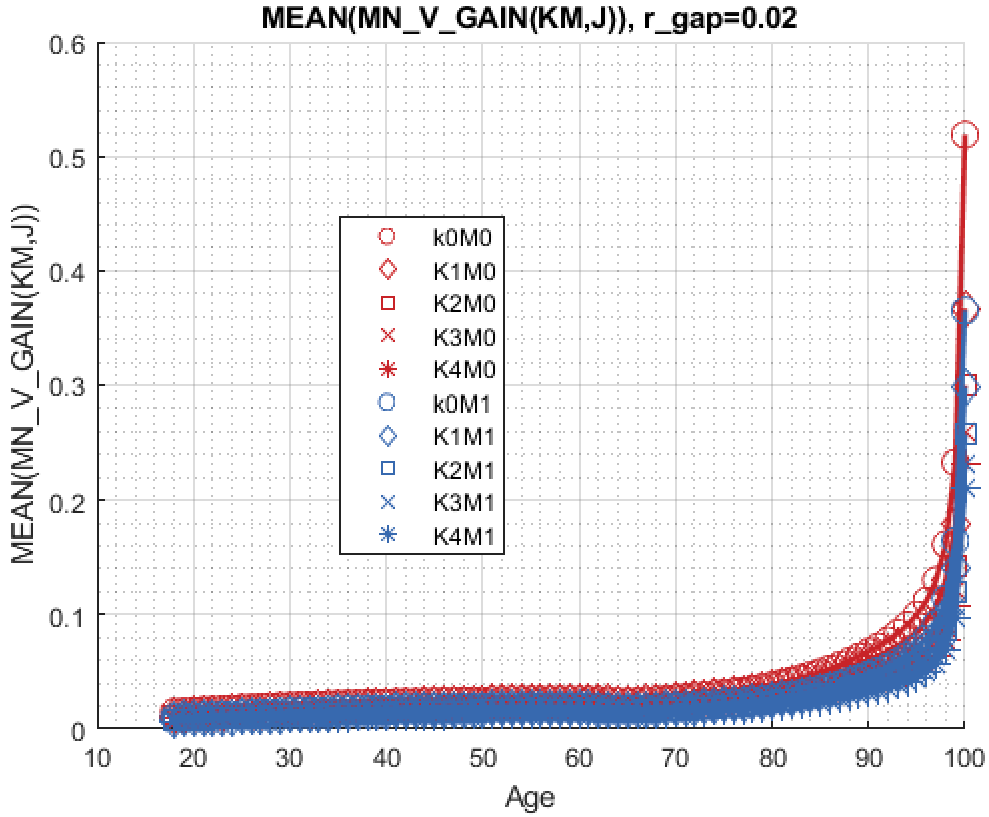
```
% Consumption Function
st_title = ['MEAN(MN_C_Gain(KM,J)), r_gap=' num2str(fl_r_gap) ];
tb_az_c = ff_summ_nd_array(st_title, mn_C_gain_r, true, ["mean"], 3, 1, cl_mp_datasetdesc, ar_p
```

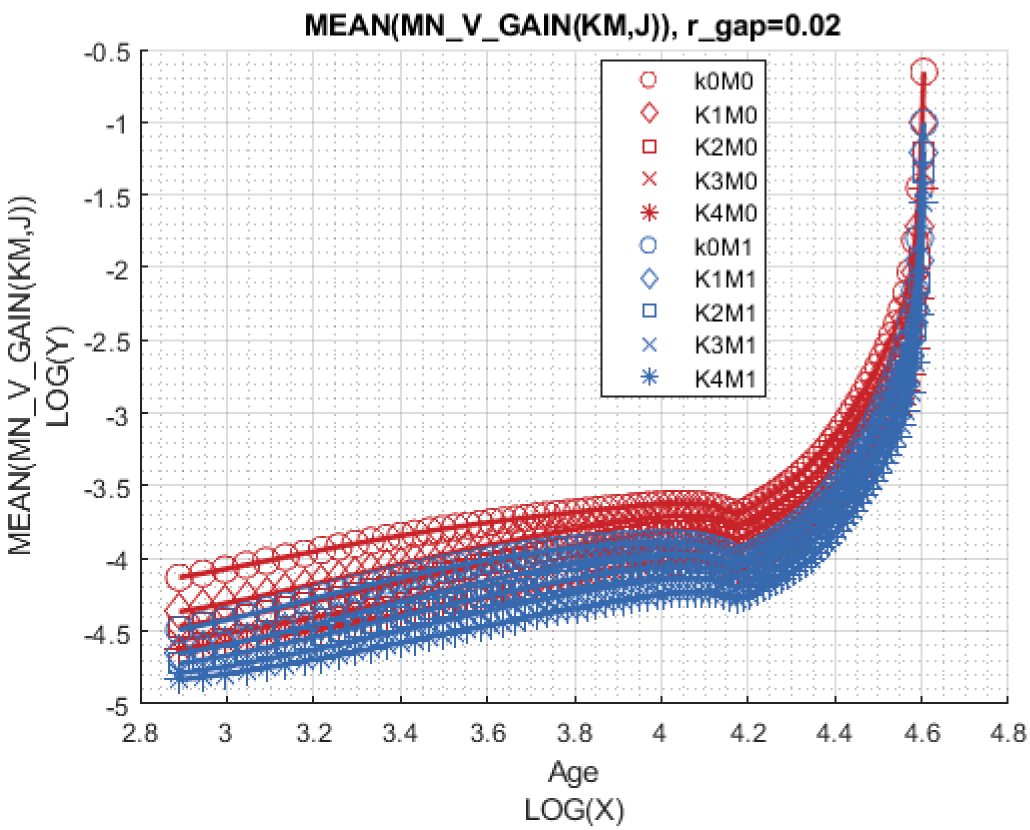
```
xxx  MEAN(MN_C_Gain(KM,J)), r_gap=0.02  xxxxxxxxxxxxxxxxxxxxxxxxxxx
```

group	kids	marry	mean_age_18	mean_age_19	mean_age_20	mean_age_21	mean_age_22	mean_age_23
1	1	0	0.055699	0.056856	0.058874	0.061289	0.064119	0.067235
2	2	0	0.051038	0.052145	0.054007	0.055436	0.057546	0.060312
3	3	0	0.050801	0.05338	0.054644	0.055147	0.05643	0.058389
4	4	0	0.050711	0.052919	0.054103	0.053992	0.05454	0.055872
5	5	0	0.052196	0.053297	0.054608	0.053912	0.053811	0.054449
6	1	1	-0.022203	-0.022187	-0.021707	-0.021466	-0.020507	-0.018751
7	2	1	-0.019706	-0.020509	-0.020942	-0.02173	-0.021723	-0.020839
8	3	1	-0.016291	-0.017215	-0.017899	-0.019714	-0.02062	-0.020552
9	4	1	-0.013267	-0.013589	-0.013895	-0.016006	-0.017459	-0.018261
10	5	1	-0.0131	-0.012701	-0.011796	-0.013633	-0.014917	-0.015545

Graph Mean Values:

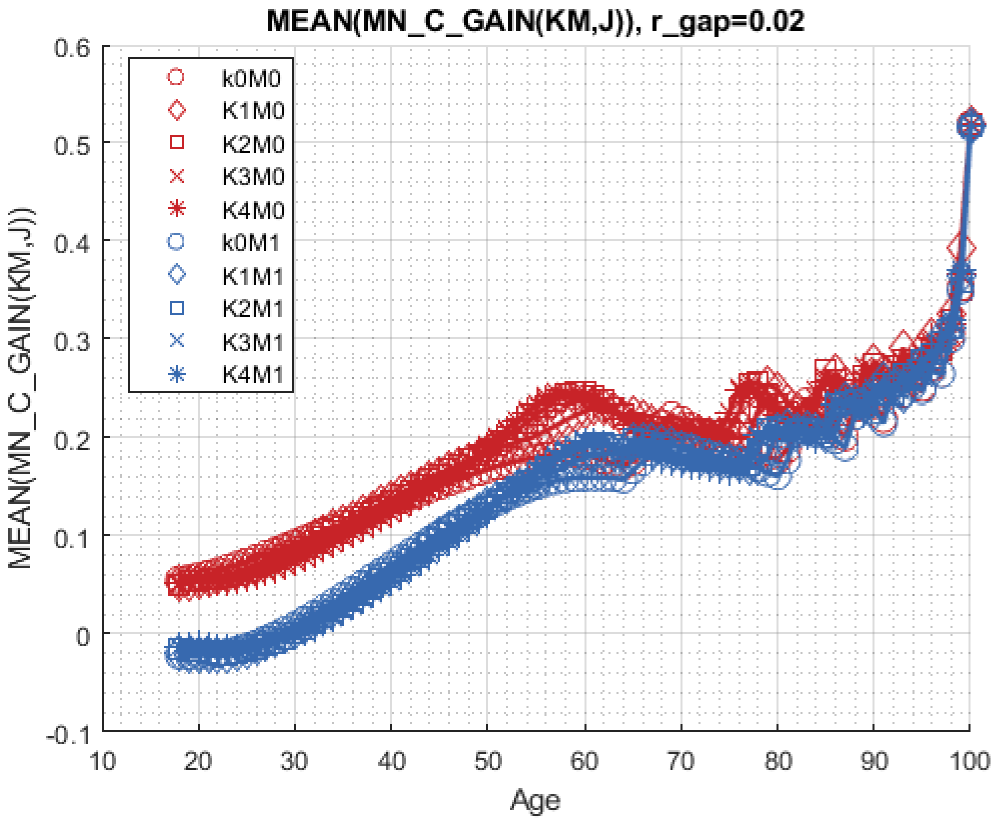
```
st_title = ['MEAN(MN\_V\_GAIN(KM,J)), r\_gap=' num2str(fl_r_gap)  ''];
mp_support_graph('cl_st_graph_title') = {st_title};
mp_support_graph('cl_st_ytitle') = {'MEAN(MN\_V\_GAIN(KM,J))'};
ff_graph_grid((tb_az_v{1:end, 4:end}), ar_row_grid, age_grid, mp_support_graph);
```

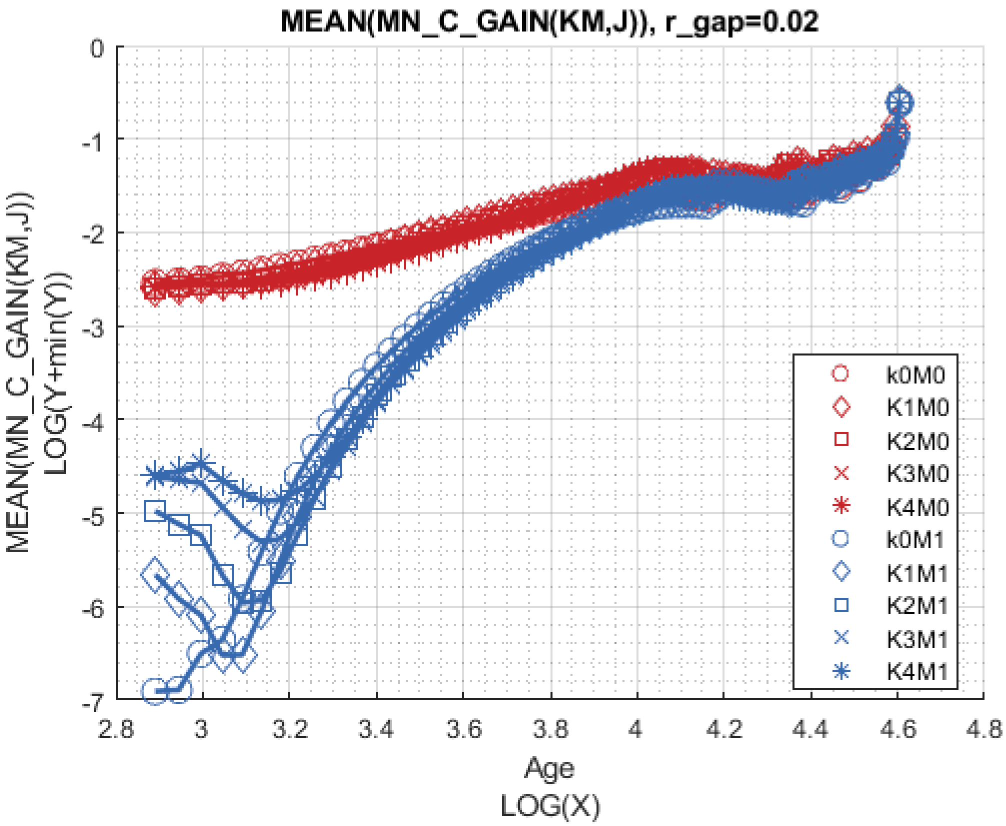




Graph Mean Consumption:

```
st_title = ['MEAN(MN\_C\_GAIN(KM,J)), r\_gap=' num2str(fl_r_gap)  ''];
mp_support_graph('cl_st_graph_title') = {st_title};
mp_support_graph('cl_st_ytitle') = {'MEAN(MN\_C\_GAIN(KM,J))'};
ff_graph_grid((tb_az_c{1:end, 4:end}), ar_row_grid, age_grid, mp_support_graph);
```





Analyze Education and Marriage

Aggregating over education, savings, and shocks, what are the differential effects of Marriage and Age.

```
% Generate some Data
mp_support_graph = containers.Map('KeyType', 'char', 'ValueType', 'any');
ar_row_grid = ["E0M0", "E1M0", "E0M1", "E1M1"];
mp_support_graph('cl_st_xtitle') = {'Age'};
mp_support_graph('st_legend_loc') = 'best';
mp_support_graph('bl_graph_logy') = true; % do not log
mp_support_graph('st_rounding') = '6.2f'; % format shock legend
mp_support_graph('cl_scatter_shapes') = {'*', 'p', '*','p' };
mp_support_graph('cl_colors') = {'red', 'red', 'blue', 'blue'};
```

MEAN(VAL(EM,J)), MEAN(AP(EM,J)), MEAN(C(EM,J))

Tabulate value and policies:

```
% Set
% NaN(n_jgrid,n_agrid,n_etagrid,n_educgrid,n_marriedgrid,n_kidsgrid);
ar_permute = [2,3,6,1,4,5];
% Value Function
st_title = ['MEAN(MN_V_Gain(EM,J)), r_gap=' num2str(fl_r_gap) ];
tb_az_v = ff_summ_nd_array(st_title, mn_V_gain_r, true, ["mean"], 3, 1, cl_mp_datasetdesc, ar_p
```

```
xxx  MEAN(MN_V_Gain(EM,J)), r_gap=0.02  xxxxxxxxxxxxxxxxxxxxxxxxxxx
    group    edu    marry    mean_age_18    mean_age_19    mean_age_20    mean_age_21    mean_age_22    mean_age_23
    _____    ___    _____    ___________    ___________    ___________    ___________    ___________    ___________
```

1	0	0	0.011474	0.011736	0.012012	0.012305	0.012599	0.012892
2	1	0	0.010783	0.011115	0.011479	0.011879	0.012285	0.012692
3	0	1	0.0084099	0.0086195	0.0088444	0.0090861	0.0093328	0.0095836
4	1	1	0.0079671	0.0082324	0.0085268	0.0088556	0.0091936	0.0095387

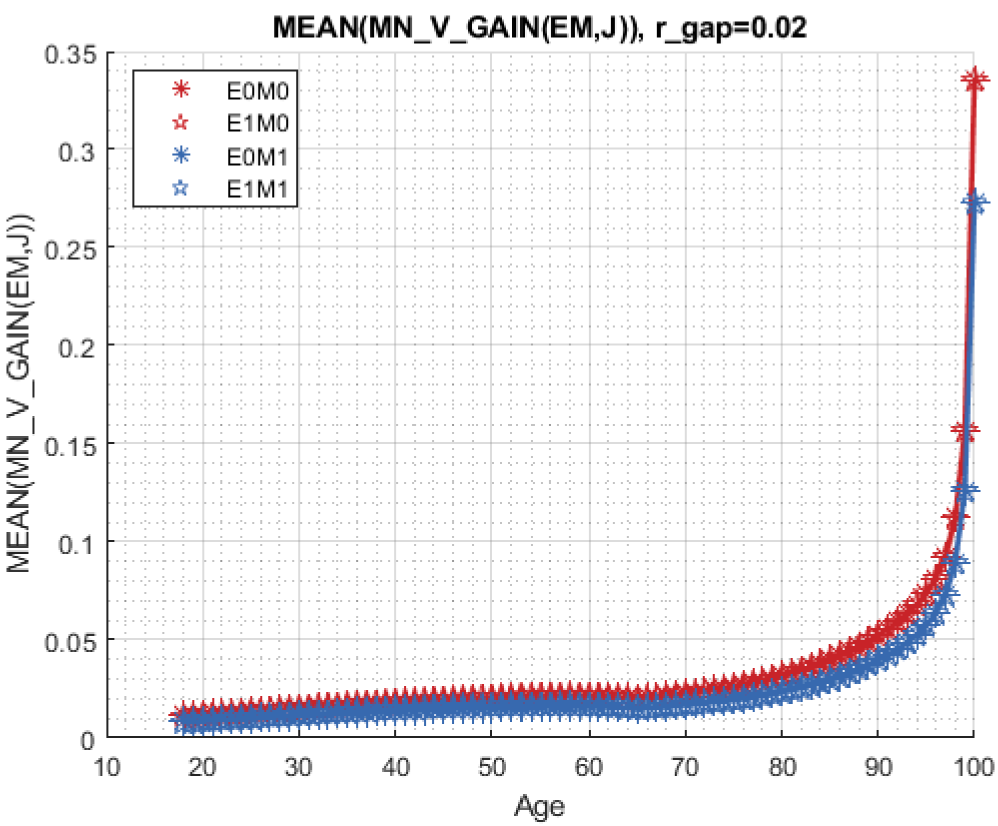
```
% Consumption
st_title = ['MEAN(MN_C_Gain(EM,J)), r_gap=' num2str(fl_r_gap) ];
tb_az_c = ff_summ_nd_array(st_title, mn_C_gain_r, true, ["mean"], 3, 1, cl_mp_datasetdesc, ar_p
```

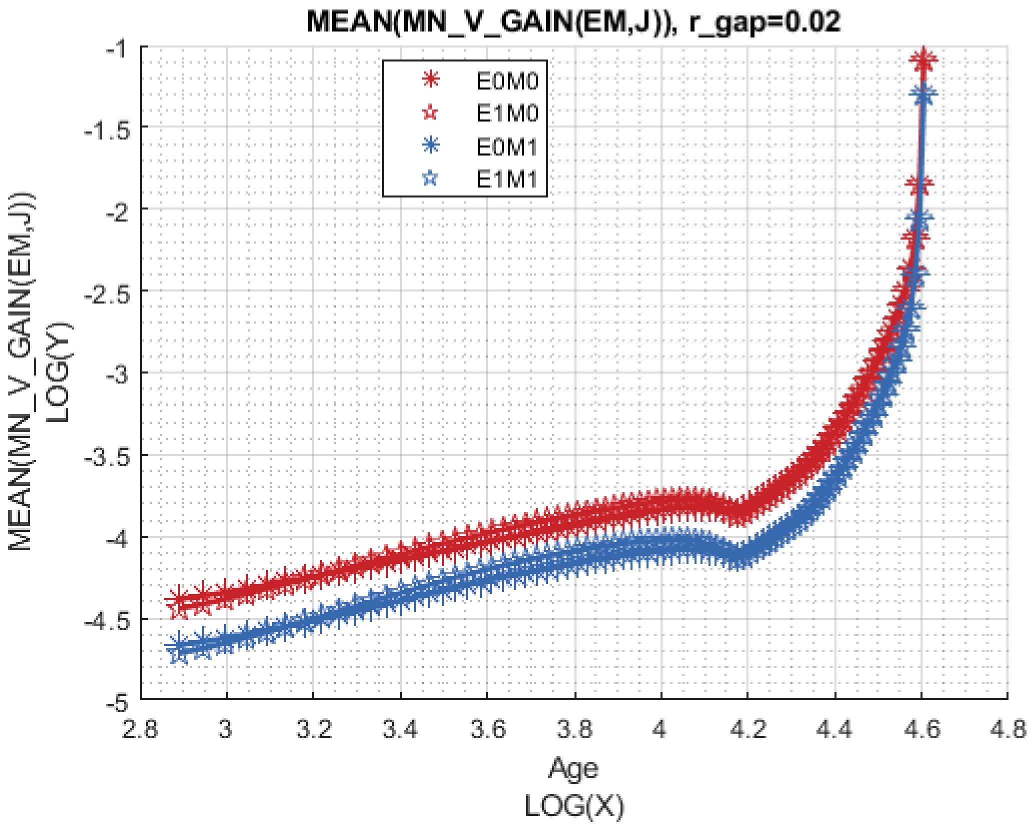
xxx MEAN(MN_C_Gain(EM,J)), r_gap=0.02   xxxxxxxxxxxxxxxxxxxxxxxxxxx

group	edu	marry	mean_age_18	mean_age_19	mean_age_20	mean_age_21	mean_age_22	mean_age_23
1	0	0	0.06916	0.070507	0.072258	0.07446	0.076888	0.07952
2	1	0	0.035018	0.036932	0.038237	0.03745	0.037691	0.038982
3	0	1	-0.0014877	-0.001014	-0.00023405	0.00057466	0.0018134	0.0035145
4	1	1	-0.032339	-0.033466	-0.034261	-0.037595	-0.039904	-0.041093

Graph Mean Values:

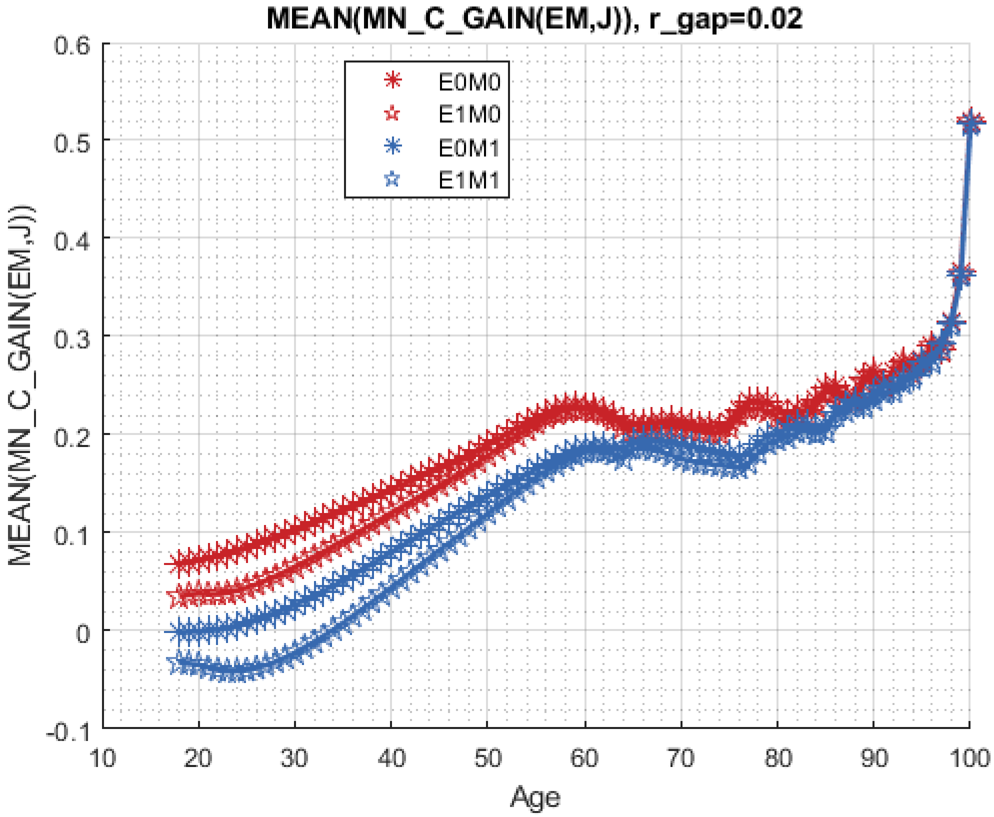
```
st_title = ['MEAN(MN\_V\_GAIN(EM,J)), r\_gap=' num2str(fl_r_gap)  ''];
mp_support_graph('cl_st_graph_title') = {st_title};
mp_support_graph('cl_st_ytitle') = {'MEAN(MN\_V\_GAIN(EM,J))'};
ff_graph_grid((tb_az_v{1:end, 4:end}), ar_row_grid, age_grid, mp_support_graph);
```

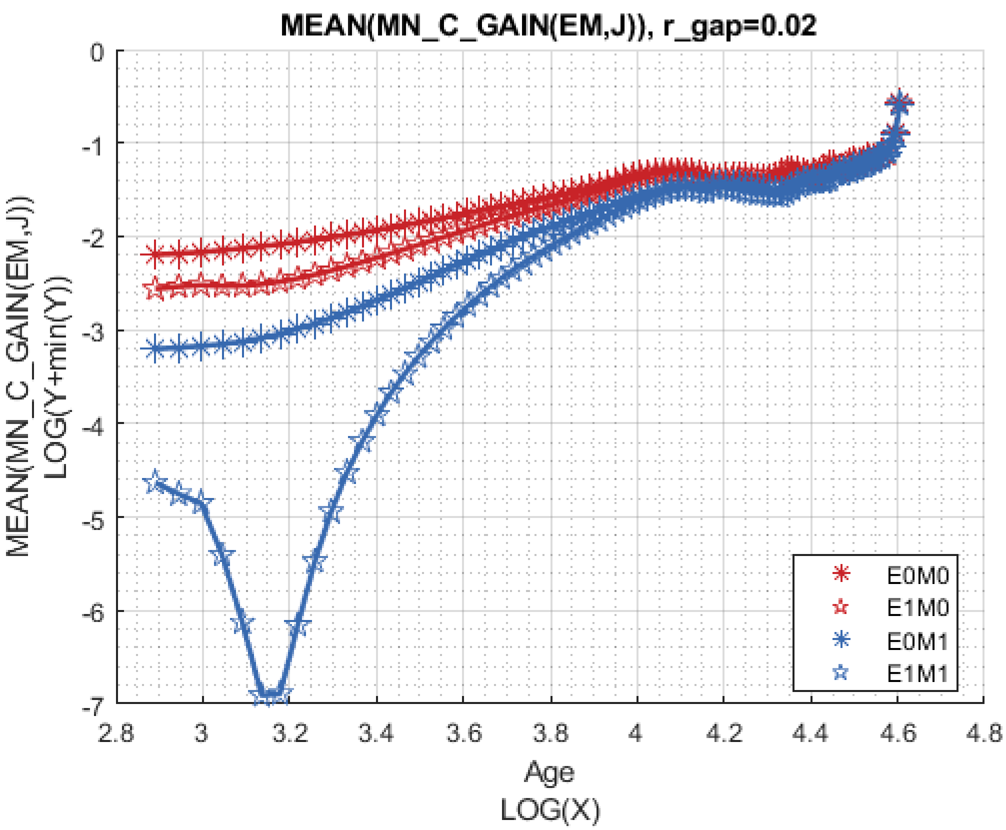




Graph Mean Consumption:

```
st_title = ['MEAN(MN\_C\_GAIN(EM,J)), r\_gap=' num2str(fl_r_gap)  ''];
mp_support_graph('cl_st_graph_title') = {st_title};
mp_support_graph('cl_st_ytitle') = {'MEAN(MN\_C\_GAIN(EM,J))'};
ff_graph_grid((tb_az_c{1:end, 4:end}), ar_row_grid, age_grid, mp_support_graph);
```


MEAN(MN_C_GAIN(EM,J)), r_gap=0.02
MEAN(MN_C_GAIN(EM,J))
Age
E0M0
E1M0
E0M1
E1M1
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
10
20
30
40
50
60
70
80
90
100


MEAN(MN_C_GAIN(EM,J)), r_gap=0.02
MEAN(MN_C_GAIN(EM,J))
LOG(Y+min(Y))
Age
LOG(X)
E0M0
E1M0
E0M1
E1M1
0
-1
-2
-3
-4
-5
-6
-7
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8