In[ ]:=
```
SetDirectory[
  "C:/Users/serha/OneDrive/Masaüstü/MyRepo/master_thesis_MMT003/210714_finalising/
    fxd_bounds/"];
```

Objective Function Terms: Initial + 25% Reduced + 50% Reduced + 75% Reduced

Objective Function Intervals: (-4,4), (-1,1), (-2,-4), (2,4)

Data Input

In[ ]:=
```
modularityvalues12m4p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-4,4)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues32m4p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-4,4)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
zscores12m4p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-4,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores32m4p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-4,4)_-5+5_quadrupled-zscores-fbs.mx"];

modularityvalues12m1p1x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-1,1)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues32m1p1x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-1,1)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
zscores12m1p1x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-1,1)_-5+5_quadrupled-zscores-fss.mx"];
zscores32m1p1x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-1,1)_-5+5_quadrupled-zscores-fbs.mx"];

modularityvalues12m2m4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-2,-4)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues32m2m4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-2,-4)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
zscores12m2m4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-2,-4)_-5+5_quadrupled-zscores-fss.mx"];
zscores32m2m4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(-2,-4)_-5+5_quadrupled-zscores-fbs.mx"];

modularityvalues12p2p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(2,4)_-5+5_quadrupled-modularityvalues-fss
     .mx"];
modularityvalues32p2p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(2,4)_-5+5_quadrupled-modularityvalues-fbs
     .mx"];
zscores12p2p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(2,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores32p2p4x75 = Import[
   "plot_values/fxd_bounds/75percentdecreased_(2,4)_-5+5_quadrupled-zscores-fbs.mx"];
```

In[ ]:=
```
modularityvalues12m4p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-4,4)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues12m1p1x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-1,1)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues12m2m4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-2,-4)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues12p2p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(2,4)_-5+5_quadrupled-modularityvalues-fss
     .mx"];
modularityvalues32m4p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-4,4)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
modularityvalues32m1p1x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-1,1)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
modularityvalues32m2m4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-2,-4)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
modularityvalues32p2p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(2,4)_-5+5_quadrupled-modularityvalues-fbs
     .mx"];
zscores12m4p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-4,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores12m1p1x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-1,1)_-5+5_quadrupled-zscores-fss.mx"];
zscores12m2m4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-2,-4)_-5+5_quadrupled-zscores-fss.mx"];
zscores12p2p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(2,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores32m4p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-4,4)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32m1p1x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-1,1)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32m2m4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(-2,-4)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32p2p4x50 = Import[
   "plot_values/fxd_bounds/50percentdecreased_(2,4)_-5+5_quadrupled-zscores-fbs.mx"];
```

In[ ]:=
```
modularityvalues12m4p4initial =
  Import["plot_values/fxd_bounds/(-4,4)_-5+5_quadrupled-modularityvalues-fss.mx"];
modularityvalues12m1p1initial =
  Import["plot_values/fxd_bounds/(-1,1)_-5+5_quadrupled-modularityvalues-fss.mx"];
modularityvalues12m2m4initial =
  Import["plot_values/fxd_bounds/(-2,-4)_-5+5_quadrupled-modularityvalues-fss.mx"];
modularityvalues12p2p4initial =
  Import["plot_values/fxd_bounds/(2,4)_-5+5_quadrupled-modularityvalues-fss.mx"];
modularityvalues32m4p4initial =
  Import["plot_values/fxd_bounds/(-4,4)_-5+5_quadrupled-modularityvalues-fbs.mx"];
modularityvalues32m1p1initial =
  Import["plot_values/fxd_bounds/(-1,1)_-5+5_quadrupled-modularityvalues-fbs.mx"];
modularityvalues32m2m4initial =
  Import["plot_values/fxd_bounds/(-2,-4)_-5+5_quadrupled-modularityvalues-fbs.mx"];
modularityvalues32p2p4initial =
  Import["plot_values/fxd_bounds/(2,4)_-5+5_quadrupled-modularityvalues-fbs.mx"];
zscores12m4p4initial = Import[
   "plot_values/fxd_bounds/(-4,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores12m1p1initial = Import[
   "plot_values/fxd_bounds/(-1,1)_-5+5_quadrupled-zscores-fss.mx"];
zscores12m2m4initial = Import[
   "plot_values/fxd_bounds/(-2,-4)_-5+5_quadrupled-zscores-fss.mx"];
zscores12p2p4initial = Import[
   "plot_values/fxd_bounds/(2,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores32m4p4initial = Import[
   "plot_values/fxd_bounds/(-4,4)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32m1p1initial = Import[
   "plot_values/fxd_bounds/(-1,1)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32m2m4initial = Import[
   "plot_values/fxd_bounds/(-2,-4)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32p2p4initial = Import[
   "plot_values/fxd_bounds/(2,4)_-5+5_quadrupled-zscores-fbs.mx"];
```

In[ ]:=
```
modularityvalues12m4p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-4,4)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues12m1p1x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-1,1)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues12m2m4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-2,-4)_-5+5_quadrupled-modularityvalues-
     fss.mx"];
modularityvalues12p2p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(2,4)_-5+5_quadrupled-modularityvalues-fss
     .mx"];
modularityvalues32m4p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-4,4)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
modularityvalues32m1p1x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-1,1)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
modularityvalues32m2m4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-2,-4)_-5+5_quadrupled-modularityvalues-
     fbs.mx"];
modularityvalues32p2p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(2,4)_-5+5_quadrupled-modularityvalues-fbs
     .mx"];
zscores12m4p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-4,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores12m1p1x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-1,1)_-5+5_quadrupled-zscores-fss.mx"];
zscores12m2m4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-2,-4)_-5+5_quadrupled-zscores-fss.mx"];
zscores12p2p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(2,4)_-5+5_quadrupled-zscores-fss.mx"];
zscores32m4p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-4,4)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32m1p1x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-1,1)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32m2m4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(-2,-4)_-5+5_quadrupled-zscores-fbs.mx"];
zscores32p2p4x25 = Import[
   "plot_values/fxd_bounds/25percentdecreased_(2,4)_-5+5_quadrupled-zscores-fbs.mx"];
```

```
In[•]:= {modmeanm4p4fss, modmeanm4p4fbs} =
         {{Mean@modularityvalues12m4p4initial, Mean@modularityvalues12m4p4x25,
           Mean@modularityvalues12m4p4x50, Mean@modularityvalues12m4p4x75},
          {Mean@modularityvalues32m4p4initial, Mean@modularityvalues32m4p4x25,
           Mean@modularityvalues32m4p4x50, Mean@modularityvalues32m4p4x75}}
        {modmeanm1p1fss, modmeanm1p1fbs} =
         {{Mean@modularityvalues12m1p1initial, Mean@modularityvalues12m1p1x25,
           Mean@modularityvalues12m1p1x50, Mean@modularityvalues12m1p1x75},
          {Mean@modularityvalues32m1p1initial, Mean@modularityvalues32m1p1x25,
           Mean@modularityvalues32m1p1x50, Mean@modularityvalues32m1p1x75}}

        {modmeanm2m4fss, modmeanm2m4fbs} =
         {{Mean@modularityvalues12m2m4initial, Mean@modularityvalues12m2m4x25,
           Mean@modularityvalues12m2m4x50, Mean@modularityvalues12m2m4x75},
          {Mean@modularityvalues32m2m4initial, Mean@modularityvalues32m2m4x25,
           Mean@modularityvalues32m2m4x50, Mean@modularityvalues32m2m4x75}}
        {modmeanp2p4fss, modmeanp2p4fbs} =
         {{Mean@modularityvalues12p2p4initial, Mean@modularityvalues12p2p4x25,
           Mean@modularityvalues12p2p4x50, Mean@modularityvalues12p2p4x75},
          {Mean@modularityvalues32p2p4initial, Mean@modularityvalues32p2p4x25,
           Mean@modularityvalues32p2p4x50, Mean@modularityvalues32p2p4x75}}
Out[•]= {{0.263054, 0.259725, 0.247466, 0.209104}, {0.265641, 0.283487, 0.271783, 0.264361}}

Out[•]= {{0.170679, 0.161676, 0.154594, 0.10896}, {0.182671, 0.20983, 0.191101, 0.173831}}

Out[•]= {{0.431538, 0.413249, 0.41254, 0.391314}, {0.270442, 0.309967, 0.349992, 0.402451}}

Out[•]= {{0.432519, 0.422058, 0.407961, 0.399662}, {0.275542, 0.308831, 0.351648, 0.41214}}

In[•]:= {zscoremeanm4p4fss, zscoremeanm4p4fbs} =
         {{Mean@zscores12m4p4initial, Mean@zscores12m4p4x25,
           Mean@zscores12m4p4x50, Mean@zscores12m4p4x75}, {Mean@zscores32m4p4initial,
           Mean@zscores32m4p4x25, Mean@zscores32m4p4x50, Mean@zscores32m4p4x75}}
        {zscoremeanm1p1fss, zscoremeanm1p1fbs} = {{Mean@zscores12m1p1initial,
           Mean@zscores12m1p1x25, Mean@zscores12m1p1x50, Mean@zscores12m1p1x75},
          {Mean@zscores32m1p1initial, Mean@zscores32m1p1x25,
           Mean@zscores32m1p1x50, Mean@zscores32m1p1x75}}

        {zscoremeanm2m4fss, zscoremeanm2m4fbs} =
         {{Mean@zscores12m2m4initial, Mean@zscores12m2m4x25,
           Mean@zscores12m2m4x50, Mean@zscores12m2m4x75}, {Mean@zscores32m2m4initial,
           Mean@zscores32m2m4x25, Mean@zscores32m2m4x50, Mean@zscores32m2m4x75}}
        {zscoremeanp2p4fss, zscoremeanp2p4fbs} =
         {{Mean@zscores12p2p4initial, Mean@zscores12p2p4x25,
           Mean@zscores12p2p4x50, Mean@zscores12p2p4x75}, {Mean@zscores32p2p4initial,
           Mean@zscores32p2p4x25, Mean@zscores32p2p4x50, Mean@zscores32p2p4x75}}
```

Out[•]= {{{22.8514, −0.949006}, {22.0625, −0.756384}, {19.231, −0.589147}, {14.5086, 0.104907}},
{{23.9807, 1.09324}, {24.3726, 1.46629}, {21.075, 1.46517}, {18.2562, 1.16346}}}

Out[•]= {{{2.75865, −0.047853}, {2.65045, 0.101006}, {2.17506, 0.107543}, {0.908024, −0.30337}},
{{3.37112, 0.72204}, {3.73323, 1.37335}, {2.83596, 0.99951}, {2.25728, 0.649746}}}

Out[•]= {{{18.1417, −0.365707}, {18.1907, 0.147069}, {19.0075, −0.402106}, {18.3042, −0.265954}},
{{14.0068, 1.08286}, {17.1897, 0.612909}, {18.2047, −0.121728}, {18.7603, −0.141816}}}

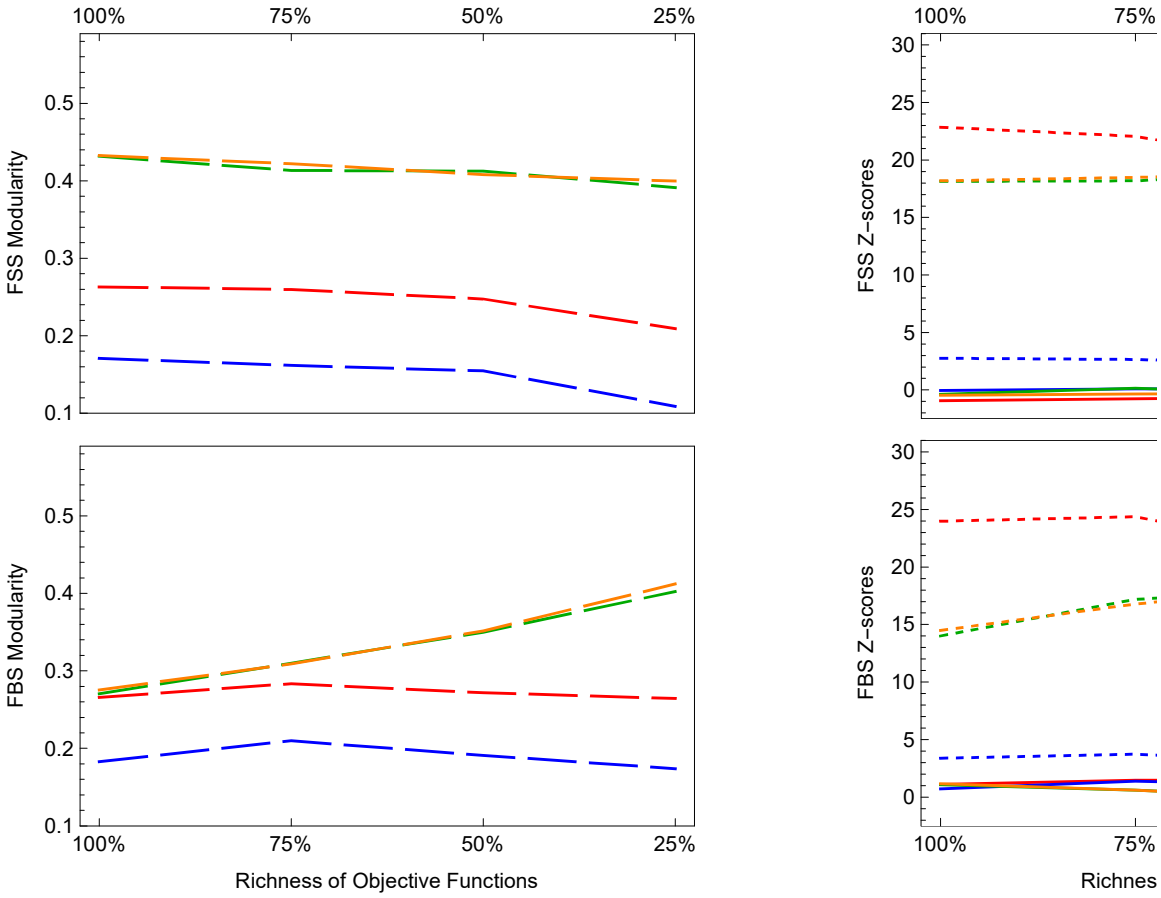
Out[•]= {{{18.1891, −0.472159}, {18.4894, −0.364599}, {18.8551, −0.291404}, {18.7303, −0.258127}},
{{14.4872, 1.14941}, {16.7866, 0.599444}, {18.3986, −0.213003}, {18.28, 0.0825762}}}

In[•]:=
```
richness = Range@4;
modvaluesfss = {Thread[{richness, modmeanm4p4fss}], Thread[{richness, modmeanm1p1fss}],
   Thread[{richness, modmeanm2m4fss}], Thread[{richness, modmeanp2p4fss}]};
modvaluesfbs = {Thread[{richness, modmeanm4p4fbs}], Thread[{richness, modmeanm1p1fbs}],
   Thread[{richness, modmeanm2m4fbs}], Thread[{richness, modmeanp2p4fbs}]};
zscoresfss = {Thread[{richness, zscoremeanm4p4fss[[All, 1]]}],
   Thread[{richness, zscoremeanm4p4fss[[All, 2]]}],
   Thread[{richness, zscoremeanm1p1fss[[All, 1]]}],
   Thread[{richness, zscoremeanm1p1fss[[All, 2]]}],
   Thread[{richness, zscoremeanm2m4fss[[All, 1]]}],
   Thread[{richness, zscoremeanm2m4fss[[All, 2]]}],
   Thread[{richness, zscoremeanp2p4fss[[All, 1]]}],
   Thread[{richness, zscoremeanp2p4fss[[All, 2]]}]};
zscoresfbs = {Thread[{richness, zscoremeanm4p4fbs[[All, 1]]}],
   Thread[{richness, zscoremeanm4p4fbs[[All, 2]]}],
   Thread[{richness, zscoremeanm1p1fbs[[All, 1]]}],
   Thread[{richness, zscoremeanm1p1fbs[[All, 2]]}],
   Thread[{richness, zscoremeanm2m4fbs[[All, 1]]}],
   Thread[{richness, zscoremeanm2m4fbs[[All, 2]]}],
   Thread[{richness, zscoremeanp2p4fbs[[All, 1]]}],
   Thread[{richness, zscoremeanp2p4fbs[[All, 2]]}]};
```

Plots

```
In[•]:= tickvalues = {{1, "100%"}, {2, "75%"}, {3, "50%"}, {4, "25%"}};
modularityplotrange = {0.1, 0.59};
zscoreplotrange = {-2.5, 31};
xaxisplotrange = {0.9, 4.1};
Row[{GraphicsRow[{GraphicsColumn[{ListLinePlot[modvaluesfss,
        Frame → True, FrameLabel → {{"FSS Modularity", None}, {None, None}},
        LabelStyle → 11, FrameTicks → {{All, None}, {None, tickvalues}},
        PlotStyle → {{Dashing[{0.08, 0.1 - 0.08}], Red}, {Dashing[{0.08, 0.1 - 0.08}], Blue},
          {Dashing[{0.08, 0.1 - 0.08}], Darker@Green}, {Dashing[{0.08, 0.1 - 0.08}],
           Orange}}, PlotRange → {xaxisplotrange, modularityplotrange}],
       ListLinePlot[modvaluesfbs, Frame → True, FrameLabel →
         {{"FBS Modularity", None}, {"Richness of Objective Functions", None}},
        FrameTicks → {{All, None}, {tickvalues, None}}, LabelStyle → 11,
        PlotStyle → {{Dashing[{0.08, 0.1 - 0.08}], Red}, {Dashing[{0.08, 0.1 - 0.08}], Blue},
          {Dashing[{0.08, 0.1 - 0.08}], Darker@Green}, {Dashing[{0.08, 0.1 - 0.08}],
           Orange}}, PlotRange → {xaxisplotrange, modularityplotrange}]},
      Spacings → 10, ImagePadding → 25], GraphicsColumn[{ListLinePlot[zscoresfss,
        Frame → True, FrameLabel → {{"FSS Z-scores", None}, {None, None}},
        LabelStyle → 11, FrameTicks → {{All, None}, {None, tickvalues}},
        PlotStyle → {{Dashed, Red}, Red, {Dashed, Blue}, Blue, {Dashed, Darker@Green},
          Darker@Green, {Dashed, Orange}, Orange}, PlotRange →
         {xaxisplotrange, zscoreplotrange}], ListLinePlot[zscoresfbs, Frame → True,
        FrameLabel → {{"FBS Z-scores", None}, {"Richness of Objective Functions", None}},
        FrameTicks → {{All, None}, {tickvalues, None}}, LabelStyle → 11,
        PlotStyle → {{Dashed, Red}, Red, {Dashed, Blue}, Blue,
          {Dashed, Darker@Green}, Darker@Green, {Dashed, Orange}, Orange},
        PlotRange → {xaxisplotrange, zscoreplotrange}]}, Spacings → 10,
      ImagePadding → 25]}, ImageSize → 900, Spacings → 1],
   Column[{LineLegend[{Blue, Red, Darker@Green, Orange},
      {"(-1, 1)", "(-4, 4)", "(-4,-2)", "(2, 4)"},
      LegendLayout → "Column", LegendFunction → "Frame",
      LegendLabel → "Objective Function\nCoefficient Intervals",
      LegendMarkerSize → {20, 20}],
     LineLegend[{Dashing[{0.4, Small}], Dashed, Black},
      {"Modularity", "Null M. Cons. \n Degrees", "Null M. Cons. \n Degrees & \n Modules"},
      LegendLayout → "Column", LegendFunction → "Frame",
      LegendMarkerSize → {26, 26}]}]}]
```

Out[ ]=


100%
75%
50%
25%
FSS Modularity
0.5
0.4
0.3
0.2
0.1
FBS Modularity
Richness of Objective Functions
FSS Z−scores
30
25
20
15
10
5
0
FBS Z−scores
Richnes