Data Import

In[•]:= `SetDirectory[`
    `"C:/Users/serha/OneDrive/Masaüstü/MyRepo/master_thesis_MMT003/210718_product_diversity`
        `"];`

In[•]:= `Get["../algoritm_packages/SingleNetworks-algorithm-package-2.wl"]`
    `(* ?SingleNetworks`* *)`

In[•]:= `datafull = Import["../data/pltcm_manipulated_59604_rev1.csv"];`
    `productionline = "PLTCM5";`
    `stepsizewidth = 11;`
    `stepsizethickness = 0.05;`

Data for First and Second Half of Complete Data

In[•]:= `Dimensions@datafull`

Out[•]= {59 604, 20}

In[•]:= `x = Round@Length@datafull / 2;`
    `{a, b} = Range[x, Length@datafull, x];`
    `data1sthalf = Take[datafull, {1, a}];`
    `data2ndhalf = Take[datafull, {a + 1, b}];`

In[•]:= `times = 10;`
    `picklist1sthalf = Table[`
        `RandomSample[Range@Length@data1sthalf, Floor@((Length@data1sthalf) * 0.9)], times];`
    `reduceddata1sthalflist = Table[data1sthalf[[i, All]], {i, picklist1sthalf}];`

    `picklist2ndhalf = Table[`
        `RandomSample[Range@Length@data2ndhalf, Floor@((Length@data2ndhalf) * 0.9)], times];`
    `reduceddata2ndhalflist = Table[data2ndhalf[[i, All]], {i, picklist2ndhalf}];`

    `picklistfull =`
       `Table[RandomSample[Range@Length@datafull, Floor@((Length@datafull) * 0.9)], times];`
    `reduceddatafulllist = Table[datafull[[i, All]], {i, picklistfull}];`

bar chart function

```
In[ ]:= plotcolumn[modularity_, randommoddegree_,
         randommodcommunity_, zscoredegree_, zscorecommunities_, eZscores_] :=
       Module[{labels, colors, modularityrange, errorBar, errorbars, charts},
         labels = {"Modularity", "Sng. Rnd. Mod.\n Degrees",
           "Sng. Rnd. Mod.\n Degrees & Modules", "Z-score cons. \n Degrees",
           "Z-score cons. \n Degrees & Modules"};
         colors = {{Purple, RGBColor[{0.266122`, 0.486664`, 0.802529`}],
            RGBColor[{0.513417`, 0.72992`, 0.440682`}]}, {RGBColor[
             {0.863512`, 0.670771`, 0.236564`}], RGBColor[{0.857359`, 0.131106`, 0.132128`}]}};
         modularityrange = {0, 0.52};
         errorBar[type_ : "Rectangle"][{{x0_, x1_}, {y0_, y1_}}, value_, meta_] := Block[
           {error, mags = QuantityMagnitude[value]}, error = Flatten[QuantityMagnitude[meta]];
           error = If[error === {}, 0, Last[error]];
           {ChartElementData[type][{{x0, x1}, {y0, y1}}, mags, meta],
             {Black, Line[{{{(x0 + x1) / 2, y1 - error}, {(x0 + x1) / 2, y1 + error}},
                {{1 / 4 (3 x0 + x1), y1 + error}, {1 / 4 (x0 + 3 x1), y1 + error}},
                {{1 / 4 (3 x0 + x1), y1 - error}, {1 / 4 (x0 + 3 x1), y1 - error}}}]}}];
         errorbars = {Mean@eZscores[[All, 1]] → StandardDeviation@eZscores[[All, 1]],
           Mean@eZscores[[All, 2]] → StandardDeviation@eZscores[[All, 2]]};
         charts = GraphicsColumn[{BarChart[{modularity, randommoddegree, randommodcommunity},
             ChartStyle → colors[[1]],
             ChartLabels → labels[[{1, 2, 3}]], Frame → True, FrameTicks →
              {{All, None}, {None, {{1, labels[[1]]}, {2, labels[[2]]}, {3, labels[[3]]}}}}},
             PlotRange → {{0.5, 3.5}, modularityrange}], GraphicsRow[
             {Show[BarChart[{errorbars[[1]], 0 → 0}, ChartElementFunction → errorBar[],
                ChartStyle → colors[[2, 1]], Frame → True, PlotRange → {{0.5, 1.5}, {-10, 50}},
                FrameTicks → {{All, None}, {{{1, labels[[4]]}, {2, labels[[5]]}}, None}}],
               BarChart[{zscoredegree, 0}, ChartStyle → Transparent, Frame → True,
                PlotRange → {{0.5, 1.5}, {-10, 50}}, FrameTicks →
                 {{All, None}, {{{1, labels[[4]]}, {2, labels[[5]]}}, None}}], AspectRatio → 2],
              Show[BarChart[{0 → 0, errorbars[[2]]}, ChartElementFunction → errorBar[],
                ChartStyle → colors[[2, 2]], Frame → True, PlotRange → {{1.5, 2.5}, {-10, 5}},
                FrameTicks → {{None, All}, {{{1, labels[[4]]}, {2, labels[[5]]}}, None}}],
               BarChart[{0, zscorecommunities}, ChartStyle → Transparent,
                Frame → True, PlotRange → {{1.5, 2.5}, {-10, 5}},
                FrameTicks → {{None, All}, {{{1, labels[[4]]}, {2, labels[[5]]}}, None}}],
                AspectRatio → 2]}]}, Spacings → 1]]
```

Investigation of Constraints Impact in Real-life Production Events

Fixed Step Size Networks

Width Feature

```
In[ ]:= AbsoluteTiming[widthdataFixedstep1 = snetworkdatabinned[9, stepsizewidth, data1sthalf];
       graphsandnodenumbers1 =
         snetworkgraph[widthdataFixedstep1[[1]], widthdataFixedstep1[[2]], 2, 7, 400, Green];
       modularityvalues1 = N@GraphAssortativity[graphsandnodenumbers1[[1]],
           FindGraphCommunities[graphsandnodenumbers1[[1]]], "Normalized" → False];
       singlerandomgraphsdegfxd1 = randomizinggraphdegfxd[graphsandnodenumbers1[[1]]];
       singlerandomerdrenmodularityvalues1 = N@GraphAssortativity[singlerandomgraphsdegfxd1,
           FindGraphCommunities[singlerandomgraphsdegfxd1], "Normalized" -> False];
       singlerandomgraphscomm1 = randomizinggraphmod[graphsandnodenumbers1[[1]]];
       singlerandomcommmodularityvalues1 = N@GraphAssortativity[singlerandomgraphscomm1,
           FindGraphCommunities[singlerandomgraphscomm1], "Normalized" -> False];
       Zscoresmodularity1 = zscorefunctionfortwonullmodels[graphsandnodenumbers1[[1]]];
       bucketnode11 = graphsandnodenumbers1[[2]]]

Out[ ]= {34.7858, 84}
```

```
In[ ]:= AbsoluteTiming[widthdataFixedstep2 = snetworkdatabinned[9, stepsizewidth, data2ndhalf];
       graphsandnodenumbers12 =
         snetworkgraph[widthdataFixedstep2[[1]], widthdataFixedstep2[[2]], 2, 7, 400, Green];
       modularityvalues12 = N@GraphAssortativity[graphsandnodenumbers12[[1]],
           FindGraphCommunities[graphsandnodenumbers12[[1]]], "Normalized" → False];
       singlerandomgraphsdegfxd12 = randomizinggraphdegfxd[graphsandnodenumbers12[[1]]];
       singlerandomerdrenmodularityvalues12 = N@GraphAssortativity[singlerandomgraphsdegfxd12,
           FindGraphCommunities[singlerandomgraphsdegfxd12], "Normalized" -> False];
       singlerandomgraphscomm12 = randomizinggraphmod[graphsandnodenumbers12[[1]]];
       singlerandomcommmodularityvalues12 = N@GraphAssortativity[singlerandomgraphscomm12,
           FindGraphCommunities[singlerandomgraphscomm12], "Normalized" -> False];
       Zscoresmodularity12 = zscorefunctionfortwonullmodels[graphsandnodenumbers12[[1]]];
       bucketnode12 = graphsandnodenumbers12[[2]]]

Out[ ]= {41.0504, 85}
```

```
In[ ]:= AbsoluteTiming[widthdataFixedstep3 = snetworkdatabinned[9, stepsizewidth, datafull];
       graphsandnodenumbers13 =
         snetworkgraph[widthdataFixedstep3[[1]], widthdataFixedstep3[[2]], 2, 7, 400, Green];
       modularityvalues13 = N@GraphAssortativity[graphsandnodenumbers13[[1]],
           FindGraphCommunities[graphsandnodenumbers13[[1]]], "Normalized" → False];
       singlerandomgraphsdegfxd13 = randomizinggraphdegfxd[graphsandnodenumbers13[[1]]];
       singlerandomerdrenmodularityvalues13 = N@GraphAssortativity[singlerandomgraphsdegfxd13,
           FindGraphCommunities[singlerandomgraphsdegfxd13], "Normalized" -> False];
       singlerandomgraphscomm13 = randomizinggraphmod[graphsandnodenumbers13[[1]]];
       singlerandomcommmodularityvalues13 = N@GraphAssortativity[singlerandomgraphscomm13,
           FindGraphCommunities[singlerandomgraphscomm13], "Normalized" -> False];
       Zscoresmodularity13 = zscorefunctionfortwonullmodels[graphsandnodenumbers13[[1]]];
       bucketnode13 = graphsandnodenumbers13[[2]]]

Out[ ]= {72.1628, 85}
```

Error Bars and Charts

```
In[◦]:= AbsoluteTiming[ewidthdataFixedstep1 =
          Table[snetworkdatabinned[9, stepsizewidth, i], {i, reduceddata1sthalflist}];
        egraphsandnodenumbers1 = Table[snetworkgraph[ewidthdataFixedstep1[[i, 1]],
            ewidthdataFixedstep1[[i, 2]], 2, 7, 400, Green], {i, Length@reduceddata1sthalflist}];
        emodularityvalues1 = Table[N@GraphAssortativity[egraphsandnodenumbers1[[i, 1]],
            FindGraphCommunities[egraphsandnodenumbers1[[i, 1]]], "Normalized" → False],
          {i, Length@reduceddata1sthalflist}];
        esinglerandomgraphsdegfxd1 = Table[randomizinggraphdegfxd[
            egraphsandnodenumbers1[[i, 1]]], {i, Length@reduceddata1sthalflist}];
        esinglerandomerdrenmodularityvalues1 =
         Table[N@GraphAssortativity[esinglerandomgraphsdegfxd1[[i]],
            FindGraphCommunities[esinglerandomgraphsdegfxd1[[i]]], "Normalized" -> False],
          {i, Length@reduceddata1sthalflist}];
        esinglerandomgraphscomm1 = Table[randomizinggraphmod[egraphsandnodenumbers1[[i, 1]]],
          {i, Length@reduceddata1sthalflist}];
        esinglerandomcommmodularityvalues1 =
         Table[N@GraphAssortativity[esinglerandomgraphscomm1[[i]],
            FindGraphCommunities[esinglerandomgraphscomm1[[i]]], "Normalized" -> False],
          {i, Length@reduceddata1sthalflist}];
        eZscoresmodularity1 = Table[zscorefunctionfortwonullmodels[
            egraphsandnodenumbers1[[i, 1]]], {i, Length@reduceddata1sthalflist}];
        ebucketnode11 = Table[egraphsandnodenumbers1[[i, 2]],
          {i, Length@reduceddata1sthalflist}]]

Out[◦]= {642.051, {84, 84, 84, 84, 84, 83, 84, 84, 84, 84}}
```

```
In[ ]:= AbsoluteTiming[ewidthdataFixedstep2 =
      Table[snetworkdatabinned[9, stepsizewidth, i], {i, reduceddata2ndhalflist}];
    egraphsandnodenumbers12 = Table[snetworkgraph[ewidthdataFixedstep2[[i, 1]],
        ewidthdataFixedstep2[[i, 2]], 2, 7, 400, Green], {i, Length@reduceddata2ndhalflist}];
    emodularityvalues12 = Table[N@GraphAssortativity[egraphsandnodenumbers12[[i, 1]],
        FindGraphCommunities[egraphsandnodenumbers12[[i, 1]]], "Normalized" → False],
      {i, Length@reduceddata2ndhalflist}];
    esinglerandomgraphsdegfxd12 = Table[randomizinggraphdegfxd[
        egraphsandnodenumbers12[[i, 1]]], {i, Length@reduceddata2ndhalflist}];
    esinglerandomerdrenmodularityvalues12 =
      Table[N@GraphAssortativity[esinglerandomgraphsdegfxd12[[i]],
        FindGraphCommunities[esinglerandomgraphsdegfxd12[[i]]], "Normalized" -> False],
      {i, Length@reduceddata2ndhalflist}];
    esinglerandomgraphscomm12 = Table[randomizinggraphmod[egraphsandnodenumbers12[[i, 1]]],
      {i, Length@reduceddata2ndhalflist}];
    esinglerandomcommmodularityvalues12 =
      Table[N@GraphAssortativity[esinglerandomgraphscomm12[[i]],
        FindGraphCommunities[esinglerandomgraphscomm12[[i]]], "Normalized" -> False],
      {i, Length@reduceddata2ndhalflist}];
    eZscoresmodularity12 = Table[zscorefunctionfortwonullmodels[
        egraphsandnodenumbers12[[i, 1]]], {i, Length@reduceddata2ndhalflist}];
    ebucketnode12 = Table[egraphsandnodenumbers12[[i, 2]],
      {i, Length@reduceddata2ndhalflist}]]

Out[ ]= {549.881, {83, 84, 85, 84, 85, 85, 85, 85, 85, 84}}
```

```
In[ ]:= AbsoluteTiming[ewidthdataFixedstep3 =
        Table[snetworkdatabinned[9, stepsizewidth, i], {i, reduceddatafulllist}];
       egraphsandnodenumbers13 = Table[snetworkgraph[ewidthdataFixedstep3[[i, 1]],
          ewidthdataFixedstep3[[i, 2]], 2, 7, 400, Green], {i, Length@reduceddatafulllist}];
       emodularityvalues13 = Table[N@GraphAssortativity[egraphsandnodenumbers13[[i, 1]],
           FindGraphCommunities[egraphsandnodenumbers13[[i, 1]]],
           "Normalized" → False], {i, Length@reduceddatafulllist}];
       esinglerandomgraphsdegfxd13 = Table[randomizinggraphdegfxd[
          egraphsandnodenumbers13[[i, 1]]], {i, Length@reduceddatafulllist}];
       esinglerandomerdrenmodularityvalues13 =
        Table[N@GraphAssortativity[esinglerandomgraphsdegfxd13[[i]],
           FindGraphCommunities[esinglerandomgraphsdegfxd13[[i]]],
           "Normalized" -> False], {i, Length@reduceddatafulllist}];
       esinglerandomgraphscomm13 = Table[randomizinggraphmod[egraphsandnodenumbers13[[i, 1]]],
          {i, Length@reduceddatafulllist}];
       esinglerandomcommmodularityvalues13 =
        Table[N@GraphAssortativity[esinglerandomgraphscomm13[[i]],
           FindGraphCommunities[esinglerandomgraphscomm13[[i]]],
           "Normalized" -> False], {i, Length@reduceddatafulllist}];
       eZscoresmodularity13 = Table[zscorefunctionfortwonullmodels[
          egraphsandnodenumbers13[[i, 1]]], {i, Length@reduceddatafulllist}];
       ebucketnode13 = Table[egraphsandnodenumbers13[[i, 2]], {i, Length@reduceddatafulllist}]]

Out[ ]= {740.209, {85, 85, 85, 85, 85, 85, 85, 85, 85, 85}}


In[ ]:= emodvalues1 = {emodularityvalues1, emodularityvalues12, emodularityvalues13};
       eZscores1 = {eZscoresmodularity1, eZscoresmodularity12, eZscoresmodularity13};
       Export["error_bar_values/" <> productionline <> "-modularity_values1.mx", emodvalues1];
       Export["error_bar_values/" <> productionline <> "-zscores1.mx", eZscores1];


In[ ]:= (*emodvalues1=Import["error_bar_values/CCM5-modularity_values1.mx"];
       eZscores1=Import["error_bar_values/CCM5-zscores1.mx"];*)


In[ ]:= set11 = plotcolumn[modularityvalues1,
          singlerandomerdrenmodularityvalues1, singlerandomcommmodularityvalues1,
          Zscoresmodularity1[[1]], Zscoresmodularity1[[2]], eZscores1[[1]]];
       set12 = plotcolumn[modularityvalues12, singlerandomerdrenmodularityvalues12,
          singlerandomcommmodularityvalues12, Zscoresmodularity12[[1]],
          Zscoresmodularity12[[2]], eZscores1[[2]]];
       set13 = plotcolumn[modularityvalues13, singlerandomerdrenmodularityvalues13,
          singlerandomcommmodularityvalues13, Zscoresmodularity13[[1]],
          Zscoresmodularity13[[2]], eZscores1[[3]]];
       Legended[Framed[GraphicsRow[{set11, Magnify[set13, 1.03], set12}, ImageSize → 1093],
         FrameMargins → 5, FrameStyle → DotDashed], {Placed["First Half", {0.155, 0.99}],
         Placed["Complete Data", {0.505, 0.99}], Placed["Second Half", {0.86, 0.99}]}]
```
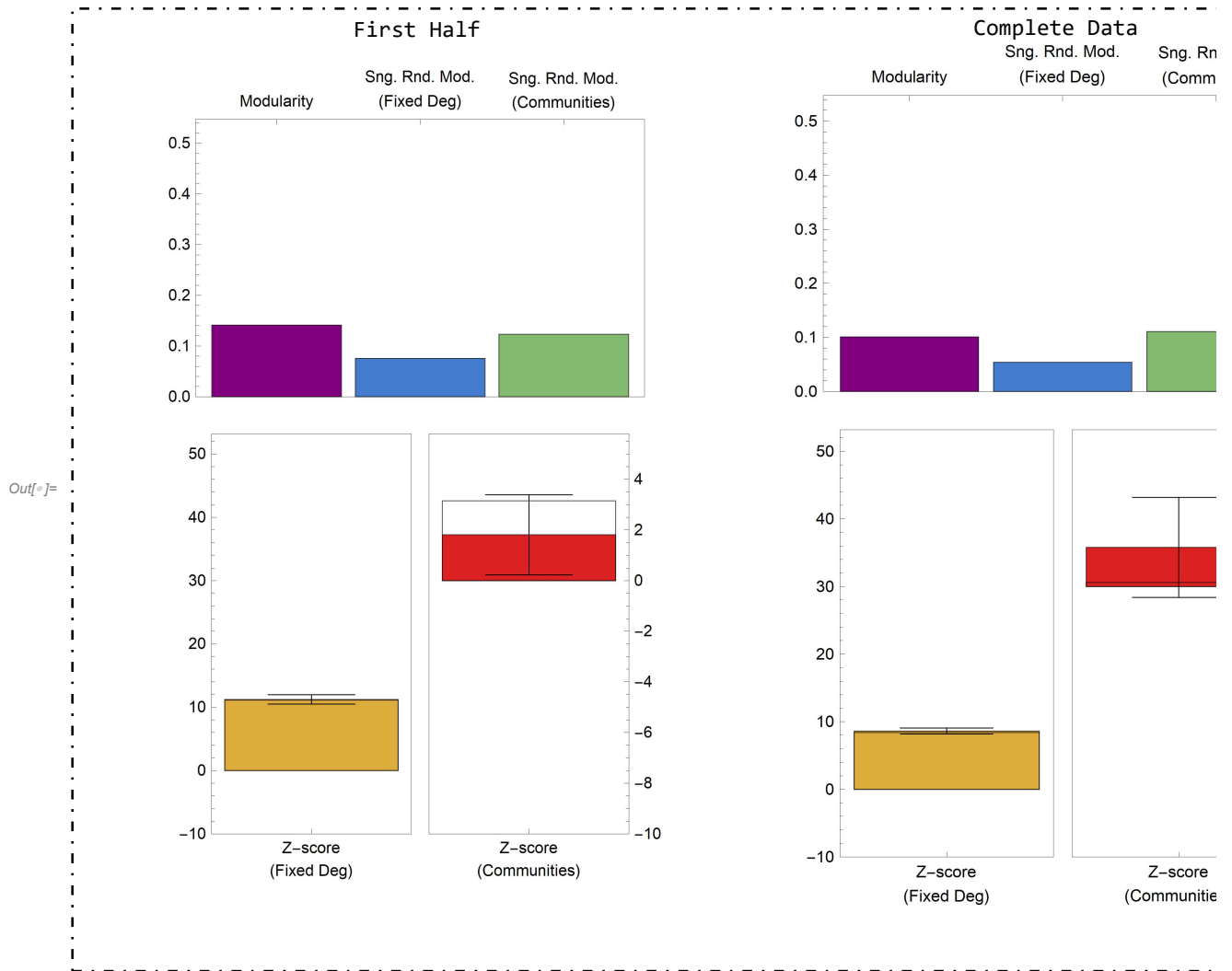
Thickness Feature

```
In[●]:= AbsoluteTiming[
   thicknessdataFixedstep1 = snetworkdatabinned[10, stepsizethickness, data1sthalf];
   graphsandnodenumbers2 = snetworkgraph[thicknessdataFixedstep1[[1]],
     thicknessdataFixedstep1[[2]], 2, 7, 400, Green];
   modularityvalues2 = N@GraphAssortativity[graphsandnodenumbers2[[1]],
      FindGraphCommunities[graphsandnodenumbers2[[1]]], "Normalized" → False];
   singlerandomgraphsdegfxd2 = randomizinggraphdegfxd[graphsandnodenumbers2[[1]]];
   singlerandomerdrenmodularityvalues2 = N@GraphAssortativity[singlerandomgraphsdegfxd2,
      FindGraphCommunities[singlerandomgraphsdegfxd2], "Normalized" -> False];
   singlerandomgraphscomm2 = randomizinggraphmod[graphsandnodenumbers2[[1]]];
   singlerandomcommmodularityvalues2 = N@GraphAssortativity[singlerandomgraphscomm2,
      FindGraphCommunities[singlerandomgraphscomm2], "Normalized" -> False];
   Zscoresmodularity2 = zscorefunctionfortwonullmodels[graphsandnodenumbers2[[1]]];
   bucketnode21 = graphsandnodenumbers2[[2]]]
```

Out[●]= {30.5468, 72}

In[ ]:= ```
AbsoluteTiming[
  thicknessdataFixedstep2 = snetworkdatabinned[10, stepsizethickness, data2ndhalf];
  graphsandnodenumbers22 = snetworkgraph[thicknessdataFixedstep2[[1]],
    thicknessdataFixedstep2[[2]], 2, 7, 400, Green];
  modularityvalues22 = N@GraphAssortativity[graphsandnodenumbers22[[1]],
    FindGraphCommunities[graphsandnodenumbers22[[1]]], "Normalized" → False];
  singlerandomgraphsdegfxd22 = randomizinggraphdegfxd[graphsandnodenumbers22[[1]]];
  singlerandomerdrenmodularityvalues22 = N@GraphAssortativity[singlerandomgraphsdegfxd22,
    FindGraphCommunities[singlerandomgraphsdegfxd22], "Normalized" -> False];
  singlerandomgraphscomm22 = randomizinggraphmod[graphsandnodenumbers22[[1]]];
  singlerandomcommmodularityvalues22 = N@GraphAssortativity[singlerandomgraphscomm22,
    FindGraphCommunities[singlerandomgraphscomm22], "Normalized" -> False];
  Zscoresmodularity22 = zscorefunctionfortwonullmodels[graphsandnodenumbers22[[1]]];
  bucketnode22 = graphsandnodenumbers22[[2]]]
```

*Out[ ]=* {33.9734, 79}

*In[ ]:=* ```
AbsoluteTiming[
  thicknessdataFixedstep3 = snetworkdatabinned[10, stepsizethickness, datafull];
  graphsandnodenumbers23 = snetworkgraph[thicknessdataFixedstep3[[1]],
    thicknessdataFixedstep3[[2]], 2, 7, 400, Green];
  modularityvalues23 = N@GraphAssortativity[graphsandnodenumbers23[[1]],
    FindGraphCommunities[graphsandnodenumbers23[[1]]], "Normalized" → False];
  singlerandomgraphsdegfxd23 = randomizinggraphdegfxd[graphsandnodenumbers23[[1]]];
  singlerandomerdrenmodularityvalues23 = N@GraphAssortativity[singlerandomgraphsdegfxd23,
    FindGraphCommunities[singlerandomgraphsdegfxd23], "Normalized" -> False];
  singlerandomgraphscomm23 = randomizinggraphmod[graphsandnodenumbers23[[1]]];
  singlerandomcommmodularityvalues23 = N@GraphAssortativity[singlerandomgraphscomm23,
    FindGraphCommunities[singlerandomgraphscomm23], "Normalized" -> False];
  Zscoresmodularity23 = zscorefunctionfortwonullmodels[graphsandnodenumbers23[[1]]];
  bucketnode23 = graphsandnodenumbers23[[2]]]
```

Out[ ]= {45.6602, 80}

Error Bars and Charts

```
In[ ]:= AbsoluteTiming[ethicknessdataFixedstep1 =
         Table[snetworkdatabinned[10, stepsizethickness, i], {i, reduceddata1sthalflist}];
       egraphsandnodenumbers2 = Table[snetworkgraph[ethicknessdataFixedstep1[[i, 1]],
            ethicknessdataFixedstep1[[i, 2]], 2, 7, 400, Green],
          {i, Length@reduceddata1sthalflist}];
       emodularityvalues2 = Table[N@GraphAssortativity[egraphsandnodenumbers2[[i, 1]],
            FindGraphCommunities[egraphsandnodenumbers2[[i, 1]]], "Normalized" → False],
          {i, Length@reduceddata1sthalflist}];
       esinglerandomgraphsdegfxd2 = Table[randomizinggraphdegfxd[
            egraphsandnodenumbers2[[i, 1]]], {i, Length@reduceddata1sthalflist}];
       esinglerandomerdrenmodularityvalues2 =
        Table[N@GraphAssortativity[esinglerandomgraphsdegfxd2[[i]],
            FindGraphCommunities[esinglerandomgraphsdegfxd2[[i]]], "Normalized" -> False],
          {i, Length@reduceddata1sthalflist}];
       esinglerandomgraphscomm2 = Table[randomizinggraphmod[egraphsandnodenumbers2[[i, 1]]],
          {i, Length@reduceddata1sthalflist}];
       esinglerandomcommmodularityvalues2 =
        Table[N@GraphAssortativity[esinglerandomgraphscomm2[[i]],
            FindGraphCommunities[esinglerandomgraphscomm2[[i]]], "Normalized" -> False],
          {i, Length@reduceddata1sthalflist}];
       eZscoresmodularity2 = Table[zscorefunctionfortwonullmodels[
            egraphsandnodenumbers2[[i, 1]]], {i, Length@reduceddata1sthalflist}];
       ebucketnode21 = Table[egraphsandnodenumbers2[[i, 2]],
          {i, Length@reduceddata1sthalflist}]]
Out[ ]= {365.087, {72, 72, 72, 72, 72, 72, 72, 72, 72, 72}}
```

```
In[ ]:= AbsoluteTiming[ethicknessdataFixedstep2 =
         Table[snetworkdatabinned[10, stepsizethickness, i], {i, reduceddata2ndhalflist}];
       egraphsandnodenumbers22 = Table[snetworkgraph[ethicknessdataFixedstep2[[i, 1]],
           ethicknessdataFixedstep2[[i, 2]], 2, 7, 400, Green],
          {i, Length@reduceddata2ndhalflist}];
       emodularityvalues22 = Table[N@GraphAssortativity[egraphsandnodenumbers22[[i, 1]],
           FindGraphCommunities[egraphsandnodenumbers22[[i, 1]]], "Normalized" → False],
          {i, Length@reduceddata2ndhalflist}];
       esinglerandomgraphsdegfxd22 = Table[randomizinggraphdegfxd[
           egraphsandnodenumbers22[[i, 1]]], {i, Length@reduceddata2ndhalflist}];
       esinglerandomerdrenmodularityvalues22 =
        Table[N@GraphAssortativity[esinglerandomgraphsdegfxd22[[i]],
           FindGraphCommunities[esinglerandomgraphsdegfxd22[[i]]], "Normalized" -> False],
          {i, Length@reduceddata2ndhalflist}];
       esinglerandomgraphscomm22 = Table[randomizinggraphmod[egraphsandnodenumbers22[[i, 1]]],
          {i, Length@reduceddata2ndhalflist}];
       esinglerandomcommmodularityvalues22 =
        Table[N@GraphAssortativity[esinglerandomgraphscomm22[[i]],
           FindGraphCommunities[esinglerandomgraphscomm22[[i]]], "Normalized" -> False],
          {i, Length@reduceddata2ndhalflist}];
       eZscoresmodularity22 = Table[zscorefunctionfortwonullmodels[
           egraphsandnodenumbers22[[i, 1]]], {i, Length@reduceddata2ndhalflist}];
       ebucketnode22 = Table[egraphsandnodenumbers22[[i, 2]],
          {i, Length@reduceddata2ndhalflist}]]

Out[ ]= {404.493, {79, 78, 79, 79, 79, 79, 79, 79, 79, 79}}
```

```
In[•]:= AbsoluteTiming[ethicknessdataFixedstep3 =
          Table[snetworkdatabinned[10, stepsizethickness, i], {i, reduceddatafulllist}];
        egraphsandnodenumbers23 =
          Table[snetworkgraph[ethicknessdataFixedstep3[[i, 1]], ethicknessdataFixedstep3[[i, 2]],
            2, 7, 400, Green], {i, Length@reduceddatafulllist}];
        emodularityvalues23 = Table[N@GraphAssortativity[egraphsandnodenumbers23[[i, 1]],
            FindGraphCommunities[egraphsandnodenumbers23[[i, 1]]],
            "Normalized" → False], {i, Length@reduceddatafulllist}];
        esinglerandomgraphsdegfxd23 = Table[randomizinggraphdegfxd[
            egraphsandnodenumbers23[[i, 1]]], {i, Length@reduceddatafulllist}];
        esinglerandomerdrenmodularityvalues23 =
          Table[N@GraphAssortativity[esinglerandomgraphsdegfxd23[[i]],
            FindGraphCommunities[esinglerandomgraphsdegfxd23[[i]]],
            "Normalized" -> False], {i, Length@reduceddatafulllist}];
        esinglerandomgraphscomm23 = Table[randomizinggraphmod[egraphsandnodenumbers23[[i, 1]]],
            {i, Length@reduceddatafulllist}];
        esinglerandomcommmodularityvalues23 =
          Table[N@GraphAssortativity[esinglerandomgraphscomm23[[i]],
            FindGraphCommunities[esinglerandomgraphscomm23[[i]]],
            "Normalized" -> False], {i, Length@reduceddatafulllist}];
        eZscoresmodularity23 = Table[zscorefunctionfortwonullmodels[
            egraphsandnodenumbers23[[i, 1]]], {i, Length@reduceddatafulllist}];
        ebucketnode23 = Table[egraphsandnodenumbers23[[i, 2]], {i, Length@reduceddatafulllist}]]

Out[•]= {501.871, {80, 80, 80, 80, 80, 80, 80, 80, 80, 80}}


In[•]:= emodvalues2 = {emodularityvalues2, emodularityvalues22, emodularityvalues23};
        eZscores2 = {eZscoresmodularity2, eZscoresmodularity22, eZscoresmodularity23};
        Export["error_bar_values/" <> productionline <> "-modularity_values2.mx", emodvalues2];
        Export["error_bar_values/" <> productionline <> "-zscores2.mx", eZscores2];


In[•]:= (* emodvalues2=Import["error_bar_values/CCM5-modularity_values2.mx"];
        eZscores2=Import["error_bar_values/CCM5-zscores2.mx"];*)


In[•]:= set21 = plotcolumn[modularityvalues2,
            singlerandomerdrenmodularityvalues2, singlerandomcommmodularityvalues2,
            Zscoresmodularity2[[1]], Zscoresmodularity2[[2]], eZscores2[[1]]];
        set22 = plotcolumn[modularityvalues22, singlerandomerdrenmodularityvalues22,
            singlerandomcommmodularityvalues22, Zscoresmodularity22[[1]],
            Zscoresmodularity22[[2]], eZscores2[[2]]];
        set23 = plotcolumn[modularityvalues23, singlerandomerdrenmodularityvalues23,
            singlerandomcommmodularityvalues23, Zscoresmodularity23[[1]],
            Zscoresmodularity23[[2]], eZscores2[[3]]];
        Legended[Framed[GraphicsRow[{set21, Magnify[set23, 1.03], set22}, ImageSize → 1093],
          FrameMargins → 5, FrameStyle → DotDashed], {Placed["First Half", {0.155, 0.99}],
          Placed["Complete Data", {0.505, 0.99}], Placed["Second Half", {0.86, 0.99}]}]
```
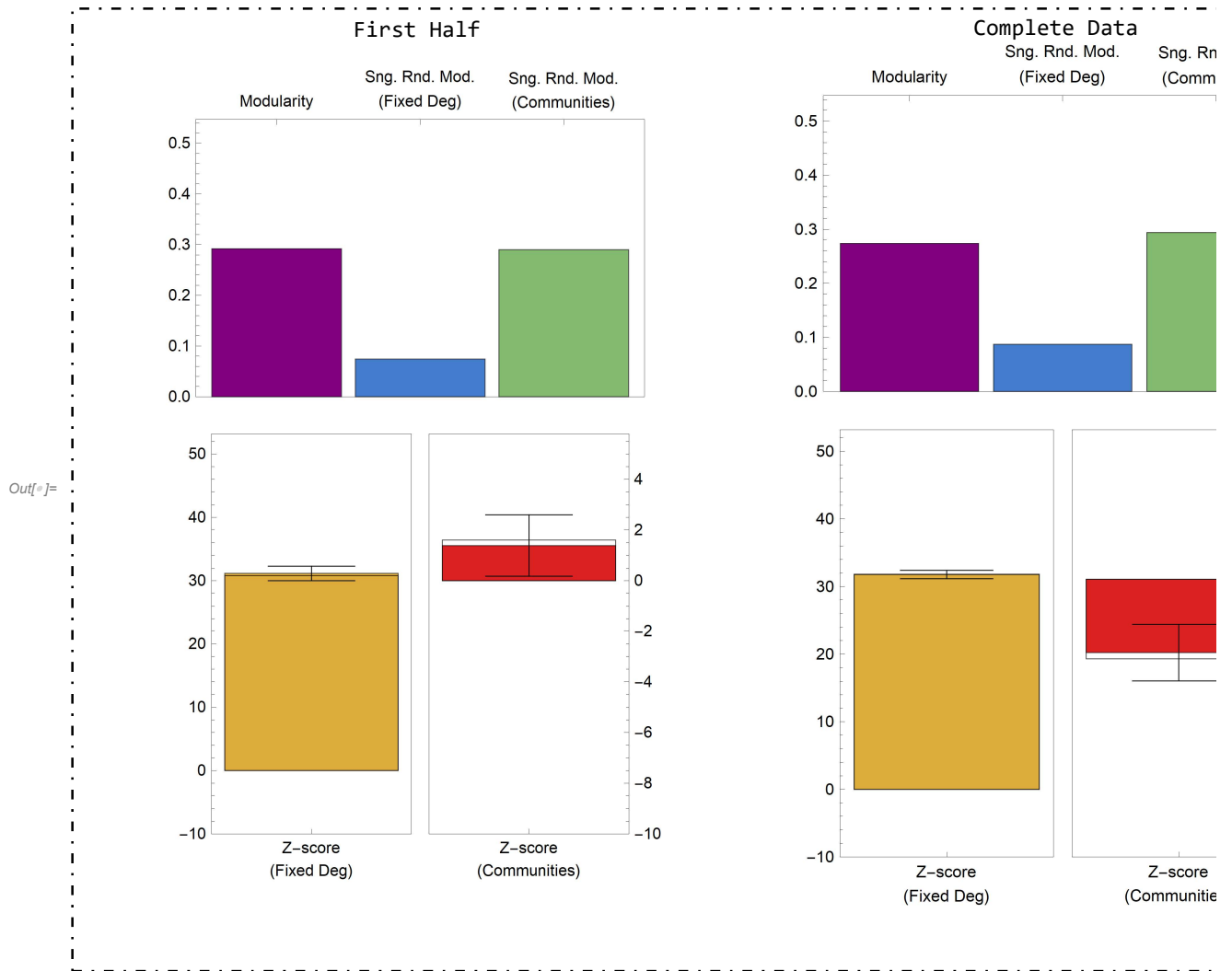
Out[○]=

Fixed Bucket Size Networks

Width Feature

In[○]:= ```
AbsoluteTiming[
  widthdataFixedbucket1 = snetworkdatafxdbucket[9, bucketnode11, data1sthalf];
  graphsandnodenumbers3 = snetworkgraph[widthdataFixedbucket1[[1]],
    widthdataFixedbucket1[[2]], 2, 7, 400, Green];
  modularityvalues3 = N@GraphAssortativity[graphsandnodenumbers3[[1]],
    FindGraphCommunities[graphsandnodenumbers3[[1]]], "Normalized" → False];
  singlerandomgraphsdegfxd3 = randomizinggraphdegfxd[graphsandnodenumbers3[[1]]];
  singlerandomerdrenmodularityvalues3 = N@GraphAssortativity[singlerandomgraphsdegfxd3,
    FindGraphCommunities[singlerandomgraphsdegfxd3], "Normalized" -> False];
  singlerandomgraphscomm3 = randomizinggraphmod[graphsandnodenumbers3[[1]]];
  singlerandomcommmodularityvalues3 = N@GraphAssortativity[singlerandomgraphscomm3,
    FindGraphCommunities[singlerandomgraphscomm3], "Normalized" -> False];
  Zscoresmodularity3 = zscorefunctionfortwonullmodels[graphsandnodenumbers3[[1]]];]
```

*Out[ ]=* {36.5005, Null}

*In[ ]:=* **bucketsize11 = widthdataFixedbucket1[[4]]**

*Out[ ]=* {355}

*In[ ]:=* **AbsoluteTiming[**
    **widthdataFixedbucket2 = snetworkdatafxdbucket[9, bucketnode12, data2ndhalf];**
    **graphsandnodenumbers32 = snetworkgraph[widthdataFixedbucket2[[1]],**
      **widthdataFixedbucket2[[2]], 2, 7, 400, Green];**
    **modularityvalues32 = N@GraphAssortativity[graphsandnodenumbers32[[1]],**
      **FindGraphCommunities[graphsandnodenumbers32[[1]]], "Normalized" → False];**
    **singlerandomgraphsdegfxd32 = randomizinggraphdegfxd[graphsandnodenumbers32[[1]]];**
    **singlerandomerdrenmodularityvalues32 = N@GraphAssortativity[singlerandomgraphsdegfxd32,**
      **FindGraphCommunities[singlerandomgraphsdegfxd32], "Normalized" -> False];**
    **singlerandomgraphscomm32 = randomizinggraphmod[graphsandnodenumbers32[[1]]];**
    **singlerandomcommmodularityvalues32 = N@GraphAssortativity[singlerandomgraphscomm32,**
      **FindGraphCommunities[singlerandomgraphscomm32], "Normalized" -> False];**
    **Zscoresmodularity32 = zscorefunctionfortwonullmodels[graphsandnodenumbers32[[1]]];]**

*Out[ ]=* {38.8727, Null}

*In[ ]:=* **bucketsize12 = widthdataFixedbucket2[[4]]**

*Out[ ]=* {351}

*In[ ]:=* **AbsoluteTiming[widthdataFixedbucket3 = snetworkdatafxdbucket[9, bucketnode13, datafull];**
    **graphsandnodenumbers33 = snetworkgraph[**
      **widthdataFixedbucket3[[1]], widthdataFixedbucket3[[2]], 2, 7, 400, Green];**
    **modularityvalues33 = N@GraphAssortativity[graphsandnodenumbers33[[1]],**
      **FindGraphCommunities[graphsandnodenumbers33[[1]]], "Normalized" → False];**
    **singlerandomgraphsdegfxd33 = randomizinggraphdegfxd[graphsandnodenumbers33[[1]]];**
    **singlerandomerdrenmodularityvalues33 = N@GraphAssortativity[singlerandomgraphsdegfxd33,**
      **FindGraphCommunities[singlerandomgraphsdegfxd33], "Normalized" -> False];**
    **singlerandomgraphscomm33 = randomizinggraphmod[graphsandnodenumbers33[[1]]];**
    **singlerandomcommmodularityvalues33 = N@GraphAssortativity[singlerandomgraphscomm33,**
      **FindGraphCommunities[singlerandomgraphscomm33], "Normalized" -> False];**
    **Zscoresmodularity33 = zscorefunctionfortwonullmodels[graphsandnodenumbers33[[1]]];]**

*Out[ ]=* {47.6103, Null}

*In[ ]:=* **bucketsize13 = widthdataFixedbucket3[[4]]**

*Out[ ]=* {702}

Error Bars and Charts

```
In[ ]:= AbsoluteTiming[ewidthdataFixedbucket1 = Table[snetworkdatafxdbucket[9, i[[1]], i[[2]]],
          {i, MapThread[{#1, #2} &, {ebucketnode11, reduceddata1sthalflist}]}];
        egraphsandnodenumbers3 = Table[snetworkgraph[ewidthdataFixedbucket1[[i, 1]],
           ewidthdataFixedbucket1[[i, 2]], 2, 7, 400, Green],
          {i, Length@reduceddata1sthalflist}];
        emodularityvalues3 = Table[N@GraphAssortativity[egraphsandnodenumbers3[[i, 1]],
            FindGraphCommunities[egraphsandnodenumbers3[[i, 1]]], "Normalized" → False],
          {i, Length@reduceddata1sthalflist}];
        esinglerandomgraphsdegfxd3 = Table[randomizinggraphdegfxd[
           egraphsandnodenumbers3[[i, 1]]], {i, Length@reduceddata1sthalflist}];
        esinglerandomerdrenmodularityvalues3 =
         Table[N@GraphAssortativity[esinglerandomgraphsdegfxd3[[i]],
            FindGraphCommunities[esinglerandomgraphsdegfxd3[[i]]], "Normalized" -> False],
          {i, Length@reduceddata1sthalflist}];
        esinglerandomgraphscomm3 = Table[randomizinggraphmod[egraphsandnodenumbers3[[i, 1]]],
          {i, Length@reduceddata1sthalflist}];
        esinglerandomcommmodularityvalues3 =
         Table[N@GraphAssortativity[esinglerandomgraphscomm3[[i]],
            FindGraphCommunities[esinglerandomgraphscomm3[[i]]], "Normalized" -> False],
          {i, Length@reduceddata1sthalflist}];
        eZscoresmodularity3 = Table[zscorefunctionfortwonullmodels[
           egraphsandnodenumbers3[[i, 1]]], {i, Length@reduceddata1sthalflist}];]

Out[ ]= {389.029, Null}

In[ ]:= AbsoluteTiming[ewidthdataFixedbucket2 = Table[snetworkdatafxdbucket[9, i[[1]], i[[2]]],
          {i, MapThread[{#1, #2} &, {ebucketnode12, reduceddata2ndhalflist}]}];
        egraphsandnodenumbers32 = Table[snetworkgraph[ewidthdataFixedbucket2[[i, 1]],
           ewidthdataFixedbucket2[[i, 2]], 2, 7, 400, Green],
          {i, Length@reduceddata2ndhalflist}];
        emodularityvalues32 = Table[N@GraphAssortativity[egraphsandnodenumbers32[[i, 1]],
            FindGraphCommunities[egraphsandnodenumbers32[[i, 1]]], "Normalized" → False],
          {i, Length@reduceddata2ndhalflist}];
        esinglerandomgraphsdegfxd32 = Table[randomizinggraphdegfxd[
           egraphsandnodenumbers32[[i, 1]]], {i, Length@reduceddata2ndhalflist}];
        esinglerandomerdrenmodularityvalues32 =
         Table[N@GraphAssortativity[esinglerandomgraphsdegfxd32[[i]],
            FindGraphCommunities[esinglerandomgraphsdegfxd32[[i]]], "Normalized" -> False],
          {i, Length@reduceddata2ndhalflist}];
        esinglerandomgraphscomm32 = Table[randomizinggraphmod[egraphsandnodenumbers32[[i, 1]]],
          {i, Length@reduceddata2ndhalflist}];
        esinglerandomcommmodularityvalues32 =
         Table[N@GraphAssortativity[esinglerandomgraphscomm32[[i]],
            FindGraphCommunities[esinglerandomgraphscomm32[[i]]], "Normalized" -> False],
          {i, Length@reduceddata2ndhalflist}];
        eZscoresmodularity32 = Table[zscorefunctionfortwonullmodels[
           egraphsandnodenumbers32[[i, 1]]], {i, Length@reduceddata2ndhalflist}];]
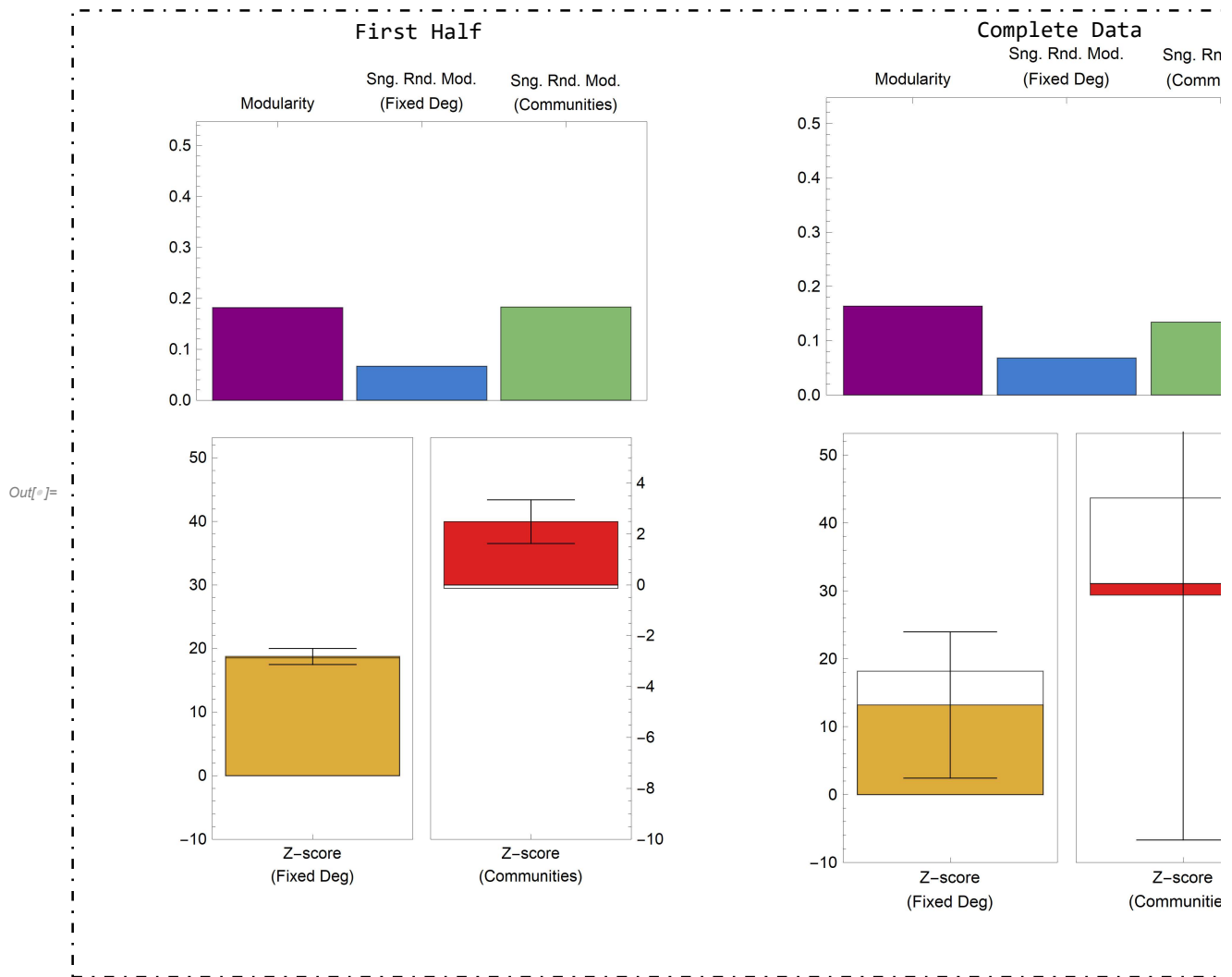```

Out[●]= {410.843, Null}

```
In[●]:= AbsoluteTiming[ewidthdataFixedbucket3 = Table[snetworkdatafxdbucket[9, i[[1]], i[[2]]],
        {i, MapThread[{#1, #2} &, {ebucketnode13, reduceddatafulllist}]}];
     egraphsandnodenumbers33 = Table[snetworkgraph[ewidthdataFixedbucket3[[i, 1]],
        ewidthdataFixedbucket3[[i, 2]], 2, 7, 400, Green], {i, Length@reduceddatafulllist}];
     emodularityvalues33 = Table[N@GraphAssortativity[egraphsandnodenumbers33[[i, 1]],
        FindGraphCommunities[egraphsandnodenumbers33[[i, 1]]],
        "Normalized" → False], {i, Length@reduceddatafulllist}];
     esinglerandomgraphsdegfxd33 = Table[randomizinggraphdegfxd[
        egraphsandnodenumbers33[[i, 1]]], {i, Length@reduceddatafulllist}];
     esinglerandomerdrenmodularityvalues33 =
      Table[N@GraphAssortativity[esinglerandomgraphsdegfxd33[[i]],
        FindGraphCommunities[esinglerandomgraphsdegfxd33[[i]]],
        "Normalized" -> False], {i, Length@reduceddatafulllist}];
     esinglerandomgraphscomm33 = Table[randomizinggraphmod[egraphsandnodenumbers33[[i, 1]]],
        {i, Length@reduceddatafulllist}];
     esinglerandomcommmodularityvalues33 =
      Table[N@GraphAssortativity[esinglerandomgraphscomm33[[i]],
        FindGraphCommunities[esinglerandomgraphscomm33[[i]]],
        "Normalized" -> False], {i, Length@reduceddatafulllist}];
     eZscoresmodularity33 = Table[zscorefunctionfortwonullmodels[
        egraphsandnodenumbers33[[i, 1]]], {i, Length@reduceddatafulllist}];]
```

Out[●]= {655.938, Null}

```
In[●]:= emodvalues3 = {emodularityvalues3, emodularityvalues32, emodularityvalues33};
     eZscores3 = {eZscoresmodularity3, eZscoresmodularity32, eZscoresmodularity33};
     Export["error_bar_values/" <> productionline <> "-modularity_values3.mx", emodvalues3];
     Export["error_bar_values/" <> productionline <> "-zscores3.mx", eZscores3];
```

```
In[●]:= (* emodvalues3=Import["error_bar_values/CCM5-modularity_values3.mx"];
     eZscores3=Import["error_bar_values/CCM5-zscores3.mx"]; *)
```

```
In[●]:= set31 = plotcolumn[modularityvalues3,
        singlerandomerdrenmodularityvalues3, singlerandomcommmodularityvalues3,
        Zscoresmodularity3[[1]], Zscoresmodularity3[[2]], eZscores3[[1]]];
     set32 = plotcolumn[modularityvalues32, singlerandomerdrenmodularityvalues32,
        singlerandomcommmodularityvalues32, Zscoresmodularity32[[1]],
        Zscoresmodularity32[[2]], eZscores3[[2]]];
     set33 = plotcolumn[modularityvalues33, singlerandomerdrenmodularityvalues33,
        singlerandomcommmodularityvalues33, Zscoresmodularity33[[1]],
        Zscoresmodularity33[[2]], eZscores3[[3]]];
     Legended[Framed[GraphicsRow[{set31, Magnify[set33, 1.03], set32}, ImageSize → 1093],
      FrameMargins → 5, FrameStyle → DotDashed], {Placed["First Half", {0.155, 0.99}],
      Placed["Complete Data", {0.505, 0.99}], Placed["Second Half", {0.86, 0.99}]}]
```

Out[●]=

Thickness Feature

In[●]:=
```
AbsoluteTiming[
  thicknessdataFixedbucket1 = snetworkdatafxdbucket[10, bucketnode21, data1sthalf];
  graphsandnodenumbers4 = snetworkgraph[thicknessdataFixedbucket1[[1]],
    thicknessdataFixedbucket1[[2]], 2, 7, 400, Green];
  modularityvalues4 = N@GraphAssortativity[graphsandnodenumbers4[[1]],
    FindGraphCommunities[graphsandnodenumbers4[[1]]], "Normalized" → False];
  singlerandomgraphsdegfxd4 = randomizinggraphdegfxd[graphsandnodenumbers4[[1]]];
  singlerandomerdrenmodularityvalues4 = N@GraphAssortativity[singlerandomgraphsdegfxd4,
    FindGraphCommunities[singlerandomgraphsdegfxd4], "Normalized" -> False];
  singlerandomgraphscomm4 = randomizinggraphmod[graphsandnodenumbers4[[1]]];
  singlerandomcommmodularityvalues4 = N@GraphAssortativity[singlerandomgraphscomm4,
    FindGraphCommunities[singlerandomgraphscomm4], "Normalized" -> False];
  Zscoresmodularity4 = zscorefunctionfortwonullmodels[graphsandnodenumbers4[[1]]];]
```

Out[●]= {25.5455, Null}

In[ ]:= **bucketsize21 = thicknessdataFixedbucket1[[4]]**

Out[ ]= {414}

In[ ]:= **AbsoluteTiming[**
  thicknessdataFixedbucket2 = snetworkdatafxdbucket[10, bucketnode22, data2ndhalf];
  graphsandnodenumbers42 = snetworkgraph[thicknessdataFixedbucket2[[1]],
    thicknessdataFixedbucket2[[2]], 2, 7, 400, Green];
  modularityvalues42 = N@GraphAssortativity[graphsandnodenumbers42[[1]],
    FindGraphCommunities[graphsandnodenumbers42[[1]]], "Normalized" → False];
  singlerandomgraphsdegfxd42 = randomizinggraphdegfxd[graphsandnodenumbers42[[1]]];
  singlerandomerdrenmodularityvalues42 = N@GraphAssortativity[singlerandomgraphsdegfxd42,
    FindGraphCommunities[singlerandomgraphsdegfxd42], "Normalized" -> False];
  singlerandomgraphscomm42 = randomizinggraphmod[graphsandnodenumbers42[[1]]];
  singlerandomcommmodularityvalues42 = N@GraphAssortativity[singlerandomgraphscomm42,
    FindGraphCommunities[singlerandomgraphscomm42], "Normalized" -> False];
  Zscoresmodularity42 = zscorefunctionfortwonullmodels[graphsandnodenumbers42[[1]]];]

Out[ ]= {68.4925, Null}

In[ ]:= **bucketsize22 = thicknessdataFixedbucket2[[4]]**

Out[ ]= {378}

In[ ]:= **AbsoluteTiming[**
  thicknessdataFixedbucket3 = snetworkdatafxdbucket[10, bucketnode23, datafull];
  graphsandnodenumbers43 = snetworkgraph[thicknessdataFixedbucket3[[1]],
    thicknessdataFixedbucket3[[2]], 2, 7, 400, Green];
  modularityvalues43 = N@GraphAssortativity[graphsandnodenumbers43[[1]],
    FindGraphCommunities[graphsandnodenumbers43[[1]]], "Normalized" → False];
  singlerandomgraphsdegfxd43 = randomizinggraphdegfxd[graphsandnodenumbers43[[1]]];
  singlerandomerdrenmodularityvalues43 = N@GraphAssortativity[singlerandomgraphsdegfxd43,
    FindGraphCommunities[singlerandomgraphsdegfxd43], "Normalized" -> False];
  singlerandomgraphscomm43 = randomizinggraphmod[graphsandnodenumbers43[[1]]];
  singlerandomcommmodularityvalues43 = N@GraphAssortativity[singlerandomgraphscomm43,
    FindGraphCommunities[singlerandomgraphscomm43], "Normalized" -> False];
  Zscoresmodularity43 = zscorefunctionfortwonullmodels[graphsandnodenumbers43[[1]]];]

Out[ ]= {59.8674, Null}

In[ ]:= **bucketsize23 = thicknessdataFixedbucket3[[4]]**

Out[ ]= {746}

Error Bars and Charts

```
In[ ]:= AbsoluteTiming[
    ethicknessdataFixedbucket1 = Table[snetworkdatafxdbucket[10, i[[1]], i[[2]]],
        {i, MapThread[{#1, #2} &, {ebucketnode21, reduceddata1sthalflist}]}];
    egraphsandnodenumbers4 = Table[snetworkgraph[ethicknessdataFixedbucket1[[i, 1]],
        ethicknessdataFixedbucket1[[i, 2]], 2, 7, 400, Green],
        {i, Length@reduceddata1sthalflist}];
    emodularityvalues4 = Table[N@GraphAssortativity[egraphsandnodenumbers4[[i, 1]],
        FindGraphCommunities[egraphsandnodenumbers4[[i, 1]]], "Normalized" → False],
        {i, Length@reduceddata1sthalflist}];
    esinglerandomgraphsdegfxd4 = Table[randomizinggraphdegfxd[
        egraphsandnodenumbers4[[i, 1]]], {i, Length@reduceddata1sthalflist}];
    esinglerandomerdrenmodularityvalues4 =
     Table[N@GraphAssortativity[esinglerandomgraphsdegfxd4[[i]],
        FindGraphCommunities[esinglerandomgraphsdegfxd4[[i]]], "Normalized" -> False],
        {i, Length@reduceddata1sthalflist}];
    esinglerandomgraphscomm4 = Table[randomizinggraphmod[egraphsandnodenumbers4[[i, 1]]],
        {i, Length@reduceddata1sthalflist}];
    esinglerandomcommmodularityvalues4 =
     Table[N@GraphAssortativity[esinglerandomgraphscomm4[[i]],
        FindGraphCommunities[esinglerandomgraphscomm4[[i]]], "Normalized" -> False],
        {i, Length@reduceddata1sthalflist}];
    eZscoresmodularity4 = Table[zscorefunctionfortwonullmodels[
        egraphsandnodenumbers4[[i, 1]]], {i, Length@reduceddata1sthalflist}];]

Out[ ]= {399.116, Null}
```

```
In[ ]:= AbsoluteTiming[
    ethicknessdataFixedbucket2 = Table[snetworkdatafxdbucket[10, i[[1]], i[[2]]],
      {i, MapThread[{#1, #2} &, {ebucketnode22, reduceddata2ndhalflist}]}];
    egraphsandnodenumbers42 = Table[snetworkgraph[ethicknessdataFixedbucket2[[i, 1]],
        ethicknessdataFixedbucket2[[i, 2]], 2, 7, 400, Green],
      {i, Length@reduceddata2ndhalflist}];
    emodularityvalues42 = Table[N@GraphAssortativity[egraphsandnodenumbers42[[i, 1]],
        FindGraphCommunities[egraphsandnodenumbers42[[i, 1]]], "Normalized" → False],
      {i, Length@reduceddata2ndhalflist}];
    esinglerandomgraphsdegfxd42 = Table[randomizinggraphdegfxd[
        egraphsandnodenumbers42[[i, 1]]], {i, Length@reduceddata2ndhalflist}];
    esinglerandomerdrenmodularityvalues42 =
     Table[N@GraphAssortativity[esinglerandomgraphsdegfxd42[[i]],
        FindGraphCommunities[esinglerandomgraphsdegfxd42[[i]]], "Normalized" -> False],
      {i, Length@reduceddata2ndhalflist}];
    esinglerandomgraphscomm42 = Table[randomizinggraphmod[egraphsandnodenumbers42[[i, 1]]],
      {i, Length@reduceddata2ndhalflist}];
    esinglerandomcommmodularityvalues42 =
     Table[N@GraphAssortativity[esinglerandomgraphscomm42[[i]],
        FindGraphCommunities[esinglerandomgraphscomm42[[i]]], "Normalized" -> False],
      {i, Length@reduceddata2ndhalflist}];
    eZscoresmodularity42 = Table[zscorefunctionfortwonullmodels[
        egraphsandnodenumbers42[[i, 1]]], {i, Length@reduceddata2ndhalflist}];]

Out[ ]= {363.898, Null}
```

```
In[ ]:= AbsoluteTiming[
        ethicknessdataFixedbucket3 = Table[snetworkdatafxdbucket[10, i[[1]], i[[2]]],
          {i, MapThread[{#1, #2} &, {ebucketnode23, reduceddatafulllist}]}];
        egraphsandnodenumbers43 = Table[snetworkgraph[ethicknessdataFixedbucket3[[i, 1]],
          ethicknessdataFixedbucket3[[i, 2]], 2, 7, 400, Green],
          {i, Length@reduceddatafulllist}];
        emodularityvalues43 = Table[N@GraphAssortativity[egraphsandnodenumbers43[[i, 1]],
            FindGraphCommunities[egraphsandnodenumbers43[[i, 1]]],
            "Normalized" → False], {i, Length@reduceddatafulllist}];
        esinglerandomgraphsdegfxd43 = Table[randomizinggraphdegfxd[
            egraphsandnodenumbers43[[i, 1]]], {i, Length@reduceddatafulllist}];
        esinglerandomerdrenmodularityvalues43 =
         Table[N@GraphAssortativity[esinglerandomgraphsdegfxd43[[i]],
            FindGraphCommunities[esinglerandomgraphsdegfxd43[[i]]],
            "Normalized" -> False], {i, Length@reduceddatafulllist}];
        esinglerandomgraphscomm43 = Table[randomizinggraphmod[egraphsandnodenumbers43[[i, 1]]],
          {i, Length@reduceddatafulllist}];
        esinglerandomcommmodularityvalues43 =
         Table[N@GraphAssortativity[esinglerandomgraphscomm43[[i]],
            FindGraphCommunities[esinglerandomgraphscomm43[[i]]],
            "Normalized" -> False], {i, Length@reduceddatafulllist}];
        eZscoresmodularity43 = Table[zscorefunctionfortwonullmodels[
            egraphsandnodenumbers43[[i, 1]]], {i, Length@reduceddatafulllist}];]

Out[ ]= {406.575, Null}
```

```
In[ ]:= emodvalues4 = {emodularityvalues4, emodularityvalues42, emodularityvalues43};
        eZscores4 = {eZscoresmodularity4, eZscoresmodularity42, eZscoresmodularity43};
        Export["error_bar_values/" <> productionline <> "-modularity_values4.mx", emodvalues4];
        Export["error_bar_values/" <> productionline <> "-zscores4.mx", eZscores4];
```

```
In[ ]:= (* emodvalues4=Import["error_bar_values/CCM5-modularity_values4.mx"];
        eZscores4=Import["error_bar_values/CCM5-zscores4.mx"]; *)
```

```
In[ ]:= set41 = plotcolumn[modularityvalues4,
            singlerandomerdrenmodularityvalues4, singlerandomcommmodularityvalues4,
            Zscoresmodularity4[[1]], Zscoresmodularity4[[2]], eZscores4[[1]]];
        set42 = plotcolumn[modularityvalues42, singlerandomerdrenmodularityvalues42,
            singlerandomcommmodularityvalues42, Zscoresmodularity42[[1]],
            Zscoresmodularity42[[2]], eZscores4[[2]]];
        set43 = plotcolumn[modularityvalues43, singlerandomerdrenmodularityvalues43,
            singlerandomcommmodularityvalues43, Zscoresmodularity43[[1]],
            Zscoresmodularity43[[2]], eZscores4[[3]]];
        Legended[Framed[GraphicsRow[{set41, Magnify[set43, 1.03], set42}, ImageSize → 1093],
          FrameMargins → 5, FrameStyle → DotDashed], {Placed["First Half", {0.155, 0.99}],
          Placed["Complete Data", {0.505, 0.99}], Placed["Second Half", {0.86, 0.99}]}]
```

Out[•]=