

Data Import

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

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

In[ ]:= datafull = Import["../data/cgl_manipulated_27147_rev1.csv"];
  stepsizewidth = 11;
  stepsizethickness = 0.05;

In[ ]:= data = TakeList[datafull, Flatten@{ConstantArray[2714, 9], 2721}];
```

Investigation of Constraints Impact in Real-life Production Events

Fixed Step Size Networks

Width Feature

```
In[ ]:= AbsoluteTiming[
  widthdataFixedstep1 = snetworkdatabinnedintimewindows[data, 9, stepsizewidth, 10];
  graphsandnodenumbers1 = Table[snetworkgraph[widthdataFixedstep1[[1]][[i]],
    widthdataFixedstep1[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
  modularityvalues1 = Table[N@GraphAssortativity[graphsandnodenumbers1[[i]][[1]],
    FindGraphCommunities[graphsandnodenumbers1[[i]][[1]], "Normalized" -> False],
    {i, Length@graphsandnodenumbers1}];
  singlerandomgraphsdegfxd1 = Table[randomizinggraphdegfxd[
    graphsandnodenumbers1[[i]][[1]], {i, Length@graphsandnodenumbers1}];
  singlerandomerdrenmodularityvalues1 =
    Table[N@GraphAssortativity[singlerandomgraphsdegfxd1[[i]],
      FindGraphCommunities[singlerandomgraphsdegfxd1[[i]], "Normalized" -> False],
      {i, Length@singlerandomgraphsdegfxd1}];
  singlerandomgraphscomm1 = Table[randomizinggraphmod[graphsandnodenumbers1[[i]][[1]],
    {i, Length@graphsandnodenumbers1}];
  singlerandomcommmodularityvalues1 =
    Table[N@GraphAssortativity[singlerandomgraphscomm1[[i]],
      FindGraphCommunities[singlerandomgraphscomm1[[i]], "Normalized" -> False],
      {i, Length@singlerandomgraphscomm1}];
  Zscoresmodularity1 = Table[zscorefunctionfortwonullmodels[
    graphsandnodenumbers1[[i]][[1]], {i, Length@graphsandnodenumbers1}];
  bucketnode11 = graphsandnodenumbers1[[All, 2]]

Out[ ]:= {278.69, {64, 59, 61, 60, 64, 63, 62, 75, 69, 71}}
```

Thickness Feature

```

In[ ]:= AbsoluteTiming[thicknessdataFixedstep1 =
  snetworkdatabinnedintimewindows[data, 10, stepsizethickness, 10];
  graphsandnodenumbers2 = Table[snetworkgraph[thicknessdataFixedstep1[[1]][[i]],
    thicknessdataFixedstep1[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
  modularityvalues2 = Table[N@GraphAssortativity[graphsandnodenumbers2[[i]][[1]],
    FindGraphCommunities[graphsandnodenumbers2[[i]][[1]], "Normalized" → False],
    {i, Length@graphsandnodenumbers2}];
  singlerandomgraphsdegfxd2 = Table[randomizinggraphdegfxd[
    graphsandnodenumbers2[[i]][[1]], {i, Length@graphsandnodenumbers2}];
  singlerandomerdrenmodularityvalues2 =
    Table[N@GraphAssortativity[singlerandomgraphsdegfxd2[[i]],
      FindGraphCommunities[singlerandomgraphsdegfxd2[[i]], "Normalized" → False],
      {i, Length@singlerandomgraphsdegfxd2}];
  singlerandomgraphscomm2 = Table[randomizinggraphmod[graphsandnodenumbers2[[i]][[1]],
    {i, Length@graphsandnodenumbers2}];
  singlerandomcommmodularityvalues2 =
    Table[N@GraphAssortativity[singlerandomgraphscomm2[[i]],
      FindGraphCommunities[singlerandomgraphscomm2[[i]], "Normalized" → False],
      {i, Length@singlerandomgraphscomm2}];
  Zscoresmodularity2 = Table[zscorefunctionfortwonullmodels[
    graphsandnodenumbers2[[i]][[1]], {i, Length@graphsandnodenumbers2}];
  bucketnode21 = graphsandnodenumbers2[[All, 2]]]

Out[ ]:= {151.2, {33, 33, 43, 43, 49, 44, 43, 39, 40, 40}}

```

Fixed Bucket Size Networks

Width Feature

```

In[ ]:= AbsoluteTiming[
  widthdataFixedbucket1 = snetworkdatafxdbucketintimewindows[data, 9, bucketnode11, 10];
  graphsandnodenumbers3 = Table[snetworkgraph[widthdataFixedbucket1[[1]][[i]],
    widthdataFixedbucket1[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
  modularityvalues3 = Table[N@GraphAssortativity[graphsandnodenumbers3[[i]][[1]],
    FindGraphCommunities[graphsandnodenumbers3[[i]][[1]], "Normalized" → False],
    {i, Length@graphsandnodenumbers3}];
  singlerandomgraphsdegfxd3 = Table[randomizinggraphdegfxd[
    graphsandnodenumbers3[[i]][[1]], {i, Length@graphsandnodenumbers3}];
  singlerandomerdrenmodularityvalues3 =
    Table[N@GraphAssortativity[singlerandomgraphsdegfxd3[[i]],
      FindGraphCommunities[singlerandomgraphsdegfxd3[[i]], "Normalized" → False],
      {i, Length@singlerandomgraphsdegfxd3}];
  singlerandomgraphscomm3 = Table[randomizinggraphmod[graphsandnodenumbers3[[i]][[1]],
    {i, Length@graphsandnodenumbers3}];
  singlerandomcommmodularityvalues3 =
    Table[N@GraphAssortativity[singlerandomgraphscomm3[[i]],
      FindGraphCommunities[singlerandomgraphscomm3[[i]], "Normalized" → False],
      {i, Length@singlerandomgraphscomm3}];
  Zscoresmodularity3 = Table[zscorefunctionfortwonullmodels[
    graphsandnodenumbers3[[i]][[1]], {i, Length@graphsandnodenumbers3}];]

Out[ ]:= {320.503, Null}

```

Thickness Feature

```

In[ ]:= AbsoluteTiming[thicknessdataFixedbucket1 =
  snetworkdatafxdbucketintimewindows[data, 10, bucketnode21, 10];
  graphsandnodenumbers4 = Table[snetworkgraph[thicknessdataFixedbucket1[[1]][[i]],
    thicknessdataFixedbucket1[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
  modularityvalues4 = Table[N@GraphAssortativity[graphsandnodenumbers4[[i]][[1]],
    FindGraphCommunities[graphsandnodenumbers4[[i]][[1]], "Normalized" → False],
    {i, Length@graphsandnodenumbers4}];
  singlerandomgraphsdegfxd4 = Table[randomizinggraphdegfxd[
    graphsandnodenumbers4[[i]][[1]], {i, Length@graphsandnodenumbers4}];
  singlerandomerdrenmodularityvalues4 =
    Table[N@GraphAssortativity[singlerandomgraphsdegfxd4[[i]],
      FindGraphCommunities[singlerandomgraphsdegfxd4[[i]], "Normalized" → False],
      {i, Length@singlerandomgraphsdegfxd4}];
  singlerandomgraphscomm4 = Table[randomizinggraphmod[graphsandnodenumbers4[[i]][[1]],
    {i, Length@graphsandnodenumbers4}];
  singlerandomcommmodularityvalues4 =
    Table[N@GraphAssortativity[singlerandomgraphscomm4[[i]],
      FindGraphCommunities[singlerandomgraphscomm4[[i]], "Normalized" → False],
      {i, Length@singlerandomgraphscomm4}];
  Zscoresmodularity4 = Table[zscorefunctionfortwonullmodels[
    graphsandnodenumbers4[[i]][[1]], {i, Length@graphsandnodenumbers4}];]

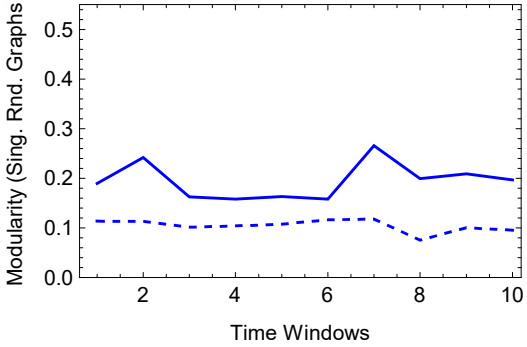
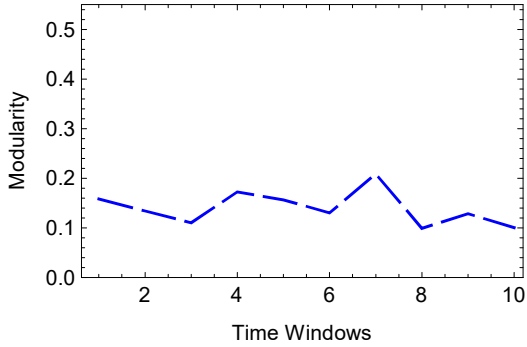
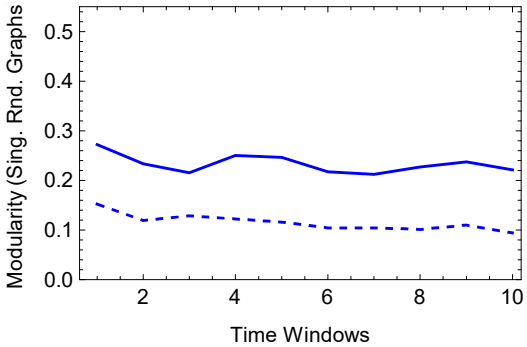
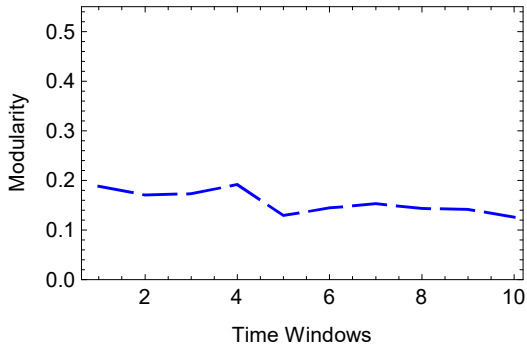
```

```
Out[ ]:= {161.521, Null}
```

Plots - Width

```
In[ ]:= padding = 5;
imagesize = 1000;
modularityplotrange = {0, 0.55};
zscorerange = {-10, 60};
Row[{GraphicsRow[
  {GraphicsColumn[{ListLinePlot[Thread[{Range@10, modularityvalues1}], Frame → True,
    FrameLabel → {"Time Windows", "Modularity"}, LabelStyle → 11, PlotStyle →
      {Dashing[{0.08, 0.1 - 0.08}], Blue}, PlotRange → {All, modularityplotrange}],
    ListLinePlot[Thread[{Range@10, modularityvalues3}], Frame → True,
      FrameLabel → {"Time Windows", "Modularity"}, LabelStyle → 11, PlotStyle →
        {Dashing[{0.08, 0.1 - 0.08}], Blue}, PlotRange → {All, modularityplotrange}]],
    Spacings → 10, ImagePadding → padding], GraphicsColumn[
  {ListLinePlot[{Thread[{Range@10, singlerandomerdrenmodularityvalues1}],
    Thread[{Range@10, singlerandomcommmodularityvalues1}], Frame → True,
    FrameLabel → {"Time Windows", "Modularity (Sing. Rnd. Graphs)"}, LabelStyle → 11,
    PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, modularityplotrange}],
    ListLinePlot[{Thread[{Range@10, singlerandomerdrenmodularityvalues3}],
      Thread[{Range@10, singlerandomcommmodularityvalues3}], Frame → True,
      FrameLabel → {"Time Windows", "Modularity (Sing. Rnd. Graphs)"}, LabelStyle → 11,
      PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, modularityplotrange}]],
    Spacings → 10, ImagePadding → padding], GraphicsColumn[
  {ListLinePlot[{Thread[{Range@10, Zscoresmodularity1[{All, 1}]}],
    Thread[{Range@10, Zscoresmodularity1[{All, 2}]}], Frame → True,
    FrameLabel → {"Time Windows", "Z-scores"}, LabelStyle → 11,
    PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, zscorerange}],
    ListLinePlot[{Thread[{Range@10, Zscoresmodularity3[{All, 1}]}],
      Thread[{Range@10, Zscoresmodularity3[{All, 2}]}], Frame → True,
      FrameLabel → {"Time Windows", "Z-scores"}, LabelStyle → 11,
      PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, zscorerange}]],
    Spacings → 10, ImagePadding → padding]],
  ImagePadding → padding, ImageSize → imagesize],
  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 → {23, 23}]]]
```

Out[]=



Plots - Thickness

```

In[ ]:= padding = 5;
imagesize = 1000;
modularityplotrange = {0, 0.55};
zscorerange = {-10, 60};
Row[{GraphicsRow[
  {GraphicsColumn[{ListLinePlot[Thread[{Range@10, modularityvalues2}], Frame → True,
    FrameLabel → {"Time Windows", "Modularity"}, LabelStyle → 11, PlotStyle →
      {Dashing[{0.08, 0.1 - 0.08}], Blue}, PlotRange → {All, modularityplotrange}],
    ListLinePlot[Thread[{Range@10, modularityvalues4}], Frame → True,
      FrameLabel → {"Time Windows", "Modularity"}, LabelStyle → 11, PlotStyle →
        {Dashing[{0.08, 0.1 - 0.08}], Blue}, PlotRange → {All, modularityplotrange}]}],
    Spacings → 10, ImagePadding → padding], GraphicsColumn[
  {ListLinePlot[{Thread[{Range@10, singlerandomerdrenmodularityvalues2}],
    Thread[{Range@10, singlerandomcommmodularityvalues1}]], Frame → True,
    FrameLabel → {"Time Windows", "Modularity (Sing. Rnd. Graphs)"}, LabelStyle → 11,
    PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, modularityplotrange}],
    ListLinePlot[{Thread[{Range@10, singlerandomerdrenmodularityvalues4}],
      Thread[{Range@10, singlerandomcommmodularityvalues3}]], Frame → True,
      FrameLabel → {"Time Windows", "Modularity (Sing. Rnd. Graphs)"}, LabelStyle → 11,
      PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, modularityplotrange}]}],
    Spacings → 10, ImagePadding → padding], GraphicsColumn[
  {ListLinePlot[{Thread[{Range@10, Zscoresmodularity2[[All, 1]]}],
    Thread[{Range@10, Zscoresmodularity2[[All, 2]]}]], Frame → True,
    FrameLabel → {"Time Windows", "Z-scores"}, LabelStyle → 11,
    PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, zscorerange}],
    ListLinePlot[{Thread[{Range@10, Zscoresmodularity4[[All, 1]]}],
      Thread[{Range@10, Zscoresmodularity4[[All, 2]]}]], Frame → True,
      FrameLabel → {"Time Windows", "Z-scores"}, LabelStyle → 11,
      PlotStyle → {{Dashed, Blue}, Blue}, PlotRange → {All, zscorerange}]}],
    Spacings → 10, ImagePadding → padding}],
  ImagePadding → padding, ImageSize → imagesize],
  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 → {23, 23}]]]

```

Out[*j*]=

