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"];
        stepsizewidth = 11;
        stepsizethickness = 0.05;

In[ ]:= data = TakeList[datafull, Flatten@{ConstantArray[5960, 9], 5964}];
```

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[ ]= {396.009, {73, 77, 77, 75, 78, 77, 75, 78, 82, 84}}
```

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[ ]= {345.547, {66, 66, 65, 67, 67, 74, 71, 75, 69, 71}}

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[ ]= {345.661, Null}

Thickness Feature

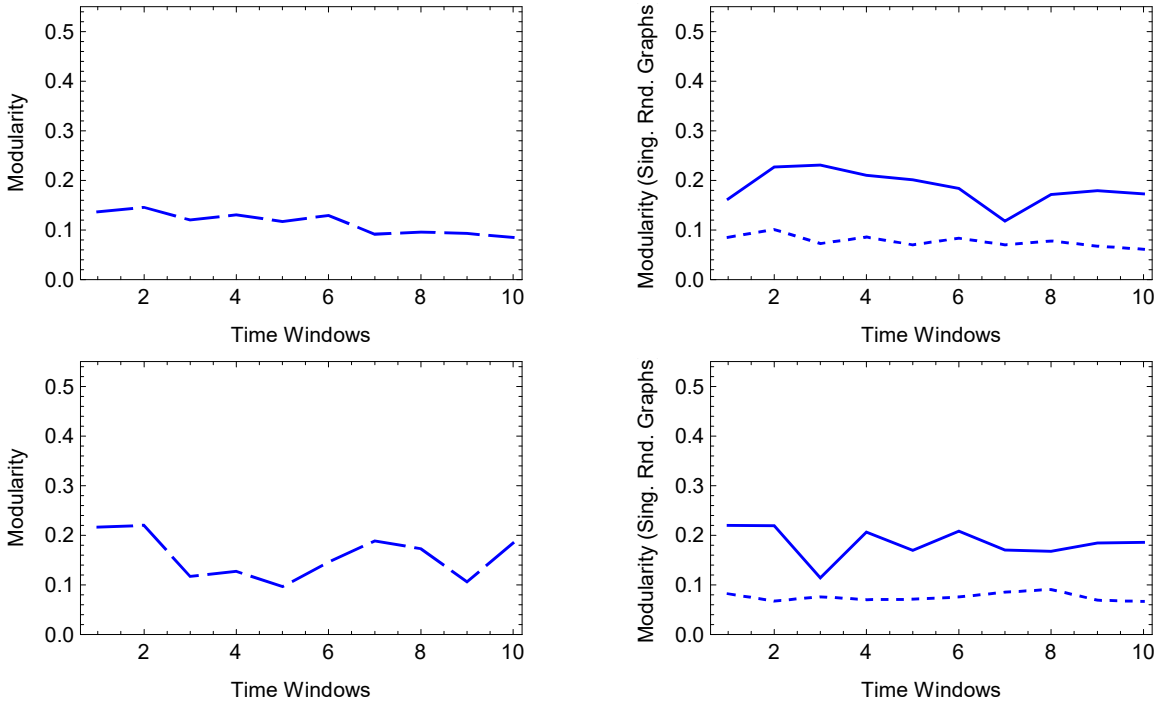
In[ ]:=
```
AbsoluteTiming[thicknessdataFixedbucket1 =
  snetworkdatafxdbucketintimewindows[data, 10, bucketnode21, 10];
 graphsandnodenumbers4 = Table[snetworkgraph[thicknessdataFixedbucket1[[1]][[i]],
    thicknessdataFixedbucket1[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
 modularityvalues4 = Table[N@GraphAssortativity[graphsandnodenumbers4[[i]][[1]],
     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[•]= {221.787, 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}]}]
```

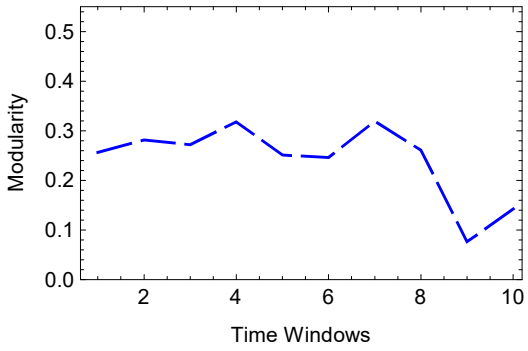
Out[ ]=

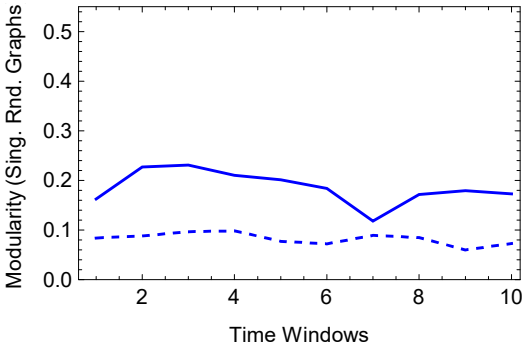


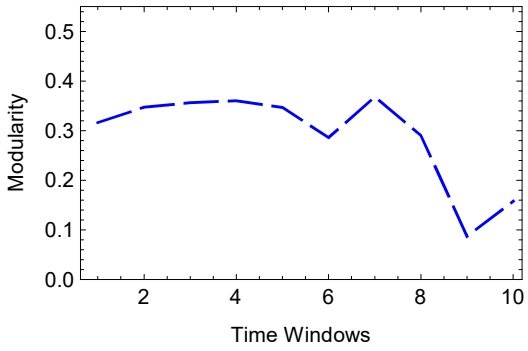
Plots - Thickness

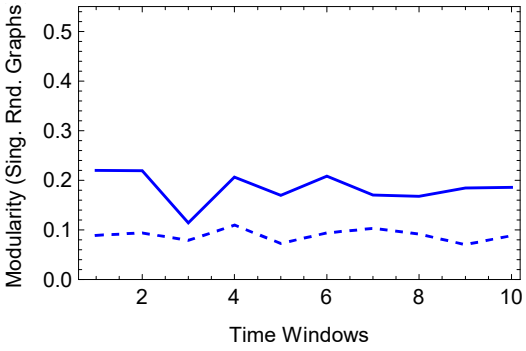
In[ ]:=
```
padding = 5;
imagesize = 1000;
modularityplotrange = {0, 0.55};
zscorerange = {-10, 60};
Row[{GraphicsRow[
   {GraphicsColumn[{ListLinePlot[Thread[{Range@10, modularityvalues2}], Frame → True,
       FrameLabel → {"Time Windows", "Modularity"}, LabelStyle → 11, PlotStyle →
        {Dashing[{0.08, 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[ ]=


Modularity
0.0
0.1
0.2
0.3
0.4
0.5
2
4
6
8
10
Time Windows


Modularity (Sing. Rnd. Graphs
0.0
0.1
0.2
0.3
0.4
0.5
2
4
6
8
10
Time Windows


Modularity
0.0
0.1
0.2
0.3
0.4
0.5
2
4
6
8
10
Time Windows


Modularity (Sing. Rnd. Graphs
0.0
0.1
0.2
0.3
0.4
0.5
2
4
6
8
10
Time Windows