```
In[ ]:= SetDirectory[
          "C:/Users/serha/OneDrive/Masaüstü/MyRepo/master_thesis_MMT003/210507_time_windows_and
            _OR_model"];

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

In[ ]:= stoichioforhomosapiens =
          Drop[Import["../210324_disc_time_windows_and_OR_model/iAT_PLT_636_stoichiomat.csv",
            HeaderLines → 1], None, {1}];
        SparseArray@stoichioforhomosapiens

Out[ ]= SparseArray[  Specified elements: 4006
                     Dimensions: {738, 1008} ]

In[ ]:= stoichiometricmatrix = stoichioforhomosapiens;
        metabolites = 738;
        fluxexchanges = 1008;
        steadystatevector = ConstantArray[{0, 0}, metabolites];
        first[a_] := First /@ GatherBy[Ordering@a, a[[#]] &] // Sort;
```

understanding the FBA model work principles

```
In[ ]:= boundaries = RandomChoice[{0.1, 0.9} → {{-5, 5}, {-500, 500}}, fluxexchanges];

In[ ]:= Dimensions@boundaries

Out[ ]= {1008, 2}

In[ ]:= subsetsizechoice = RandomInteger[{1, fluxexchanges}]
        subsetpositions = RandomSample[Range@fluxexchanges, subsetsizechoice];

Out[ ]= 218

In[ ]:= Dimensions@subsetpositions

Out[ ]= {218}

In[ ]:= coefficients = Table[RandomReal[{-2, 2}, subsetsizechoice], sequencesize = 300];
        Dimensions@coefficients

Out[ ]= {300, 218}

In[ ]:= objectivefunctions = Table[ReplacePart[ConstantArray[0., fluxexchanges],
            MapThread[#1 → #2 &, {subsetpositions, coefficients[[i]]}]], {i, sequencesize}];
        Dimensions@objectivefunctions

Out[ ]= {300, 1008}

In[ ]:= solutionvectors = Table[LinearProgramming[-objectivefunctions[[i]], stoichiometricmatrix,
            steadystatevector, boundaries], {i, Length@objectivefunctions}];
```

```
In[•]:= Dimensions@boundaries
        Dimensions@objectivefunctions
        Dimensions@solutionvectors
Out[•]= {1008, 2}
Out[•]= {300, 1008}
Out[•]= {300, 1008}
In[•]:= Position[boundaries, _?(# ≠ {-500, 500} &)];
In[•]:= Position[solutionvectors[[1]], _?(Abs@# < 5 &)];
In[•]:= Length @Cases[stoichiometricmatrix.solutionvectors[[1]], _?(Abs@# < 10^(-5) &)]
Out[•]= 738
In[•]:= MapThread[Dot, {objectivefunctions, solutionvectors}][[{1, 2, 3}]]
Out[•]= {60 645.5, 61 757.8, 66 689.5}
In[•]:= objectivefunctions[[1]].solutionvectors[[1]]
        boundaries[[1]]
        objectivefunctions[[1]];
        solutionvectors[[1]]
Out[•]= 60 645.5
Out[•]= {-500, 500}
Out[•]= {411.808, 88.192, 88.192, -309.54, -221.348, 500., 278.652, 278.652, 500., 251.758,
          1.1082 × 10^-6, 58.5749, -500., 500., 500., 5., -4.45757 × 10^-7, 500., 500., 500.,
          -4.45746 × 10^-7, -207.327, 500., -500., -292.673, -207.327, -207.327, 25.2985,
          -4.45761 × 10^-7, 1.4163 × 10^-6, 9.70505 × 10^-7, -500., -500., -500., -500., -182.029,
          187.029, 209.311, 5., 500., 5., -245.994, -500., 250.994, 100.605, -399.395, 500.,
          500., 500., -108.707, 500., -249.006, -249.006, -249.006, -399.395, 496.104, 173.854,
          500., -30.4101, 5., -500., -322.25, 496.104, 496.104, 3.89617, -318.743, 181.257, 500.,
          500., -495., -500., -500., 5., -500., 5., 5., -500., 1.24562 × 10^-7, 500., 1.55226 × 10^-8,
          500., 500., 500., 500., -500., -318.324, -500., 489.099, 157.094, 0.901267, 181.676,
          0.419939, -500., 0.481328, 0.481328, -500., 0.481328, -167.094, -500., 490., 88.192,
          500., 500., 500., -262.782, -257.782, -242.218, 5.75767 × 10^-10, -500., -500., 500.,
          291.765, 15., 111.727, 500., 500., -208.235, 1.73039 × 10^-7, 111.727, 500., -208.235,
          111.727, -208.235, -500., -500., -500., -500., 500., -5.89285 × 10^-7, 15., 15., 5.,
          4.94953, -0.0504689, 500., 500., -5.89289 × 10^-7, -5.89296 × 10^-7, -0.0319354, -0.031936,
          5., 79.2417, 5., 485., -5., 7.1049 × 10^-8, 79.2097, 79.2097, -5., 0.0178408, 117.071,
          -500., -500., 1.64758 × 10^-7, -495., 500., -500., -500., -500., -201.281, -500.,
          -500., -350.605, 149.395, -32.3616, 181.757, 181.757, -5., -0.0790054, -162.91,
          -162.831, 181.757, 500., -0.0790054, -500., -0.0790054, -350.605, 113.105, -99.6604,
          5., -212.765, 113.105, -125.846, -125.925, 130.925, 5., 5., -160.524, 113.105,
          386.895, 500., -4.68757 × 10^-6, -182.904, -339.476, 5., -344.476, 5., -322.096, 5.,
          -500., -0.0284516, 5., 5., -162.884, -121.745, -162.856, -0.0284516, -0.0284516,
```

187.12, −86.5152, 100.605, 251.895, 248.105, −10., 500., −345.605, 5., 500., 4.94881,
154.395, 207.288, 37.7116, −500., −0.0511861, 245., 5., 5., 5., 500., 500., 208.235,
500., −5., 9.28795×10^{-8}, 5., −192.226, −5., 500., 5., −500., −149.11, 167.011, 500.,
−5., 1.54×10^{-7}, 1.53996×10^{-7}, −321.121, −500., −5., −0.00757184, −500., 500.,
1.53995×10^{-7}, −134.967, 5., −496.345, −253.606, -2.80896×10^{-7}, 7.69936×10^{-8},
7.70044×10^{-8}, 10., 500., −500., -1.51318×10^{-7}, 2.80894×10^{-7}, −500., 312.774, 372.869,
−500., -2.10159×10^{-8}, −5., −5., 495., 127.131, 500., 5., 500., −32.2497, −10., 500.,
5., 5., −162.87, −500., 430.807, −81.3276, 500., 5., 5., 7.70015×10^{-8}, 5., −452.824,
−500., 442.824, 496.896, 413.672, 0.625, 3.10379, 500., 0.625, 2.09938×10^{-8}, 15.8533,
180.06, −5., 69.2665, 500., −265.179, −500., 5., −5., 391.966, −125.88, 15.1898,
-6.00664×10^{-9}, -4.89625×10^{-8}, −364.12, 15.1898, 5., -7.61416×10^{-8}, 5., −500., −5.,
500., 5., 5., −500., −500., −5., 500., −500., −500., 2.17138×10^{-7}, -2.17136×10^{-7},
181.948, −500., −318.052, 500., 353.43, 0.251399, 65.6595, 500., 5., 5., 413.485,
278.724, 86.5152, 81.5152, 5., −5., −500., −500., −500., 5., −15., 5., 5., 0.625,
1.13173×10^{-8}, −500., −5., −5., 500., −500., 5., −500., −500., 500., −199.301, −500.,
−300.699, −300.702, 3.02246×10^{-8}, 500., 500., 495., 0.00298801, −500., 5., 2.5,
−85.6925, 500., 5., 0.00298801, −490., −5., −5., −5., 5., −500., 205.424, −127.954,
0.00298801, −5., 333.378, 500., 0.625, 349.124, 4.375, −500., 205.424, 349.124, 205.424,
500., 2.17135×10^{-7}, −500., 92.8241, −500., 5., 407.176, 181.96, −318.04, −1.36363,
500., −311.15, −5., 500., 246.929, 5., 5., 5., 0.3125, 1.26868×10^{-7}, −92.8241, −500.,
500., −162.862, −5., −496.928, −183.83, 3.07181, 205.424, 500., 159.629, −285.804,
162.701, −500., 5., 205.424, 162.701, 500., −17.5503, 168.426, −500., 134.967,
−5., 500., 5., 5., −349.124, −463.057, −455.197, 500., 500., −500., −5., −5., −5.,
495., 500., −5., −500., −162.87, −155.876, 1.53994×10^{-7}, −500., −108.49, 5., −5.,
4.34271×10^{-7}, 139.878, −0.454546, −5., -1.20128×10^{-8}, −500., −500., −500., 78.6482,
250., -3.08222×10^{-9}, −0.454546, −5., 500., −5., −0.454546, 36.9431, 5., 5., 5.,
−0.454546, 1.04963×10^{-7}, −500., 5., −500., −500., −5., −0.059234, −500., −324.94,
495., −5., 500., 5., −457.824, −500., −269.951, −74.1928, −5., 5., 5., −413.672,
−5., 3.71135×10^{-7}, −349.124, 264.43, -2.80895×10^{-7}, 3.71135×10^{-7}, -2.80897×10^{-7},
−253.071, 264.43, −11.2392, −253.071, 500., −62.5044, −500., 5.91072, 3.33333,
−500., 500., 500., −495., 5., 5., −5., −473.855, 368.212, −10., 131.788, −255.424,
260.424, 5., 5., 5., −10., 5., −99.0825, 0.625, 413.672, 5., −4.375, 0.625, −500.,
1.54001×10^{-7}, 5., 104.083, −500., −162.869, -3.08671×10^{-9}, −0.00757184, 0.00757211,
261.318, −91.9609, 5., 122.578, 15.9715, 5., 56.6373, 500., 500., −76.4286, 56.6088,
-3.08614×10^{-9}, 0.0716466, 56.6805, 56.6805, −500., 500., −500., -6.92401×10^{-7},
−500., 304.755, 500., −500., −500., −500., 303.791, −5., −191.209, −5., 500.,
500., 6.41384×10^{-7}, 500., 500., 500., 138.565, 500., −500., −500., 5., 5., −500.,
−0.000024447, 413.672, −500., −500., 227.371, −272.629, 500., −500., 500., 303.791,
233.016, −39.6136, −39.6136, −5., 5., 500., 500., 500., −5., 1.78831×10^{-6}, 36.9431,
495., -1.53922×10^{-7}, 31.9431, −245., −500., 255., 255., −5., 255., −215.386, 145.876,
−250., −500., −300.699, −199.301, −500., 8.9052×10^{-9}, −245.57, 349.124, 349.124,
−500., 1.66945×10^{-7}, −500., 15.9715, 26.1451, 69.1928, 2.17135×10^{-7}, −0.136022,
−109.427, −5., 5., 5., 413.672, 36.9431, -1.0233×10^{-7}, −500., 5., −5., −62.1758,
−5., −369.453, 1.75415×10^{-7}, −500., 1.75442×10^{-7}, 250., 500., −500., −5., −5.,
−201.209, 250., 250.512, 500., −270.401, 74.1928, 5., −500., 500., −74.1928, −149.11,

500., 0.625, 5., 5., −294.576, −145.328, -1.7541×10^{-7}, 30., 500., −0.30116, 500., 0.182075, 4.81793, 344.124, −268.083, 311.15, −500., −5., 5., 263.083, 5., −500., 5., −47.1758, 364.453, −155.876, 5., −215.424, 5., -1.20104×10^{-8}, 500., 64.5482, −0.0126115, −5., −5., −5., −5., 5., −364.453, −5., −5., 5., −5., −364.453, 500., 500., 31.9431, 500., −15., −0.454546, −500., −500., −0.454546, −215.424, −495., 3.49905×10^{-8}, −500., −10., −15., −5., −500., 5., 386.966, 5., 413.672, −500., −500., −500., −5., 5., 484.076, -3.19214×10^{-7}, −500., 5., −283.933, −5., 495., −273.604, −5., −5., −5., 10., −500., 386.966, −484.81, −5., −5., -3.24928×10^{-8}, −62.1758, −5., −273.604, −500., 495., −5., −500., −5., 5., 500., −485., −5., -7.61406×10^{-8}, 500., −500., 278.604, −5., 4.88313×10^{-8}, 10., −2.5, 500., −76.4286, 500., 500., −31.9431, −2.5, −5., −500., -1.78104×10^{-8}, 5., −5., −5., −495., 5., 0.30116, −0.30116, 386.966, −500., −0.0644153, 500., −335.579, −500., −495., 5., −0.0644153, 5., −500., −0.0340786, 5., 3.6554, 496.345, −5., −5., 0.625, 500., -2.16088×10^{-7}, 166.667, 500., −5., −192.226, 500., −500., −187.226, −5., −101.605, 101.605, −500., −57.1758, −5., −5., 5., 1.66945×10^{-7}, −5., −5., -2.80897×10^{-7}, −488.761, 0.00757183, 1.36363, 495., 5., −0.91072, −345.411, −66.2619, −5., 339.124, 500., 5., 5., −5., 495., −500., −149.11, −5., 5.99471×10^{-9}, 30., 500., −5., −500., 500., −255.424, −191.209, −191.209, −191.209, −500., 500., 1.53998×10^{-7}, 1.53997×10^{-7}, −191.209, 1.54×10^{-7}, 5., −500., −5., 260.424, 78.6482, −500., −500., 5., 5., 8.9052×10^{-9}, −5., 69.1928, −5., −484.028, −5., −0.328512, 500., 1.21891×10^{-7}, 500., 1.7542×10^{-7}, −500., 500., 5., 495., 5., 5., −149.11, 500., −0.00757184, −500., −500., 4.375, 428.571, −500., 0.025223, 500., 1.5399×10^{-7}, 500., 386.966, 10., −5., 5., −5., −5., 500., 5., -3.73311×10^{-7}, 36.9431, −5., 500., 250.512, −130.887, −74.1928, −270.401, 145.328, 5., −5., 5., −273.604, 68.7108, -1.20081×10^{-8}, 3.71132×10^{-7}, 485., 5., −270.401, -7.61423×10^{-8}, −0.025223, 5., 283.933, 5., 1.51318×10^{-7}, 5., −145.876, 122.714, −500., 500., 1.04964×10^{-7}, 500., −5., 10., 3.19214×10^{-7}, 500., −15.9715, −5., 5., -7.61423×10^{-8}, 364.453, −5., −495., 69.1928, 5., 81.3276, 490., −500., 500., −5., 154.11, 2.80895×10^{-7}, -2.80894×10^{-7}, 5., −500., −391.966, 5., −5., 15., 3.06989×10^{-9}, −500., −92.8241, −349.124, −500., −4.375, 205.424, −205.424, 500., 5., 9.56519×10^{-7}, −500., −139.878, −5., 500., 500., 500., −500., 5., 192.226, 5., 191.209, −5., −500.}

In[ ]:=
```
Table[objectivefunctions[[i]].solutionvectors[[i]], {i, 5}]
```

Out[ ]= {77519.8, 77179.2, 76169.4, 76198.8, 78628.7}

In[ ]:=
```
Table[objectivefunctions[[i]].solutionvectors[[i]], {i, 5}]
```

Out[ ]= {14669.4, 12421.7, 16990.3, 16972., 13665.4}

In[ ]:=
```
objectivefunctions[[10]].solutionvectors[[10]]
boundaries[[10]]
objectivefunctions[[10]]
solutionvectors[[10]]
```

Out[ ]= 73673.9

Out[ ]= {−5, 5}

Out[ ]= {0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.0743208, 0., −1.51254, 0., 0.789921, 0., 1.10033, 0., 0., 0., 0., 0., 0., −1.39722, 0.741487, 0., 0., −1.63606, 0., 0., 0., −1.32184,

−1.93766, 0., 1.72376, 0.49043, −1.54416, 0., −1.89038, 0., 0., 1.97131, 0., 0.755996,
1.29641, 0., 0., 1.30722, 0.0390453, 0., 0., 0.283093, −0.806, −0.892888, 1.67428,
0.000277294, 0., 0., 0., 0., 0., −0.00665316, −0.581931, −0.987455, 0., −1.6139, 0.,
0., 1.70869, 0., 0., −0.715869, 0., −0.241224, 0., 0., 0., 1.72684, 0., 0., 0.972165, 0.,
0., 0.31114, −0.213014, 0.254684, −0.342883, −0.729748, 0., 0., 0., 0.553164, 0., 0.,
0., 0., −0.234706, −0.687096, 0., −1.6107, 0., 0.0697311, 0., 0., 0., 0., 0., 1.94689,
0., 0., 0., 0., −0.464159, 0., 0., −0.0788626, 0., −0.864027, 1.51008, 0., 0.940774,
0., 0., 0., 0., 1.03849, −1.04517, 0., 0., 0.682586, 1.9233, −1.93074, 0., 0., 0., 0.,
0., 0., 0., 0., 1.18528, 0.908618, 1.98442, −0.298979, 0., 0., 0.364933, 0., 0., 0.,
−0.868577, 0., 0., −1.81066, 0., 0., 0., 0., −1.5164, 0.863457, 0., 0., 0., 1.49768,
0., 0., 0., 0., 0.643025, 1.46433, −0.114655, 1.33704, 0., −0.415086, −0.0512621,
−1.68597, 0., −1.45376, 1.34326, −1.88125, −1.63474, 1.39656, −1.13204, 0., 0.,
−1.08575, −1.45066, 0.762774, 0., 0., 0., 0., −0.535283, 0., 0., 0.74898, 1.17841, 0.,
1.37378, 0., 0.838042, −0.714709, 0., 0., −1.46737, 0., −1.4719, −0.815447, 0., 0.,
0., −0.544056, −0.267654, −1.9779, 0., 0., 0., −0.0149158, −1.2532, 0., −1.89285,
1.9057, 0., 0.433256, −0.436692, 0., 0., 0., 0., 1.53041, 0., −0.820962, −0.452673,
−1.48449, 0., 0., 0., 1.41382, −1.25392, 0., 0., 1.78508, 0., 0., 0., 0., −1.93154,
0., −1.3202, −0.479927, 0., 0., 0., 0., 0., 0., 0., 0.952194, −0.18533, 1.74231, 0.,
0., 0., −0.885353, −0.554977, 0., 0., 0., 0.763731, −1.58657, 1.04327, −0.692071, 0.,
−0.301438, 0., 0., −1.56534, 0., −1.81719, 0., 0., 0.883141, −0.590216, −1.65284,
0., 0., 0.84477, 0., 0.206431, 1.82403, 0.0297198, 0., −1.91312, 0., −0.497163, 0.,
−1.58167, −1.58901, 0., 0., −1.96533, −1.7632, 0.710824, 1.48007, 0., 0., −1.45054,
0.732252, −1.2801, 0., −0.853697, 0., 0., 0., 0., −0.775483, −0.501458, 0., 0., 0., 0.,
0., 0., 0., −1.67173, −0.698819, 0.229411, −1.91115, 1.07467, 0., −0.84229, −1.04069,
1.15636, −0.675331, 0., −0.419105, −1.51932, −1.70313, 0., 0., 0., 0., 1.02335, 0.,
0., 0.179348, 1.16567, 0.192778, 0., −1.72948, 0., 0.52617, 0.0662661, 0., 0., 0.,
0., 0., 0., 0., 1.16311, −0.787411, 0., 0., 0., −0.865694, 0., −1.25777, −1.71786,
0., 0.489379, 0., 0.759155, 0., 0., 0., −1.86024, 0., 0., 0., 1.96622, 0., 0., 0., 0.,
1.79577, −1.9267, −1.83484, 0., 0., 0., 0., −0.184369, 0., 0., −0.391675, 1.70594,
1.15792, 1.62465, 0., 0.579015, 0., 0., 0., −0.744815, −1.01316, −0.926818, 0., 0.,
−0.192285, 0., 0., 0., 0., 0., 0., −1.87135, −0.693475, 0., 0., −0.0587214, 0.109793,
0., −1.09614, −0.147566, 0., 1.11734, 0., −1.26718, −0.514077, 0., 0.547563, 0., 0.,
−1.63197, 0., 0., 0., −0.103143, 1.198, 0.577116, 0., 0., 0., 0., −1.31338, 0., 0.350983,
0., 0., −1.95149, −1.08633, 0., 0.286592, 0., 1.64368, −0.912392, 0.130304, 0.,
−0.56113, −0.231618, 0., 0., 0., 0., 0., 1.1524, 0., 0., 1.4362, 0., 1.92338, −1.66701,
−0.557448, 0., 1.03098, 0., 0., −0.49801, 0., 0., −0.830556, 0., 1.02909, −1.13532,
−1.52385, 0., 0., 0.851461, 0., 0., 0., 0., 0., 0., 1.04567, −0.421924, 0.678382, 0.,
−0.699769, −0.616183, 0., −1.462, 1.67146, −1.63286, 0., −0.912884, −0.0691518,
0.619384, −1.7275, 1.5236, 0., −1.63626, −0.329837, 0.250656, 0., 0.111538, 0., 0.,
0., 0.994697, −1.94197, 0., 0., 0.188602, 0., −0.114549, 1.19589, 0., 0.777343, 0., 0.,
0., 0., 0., −0.17163, −1.9527, 1.4577, 0., 1.47915, 0., 0., 0.736673, 0., 0., 1.76316,
−1.70008, 0., −1.22674, −0.340705, 0., 0.482001, 0., 0., 1.27928, 0., 0., −1.14285,
0., 0., −0.696967, −0.676592, 0., 1.70049, 0., 0., −1.80776, 0., 0., −0.846925,
−1.31549, 0., 0., 0., 0., 0., 0., 1.72523, 0.361176, 0., 0.191861, −1.31027, 0., 0.,
0., 0.817594, 0., 1.22361, −1.61295, −0.724137, 0.315625, −0.702842, 0., −0.728991,
0., 0., 1.39477, 0., 0., 0., 0., 0., 0.260858, 1.61302, −1.07829, 0., 0., −0.0409778,

0., 0., 0., 1.65527, −0.105112, −0.0290855, 0., −0.527117, 0.651842, 0., −0.648148,
0., 0.59403, −1.13825, 0.241619, 0., 0., 0., 1.59412, 0., 0.0536986, 0., 0., −1.25706,
0., −0.76337, 0.479827, 0., 0., 0.836229, −1.87922, 1.19469, 0., 0., −0.742222, 0.,
0., −0.927921, 0., 0.537939, 0.327022, −1.35728, −1.41844, 0., 0., 0., 0., 0., 0.,
0., 0., −0.515209, −1.29473, −1.80062, 0., 0., 0., 0., 0., 0.0311344, −0.905734, 0.,
0., −1.4522, 0.905414, 0.794447, 0., 0.187688, 0., 0., 0., 0., 0., 0., 0., 0.59399,
0., 0., 0., 0., 0., 1.32512, 0., 0., 0., 0., 0., 0., −1.0075, −0.781461, 1.35189, 0.,
0., 0., −1.096, 0., −1.49225, 0., −0.520712, 0., 0., 0., 0.769472, 0., 0., 0., 0.,
0.725443, 0., 0., 0., −1.06061, 0., 0., 0., −1.60287, 0., 0., −0.103215, 0., 0., 0.,
0., −1.05651, 0.0689921, 0., 0.0768559, −1.48121, 0., 0.744189, 0., −0.0590652,
0., 0., 0.597244, 0., 0.715352, 1.95646, 0., 0., 0.100142, 0., 0., 0., 0., −1.79111,
−1.56752, 0.801895, 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.451618, −1.30251, 0., 0., 0.,
0.619134, 0.708209, 1.31019, 1.30095, 1.94052, 1.12197, 0., 0., −1.6699, 0.588378,
0., 0.767933, 0., 0., 1.40314, 0., 0., 0., 0.824856, −1.30813, 0., −1.81044, −1.15621,
0.0698784, 0., 0., 0.686237, −1.89028, 1.61357, 0., 0., −1.70517, 1.50283, −0.861526,
0., −1.43148, 1.03298, 0., 0.506978, −1.53789, 0.114757, −0.312015, 0., 0., 1.26988,
0., −0.80521, 0., 0., −1.27561, −0.608301, −1.48513, 0., −0.767119, 1.12799, 0.,
−0.682001, 0., 0., 0., 0., −0.589831, 0.517662, 0., 0., 0., 0., −0.0946492, 0., 0.,
0., 0., −1.23825, 0., 0., 0., 0., 0., 0., 0., 0.943275, 0., 0., −1.11647, −0.632411,
0., 0., 0., 1.04315, 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.233012, 0.535859, 0.,
0., −1.42698, 0., −0.459085, 0., 0., 0., −1.56034, 1.03963, −0.891736, −0.829834,
−0.345172, 0., 0., −1.07236, 0., 0., −0.777663, 0., 1.08328, 0., 0., −1.65475, 0., 0.,
−0.596788, 0.331755, −1.23151, −1.49698, 1.697, −1.27809, 1.69587, 0., −0.463969,
0., 0., 0., 0.741838, 0., 0., 0., 0., 0., 0., 0., 0., 1.45996, 0., 0., 0., 0., 0., 0., 0.,
0., 0., 1.69197, −1.75858, 0., 1.1597, 0., −0.634979, 0., 0., −1.4445, 0., 1.51156, 0.,
−1.81822, 0., −1.67246, −0.749058, 0., 1.0531, 0., 0., −0.53606, −0.756045, −1.50515,
0., 0., 0., 0., 0., 0., −1.11596, −1.89444, 1.98738, 0., 0.644983, 0., 0., 1.9174,
−0.582909, −1.80651, −0.863224, 0., 1.93326, −0.509123, 0., −1.61992, 0., −0.0944942,
−1.65846, 0., 0., 0., 0., 0., 0., 0., −0.173637, 0., 0.741266, 0., 0., 0., 0., −1.21356,
0.818932, 0., 0., 0., 0., 0., −1.75388, 0., 0., −1.50656, 0., 0., 0., −0.791126, 0., 0.}

Out[•]= {363.452, 136.548, 136.548, 363.452, 500., −72.5131, 427.487, 427.487, 500., −0.0335984,
-4.12833×10^{-8}, −143.434, −500., −500., 500., 1.26702×10^{-7}, 500., 500., 351.374,
−148.626, 500., 500., 500., -2.53747×10^{-7}, −500., 500., 500., −500., 500., −500.,
3.42682×10^{-8}, −500., −500., −500., 500., -4.00991×10^{-9}, −500., 500., −500., 500.,
−500., 500., 153.503, −500., -1.16412×10^{-8}, −5., 5., 5., 5., 500., -3.38329×10^{-8},
−500., −500., −500., 500., −500., −500., 346.497, 72.5467, 4.97739×10^{-9}, −500.,
2.84952×10^{-7}, −500., −500., 500., −500., -7.6967×10^{-8}, 1.33797×10^{-8}, 500.,
−31.6736, −500., −500., −31.6736, 9.85988×10^{-8}, −31.6736, −500., −468.326, 500.,
500., -2.69836×10^{-8}, 5., 5., 5., 500., 1.04137×10^{-8}, 500., 1.04183×10^{-8}, −500.,
−500., -4.30071×10^{-8}, 500., 5., 1.04528×10^{-8}, −5., −5., 9.86396×10^{-8}, −5., −5.,
9.87113×10^{-8}, −500., 136.548, 500., 500., 500., 500., 500., −88.239, 500., 411.761,
411.761, −348.952, 5.35226×10^{-8}, 500., −495., −411.761, −500., 500., -7.14776×10^{-8},
5., −500., 500., 5., 500., −156.048, 500., 500., 500., −5., −208.942, 500., 500.,
5., 234.235, 229.235, −208.85, 0.0918253, −208.942, −208.942, −286.058, −495., 5.,
500., 5., -8.0912×10^{-8}, -1.99976×10^{-8}, 5., 5., 5., 500., −500., −5., 215.87, 220.87,

−500., −500., −3.69752 × 10^−8, −500., −500., −500., 1.12253 × 10^−6, 220.87, −500., −0.339603, 268.308, −231.692, 500., 500., −5.52497 × 10^−8, 5., 10., 5., 500., −452.222, 5., −30.8082, 5., −231.692, 500., 495., −469.192, −5., 500., −500., −495., −5., −500., −500., 5., 500., 5.32953 × 10^−9, 500., 1.17255 × 10^−8, 500., −7.8336 × 10^−7, −469.192, −500., 500., 5., −469.192, 5., −500., 500., 500., −149.883, −5., 350.117, −500., −500., 6.79535 × 10^−8, 1.48881 × 10^−8, 8.32114 × 10^−8, −5.48862 × 10^−8, −500., −500., −500., −231.692, −4.96923 × 10^−7, 500., −500., 268.308, −500., 500., 490., −500., −5.1142 × 10^−10, 500., −4.96941 × 10^−7, −4.96937 × 10^−7, −450.821, 500., −5., −255., 5., −5., −25.8082, 5., −500., 475., 421.437, 5., −242.5, 5., 489.179, 25.8082, 394.239, 394.239, −500., −500., −252.5, −500., −265.25, −26.4169, 394.239, 285.033, 5., −500., 325.638, 5., 197.12, 197.12, 1.28913 × 10^−7, 500., −5.82107, 494.179, −5., 500., 135.1, 5., 500., 21.6234, 5., 5., −490., −500., −5., 5., −5., −5., −232.426, 5., 421.437, 471.437, −500., −500., 15., −410.492, 5., 5., 5., 197.12, 421.437, 1.36502 × 10^−8, −5., −500., 79.5076, −405.492, 0.625, −500., −420.492, 0.625, −21.6234, −5., 500., 490., 5., 15.5984, −500., 500., −2.17407 × 10^−7, 407.083, 247.5, 500., −5., 3.33333, −2.80349 × 10^−8, −256.955, −5., 1.42455 × 10^−7, 255.083, 233.944, −244.917, 20.0739, −3.33333, −262.5, −262.5, −500., −500., 262.5, −8.5949 × 10^−9, 500., −5., −10., 10., −500., 5., −500., −8.59399 × 10^−9, −500., −1.53067 × 10^−8, −205.719, −8.60211 × 10^−9, −262.5, 5., −500., −351.566, 7.95797 × 10^−8, 500., −500., −15., −5., −5., −5., 5., 500., −500., −500., 0.625, −5., 10., −5., −5., −161.517, 5., 136.364, 5., −5., 500., −495., −500., 500., 500., −250., −490., 500., 5., 4.67367 × 10^−7, 86.359, −176.517, 2.5, −494.516, 5., −5., 4.67367 × 10^−7, 500., 5., 5., −500., 5., −5., 134.508, 500., 4.67372 × 10^−7, −500., −365.492, 500., 0.625, 5., 4.375, 5., 134.508, 5., 134.508, −5., −10., −500., −3.15626 × 10^−8, −500., −5., 500., −500., −495., 363.636, −86.359, 500., −136.364, −5., −500., −5., −5., −5., 0.3125, −5., 3.15622 × 10^−8, −500., −5., 335.968, −5., −5., −500., −10., 134.508, 206.341, 5., −5., −5., 491.969, −5., 134.508, −5., 500., 309.258, −319.258, −500., −285.033, 5., 5., −5., 5., −5., −500., −5., 481.59, −490., 5., 25.8082, −5., −5., 500., −41.6165, −5., 5., −500., −5., 394.239, 500., 429.059, −176.517, 5., −20., 500., −45.4545, 5., 6.66667, −500., 500., 447.748, −500., −223.874, −20., −45.4545, −15., −447.748, −15., −45.4545, −25., 5., 5., 5., −45.4545, 5., 86.359, −5., 86.359, −5., 2.17409 × 10^−7, 500., −2.73063 × 10^−7, 500., −500., 2.17409 × 10^−7, −490., 5., −500., 5., −493.074, 5., 5., 5., 5., 405.492, −136.364, 384.239, −5., −5., 5., 384.239, 5., −413.641, −5., 326.718, −413.641, −500., −500., −248.155, −78.5627, −9.01252, −5., 500., 500., 5., 1.42387 × 10^−7, 5., 10., −176.437, −495., −232.426, −5., −48.4097, 53.4097, 5., 5., 5., −232.426, 5., −495., 0.625, −405.492, −10., −4.375, 0.625, −500., 394.239, −5., 500., 500., −48.2713, −20., −500., 384.239, 247.5, −500., −25.8082, −500., 5., 5., 1.30936 × 10^−8, −500., 495., −5., −500., −20., 461.556, −38.4443, −38.4443, −500., −31.1148, −500., 500., 5., −207.325, −495., −500., −500., −500., 5., −399.63, 500., 5., 427.269, −500., 5., −500., −500., −500., 250.769, 5., 500., 432.269, 5., 5., 349.512, −150.488, −405.492, 500., 500., −500., 2.31523 × 10^−10, −394.63, 500., −490., 500., 500., 500., 500., −500., −5., 468.885, −5., −5., 490., −485., −25., 500., −394.239, −40., 495., 500., −5., −5., −15., −5., −500., 500., −5., 5., 500., −495., 5., −5., 5., −457.748, −457.748, 5., 50., 5., 5., −181.437, 485., −10., −495., −5., 5., 421.437, 471.437, −405.492, −25., −231.692, −149.59, 421.437, −136.364, 5., −500., 500., −1.03287 × 10^−7, −500., −1.03282 × 10^−7,

-2.48331×10^{-6}, 384.239, −500., −15., −15., 37.6388, 500., 434.63, 5., −5., −5., 5., −495., 500., 5., −242.5, −365.492, 0.625, 15., 5., 500., −160.769, 1.03282×10^{-7}, 30., 250., −352.859, 500., 1.20703×10^{-6}, 500., -2.07669×10^{-7}, 252.5, −500., −5., −5., 5., 5., −257.5, 5., −5., 3.4097, −495., −5., −5., −25., −5., 6.66667, 66.8784, 5., −250., −399.63, −399.63, −399.63, 5., 5., 11.9265, 5., 5., −5., 407.083, 11.9265, 427.269, 427.269, −40., 427.269, 500., −67.0779, −495., −495., −45.4545, −25., 5., 1.66667, 94.5076, −490., 500., −5., −5., 5., −5., 5., −405.492, −5., 500., 491.969, −500., 500., 393.084, 5., −312.069, 240., 5., 15., 500., 455.821, −252.5, 15., 5., 2.28108×10^{-6}, −500., −5., −500., 15., −5., 10., 5., 5., 500., −490., 500., 5., 5., −5., −5., −490., 500., −5., 255.083, −500., 500., -3.89406×10^{-9}, 407.083, −248.918, 10., −500., −490., −5., −5., −495., 265., 500., 407.083, −500., 10., 5., -2.44362×10^{-7}, −5., 5., 1.42409×10^{-7}, 352.859, −352.859, −5., 490., 500., −490., 5., 5., 5., 487.962, 500., 5., 5., 432.606, 1.42394×10^{-7}, −500., 384.239, −5., -2.44367×10^{-7}, 0.625, 8.075×10^{-8}, −500., −166.667, −500., −5., 500., 5., −500., 10., -2.44361×10^{-7}, 185.742, 5., 5., −10., −5., −455.821, 1.42422×10^{-7}, 50., −5., −5., 5., 354.024, −5., −500., −173.282, 5., 500., 500., −500., −5., −500., −490., 5., 1.42373×10^{-7}, −5., 495., −500., −242.5, −15., −3.33333, 30., 138.757, −15., 500., 500., −48.4097, 500., 500., 500., 253.918, −253.918, 394.239, 394.239, 500., 394.239, 5., −500., 5., 53.4097, −500., −500., −5., 15., 15., −5., −5., −20., 5., −495., −15., −224.921, −500., −500., -1.85139×10^{-9}, -1.03284×10^{-7}, −5., −5., −5., 5., −5., -2.17409×10^{-7}, −242.5, −500., −500., 500., 5., 4.375, 468.885, −105.761, 500., 500., 394.239, 500., −5., −27.0375, 10., −176.517, 5., 25.8082, 10., 5., −500., −25., −471.437, −490., 434.63, −5., 5., −5., 160.769, 5., −500., −257.5, 500., 10., 6.66667, 384.239, −500., −10., −5., 255.083, −500., 5., −5., −15., −494.179, −10., −500., −5., 271.417, 5., 5., −500., −240., −500., −5., 500., −5., 5., −5., 255.083, −495., −176.517, −5., 485., 5., 410.492, −243.045, −500., −5., −421.437, 495., −5., 5., 471.437, 420.492, −247.5, −262.5, 262.5, 411.437, 20., −500., 3.15633×10^{-8}, −5., 500., −4.375, 134.508, −134.508, 500., −5., −458.384, 500., −500., 5., −447.748, 495., −500., 500., −5., −5., 5., −500., −15., 500.}

In[ ]:=
```
function[stoichiometricmatrix_, steadystatevector_,
  boundaries_, fluxexchanges_, sequencesize_] := Module[
  {subsetsizechoice, subsetpositions, coefficients, objectivefunctions, solutionvectors},
  SeedRandom@5;
  subsetsizechoice = RandomInteger[{1, fluxexchanges}];
  subsetpositions = RandomSample[Range@fluxexchanges, subsetsizechoice];
  coefficients = Table[RandomReal[{-2, 2}, subsetsizechoice], sequencesize];
  objectivefunctions = Table[ReplacePart[ConstantArray[0., fluxexchanges],
     MapThread[#1 → #2 &, {subsetpositions, coefficients[[i]]}]], {i, sequencesize}]]
```

In[ ]:=
```
trial = Table[
  function[stoichiometricmatrix, steadystatevector, boundaries, fluxexchanges, 300], 2]
```

Out[ ]=

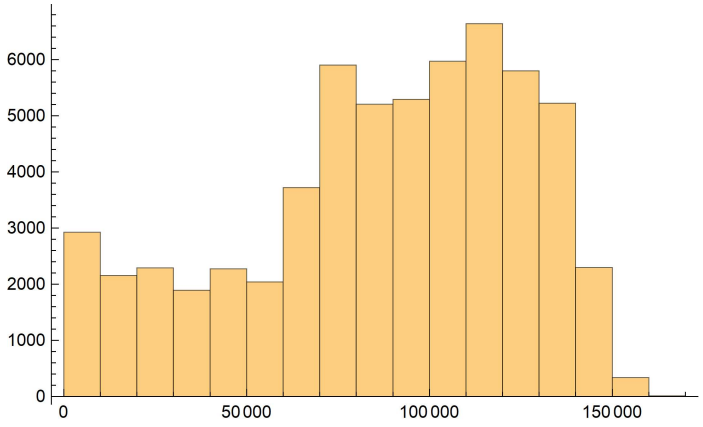
{{ … 1 … }, { … 1 … }}

large output | show less | show more | show all | set size limit…

```
In[ ]:= Dimensions@trial
Out[ ]= {2, 300, 1008}

In[ ]:= trial[[1]] == trial[[2]]
Out[ ]= True

In[ ]:= syntheticseqgenerator[stoichiometricmatrix_,
  steadystatevector_, boundaries_, fluxexchanges_, sequencesize_] := Module[
  {subsetsizechoice, subsetpositions, coefficients, objectivefunctions, solutionvectors},
  subsetsizechoice = RandomInteger[{1, fluxexchanges}];
  subsetpositions = RandomSample[Range@fluxexchanges, subsetsizechoice];
  coefficients = Table[RandomReal[{-20, 20}, subsetsizechoice], sequencesize];
  objectivefunctions = Table[ReplacePart[ConstantArray[0., fluxexchanges],
     MapThread[#1 → #2 &, {subsetpositions, coefficients[[i]]}]], {i, sequencesize}];
  solutionvectors = Chop[Table[LinearProgramming[-objectivefunctions[[i]],
      stoichiometricmatrix, steadystatevector, boundaries],
     {i, Length@objectivefunctions}], 10^-5];
  {objectivefunctions, solutionvectors, MapThread[Dot,
    {objectivefunctions, solutionvectors}]}]

In[ ]:= boundaries = RandomChoice[{0.1, 0.9} → {{-5, 5}, {-500, 500}}, fluxexchanges];

In[ ]:= AbsoluteTiming[objfuncsforsequences = Table[syntheticseqgenerator[
      stoichiometricmatrix, steadystatevector, boundaries, fluxexchanges, 300], 200];]
Out[ ]= {3919.27, Null}

In[ ]:= AbsoluteTiming[
   objfuncsforsequenceswider = Table[syntheticseqgenerator[stoichiometricmatrix,
      steadystatevector, boundaries, fluxexchanges, 300], 200];]
Out[ ]= {5029.5, Null}

In[ ]:= Dimensions@objfuncsforsequences[[All, 2]]
Out[ ]= {200, 300, 1008}

In[ ]:= Length@first[(Flatten[objfuncsforsequences[[All, 2]], 1])^T]
  Length@(Flatten[objfuncsforsequences[[All, 2]], 1])[[
    first@Flatten[objfuncsforsequences[[All, 2]], 1], All]]
  Length@first[(Flatten[objfuncsforsequenceswider[[All, 2]], 1])^T]
  Length@(Flatten[objfuncsforsequenceswider[[All, 2]], 1])[[
    first@Flatten[objfuncsforsequences[[All, 2]], 1], All]]
Out[ ]= 1008

Out[ ]= 60 000

Out[ ]= 1008

Out[ ]= 60 000
```

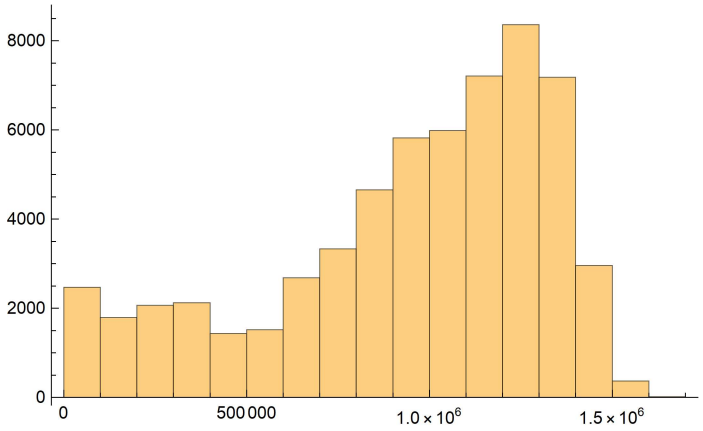
```
datafull = Join[Partition[Range@60000, 1],
    Partition[Flatten@Table[ConstantArray[i, 300], {i, 200}], 1],
    Partition[Flatten[objfuncsforsequences[[All, 3]], 1], 1], 2];
Histogram@datafull[[All, 3]]
```

Out[ ]=



In[ ]:=
```
datafull2 = Join[Partition[Range@60000, 1],
    Partition[Flatten@Table[ConstantArray[i, 300], {i, 200}], 1],
    Partition[Flatten[objfuncsforsequenceswider[[All, 3]], 1], 1], 2];
Histogram@datafull2[[All, 3]]
```

Out[ ]=



In[ ]:=
```
x2 = Round@Ceiling[Length@datafull / 19, 1];
{a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, r, s, t} =
  Join[Range[x2, Length@datafull, x2], {Length@datafull}];
data2 = Join[{Take[datafull, {1, a}]},
    Flatten[Table[{Take[datafull, {z[[1]] - x2 / 2, z[[2]] - x2 / 2}],
        Take[datafull, {z[[1]], z[[2]]}]}, {z,
        Partition[{a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, r, s, t}, 2, 1]}], 1]];
win2 = Length@data2;
```

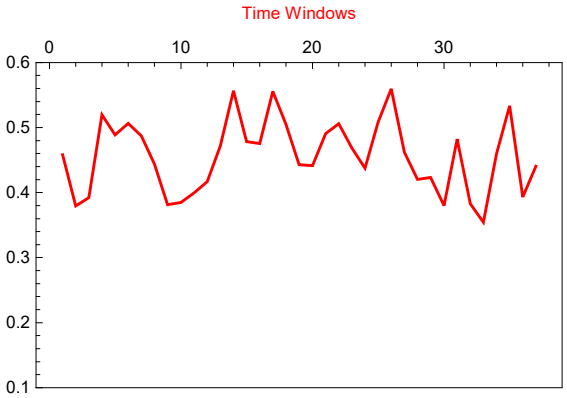
In[ ]:=
```
AbsoluteTiming[
 widthdataintimewindowsFixedstep2 = snetworkdatabinnedintimewindows[data2, 3, 2500, win2];]
```

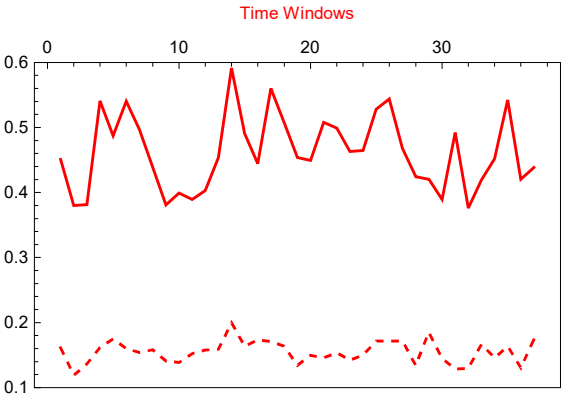
Out[ ]= {11.691, Null}

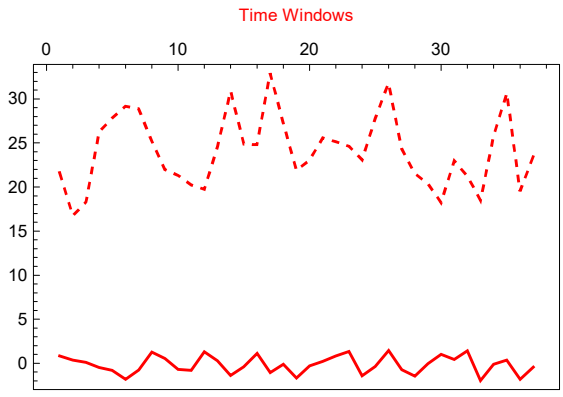
```
In[ ]:= graphsandnodenumbers12 = Table[snetworkgraph[widthdataintimewindowsFixedstep2[[1]][[i]],
          widthdataintimewindowsFixedstep2[[2]][[i]], 2, 7, 400, Green], {i, Range@win2}];
        graphsandnodenumbers12[[All, 2]]
Out[ ]= {41, 35, 40, 47, 55, 58, 59, 50, 54, 57, 52, 50, 53, 60, 53, 50, 57, 48,
         37, 47, 49, 44, 48, 50, 51, 54, 48, 49, 51, 46, 43, 48, 48, 46, 49, 47, 51}

In[ ]:= modularityvalues12 = Table[N@GraphAssortativity[graphsandnodenumbers12[[i]][[1]],
          FindGraphCommunities[graphsandnodenumbers12[[i]][[1]]], "Normalized" → False],
        {i, Length@graphsandnodenumbers12}];

In[ ]:= singlerandomgraphsdegfxd12 =
          Table[randomizinggraphdegfxd[i], {i, graphsandnodenumbers12[[All, 1]]}];
        singlerandomerdrenmodularityvalues12 =
          Table[N@GraphAssortativity[singlerandomgraphsdegfxd12[[i]],
            FindGraphCommunities[singlerandomgraphsdegfxd12[[i]]], "Normalized" -> False],
          {i, Length@singlerandomgraphsdegfxd12}];
        singlerandomgraphscomm12 = Table[randomizinggraphmod[i],
          {i, graphsandnodenumbers12[[All, 1]]}];
        singlerandomcommmodularityvalues12 =
          Table[N@GraphAssortativity[singlerandomgraphscomm12[[i]],
            FindGraphCommunities[singlerandomgraphscomm12[[i]]], "Normalized" -> False],
          {i, Length@singlerandomgraphscomm12}];

In[ ]:= AbsoluteTiming[Zscoresmodularity12 =
          Table[zscorefunctionfortwonullmodels[i], {i, graphsandnodenumbers12[[All, 1]]}];]
Out[ ]= {479.992, Null}

In[ ]:= bucketnode12 = graphsandnodenumbers12[[All, 2]]
Out[ ]= {41, 35, 40, 47, 55, 58, 59, 50, 54, 57, 52, 50, 53, 60, 53, 50, 57, 48,
         37, 47, 49, 44, 48, 50, 51, 54, 48, 49, 51, 46, 43, 48, 48, 46, 49, 47, 51}
```

In[ ]:=
```
modularityvaluestimewinsmall = modularityvalues12;
randommodtimewinsmalldegreefxd = singlerandomerdrenmodularityvalues12;
randommodtimewinsmallcomm = singlerandomcommmodularityvalues12;
Zscoretimewinsmall = Zscoresmodularity12;
modularityplotrange = {0.1, 0.6};
(*MinMax[{modularityvalues1,singlerandomcommmodularityvalues1,
  singlerandomerdrenmodularityvalues1,modularityvalues12}]*)
padding = 38;
Row[{ListLinePlot[Thread[{Range@win2, modularityvaluestimewinsmall}],
    Frame → True, ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
    FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}}, PlotStyle → Red,
    ImageSize → 350, PlotRange → {{-1, win2 + 2}, modularityplotrange}],
  Row[{ListLinePlot[{Thread[{Range@win2, randommodtimewinsmalldegreefxd}],
      Thread[{Range@win2, randommodtimewinsmallcomm}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}},
     PlotStyle → {{Dashed, Red}, Red}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, modularityplotrange}],
    ListLinePlot[{Thread[{Range@win2, Zscoretimewinsmall[[All, 1]]}],
      Thread[{Range@win2, Zscoretimewinsmall[[All, 2]]}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}},
     PlotStyle → {{Dashed, Red}, Red}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, MinMax[Flatten[Zscoretimewinsmall], 1]}]}],
  LineLegend[{Dashed, Black}, {"Degrees Fixed N.M.", "Modularity N.M."},
   LegendMargins → 0, LegendMarkerSize → {20, 20}], Spacer@0.1}]
```

Out[ ]=







Degrees Fixed N.M.

Modularity N.M.

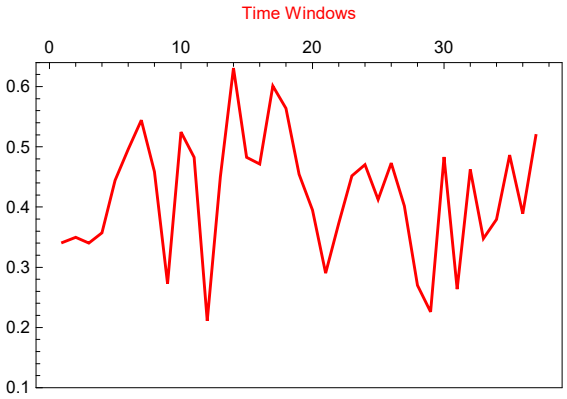
In[ ]:=
```
AbsoluteTiming[widthdataintimewindowsFixedbucket2 =
    snetworkdatafxdbucketintimewindows[data2, 3, bucketnode12, win2];]
```

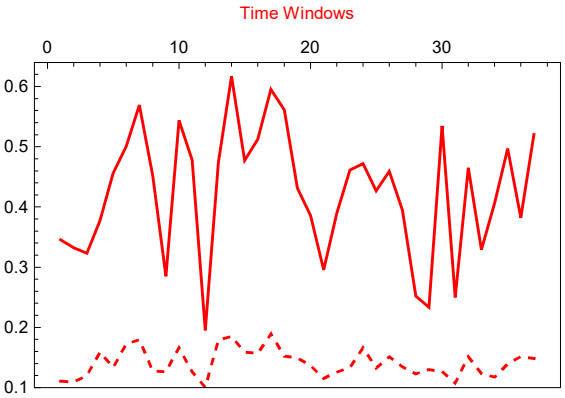
Out[ ]= {2.5902, Null}

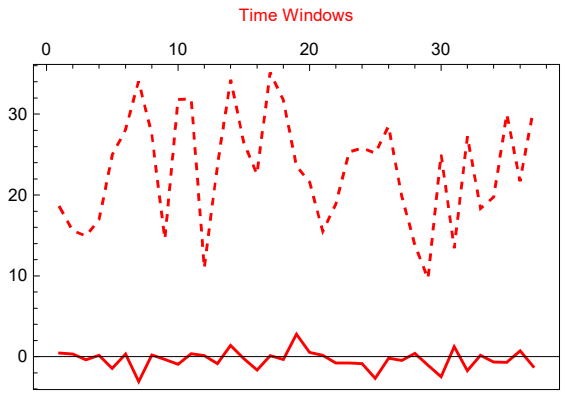
```
In[•]:= bucketsize32 = Flatten@widthdataintimewindowsFixedbucket2[[4]]
Out[•]= {78, 91, 79, 68, 58, 55, 54, 64, 59, 56, 61, 64, 60, 53, 60, 64, 56, 66,
  86, 68, 65, 72, 66, 64, 62, 59, 66, 65, 62, 69, 74, 66, 66, 69, 65, 68, 62}

In[•]:= graphsandnodenumbers32 =
    Table[snetworkgraph[widthdataintimewindowsFixedbucket2[[1]][[i]],
      widthdataintimewindowsFixedbucket2[[2]][[i]], 1.5, 7, 400, Green], {i, Range@win2}];
  modularityvalues32 = Table[N@GraphAssortativity[graphsandnodenumbers32[[i]][[1]],
      FindGraphCommunities[graphsandnodenumbers32[[i]][[1]]], "Normalized" → False],
    {i, Length@graphsandnodenumbers32}];

In[•]:= singlerandomgraphsdegfxd32 =
    Table[randomizinggraphdegfxd[i], {i, graphsandnodenumbers32[[All, 1]]}];
  singlerandomerdrenmodularityvalues32 =
    Table[N@GraphAssortativity[singlerandomgraphsdegfxd32[[i]],
      FindGraphCommunities[singlerandomgraphsdegfxd32[[i]]], "Normalized" -> False],
    {i, Length@singlerandomgraphsdegfxd32}];
  singlerandomgraphscomm32 = Table[randomizinggraphmod[i],
    {i, graphsandnodenumbers32[[All, 1]]}];
  singlerandomcommmodularityvalues32 =
    Table[N@GraphAssortativity[singlerandomgraphscomm32[[i]],
      FindGraphCommunities[singlerandomgraphscomm32[[i]]], "Normalized" -> False],
    {i, Length@singlerandomgraphscomm32}];

In[•]:= AbsoluteTiming[Zscoresmodularity32 =
    Table[zscorefunctionfortwonullmodels[i], {i, graphsandnodenumbers32[[All, 1]]}];]
Out[•]= {495.024, Null}
```

In[ ]:=
```
modularityvaluestimewinsmall = modularityvalues32;
randommodtimewinsmalldegreefxd = singlerandomerdrenmodularityvalues32;
randommodtimewinsmallcomm = singlerandomcommmodularityvalues32;
Zscoretimewinsmall = Zscoresmodularity32;
modularityplotrange = {0.1, 0.64};
(*MinMax[{modularityvalues1,singlerandomcommmodularityvalues1,
  singlerandomerdrenmodularityvalues1,modularityvalues12}]*)
padding = 38;
Row[{ListLinePlot[Thread[{Range@win2, modularityvaluestimewinsmall}],
    Frame → True, ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
    FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}}, PlotStyle → Red,
    ImageSize → 350, PlotRange → {{-1, win2 + 2}, modularityplotrange}],
  Row[{ListLinePlot[{Thread[{Range@win2, randommodtimewinsmalldegreefxd}],
      Thread[{Range@win2, randommodtimewinsmallcomm}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}},
     PlotStyle → {{Dashed, Red}, Red}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, modularityplotrange}],
    ListLinePlot[{Thread[{Range@win2, Zscoretimewinsmall[[All, 1]]}],
      Thread[{Range@win2, Zscoretimewinsmall[[All, 2]]}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}},
     PlotStyle → {{Dashed, Red}, Red}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, MinMax[Flatten[Zscoretimewinsmall], 1]}]}],
  LineLegend[{Dashed, Black}, {"Degrees Fixed N.M.", "Modularity N.M."},
   LegendMargins → 0, LegendMarkerSize → {20, 20}], Spacer@0.1}]
```

Out[ ]=







Degrees Fixed N.M.

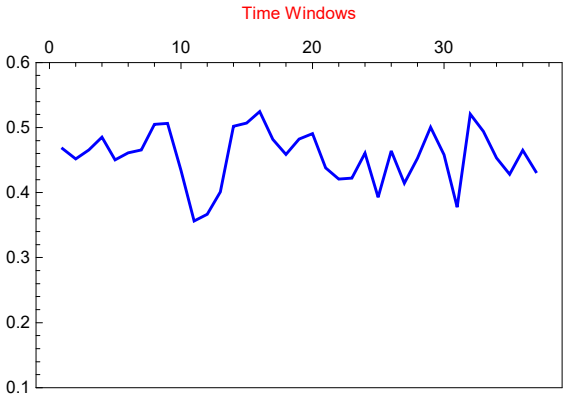
Modularity N.M.

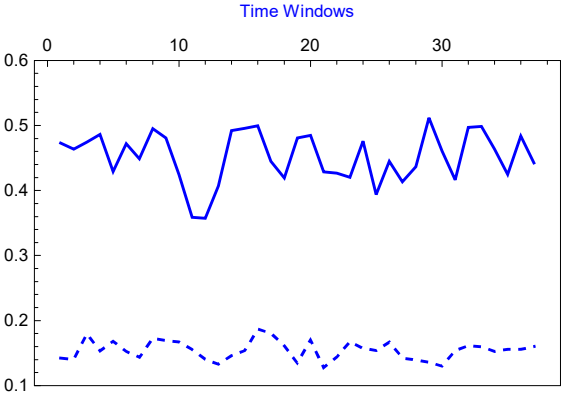
wider objective coefficients

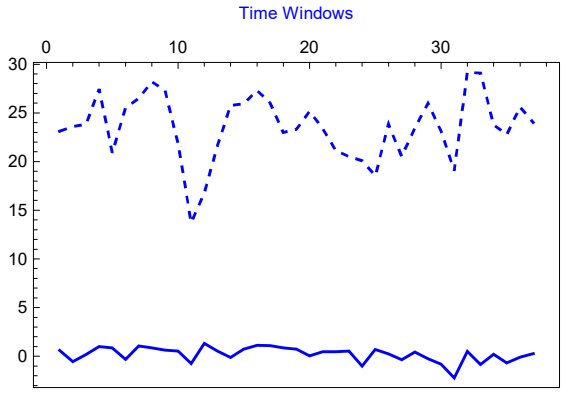
```
In[•]:= x2 = Round@Ceiling[Length@datafull2 / 19, 1];
        {a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, r, s, t} =
          Join[Range[x2, Length@datafull2, x2], {Length@datafull2}];
        data2 = Join[{Take[datafull2, {1, a}]},
           Flatten[Table[{Take[datafull2, {z[[1]] - x2 / 2, z[[2]] - x2 / 2}],
              Take[datafull2, {z[[1]], z[[2]]}]}, {z,
              Partition[{a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, r, s, t}, 2, 1]}], 1]];
        win2 = Length@data2;

In[•]:= AbsoluteTiming[widthdataintimewindowsFixedstep2 =
           snetworkdatabinnedintimewindows[data2, 3, 25000, win2];]

Out[•]= {11.0224, Null}

In[•]:= graphsandnodenumbers12 = Table[snetworkgraph[widthdataintimewindowsFixedstep2[[1]][[i]],
            widthdataintimewindowsFixedstep2[[2]][[i]], 2, 7, 400, Green], {i, Range@win2}];
        graphsandnodenumbers12[[All, 2]]

Out[•]= {54, 46, 47, 51, 46, 55, 56, 56, 54, 44, 35, 36, 45, 47, 45, 52, 53, 51,
         44, 48, 49, 41, 42, 42, 47, 49, 45, 48, 43, 46, 52, 53, 56, 47, 48, 49, 52}

In[•]:= modularityvalues12 = Table[N@GraphAssortativity[graphsandnodenumbers12[[i]][[1]],
             FindGraphCommunities[graphsandnodenumbers12[[i]][[1]]], "Normalized" → False],
           {i, Length@graphsandnodenumbers12}];

In[•]:= singlerandomgraphsdegfxd12 =
          Table[randomizinggraphdegfxd[i], {i, graphsandnodenumbers12[[All, 1]]}];
        singlerandomerdrenmodularityvalues12 =
          Table[N@GraphAssortativity[singlerandomgraphsdegfxd12[[i]],
             FindGraphCommunities[singlerandomgraphsdegfxd12[[i]]], "Normalized" -> False],
           {i, Length@singlerandomgraphsdegfxd12}];
        singlerandomgraphscomm12 = Table[randomizinggraphmod[i],
           {i, graphsandnodenumbers12[[All, 1]]}];
        singlerandomcommmodularityvalues12 =
          Table[N@GraphAssortativity[singlerandomgraphscomm12[[i]],
             FindGraphCommunities[singlerandomgraphscomm12[[i]]], "Normalized" -> False],
           {i, Length@singlerandomgraphscomm12}];

In[•]:= AbsoluteTiming[Zscoresmodularity12 =
           Table[zscorefunctionfortwonullmodels[i], {i, graphsandnodenumbers12[[All, 1]]}];]

Out[•]= {1602.38, Null}

In[•]:= bucketnode12 = graphsandnodenumbers12[[All, 2]]

Out[•]= {54, 46, 47, 51, 46, 55, 56, 56, 54, 44, 35, 36, 45, 47, 45, 52, 53, 51,
         44, 48, 49, 41, 42, 42, 47, 49, 45, 48, 43, 46, 52, 53, 56, 47, 48, 49, 52}
```

In[ ]:=
```
modularityvaluestimewinsmall = modularityvalues12;
randommodtimewinsmalldegreefxd = singlerandomerdrenmodularityvalues12;
randommodtimewinsmallcomm = singlerandomcommmodularityvalues12;
Zscoretimewinsmall = Zscoresmodularity12;
modularityplotrange = {0.1, 0.6};
(*MinMax[{modularityvalues1,singlerandomcommmodularityvalues1,
  singlerandomerdrenmodularityvalues1,modularityvalues12}]*)
padding = 38;
Row[{ListLinePlot[Thread[{Range@win2, modularityvaluestimewinsmall}],
    Frame → True, ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
    FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}}, PlotStyle → Blue,
    ImageSize → 350, PlotRange → {{-1, win2 + 2}, modularityplotrange}],
  Row[{ListLinePlot[{Thread[{Range@win2, randommodtimewinsmalldegreefxd}],
      Thread[{Range@win2, randommodtimewinsmallcomm}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Blue]}},
     PlotStyle → {{Dashed, Blue}, Blue}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, modularityplotrange}],
    ListLinePlot[{Thread[{Range@win2, Zscoretimewinsmall[[All, 1]]}],
      Thread[{Range@win2, Zscoretimewinsmall[[All, 2]]}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Blue]}},
     PlotStyle → {{Dashed, Blue}, Blue}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, MinMax[Flatten[Zscoretimewinsmall], 1]}]}],
  LineLegend[{Dashed, Black}, {"Degrees Fixed N.M.", "Modularity N.M."},
   LegendMargins → 0, LegendMarkerSize → {20, 20}], Spacer@0.1}]
```

Out[ ]=







Degrees Fixed N.M.

Modularity N.M.

In[ ]:=
```
AbsoluteTiming[widthdataintimewindowsFixedbucket2 =
    snetworkdatafxdbucketintimewindows[data2, 3, bucketnode12, win2];]
```

Out[ ]= {8.88334, Null}

In[•]:=
```
bucketsize32 = Flatten@widthdataintimewindowsFixedbucket2[[4]]
```

Out[•]=
```
{59, 69, 68, 62, 69, 58, 57, 57, 59, 72, 91, 88, 71, 68, 71, 61, 60, 62,
 72, 66, 65, 78, 76, 76, 68, 65, 71, 66, 74, 69, 61, 60, 57, 68, 66, 65, 61}
```

In[•]:=
```
graphsandnodenumbers32 =
  Table[snetworkgraph[widthdataintimewindowsFixedbucket2[[1]][[i]],
    widthdataintimewindowsFixedbucket2[[2]][[i]], 1.5, 7, 400, Green], {i, Range@win2}];
modularityvalues32 = Table[N@GraphAssortativity[graphsandnodenumbers32[[i]][[1]],
    FindGraphCommunities[graphsandnodenumbers32[[i]][[1]]], "Normalized" → False],
  {i, Length@graphsandnodenumbers32}];
```

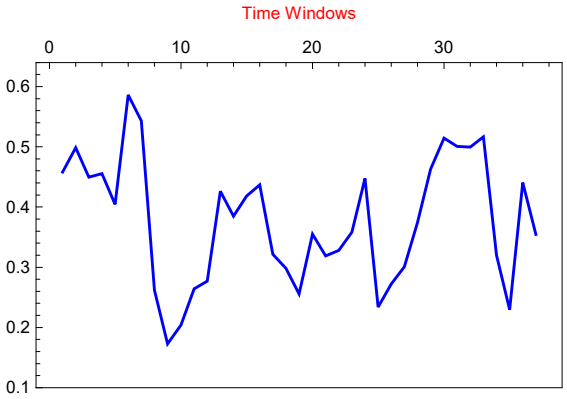
In[•]:=
```
singlerandomgraphsdegfxd32 =
  Table[randomizinggraphdegfxd[i], {i, graphsandnodenumbers32[[All, 1]]}];
singlerandomerdrenmodularityvalues32 =
  Table[N@GraphAssortativity[singlerandomgraphsdegfxd32[[i]],
    FindGraphCommunities[singlerandomgraphsdegfxd32[[i]]], "Normalized" -> False],
  {i, Length@singlerandomgraphsdegfxd32}];
singlerandomgraphscomm32 = Table[randomizinggraphmod[i],
  {i, graphsandnodenumbers32[[All, 1]]}];
singlerandomcommmodularityvalues32 =
  Table[N@GraphAssortativity[singlerandomgraphscomm32[[i]],
    FindGraphCommunities[singlerandomgraphscomm32[[i]]], "Normalized" -> False],
  {i, Length@singlerandomgraphscomm32}];
```

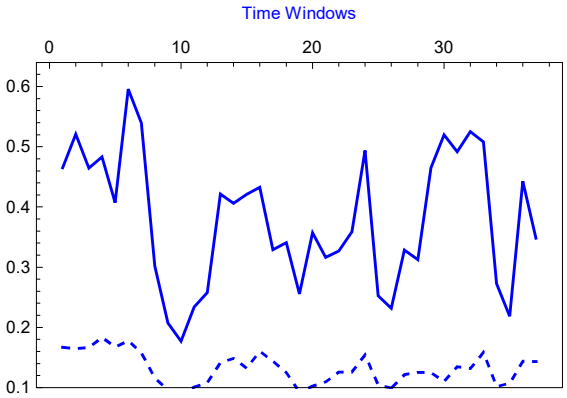
In[•]:=
```
AbsoluteTiming[Zscoresmodularity32 =
  Table[zscorefunctionfortwonullmodels[i], {i, graphsandnodenumbers32[[All, 1]]}];]
```

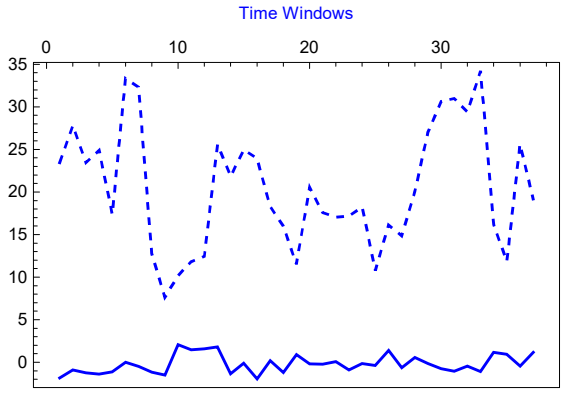
Out[•]=
```
{542.518, Null}
```

In[ ]:=
```
modularityvaluestimewinsmall = modularityvalues32;
randommodtimewinsmalldegreefxd = singlerandomerdrenmodularityvalues32;
randommodtimewinsmallcomm = singlerandomcommmodularityvalues32;
Zscoretimewinsmall = Zscoresmodularity32;
modularityplotrange = {0.1, 0.64};
(*MinMax[{modularityvalues1,singlerandomcommmodularityvalues1,
  singlerandomerdrenmodularityvalues1,modularityvalues12}]*)
padding = 38;
Row[{ListLinePlot[Thread[{Range@win2, modularityvaluestimewinsmall}],
    Frame → True, ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
    FrameLabel → {{None, None}, {None, Style["Time Windows", Red]}}, PlotStyle → Blue,
    ImageSize → 350, PlotRange → {{-1, win2 + 2}, modularityplotrange}],
  Row[{ListLinePlot[{Thread[{Range@win2, randommodtimewinsmalldegreefxd}],
      Thread[{Range@win2, randommodtimewinsmallcomm}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Blue]}},
     PlotStyle → {{Dashed, Blue}, Blue}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, modularityplotrange}],
    ListLinePlot[{Thread[{Range@win2, Zscoretimewinsmall[[All, 1]]}],
      Thread[{Range@win2, Zscoretimewinsmall[[All, 2]]}]}, Frame → True,
     ImagePadding → padding, FrameTicks → {{All, None}, {None, All}},
     FrameLabel → {{None, None}, {None, Style["Time Windows", Blue]}},
     PlotStyle → {{Dashed, Blue}, Blue}, ImageSize → 350,
     PlotRange → {{-1, win2 + 2}, MinMax[Flatten[Zscoretimewinsmall], 1]}]}],
  LineLegend[{Dashed, Black}, {"Degrees Fixed N.M.", "Modularity N.M."},
   LegendMargins → 0, LegendMarkerSize → {20, 20}], Spacer@0.1}]
```

Out[ ]=







Degrees Fixed N.M.

Modularity N.M.