## 3. Methodology

In this section models were created, trying to outperform the buy and hold strategy.

starting by analyzing the data and using simple models, more complex models and combined tools are added step by step in different approaches.

### 3.1. Data Analysis

As mentioned in section 1.1 We are now going to analyze the data further to gain as much information as possible just by using some simple tools and comparisons.

#### 3.1.1. correlation

One could nearly tell just by looking at the indexes how strong they're correlated. The correlation matrix confirms the assumption, the correlation is nearly 1 for every index to each other.

Table 1: Correlations oft the four indexes

|  | Index 1 | Index 2 | Index 3 | Index 4 |
|---|---|---|---|---|
| Index 1 | 1.0000000 | 0.9899111 | 0.9788826 | 0.9672956 |
| Index 2 | 0.9899111 | 1.0000000 | 0.9975499 | 0.9921171 |
| Index 3 | 0.9788826 | 0.9975499 | 1.0000000 | 0.9983460 |
| Index 4 | 0.9672956 | 0.9921171 | 0.9983460 | 1.0000000 |

#### 3.1.2. transformation, volatility and clusters

Applying the natural logarithm to the series is an approach to cancel out increasing volatility **??**.
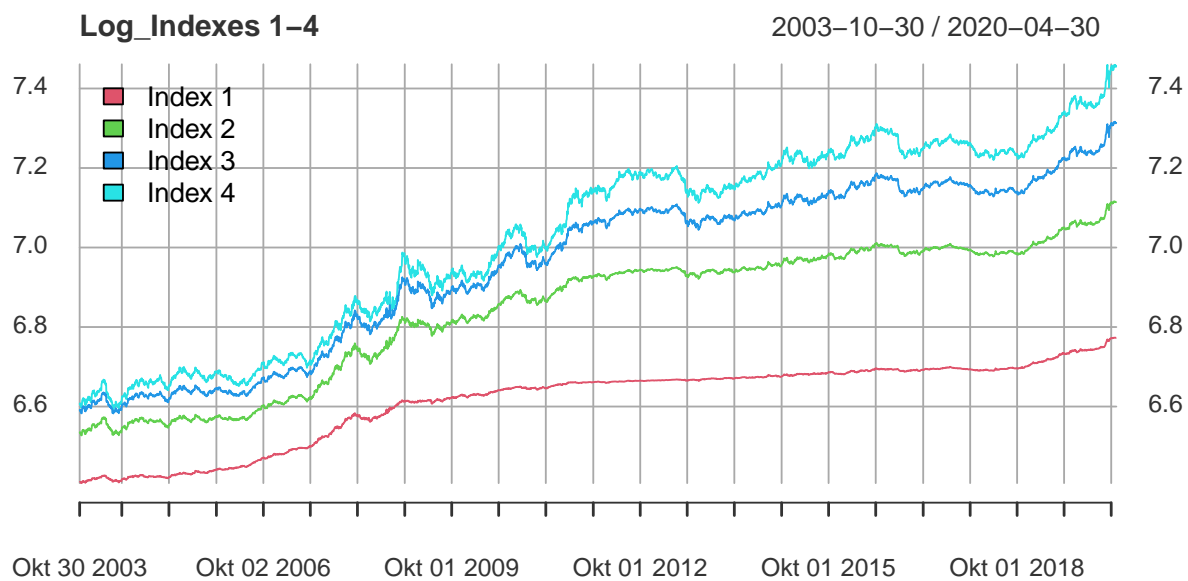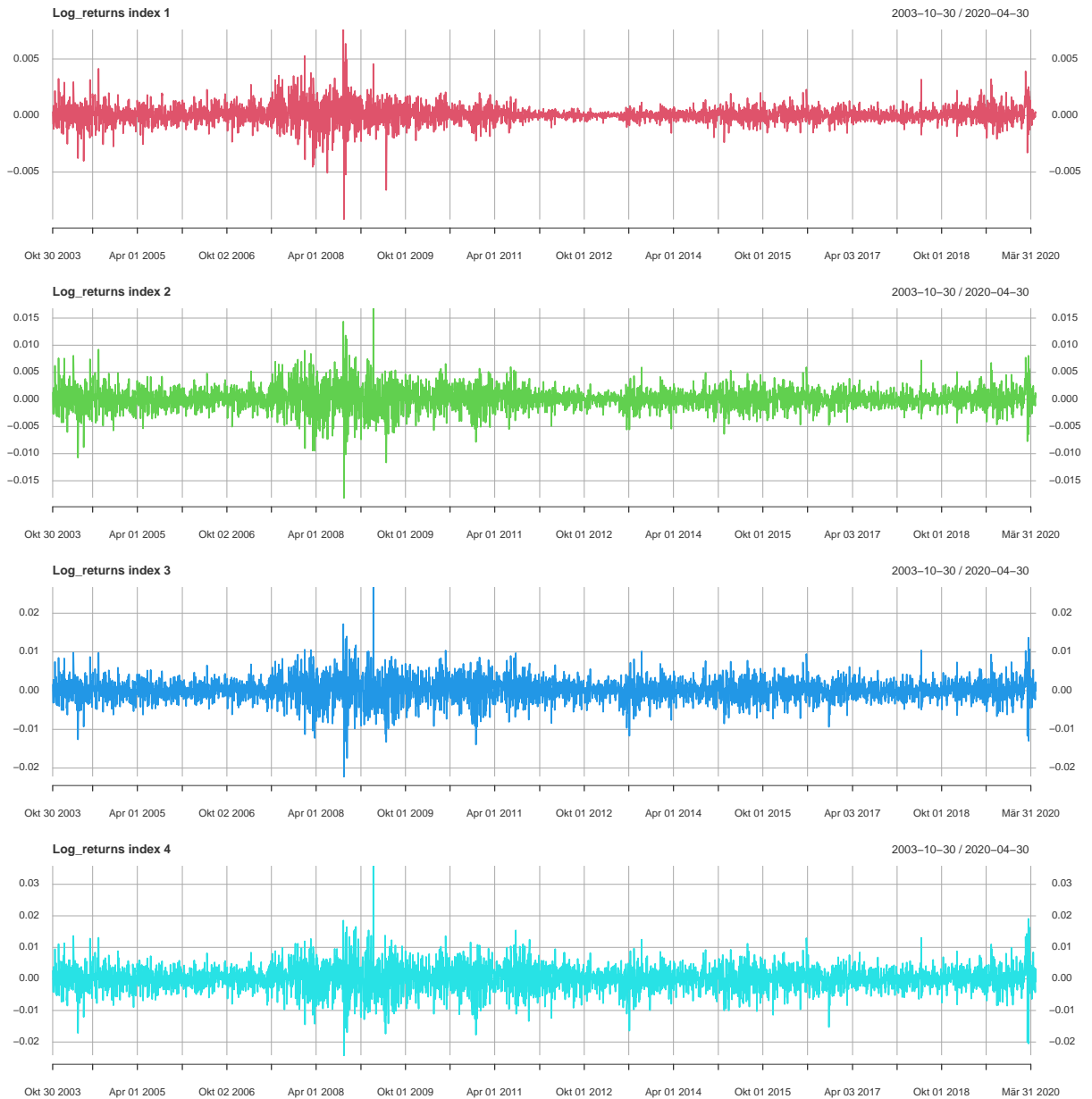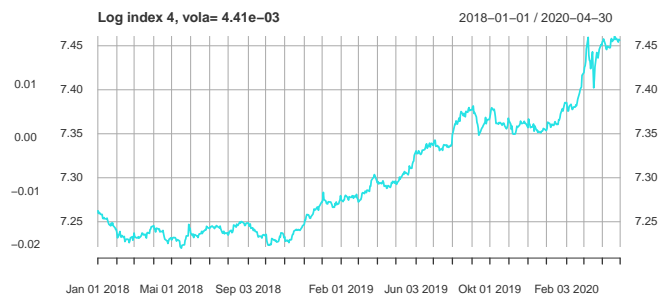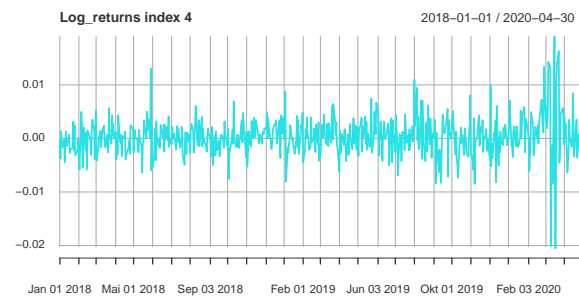


Figure 1: Visualization log_indizes

By taking the returns of the transformed series we can visualize volatility clusters as seen in figure **??**, clearly visible are the increasng volatiliy clusters in the finbanacial crisis, due the ghigh correaltion the indezes look pretty similir

**Log_returns index 1**     2018-01-01 / 2020-04-30

**Log index 1, vola= 6.10e-04**     2018-01-01 / 2020-04-30

**Log_returns index 2**     2018-01-01 / 2020-04-30

**Log index 2, vola= 1.57e-03**     2018-01-01 / 2020-04-30

**Log_returns index 3**     2018-01-01 / 2020-04-30

**Log index 3, vola= 2.79e-03**     2018-01-01 / 2020-04-30

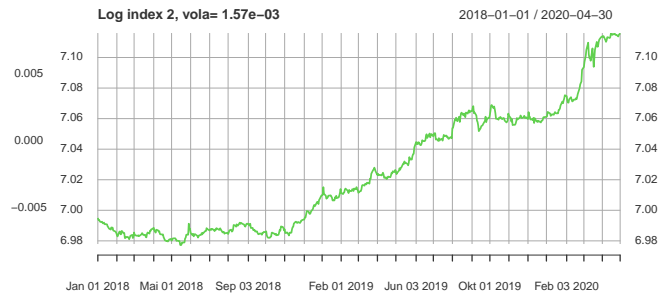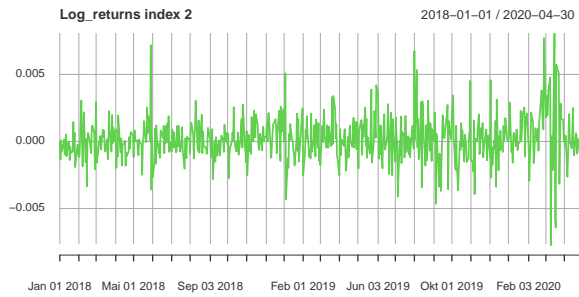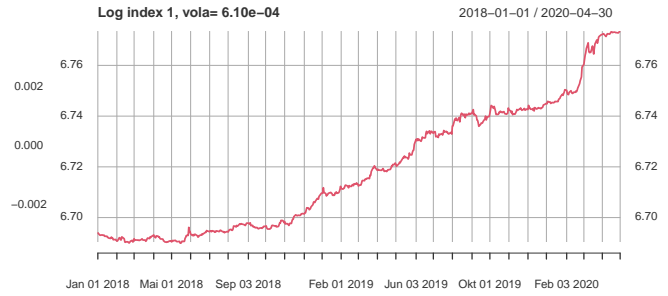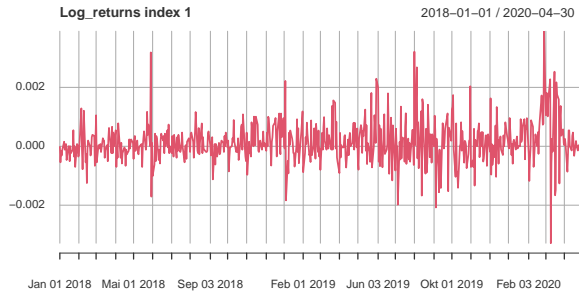**Log_returns index 4**     2018-01-01 / 2020-04-30

**Log index 4, vola= 4.41e-03**     2018-01-01 / 2020-04-30
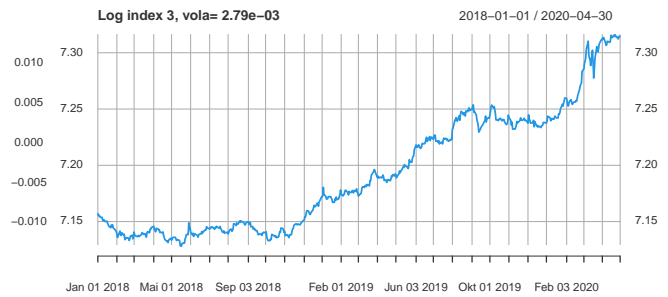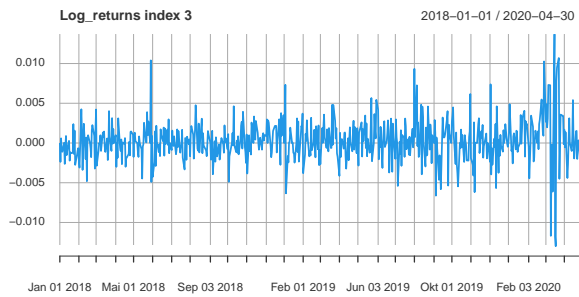
### 3.1.5 periodicity

```
## $DFT
##    [1]   1.282112e-03+0.000000e+00i  -1.347946e-04-3.007434e-04i
##    [3]   3.132441e-04-2.603213e-04i   5.288351e-05-4.342329e-04i
##    [5]  -2.713600e-04-4.652251e-04i  -2.551659e-05-2.250935e-04i
##    [7]  -3.664969e-04-9.217152e-05i  -2.717648e-04-1.236588e-04i
##    [9]  -2.032501e-04+2.702495e-05i  -3.338524e-04+9.472463e-05i
##   [11]   5.685114e-05-2.204384e-06i  -1.782612e-04-7.122921e-06i
##   [13]   2.949365e-04+4.335962e-04i   1.884917e-04+1.256230e-05i
##   [15]  -1.264255e-04-1.184852e-05i   2.365061e-04+2.046574e-04i
##   [17]   1.844846e-04-1.492249e-04i  -7.585935e-05-4.628853e-04i
##   [19]  -1.966033e-04-7.023414e-05i   1.805948e-04-7.001699e-05i
```
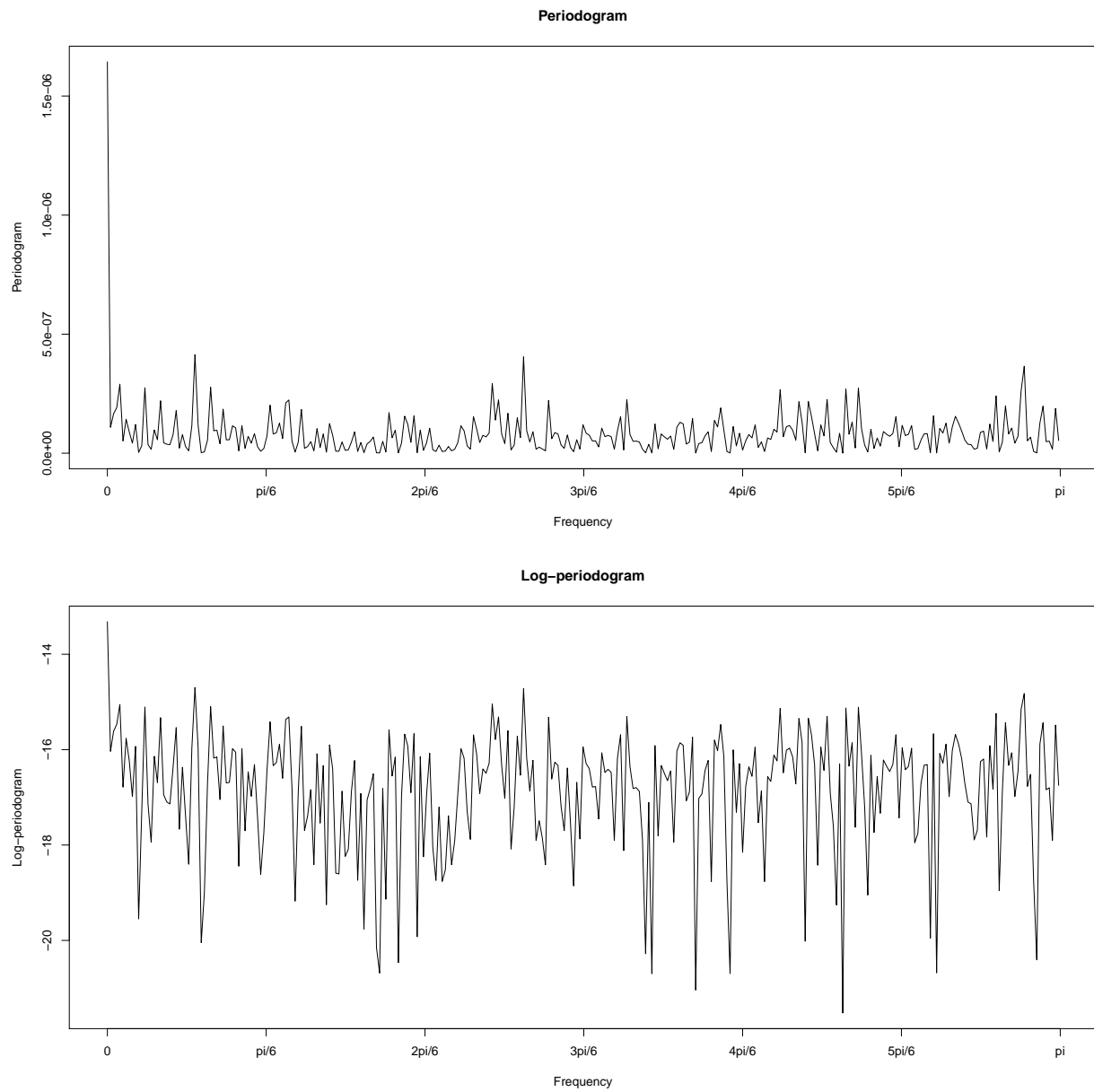
3

**Periodogram**



**Log–periodogram**

Figure 2: peridodogramm

4

```
##   [21] -1.665074e-04+9.137738e-05i -1.492621e-04-2.352690e-04i
##   [23] -3.573803e-04+2.259881e-04i  7.457794e-05+1.251010e-04i
##   [25]  1.321793e-04+2.455846e-04i  6.237552e-05+1.541902e-04i
##   [27]  9.117122e-05+4.322518e-05i  3.131854e-04+1.342511e-04i
##   [29]  3.886758e-04-5.131184e-04i  1.730746e-04-2.959691e-04i
##   [31] -4.385622e-05-6.637758e-06i -3.379180e-05+6.672512e-05i
##   [33] -1.329552e-04-1.921405e-04i -5.108011e-04-1.279647e-04i
##   [35] -2.964138e-04-7.988085e-05i  1.916618e-04+2.445270e-04i
##   [37] -1.898314e-04-5.883901e-05i -3.946272e-04+1.713199e-04i
##   [39]  5.908037e-05+2.291379e-04i -2.296461e-04-6.218111e-05i
##   [41]  1.661605e-04+2.955250e-04i  3.263215e-04+4.871442e-06i
##   [43]  8.958860e-05-4.188775e-05i  2.552662e-04+2.237736e-04i
##   [45]  7.346806e-05-1.230288e-04i  2.150874e-04-1.566635e-04i
##   [47]  1.807568e-04-9.810267e-05i -8.118797e-05-2.753855e-04i
##   [49]  1.534901e-04+5.937791e-05i -8.980767e-05-1.211315e-05i
##   [51] -1.321394e-04+4.585169e-05i  1.644695e-05-2.669810e-04i
##   [53] -1.670569e-04+4.168244e-04i  2.395366e-04-1.519419e-04i
##   [55] -2.872802e-04+5.652579e-05i -2.329144e-04+2.684688e-04i
##   [57]  2.466199e-04+3.021499e-05i  2.338153e-04-3.961002e-04i
##   [59] -3.912315e-04-2.650053e-04i  1.179213e-04+1.906206e-04i
##   [61]  6.175669e-05+2.973126e-05i  2.016555e-04+7.365904e-05i
##   [63] -1.208991e-04-4.106767e-04i  1.381222e-04-3.914986e-05i
##   [65] -1.634735e-04+3.651645e-05i  1.728774e-04-1.371881e-04i
##   [67] -4.343526e-05-9.059655e-05i -2.614124e-04-1.868144e-04i
##   [69] -1.407925e-04+6.566166e-05i  2.835365e-04+1.979102e-05i
##   [71]  3.199924e-05-5.774187e-05i -2.855316e-04+2.068250e-04i
##   [73]  2.685737e-04+5.163065e-05i -3.151989e-05+8.626919e-05i
##   [75]  7.271192e-05-5.494331e-05i  2.138565e-04+3.688100e-05i
##   [77]  4.846383e-05-9.828226e-05i -9.264356e-05-7.314445e-05i
##   [79] -1.280883e-04+1.749831e-04i  7.559004e-05-2.895953e-04i
##   [81]  1.909084e-05-8.307919e-05i  1.391293e-04+1.598646e-04i
##   [83]  2.633361e-05-4.387312e-05i -1.956219e-04+3.099775e-05i
##   [85]  1.063829e-04+1.956502e-04i  2.089692e-04-1.550278e-04i
##   [87]  2.430222e-05-3.443299e-05i  1.822746e-05-2.659161e-05i
##   [89] -8.119944e-05+2.080200e-04i -3.171002e-05+6.231099e-05i
##   [91] -9.448804e-07-4.127953e-04i -1.199492e-04+2.244780e-04i
##   [93]  2.753156e-04-1.431004e-04i -2.543222e-05-2.543865e-05i
##   [95] -1.807197e-04-9.872655e-05i  3.582619e-04-1.649696e-04i
##   [97] -2.522220e-04-2.404293e-04i  2.130109e-04-1.681823e-05i
##   [99] -3.866397e-04+8.903268e-05i -4.460998e-05-1.532942e-05i
##  [101] -2.909651e-04+1.129037e-04i -6.251846e-06+1.088816e-04i
##  [103]  2.078136e-04-6.943125e-06i  2.639087e-04+1.866032e-04i
##  [105]  1.203671e-04+1.676461e-06i  1.887243e-05-8.301302e-05i
##  [107]  7.412008e-06+1.836032e-04i  7.929145e-05+2.844645e-05i
##  [109]  3.282815e-05+8.914536e-05i  8.230523e-05-1.461563e-04i
##  [111]  7.166898e-05-7.031987e-05i -1.292923e-04-3.531206e-06i
##  [113]  1.943556e-04+8.403467e-05i  1.158892e-04-3.187031e-04i
##  [115] -6.410224e-05-2.995802e-04i -1.309749e-04+1.151394e-04i
##  [117]  9.185982e-05-9.336954e-05i -2.947819e-04-2.580718e-04i
##  [119] -3.193729e-04-2.920190e-05i -7.915319e-05+1.964278e-04i
##  [121] -9.124851e-05+2.586162e-04i  1.474055e-04+2.162984e-04i
##  [123]  2.647074e-04+1.204769e-04i  2.052224e-04+5.002838e-04i
##  [125]  3.410122e-04+1.512052e-04i  4.711660e-04+4.129143e-05i
##  [127]  1.503304e-04-2.425398e-04i  1.919490e-04-5.994501e-05i
```

```
## [129] -2.794451e-04-2.992106e-04i -3.020111e-05-1.144087e-04i
## [131] -7.799012e-08-1.834790e-04i -2.528106e-04-2.914206e-04i
## [133] -2.109885e-04-1.457626e-04i -5.467019e-04-3.252435e-04i
## [135] -2.704841e-04+1.469944e-04i -6.876594e-05-2.062591e-04i
## [137] -1.807500e-04-2.394465e-04i -8.669822e-05+9.618506e-05i
## [139]  2.686666e-05+1.568975e-04i -9.410832e-05+9.371405e-05i
## [141]  8.725697e-06+9.999538e-05i  3.385205e-04+3.277654e-04i
## [143]  2.463291e-04+6.796877e-06i  2.503376e-04+1.546996e-04i
## [145] -4.899055e-06+2.840419e-04i  1.435136e-04+1.159899e-04i
## [147]  1.371209e-04-4.283928e-05i -1.217721e-04-2.485103e-04i
## [149]  2.102409e-05+1.536733e-04i -8.038185e-05-2.470811e-06i
## [151]  2.585009e-05+2.367562e-04i -1.062877e-04-7.734418e-05i
## [153] -1.371781e-04-3.175570e-04i  2.041687e-04+2.056976e-04i
## [155]  1.848510e-04-2.032798e-04i -2.262033e-04-1.348361e-05i
## [157] -1.902534e-04-1.252615e-04i -1.584525e-04+3.463254e-05i
## [159]  1.340819e-04+2.957302e-04i  3.240525e-05-2.619456e-04i
## [161] -1.921929e-04+1.938666e-04i  2.623065e-04+3.037749e-05i
## [163] -4.563004e-07+1.294879e-04i -2.245100e-04-2.080236e-04i
## [165]  3.430891e-04-1.907054e-04i -2.379565e-05+1.139508e-04i
## [167]  4.622817e-04+1.100698e-04i  2.729203e-04-6.770885e-05i
## [169] -1.825291e-04+1.284567e-04i  2.240349e-04-2.452120e-05i
## [171] -3.749370e-05-2.132956e-04i -1.207693e-04-4.976573e-05i
## [173] -2.559895e-05+3.004091e-05i -1.914826e-04+2.388237e-05i
## [175]  2.958360e-05+1.226179e-05i -2.520139e-04-2.431326e-04i
## [177] -1.332879e-04-2.567272e-05i  4.131081e-05+2.810451e-04i
## [179]  2.420275e-04-9.946565e-05i -1.779383e-04-1.645417e-04i
## [181] -2.615986e-04+5.911817e-05i  1.042594e-04-7.291298e-05i
## [183] -2.726994e-04-1.879459e-04i -4.452977e-05+3.578145e-04i
## [185]  3.140481e-04-1.572796e-04i -1.595690e-04+1.141160e-04i
## [187] -5.197568e-05+2.088166e-04i  3.167022e-04+2.136117e-04i
## [189]  2.425364e-05+1.182386e-05i  9.123243e-05-1.795789e-04i
## [191] -9.523399e-05+1.881141e-04i  2.698017e-04-4.597442e-06i
## [193] -1.369985e-05-2.992484e-04i -8.344369e-05-1.022853e-05i
## [195]  3.204362e-04-1.870598e-04i -1.269514e-04-3.065871e-04i
## [197] -2.331502e-04+3.690090e-04i -1.456548e-04-2.771942e-04i
## [199] -1.871524e-05-8.146280e-05i -2.925543e-05+1.310489e-05i
## [201] -3.265657e-04+7.288828e-05i  5.032411e-05+1.664874e-04i
## [203] -2.237041e-04+1.837890e-04i  9.333899e-05+6.578667e-05i
## [205] -2.217791e-04+5.534521e-05i  2.495486e-04-1.271789e-04i
## [207]  2.394927e-04-8.331049e-05i  3.339892e-04-8.349369e-05i
## [209] -8.555030e-05-1.302840e-04i  2.160343e-04+2.739338e-05i
## [211]  5.271363e-05+6.559493e-05i  1.450132e-04-2.071756e-04i
## [213] -1.463450e-04-1.906713e-04i -1.563962e-04+2.759924e-04i
## [215] -1.940883e-04-2.260379e-04i -4.174542e-04+3.044267e-04i
## [217]  5.968599e-05+2.562540e-04i  3.331556e-04+1.407870e-05i
## [219] -2.995163e-04+1.628580e-04i  5.369926e-05+3.058734e-04i
## [221]  4.709620e-05+2.297186e-04i  4.644302e-04-2.611218e-05i
## [223]  2.330920e-04-2.752373e-04i  4.498269e-05+1.236850e-06i
## [225]  4.578249e-04-8.804508e-05i -4.014116e-05-3.907209e-04i
## [227] -2.843049e-04-3.819283e-05i -8.301315e-06+9.953559e-05i
## [229]  2.185113e-04-2.662472e-04i -2.685972e-04-2.602937e-05i
## [231] -3.582667e-04+3.121382e-04i -1.755080e-04+1.205529e-04i
## [233] -1.123016e-04+1.003115e-04i -6.354826e-05-1.696353e-05i
## [235]  4.081603e-05+2.862845e-04i  7.519913e-06-1.983573e-05i
```

```
## [237]   6.740170e-06+5.191596e-04i  -2.294439e-04+1.643241e-04i
## [239]   3.465569e-04-1.001122e-04i   1.177606e-04+9.070272e-05i
## [241]   5.212288e-04+4.759362e-05i  -2.045432e-04-2.466952e-04i
## [243]  -1.640587e-04-8.351788e-05i   1.682820e-06-7.302932e-05i
## [245]  -1.259792e-04-2.899497e-04i   4.240992e-05+1.341758e-04i
## [247]  -1.324361e-05-2.522587e-04i  -1.550712e-04-7.489535e-05i
## [249]  -3.001335e-04-2.402411e-05i   2.115791e-04-1.866074e-04i
## [251]  -2.264768e-04-1.405681e-04i  -1.979349e-05+2.864389e-04i
## [253]   2.313987e-04+3.167367e-04i  -4.700202e-06-1.638496e-04i
## [255]  -3.405291e-04+3.310650e-05i   5.089533e-05+2.672930e-04i
## [257]   2.588869e-04-1.104809e-04i  -3.034898e-05+3.390678e-04i
## [259]  -6.627508e-05+1.076257e-04i   1.378652e-04-1.991130e-05i
## [261]   7.634097e-05-2.219788e-04i   2.275418e-04-1.714935e-04i
## [263]   2.850108e-04+3.195419e-05i   4.243863e-05-1.894555e-05i
## [265]  -3.890863e-04-7.458194e-05i   1.046722e-05-3.058013e-05i
## [267]   2.320069e-04-2.238481e-04i  -2.534595e-04+1.427819e-04i
## [269]   3.381169e-04+1.090086e-04i  -2.002367e-04+4.423808e-05i
## [271]  -2.964989e-04+1.481743e-04i  -2.522756e-04+3.020921e-04i
## [273]   2.381884e-04-2.645714e-04i  -3.029610e-04-3.977400e-05i
## [275]  -1.697574e-04+1.644715e-04i   1.837816e-04+6.168018e-05i
## [277]  -1.591048e-04+1.039434e-04i   1.189749e-04-5.282830e-05i
## [279]   1.428918e-04-1.655413e-05i   1.253279e-04-2.679445e-04i
## [281]  -1.617753e-04+2.576105e-04i   1.146753e-04-6.960150e-05i
## [283]  -2.838065e-04-2.044314e-04i  -2.210062e-04+1.938058e-05i
## [285]   4.828256e-04-8.611750e-05i   6.654846e-05-3.764722e-05i
## [287]   2.115966e-04-4.127100e-05i  -2.688970e-04+3.547699e-04i
## [289]  -1.317760e-04+2.519557e-04i   3.205019e-04+5.242191e-05i
## [291]   2.051228e-04-9.030344e-06i   2.645722e-04-3.146360e-05i
## [293]  -3.240725e-04-3.971966e-04i  -4.095139e-04+4.447124e-04i
## [295]   2.115185e-04-8.563088e-05i   1.903530e-04-1.755484e-04i
## [297]   1.674044e-05-8.238987e-05i  -3.595862e-05+8.865995e-06i
## [299]  -3.392349e-04+1.066757e-04i  -4.363520e-04+8.592792e-05i
## [301]   2.041094e-04-8.343553e-05i  -1.547610e-04+1.631643e-04i
## [303]   7.104828e-05+1.084786e-04i   4.151813e-04+1.266292e-04i
## [305]   4.452955e-05-2.262181e-04i
##
## $per
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##    [6] 5.131820e-08 1.428155e-07 8.914760e-08 4.204096e-08 1.204302e-07
##   [11] 3.236912e-09 3.182780e-08 2.749932e-07 3.568693e-08 1.612379e-08
##   [16] 9.781978e-08 5.630266e-08 2.200174e-07 4.358569e-08 3.751684e-08
##   [21] 3.607453e-08 7.763068e-08 1.787913e-07 2.121214e-08 7.778316e-08
##   [26] 2.766534e-08 1.018061e-08 1.161084e-07 4.143594e-07 1.175525e-07
##   [31] 1.967428e-09 5.594127e-09 5.459505e-08 2.772927e-07 9.424208e-08
##   [36] 9.652769e-08 3.949798e-08 1.850811e-07 5.599469e-08 5.660382e-08
##   [41] 1.149443e-07 1.065094e-07 9.780702e-09 1.152355e-07 2.053365e-08
##   [46] 7.080604e-08 4.229716e-08 8.242866e-08 2.708495e-08 8.212147e-09
##   [51] 1.956319e-08 7.154934e-08 2.016506e-07 8.046412e-08 8.572509e-08
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##   [61] 4.697836e-09 4.609061e-08 1.832719e-07 2.061045e-08 2.805703e-08
##   [66] 4.870717e-08 1.009436e-08 1.032361e-07 2.413399e-08 8.078464e-08
##   [71] 4.358075e-09 1.243049e-07 7.479757e-08 8.435878e-09 8.305790e-09
##   [76] 4.709483e-08 1.200815e-08 1.393294e-08 4.702571e-08 8.957929e-08
##   [81] 7.266611e-09 4.491364e-08 2.618310e-09 3.922880e-08 4.959633e-08
```

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##  [86] 6.770178e-08 1.776229e-09 1.039354e-09 4.986566e-08 4.888185e-09
##  [91] 1.704008e-07 6.477817e-08 9.627640e-08 1.293923e-09 4.240653e-08
##  [96] 1.555665e-07 1.214222e-07 4.565648e-08 1.574171e-07 2.225041e-09
## [101] 9.740795e-08 1.189430e-08 4.323470e-08 1.044686e-07 1.449105e-08
## [106] 7.247331e-09 3.376507e-08 7.096334e-09 9.024583e-09 2.813583e-08
## [111] 1.008133e-08 1.672897e-08 4.483591e-08 1.150020e-07 9.385739e-08
## [116] 3.041150e-08 1.715610e-08 1.534974e-07 1.028518e-07 4.484912e-08
## [121] 7.520865e-08 6.851337e-08 8.458467e-08 2.924001e-07 1.391523e-07
## [126] 2.237024e-07 8.142479e-08 4.043780e-08 1.676166e-07 1.400146e-08
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## [156] 5.134973e-08 5.188680e-08 2.630660e-08 1.054343e-07 6.966559e-08
## [161] 7.452237e-08 6.972747e-08 1.676733e-08 9.367854e-08 1.540787e-07
## [166] 1.355101e-08 2.258198e-07 7.906999e-08 4.981802e-08 5.079292e-08
## [171] 4.690080e-08 1.706184e-08 1.557762e-09 3.723597e-08 1.025541e-09
## [176] 1.226245e-07 1.842475e-08 8.069295e-08 6.847073e-08 5.873601e-08
## [181] 7.192879e-08 1.618633e-08 1.096886e-07 1.300141e-07 1.233631e-07
## [186] 3.848472e-08 4.630585e-08 1.459302e-07 7.280426e-10 4.057193e-08
## [191] 4.445641e-08 7.281408e-08 8.973729e-08 7.067472e-09 1.376708e-07
## [196] 1.101123e-07 1.905267e-07 9.805195e-08 6.986447e-09 1.027618e-09
## [201] 1.119579e-07 3.025058e-08 8.382191e-08 1.304005e-08 5.224907e-08
## [206] 7.844898e-08 6.429737e-08 1.185200e-07 2.429277e-08 4.742122e-08
## [211] 7.081421e-09 6.395056e-08 5.777239e-08 1.006315e-07 8.876339e-08
## [216] 2.669436e-07 6.922851e-08 1.111909e-07 1.162328e-07 9.644218e-08
## [221] 5.498869e-08 2.163773e-07 1.300875e-07 2.024972e-09 2.173555e-07
## [226] 1.542741e-07 8.228799e-08 9.976246e-09 1.186347e-07 7.282201e-08
## [231] 2.257853e-07 4.533608e-08 2.267405e-08 4.326143e-09 8.362474e-08
## [236] 4.500052e-10 2.695721e-07 7.964692e-08 1.301241e-07 2.209454e-08
## [241] 2.739446e-07 1.026964e-07 3.389048e-08 5.336114e-09 9.994159e-08
## [246] 1.980174e-08 6.380984e-08 2.965639e-08 9.065726e-08 7.958802e-08
## [251] 7.105110e-08 8.243902e-08 1.538675e-07 2.686878e-08 1.170561e-07
## [256] 7.403588e-08 7.922847e-08 1.158880e-07 1.597568e-08 1.940327e-08
## [261] 5.510251e-08 8.118528e-08 8.225221e-08 2.159971e-09 1.569506e-07
## [266] 1.044707e-09 1.039352e-07 8.462840e-08 1.262059e-07 4.205176e-08
## [271] 1.098672e-07 1.549027e-07 1.267317e-07 9.336732e-08 5.586845e-08
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## [281] 9.253442e-08 1.799478e-08 1.223384e-07 4.921937e-08 2.405367e-07
## [286] 5.846012e-09 4.647641e-08 1.981673e-07 8.084655e-08 1.054695e-07
## [291] 4.215692e-08 7.098840e-08 2.627881e-07 3.654708e-07 5.207271e-08
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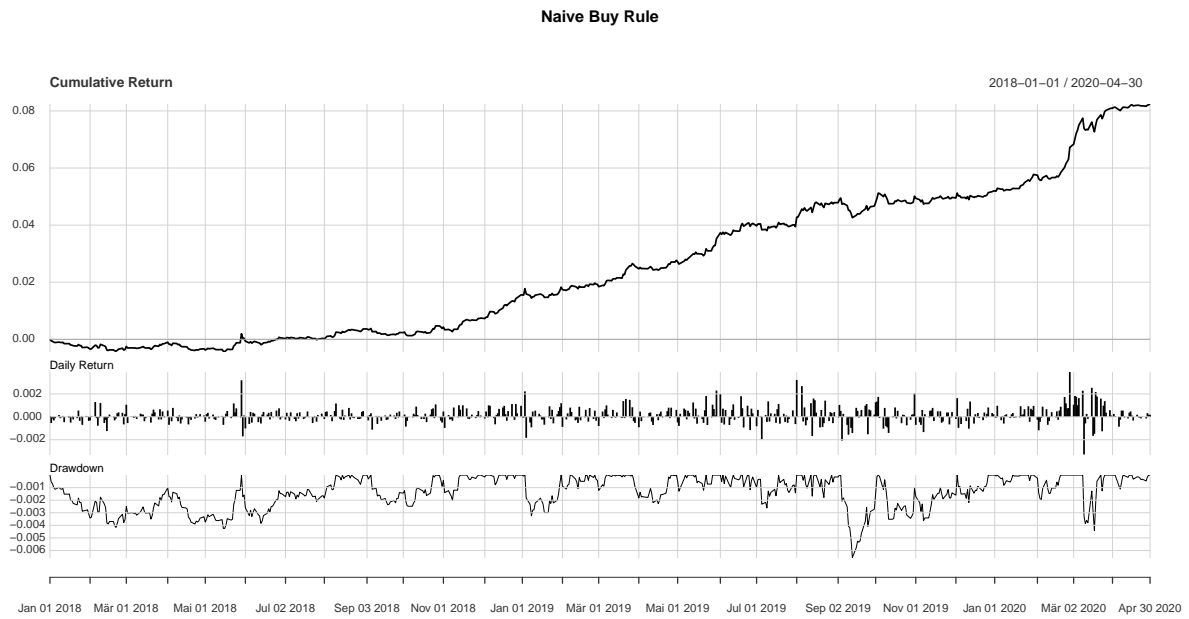
Figure 3: peridodogramm

## 3.2. using simple methods

in Section 2 we have learned different indicators and models for timeseries. these models and indicators are now used to trade the underlying asset. As an example we are taking the MA Crossings, as mentioned 2.3.3. the points where the two MAs cross, are now used to create a trading signal. when the longer MA comes from below to the crossing we are going long the asset and if it approaches the point from above we're shorting the position. Technically we apply a 1 to a vector at each crossing, where we intend to buy and apply a -1 at the points we want to sell.

**sna** **[2015–10–30/2020–04–**

Last 1731.67728658523

Okt 30 2015   Apr 03 2017   Apr 02 2018   Apr 01 2019   Mär 3

### 3.2.1. sma signals to trade



**sna** **[2015–10–30/2020–04–30]**

Last 1731.67728658523

1700

1600

1500

1400

Okt 30 2015   Apr 03 2017   Apr 02 2018   Apr 01 2019   Mär 31 2020

**sna**          **[2015–10–30/2020–04–30]**

Last 1731.67728658523

1700

1600

1500

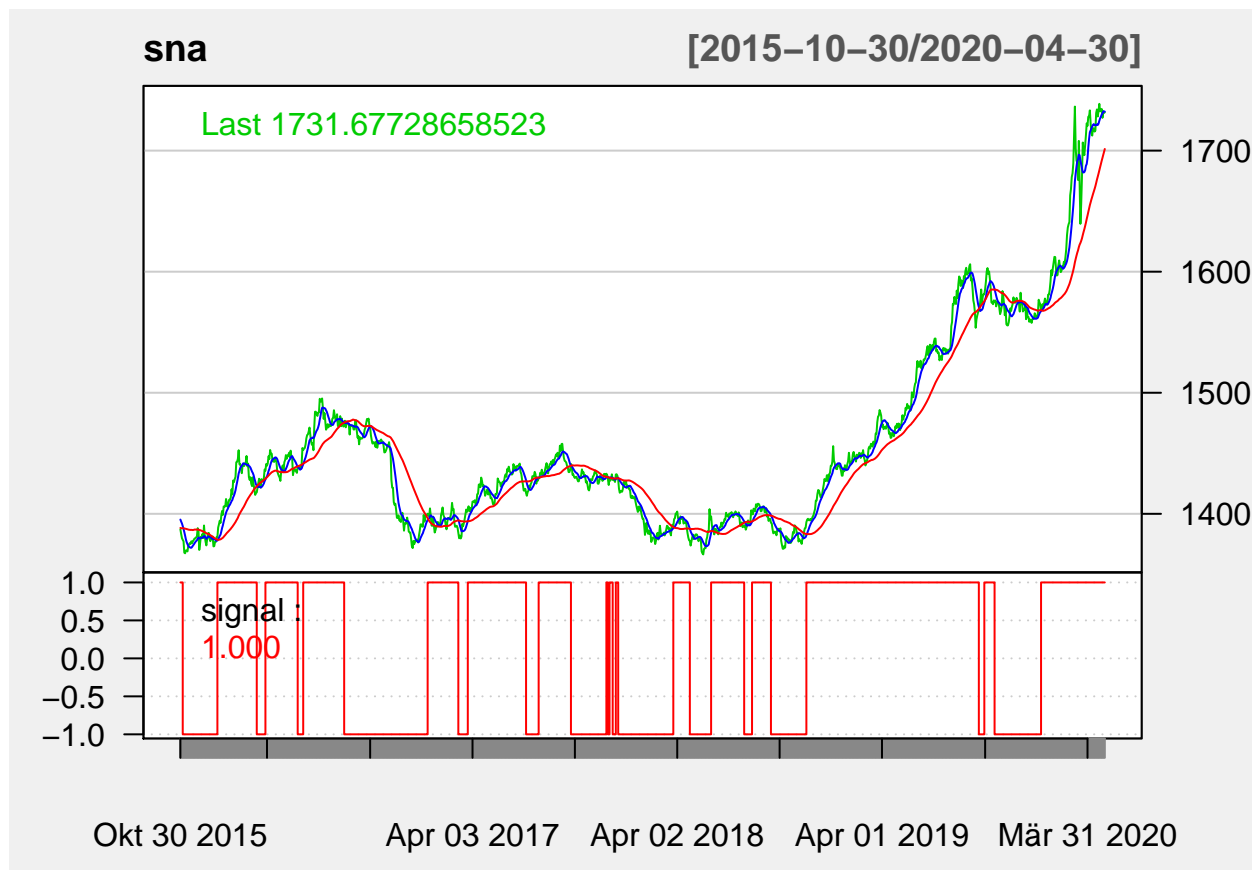1400

Okt 30 2015     Apr 03 2017   Apr 02 2018   Apr 01 2019   Mär 31 2020

```
## [1] 0.0001624021
```

**returns daily**                                           2015–10–30 / 2020–04–30
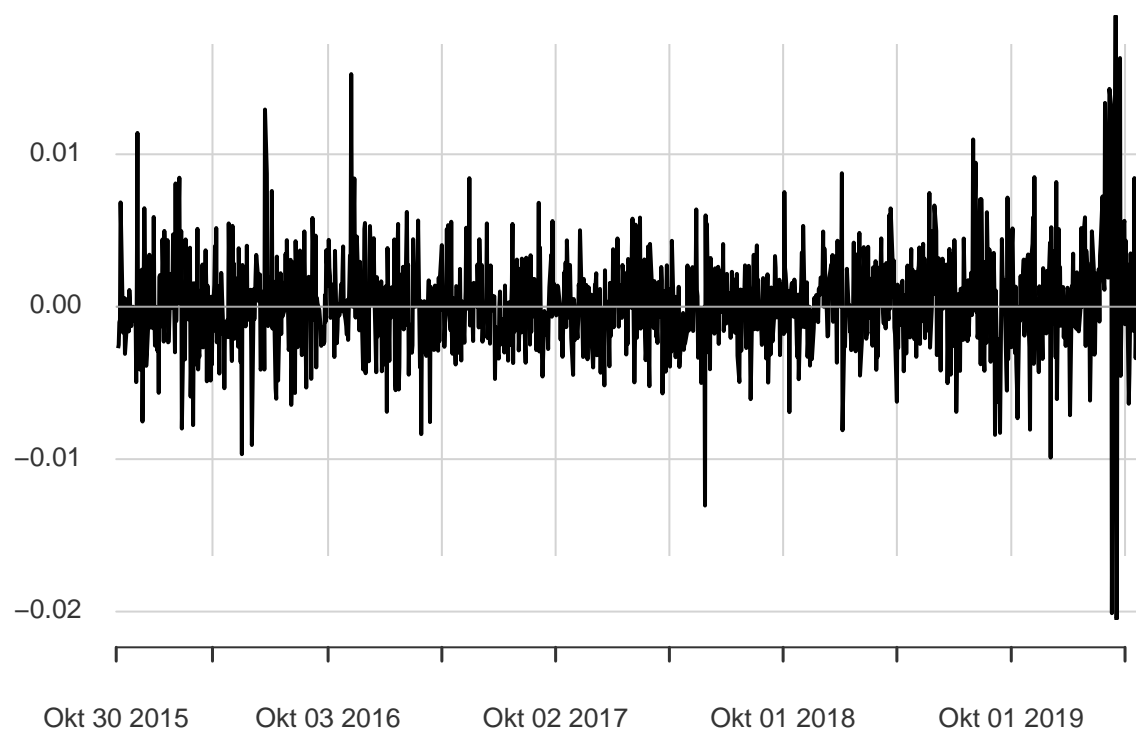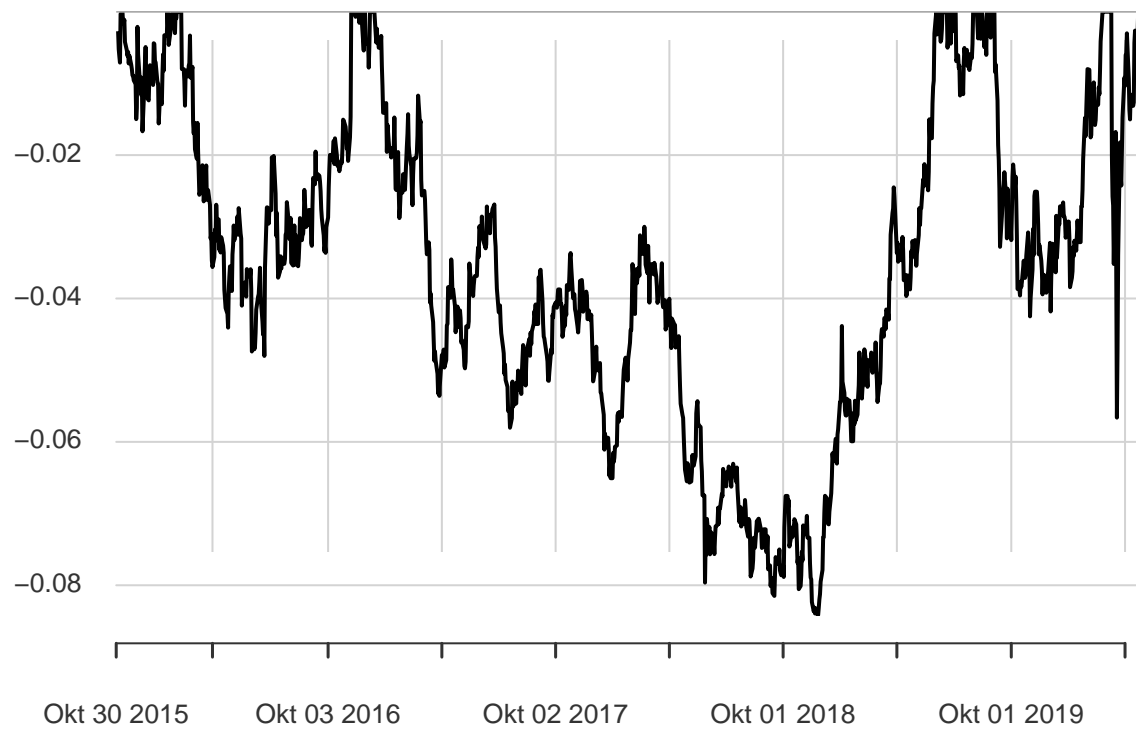
**Naive Rule: Cum Returns**  2015−11−02 / 2020−04−30

**Naive Rule: Percentage Drawdown**　　　　2015–10–30 / 2020–04–30

# Naive Buy Rule

## Cumulative Return

2015−11−02 / 2020−04−30