Assignment 2. Portfolio Optimization

Q1. Using the specified weights, the portfolio mean daily returns for the period between 01/01/2013 and 01/03/2018 is 0.0244% and the variance-covariance matrix is calculated as:

BND VB VEA VOO VWO

BND 8.036618e-06 3.947342e-07 1.239251e-06 5.220402e-07 2.345350e-06

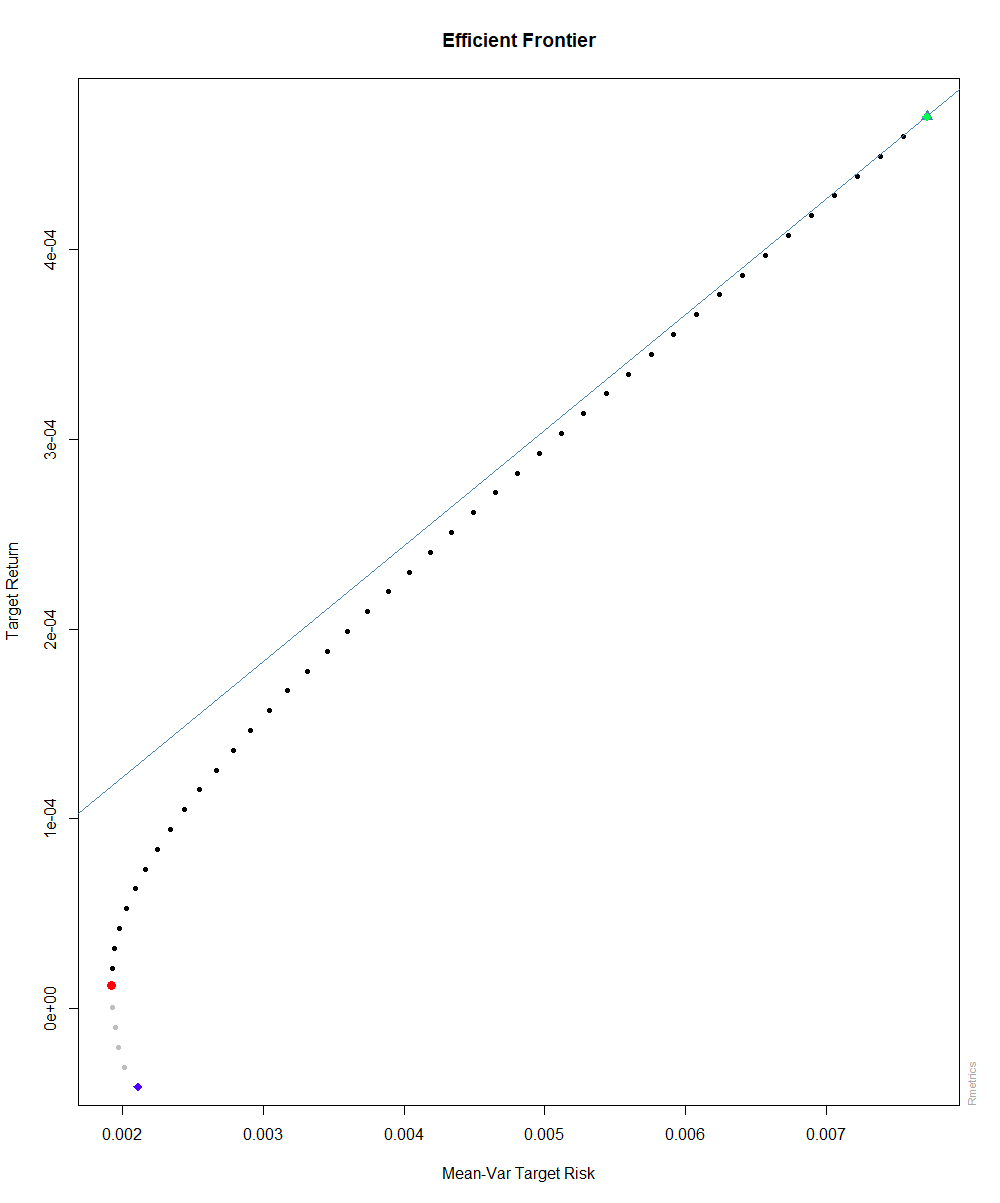
VB 3.947342e-07 1.534176e-04 1.108804e-04 1.201446e-04 1.161335e-04

VEA 1.239251e-06 1.108804e-04 1.145037e-04 9.888072e-05 1.161052e-04

VOO 5.220402e-07 1.201446e-04 9.888072e-05 1.128931e-04 1.046999e-04

VWO 2.345350e-06 1.161335e-04 1.161052e-04 1.046999e-04 1.655602e-04

Q2. The optimal portfolio is made up entirely of the S&P500 ETF (VOO). The expected mean and variance of the optimal portfolio are 0.05% and 1.29%. The efficient frontier with the minimum variance (colored red) and tangency (colored green) portfolios is presented below



Q3. Using the specified weights, the portfolio mean daily returns for the period between 03/02/2018 and 02/03/2021 was higher than Question 1’s returns at 0.0257% and the variance-covariance matrix is given as:

BND VB VEA VOO VWO

BND 1.4112e-05 7.4039e-06 7.5426e-06 6.0619e-06 7.1868e-06

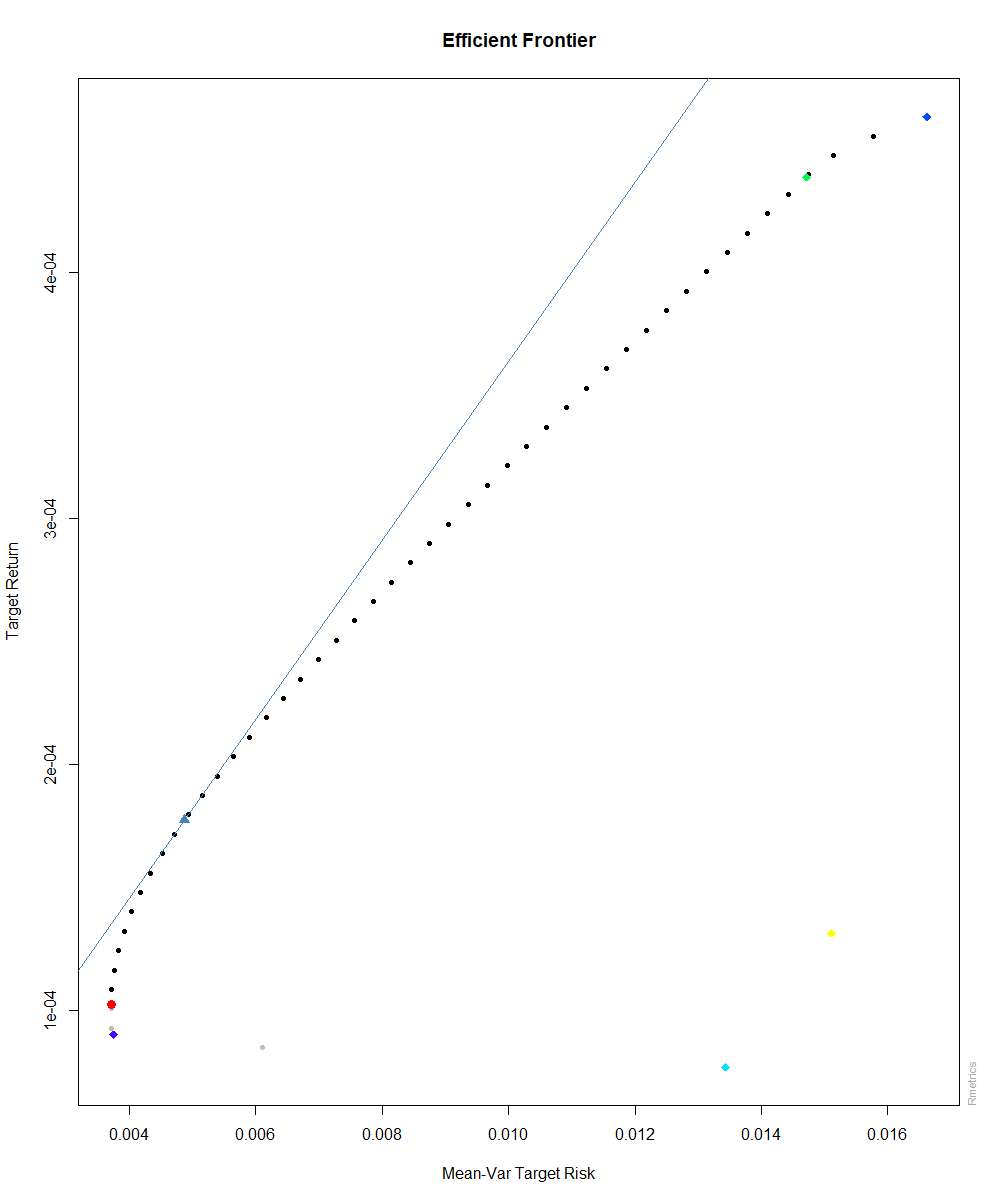
VB 7.4039e-06 2.7618e-04 2.0067e-04 2.2739e-04 2.0006e-04

VEA 7.5426e-06 2.0067e-04 1.8046e-04 1.7955e-04 1.7983e-04

VOO 6.0619e-06 2.273918e-04 1.7954e-04 2.1658e-04 1.8489e-04

VWO 7.1868e-06 2.000555e-04 1.7983e-04 1.8489e-04 2.2841e-04

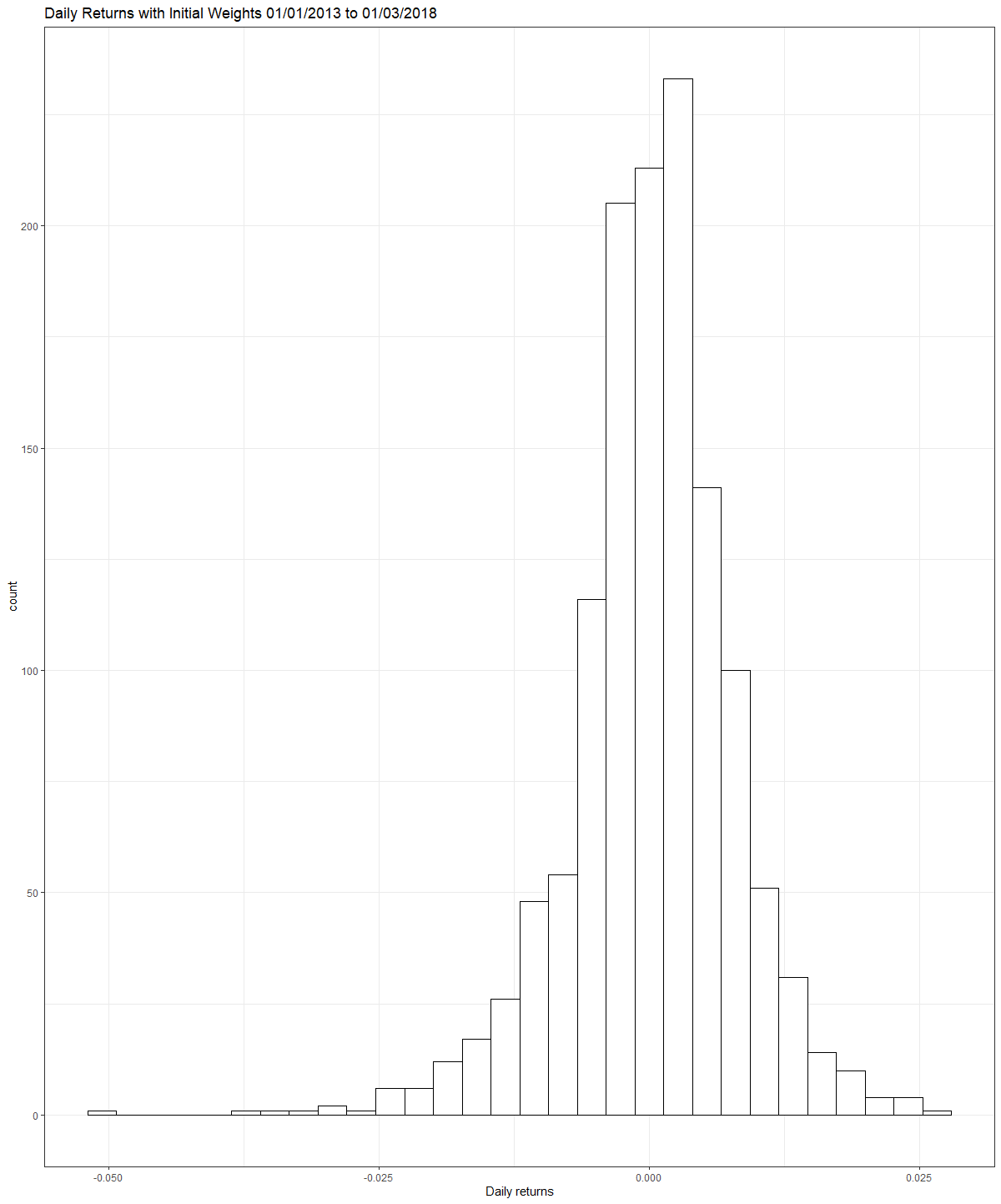
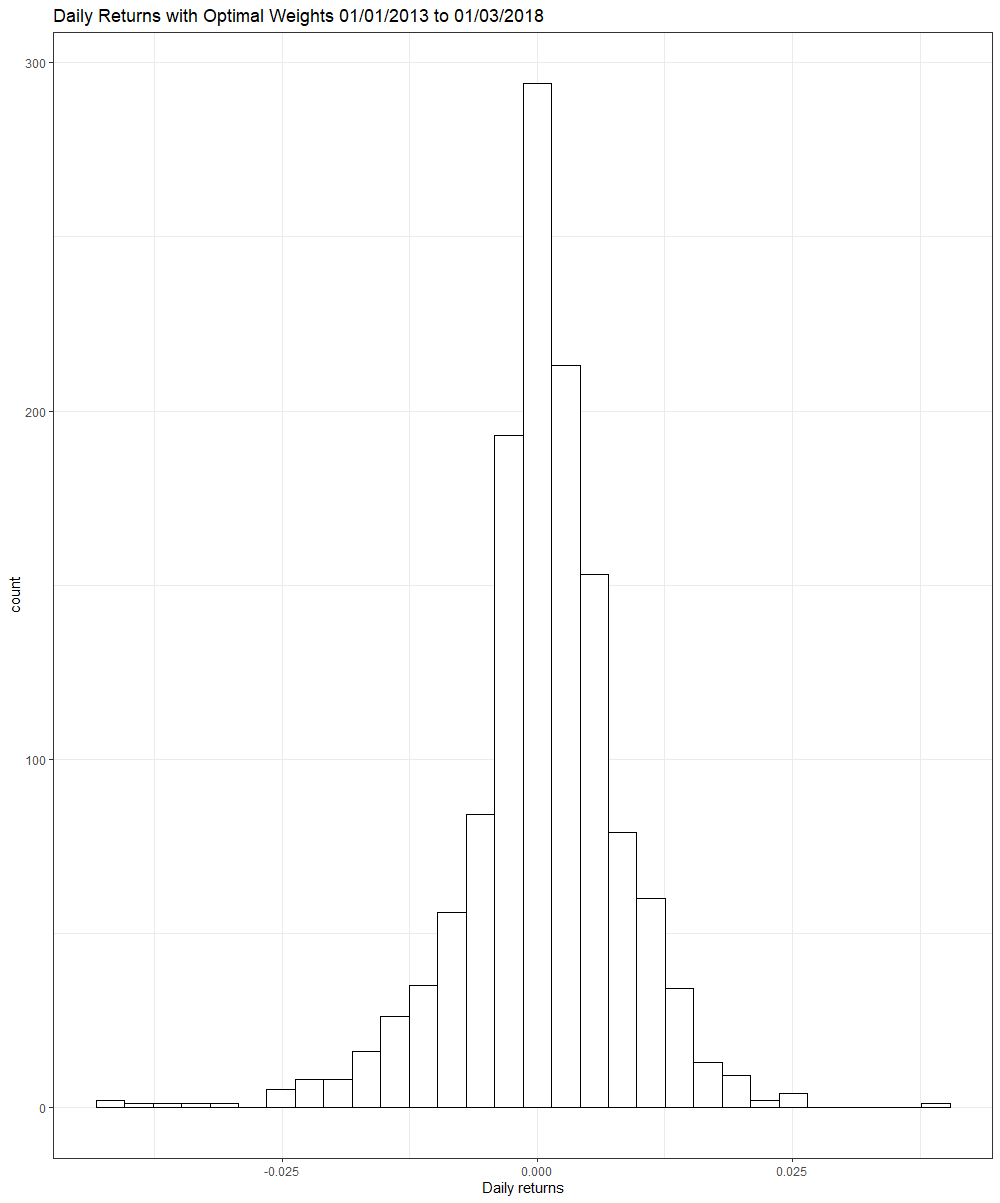
The optimal portfolio for this period comprises of 74.94% aggregate bonds ETF (BND) and 25.06% S&P500 ETF (VOO). The mean and variance of the optimal portfolio are 0.02% and 0.5%. The efficient frontier is shown in the figure below.

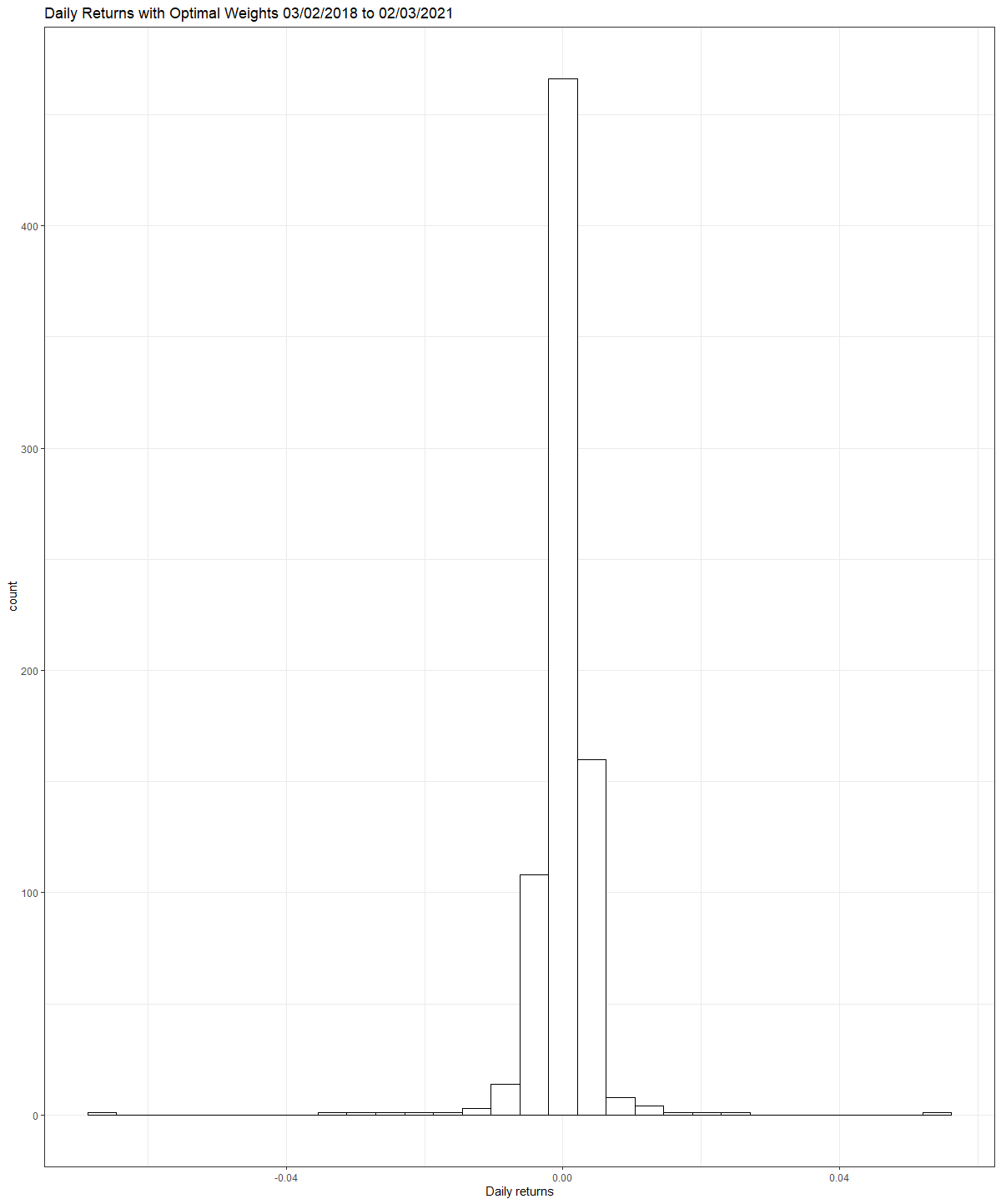


Q4. The distribution of daily returns for the specified portfolio weights and optimal portfolio weights for the period 01/01/2013 to 01/03/2018 are given in the histograms below. Both distributions are left-skewed; i.e., more daily returns occur above the mean than below it but there are a few extremely low returns for both portfolios.

The distribution of daily returns for the specified portfolio weights and optimal weights for the period 03/02/2018 to 02/03/2021 are substantially more left skewed than for the preceding period, which is expected given the economic conditions in 2020. The optimal portfolio distribution (2018 – 2021) is more skewed than the portfolio with specified weights indicating more extreme daily losses for the optimal portfolio.

**Daily Returns Between 01-01-2013 to 01-03-2018**



**Daily Returns Between 03-02-2018 to 2021-03-02**

