Chebyshev with a Bitcoin illustration

Chebyshev inequality

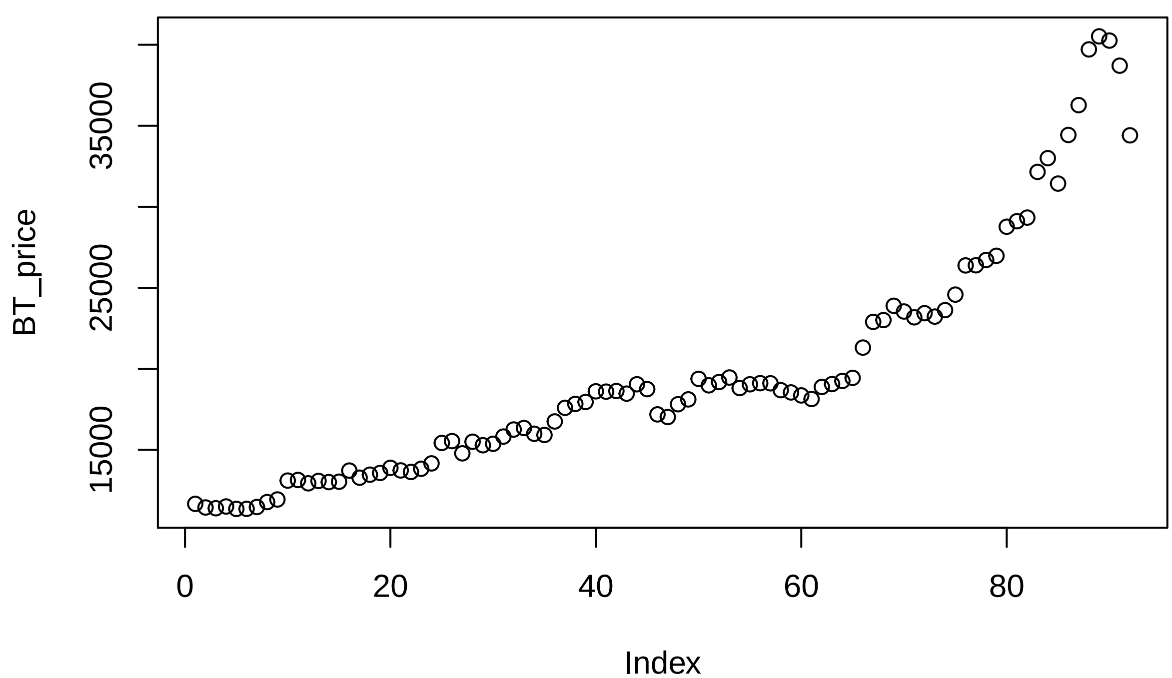
In this short note, we show how to use the Chebyshev inequality on a financial asset. It will help predict the probability of an extreme return. To do so, we focus on the Bitcoin prices.

In this exercise, we shall do the following:

1. Compute the returns of a financial asset
2. We compute the Chebyshev inequality for any chosen next return.

First, we load the data and plot the BTC prices.

```
url = "https://raw.githubusercontent.com/adufays/GDP_expectancy/main/DATA_BT.csv"
DATA = read.csv(url)
date = DATA$date
BT_price = DATA$BT_price
plot(BT_price)
```



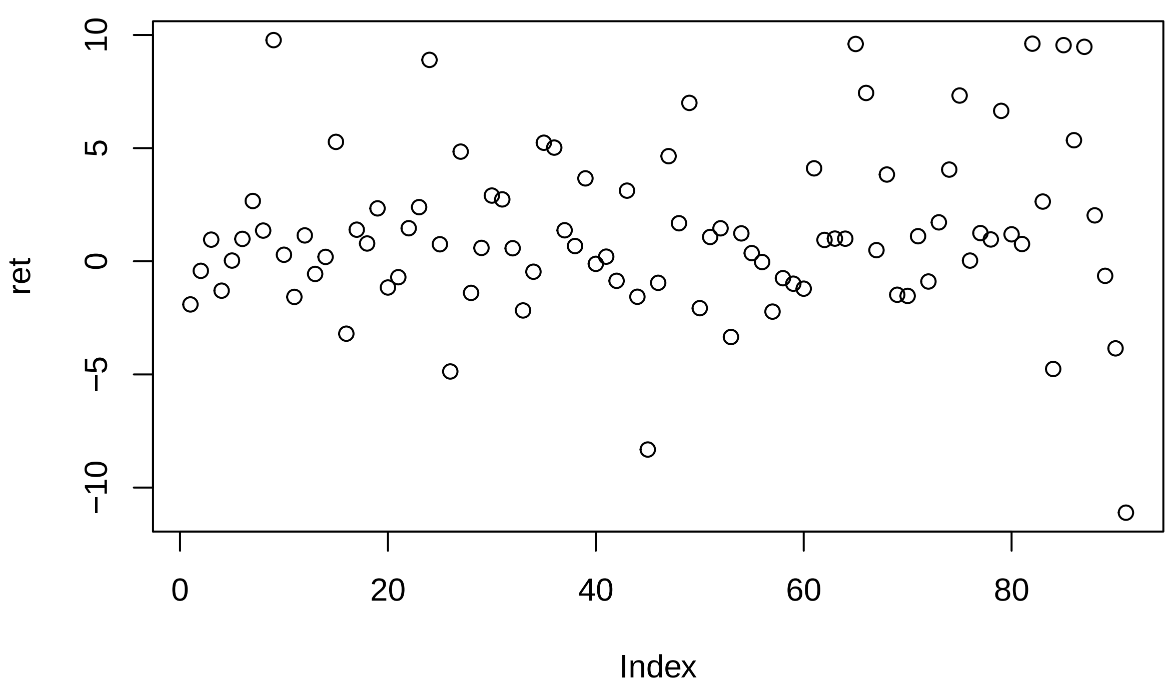

```
(date)
```

```
##  [1] "2020-10-13" "2020-10-14" "2020-10-15" "2020-10-16" "2020-10-17"
```

```
##  [6] "2020-10-18" "2020-10-19" "2020-10-20" "2020-10-21" "2020-10-22"
## [11] "2020-10-23" "2020-10-24" "2020-10-25" "2020-10-26" "2020-10-27"
## [16] "2020-10-28" "2020-10-29" "2020-10-30" "2020-10-31" "2020-11-01"
## [21] "2020-11-02" "2020-11-03" "2020-11-04" "2020-11-05" "2020-11-06"
## [26] "2020-11-07" "2020-11-08" "2020-11-09" "2020-11-10" "2020-11-11"
## [31] "2020-11-12" "2020-11-13" "2020-11-14" "2020-11-15" "2020-11-16"
## [36] "2020-11-17" "2020-11-18" "2020-11-19" "2020-11-20" "2020-11-21"
## [41] "2020-11-22" "2020-11-23" "2020-11-24" "2020-11-25" "2020-11-26"
## [46] "2020-11-27" "2020-11-28" "2020-11-29" "2020-11-30" "2020-12-01"
## [51] "2020-12-02" "2020-12-03" "2020-12-04" "2020-12-05" "2020-12-06"
## [56] "2020-12-07" "2020-12-08" "2020-12-09" "2020-12-10" "2020-12-11"
## [61] "2020-12-12" "2020-12-13" "2020-12-14" "2020-12-15" "2020-12-16"
## [66] "2020-12-17" "2020-12-18" "2020-12-19" "2020-12-20" "2020-12-21"
## [71] "2020-12-22" "2020-12-23" "2020-12-24" "2020-12-25" "2020-12-26"
## [76] "2020-12-27" "2020-12-28" "2020-12-29" "2020-12-30" "2020-12-31"
## [81] "2021-01-01" "2021-01-02" "2021-01-03" "2021-01-04" "2021-01-05"
## [86] "2021-01-06" "2021-01-07" "2021-01-08" "2021-01-09" "2021-01-10"
## [91] "2021-01-11" "2021-01-12"
```

Now, we compute the returns in percentage and have a look at them.

```r
T = length(BT_price)
ret = 100*(BT_price[2:T]-BT_price[1:(T-1)])/BT_price[1:(T-1)]
plot(ret)
```




```r
(mean_ret = mean(ret))
```

```
## [1] 1.261616
```

```
var_ret = var(ret)
(sqrt(var_ret))
```

```
## [1] 3.6754
```

```
CI_Norm = data.frame(cbind(mean_ret-1.96*sqrt(var_ret),mean_ret+1.96*sqrt(var_ret)))
rownames(CI_Norm) = c('CI 95%')
(CI_Norm)
```

```
##               X1     X2
## CI 95% -5.942168 8.4654
```

We observe that the standard deviation is large as it is equal to 3.67. Assuming a Normal distribution, the 95% confidence interval leads to returns from -6% to 8.5%. Now, we use the Chebyshev inequality to get an idea of what could be the range of the next return (assuming that the variance is constant).

```
n = 10 ## One percent
a = n*sqrt(var_ret)
prob_chebyshev = var_ret/a^2
paste("A return being greater than (in absolute value) ",a, " has a probability of occuring tomorrow tha
```

```
## [1] "A return being greater than (in absolute value)  36.7539992266237  has a probability of occurin
```