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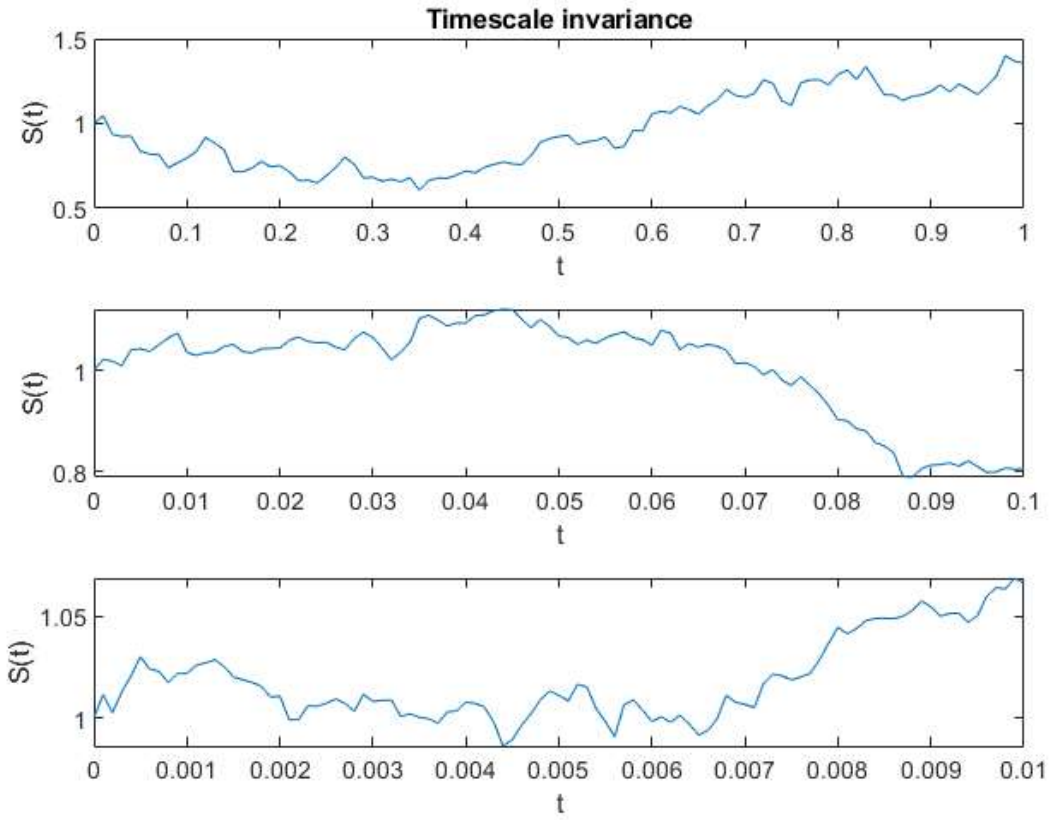
Exercise 1:

P7.1. Write a program that illustrates the timescale invariance of the asset model, in the style of Figure 7.5

```
%CH07 Program for Chapter 7 % % Plot discrete sample paths
warning off;
clear all;
randn('state',100) ;
clf

%%%%%%%%% Problem parameters %%%%%%%%%%
S=1; mu=0.05; sigma = 0.5; L = 1e2;

for i = 0:2
    T = 10^-i;
    dt =T/L; M = 1;

    tvals = [0:dt:T];
    Svals = S*cumprod(exp((mu-0.5*sigma^2)*dt + sigma*sqrt(dt)*randn(M,L)),2);
    Svals = [S*ones(M,1) Svals]; % add initial asset price


    h(i+1) = subplot(3,1,i+1);

    plot(tvals,Svals)
    xlabel('t'), ylabel('S(t)')

    if i==0
            title('Timescale invariance')
    end
end
```



Exercise 2:

Solve Exercise 8.10 from the book by Higham, page 83

For V(S,t)=S we get

$$\frac{\partial}{\partial t}S + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2}{\partial S^2}S + \mathrm{rS}\frac{\partial}{\partial S}S - \mathrm{rS} = 0$$

$$0 + 0 + \mathrm{rS} - \mathrm{rS} = 0$$

At V=S for every t, it's a derivative that always has the stock price, without actually owning the stock.

For V(S,t)=e^rt

$$\frac{\partial}{\partial t}e^{\mathrm{rt}} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2}{\partial S^2}e^{\mathrm{rt}} + \mathrm{rS}\frac{\partial}{\partial S}e^{\mathrm{rt}} - \mathrm{r}e^{\mathrm{rt}} = 0$$

$$\mathrm{r}e^{\mathrm{rt}} + 0 + 0 - \mathrm{r}e^{\mathrm{rt}} = 0$$

For this situation, the value can be replicated by just putting money on the bank, as it equals the compound rate.

Exercise 3:

a) generate 10 asset paths driven by geometric Brownian motion and the parameters above

```
studentno = 4461487;
mu = studentno;
```

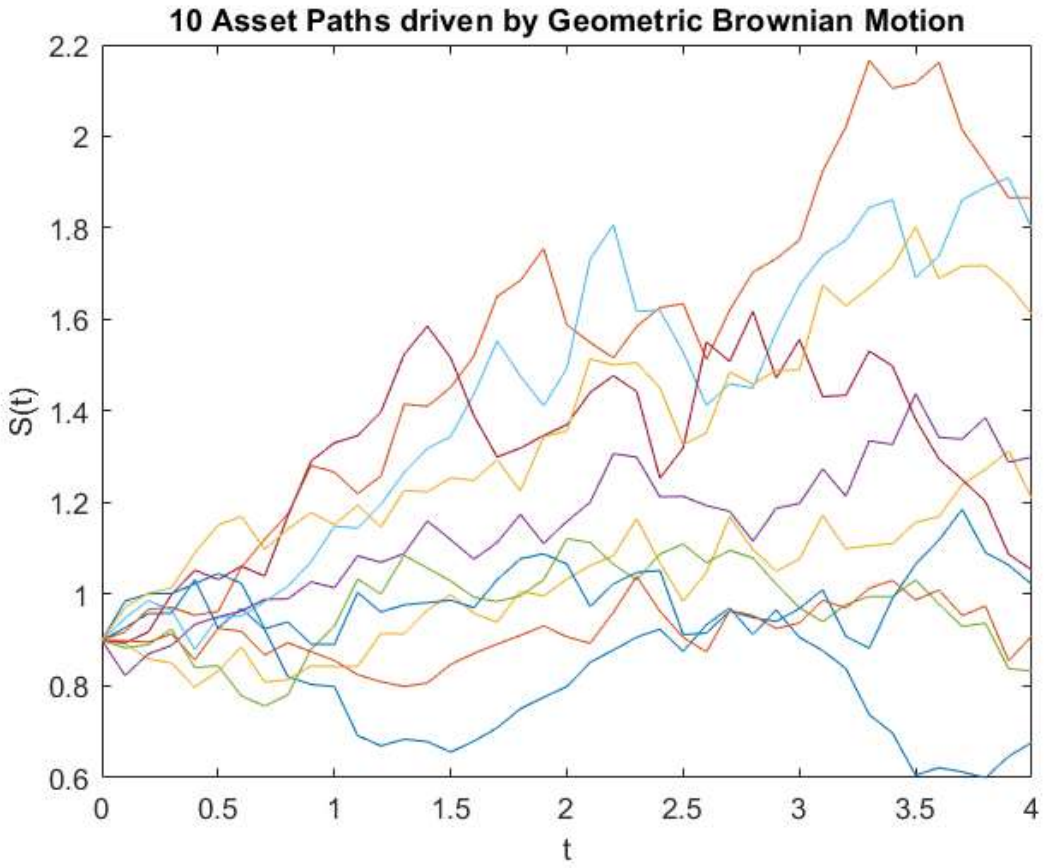
```
%divide mu by 10 until mu<0.1
while mu>0.1
mu = mu / 10;
end

mu
```

```
mu = 0.0446
```

```
sigma = mu*4
```

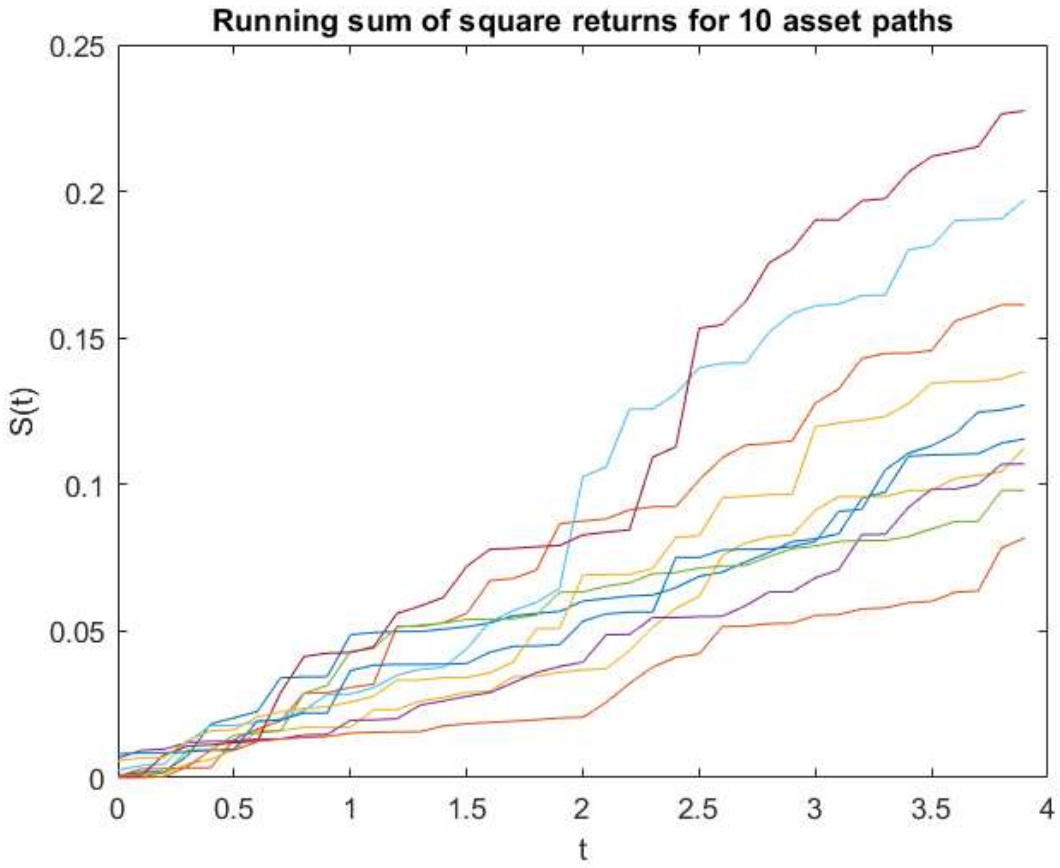
```
sigma = 0.1785
```

```
s0 = 0.9;

T=4;
dt= 10^-1;

steps = T/dt;

%using matlab geometric Brownian Motion function
obj = gbm(mu, diag(sigma), 'StartState', s0) ;
[X1,T] = obj.simulate(steps, 'DeltaTime', dt,'ntrials', 10);
X1 = squeeze(X1);
figure()
plot(T,X1)
xlim([0, 4])
xlabel('t'), ylabel('S(t)')
title('10 Asset Paths driven by Geometric Brownian Motion')
```



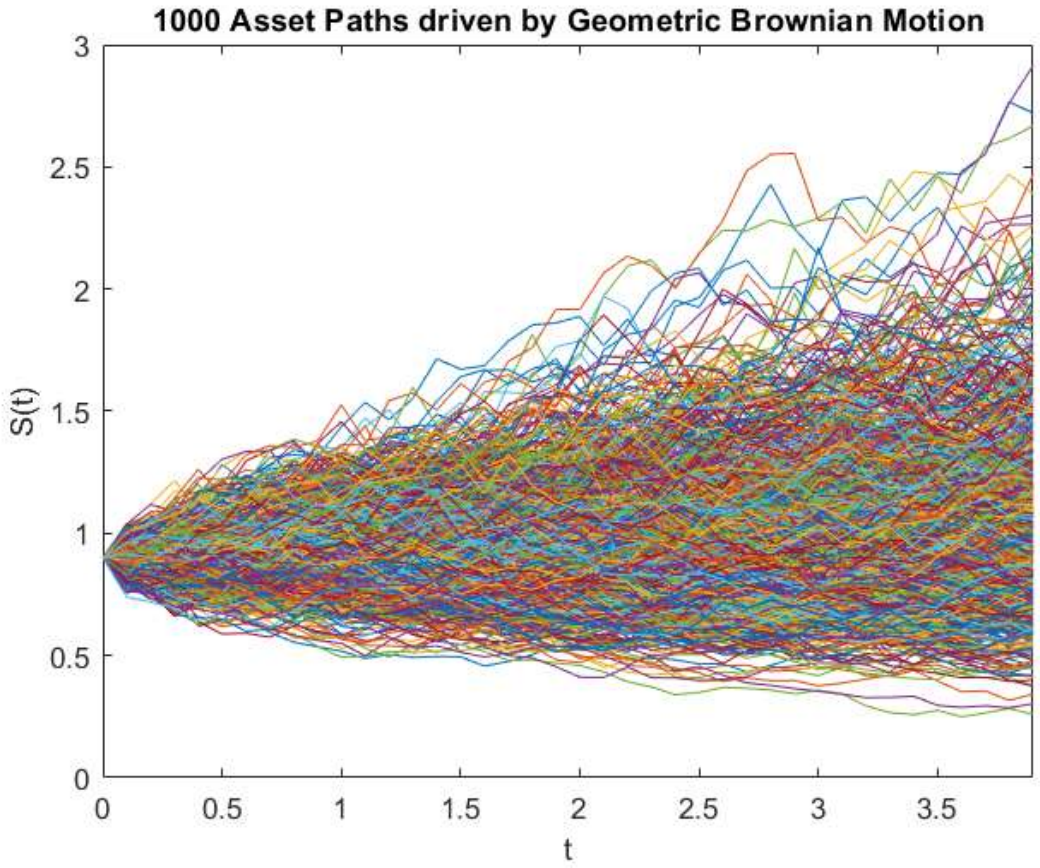
b) Plot for these paths the "running sum of square returns".

```
xsize = size(X1);
for k = 1: xsize(1)-1
   DX1(k,:) = (X1(k+1,:)-X1(k,:)).^2;
end

a=X1(1:end-1,:);
DX1 = DX1./a;
C1 = cumsum(DX1, 1);
plot(T(1:end-1),C1);
xlim([0, 4])
xlabel('t'), ylabel('S(t)')
title('Running sum of square returns for 10 asset paths');
```

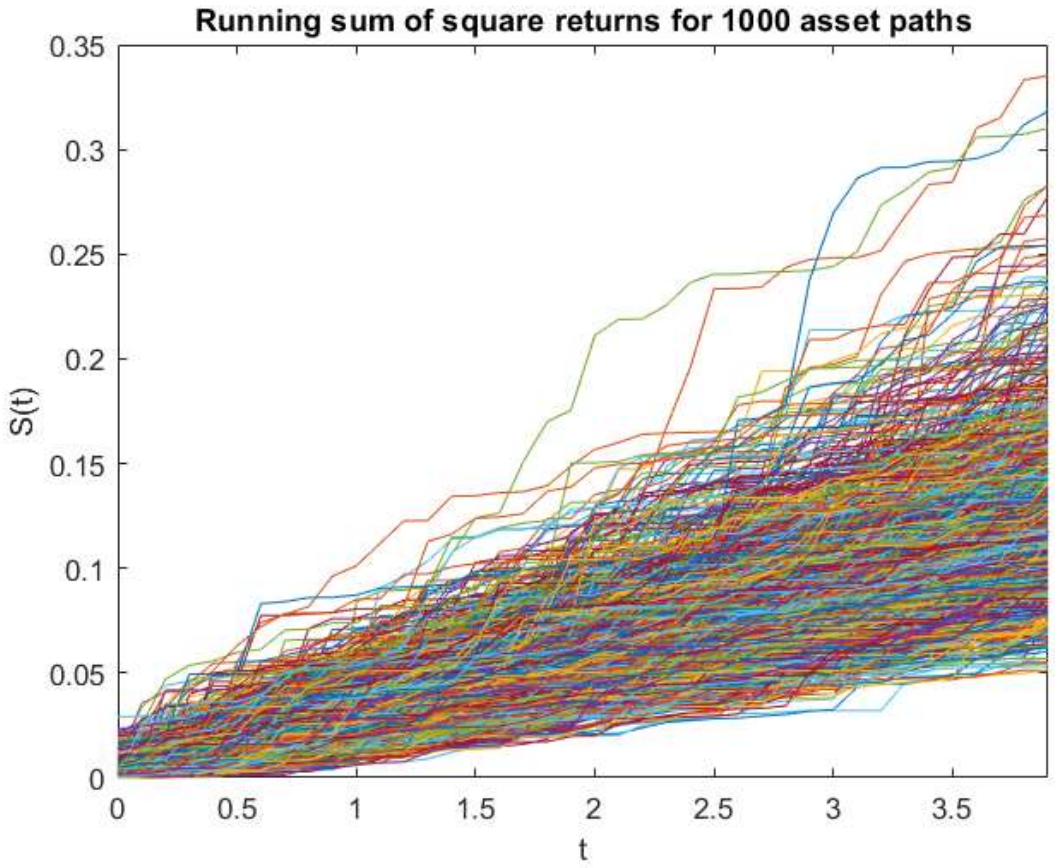


Repeat this exercise with 1000 asset paths

```
[X2,T2] = obj.simulate(steps, 'DeltaTime', dt,'ntrials', 1000);
X2 = squeeze(X2);
figure()
plot(T2,X2)
xlim([0, 4-dt])
xlabel('t'), ylabel('S(t)')
title('1000 Asset Paths driven by Geometric Brownian Motion')
```



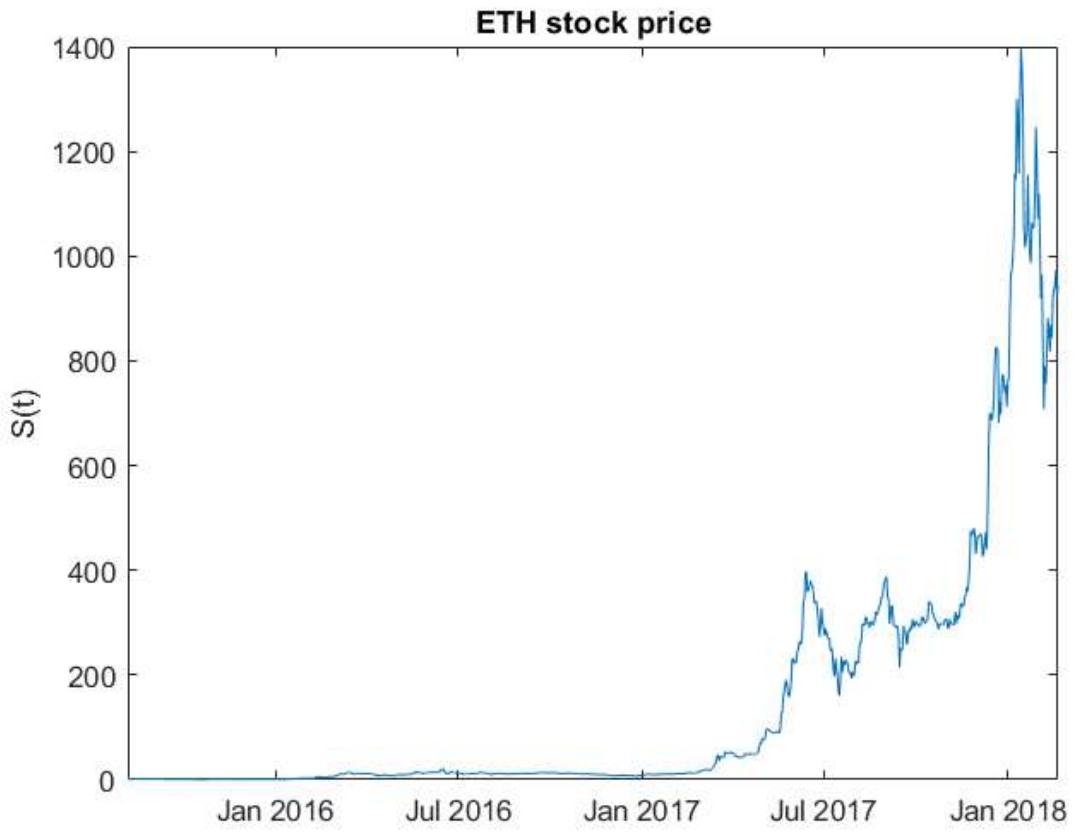

```
x2size = size(X2);
for l = 1: x2size(1)-1
   DX2(l,:) = (X2(l+1,:)-X2(l,:)).^2;
end

b=X2(1:end-1,:);
DX2 = DX2./b;

C2 = cumsum(DX2, 1);
plot(T2(1:end-1),C2);
xlim([0, 4-dt])
xlabel('t'), ylabel('S(t)')
title('Running sum of square returns for 1000 asset paths');
```



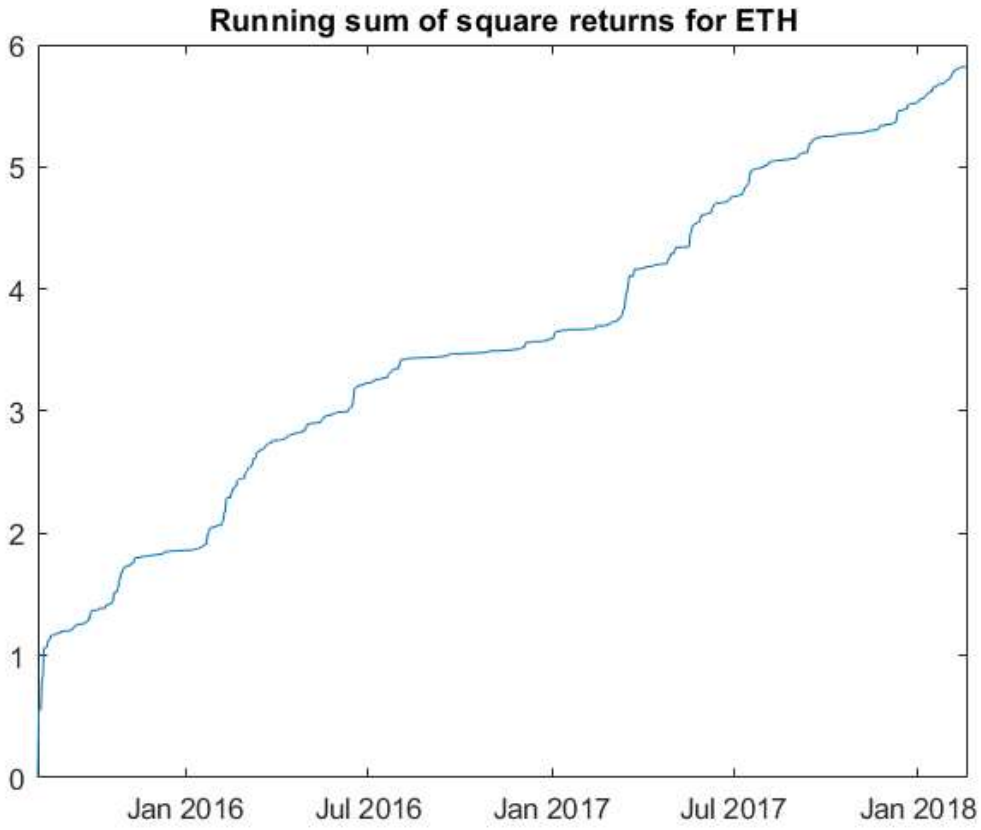
c)

```
%import data for ethereum
ethFileName = 'cryptodata/ethereum_price.csv';
warning off
ethTable = readtable(ethFileName);

%select correct rows
ethDateRow = flipud(ethTable{:, 'Date'});
y = flipud(ethTable{:, 'Open'});

%do the same for eth classic
ethClassicFileName = 'cryptodata/ethereum_classic_price.csv';
ethClassicTable = readtable(ethClassicFileName);
warning on
ethClassicDateRow = flipud(ethClassicTable{:, 'Date'});
y2 = flipud(ethClassicTable{:, 'Open'});

ethsize = size(y);
ethClassicSize = size(y2);

for m = 1 : ethsize(1) - 1
    ethChange(m) = ((y(m+1)-y(m))/y(m))^2;
end

for n = 1: ethClassicSize(1)-1
```

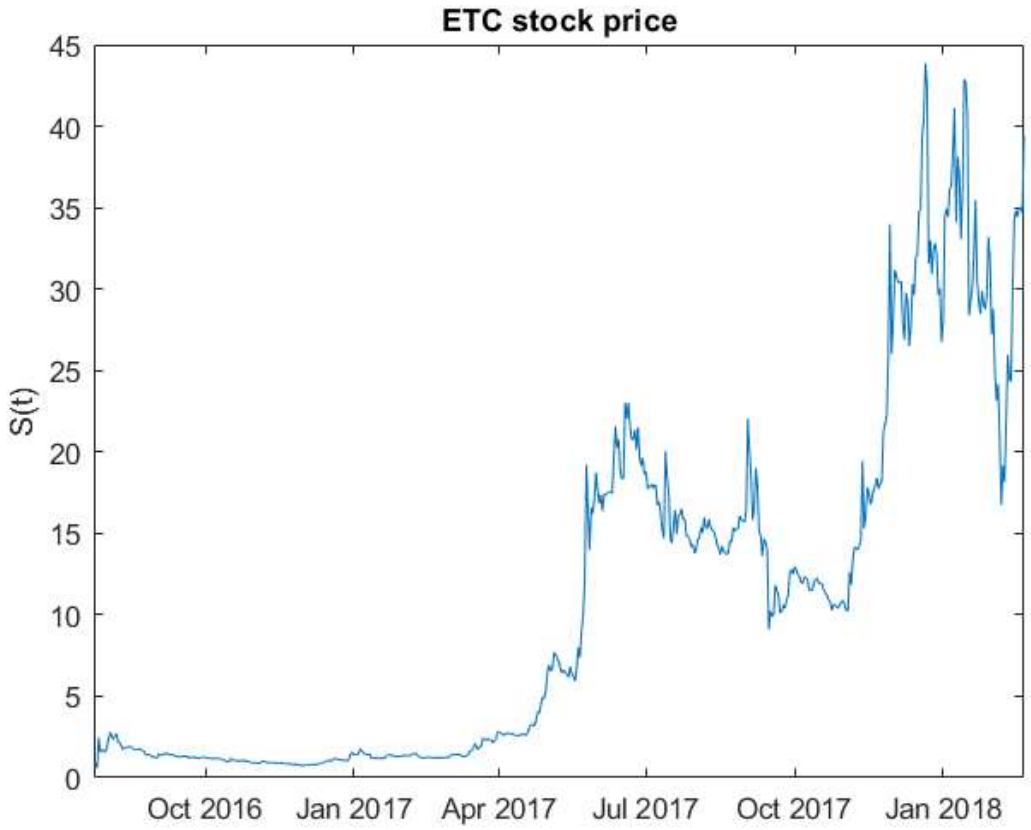
```
    ethClassicChange(n) = ((y2(n+1)-y2(n))/y2(n))^2;
end

warning off
plot(ethDateRow, y)
ylabel('S(t)')
title('ETH stock price');
xlim([ethDateRow(1), ethDateRow(end)])
```



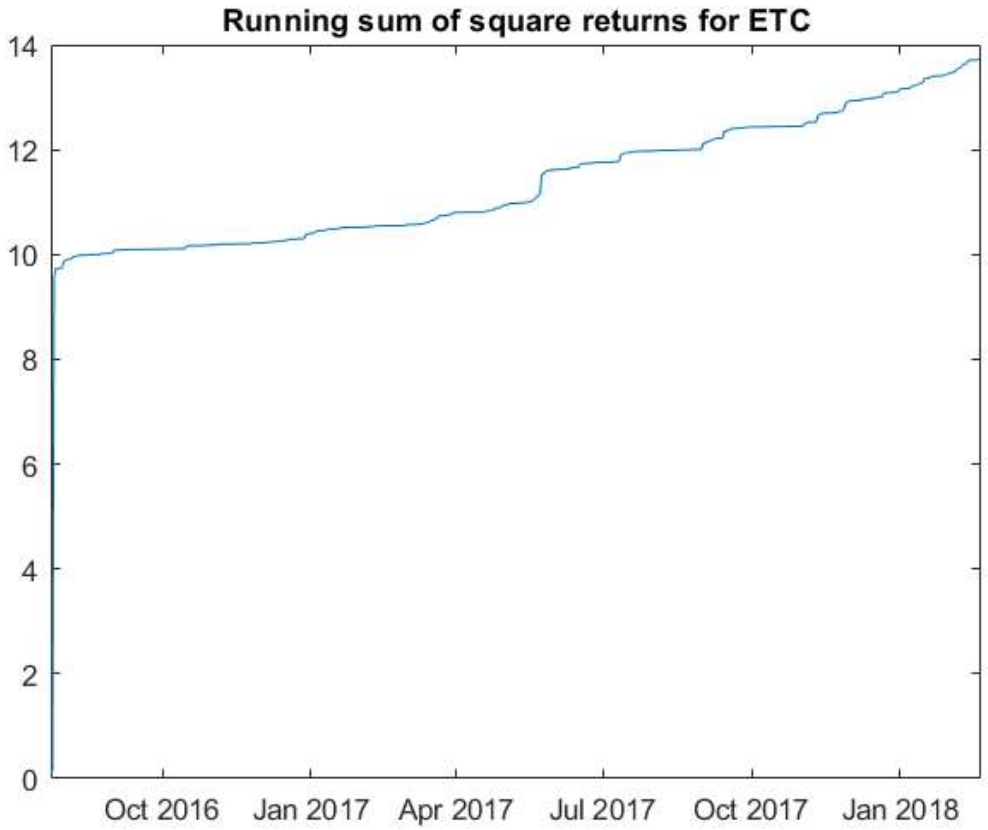

```
plot(ethDateRow(1:end-1), cumsum(ethChange));
title('Running sum of square returns for ETH');
xlim([ethDateRow(1), ethDateRow(end)])
```




```
plot(ethClassicDateRow, y2)
ylabel('S(t)')
title('ETC stock price');
xlim([ethClassicDateRow(1), ethClassicDateRow(end)])
```




```
plot(ethClassicDateRow(1:end-1), cumsum(ethClassicChange));
title('Running sum of square returns for ETC');
xlim([ethClassicDateRow(1), ethClassicDateRow(end)])
```




```
%%eth classic dataset has a jump at the beginning, distorting the graph a bit
```