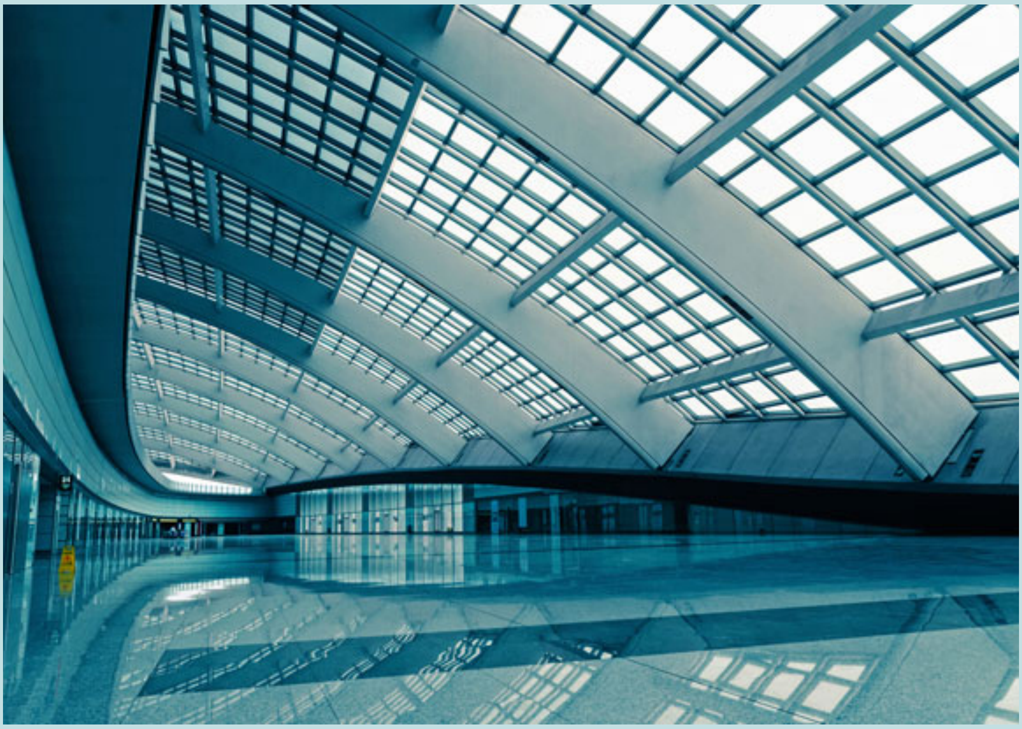
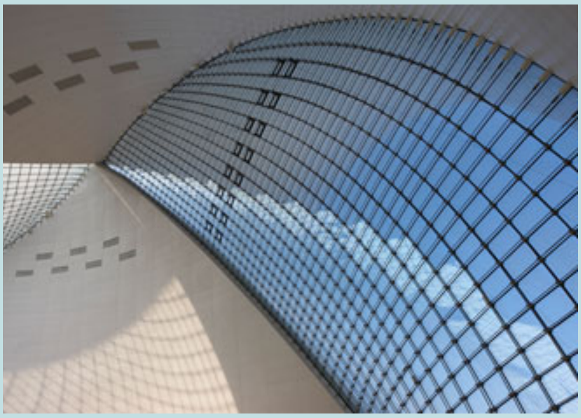
Investment Science Project 2

2021-06-13





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Main Function introduction

We define 2 Binomial Trees:

EuropeanBSTree for calculate European option valuation

AmericanBSTree for calculate European option valuation

Both of them use same parmater: (K, T, S, sig, r, N, PorC)

The idea of the binary tree is as follows:

1. The development of the matter is divided into stages

2. There are only two results at each stage: getting better and getting worse

1. European call option ($S_0 = 70, K = 60, T = 10, r = 0.05, \sigma = 0.2, N = 10$) 2. American call option ($S_0 = 70, K = 60, T = 10, r = 0.05, \sigma = 0.2, N = 10$) 3. European put option ($S_0 = 100, K = 95, T = 5, r = 0.04, \sigma = 0.1, N = 10$) 4. American put option ($S_0 = 100, K = 95, T = 5, r = 0.04, \sigma = 0.1, N = 10$)

The result is:

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----------
 [0.0, 0.0, 0.0, 0.0, 5.461676140858621,
28.57140670004431, 71.26685469917125,
135.24664638816728, 231.12135754358215,
374.79110069961007, 468.9373975102776]
----------
 [0.0, 0.0, 0.0, 2.9829906267624366,
17.817093453955827, 50.49683371846918,
102.73481935795816, 181.01425185239214,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [0.0, 0.0, 1.629212873459333, 10.939415005418823,
34.796759321696804, 76.56477005849895,
140.4780739715357, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [0.0, 0.8898233079352568, 6.634686109079305,
23.43600226362549, 55.91203611329944,
107.73803886630338, 185.93612340331967,
236.2531521624288, 298.3171967618619,
374.79110069961007, 468.9373975102776]
----------
 [0.4859926730529892, 3.984084122466048,
15.487443406913142, 40.030372868474046,
81.4908582059325, 145.19285396529614,
185.93612340331967, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [2.372834791479847, 10.07254034133474,
28.13666510564372, 60.72244290182915,
112.30846918969786, 145.19285396529614,
185.93612340331967, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [6.46244008246257, 19.447336675220058,
44.561720267885484, 85.93559131360026,
112.30846918969786, 145.19285396529614,
185.93612340331967, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [13.239193151729225, 32.21554183968442,
64.98548795971672, 85.93559131360026,
112.30846918969786, 145.19285396529614,
```

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185.93612340331967, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [22.95777716953507, 48.542254610242004,
64.98548795971672, 85.93559131360026,
112.30846918969786, 145.19285396529614,
185.93612340331967, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]
----------
 [35.811526166216964, 48.542254610242004,
64.98548795971672, 85.93559131360026,
112.30846918969786, 145.19285396529614,
185.93612340331967, 236.2531521624288,
298.3171967618619, 374.79110069961007,
468.9373975102776]

 EuropeanBSTree call price 35.81
----------
 [0.0, 0.0, 0.0, 0.0, 5.493285208229139,
28.424427601169054, 70.4745505572928,
133.20596252209037, 226.79023220908445,
366.4015570388635, 457.2339269251456]
----------
 [0.0, 0.0, 0.0, 3.0176182378949057,
17.822105058735385, 50.13748375273137,
101.4976199123152, 178.11793950940083,
292.4220246255005 7, 366.4015570388635,
457.2339269251456]
----------
 [0.0, 0.0, 1.6576637630310564, 11.002974106630253,
34.70466991621725, 75.9058374418322,
138.6372494066298, 232.22151909362384,
292.4220246255005 7, 366.4015570388635,
457.2339269251456]
----------
 [0.0, 0.9106019829675955, 6.710464055004144,
23.486370227321235, 55.64507960491372,
106.66401980979391, 183.28433940687952,
232.22151909362384, 292.4220246255005 7,
366.4015570388635, 457.2339269251456]
----------
 [0.5002196403620015, 4.052221053216233,
15.598674584277257, 40.00662268891233,
80.95739600557802, 143.551681007849,
183.28433940687952, 232.22151909362384,
292.4220246255005 7, 366.4015570388635,
457.2339269251456]
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 [2.427039322709616, 10.197388139368817,
28.245900276417604, 60.550904409189705,
111.3938832037278, 143.551681007849,
183.28433940687952, 232.22151909362384,
292.4220246255057, 366.4015570388635,
457.2339269251456]
----------
 [6.577145439915149, 19.614618126521624,
44.6143915998751, 85.52730028958565,
111.3938832037278, 143.551681007849,
183.28433940687952, 232.22151909362384,
292.4220246255057, 366.4015570388635,
457.2339269251456]
----------
 [13.41822985787066, 32.39109049531762,
64.91314965908033, 85.52730028958565,
111.3938832037278, 143.551681007849,
183.28433940687952, 232.22151909362384,
292.4220246255057, 366.4015570388635,
457.2339269251456]
----------
 [23.186148535268632, 48.676653025356586,
64.91314965908033, 85.52730028958565,
111.3938832037278, 143.551681007849,
183.28433940687952, 232.22151909362384,
292.4220246255057, 366.4015570388635,
457.2339269251456]
----------
 [36.05800785416152, 48.676653025356586,
64.91314965908033, 85.52730028958565,
111.3938832037278, 143.551681007849,
183.28433940687952, 232.22151909362384,
292.4220246255057, 366.4015570388635,
457.2339269251456]

 AmericanBSTree call price 36.06
----------
 [23.805489913337468, 33.06565393618372,
23.64719362609574, 12.751586968627805,
3.1863678655843772, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [28.96281232763221, 26.68598852927765,
16.556156859567505, 6.684961100641469,
1.186470129118592, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [27.005364510781334, 20.000248640870755,
10.228210457819475, 3.2103845199179184,
0.4417918541343673, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
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 [22.21262935734535, 13.66437664274939,
5.759959518731116, 1.4639519066988418,
0.1645048093410307, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [16.576815652621878, 8.589179027714259,
3.0346172787681325, 0.64510714791965,
0.06125471088495496, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [11.393363698540458, 5.042814316534467,
1.522086806356024, 0.2774440153315292,
0.022808692466984082, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [7.30763889251196, 2.802919145030946,
0.7354031762074942, 0.11717259467275332,
0.022808692466984082, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [4.424786859619142, 1.4906976943691257,
0.3450556340430689, 0.11717259467275332,
0.022808692466984082, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [2.553711994532695, 0.7648122635815842,
0.3450556340430689, 0.11717259467275332,
0.022808692466984082, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [1.415779408428751, 0.7648122635815842,
0.3450556340430689, 0.11717259467275332,
0.022808692466984082, 0.0, 0.0, 0.0, 0.0, 0.0, 0]

 EuropeanBSTree put price 1.42
----------
 [23.40612595106589, 32.16024385533445,
22.900023831485793, 12.233084615669954,
3.009125802173744, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [28.306116372929942, 25.84988753421715,
15.911165075094226, 6.3395289608789405,
1.1059134250269127, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [26.240738289177898, 19.248780557847667,
9.7317640235881, 3.0074724018771604,
0.4064451219590916, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [21.437312332929924, 13.036754552465245,
5.419231020641523, 1.3543260918690003,
0.14937664506633574, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [15.86598114469055, 8.111514065305979,
2.82144183626265, 0.5892616138793034,
0.054898880281111784, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
```

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 [10.800815804161953, 4.709780029282825,
1.3979639641589514, 0.25020071449267595,
0.02017642754515892, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [6.8550966128303905, 2.587440524197454,
0.6670721711048807, 0.1043153960103005,
0.02017642754515892, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [4.104654040137005, 1.359636721671825,
0.3090740911589938, 0.1043153960103005,
0.02017642754515892, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [2.341562428844496, 0.6890566210761254,
0.3090740911589938, 0.1043153960103005,
0.02017642754515892, 0.0, 0.0, 0.0, 0.0, 0.0, 0]
----------
 [1.2827410513087927, 0.6890566210761254,
0.3090740911589938, 0.1043153960103005,
0.02017642754515892, 0.0, 0.0, 0.0, 0.0, 0.0, 0]

 AmericanBSTree put price 1.28
```

(2) the price of the following options based on the binomial option pricing model.

EuropeanBSTree call price 35.81

AmericanBSTree call price 36.06

EuropeanBSTree put price 1.42

AmericanBSTree put price 1.28

[Black-Scholes-Merton Model]

Using the same set-up as above, find the prices of European call and put options based on the Black-Scholes- Merton model and compare the results against those of binomial trees

```
1. European call option (S0 = 70, K = 60, T = 10, r
= 0.05, σ = 0.2, N = 10)
```

Black Scholes call price 36.02
3. European put option ($S0 = 100$, $K = 95$, $T = 5$, $r = 0.04$, $\sigma = 0.1$, $N = 10$)
Black Scholes put price 1.29