C++ in Quantitative Finance part #1
Individual home project for:
Zimin Luo (417124)

deadline: 2021-01-31, 23:59:59

PROBLEM

Write a C++ program that will run a Monte Carlo simulation to approximate the theoretical price of the up-and-out put option with a barrier active between the moment of pricing and the option expiry. Write a short report on it.

Your code should be ready to price the option for any values of its characteristics, nevertheless please find and include in your report the theoretical price for the following values:

- price of the underyling at the moment of option pricing: $S_0 = 145$,
- strike price $K = 150$,
- annualized volatility rate $\sigma = 25\%$
- annualized risk-free rate $r = 5\%$
- time to maturity $t = 1$ year

As far as the barrier level b is concerned, it's up to you. Choose a reasonable value, that will slightly influence the price of a corresponding non-barrier option. Try to avoid the barrier that will make the option price to be zero.

RULES

1. The project is to be prepared **individually**. Our hint is: use class materials. In particular, the `cpp09` might be helpful (materials with path-dependent options).
2. Project submitted after the deadline will get lower number of points. Projects submitted after **2021-02-10** will not be accepted.
3. Use comments in your code as much as possible.
4. Solution of the project should consist of two files:
   (a) a `zip` file with `*.cpp` and `*.h` files only
   (b) a `pdf` file with a short report (see below)
5. Your report (a `pdf` file) should include short information about:
   - objective of the project,
   - assumptions (for example: dynamics of the prices of underyling, number of iterations in Monte Carlo, etc.),
   - destription of the option to be priced and its characteristics,
   - description and explanation of code elements,

- information about the results of the simulation, ie. approximation of the theoretical price of your option.

The report is expected to be 2-6 pages long. Poor English, bad formatting or similar problems will disqualify it. Do not forget to include your name on the title page!

6. Calculation of standard deviation of theoretical price approximations will be given extra points.

7. Your files should have following names: `XXXXX.pdf` and `XXXXX.zip`, where `XXXXX` is your surname. Examples: `sakowski.pdf`, `sakowski.zip`.

8. Send your project solution (two files: `*.pdf` and `*.zip`) by replying to the email with this attachment. You should get a confirmation of this.

9. You must agree to abide by the following Honor Code:

   (a) My solutions of home project will be my own work.

   (b) I will not make solutions to homeworks available to anyone else.

   (c) I will not engage in any other activities that will dishonestly improve my results or dishonestly improve/hurt the results of others.

10. Cheating is a very serious offence. Please keep in mind that any evidence of copying of your home project solutions (the report as well as the code) will be treated as cheating and will be reported immediately to the Dean. Please take is seriously.

11. Additionally, you are asked to include in your report a following declaration:

    In accordance with the Honor Code, I certify that my answers here are my own work, and I did not make my solutions available to anyone else.

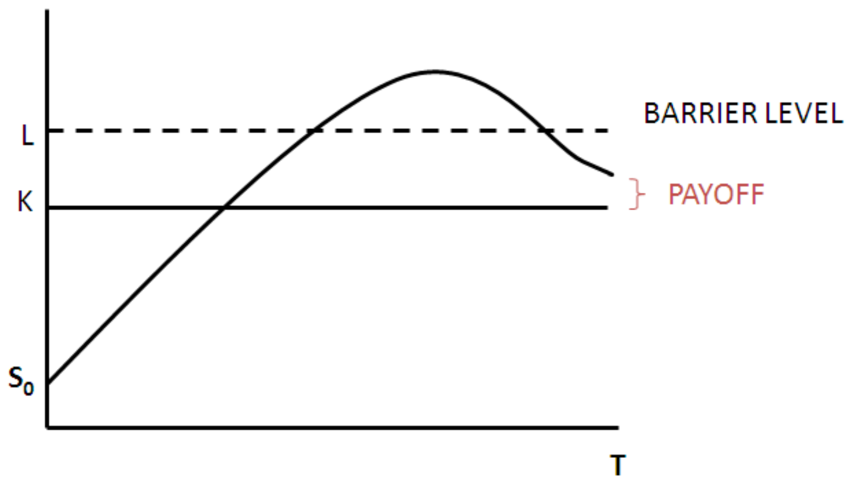
Good luck!

Przemek and *Paweł*

A short refresher: payoffs of barrier options with continuous barriers

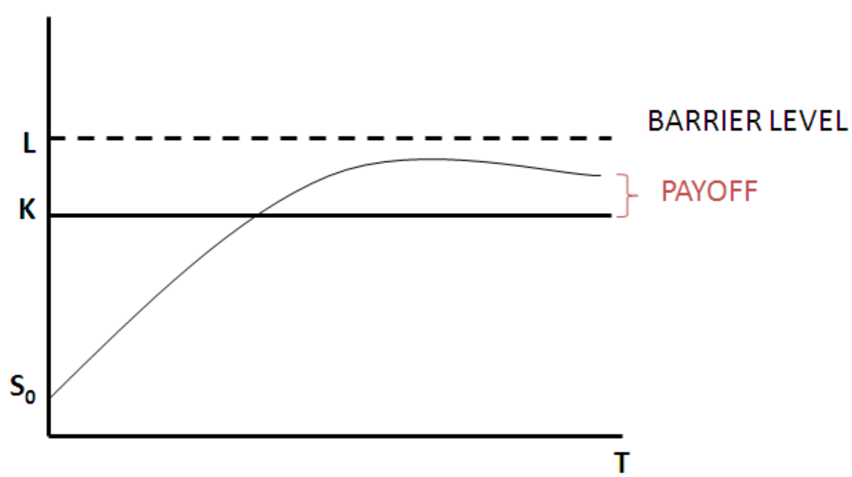
1. CALL UP-and-IN
   - the price has to increase to reach the barrier
   - activated when asset price reaches the barrier

$$\Phi_t = \max(S_T - X, 0) \quad \text{if} \quad \max_{0 \le t \le T}(S_t) \ge L \tag{1}$$



2. CALL UP-and-OUT
   - the price has to increase to reach the barrier
   - canceled when the asset price reaches the barrier

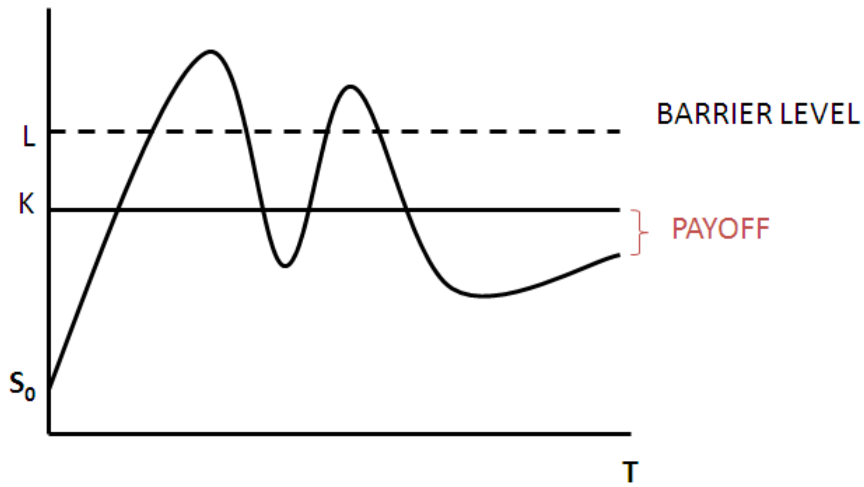
$$\Phi_t = \max(S_T - X, 0) \quad \text{if} \quad \max_{0 \le t \le T}(S_t) \le L \tag{2}$$



3. PUT UP-and-IN

   - the price has to increase to reach the barrier
   - activated when asset price reaches the barrier

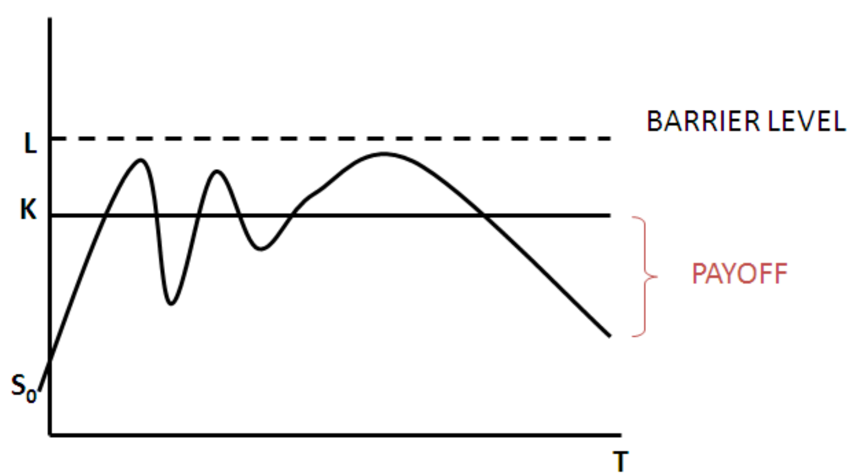
$$\Phi_t = \max(X - S_T, 0) \quad \text{if} \quad \max_{0 \le t \le T}(S_t) \ge L \tag{3}$$



4. PUT UP-and-OUT

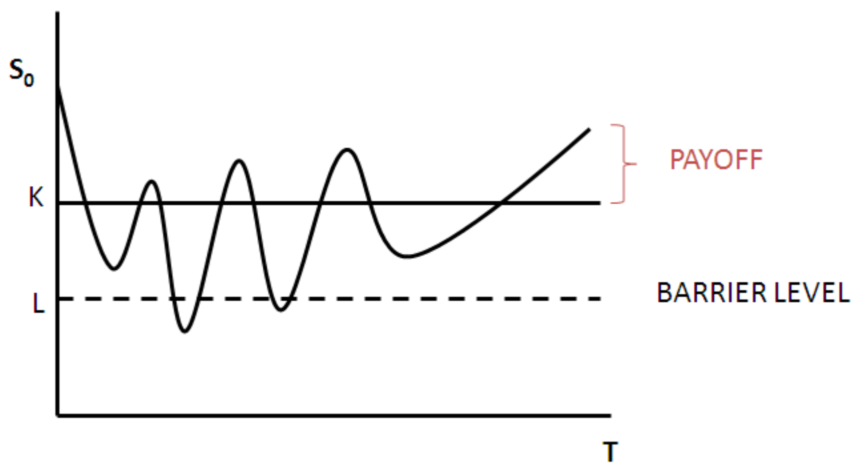
   - the price has to increase to reach the barrier
   - canceled when the asset price reaches the barrier

$$\Phi_t = \max(X - S_T, 0) \quad \text{if} \quad \max_{0 \le t \le T}(S_t) \le L \tag{4}$$



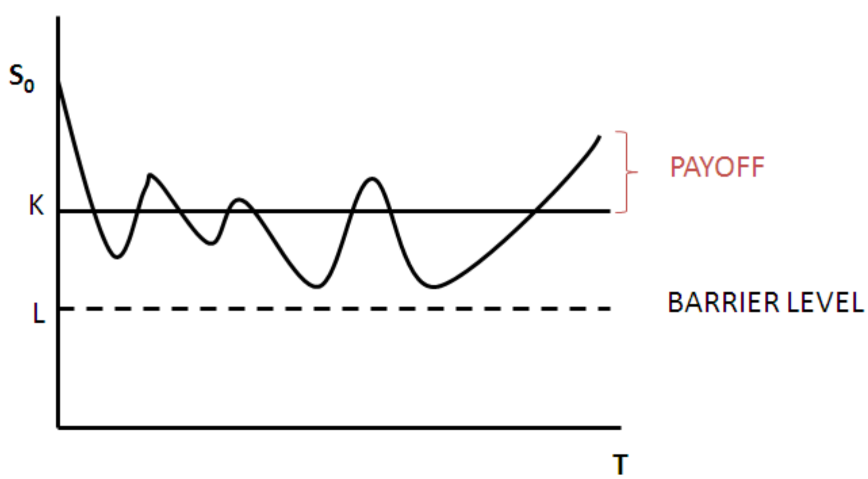
5. CALL DOWN-and-IN
   - the price has to decrease to reach the barrier
   - activated when asset price reaches the barrier

$$\Phi_t = \max(S_T - X, 0) \quad \text{if} \quad \min_{0 \le t \le T}(S_t) \le L \tag{5}$$



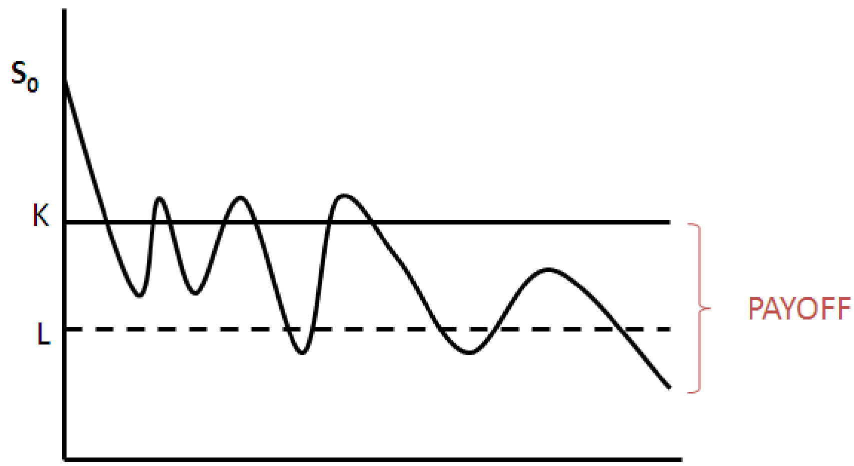
6. CALL DOWN-and-OUT
   - the price has to decrease to reach the barrier
   - canceled when asset price reaches the barrier

$$\Phi_t = \max(S_T - X, 0) \quad \text{if} \quad \min_{0 \le t \le T}(S_t) \ge L \tag{6}$$



7. PUT DOWN-and-IN
   - the price has to decrease to reach the barrier
   - activated when asset price reaches the barrier

$$\Phi_t = \max(X - S_T, 0) \quad \text{if} \quad \min_{0 \le t \le T}(S_t) \le L \tag{7}$$



8. PUT DOWN-and-OUT
   - the price has to decrease to reach the barrier
   - canceled when asset price reaches the barrier

$$\Phi_t = \max(X - S_T, 0) \quad \text{if} \quad \min_{0 \le t \le T}(S_t) \ge L \tag{8}$$