ESILV
ENGINEERING SCHOOL
DE VINCI PARIS

12/20/2024

VBA Project
Best-Of Option pricing

MARTIN ELOI

NGUYEN FLORINE

PHILBERT LUCAS

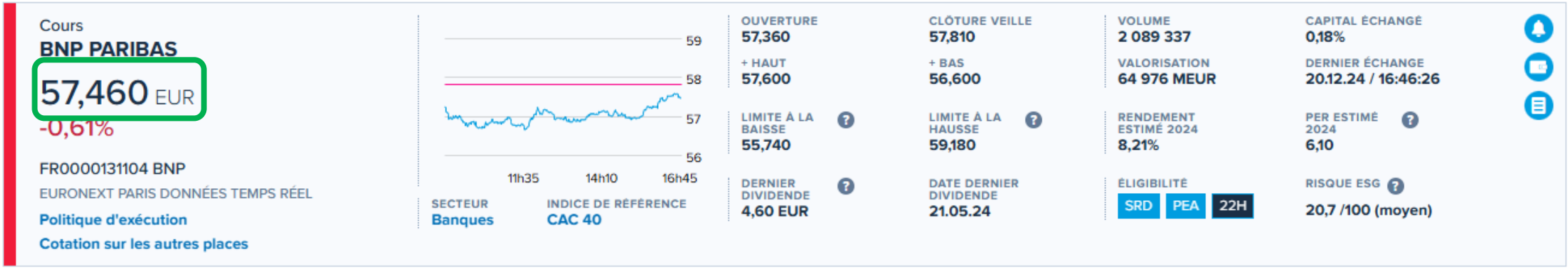
Summary

Project Objective

The aim of this project is to retrieve the real-time spot prices of two assets (Société Générale and BNP) and simulate N price series for these correlated assets over T time steps. Using these simulations, we calculate the price of a "Best-Of" call option and a "Worst-Of" call option which are financial derivatives. Finally, we compare the two option prices to draw meaningful conclusions.

Retrieving spot price

The subroutine « DownloadLastSpotPrice » uses a HTTP request to download the content of Boursorama webpages.
Then, we use a regular expression to identify and extract the last spot prices of Société Générale and BNP Paribas asset.



Downloading Historical Data

« FetchDataAlphaVantage » is used to load historical price data for both assets through the AlphaVantage API. This data is essential for calculating volatility and correlation parameters.

	A	B	C	D	E	F
1	timestamp	open	high	low	close	volume
2	19/12/2024	26,36	26,83	26,32	26,77	2199883
3	18/12/2024	26,73	27,11	26,64	26,94	2072513
4	17/12/2024	26,89	27,11	26,68	26,69	2356380
5	16/12/2024	26,96	27,22	26,6	27,06	1884058
6	13/12/2024	27,26	27,46	27,02	27,18	1962764
7	12/12/2024	27,29	27,42	26,85	27,31	3491999
8	11/12/2024	26,8	27,19	26,79	26,83	2963606
9	10/12/2024	26,66	26,76	26,57	26,68	1922582
10	09/12/2024	26,35	26,85	26,26	26,75	3666250
11	06/12/2024	25,65	26,3	25,62	25,94	3737986
12	05/12/2024	24,41	25,72	24,41	25,62	4792048
13	04/12/2024	24,16	24,68	24,15	24,56	2614703
14	03/12/2024	24,58	24,87	24,03	24,28	2686962
15	02/12/2024	24,46	24,94	24,23	24,44	4738280
16	29/11/2024	24,8	25,1	24,75	25,1	2629595
17	28/11/2024	24,6	25,08	24,53	25	2648341
18	27/11/2024	25,07	25,07	24,31	24,55	4514296
19	26/11/2024	25,46	25,88	25,34	25,44	2591174
20	25/11/2024	26,16	26,22	25,49	25,8	3169614

We get this kind of table for both assets. The most important column is the « Close » one because it is useful for calculating correlation and volatility.

Excel: Choice of the parameters

- For T the number of timesteps, we chose 250 days because it's approximately the number of days in one year of the stock market (252).
- For the number of paths (different simulations of BNP and SG prices evolution), we chose 100 because it’s fast enough to simulate and the results are still relevant.
- We chose arbitrary the strike value of the call but we can easily change it and all the results will be updated automatically.
- Then, by searching on the web, we found that a risk-free rate of 3% would be relevant for our simulation.

Results and analysis

- We did many simulations. For example, we obtained:
  - Best-Of Call price: 31,6.
  - Worst-Of Call price: 2,05.

- For these parameters :
  - Initial price of Société Générale : **26,6**.
  - Initial price of BNP Paribas: **57,4**.
  - Strike : **30**.
  - Maturity : **1 year**.
  - Volatility (for both assets) : **0,2**.
  - Correlation between assets : **-0,2** (lightly negatively correlate).

VBA: Calculating Key Parameters

To simulate price series, we have to estimate volatility and correlation of the assets.

To calculate volatility, we use the daily logarithmic returns of historical prices and the following formula for annualization.

$$\sigma_{\text{annual}} = \sigma_{\text{daily}} \times \sqrt{250}$$

We have chosen 250 time steps, which correspond to trading days in 1 year.

Simulating Price Series

The sub “Simulation” is based on Monte Carlo simulation. To get the range of multiple paths, we calculate N simulations of a geometric Brownian motion (GBM) model. This mathematical framework is used to simulate correlated price paths for Société Générale and BNP Paribas stocks. These simulations are necessary for calculating the payoffs of "Best-Of" and "Worst-Of" options. Here is the formula of the GBM:

$$S_t = S_{t-1} \cdot \exp\left(\left(\mu - \frac{\sigma^2}{2}\right)\Delta t + \sigma \cdot \sqrt{\Delta t} \cdot Z\right)$$

-S(t): The simulated price of the asset at time t.

_S(t−1): The price of the asset at the previous time step.

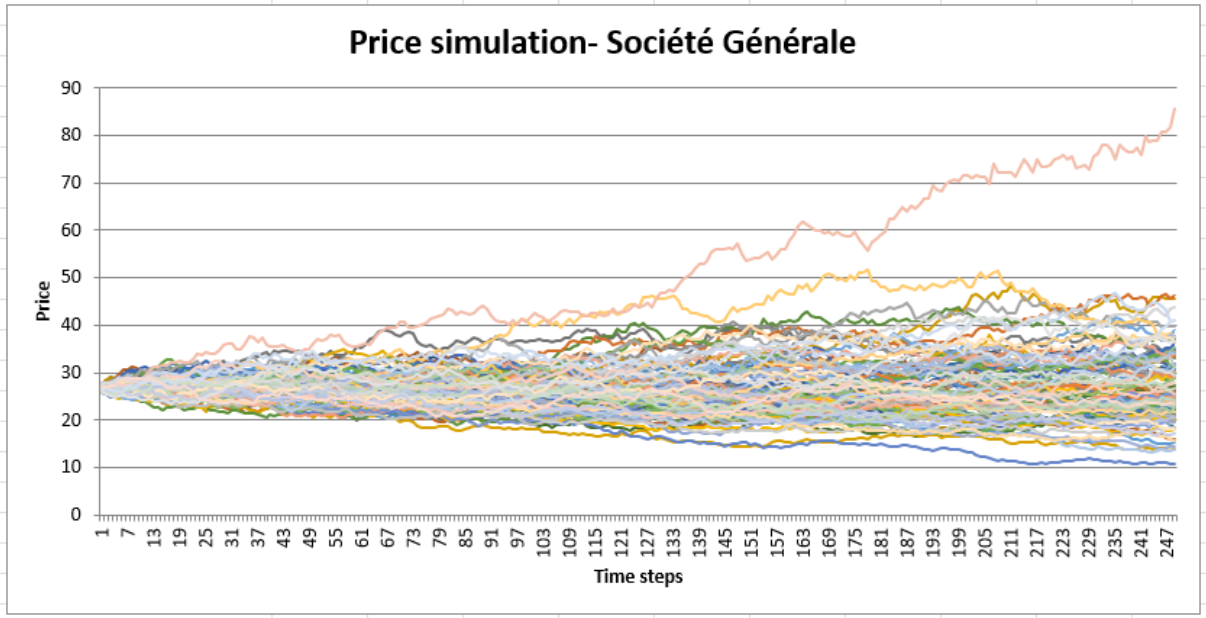
_μ: the average expected return of the asset.

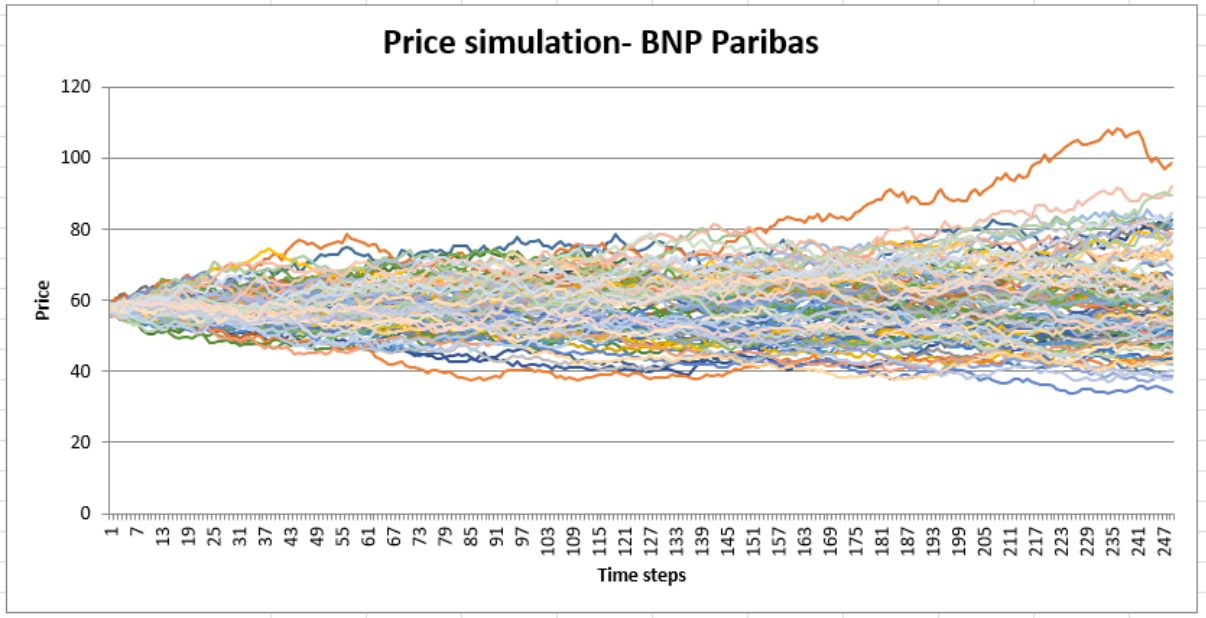
_σ: The volatility term, indicating the degree of price fluctuations

_Δt: The time increment, here we have 1/250

_Z is a standard normal random variable.

Graphs of the simulations





Best-of and Worst-of pricing

We computed the payoff for the best-of and the worst-of for each simulation. Then we compute the average best-of payoff and the average worst-of payoff:

➢ **Best-Of option:**

$$Payoff=max(\ max(S(SG)\ ;\ S(BNP)\ )-K\ ;\ 0)$$

➢ **Worst- Of option:**

$$Payoff=max(\ K-min(S(SG)\ ;\ S(BNP))\ ;\ 0)$$

➢ **Parameters :**

- S(SG) = last spot price for SG assets.
- S(BNP) = last spot price for BNP assets.
- K = strike value

Best-of and Worst-of pricing

Then we price our payoff average for the best-of and the worst-of with the formula :

$$Price = exp(-rT) \times payoff\_average$$

- ***Parameters :***

  - T = maturity (in years)
  - r = risk-free rate

Comparative analysis

- **Best-Of Call Price (31.6):**
  - The high price reflects that the option captures the **best performance** between SG and BNP.
  - The **negative correlation** between assets (-0.2) amplifies the performance gap, increasing the likelihood that at least one asset significantly surpasses the strike of 30.
  - The strong probability of exceeding the strike justifies the higher price.
- **Worst-Of Call Price (2.05):**
  - The much lower price reflects that the option captures the **worst performance** between SG and BNP.
  - With **negative correlation**, the performances of the two assets are divergent: the "worst-performing" asset is more likely to remain below the strike of 30.
  - This significantly reduces the probability of the option being in-the-money at maturity, justifying a lower price.

Comparative analysis

➢ **Price Difference:**

The significant gap between the Best-Of (31.6) and Worst-Of (2.05) prices reflects:

- Greater opportunity for the Best-Of to benefit from the divergence between assets.
- A much lower probability for the Worst-Of to generate positive value, as the worst-performing asset must still exceed the strike.

➢ **Impact of Parameters:**

- **Negative Correlation (-0.2):** Amplifies the divergence in performance between the two assets, widening the price gap between the options.
- **Strike (30):** Relatively close to BNP's initial price (57.4), but higher than SG's initial price (26.6). This slightly favors BNP in the calculations but does not fundamentally alter the conclusions.
- **Volatility (0.2):** Moderate, it does not create extreme price deviations but still encourages some dispersion.