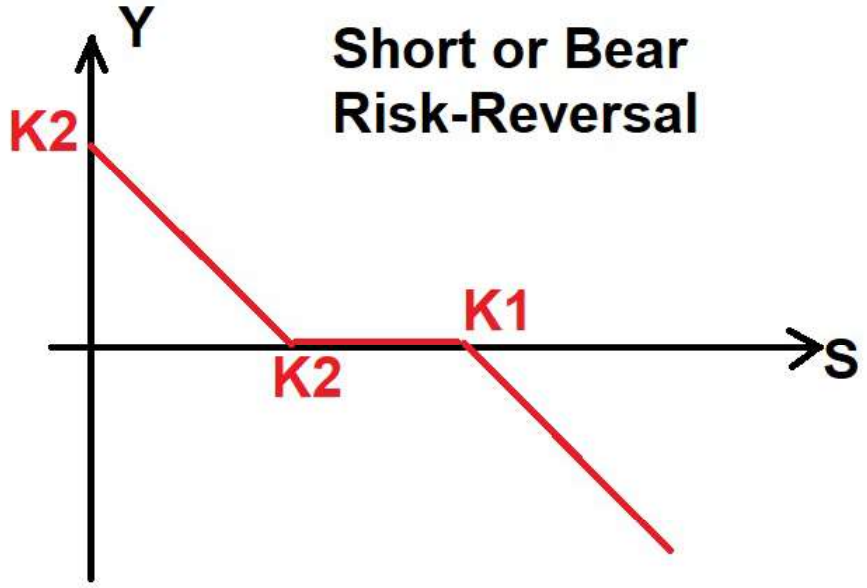
Coursework 2023-2024 I

Consider a bear (or short) risk reversal option payoff on a stock price S, with maturity T, defined as

$$Y = -(S_T - K_1)^+ + (K_2 - S_T)^+$$

with $K_2 < S_0 < K_1$. The payoff is illustrated in the picture below.



Coursework 2023-2024 II

Assume the stock follows a Black Scholes price model under the measure P given by

$$dS_t = \mu S_t dt + \sigma S_t dW_t^P, \quad S_0 = s_0.$$

We have the following values:

$$s_0 = 100; K_2 = 95; K_1 = 105; \mu = 0.1; \sigma = 0.4; r = 0.05; T = 10y.$$

1. Explain what kind of investor would be interested in holding this payoff and what they would expect from the market when purchasing it.
2. Calculate the price of the bear risk reversal in the Black Scholes model at time 0.

Coursework 2023-2024 III

3. We wish to calculate the VaR and ES of the bear risk reversal position over a risk horizon $H = 1y$ at 95% confidence level. Write a Python or Matlab/Octave code that does this and present the values of the VaR and expected shortfall you found. Run at least 10.000 scenarios.
4. Produce a histogram of the density of the loss distribution at 1 year and show the VaR and ES points in the loss graph.
5. Increase the volatility to the following values:

$$a)\ \sigma = 0.6; \quad b)\sigma = 0.8; \quad c)\sigma = 1.$$

For the three cases, show the VaR and ES figures.

Coursework 2023-2024 IV

6. More generally, can you deduce a pattern about how the risk of loss with this contract evolves with the volatility over one year? Are VaR and/or ES increasing, decreasing or neither increasing nor decreasing in σ? You may run more cases if this helps you, or try to reason analytically. If you find a pattern numerically, increasing or decreasing, but you cannot prove it analytically, can you give some intuition on why the pattern is the way it is?

- Coursework submission is expected by March 14, 2024.
- Coursework will contribute 10% of the final mark.