MFE 409; Risk Management HW5

Aliaksei Kanstantsinau

Part 1: VaR for option on two underlying.

Problem 1.

We are interested in managing the risk of an option on two stocks with prices S 1,t and S 2,t . Assume a short rate r and ... where all the parameters are in daily units. Call M (S 1,t , S2,t) the price of the option. Derive a formula for the 99% 1-day VaR for the option using the delta approach:

$$VaR_{.99} = -\mu - \sqrt{\sigma_{1}^{2}G(S_1)^2 + \sigma_{2}^{2}G(S_2) + 2\rho \sigma_1 \sigma_2 G(S_1)(S_2)}$$

In [16]:
```
import numpy as np
from scipy.stats import multivariate_normal
from scipy.stats import norm, mvn
```

Problem 2.

Compute the price of the option at date 0.

- The answer is wrong but I don't have time to fix it

In [33]:
```
def option_price(S10, S20, K, r, T, rho, sigma1, sigma2):
    tao = T
    # define gammas
    gamma_1 = np.log(S10/K) + (r - .5*sigma1) * tao
    gamma_2 = np.log(S20/K) + (r - .5*sigma2) * tao
    sigma = sigma1**2 + sigma2**2 - 2*rho*sigma1*sigma2
    # define alpha
    alpha1 = gamma_1 + sigma1*np.sqrt(tao)
    alpha2 = gamma_2 + sigma2*np.sqrt(tao)
    cov_matrix = np.array([[sigma1**2, rho * sigma1 * sigma2],
                           [rho * sigma1 * sigma2, sigma2**2]])
    # define normal bivariate
    def N2(mean1, mean2, cov):
        return multivariate_normal(mean=[mean1, mean2], cov=cov).cdf([0, 0])

    price = S10 * N2(alpha1, alpha2, cov_matrix) + S20 * N2(alpha2, alpha1,
    return price

test = option_price(99, 101, 100, .002, .5, .35, .015, .015)
test
```

Out[33]:
```
-10.17359330779254
```

Problem 3.

Compute the 99% 1-day VaR for the option using the formula you have derived in question 1

In [14]:
```
def var_99(sigma1, sigma2, rho, mu, S1, S2):
    return -mu + 2.32*(np.sqrt(sigma1**2*S1**2 + sigma2**2*S2**2 - 2*rho*sig
test2 = var_99(.015, .015, .35, .0025, 99, 101)
print(f'1-day 99% VaR:', test2)
```

```
1-day 99% VaR: 3.9657224998102105
```

Problem 4.

Compute the 99% 1-day VaR for the option using simulations. Compare to the results of the previous question and explain the intuition behind this result.

- Given that my option price function does not return correct result calculate_vars option won't return the correct one either. However, logic-wise this should be the implementation.

In [31]:
```
def simulate_asset_prices(S, K, r, sigma, T, rho, N):
    dt = 1/125
    Z1 = norm.rvs(size=N)
    Z2 = rho * Z1 + np.sqrt(1 - rho**2) * norm.rvs(size=N)
    S1_end = S[0] * np.exp((r - 0.5 * sigma[0]**2) * dt + sigma[0] * np.sqrt
    S2_end = S[1] * np.exp((r - 0.5 * sigma[1]**2) * dt + sigma[1] * np.sqrt
    return S1_end, S2_end

def calculate_var(S, K, r, T, sigma, rho, N, percentile=99):
    initial_price = option_price(S[0], S[1], K, r, T, rho, sigma[0], sigma[1
    S1_end, S2_end = simulate_asset_prices(S, K, r, sigma, T, rho, N)
    simulated_prices = [option_price(s1, s2, K, r, T, rho, sigma[0], sigma[1
    losses = initial_price - np.array(simulated_prices)
    return np.percentile(losses, percentile)


var_result = calculate_var([99, 101], 100, .002, .5, [.015, .015], .35, 1000
var_result
```

Out[31]:
```
0.3672145296053435
```

Problem 6.

Now assume you are a trader in the real world and you do not know for sure that the model for the underlying is correct. What other types of risks would you worry about? If you had to worry about just one more risk, what would it be? Explain (quantitatively) how you get to this conclusion.

- Operating on pure intuition, asuuming we don't know whether the model is correct, we can assume that our VaR calculation is incorrect and so is any calculation related to hedging process.

Part 2. Case Study: Implementing Quantitative Risk Management and VaR in a Chinese Investment Bank

Problem 1.

Explain the objectives and priorities of each player: Jasper Wang, Jianguo Lu, and Charles Pan. What is motivating the different players? What tensions existed among their different objectives?

- Jasper Wang runs risk management for Chinese investment bank. He's been working in the US for 10 years doing risk for major investment banks. He is familiar with risk and quantitative tools used to control it. He faced an issue with traders and his VaR-based risk management approach he was hired to implement.
- Charles Pan CEO of Guang Guo, hired Jasper as a professional bank needs since there weren't many risk professionals in China at that time. He was aware of return on equity and risk-adjusted returns, however, he couldn't prove Jianguo who was a powerful figure wrong.
- Jianguo Lu was in charge of trading strategy and asset allocation. Interested in pursuing various investment opportunities, without accounting for risk-measures arguing that Chinese markets are different from Western markets and are dominated by speculative retail investors prone to unpredictable movements that can't be captured by statistical modeling. Supporting his point by the fact that despite advanced risk measures Europe and US have recently suffered from crisis.

Problem 2.

Why does Jasper choose to make the VaR model the first step towards rationalizing the trading function? What is the appeal of the VaR model generally?

- The appealing of the Var model is that we can estimate the 'maximum loss' in statistical sense. Implementing VaR would provide the bank with a good idea of what could be lost and lean towards risk-adjusted returns.

Problem 3.

Why do Jianguo and the traders resist the VaR model? Do you think their pattern of resistance to risk management is unique to China, or might it be found elsewhere too?

- I've briefly answered to this question above, I wouldn't assume that their pattern of resistance is unique to China. Finance professionals there are in belief that their market operates differently therefore they shouldn't pay too much attention to risk-measures developed in other markets. It is like trying to fit a Mercedes part into BMW, part name is the same but part looks completely different. I think that pattern

would be similar in every place where market is believed to be driven by something other than the Western markets.

Problem 4.

Using the spreadsheet provided, run backtests of the VaR predictions against actual daily gains or losses for both the S&P 500 index and the Shanghai Composite index.

(a) Starting with a lookback period of three months, observe the number of exceptions in all years for both the Shanghai and S&P indexes. How do they compare?

- Average number or exceptions for S&P based on 3 month is 6.1% while Shanghai 3 month is 5.6%. Assuming 95% CI this does not seem disasterous

(b) Try different lookback periods (say, 3, 6 and 9 months) to see if thelength of the period changes your conclusions.

- When we try various longer periods, the number of exceptions goes down.

(c) Given that Jasper's VaR model assumes a 95% confidence level, how well does the backtest validate the model?

- We would expect 5% exceptions, which average number of exceptions is slightly higher meaning a better stategy/model can be implemented however, again, if we calculate binomial probability here it wont be super far off.

Problem 5.

How might Jasper use the backtest results to bolster his case for introducing the VaR model?

- It is clear that with such a small difference, adjusting VaR measure won't have tremendous impact on returns and trading strategy. Which is return would make Jiaguo more open to try and test it.

Problem 6.

How successful do you think Jasper will be in his attempt to implement Western risk management practices? What advice would you give to someone in a role similar to his?

- I think he can be successful if he proves that this adjustment would be beneficial to the bank based on historical data.

Problem 7.

What is the current regulation environment of risk followed by Chinese banks and how has it evolved since the crisis?

- Here is what I found in Reuters article dated 2023:

1. New draft rules that will bring Chinese markets closer to global standards.
2. New rules will include more sprecific factors to measure bank's risk exposure to mortgage lending.

Despite those minor changes implementation of new rules would leave capital adequacy ratios in the banking sector generally unchanged.