Final Project: A Multi-asset Yield Enhancement Tool

Zixuan Zhou, Yao Zhang

December 18, 2025

Our goal: a yield enhancement product which pays high coupon and has several stocks as underlying risk events.

1 Product Description

We include a product term sheet on the next page.

2 Deliverables Ahead:

1. Description of the product. by Yao
2. Monte Carlo to pin down the issue price. An analytic price under extreme cases. by Zixuan&Yao
3. Use the history of the stocks to backtest our derivation. by Yao
4. Test our model at extreme cases. Check the behavior of our model at some configured cases. by Yao
5. Calibrate the paramters depending on the market information. by Zixuan
6. Calculate the Greeks and do the risk analysis. by Zixuan
7. Write up the report in format. by Zixuan&Yao

3 Remarks*

The paramters specified above will be adjusted during the test. They are just for demonstrate at this pooint.

4 Monte Carlo

This is a placeholder for now. Work undergoing.

5 Historical Back test

This is a placeholder for now. Work undergoing.

6 Calibration of Inputs

We obtained the data from Yahoo Finance to align our model with market information. As shown in the table below.

Underlying	**TSLA**	**META**	**MSFT**
Spot S_0	439.58	666.80	491.02
Dividend yield q	0%	0.32%	0.77%
ATM implied vol σ	50.17%	32.2%	23.3%
Source		Yahoo Finance	

Table 2: Market Parameters for Underlying

ATM implied volatilities are taken from European options with maturity closest to the note maturity. For simplicity, volatilities are assumed flat across strikes.

Calibrate the Correlation

Here we calibrated correlations between the three underlying assets. The correlations are estimated from time-adjusted historical log-returns. Obeservation window is 10 years.

$$\rho_{ij} = \frac{Cov(R_i R_j)}{\sqrt{Var(R_i)Var(R_j)}}$$

$$r_{i,k} = \frac{\log \frac{S_i(t_k)}{S_i(t_{k-1})}}{\sqrt{t_k - t_{k-1}}}, \quad k = 1, ...N, \quad R_i = (r_{i,1}, r_{i,2}, ...r_{i,N})$$

Our estimation for historical correlation is reported in table below:

Stock	**META**	**MSFT**	**TSLA**
META	1.0000	0.5848	0.3254
MSFT	0.5848	1.0000	0.4097
TSLA	0.3254	0.4097	1.0000

Table 3: Correlation matrix for stock returns

Estimation uncertainty is quantified using Fisher' s transformation, as the formula below.

$$z = \frac{1}{2}\ln\left(\frac{1+\hat{\rho}}{1-\hat{\rho}}\right)$$

$$\bar{z} = \frac{1}{2}\left[\ln\left(\frac{1+\rho_{true}}{1-\rho_{true}}\right) + \frac{\rho_{true}}{N-1}\right], \sigma(z) \approx \frac{1}{\sqrt{N-3}}$$

A 95% confidence interval for z has the following formula.

$$-\frac{1.96}{\sqrt{N-3}} + \bar{z} \leq z \leq \bar{z} + \frac{1.96}{\sqrt{N-3}}$$

Then from z to ρ we have that:

$$\hat{\rho} = \frac{e^{2z}-1}{e^{2z}+1}$$

For the estimation, we report 95% confidence intervals as below.

- 95.0% CI for correlation between META and MSFT: (0.5585, 0.6100)
- 95.0% CI for correlation between META and TSLA: (0.2900, 0.3599)
- 95.0% CI for correlation between TSLA and MSFT: (0.3766, 0.4418)

Calibrate the Strike

Fixing a promised $B_1 = 1.2$ and $B_2 = 1.1$, we calibrated the strike K. And we have a calibrated strike $K^* = 0.625$. Thus if we want to issue at 100% par value, we need to lower the strike to increase the product value.

Calibrate the Barriers

With coupon fixed at 10% and with $K = 0.8$, $B_2 = 1.2$, the structure is too cheap; varying B_1 alone cannot bring the issue price to par if we require a realistic KO barrier $B_1 > 1$.

The same issue existed when we tried to calibrate B_2 given $B_1 = 1.1$ and $K = 0.8$—-the structure is also too cheap; varying B_2 alone cannot bring the issue price to par if we require a realistic KO barrier $B_2 > 1$.

Thus we reached to the conclusion that if we want to issue it with terms specified exactly in the term sheet, we have to discount it to an issue price lower than the 100% par, as our Monte Carlo results before also implied. That is, our product is overly investor-friendly under the original intended terms.

In addition to the above, as we experimented various strike K, we found that lower strike K would lead to reasonable calibration of B_1 and B_2. As we successfully calibrated the present value of our product to 100% par by setting: $K = 65\%, \quad B_1 = 1.07, \quad B_2 = 1.046$.

A lower K increases investor downside risk at maturity (higher chance of capital loss if the underlying ends below K), which reduces our product's value to the investor. This offsets the high 10% coupon and attractive barriers, allowing the overall structure to price at par without discounting the issue price.

Calibrate the Coupon Rate

Keeping the structural parameters fixed at $K = 0.8$, $B_1 = 1.2$, and $B_2 = 1.1$, we calibrate the quarterly coupon rate c such that the note issues at par. Since coupon cashflows enter the payoff linearly, the time-0 price is affine in c. We therefore compute the Monte Carlo present value at $c = 0$ and at a reference coupon $c_1 = 10\%$, and solve for c^* from

$$V_0(c) = V_0(0) + \frac{c}{c_1}\big(V_0(c_1) - V_0(0)\big) = N.$$

Using the calibrated market inputs, we obtain $V_0(0) = 784{,}596.74$ and $V_0(10\%) = 990{,}507.83$ (USD), which implies a fair coupon of

$$c^* = 10\% \cdot \frac{N - V_0(0)}{V_0(10\%) - V_0(0)} \approx 15.69\% \text{ p.a.}$$

The corresponding Monte Carlo check satisfies $V_0(c^*) \approx N$. That is, to increase our product issue price to 100%par, we need to raise our coupon rate up to round 15.69% p.a..

7 Risk Analysis

This is a placeholder for now. Work undergoing.

Parameter	**Specification**
Issue Date	December 8, 2025
Note Tenor	24 months
Maturity Date	December 8, 2027
Denomination (N)	USD 1M
Issue Price	TBD(the PV of cashflow)
Coupon	10% p.a. payable quarterly
Coupon Dates	End of each quarterly observation period: March 8, 2026; June 8, 2026; September 8, 2026; December 8, 2026; March 8, 2027; June 8, 2027; September 8, 2027; December 8, 2027
Underlying Stocks	TSLA, META, MSFT (denoted as S^1, S^2, S^3)
Underlying Performance	Denoted as P_t. At time t in year i: $P_t = \min\left\{\frac{S^1(t)}{S^1_i(0)}, \frac{S^2(t)}{S^2_i(0)}, \frac{S^3(t)}{S^3_i(0)}\right\}$, where $i \in \{1, 2\}$, $t \in [0, 2]$, and $S^j(t)$ is the close price of jth stock at day t
Observation Period	Aligned with the product tenor
Observation Dates	Daily throughout the period
Initial Underlying Prices	TSLA: \$439.58, META: \$666.80, MSFT: \$491.02
Initial Implied Volatility	TSLA: 50.17%, META: 32.2%, MSFT: 23.3% (all At-The-Money)
Interest Rate	4% annual risk-free rate at issue date
Observation Phases	Phase 1: Dec 8, 2025 – Dec 8, 2026 (1 year). Phase 2: Dec 8, 2026 – Dec 8, 2027 (1 year). Periodic initial price for each stock: $S^j_i(0)$, where i is the phase number and j is the stock number
Strike (K)	80% throughout the tenor
Up-and-Out Barrier	Phase 1: $B_1 = 120\%$. Phase 2: $B_2 = 110\%$
Early Termination	If P_t breaches knock-out barrier on any observation date, the note will be early redeemed at par
Maturity Payoff	If not early terminated: (1) If $P_T > K$, investor receives full par N; (2) Otherwise, investor receives $N/(KB_1S^*_0)$ shares of S^*_T, where S^*_T is the worst performing stock at maturity T

Table 1: Structured Note Specification