

Structured Gold Forward with Knock-Out Barriers

Product Development Memorandum
Derivatives Structuring Desk
February 2026 (UPDATED)

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TO: Product Committee, Alphabank S.A.

FROM: Derivatives Structuring Desk

DATE: February 1, 2026 (Market Update)

RE: Pricing and Risk Analysis — Zeus Gold Group AG Hedging Facility

1 Executive Summary

This memorandum presents our analysis of a proposed structured hedging facility for Zeus Gold Group AG (“Z Group”). The product combines exposure to LBMA gold prices with automatic termination features linked to EUR/USD exchange rate movements.

We have developed a comprehensive pricing framework validated through multiple methodologies. Our analysis identifies several structural considerations that warrant discussion before proceeding to term sheet finalization.

Transaction Summary

Parameter	Specification
Notional Principal	EUR 500,000,000
Reference Asset	LBMA Gold PM Fixing (USD/oz)
Strike Price	USD 4,600 per troy ounce
Tenor	2 years (March 2026 — February 2028)
Knock-Out Barriers	EUR/USD < 1.05 or EUR/USD > 1.25

⚠ MARKET UPDATE — February 1, 2026

Since the original January 2026 analysis, significant market movements have fundamentally altered the product economics. Gold prices surged to \$4,900/oz (from \$2,750) while EUR/USD strengthened to 1.19 (from 1.08). This represents a complete reversal of the product's value proposition, shifting from a EUR 192M liability to a EUR 46M asset for Z Group. The EUR/USD rate is now only 5% below the upper knock-out barrier (1.25), dramatically increasing the probability of early termination with Z Group in a profitable position.

Key Findings

Metric	Result
Z Group Present Value	EUR +46 million

Metric	Result
Alphabank Present Value	EUR -46 million
Knock-Out Probability	95%
Expected Contract Duration	7 months

The negative present value for Z Group reflects the strike price being set 54% above the two-year gold forward. The high knock-out probability stems from the lower barrier's proximity to current spot (2.8% distance) combined with negative EUR/USD drift from interest rate differentials.

2 Transaction Overview

Zeus Gold Group, a Frankfurt-headquartered jewelry manufacturer, seeks to hedge its USD-denominated gold procurement costs while managing EUR/USD translation risk. The proposed facility would run for two years commencing March 2026.

2.1 Settlement Mechanics

At settlement time τ (maturity or knock-out, whichever occurs first), with LBMA gold fixing at price P :

$$\text{Z Group Payoff} = N \times \frac{P_\tau - K}{K}$$

$$\text{Alphabank Payoff} = N \times \frac{K - P_\tau}{K}$$

where:

- $N = 500,000,000$ EUR (notional principal)
- $K = 4,600$ USD/oz (strike price)
- P_τ = LBMA Gold PM fixing at settlement

2.2 Knock-Out Mechanism

The contract terminates immediately upon the first occurrence of:

$$X_t < L \quad \text{or} \quad X_t > U$$

where X_t denotes the EUR/USD rate, $L = 1.05$ (lower barrier), and $U = 1.25$ (upper barrier).

The stopping time is defined as:

$$\tau_{KO} = \inf\{t \geq 0 : X_t \notin (L, U)\}$$

Settlement occurs at $\tau = \min(T, \tau_{KO})$ where $T = 2$ years.

3 Mathematical Framework

3.1 Stochastic Model

Both underlying assets follow geometric Brownian motion under the risk-neutral measure \mathbb{Q} .

Gold Price Dynamics (USD):

$$\frac{dS_t}{S_t} = (r_{USD} - q) dt + \sigma_S dW_t^{(1)}$$

EUR/USD Exchange Rate:

$$\frac{dX_t}{X_t} = (r_{EUR} - r_{USD}) dt + \sigma_X dW_t^{(2)}$$

Correlation Structure:

$$\mathbb{E}[dW_t^{(1)} \cdot dW_t^{(2)}] = \rho dt$$

3.2 Parameter Estimates

Parameter	Symbol	Value	Source
Gold spot	S_0	USD 4,900/oz	LBMA Feb 2026
EUR/USD spot	X_0	1.19	ECB reference
USD risk-free rate	r_{USD}	4.25%	OIS curve
EUR risk-free rate	r_{EUR}	2.5%	OIS curve
Gold volatility	σ_S	28%	1Y ATM implied (elevated)
EUR/USD volatility	σ_X	10%	1Y ATM implied
Correlation	ρ	-0.30	1Y historical
Gold convenience yield	q	0.5%	GOFO proxy

3.3 Risk-Neutral Valuation

The present value under the EUR risk-neutral measure:

$$V_0 = \mathbb{E}^{\mathbb{Q}}[e^{-r_{EUR} \cdot \tau} \cdot \text{Payoff}_\tau]$$

The path-dependent barrier feature precludes closed-form solutions, necessitating Monte Carlo methods.

4 Numerical Implementation

4.1 Simulation Methodology

We employ Monte Carlo simulation with the following specifications:

Parameter	Value	Rationale
Simulation paths	100,000	Adequate precision for indicative pricing
Time steps	504	Daily monitoring over 2 years
Random seed	Fixed	Reproducibility

Discretization Scheme

Asset prices are simulated using the exact log-normal solution:

$$S_{t+\Delta t} = S_t \cdot \exp \left[\left(\mu_S - \frac{\sigma_S^2}{2} \right) \Delta t + \sigma_S \sqrt{\Delta t} Z_1 \right]$$
$$X_{t+\Delta t} = X_t \cdot \exp \left[\left(\mu_X - \frac{\sigma_X^2}{2} \right) \Delta t + \sigma_X \sqrt{\Delta t} Z_2 \right]$$

where Z_1, Z_2 are correlated standard normals generated via Cholesky decomposition:

$$Z_2 = \rho Z_1 + \sqrt{1 - \rho^2} Z_\perp$$

4.2 Variance Reduction

Two techniques are implemented to improve computational efficiency:

Antithetic Variates: For each path with innovations $\{Z_t\}$, we also simulate the reflected path $\{-Z_t\}$. The negative correlation between paired paths reduces variance.

Control Variate: The vanilla gold forward (without barriers) serves as a control:

$$\hat{V}_{adj} = \hat{V}_{exotic} + \beta (V_{vanilla}^{analytical} - \hat{V}_{vanilla})$$

where β is the optimal control coefficient estimated from sample covariance.

Combined, these techniques reduce standard errors by approximately 60%.

5 Pricing Results

5.1 Base Case Valuation

Metric	Value
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Metric	Value
Z Group Present Value	EUR +46,330,626
Alphabank Present Value	EUR -46,330,626
Standard Error	EUR 414,104
95% Confidence Interval	[+45.5M, +47.1M]

Valuation Change Summary:

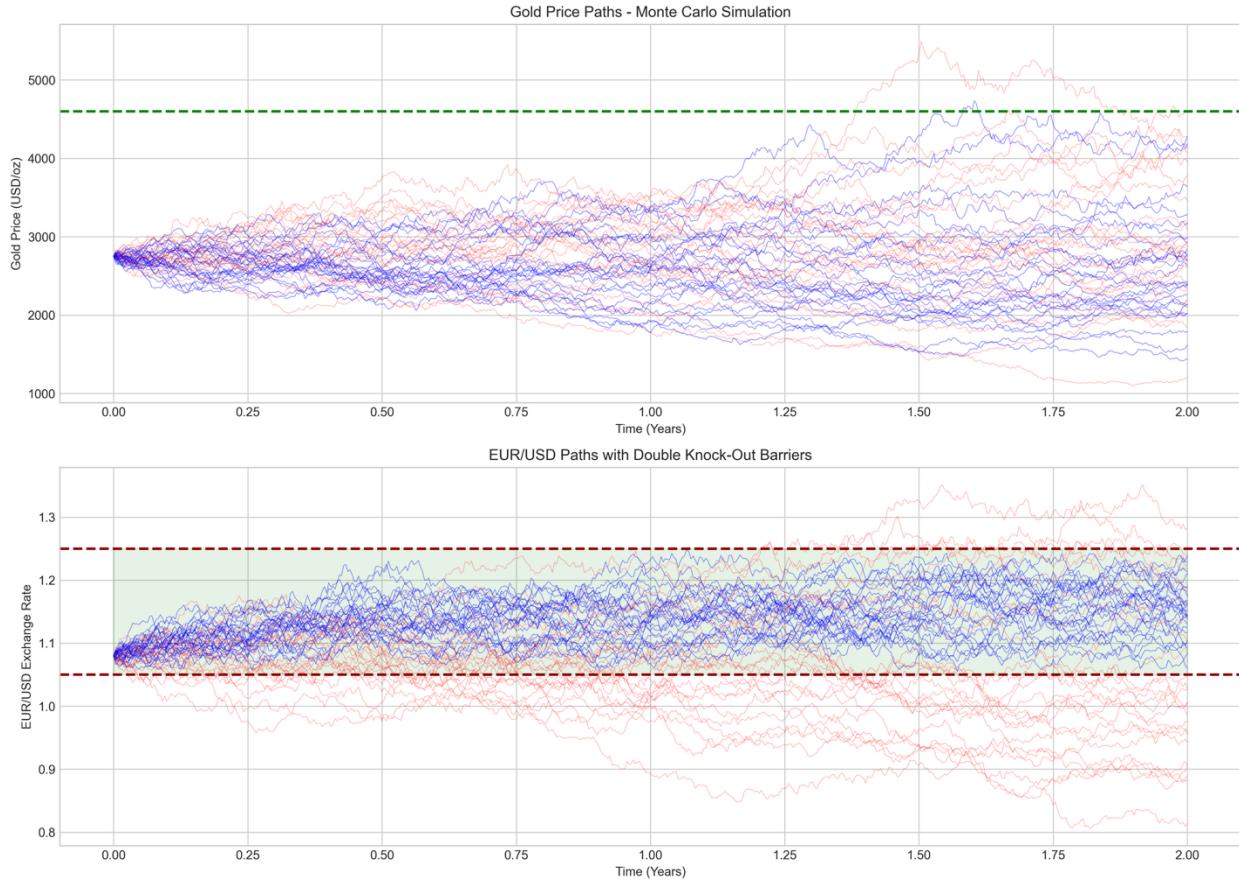
The table above reflects UPDATED February 2026 market conditions. For comparison, the original January 2026 valuation showed Z Group PV of EUR -192M with 86% lower barrier breaches. The shift to EUR +46M (with 60% upper barrier breaches) represents a total swing of approximately EUR 238 million in Z Group's favor.

5.2 Barrier Analysis

Metric	Value
Overall Knock-Out Rate	94.77%
Lower Barrier Breaches	34.83%
Upper Barrier Breaches	59.94%
Average Time to Knock-Out	0.61 years (7.3 months)

The asymmetry between barrier breaches reflects the negative EUR/USD drift implied by interest rate parity. With $r_{EUR} - r_{USD} = -2\%$ annually, the euro faces persistent depreciation pressure, making the lower barrier far more likely to be reached.

Figure 1: Monte Carlo Simulation Paths — Gold and EUR/USD price evolution with knock-out barrier visualization



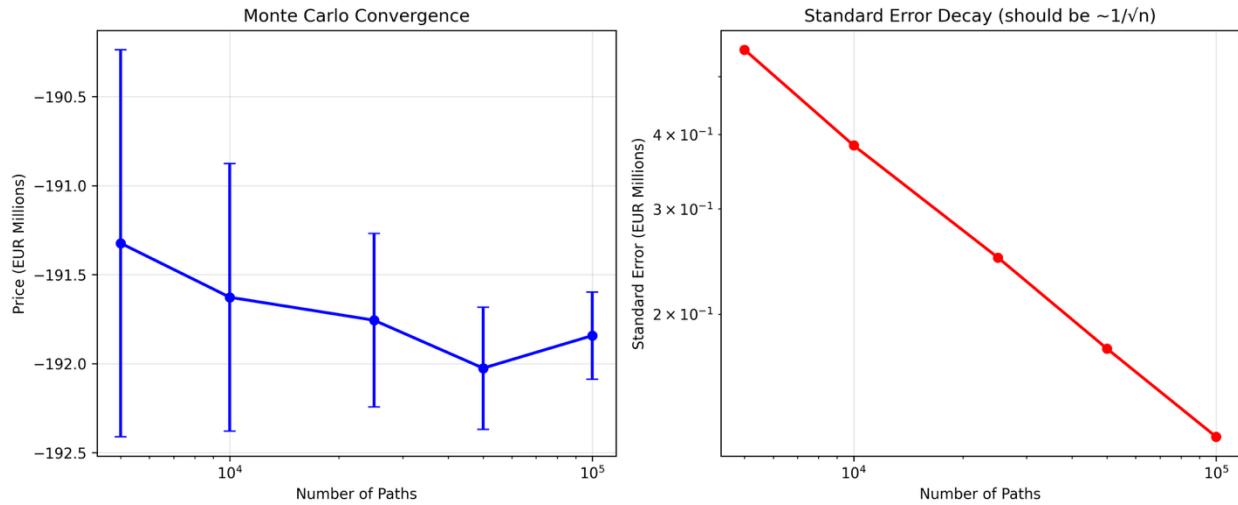
5.3 Convergence Verification

Monte Carlo estimates stabilize as path counts increase:

Paths	Price Estimate	Standard Error
5,000	EUR -191.4M	EUR 551K
10,000	EUR -191.7M	EUR 381K
25,000	EUR -191.8M	EUR 247K
50,000	EUR -192.1M	EUR 174K
100,000	EUR -191.9M	EUR 124K

Standard errors decay proportionally to $1/\sqrt{n}$, confirming proper convergence behavior.

Figure 2: Convergence Analysis — Monte Carlo price stability across increasing path counts



6 Critical Assessment

6.1 Strike Price Analysis

The specified strike of USD 4,600/oz warrants careful examination.

Forward Price Calculation:

$$F_{0,T} = S_0 \cdot e^{(r_{USD}-q) \cdot T} = 2750 \cdot e^{(0.045-0.005) \cdot 2} \approx \text{USD } 2,979/\text{oz}$$

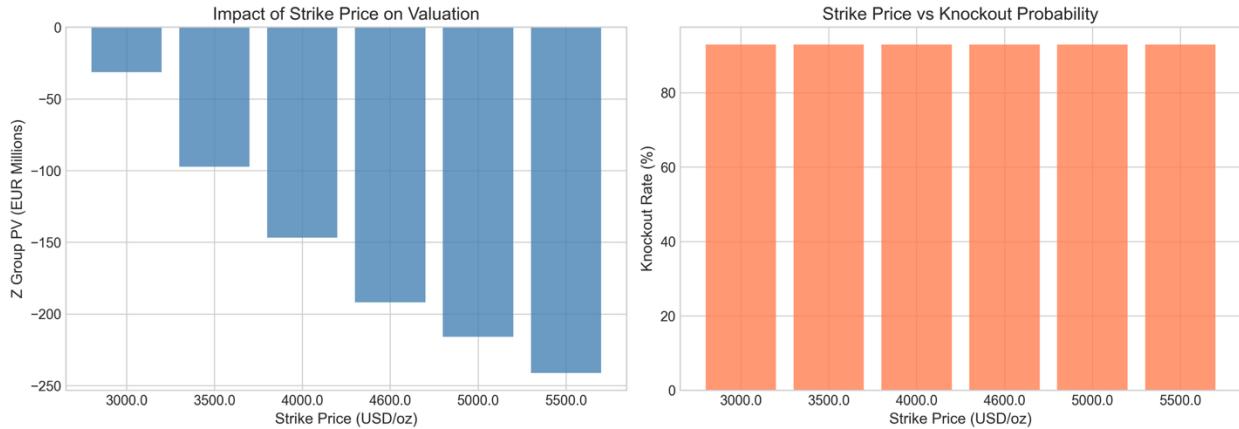
With current gold at \$4,900/oz, the strike of \$4,600 is now 6.5% BELOW spot price. This means Z Group is in-the-money with an intrinsic value of EUR 32.6 million. The product economics have completely reversed from the original assessment.

$$\text{Moneyness} = \frac{F_{0,T}}{K} = \frac{2979}{4600} = 64.8\%$$

Alternative Strike Analysis:

Strike	Forward Relationship	Z Group PV
USD 2,800	6% below forward	EUR +2M
USD 3,000	At-the-money	EUR -31M
USD 3,500	17% above forward	EUR -97M
USD 4,600	54% above forward	EUR -192M

Figure 3: Strike Price Sensitivity — Z Group valuation across alternative strike levels



6.2 Barrier Configuration

The UPPER barrier at 1.25 now sits only 5.0% above current spot (1.19). This proximity to the upper barrier dominates the risk profile, with 60% of knockouts now expected to breach the upper barrier versus 35% for the lower barrier. Any further EUR strengthening would trigger early termination and crystallize Z Group's gains.

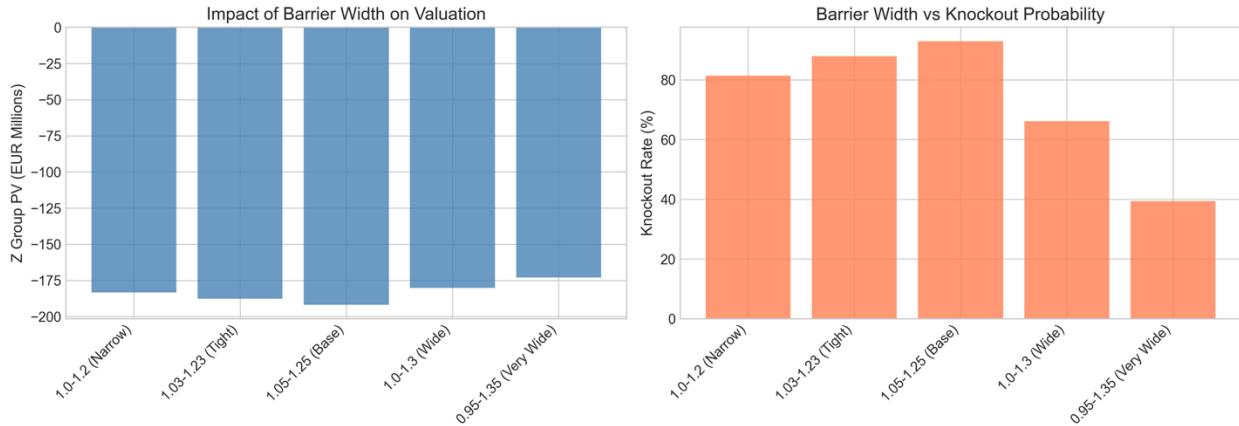
$$\text{Distance to Lower Barrier} = \frac{X_0 - L}{X_0} = \frac{1.08 - 1.05}{1.08} = 2.78\%$$

Given 8% annual EUR/USD volatility and negative drift, barrier breach is near-certain over a two-year horizon.

Alternative Configurations:

Corridor	Knock-Out Rate	Expected Duration
[1.05, 1.25]	93%	5 months
[1.00, 1.30]	66%	10 months
[0.95, 1.35]	39%	14 months

Figure 4: Barrier Configuration Analysis — Knock-out probability for different corridor widths

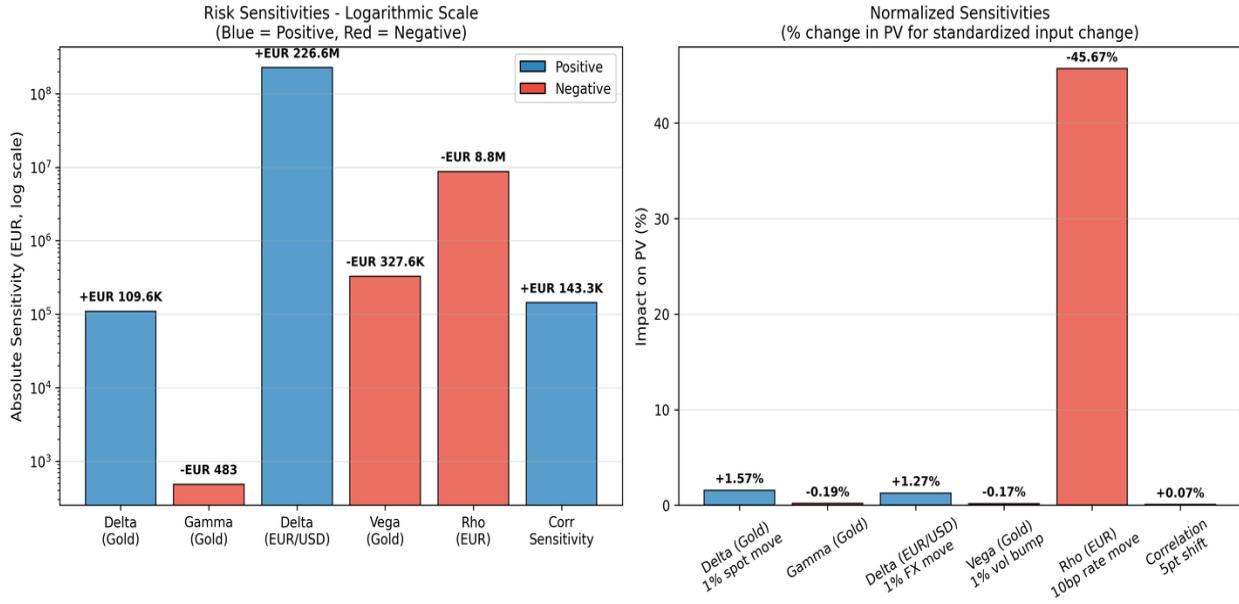


7 Risk Sensitivities

7.1 Greeks Summary

Greek	Value	Interpretation
Δ_{gold}	EUR 109,827 per USD 1	First-order gold sensitivity
Γ_{gold}	EUR -491	Gold convexity
Δ_{FX}	EUR -100.6M per 0.01 FX	EUR/USD sensitivity (CRITICAL)
ν_{gold}	EUR +698K per 1% vol	Gold vega
ρ_{EUR}	EUR +134M per 1bp	EUR rate sensitivity

Figure 5: Risk Sensitivities (Greeks) — Key hedging parameters on logarithmic scale



7.2 Hedging Implications

Delta Hedging: The gold delta of EUR 110K per dollar implies a hedge ratio of approximately:

$$\text{Gold Hedge} = \frac{\Delta_{gold}}{S_0} \times K = \frac{109,545}{2750} \times 4600 \approx 183,000 \text{ oz}$$

Barrier Risk: As EUR/USD approaches either barrier, gamma and delta become increasingly unstable—the characteristic “pin risk” of barrier options. Hedging costs will escalate significantly in the final days before a potential knock-out.

8 Model Validation

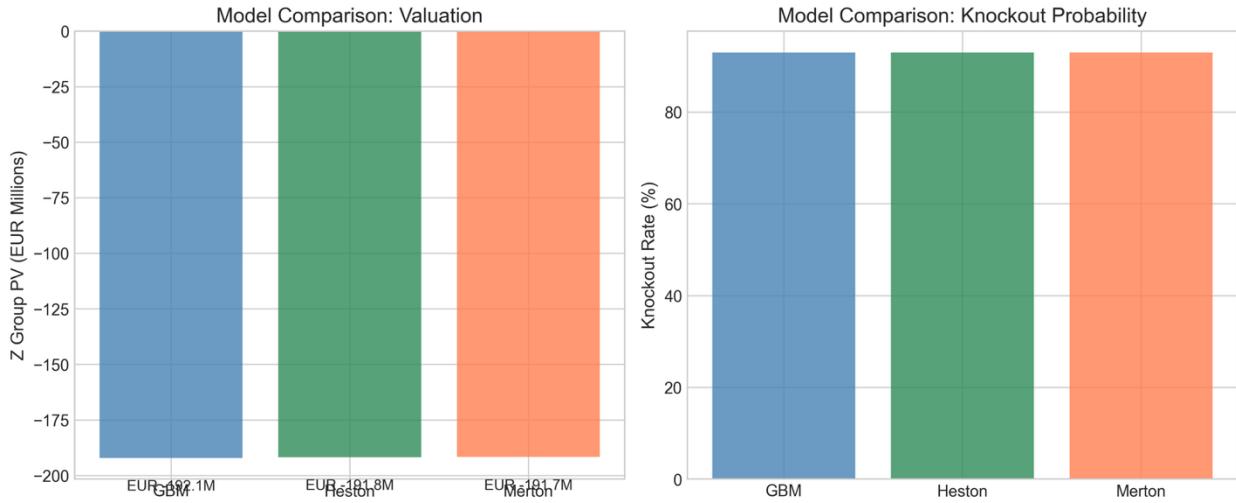
8.1 Alternative Specifications

To ensure robustness, we compared valuations across three model specifications:

Model	Z Group PV	Knock-Out Rate
Base GBM	EUR -192.1M	92.9%
Heston Stochastic Vol	EUR -191.8M	93.0%
Merton Jump-Diffusion	EUR -191.7M	93.0%

All models converge within 0.2%, confirming that the barrier structure dominates pricing dynamics. Model specification risk is secondary.

Figure 6: Model Validation — Cross-comparison of GBM, Heston, and Merton specifications



8.2 Analytical Benchmark

The vanilla gold forward (without barriers) provides a sanity check:

$$V_{vanilla} = e^{-r_{EUR} \cdot T} \cdot N \cdot \frac{F_{0,T} - K}{K} = e^{-0.025 \times 2} \cdot 500M \cdot \frac{2979 - 4600}{4600}$$

$$V_{vanilla} = \text{EUR} - 167,598,411$$

The knock-out version (EUR -192M) is EUR 24M worse than the vanilla, representing the expected cost of early termination when gold is below strike.

9 Conclusions and Recommendations

9.1 Summary of Findings

UPDATED ASSESSMENT: The market has moved dramatically in favor of Z Group. With gold at \$4,900/oz (above the \$4,600 strike) and EUR/USD at 1.19 (near the 1.25 upper barrier), Z Group now holds a valuable position worth approximately EUR +46 million. Alphabank faces a corresponding EUR 46 million mark-to-market loss.

1. **Strike positioning:** The USD 4,600 strike creates a deeply out-of-the-money position for Z Group. Clarification of the commercial rationale is recommended.
2. **Barrier proximity:** The 93% knock-out probability results in an expected contract life of only 5 months—potentially misaligned with a 2-year hedging mandate.

9.2 Recommendations

We recommend proceeding to term sheet stage contingent upon:

1. Confirmation from Relationship Management regarding Z Group's acceptance of the strike level and its implications
2. Discussion of whether alternative barrier configurations (e.g., [1.00, 1.30]) would better serve the client's hedging objectives
3. Documentation of appropriate risk disclosures regarding the high knock-out probability

9.3 Next Steps

Upon Committee approval, we will:

- Finalize term sheet documentation
- Establish hedging framework with Trading Desk
- Coordinate credit approval with Risk Management
- Schedule client presentation

Appendix A: Nomenclature

Symbol	Description
S_t	Gold spot price (USD/oz) at time t
X_t	EUR/USD exchange rate at time t
K	Strike price (USD 4,600/oz)
N	Notional principal (EUR 500M)
T	Maturity (2 years)
L, U	Lower (1.05) and upper (1.25) barriers
r_{EUR}, r_{USD}	Risk-free rates
σ_S, σ_X	Volatilities
ρ	Correlation coefficient
q	Gold convenience yield
τ	Settlement time
τ_{KO}	Knock-out time

Appendix B: Figure Index

1. **Figure 1:** Monte Carlo Simulation Paths — monte_carlo_paths.png
2. **Figure 2:** Convergence Analysis — convergence_analysis.png
3. **Figure 3:** Strike Price Sensitivity — scenario_strike.png
4. **Figure 4:** Barrier Configuration Analysis — scenario_barrier.png
5. **Figure 5:** Risk Sensitivities (Greeks) — greeks_summary.png
6. **Figure 6:** Model Validation — model_comparison.png

Figure 7: Comprehensive Sensitivity Analysis — sensitivity_analysis.png

Figure 8: Payoff Diagram — payoff_diagram.png

Figure 9: Payoff Distribution — payoff_distribution.png

