Estimating Risk of Derivatives Positions: Comparative Analysis of Different Approaches

Alfa-Bank

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Agenda

1. Importance of proper accounting for derivatives risks

2. 3 main approaches to estimate derivatives risk:
   - *Delta-normal*
   - *Grid-search*
   - *Monte-Carlo simulations*

3. Backtesting results

4. Questions

I. Importance of accounting for derivatives risk

Famous derivatives debacles:

1. Metallgesellschaft

2. Orange County

3. Barings

4. Long Term Capital Management

II. Derivatives risk estimation

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3 main approaches:

1. Delta-Normal
2. Grid-search
3. Monte-Carlo simulations

II. Derivatives risk estimation

Assume we buy a 1Month LKOH ATM call with:

Spot ($) ***68.4***

Strike ($) ***68.4***

Implied volatility ***50%***

Notional ***10’000*** *shares*

Delta (shares) ***5’397****, Delta ($)* ***370’000***

Volatility of the spot price ***90%***

II. Derivatives risk estimation

1). Delta-Normal approach:

One-day $VaR_{1-\alpha} = q_{1-\alpha} \cdot Delta \cdot P \cdot \sigma$

In our case

$$VaR_{99\%} = 3 \cdot 5'397 \cdot 68.4 \cdot 90\% / \sqrt{260} =$$

$$= 61'814 \ USD$$

II. Derivatives risk estimation

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2). Grid-search approach:

There are (usually) 3 variables affecting option's price:

- *Underlying asset spot price*
- *Implied volatility*
- *Interest rate*

Grid-search approach uses **full revaluation** of derivatives position for different underlying variables **scenarios** – where each variable moves within predetermined range (e.g., +/- 3 std. deviations)

(!) Note that correlations between variables are not accounted for

II. Derivatives risk estimation

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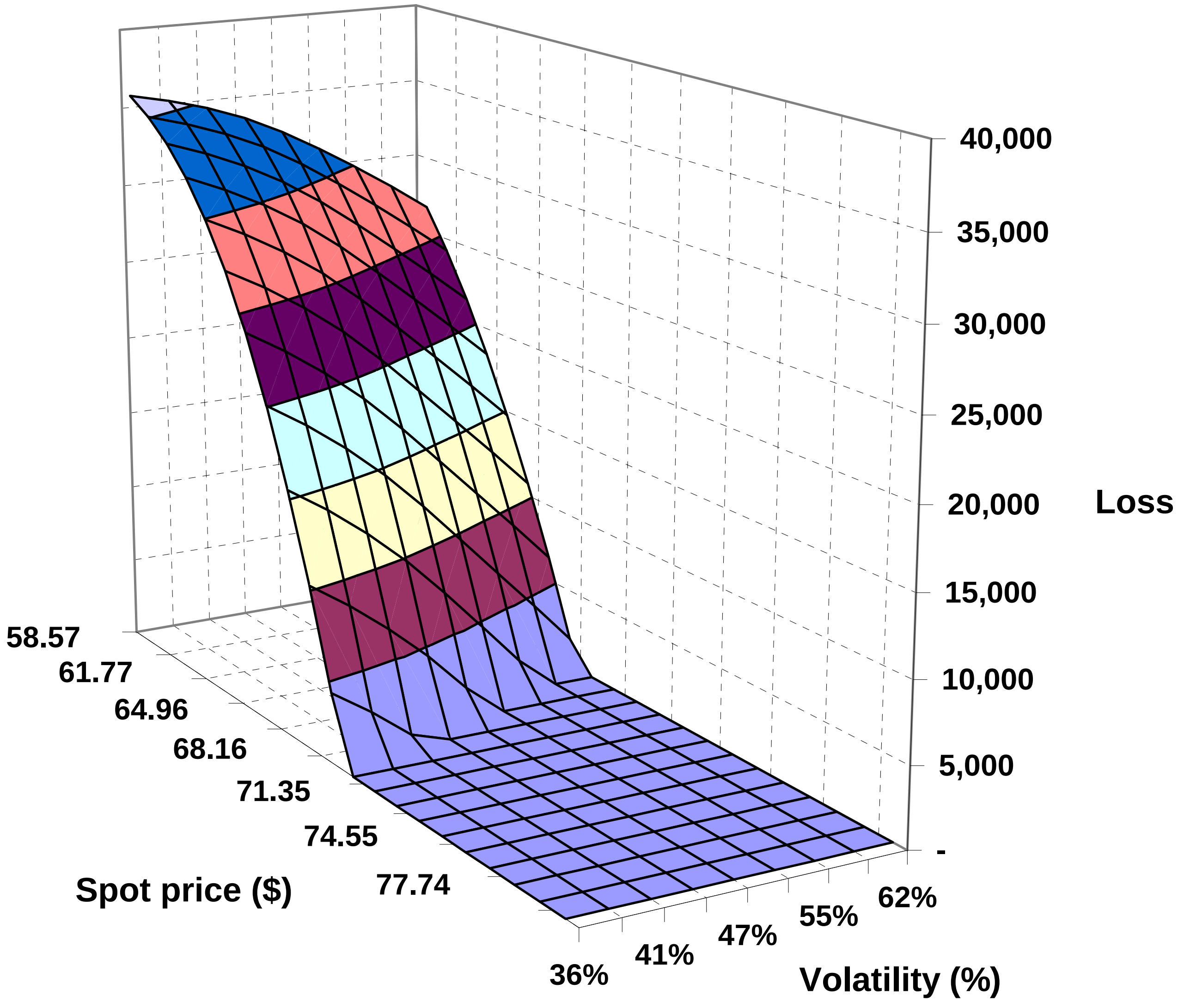
2). Grid-search approach:

One-day loss on a bought call

Spot/ Volatility	36%	39%	41%	44%	47%	51%	55%	58%	62%
58.57	35,989	35,445	34,749	33,858	32,715	31,361	29,894	28,327	26,662
59.64	35,058	34,362	33,496	32,415	31,062	29,494	27,825	26,070	24,225
60.70	33,790	32,929	31,882	30,606	29,041	27,260	25,394	23,456	21,439
61.77	32,114	31,083	29,854	28,383	26,611	24,626	22,573	20,463	18,287
62.83	29,963	28,765	27,360	25,704	23,738	21,564	19,341	17,075	14,754
63.90	27,273	25,920	24,356	22,533	20,394	18,054	15,680	13,279	10,831
64.96	23,991	22,506	20,804	18,842	16,557	14,077	11,578	9,064	6,511
66.03	20,078	18,489	16,681	14,609	12,213	9,625	7,029	4,427	1,791
67.09	15,507	13,850	11,972	9,827	7,355	4,694	2,031	-	-
68.16	10,272	8,583	6,673	4,493	1,984	-	-	-	-
69.22	4,380	2,698	793	-	-	-	-	-	-
70.29	-	-	-	-	-	-	-	-	-
71.35	-	-	-	-	-	-	-	-	-
72.42	-	-	-	-	-	-	-	-	-
73.48	-	-	-	-	-	-	-	-	-
74.55	-	-	-	-	-	-	-	-	-
75.61	-	-	-	-	-	-	-	-	-
76.68	-	-	-	-	-	-	-	-	-
77.74	-	-	-	-	-	-	-	-	-
78.81	-	-	-	-	-	-	-	-	-
79.87	-	-	-	-	-	-	-	-	-

II. Derivatives risk estimation

LKOH: grid-search one-day loss (1M ATM call)



II. Derivatives risk estimation

2). Grid-search approach:

Spot/ Volatility	36%	39%	41%	44%
58.57	**35,989**	35,445	34,749	33,858
59.64	35,058	34,362	33,496	32,415
60.70	33,790	32,929	31,882	30,606
61.77	32,114	31,083	29,854	28,383

One-day $VaR_{99\%} = 35'989\ USD$

II. Derivatives risk estimation

3). Monte-Carlo simulations approach:

Main problem with grid-search approach is it's inability to account for correlations between different assets *(e.g., 2 almost ofsetting positions in assets with correlation of 70%-80%)*

Solution – Monte-Carlo simulations

Monte-Carlo approach uses **full revaluation** of derivatives position for different **simulated** underlying variables **scenarios** with accounting for **correlations** between variables

II. Derivatives risk estimation

3). Monte-Carlo simulations approach:

Methodology:

1. Adjust returns of underlying assets for volatility trends (*GARCH-techniques*)
2. Simulate volatility adjusted returns of underlying assets by randomly picking them from the sample
3. Simulate the change of the risk-free rate
4. Simulate implied volatilities (*GARCH-techniques*)
5. Revalue position using simulated variables and take quantiles of the resulting P&L series

II. Derivatives risk estimation

3). Monte-Carlo simulations approach:

Adjusting for volatility trends

1. Estimate *GARCH*-model for returns of the underlying assets

2. Divide each return by the corresponding *GARCH* std. deviation to get "standardized" return

3. Multiply "standardized" returns by the volatility forecast to get volatility adjusted returns

II. Derivatives risk estimation

3). Monte-Carlo simulations approach:

Simulating “implied” volatilities

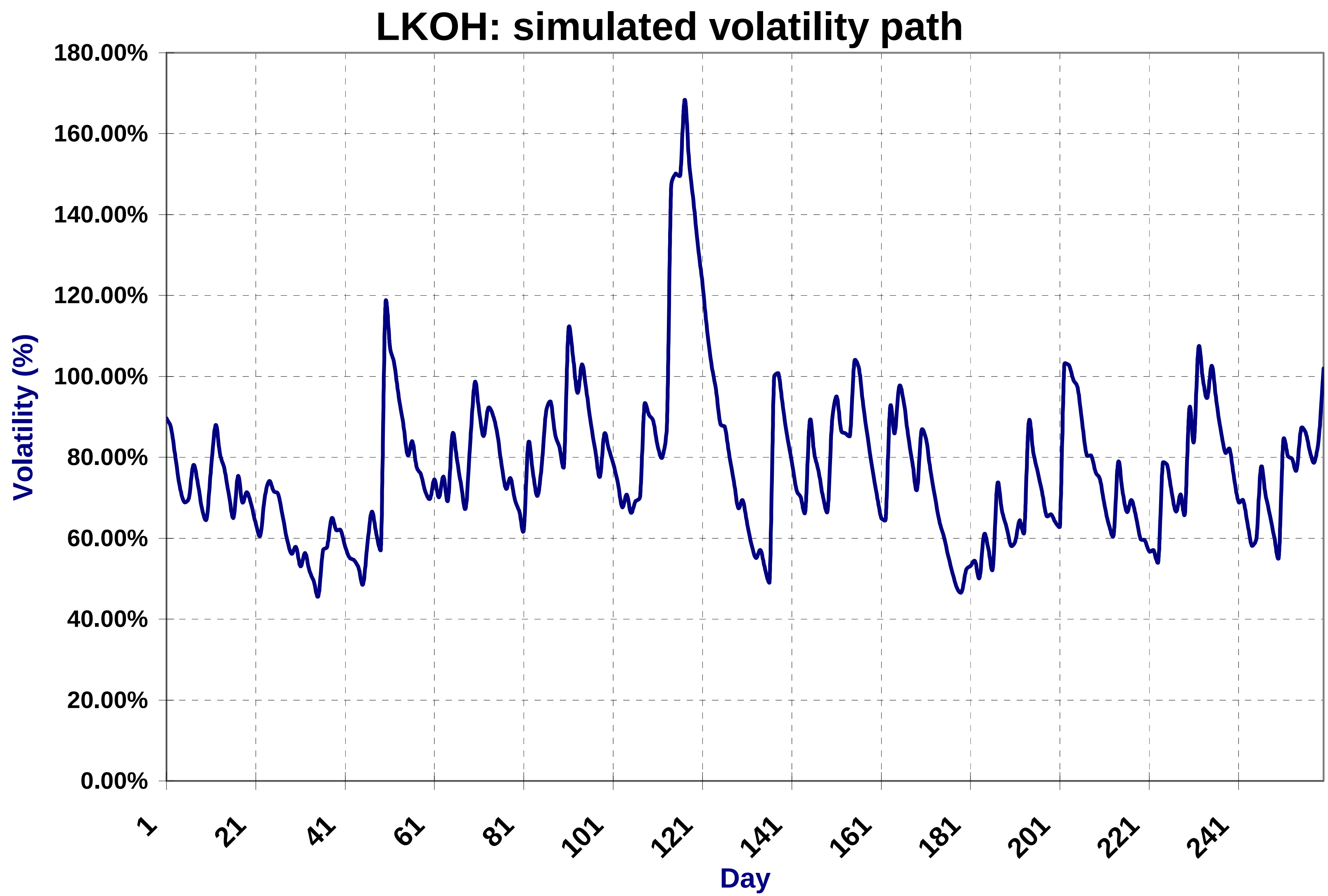
1. Randomly pick volatility adjusted returns from the sample

2. Recalculate volatility using *GARCH*-equation

3. Calculate average volatility over the needed simulated period *(e.g., 1M, 3M, 6M, 1Y)*

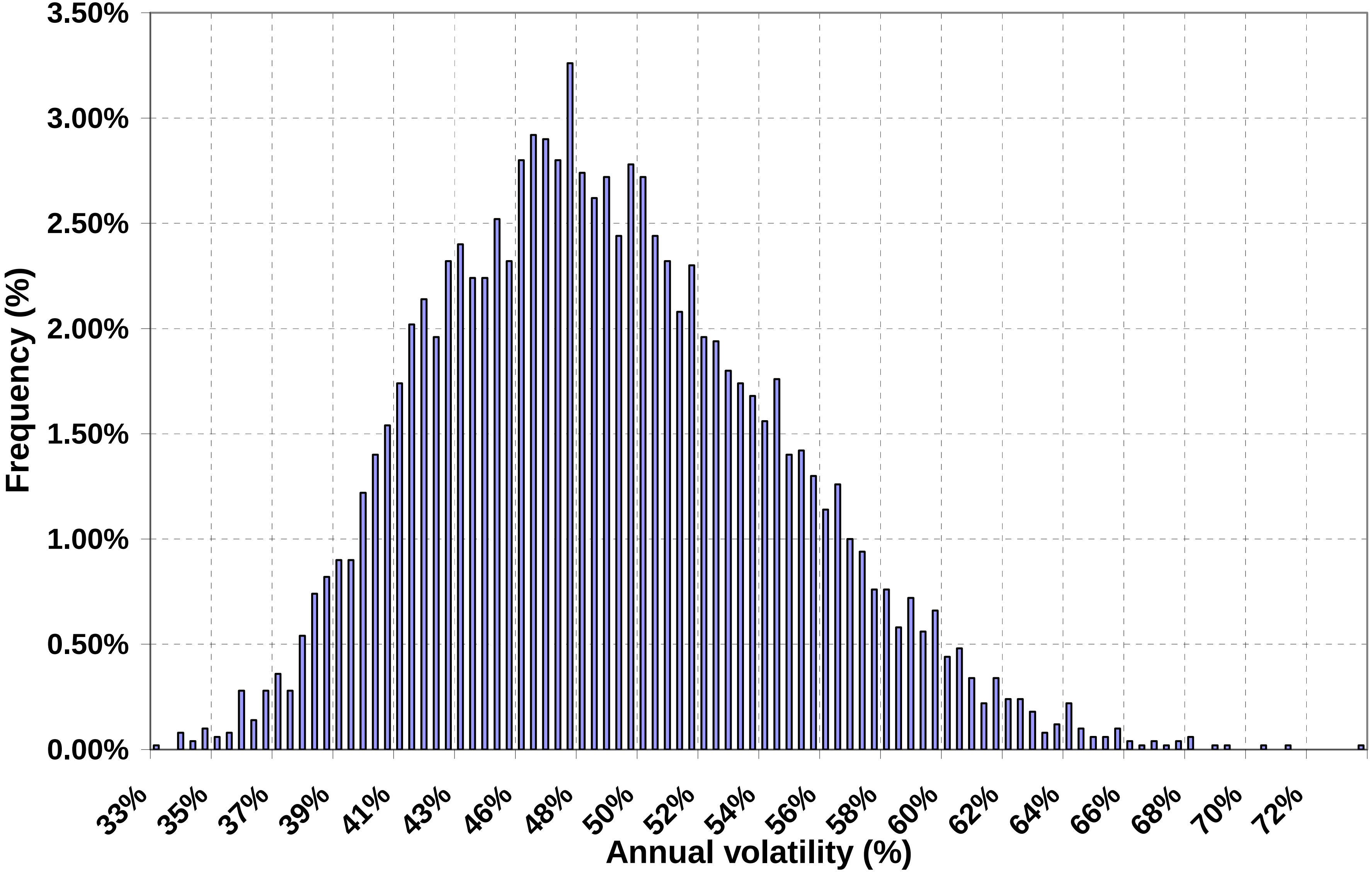
II. Derivatives risk estimation

3). Monte-Carlo simulations approach:



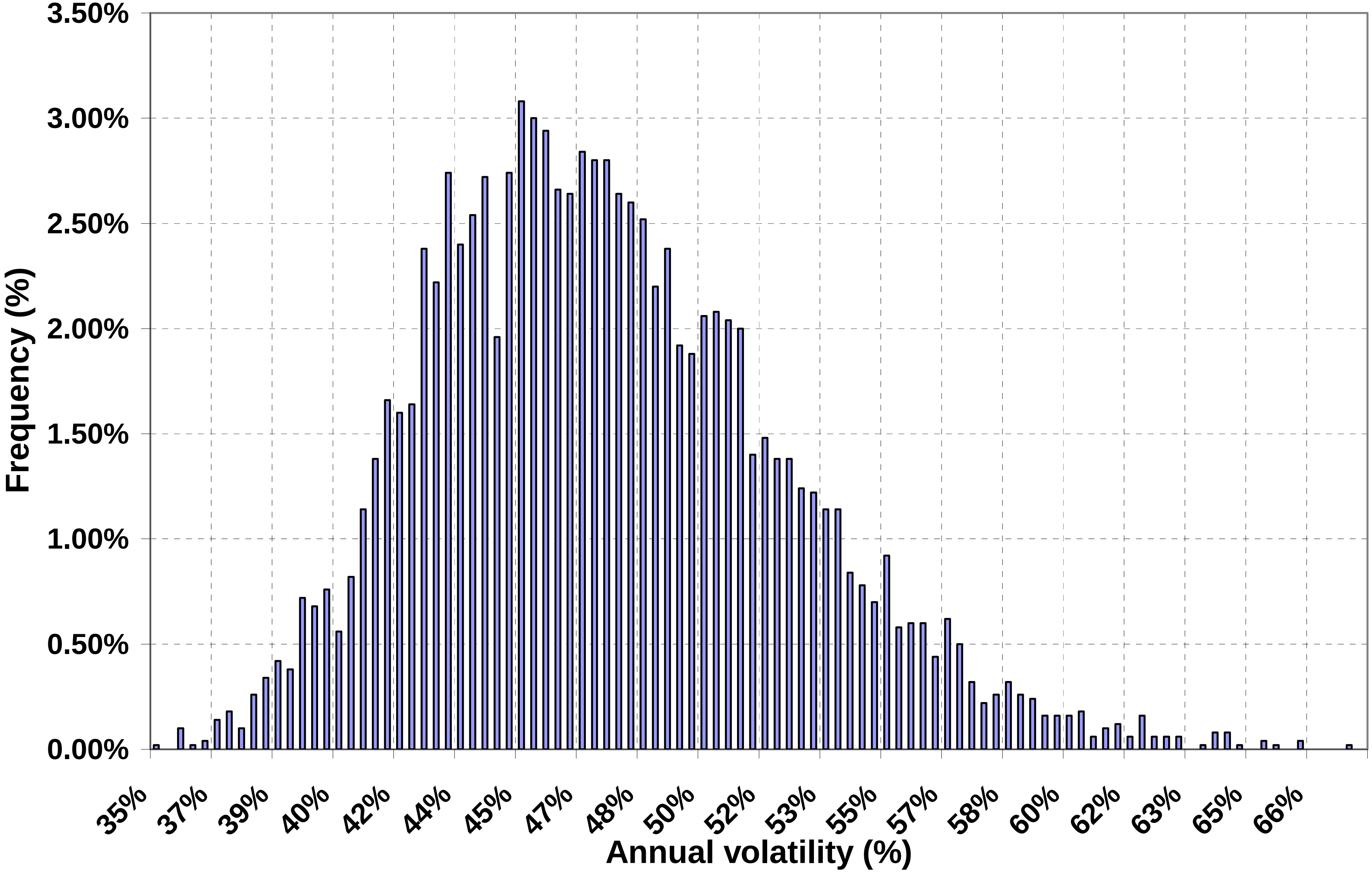
II. Derivatives risk estimation

LKOH: *1M* "implied" volatility distribution

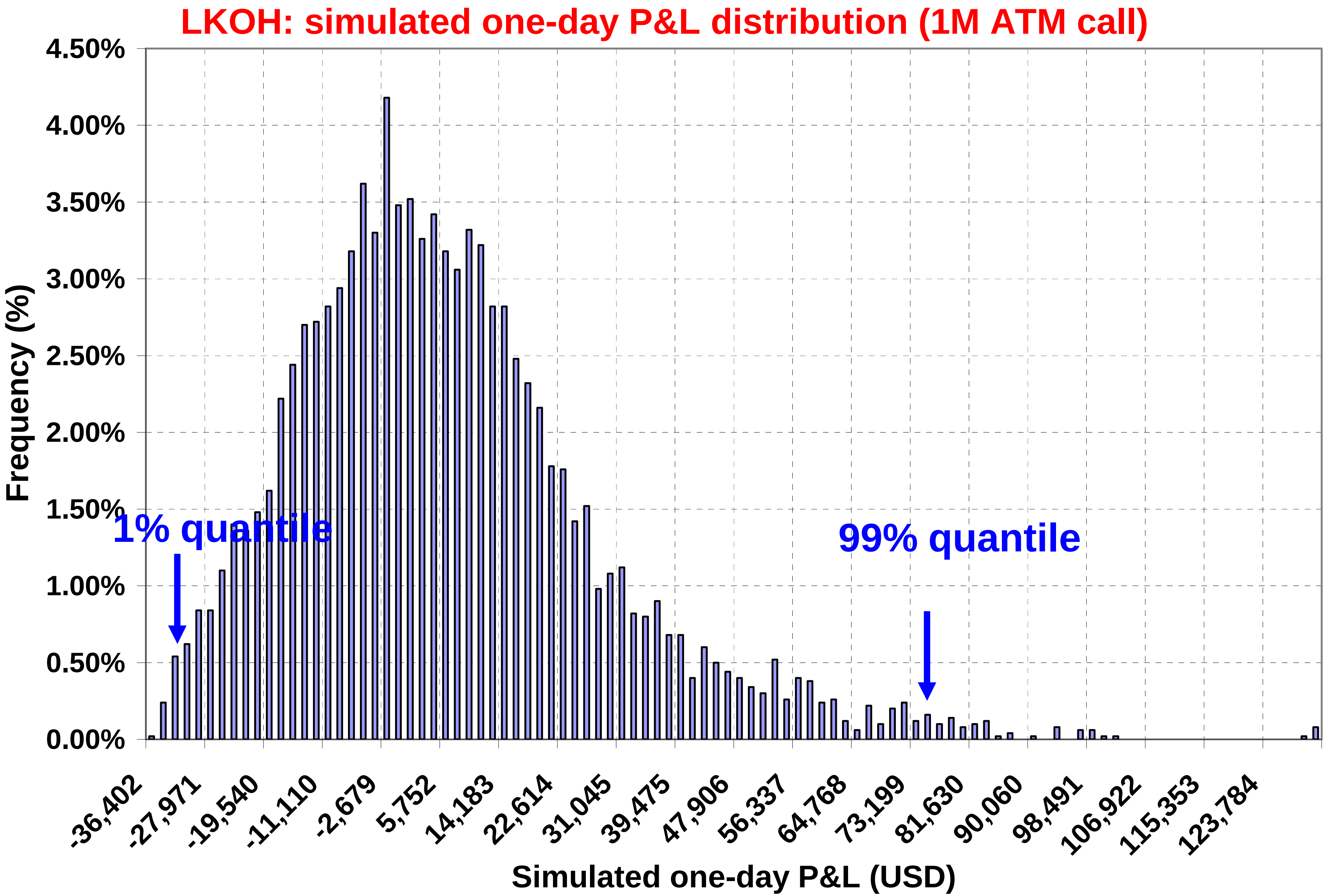


II. Derivatives risk estimation

LKOH: *6M* "implied" volatility distribution



II. Derivatives risk estimation



II. Derivatives risk estimation

VaR Comparison:

1M ATM LKOH call

Model	One-day VaR 99%
Delta-Normal	61,814
Grid-search	35,989
Monte-Carlo	32,559

II. Derivatives risk estimation

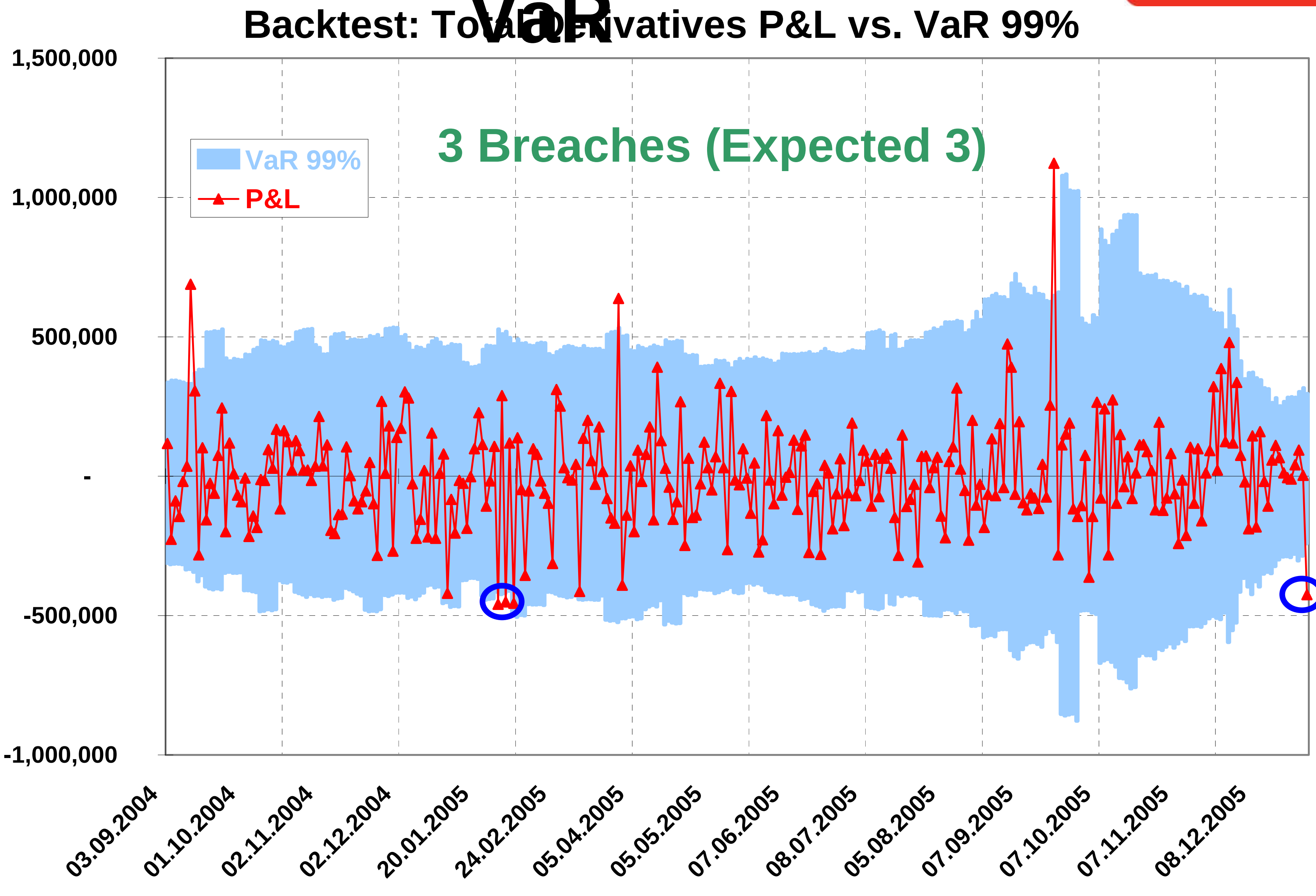
Results:

1. Delta-Normal approach in general gives inaccurate estimations of VaR *(esp. for ATM options)*

2. Grid-search approach is easy to implement, however it cannot account for correlation between simulated variables and different assets

3. Monte-Carlo approach gives accurate estimates of VaR. However, it is relatively difficult to implement

III. Backtesting Monte-Carlo VaR



IV. Questions

Your questions?

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