Initial margin, default fund and default management for a clearing house of crypto futures and options

Model whitepaper, version 0.1.0

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1 Purpose and scope

This paper documents a margin and default-resources framework for a clearing house that clears bitcoin and ether futures and options. It states the models, the data, the assumptions, the back-testing and the limits, in the order a risk committee, an auditor or a regulator reviews them. Every figure comes from `results/results.json`, written by `python -m ccp.cli` on public market data, and is recomputed when the code or the data change.

It is a demonstration on public data. No figure here is a margin requirement of any clearing house, and no model has had an independent validation.

2 Products and data

- **Prices**: Coinbase Exchange daily closes, BTC-USD and ETH-USD, 2016-05-19 to 2026-11-27 (3,843 days).
- **Options and futures**: a Deribit snapshot (20261127T1946 UTC) of every listed option (1,722) and future
  (28) with mark price, mark implied volatility and open interest, and the order books of the futures.
- **Implied volatility**: the Deribit DVOL index, daily, from 2024-03-03.

Data checks run before each margin run: gaps, non-positive prices, a mark implied volatility outside 5% to 400%, and an order book whose best bid is above its best ask stop the run.

3 Initial margin model

Method. Filtered historical simulation (Barone-Adesi et al. 1999). Each asset's daily log return has a GARCH(1,1) with Student-t errors (Bollerslev 1986); returns divided by their conditional volatility give standardised residual vectors that keep the dependence between assets on the same day. A scenario draws two days of residual vectors (the margin period of risk), scales them by today's volatility forecast and adds them up. The margin is the 99% expected shortfall of the portfolio's loss across scenarios, a coherent measure (Acerbi and Tasche 2002).

Options. Every option is revalued in full with Black-76 (Black 1976) on each scenario of the forward and of implied volatility, so gamma and vega enter the margin. Each drawn day carries its own change of implied volatility: the DVOL change where DVOL exists, and before it the change predicted from that day's return by a regression on the overlap, plus a residual drawn from the overlap.

Today's margins, US$ per position, 2.68% daily BTC volatility forecast:

Position (US$ 1 m futures; options as named)	99% ES, US$ thousand	99% VaR, US$ thousand
Long BTC	122	95
Long ETH	147	116
Long BTC, short ETH	134	98
Short BTC straddle (30 days, 10 BTC)	39	
Short BTC 25-delta put (30 days, 10 BTC)	33	
Long BTC call spread (30 days, 10 BTC)	21	

Long US$ 1 m of BTC against short US$ 1 m of ETH needs more margin than the long BTC position alone, although the two move together (correlation 0.75 of standardised returns). ETH is a third more volatile and has its own right tail: its three largest two-day rises, in 2017, were 37% to 47%, against 22% to 40% for BTC. A short leg carries that tail.

A SPAN-style benchmark. A 16-scenario grid of price (±15%) and volatility (±15 points) with two extreme moves counted at 35% gives 73 thousand for the short straddle, against 39 thousand by FHS. The grid does not respond to the market; FHS does.

4 Back-testing

From 2019, the margin is set every other day from data up to that day only, and compared with the loss over the next two days (non-overlapping windows, so breaches are independent under the model). The tests use the 99% VaR: Kupiec (Kupiec 1995) for the breach rate, Christoffersen (Christoffersen 1998) for clustering, and the traffic light over the last 250 windows.

Portfolio	Model	VaR breaches	Kupiec p	Christoffersen p	Zone	ES coverage	Mean margin, k
Long BTC	FHS (GARCH)	16 / 1443	0.683	0.549	green	99.58%	160
Long BTC	Historical simulation	9 / 1443	0.123	0.737	green	99.79%	165
Long ETH	FHS (GARCH)	20 / 1443	0.164	0.279	yellow	99.51%	191
Long ETH	Historical simulation	7 / 1443	0.029	0.794	green	99.79%	218
Long BTC, short ETH	FHS (GARCH)	12 / 1443	0.508	0.654	green	99.58%	167
Long BTC, short ETH	Historical simulation	7 / 1443	0.029	0.794	green	99.79%	195

FHS passes both tests on all three portfolios. Plain historical simulation breaches less than 1% of the time: its window keeps the 2017 to 2020 crashes long after they pass, so it charges too much in calm years, and Kupiec rejects it at 5% for ETH and for the spread. That is the trade-off the next section measures.

5 Procyclicality

A margin that jumps in a crisis drains liquidity from members when it is scarcest (Glasserman and Wu 2018). Over the back-test, for US$ 1 m long BTC:

Tool	Peak to trough	Largest 15-day increase	Mean margin, k	Margin breaches
Model only	9.5x	+407%	160	6
Buffer 25%	7.6x	+306%	196	4
Floor at half the stressed margin	6.4x	+407%	163	4
25% weight on stressed	5.3x	+264%	174	4

The stressed period is the 250-day window with the highest BTC volatility, 2017-07-08 to 2018-03-14. The 25% weight on the stressed margin nearly halves the peak-to-trough ratio for 9% more margin on average; the buffer cuts the largest jump for 22% more. The choice is a policy decision for the risk committee, and the table is the input to it.

6 Stress testing and the default fund

Ten synthetic members hold the live Deribit open interest, split at random on each side so the book nets to zero. Each member's margin is its FHS expected shortfall. Under each scenario (the six worst and six best two-day moves of BTC since 2016, and two hypothetical moves), the loss a member's margin does not cover is what the default fund must absorb if it fails. **Cover 2**, the sum of the two largest uncovered losses in the worst scenario (Duffie and Zhu 2011), is **US$ 149.6 m** (hypothetical: -40%, vol +30 pts, members D and G), against US$ 194.3 m of total margin. The historical March 2020 move gives almost as much. Concentrated positions drive the result, as Menkveld (2017) warns: the two members with the largest net long BTC carry it.

7 Default management

The largest member in Cover 2 holds US$ 285.9 m of net long BTC futures. The bid side of the BTC perpetual's book holds US$ 47.8 m within its 1,000 visible levels, so a single market order cannot close it. Selling in slices over hours trades impact for price risk (Almgren and Chriss 2001):

Hours	Slices	Impact, US$ m	Price risk, US$ m	Total, US$ m	Book exhausted
0	1	12	0	12	yes
1	4	12	1.4	13.4	yes
4	16	0.6	3.4	4	no
12	48	0.3	6.2	6.5	no
24	96	0.2	8.8	9.1	no
72	288	0.1	15.4	15.5	no

Where the book runs out (no slicing, or one hour), the impact shown counts only the part the visible book could fill, so it understates the cost. The cheapest schedule here is about four hours. The calculation assumes the book refills between slices, which is optimistic in a crisis; a default management auction, where members bid for the portfolio after its delta is hedged, is the alternative when the book is this thin.

8 Binary options

Binary options pay a fixed amount if the underlying ends above a level. Priced from the live surface (a tight call spread on the interpolated smile), an at-the-money binary on the 2026-12-25 expiry is worth 0.520 per US$ 1, against 0.474 with one volatility: the skew matters. The scenario margin of a short binary as a share of its maximum loss rises as expiry approaches:

Days to expiry	Scenario margin / maximum loss
30	65%
14	84%
7	96%
4	100%
3	100%

Within a week of expiry the scenario margin reaches the maximum loss, so collecting the full maximum loss is the right rule there; earlier, a scenario margin capped at the maximum loss frees collateral.

9 Governance and monitoring

The model inventory, the change policy and the monitoring thresholds are in `docs/` and `config/monitoring.yml`. Each metric has amber and red levels and an escalation path (amber to the head of risk methodology within one business day, red to the CRO the same day and to the Risk Committee). CI runs the test suite on every change.

10 Limits

- Prices and options come from one exchange and one snapshot; option back-testing needs a daily history of the surface that is not public.
- Members are synthetic; real member portfolios are more concentrated and more hedged.
- The liquidation assumes the book refills between slices and ignores the information a large seller gives away.
- DVOL starts in 2024; earlier volatility changes are predicted from returns.

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