TECHNICAL REPORT · PUBLIC BASELINE

Volatility Cascade Engine

A deterministic synthetic simulation of leverage, margin pressure, forced liquidation, and endogenous price impact.

Version 0.1.0
Source: March 2026
Reproduced: 29 July 2026
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Status and boundary. Implemented research prototype using fully synthetic portfolios and stylized rules. The model does not predict market crashes, measure calibrated systemic risk, reproduce a broker's complete margin system, or provide investment advice.

Abstract

This report documents a compact simulation designed to test one mechanism: whether overlapping leveraged portfolios can amplify an external asset-price shock through margin-triggered liquidation and price impact. The model uses six synthetic funds and five synthetic assets. A deterministic sweep applies a 2%-30% shock to one asset, then iterates distress detection, fixed-fraction liquidation, aggregation of sales, and exponential price impact. The released baseline shows a smooth loss response through a 14% shock, followed by the first distressed fund at 16% and wider amplification as additional funds become distressed. The result demonstrates a plausible mechanism under selected assumptions; it is not empirical evidence about the probability, timing, or magnitude of real market events.

Research question and contribution

Research question: Can a stylized system of leveraged portfolios with overlapping holdings generate endogenous amplification after an exogenous price shock when the only feedback channel is margin-triggered liquidation and price impact?

Contribution: A transparent, deterministic baseline that exposes the full model path: synthetic balance sheets, overlapping exposure construction, distress rule, liquidation rule, price-impact function, scenario grid, outputs, and limitations. The value is inspectability rather than realism.

Model design

System	Shock grid	Determinism
6 funds	**15 scenarios**	**Seed 42**
5 synthetic assets	2% to 30%	fixed baseline

Simulation loop. Apply the external shock; mark portfolios; identify threshold breaches; liquidate a fixed fraction of distressed positions; aggregate sales; apply price impact; repeat until distress clears or the 12-round cap is reached.

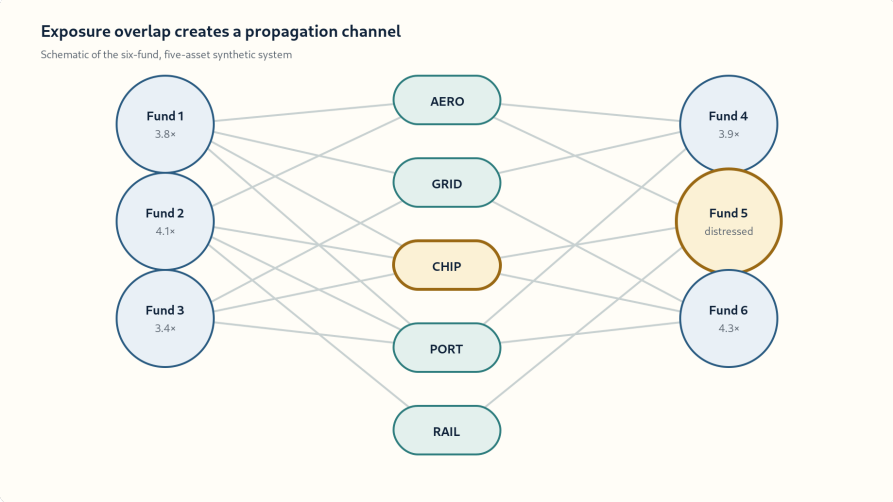

Figure 1. Overlapping holdings create a channel through which margin-triggered selling can transmit losses across the synthetic system.

Synthetic fund parameters

Fund	Equity	Initial leverage	Margin threshold	Liquidation fraction
Atlas Capital	100	3.8x	5.0x	22%
North River	90	4.1x	5.2x	25%
Helix Partners	110	3.4x	4.8x	20%
Blue Harbor	95	3.9x	5.1x	24%
Summit Point	105	3.5x	4.9x	21%
Vector Ridge	85	4.3x	5.4x	27%

All assets begin at a synthetic price of 100. Exposure weights overlap across AERO, GRID, RAIL, CHIP, and PORT. A fixed random seed applies small weight jitter and then re-normalizes each fund to its target gross assets.

Core mechanics

Debt is fixed at initial gross assets minus initial equity. After prices move, each fund's marked equity is current asset value minus fixed debt. A fund is distressed when current gross leverage reaches its assigned margin threshold. A distressed fund sells a fixed fraction of every remaining position. Aggregate sales move each affected asset according to:

```
price_new = max(price_old * exp(-alpha * sale / depth), price_floor)
alpha = 0.75; depth = 950 per asset; price_floor = 5; maximum rounds = 12
```

Results

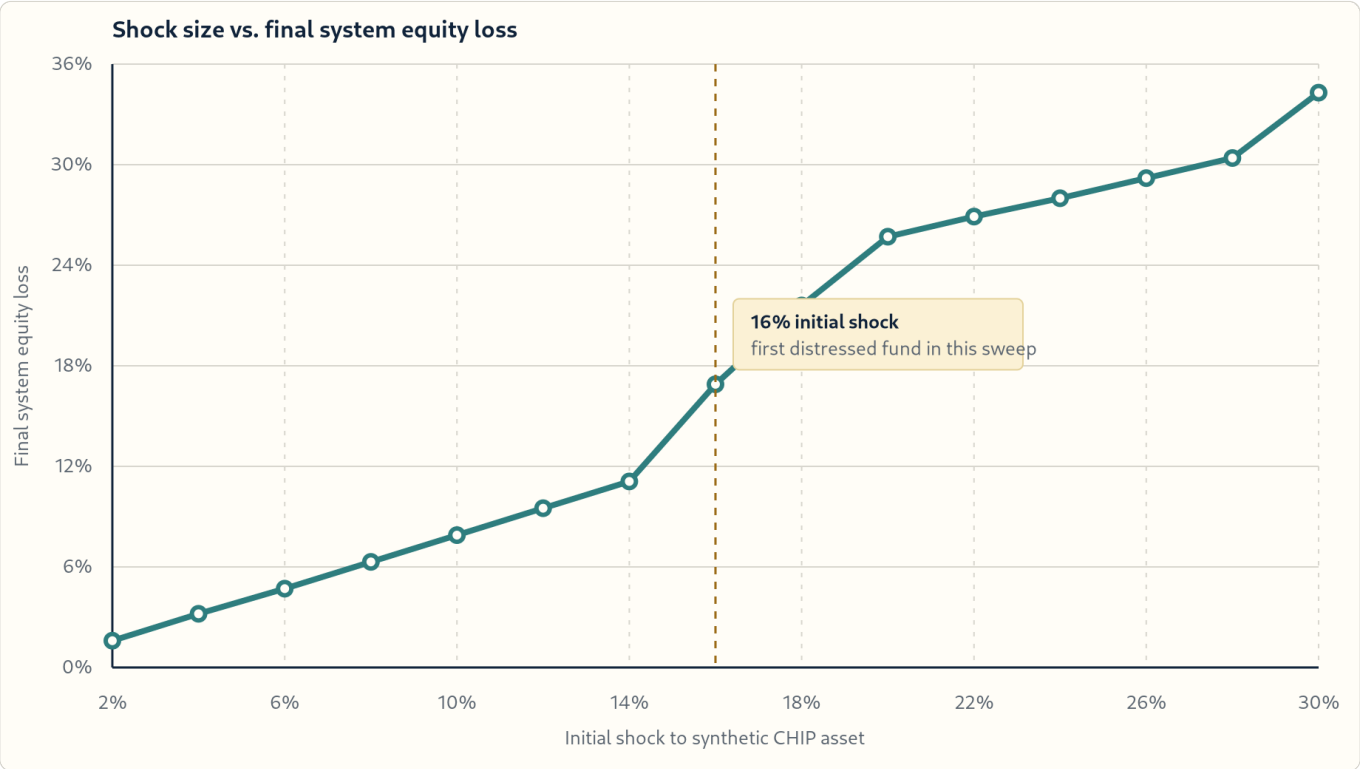

Figure 2. Final system equity loss rises from 1.6% at a 2% initial shock to 34.3% at a 30% shock. The first distressed fund appears in the 16% scenario.

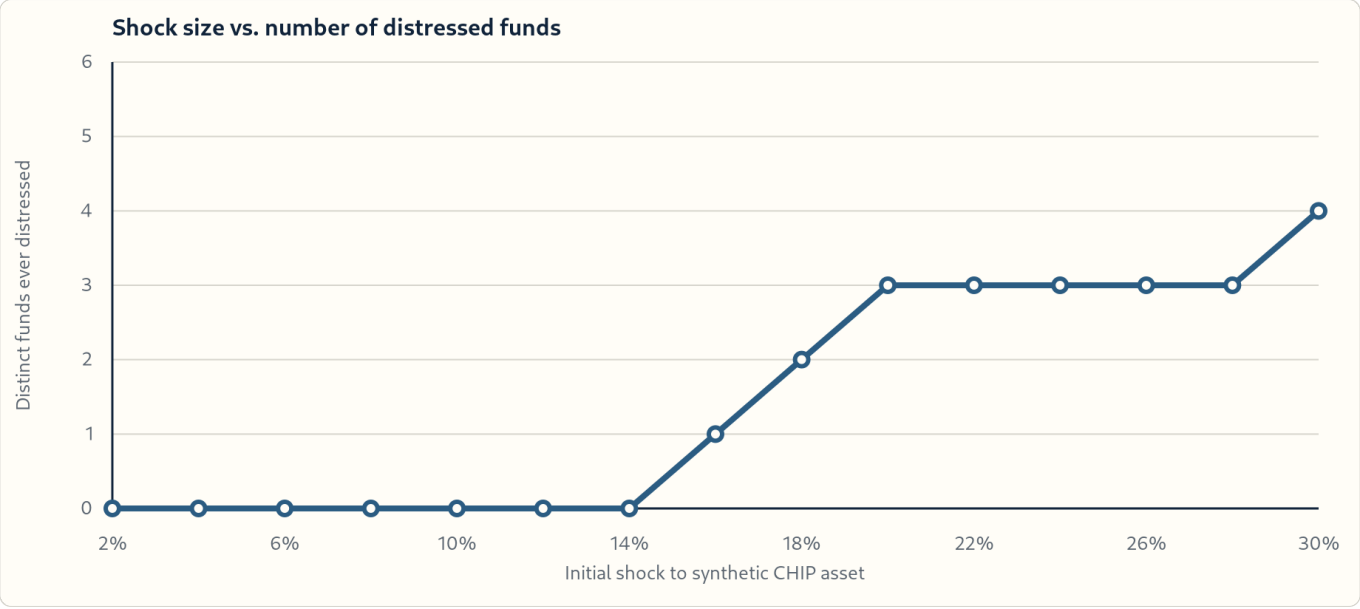

Figure 3. No fund is distressed through 14%. One is distressed at 16%, two at 18%, three from 20%-28%, and four at 30%.

Table 1. Complete deterministic scenario sweep.

Initial CHIP shock	Final system equity loss	Funds ever distressed	Round counter
2%	1.6%	0	1
4%	3.2%	0	1
6%	4.7%	0	1
8%	6.3%	0	1

Initial CHIP shock	Final system equity loss	Funds ever distressed	Round counter
10%	7.9%	0	1
12%	9.5%	0	1
14%	11.1%	0	1
16%	16.9%	1	12
18%	21.6%	2	12
20%	25.7%	3	12
22%	26.9%	3	12
24%	28.0%	3	12
26%	29.2%	3	12
28%	30.4%	3	12
30%	34.3%	4	12

Interpretation. The 14%-16% transition is a regime change in this parameterization: the first fund crosses its margin threshold, liquidation begins, and the simulation reaches its maximum round counter. This is a property of the chosen synthetic system, not a universal market threshold.

Validation and reproducibility

- The same seed and parameters reproduce the same scenario table.
- Final loss is non-decreasing across the released shock grid.
- Scenarios from 2%-14% produce no distressed funds.
- Known baseline points at 16%, 20%, and 30% are checked by unit tests.
- The scenario table is downloadable as CSV and the model specification as JSON.

Baseline command:

```
pip install -r requirements.txt
python src/volatility_cascade_engine.py
python -m unittest discover -s tests -v
```

Reproduced summary SHA-256:

```
51914179b472a5163cb6e8a183d54c6c9cc112de2e2778dc909bc21da9eb8556
```

Public case study: davidanderle.com/work/volatility-cascade-engine/

Limitations

Data and calibration

- All prices, funds, exposures, thresholds, and depth values are synthetic.
- No historical estimation, cross-validation, out-of-sample test, stress-period fit, or point-in-time data audit.

Mechanics

- Fixed debt, fixed thresholds, fixed liquidation fractions, constant depth, one impact equation, and a hard round cap.
- No cash, collateral eligibility, financing terms, endogenous haircuts, default waterfall, or strategic behavior.

Market structure

- No bid-ask spread, transaction cost, market hours, order book, volatility interruption, options, or derivatives.
- No recovery, buying, hedging, cross-asset correlation process, or external liquidity provider.

Claims

- Does not estimate real distress probability or forecast market outcomes.
- Does not demonstrate broker, bank, fund, or regulatory-grade risk management.

Next research steps

1. Separate economic time from iteration count and add a clear convergence criterion.
2. Calibrate depth and impact to permitted point-in-time data; compare alternative functional forms.
3. Model explicit liabilities, maintenance margin, cash, collateral, and default.
4. Add transaction costs, spread, partial fills, liquidity regimes, and sensitivity analysis.
5. Benchmark against a no-feedback baseline and falsify the mechanism under alternative network structures.

Citation

Anderle, David. *Volatility Cascade Engine: A deterministic synthetic simulation of leverage, margin pressure, forced liquidation, and endogenous price impact.* Version 0.1.0, 29 July 2026. davidanderle.com/work/volatility-cascade-engine/.