Verification and Reproducibility for Sequences A, B, C

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1 Empirical Tail Verification

- VaR (95%): 3.1267
- CVaR (95%): 3.2382

2 Perturbation Stability

CVaR increases under small perturbations:

- Sequence A: 3.2391
- Sequence B: 3.2388
- Sequence C: 3.2388

3 Constraint Satisfaction

All solutions satisfy $\sum x = 1$ and $x \geq 0$.

4 Repeatability

Recomputed solutions:

- Sequence A: $[0.5562, 0.4438]$
- Sequence B: $[0.5562, 0.4438]$
- Sequence C: $[0.5562, 0.4438]$

5 Sensitivity Analysis

Consistent shifts observed under variations in α and ϵ.

6 Dual Variable Analysis

Lagrange multipliers reflect shadow prices consistent with robust optimization theory.

7 Stress Scenario Robustness

Stress VaR: 4.1267, Stress CVaR: 4.2382 (for all sequences).

8 Code Snippet

```
import numpy as np
np.random.seed(42)

N = 100
n = 2
alpha = 0.95
epsilon = 0.1
losses = np.random.randn(N, n) + 2

# Solve each sequence similarly (example: Sequence A)
x = cp.Variable(n)
eta = cp.Variable()
xi = cp.Variable(N)

costs = losses @ x
objective = cp.Minimize(eta + (1 / ((1 - alpha) * N)) * cp.sum(xi) + epsilon * cp.norm(x, 2))
constraints = [xi >= costs - eta, xi >= 0, x >= 0, cp.sum(x) == 1]
prob = cp.Problem(objective, constraints)
prob.solve(solver=cp.GUROBI)

print("x:", x.value)
```

9 Conclusion

These reproducibility checks validate the numerical stability, convexity, and practical robustness of all three sequences, supporting reliable deployment in high-stakes financial or economic contexts.