- **10‑day horizon back‑test (overlapping returns) to satisfy regulatory use‑cases**

The backtesting results

- For 1 day step size keeping time in mind i have ran for 2020 to 2025 but with 10 step size to get enough points i have ran it for window 2000 to 2025.

Metric	10-Day Step (2000–2025)	1-Day Step (2020–2025)	Observations
VaR Violations	5.74%	4.60%	1-day step aligns slightly better with 5% nominal rate
Kupiec p-value	0.4691	0.7563	Both >0.05, no rejection of unconditional coverage
Christoffer sen p-value	0.5288	0.5683	Both >0.05, violations appear independent
Acerbi−Sze kely ES Stat	2.1169	2.0899	Similar, both pass ES backtest based on p-values
Acerbi−Sze kely ES p-value	0.7592	0.6708	No rejection in either case
Mean Absolute ES Error	0.5764	1.0589	Lower in 10-day step run
Empirical ES (%)	−1.39%	−3.12%	2020−2025 period shows much deeper realized tail losses

Violation Rate:
 The 1-day step size more closely matches the nominal 5% target, but both passes the

Kupiec test, indicating correct unconditional coverage.

Independence of Exceedances:
Christoffersen test results show no clustering of VaR breaches for either step size.

Expected Shortfall Accuracy:
Both pass the Acerbi–Szekely ES backtest, but the 10-day step size yields lower mean absolute ES error, indicating more accurate ES magnitude forecasts.but that is due to ;

    Step size 1 produces forecasts for every trading day.

    Step size 10 produces forecasts only every 10th day.

    As a result, the two runs evaluate performance on different sets of dates. Extreme losses occurring on days skipped by the 10-day step model are excluded from its backtest statistics.Missing consecutive days in the 10-day step run reduces the representation of clustered crisis periods in its statistics, resulting in less es error.

- **Dynamic copula check – re-fit t-copula with v free and test BB7. Retain model with higher GoF p and narrower λ CI.**
  The results by fitting with bb7 for one day step size for period 2020 to 2025 is
  Empirical ES in %: -1.64%

  📊 Backtest Results (VaR Level: 5%)

  VaR violations: 11 / 261 (4.21%)
  Kupiec Test p-value: 0.5277
  Christoffersen p-value: 0.4721
  Acerbi–Szekely ES stat: 2.0215
  Acerbi–Szekely crit value: 1.6130
  Acerbi–Szekely ES p-value: 0.5643
  Mean Absolute ES Error: 0.5403
  Empirical ES in % : -1.64%,critical value 95% : 2.4559386973180075, p value right : 0.4357

  Global GoF p-value: 0.2800 for student copula
  Global GoF p-value: 0.4200 for bb7

Tail-dependence summary (2000–2015)

Metric	95% CI	95% CI	Empirical	bb7 (sim)	student (sim)
λ_L	0.2924344283	0.3683426423	0.3299145299	0.3407917384	0.3210332103
λ_U	0.2331593089	0.3031358885	0.2674616695	0.2527075812	0.3206239168

These are lying in confidence intervals for bb7 but the copula selection if it is done based on aic criterion then it is selecting t copula because it is checking for both likelihood and parameters.less parameters means less overfitting . so with aic criterion student copula is preferred and it is anyways only little higher than upper confidence interval and as lower confidence intervals are important for var so shall we proceed with t copula as it overfit less .

● **Additional assets / vine-copula pilot – add two more NIFTY constituents and fit a 4-dim Student-vine**

Empirical ES in %: -2.51%

📊 Backtest Results (VaR Level: 5%)

VaR violations: 12 / 261 (4.60%)
Kupiec Test p-value: 0.7563
Christoffersen p-value: 0.1046
Acerbi–Szekely ES stat: 2.0027
Acerbi–Szekely crit value: 1.5364
Acerbi–Szekely ES p-value: 0.5657
Mean Absolute ES Error: 0.6150
Empirical ES in % : -2.51%,critical value 95% : 2.4559386973180075, p value right : 0.4343
    Statistically acceptable

Tail dependencies :

Pair	LowerTail_raw	UpperTail_raw	LowerTail_pit	UpperTail_pit
HINDUNILVR.NS - INFY.NS	0.3102	0.3017	0.3124	0.3021
HINDUNILVR.NS - SBIN.NS	0.3516	0.2964	0.3511	0.2848

HINDUNILVR.NS - TATAMOTORS.NS	0.3449	0.3071	0.3498	0.2968
INFY.NS - SBIN.NS	0.3877	0.3284	0.3872	0.3075
INFY.NS - TATAMOTORS.NS	0.3663	0.3551	0.3712	0.3409