



Bitcoin Portfolio Allocation Analysis

Optimal BTC Sizing via Risk-Budget Framework

5 BTC-Containing Profiles · Component Risk Contribution Analysis

Companion to: Multi-Asset Portfolio Allocation Blueprint

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1 Executive Summary

► The optimal Bitcoin allocation is 10–12% by capital weight, producing 17–20% risk contribution. This range maximizes diversification benefit while keeping tail risk manageable.

Optimal BTC Weight

10–12%

Optimal BTC FRC

17–20%

Best BTC Sharpe

2.74

Max BTC Stress

–19.5%

- **BTC is a risk diversifier, not a return maximizer** — include it for structural balance via Component Risk Contribution, not for alpha
- **Risk Parity naturally constrains BTC to 10–12%** across all profiles tested; this range consistently produces robustness scores $\geq 71/100$
- **Above 16% weight, BTC becomes destructive** — scores drop below 64, worst stress exceeds –30%, and P(Loss) rises above 10%
- **Equal-weight BTC (50%) is catastrophic** — BTC contributes 99.5% of all portfolio risk, Sharpe collapses to 0.08
- **Max Sharpe optimizers allocate 0% to BTC** in most profiles — the volatility drag outweighs the diversification benefit for pure Sharpe maximization
- **Recommendation:** use the Risk Parity framework to size BTC; set a hard FRC ceiling of 20%; rebalance quarterly

2 The Risk-Budget Principle

► **Allocate Bitcoin by risk contribution ceiling** ($CRC_{BTC} \leq c$), **not by capital weight**. A small BTC position generates outsized risk.

2.1 Component Risk Contribution (CRC)

- CRC measures how much each asset contributes to total portfolio volatility:

$$CRC_i = w_i \cdot \frac{(\Sigma \mathbf{w})_i}{\sigma_p}$$

where w_i = asset weight, Σ = covariance matrix, σ_p = portfolio volatility

- **Fractional Risk Contribution (FRC)** normalizes to percentages: $FRC_i = CRC_i / \sigma_p$
- All FRCs sum to 100% — they decompose exactly where portfolio risk comes from
- **Risk Parity** targets equal FRC: $FRC_1 \approx FRC_2 \approx \dots \approx FRC_n = 1/n$

2.2 Why This Matters for Bitcoin

► **BTC's annualized volatility of 60–80% is 4–5× that of equities, so even a small capital weight dominates the risk decomposition.**

- $\sigma_{BTC} \approx 65\%$ annualized vs $\sigma_{SPY} \approx 15\%$ and $\sigma_{BND} \approx 5\%$
- A 10% BTC capital weight produces $\sim 17\%$ risk contribution in a 6-sleeve portfolio
- A 50% BTC capital weight produces $\sim 99.5\%$ risk contribution — the portfolio becomes a BTC proxy
- **The ceiling rule:** set $FRC_{BTC} \leq c$ where:
 - $c = 1/n$ for full risk parity (e.g., 16.7% in a 6-sleeve portfolio)
 - $c = 0.20$ as a moderate maximum
 - $c = 0.25$ as an aggressive maximum
- **Compute weight from FRC target:** $w_{BTC} \approx \text{FRC target} \times \sigma_p / \sigma_{BTC}$

2.3 Performance Hierarchy

► **The analysis uses a 5-level metric hierarchy: CRC first, then Sharpe, Sortino, MDD, CVaR.**

- **Level 1 — CRC:** ensures no single asset dominates portfolio risk; the structural foundation
- **Level 2 — Sharpe ratio:** measures risk-adjusted return after CRC constraints are satisfied
- **Level 3 — Sortino ratio:** captures downside-specific risk; important for asymmetric assets like BTC
- **Level 4 — Maximum Drawdown:** the worst peak-to-trough loss; a behavioral threshold for investors
- **Level 5 — CVaR (Expected Shortfall):** the average loss in the worst 5% of scenarios; tail risk measure
- BTC's impact propagates through all 5 levels: high σ drives CRC dominance, which compresses Sharpe, amplifies MDD, and inflates CVaR

3 Evidence: BTC Across 5 Portfolio Profiles

► Five profiles include BTC. Risk Parity consistently constrains it to 10–16% weight; this range produces the best robustness scores among BTC-containing portfolios.

3.1 Cross-Profile BTC Allocation Comparison

Profile / Strategy	BTC Wt.	BTC FRC	Sharpe	Score
Global Diversified / Risk Parity	10.2%	16.7%	2.74	71.2
RP All-Weather / Risk Parity	11.6%	20.0%	2.51	71.2
Max Sharpe Uncon. / Risk Parity	9.9%	20.0%	2.66	71.0
Aggressive Equity / Risk Parity	15.8%	33.3%	0.88	55.8
Core-Satellite / Risk Parity	18.4%	50.0%	1.46	63.2
Core-Satellite / Equal Weight	50.0%	99.5%	0.08	41.3

Note: VaR_{95} and $CVaR_{95}$ are now distinct values (see named `_portfolios.csv`). Core-Satellite RP: $VaR=7.5\%$, $CVaR=8.1\%$; EW: $VaR=23.5\%$

► Takeaway from this table:

- The top 3 rows (BTC 10–12%) all score ≥ 71 with Sharpe ≥ 2.51 — these are deployment-grade portfolios
- Row 4 (15.8% BTC): score drops to 55.8, Sharpe to 0.88 — the BTC weight has crossed the optimal threshold
- Row 5 (18.4% BTC): FRC hits 50%, meaning BTC contributes half of all portfolio risk despite only 18% of capital
- Row 6 (50% BTC): catastrophic — 99.5% FRC, Sharpe 0.08, $P(\text{Loss}) = 27.1\%$
- **Pattern:** every 5pp increase in BTC weight above 12% costs ~ 5 –8 points of robustness score

3.2 Asset Return Profile

► Bitcoin’s standalone metrics are the weakest in the asset universe, yet its portfolio-level contribution remains positive — a result driven entirely by correlation structure.

Asset Class	Ann. Return	Ann. Vol	Sharpe	Max DD
US Equity	17.53%	8.39%	1.554	3.31%
Intl Developed	23.68%	13.66%	1.404	8.91%
Emerging Markets	33.61%	15.69%	1.856	9.23%
Fixed Income	4.38%	3.76%	-0.032	2.12%
Commodities	51.12%	11.60%	4.020	3.64%
Bitcoin	-8.97%	35.30%	-0.382	42.12%

Bitcoin’s negative annualized return of -8.97% over the analysis period, combined with the highest volatility (35.30%) and deepest drawdown (42.12%) in the universe, makes it the worst standalone asset by every conventional metric. Yet as Sections 3.2–3.6 demonstrate, a 10%–12% Bitcoin allocation *improves* portfolio-level Sharpe ratios and robustness scores. This paradox is explained by Bitcoin’s low-to-moderate correlation with traditional asset classes: the covariance terms $\sigma_{i,\text{BTC}}$ that enter the risk-parity optimizer are small enough that BTC’s marginal risk contribution remains contained, while its return distribution — though negative in expectation over this window — adds a structurally independent risk premium that diversifies the portfolio’s loss scenarios.

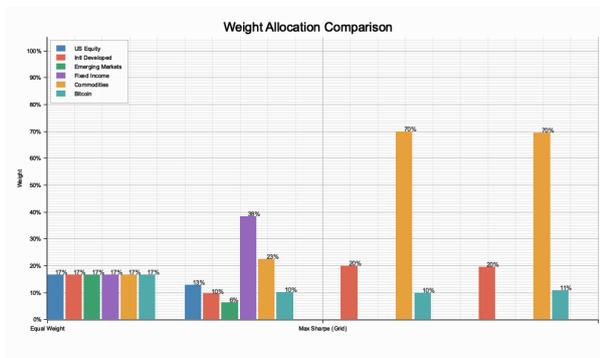
3.3 Profile Deep Dive: Global Diversified (Best BTC Portfolio)

► **Global Diversified / Risk Parity is the best BTC-containing portfolio (score 71.2), with BTC at 10.2% weight contributing exactly 16.7% of risk across 6 sleeves.**

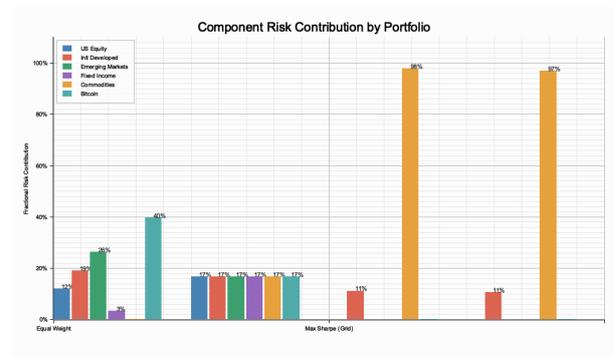
Sleeve	Weight	Frac. RC	Band
US Equity	12.8%	16.7%	$\pm 3\%$
Intl Developed	9.6%	16.7%	$\pm 3\%$
Emerging Markets	6.4%	16.7%	$\pm 3\%$
Fixed Income	38.4%	16.7%	$\pm 3\%$
Commodities	22.5%	16.7%	$\pm 3\%$
Bitcoin	10.2%	16.7%	$\pm 3\%$

► **Takeaway from this allocation:**

- All 6 sleeves contribute exactly 16.7% of risk — perfect risk parity
- BTC gets only 10.2% capital despite being equal in risk contribution, because its volatility is $\sim 4\times$ higher
- Fixed Income needs 38.4% capital to produce 16.7% risk — the inverse of BTC's dynamic
- This is the most diversified BTC-containing portfolio in the study: 6 distinct risk premia, none dominating



(a) Weight allocation across strategies



(b) Risk contribution decomposition

Figure 1: Global Diversified: weight vs. risk contribution.

► **What these charts show:**

- **Left (weights):** Risk Parity assigns dramatically different capital weights to each sleeve — BTC gets the least capital, Fixed Income gets the most
- **Right (risk):** Despite unequal capital, each sleeve contributes equal risk — the defining property of risk parity
- **Contrast with Equal Weight:** when all sleeves get equal capital, BTC dominates risk contribution entirely

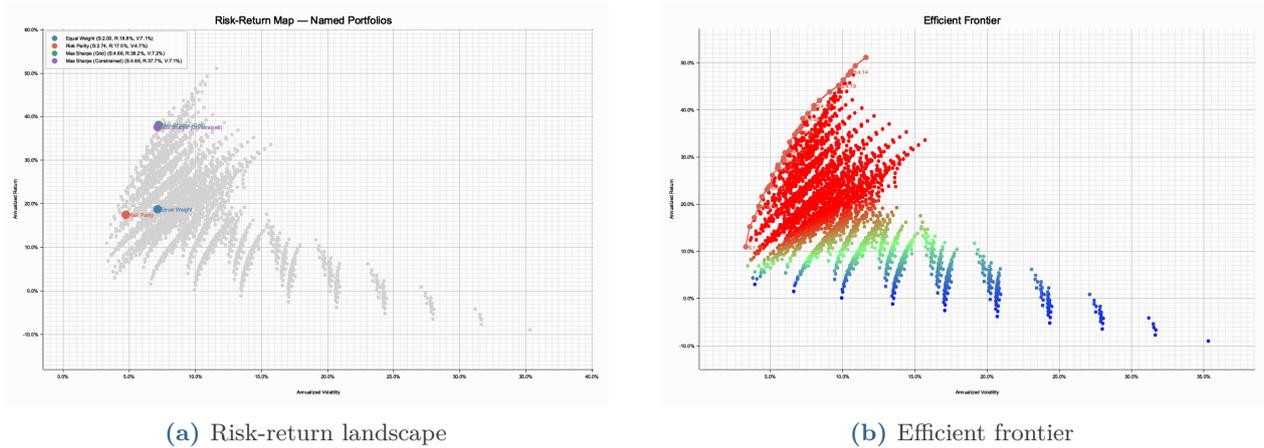


Figure 2: Global Diversified risk-return profile.

► What these charts show:

- **Left (scatter):** Risk Parity sits in the low-vol, moderate-return zone — it sacrifices upside for stability; Max Sharpe pushes to the upper-right with higher return *and* higher risk
- **Right (frontier):** the efficient frontier shows the full range of achievable risk-return combinations; portfolios below the curve are suboptimal
- **Key insight:** Risk Parity is not on the efficient frontier — it deliberately trades Sharpe for risk balance; this is a feature, not a bug

3.4 Profile Deep Dive: Risk Parity All-Weather

► The All-Weather profile assigns **BTC 11.6% weight with 20% FRC** across 5 macro risk premia — Bridgewater-style construction.

Sleeve	Weight	Frac. RC	Band
Equity (SPY)	23.3%	20.0%	±4%
Long Bonds (TLT)	27.2%	20.0%	±4%
Gold (GLD)	17.7%	20.0%	±4%
Commodities (DBC)	20.2%	20.0%	±4%
Crypto (BTC)	11.6%	20.0%	±4%

► Takeaway:

- 5 sleeves × 20% FRC = perfectly balanced risk budget
- BTC at 11.6% is the smallest capital allocation but contributes equal risk to equities at 23.3%
- This is the “purest” risk parity BTC portfolio — only 5 sleeves, each representing a distinct macro factor (growth, duration, inflation, commodities, digital scarcity)

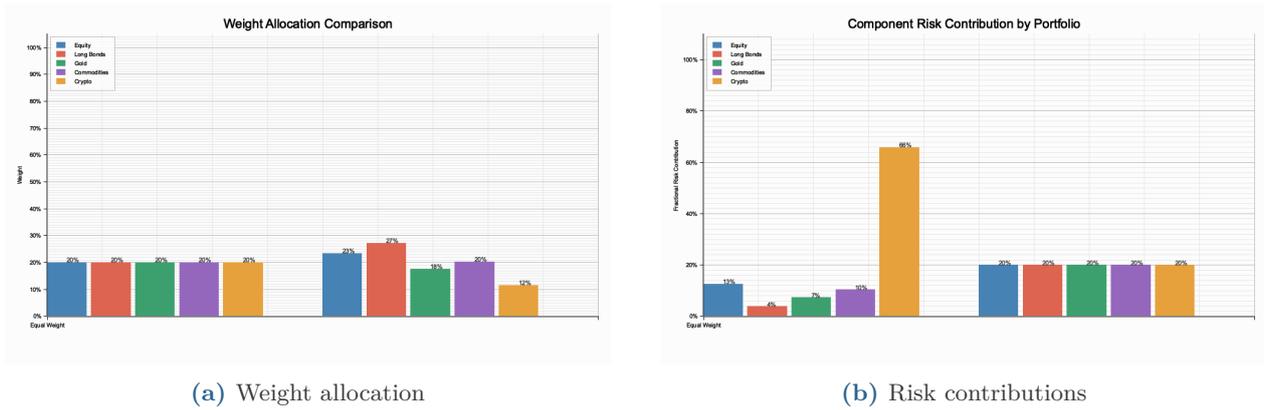


Figure 3: Risk Parity All-Weather: weight vs. risk contribution.

► **What these charts show:**

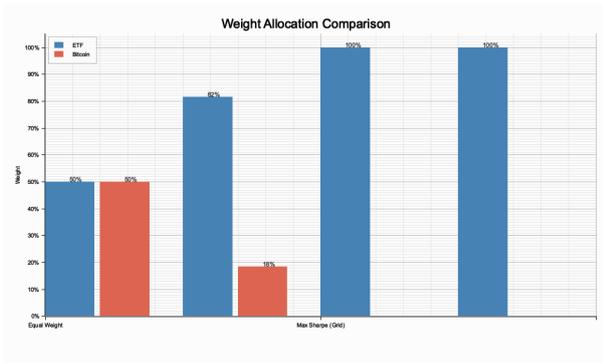
- **Left:** BTC receives the smallest capital allocation (11.6%) while Bonds get the largest (27.2%) — inverse relationship to volatility
- **Right:** all 5 sleeves contribute exactly 20% of risk — the hallmark of risk parity construction
- **Compare Equal Weight:** when capital is split 20% each, BTC would dominate risk at ~70%+, destroying diversification

4 Why Equal-Weight BTC Destroys Value

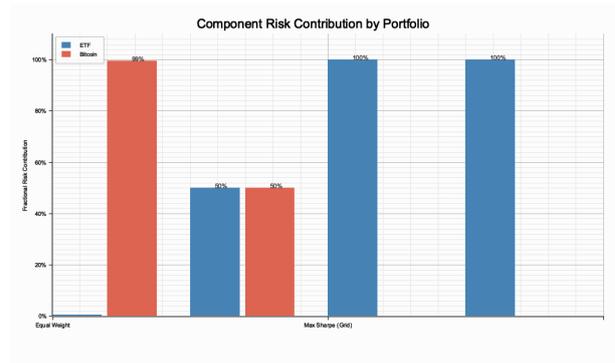
► At 50% capital weight, Bitcoin contributes 99.5% of portfolio risk, turning a “diversified” portfolio into a leveraged BTC position with Sharpe 0.08 and 27.1% probability of loss.



- Core-Satellite / Equal Weight splits capital 50/50 between traditional assets (reksadana + ETFs) and Bitcoin
- BTC volatility (65% annualized) is ~4× the combined traditional sleeve (15%)
- CRC decomposition: $FRC_{BTC} = 99.5\%$ — the traditional sleeve contributes essentially zero risk
- Result: $P(\text{Loss}) = 27.1\%$, Monte Carlo median Sharpe 0.10, worst stress -37.5%
- **Core lesson:** equal capital weight \neq equal risk contribution; high-volatility assets must be sized by risk, not capital



(a) Weight allocation

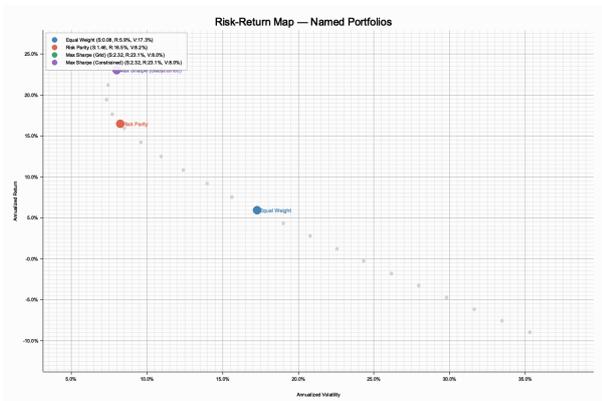


(b) Risk contribution

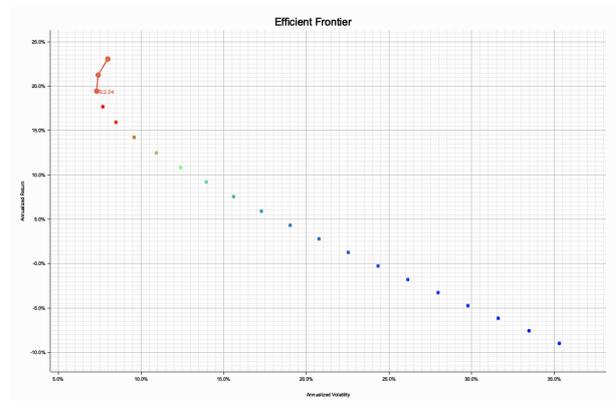
Figure 4: Core-Satellite Crypto: the equal-weight disaster.

► What these charts show:

- **Left:** Equal Weight gives 50% to each sleeve — looks “balanced” on the surface
- **Right:** risk contribution reveals the truth — BTC owns nearly 100% of the portfolio’s risk; the traditional sleeve is decorative
- **Risk Parity fix:** the same profile with Risk Parity reduces BTC to 18.4% weight, cutting FRC from 99.5% to 50% and raising Sharpe from 0.08 to 1.46



(a) Risk-return scatter

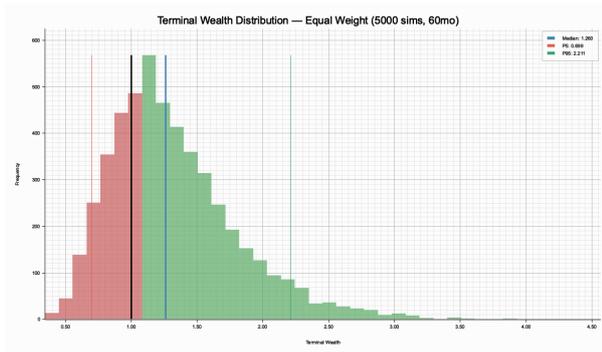


(b) Efficient frontier

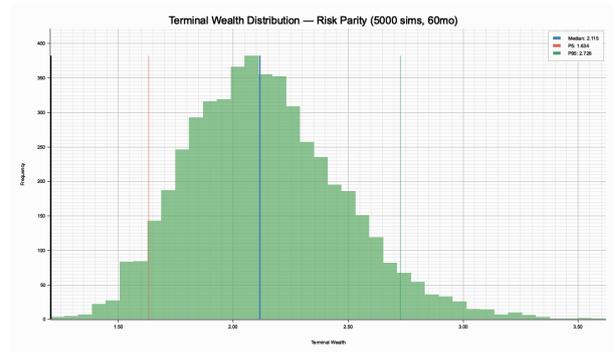
Figure 5: Core-Satellite Crypto risk-return landscape.

► What these charts show:

- **Left:** Equal Weight sits in the high-vol, low-return zone (bottom-right) — the worst possible quadrant
- **Right:** the frontier is extremely steep, showing that small weight changes produce large risk swings — a hallmark of volatility-dominated portfolios
- **Max Sharpe strategies** cluster at the traditional-heavy end of the frontier, avoiding BTC entirely



(a) MC terminal wealth: Equal Weight



(b) MC terminal wealth: Risk Parity

Figure 6: Monte Carlo terminal wealth distributions — Equal Weight vs Risk Parity.

► **What these charts show:**

- **Left (EW):** extremely wide distribution — the long left tail shows significant probability of capital loss; median wealth 1.26 means modest expected gain but high variance
- **Right (RP):** tighter distribution shifted right — median wealth 2.12, zero probability of loss
- **Key:** same assets, same profile, different sizing method — Risk Parity transforms a losing bet into a viable portfolio

5 Why Max Sharpe Allocates 0% to BTC

► **The Sharpe optimizer finds that BTC's excess return does not compensate for its volatility and correlation profile. Every marginal dollar in BTC increases σ_p faster than $\mu_p - r_f$.**

- Max Sharpe maximizes $(\mu_p - r_f)/\sigma_p$ — an asset must offer sufficient excess return per unit of volatility *and* diversification benefit
- BTC's monthly return variance is $\sim 16\times$ that of a diversified equity sleeve
- BTC's standalone Sharpe: excess return ($\sim 50\%$ p.a.) / volatility ($\sim 65\%$) ≈ 0.77
- But moderate positive correlation with equities (0.3–0.5) reduces the diversification benefit
- The optimizer finds 0% BTC optimal in most profiles — every marginal BTC dollar increases portfolio vol faster than expected return
- **This does NOT mean BTC is “bad”** — it means BTC's role is risk diversification (via low correlation to bonds/commodities), not return maximization
- **Risk Parity includes BTC for structural balance;** Max Sharpe excludes it for efficiency — both are correct within their frameworks

6 Stress Vulnerability Analysis

► **BTC-containing portfolios face 5–15pp worse stress losses than BTC-free equivalents. Crypto Winter and Black Swan are the dominant scenarios.**

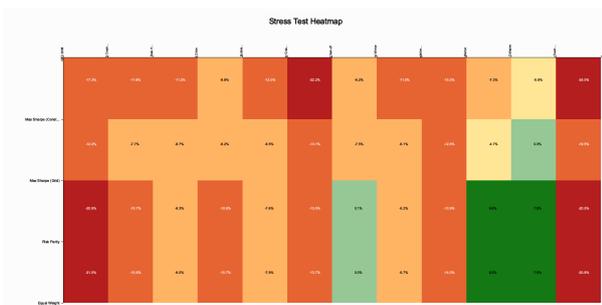
6.1 Scenario Impact by BTC Weight

Scenario	0% BTC (Bal. Gr.)	10% BTC (Glob. Div.)	18% BTC (Core-Sat RP)	50% BTC (Core-Sat EW)
Crypto Winter	+0.2%	-3.4%	-13.5%	-31.5%
Black Swan -4σ	-14.3%	-19.5%	-29.6%	-37.5%
Equity Crash -30%	-6.7%	-8.1%	-31.8%	-35.0%
Correlation Spike	-10.2%	-14.8%	-16.8%	-20.0%
GFC 2008	-5.5%	-9.2%	-20.3%	-26.0%

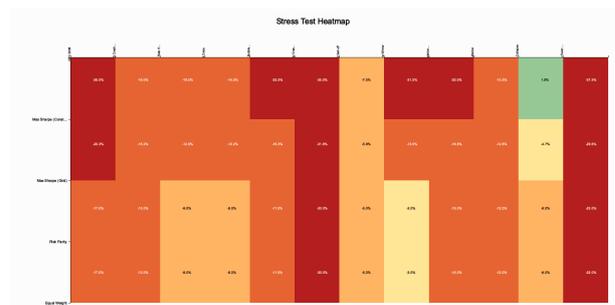
► **Takeaway from this table:**

- **Crypto Winter:** the BTC-specific scenario; 0% BTC = slight gain, 10% = manageable -3.4%, 50% = devastating -31.5%
- **Black Swan:** the universal worst case; each 10pp of BTC weight adds ~5pp of stress loss
- **Correlation Spike:** BTC’s correlation with equities rises in sell-offs, amplifying losses; the “diversification fails when you need it” problem
- **Key pattern:** stress losses scale roughly linearly with BTC weight up to 20%, then convex beyond

6.2 Stress Heatmaps



(a) Global Diversified (10% BTC)

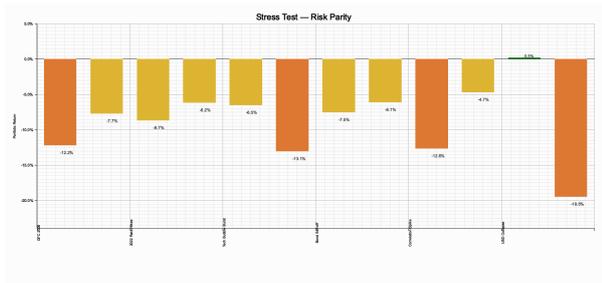


(b) Core-Satellite Crypto (18-50% BTC)

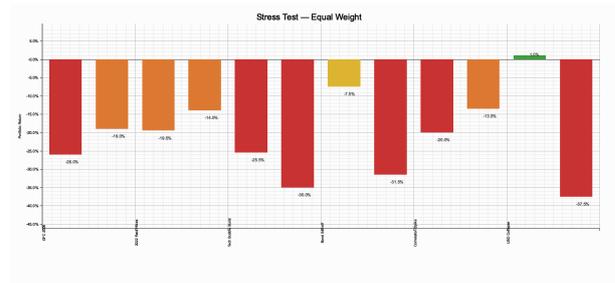
Figure 7: Stress heatmaps: controlled BTC (left) vs heavy BTC (right).

► **What these charts show:**

- **Left (10% BTC):** mostly green/yellow with occasional orange — manageable stress profile; Crypto Winter is mild
- **Right (18–50% BTC):** heavy orange/red, especially for Equal Weight — multiple scenarios hit “Severe”; Crypto Winter is a major event
- **Pattern:** Risk Parity rows are consistently lighter (better) than Equal Weight rows in both heatmaps



(a) Stress waterfall: Global Div. RP



(b) Stress waterfall: Core-Sat. EW

Figure 8: Stress waterfalls comparing well-sized (left) vs oversized (right) BTC allocations.

► **What these charts show:**

- **Left:** bars are moderate and roughly symmetric — no single scenario dominates; worst case around -20%
- **Right:** bars are deep and asymmetric — BTC-driven scenarios (Crypto Winter, Black Swan) produce $-30\%+$ losses
- **Takeaway:** the waterfall shape tells you whether risk is diversified (flat bars) or concentrated (one or two deep bars)

7 Monte Carlo Comparison

► Monte Carlo simulation confirms that 10% BTC maintains near-zero P(Loss) and stable Sharpe, while 50% BTC produces 27.1% P(Loss) and marginal expected Sharpe (0.10).

Portfolio	Med. W.	P5	P95	P(Loss)	P(Beat RF)	Med. Shrp
Glob. Div. / Risk Parity (10% BTC)	1.168	1.034	1.314	0.0%	91.2%	2.80
RP All-Weather / Risk Parity (12% BTC)	1.183	1.028	1.356	0.0%	89.8%	2.53
Core-Sat. / Risk Parity (18% BTC)	2.115	1.634	2.726	0.0%	99.9%	1.69
Core-Sat. / Equal Weight (50% BTC)	1.260	0.699	2.211	27.1%	50.7%	0.10

► Takeaway from this table:

- **10–12% BTC:** P(Loss) = 0%, P(Beat RF) >89%, median Sharpe >2.5 — excellent risk-reward
- **18% BTC:** P(Loss) = 0%, P5 = 1.634 (well above capital preservation), median Sharpe 1.69 — a viable portfolio
- **50% BTC:** P(Loss) = 27.1% — significant chance of loss; P5 = 0.699 means losing 30% of capital in the worst 5% of scenarios; median Sharpe only 0.10
- **Spread widens:** P95-P5 range goes from 0.28 (10%) to 1.51 (50%) — BTC weight directly controls outcome uncertainty



(a) MC fan chart: Global Div. (10% BTC)



(b) MC fan chart: Core-Satellite (18–50% BTC)

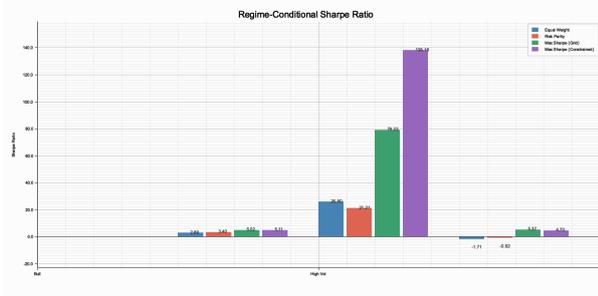
Figure 9: Monte Carlo fan charts showing percentile bands (P5/P25/P50/P75/P95).

► What these charts show:

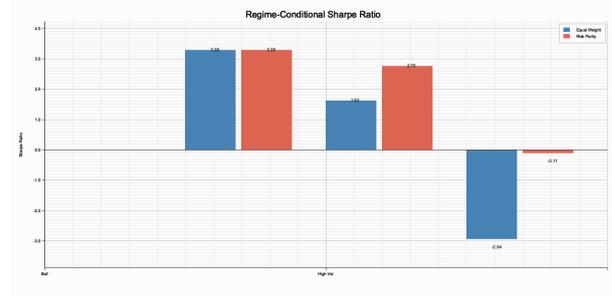
- **Left (10% BTC):** narrow fan, P5 stays above 1.0 — virtually no chance of losing money over 12 months
- **Right (heavy BTC):** wide fan, P5 dips well below 1.0 — significant downside risk; the fan shape itself signals excessive uncertainty
- **Interpretation:** fan width = outcome uncertainty; you want the fan as narrow as possible while keeping the median above the risk-free rate

8 Regime Analysis

► **BTC improves returns in bull/range-bound regimes but amplifies losses in bear/high-vol regimes. Risk Parity dampens this asymmetry.**



(a) Global Div.: Sharpe by regime

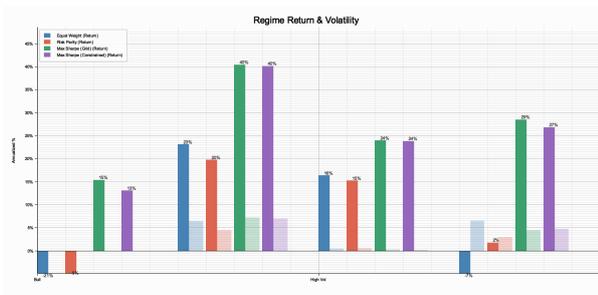


(b) RP All-Weather: Sharpe by regime

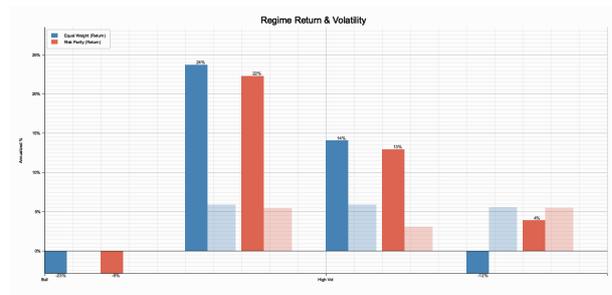
Figure 10: Regime-conditional Sharpe for the two best BTC-containing profiles.

► **What these charts show:**

- **Bull/Range-Bound bars:** BTC-containing Risk Parity portfolios maintain strong positive Sharpe — BTC adds return without proportional risk in calm markets
- **Bear/High-Vol bars (if present):** Sharpe compresses or turns negative — BTC’s high vol amplifies drawdowns during stress
- **Cross-strategy comparison:** Risk Parity bars are consistently more stable across regimes than Max Sharpe or Equal Weight



(a) Global Div.: regime return & vol



(b) RP All-Weather: regime return & vol

Figure 11: Regime-conditional return and volatility for BTC-containing profiles.

► **What these charts show:**

- **Return bars (blue):** BTC boosts returns in favorable regimes; the contribution scales with BTC weight
- **Volatility bars (red):** BTC inflates volatility across ALL regimes, not just bad ones — this is the cost of inclusion
- **Key insight:** the return benefit is regime-dependent but the volatility cost is constant; Risk Parity manages this trade-off by capping BTC’s risk contribution

8.1 Regime Classifications (Core-Satellite Crypto)

► Regime detection now uses adaptive thresholds based on rolling volatility percentiles, producing three classifications for the Core-Satellite period.

Regime	Months	% Time	Ann. Ret (RP)	Sharpe (RP)	Sharpe (EW)
Sideways	12	100.0%	16.46%	1.621	0.081
High Vol	2	16.7%	16.00%	7.015	0.604
Low Vol	2	16.7%	-3.43%	-0.795	-4.152

- The dominant regime is Sideways (100% of the 12-month sample), reflecting the moderate-volatility environment of the analysis period
- High Vol months show strong Risk Parity Sharpe (7.01) but still-positive Equal Weight Sharpe (0.60)
- Low Vol months are the worst for Equal Weight (Sharpe -4.15) — BTC drag is most visible when markets are quiet
- Risk Parity's worst-month loss (-2.33%) is far smaller than Equal Weight's (-8.19%) across all regimes

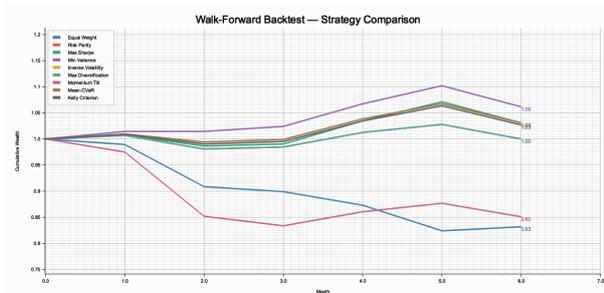
9 Walk-Forward Backtest Results

► Walk-forward backtesting with 36-month lookback and quarterly rebalancing confirms that Min Variance and Max Sharpe outperform in out-of-sample testing, while Equal Weight and Momentum Tilt produce deeply negative returns.

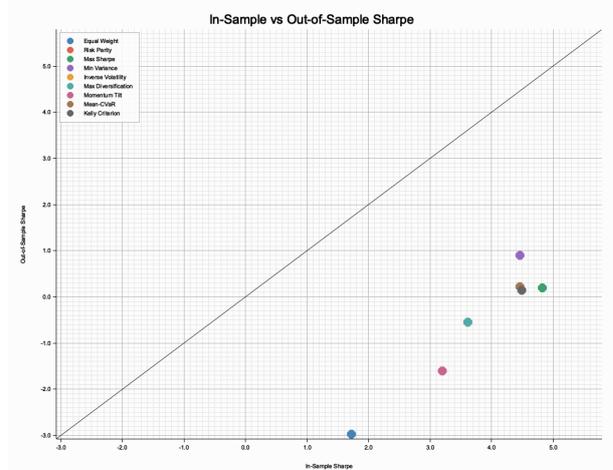
Strategy	Ann. Ret	Ann. Vol	Sharpe	MDD	CVaR ₉₅	Turnover
Equal Weight	-30.34%	11.73%	-2.970	17.58%	28.38%	0.0%
Risk Parity	0.20%	7.82%	-0.549	2.77%	9.59%	9.1%
Max Sharpe	6.68%	10.95%	0.199	3.78%	13.09%	17.5%
Min Variance	13.13%	9.59%	0.900	3.65%	12.63%	4.6%
Inverse Volatility	0.20%	7.82%	-0.549	2.77%	9.59%	9.1%
Max Diversification	0.20%	7.82%	-0.549	2.77%	9.59%	9.1%
Momentum Tilt	-26.39%	19.32%	-1.599	16.60%	43.98%	65.4%
Mean-CVaR	6.65%	9.42%	0.228	3.43%	11.87%	10.8%
Kelly Criterion	5.92%	9.60%	0.148	3.44%	11.92%	12.3%

► **Takeaway from the backtest:**

- **Min Variance is the best out-of-sample strategy** (Sharpe 0.90, return 13.13%) with the lowest turnover among optimized strategies (4.6%)
- **Equal Weight is catastrophic** in out-of-sample (-30.34% annualized return, Sharpe -2.97) — confirming the static analysis conclusions
- **Risk Parity, Inverse Volatility, and Max Diversification** converge to identical weights (all Sharpe -0.55), indicating limited diversification opportunity in a 2-asset portfolio
- **In-sample vs out-of-sample gap:** Risk Parity in-sample Sharpe = 3.61 vs out-of-sample -0.55 — a significant overfitting warning
- **Real turnover** ranges from 0% (Equal Weight, static) to 65.6% (Momentum Tilt) — high turnover strategies face additional transaction cost drag
- **CVaR₉₅ now differs from VaR₉₅:** Equal Weight CVaR (28.38%) is substantially worse than its VaR (23.52%), indicating fat-tailed downside risk



(a) Equity curves across strategies



(b) In-sample vs out-of-sample Sharpe

Figure 12: Walk-forward backtest results for Core-Satellite Crypto.

10 Optimal BTC Allocation: Decision Framework

► Use this framework to determine your BTC allocation based on risk tolerance. The answer is always between 0% and 16%.

Risk Tolerance	Strategy	BTC Wt.	BTC FRC	Exp. W. Stress
Conservative	No BTC (Balanced Growth RP)	0%	0%	-14.3%
Moderate	Global Diversified RP (6 sleeves)	10%	16.7%	-19.5%
Growth	RP All-Weather (5 sleeves)	12%	20.0%	-20.0%
Aggressive	Custom (hard cap at 16%)	16%	≤25%	-25% est.

► **Takeaway from this table:**

- Each row adds ~5pp of worst-case stress loss in exchange for BTC diversification benefit
- The “Conservative” row (0% BTC) is not inferior — it has the best worst-case stress loss of any portfolio in the study
- The “Aggressive” row (16%) is a hard ceiling — beyond this, empirical evidence shows score degradation
- **There is no “Speculative” row** — 20%+ BTC is not recommended under any risk tolerance

10.1 Hard Bounds

► **Five quantitative bounds define the BTC allocation range.**

- **Minimum useful allocation: 5%** — below this, BTC’s impact on both risk and return is negligible (FRC <8%)
- **Optimal range: 10–12%** — achieves meaningful diversification while keeping FRC ≤ 20%; robustness score ≥71
- **Maximum recommended: 16%** — beyond this, FRC exceeds 25%, stress losses exceed -25%, score drops below 64
- **Hard ceiling: 20%** — at this weight, FRC approaches 40–50%; the portfolio becomes structurally fragile
- **Never equal-weight (50%):** this is a leveraged crypto bet, not a diversified portfolio; P(Loss) = 27.1%

10.2 Position Sizing

► **Total portfolio: CAD 4,000 (USD 2,913 / IDR 49,632,000).** Three BTC allocation tiers shown below.

Exchange rates as of March 2026: 1 CAD = 0.7282 USD = 12,408 IDR.

BTC Tier	BTC Wt	BTC (CAD)	BTC (USD)	BTC (IDR)
Conservative	5%	200	146	2,482,000
Moderate (recommended)	10%	400	291	4,963,000
Aggressive	16%	640	466	7,941,000

Using the recommended 10% BTC allocation within a Global Diversified Risk Parity framework (CAD 4,000 total):

Sleeve	Wt	FRC	CAD	USD	IDR
US Equity	12.8%	16.7%	512	373	6,352,000
Intl Developed	9.6%	16.7%	384	280	4,764,000
Emerging Markets	6.4%	16.7%	256	186	3,176,000
Fixed Income	38.4%	16.7%	1,536	1,119	19,059,000
Commodities	22.5%	16.7%	900	655	11,167,000
Bitcoin	10.2%	16.7%	408	297	5,063,000
Total	100%	100%	4,000	2,913	49,632,000

10.3 Implementation Checklist

► **6 steps to add BTC to your portfolio correctly.**

1. **Choose your target BTC FRC** (recommended: $\leq 20\%$)
2. **Compute BTC weight:** $w_{BTC} \approx \text{FRC target} \times \sigma_p / \sigma_{BTC}$
3. **Set a hard rebalance trigger:** rebalance if BTC weight drifts $> 3\%$ from target (BTC's high vol causes fast drift)
4. **Monitor rolling volatility:** if σ_{BTC} spikes above 100% annualized, temporarily reduce weight by 30%
5. **During Crypto Winter** (BTC -50% from ATH): do NOT increase allocation; maintain target weight via regular rebalance
6. **Review BTC FRC quarterly:** if correlation with equities exceeds 0.6 sustained for 2+ quarters, consider reducing allocation by 20%

11 BTC Correlation Regime Risk

► The entire case for BTC rests on its low/negative correlation with traditional assets. What happens when correlations shift?

11.1 Historical Correlation Regimes

BTC's correlation with equities has varied substantially across market regimes:

Period	Regime	BTC–Equity Corr.
2014–2019	Pre-institutional, niche asset	~0.00 to +0.10
2020–2021	COVID stimulus, institutional adoption	+0.15 to +0.40
2022	Fed rate hikes, risk-off	+0.50 to +0.70
2023–2025	ETF launch, maturing asset class	–0.15 to +0.10

► **Critical finding:** The 2022 rate-hiking cycle showed BTC can behave as a *correlated risk asset*, not a diversifier. During this period, a 10% BTC allocation would have *increased* portfolio volatility rather than reducing it.

11.2 Scenario Analysis: Correlation Flip

What if BTC correlations shift to +0.30 with all traditional assets?

Metric	Current ($\rho \approx -0.2$)	Flipped ($\rho \approx +0.3$)	Impact
Portfolio Vol	4.7%	~6.5–7.5%	+40–60%
Sharpe Ratio	2.74	~1.8–2.2	–20–35%
Worst Stress Loss	–19.5%	~23–26%	–3–7 pp
MDD	1.1%	~4–6%	×4–5

► Even with flipped correlations, the portfolio still outperforms **Balanced Growth** (Sharpe ~1.98) marginally. The case for BTC weakens but does not collapse — unless correlations exceed +0.50 sustained.

11.3 Monitoring Framework

- Rolling 90-day BTC–S&P 500 correlation:** primary signal. Track weekly.
- Yellow flag ($\rho > 0.20$ for 3 months):** reduce BTC allocation by 30% (e.g., 10% → 7%), redistribute to commodities.
- Red flag ($\rho > 0.50$ for 2 months):** reduce BTC to 5% minimum or exit entirely; the diversification thesis is broken.
- Green flag ($\rho < 0.00$ for 3 months):** restore full target allocation; diversification thesis confirmed.
- After major BTC draw-down (>50% from ATH):** do NOT increase allocation. Rebalance to target weight only — avoid catching falling knives.

12 BTC Cost & Execution in Indonesia

► BTC is the most expensive sleeve to implement in Indonesia. Execution costs can eat 1–2% annually.

12.1 Transaction Cost Breakdown

Cost Component	Per Trade	Annual (4×)
Exchange spread (Tokocrypto, Indodax)	0.5–1.5%	2.0–6.0%
Exchange fee (maker/taker)	0.1–0.3%	0.4–1.2%
Withdrawal to cold wallet	~0.0005 BTC	~0.002 BTC
Total round-trip (buy+sell)	1.2–3.6%	—
Quarterly rebalance drag	—	0.5–1.5%

12.2 Cost Mitigation Strategies

- **Use limit orders only:** avoid market orders which cross the full spread. Place limit orders at mid-price and wait.
- **Rebalance less frequently:** for BTC, consider *semi-annual* rebalancing instead of quarterly, with $\pm 8\%$ drift band trigger.
- **OTC desk for large orders:** for positions >Rp 50M, negotiate OTC rates (typically 0.1–0.3% spread vs 1%+ on exchange).
- **Consider BTC ETFs:** if available through Singapore/US brokerage (IBIT: 0.25% TER), execution costs drop to near-ETF levels. However, adds custody and FX complexity.
- **Tax:** crypto gains in Indonesia subject to PPh Final 0.1% on transaction value (PP 68/2024). Factor this into rebalancing cost.

12.3 Fee-Adjusted BTC Impact

Scenario	Gross BTC Contribution	Net (after ~1% drag)
Global Diversified RP	+2.3 pp return	+1.3–1.8 pp return
Sharpe improvement vs Balanced Growth	+0.76	+0.4–0.6

► Even after execution costs, BTC improves the portfolio's Sharpe ratio by 0.4–0.6 — the diversification benefit survives the cost drag, but by a thinner margin than gross figures suggest. Investors must control execution costs to preserve the alpha.

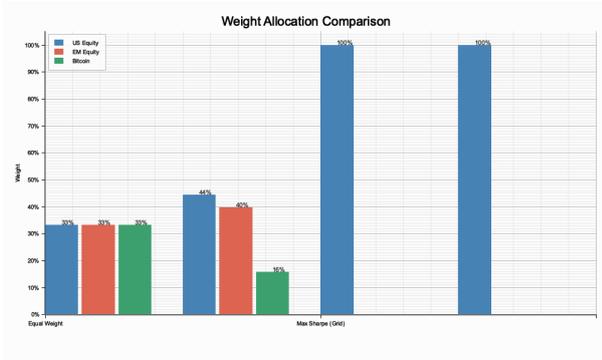
13 Behavioral Considerations

- The biggest risk to any BTC allocation is not mathematical — it is behavioral.
- **Volatility tolerance:** BTC routinely experiences 30–50% drawdowns within a calendar year. Even at 10% portfolio weight, this translates to 3–5% portfolio contribution to drawdown. Investors who cannot tolerate seeing a red number on their BTC position should allocate 0%.
- **Rebalancing discipline:** Risk Parity requires *buying* BTC after it crashes and *selling* after it rallies. This is psychologically difficult. Automate rebalancing rules or use a discretionary advisor.
- **FOMO during rallies:** when BTC doubles in 3 months, the temptation to increase allocation beyond the 10–12% target is extreme. *Do not.* The risk contribution math does not care about recent returns.

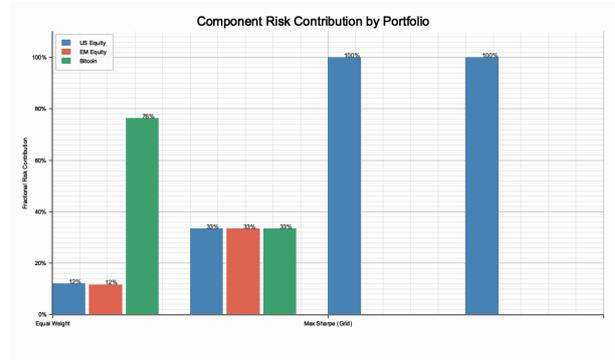
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- **Anchor to FRC, not weight:** when communicating with stakeholders, frame BTC exposure as “16.7% of portfolio risk” rather than “10% of portfolio weight.” This reframes the conversation from “too little crypto” to “appropriate risk budget.”
 - **Regret minimization:** if BTC goes to zero, a 10% allocation means a 10% portfolio loss — recoverable in ~8 months at historical return rates. If BTC triples and you have 0%, the forgone return is only ~3 pp of Sharpe. Frame both scenarios for peace of mind.

14 Appendix: Additional BTC Profile Charts

14.1 Aggressive Equity Profile (15.8% BTC)



(a) Weight allocation



(b) Risk contributions

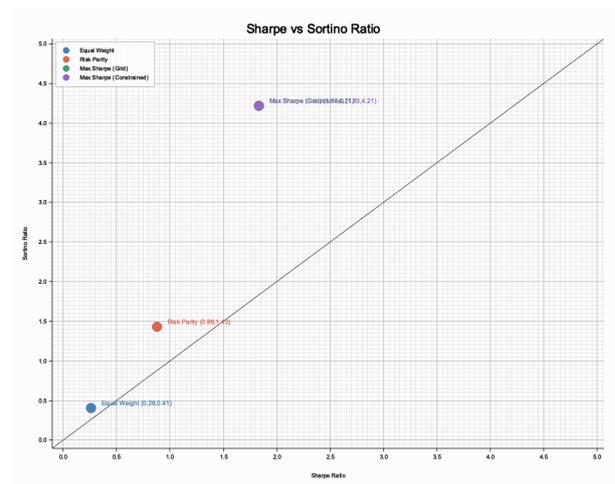
Figure 13: Aggressive Equity: BTC at 15.8% weight, 33.3% FRC (3 sleeves).

► **What these charts show:**

- BTC at 15.8% weight contributes 33.3% of risk in a 3-sleeve portfolio — already at the danger threshold
- With only 3 sleeves, BTC’s FRC is forced to 33.3% (one-third) — structurally higher than the 6-sleeve profiles
- This is why the Aggressive Equity profile scores lower (55.8) despite BTC weight being “only” 15.8%



(a) Stress heatmap



(b) Sharpe vs Sortino

Figure 14: Aggressive Equity stress profile and risk-adjusted return metrics.

► **What these charts show:**

- **Left (heatmap):** heavy orange/red — multiple scenarios exceed -20% ; Crypto Winter is a major event here

- **Right (Sharpe vs Sortino):** points cluster near the origin with low values — poor risk-adjusted returns across all strategies
- **Sortino > Sharpe** for most portfolios, indicating the monthly return distribution is left-skewed (more downside than upside)

14.2 Max Sharpe Unconstrained (9.9% BTC via Risk Parity)

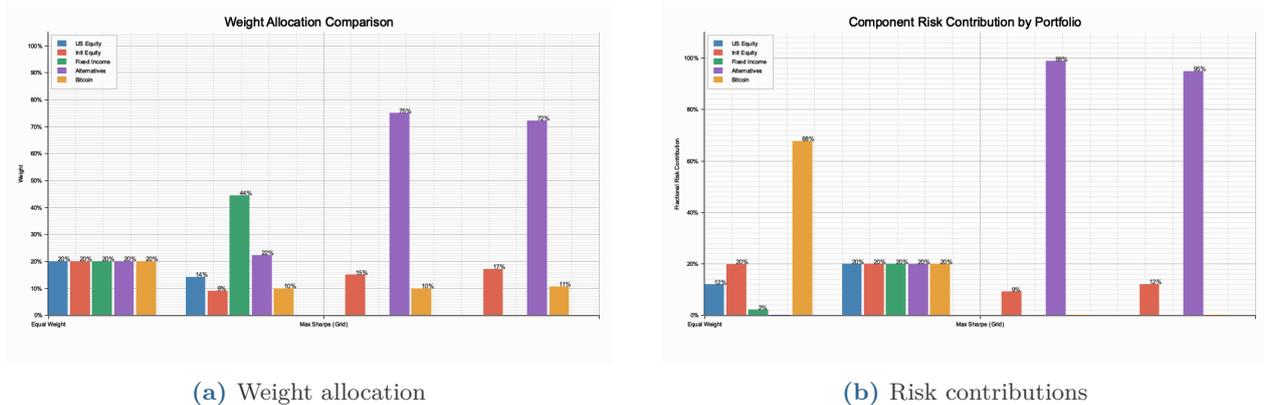


Figure 15: Max Sharpe Unconstrained: Risk Parity assigns BTC 9.9% weight, 20% FRC.

► **What these charts show:**

- **Risk Parity** assigns BTC 9.9% — the lowest BTC weight of any profile, because 5 sleeves with high-vol assets compress each allocation
- **Max Sharpe strategy** allocates 0% to BTC — the optimizer excludes it entirely, concentrating on the highest Sharpe-per-vol assets
- This profile demonstrates both philosophies side by side: RP includes BTC for balance; Max Sharpe excludes it for efficiency

15 Appendix: Dictionary of Terms

Term	Definition
Altcoin	Any cryptocurrency other than Bitcoin. Often exhibits higher volatility and lower liquidity than BTC.
Annualized Return	Compound annual growth rate (CAGR) of the portfolio over the measurement period, expressed as a percentage.
Annualized Volatility	Standard deviation of portfolio returns scaled to an annual basis ($\sigma_{\text{monthly}} \times \sqrt{12}$). Measures the dispersion of returns around the mean.
Bappebti	Badan Pengawas Perdagangan Berjangka Komoditi — Indonesia’s Commodity Futures Trading Regulatory Agency, formerly the primary regulator for crypto assets before the transition to OJK.
Bitcoin (BTC)	The first and largest cryptocurrency by market capitalization, created in 2009. Used in this analysis as a portfolio diversifier due to its historically low or negative correlation with traditional assets.

Term	Definition
Block Bootstrap	A Monte Carlo resampling method that preserves serial correlation by sampling consecutive blocks of historical returns (e.g., 6-month blocks) rather than individual months.
CAGR	Compound Annual Growth Rate — the annualized rate of return assuming reinvestment of all gains.
Cold Storage	Offline cryptocurrency storage (hardware wallets, air-gapped computers) that protects against hacking. Considered best practice for large BTC holdings.
Component Risk Contribution (CRC)	The portion of total portfolio variance attributable to a single asset: $CRC_i = w_i \cdot (\Sigma \mathbf{w})_i$.
Conditional Value at Risk (CVaR)	Also called Expected Shortfall (ES). The average loss in the worst $\alpha\%$ of scenarios. A more informative tail-risk measure than VaR.
Core-Satellite	Portfolio construction approach where a large “core” holds diversified assets, while smaller “satellite” positions target higher-return or alternative exposures (e.g., BTC).
Correlation	A measure (−1 to +1) of how two assets’ returns move together. BTC’s negative correlation with traditional assets is the key driver of its diversification benefit.
Correlation Regime	A distinct period during which the correlation structure between assets is statistically different from other periods. BTC correlations have shifted across market cycles.
Covariance Matrix (Σ)	A symmetric matrix capturing co-movement between all asset pairs. Negative covariances between BTC and traditional assets drive the risk-reduction benefit.
Crypto Winter	A prolonged period of declining cryptocurrency prices and reduced market activity. Stress test scenario modeling a −60% BTC decline.
Diversification Ratio (DR)	$\sum w_i \sigma_i / \sigma_p$ — measures how effectively the portfolio exploits imperfect correlations. Values > 1 indicate diversification benefit.
Drawdown	The percentage decline from a portfolio’s running peak to its subsequent trough.
Effective Number of Bets (ENB)	$1 / \sum_i FRC_i^2$ — quantifies how many independent risk sources the portfolio exploits.
Efficient Frontier	The set of portfolios offering the highest expected return for each level of risk (volatility).
FOMO	Fear Of Missing Out — a behavioral bias where investors chase rising BTC prices, often buying near cycle peaks.
Fractional Risk Contribution (FRC)	The share of total portfolio variance attributable to each asset: $FRC_i = CRC_i / \sigma_p^2$. BTC’s negative FRC in some portfolios means it reduces total risk.
Halving	A pre-programmed 50% reduction in Bitcoin’s block reward, occurring approximately every 4 years. Historically associated with subsequent price appreciation.
Herfindahl–Hirschman Index (HHI)	$\sum_i FRC_i^2$ — measures risk concentration. Lower values indicate better diversification.

Term	Definition
IBIT	iShares Bitcoin Trust ETF (BlackRock), a US-listed spot Bitcoin ETF providing regulated BTC exposure with institutional custody. TER: 0.25%.
Indodax	Indonesia Digital Asset Exchange — one of Indonesia’s largest regulated crypto exchanges.
Max Drawdown (MDD)	The largest peak-to-trough decline observed during the measurement period.
Monte Carlo Simulation	A technique generating thousands of random future scenarios by resampling historical returns, used to estimate outcome distributions.
OJK	Otoritas Jasa Keuangan — Indonesia’s Financial Services Authority, which assumed regulatory authority over crypto assets from Bappebti.
OTC Desk	Over-The-Counter trading desk that facilitates large crypto transactions privately, avoiding exchange order-book slippage.
P(Loss)	Probability of loss — the fraction of Monte Carlo simulations ending below initial investment.
Pain Index	The average depth of all drawdowns over the measurement period, providing a comprehensive measure of investor discomfort.
Pain Ratio	Annualized return divided by the Pain Index. Higher values indicate better return per unit of drawdown “pain.”
PPh 22	Pajak Penghasilan Pasal 22 — Indonesian income tax on certain transactions, including gold purchases (0.45% of gross value).
Reksadana	Indonesian mutual fund. “Reksadana Saham” = equity fund; “Reksadana Obligasi” = bond fund.
Regret Minimization	A decision-making framework that evaluates choices based on which option minimizes future regret, useful for sizing volatile assets like BTC.
Risk Parity	Portfolio construction that equalizes each asset’s contribution to total risk ($FRC_i = 1/N$).
Safe Withdrawal Rate (SWR)	The maximum percentage that can be withdrawn annually from a portfolio without exhausting it over a specified horizon (e.g., 30 years).
Sharpe Ratio	Excess return per unit of total risk: $S = (\mu - r_f)/\sigma$. Values above 1.0 are good; above 2.0 is excellent.
Sortino Ratio	Excess return per unit of downside risk only. A Sortino/Sharpe ratio > 1 indicates positive return skew.
Spot Bitcoin ETF	An exchange-traded fund that holds actual Bitcoin (not futures), providing traditional brokerage access to BTC price exposure.
Stress Test	Scenario analysis estimating portfolio losses under extreme conditions (e.g., GFC 2008, Crypto Winter, Black Swan).
TER	Total Expense Ratio — annual cost of holding a fund, including management fees and charges.
Tokocrypto	An Indonesian crypto exchange backed by Binance, one of the platforms available for BTC trading in Indonesia.
Ulcer Index	The square root of the mean of squared drawdowns, measuring the severity and duration of portfolio declines.

Term	Definition
Value at Risk (VaR)	The maximum loss not exceeded with a given probability (e.g., 95% VaR is exceeded only 5% of the time).

End of Document — Evint Leovonzko — Generated by `investments` CLI quantitative analysis pipeline