

Is Diversification Enough When Markets Crash? Downside Risk and Conditional Value-at-Risk Allocation in Nigeria.

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Abstract: Investors in Nigerian equities have lived through severe losses, including a fall of about 70 per cent in 2008–2009 and a 30 per cent loss in the single month of January 2009. This paper asks whether simple diversification protects against such losses, or whether allocation rules that target tail risk directly do better. Using monthly All-Share Index returns and twelve-month deposit rates from the Central Bank of Nigeria for February 2007 to December 2025 (227 months), I compare equities only, deposits only, a fixed 50/50 mix, a volatility-managed rule and a conditional value-at-risk (CVaR) budget rule that holds the largest equity weight whose historical 95 per cent CVaR over the previous 36 months stays above –5 per cent a month. All weights use past information only. The fixed 50/50 mix halved the 95 per cent CVaR of equities, from –14.7 to –6.9 per cent a month (block-bootstrap 95% interval for the improvement: 4.9 to 11.2 points), and cut the maximum drawdown from 70 to 39 per cent. The CVaR rule did not improve on it. Because the three years before 2008 had been calm, the rule held 85 per cent equities going into the crash, and over the full sample it delivered lower growth (8.6 against 9.3 per cent a year) and a slightly worse realised CVaR (–7.7 per cent) than the fixed mix. A pure minimum-CVaR rule is degenerate, holding no equities in 95 per cent of months. Tighter loss limits reduce drawdowns, but the results are sensitive to the limit and window chosen. In Nigeria, plain diversification did most of the work of downside protection; tail-risk rules estimated from recent history arrived too late.

Keywords: downside risk; conditional value at risk; expected shortfall; portfolio allocation; drawdown; Nigeria

JEL classification: G11; G12; G17

1. INTRODUCTION

Investors do not experience risk symmetrically. A month in which the market rises by 10 per cent is pleasant; a month in which it falls by 30 per cent can force a pension fund to sell, wipe out a household's savings or end a fund manager's career. Nigerian equity investors know this better than most. Between March 2008 and March 2009 the All-Share Index lost about 70 per cent of its value, and in January 2009 alone it fell by 30 per cent. The index fell by 19 per cent in March 2020 and by 17 per cent in January 2016. An investor who held only equities through 2007–2025 would have seen negative returns in almost half of all months.

Traditional portfolio theory measures risk by variance (Markowitz, 1952), which treats gains and losses alike. A long line of work argues that investors care more about losses than about gains. Roy (1952) proposed a safety-first rule that minimises the probability of falling below a disaster level. Kahneman and Tversky (1979) showed that people weigh losses more heavily than equivalent gains. Sortino and van der Meer (1991) proposed measuring risk only by deviations below a target. Ang et al. (2006) found that stocks with greater sensitivity to market downturns earn higher average returns, which suggests that investors demand compensation for downside risk in particular.

Conditional value at risk (CVaR), also known as expected shortfall, has become the standard measure of tail loss. It is the average loss in the worst outcomes beyond a given quantile. Artzner et al. (1999) show that it satisfies a set of desirable properties for a risk measure, which value at risk does not, and Rockafellar and Uryasev (2000) show that portfolios can be optimised with respect to CVaR using linear programming. In principle, an investor worried about crashes can choose weights that keep CVaR within a budget.

In practice, every CVaR rule must estimate tail risk from past data, and the past may be a poor guide to the next crash. DeMiguel et al. (2009) show that estimation error often makes optimised portfolios worse than naive equal weighting. Tail estimates are especially fragile, because they rest on a handful of extreme observations. The question for a

Nigerian investor is therefore practical: does a rule that explicitly targets tail risk protect her better than a simple fixed mix?

This paper answers that question with nineteen years of monthly data. It makes three contributions. First, it documents the downside risk of Nigerian equities and of simple equity–deposit mixes, using CVaR, value at risk, downside deviation and drawdown, and it tests whether the reduction in tail risk from diversification is statistically reliable. Second, it implements a well-posed CVaR budget rule, shows why a naive minimum-CVaR rule is degenerate in this setting, and compares both with volatility management and a fixed mix. Third, it examines how each rule performed in specific crash and recovery episodes and how sensitive the CVaR rule is to its parameters.

Section 2 reviews the literature. Section 3 describes the data, Section 4 the strategies and measures, and Section 5 the results. Section 6 discusses the findings and Section 7 concludes.

2. LITERATURE REVIEW

2.1 Downside risk

Markowitz (1952) introduced variance as the measure of portfolio risk, but he also discussed semivariance as an alternative more closely aligned with investors' concerns. Roy (1952) argued that investors seek to minimise the chance of disaster. Sortino and van der Meer (1991) developed downside deviation and the ratio that bears Sortino's name. Estrada (2007) shows that in emerging markets downside measures explain the cross-section of returns better than variance-based ones. Ang et al. (2006) find that US stocks with high downside betas earn a premium of about 6 per cent a year. Longin and Solnik (2001) show that correlations between international equity markets rise in bear markets but not in bull markets, which means that diversification across equity markets offers least protection when it is most needed. For a Nigerian investor, diversifying into deposits, whose returns do not fall in a crash, avoids this problem.

2.2 Value at risk and conditional value at risk

Value at risk (VaR) at the 95 per cent level is the loss exceeded in 5 per cent of periods. It says nothing about how large losses beyond that threshold are. Artzner et al. (1999) set out axioms for a coherent risk measure and show that VaR is not coherent because it does not always reward diversification. CVaR, the expected loss conditional on exceeding VaR, is coherent. Rockafellar and Uryasev (2000) show that minimising CVaR can be written as a linear program, and Krokmal et al. (2002) show how to optimise expected returns subject to CVaR constraints. These methods are widely used by banks and asset managers. Their effectiveness depends on how well the historical scenarios used to estimate CVaR represent future losses.

2.3 Estimation risk and simple rules

DeMiguel et al. (2009) compare fourteen optimised strategies with a naive 1/N rule and find that none consistently outperforms it out of sample, because the gains from optimisation are smaller than the losses from estimation error. Moreira and Muir (2017) show that scaling exposure inversely to recent volatility can improve risk-adjusted returns, since volatility is persistent while expected returns do not rise proportionally with it. Volatility is easier to estimate than tail risk, so volatility management may succeed where tail-risk rules struggle.

2.4 The Nigerian market

The Nigerian equity market shows volatility clustering, fat tails and leverage effects, with negative shocks raising future volatility more than positive ones (Emenike, 2010; Atoi, 2014). These features mean that the largest losses are concentrated in a few episodes and that calm periods can give little warning of what follows. Omotor (2010) finds that Nigerian equities may hedge inflation in the long run, but the very long recovery after 2008–2009 means that this long run can be very long indeed.

2.5 Hypotheses

H1: A fixed 50/50 mix of equities and deposits does not reduce tail risk relative to equities alone.

H2: A CVaR-budget rule does not reduce tail risk or improve growth relative to a fixed 50/50 mix.

3. DATA

3.1 Sources and returns

Monthly values of the All-Share Index of the Nigerian Exchange come from Table A.19.1 of the Central Bank of Nigeria (CBN) Statistical Bulletin 2024, Financial Sector (Central Bank of Nigeria, 2025), extended to December 2025

with Table A.12 of the CBN's fourth-quarter 2025 bulletin (Central Bank of Nigeria, 2026c). The twelve-month deposit rate comes from the CBN money-market indicators (Central Bank of Nigeria, 2026b), and inflation and the naira-dollar rate from the CBN releases (Central Bank of Nigeria, 2026a). The equity return is the monthly percentage change in the index, without dividends. The deposit return is last month's annual twelve-month deposit rate divided by twelve, a stylised accrual rather than the return on a traded instrument.

3.2 Sample

The first twelve monthly returns are used only to estimate initial volatility, and the CVaR rule requires at least 24 months of history, during which it holds 50 per cent equity. The evaluation sample is February 2007 to December 2025, 227 months. With 227 months, the 5 per cent tail contains about twelve observations, so tail statistics rest on a small number of months and should be read with that in mind.

3.3 The tail of Nigerian equity returns

The five worst monthly equity returns in the sample were -30.6 per cent (January 2009), -21.4 per cent (October 2008), -18.8 per cent (March 2020), -16.5 per cent (January 2016) and -15.1 per cent (March 2009). Three of the five fell within the single crash of 2008–2009. This concentration is the central challenge for any rule that estimates tail risk from recent history: in early 2008, the previous three years contained no month resembling what was about to happen.

4. STRATEGIES AND MEASURES

4.1 Strategies

Five strategies are compared.

1. **Equity only.**
2. **Deposit proxy.**
3. **Balanced 50/50**, rebalanced monthly.
4. **Volatility-managed:** equity weight $w_t = \min(1, 0.15/\sigma_{t-1})$, where σ_{t-1} is the annualised standard deviation of the previous twelve monthly equity returns.
5. **CVaR budget:** at the start of each month, for each equity weight $w \in \{0, 0.05, \dots, 1\}$, compute the historical 95 per cent CVaR of the hypothetical portfolio $w r^E + (1 - w) r^D$ over the previous 36 months. Choose the largest w for which

$$\text{CVaR}_{0.95}(w) \geq -5\%,$$

that is, the largest equity weight whose average loss in the worst 5 per cent of past months is no worse than 5 per cent a month. This follows the logic of the CVaR-constrained optimisation of Krokmal et al. (2002), maximising exposure to the higher-return asset subject to a tail-loss budget.

A natural alternative would be to choose the weight that minimises historical CVaR outright, in the spirit of Rockafellar and Uryasev (2000). In this two-asset setting that rule is degenerate. Because the deposit leg never produces a loss, the minimum-CVaR portfolio is almost always 100 per cent deposits; in the sample it holds no equities in 94.7 per cent of months and behaves like the deposit proxy. I therefore use the CVaR budget rule as the tail-risk strategy and report the minimum-CVaR result only for completeness.

4.2 Measures

For each strategy I report the compound annual growth rate (CAGR), annualised volatility, annualised downside deviation below zero, monthly 5 per cent VaR (the 5th percentile of monthly returns), monthly 95 per cent CVaR (the mean of returns at or below that percentile), maximum drawdown, the share of negative months, the Sharpe and Sortino ratios with the deposit return as the benchmark, and real and US dollar CAGRs.

4.3 Inference and robustness

The statistical reliability of differences in CVaR and CAGR is assessed with a paired moving-block bootstrap of monthly returns, with twelve-month blocks and 2,000 replications. The sensitivity of the CVaR rule is examined for loss limits of 3, 5, 7 and 10 per cent and look-back windows of 24, 36 and 60 months. Performance in four episodes is reported separately: the 2008–2009 crash, the 2016 recession, the pandemic shock of early 2020 and the rally of 2023–2025.

5. RESULTS

5.1 Overall performance

Table 1 reports the main results. Equities alone had a monthly CVaR of −14.7 per cent: in the worst twelve months, the average loss was almost 15 per cent. Their maximum drawdown was 69.8 per cent, and they grew more slowly (7.9 per cent a year) than deposits (8.9 per cent). The 50/50 mix halved every risk measure. Its CVaR was −6.9 per cent, its downside deviation 7.1 per cent a year and its maximum drawdown 39.1 per cent, while its growth rate of 9.3 per cent a year was higher than that of either component.

Table 1 Downside risk and performance of five strategies, February 2007 – December 2025 (227 months)

Measure	Equity only	Deposit proxy	Balanced 50/50	Volatility-managed	CVaR budget (5%)
CAGR (%)	7.92	8.91	9.30	10.84	8.64
Volatility (%)	25.76	0.82	12.87	18.64	12.59
Downside deviation (%)	15.51	0.00	7.13	10.24	7.27
Monthly VaR, 5% (%)	−9.06	0.38	−4.04	−6.02	−3.98
Monthly CVaR, 5% (%)	−14.66	0.34	−6.91	−10.21	−7.71
Maximum drawdown (%)	−69.76	0.00	−39.13	−43.51	−41.47
Negative months (%)	48.0	0.0	41.9	43.6	41.0
Sharpe ratio	0.09	–	0.09	0.18	0.04
Sortino ratio	0.14	–	0.14	0.30	0.06
Real CAGR (%)	−5.71	−4.84	−4.51	−3.17	−5.08
US dollar CAGR (%)	−5.07	−4.19	−3.86	−2.50	−4.43
Average equity weight	1.00	0.00	0.50	0.73	0.46

Note. Equity = All-Share Index price return; deposit = previous month's twelve-month deposit rate ÷ 12. VaR and CVaR are monthly; negative values are losses. Sharpe and Sortino ratios use the deposit return as the benchmark. Real returns deflate by the monthly equivalent of year-on-year inflation.

The bootstrap confirms that the reduction in tail risk from diversification is reliable. The 50/50 mix improved CVaR relative to equities by a median of 7.5 percentage points, with a 95 per cent interval of 4.9 to 11.2 points. H1 is rejected. The volatility-managed rule also reduced tail risk, though by less (median 4.2 points, interval 0.6 to 9.4), because it held more equity on average. It produced the highest growth and risk-adjusted return of all the strategies, but its tail risk and drawdown were worse than those of the fixed mix.

5.2 The CVaR budget rule

The CVaR budget rule, despite being designed to control tail losses, did not do better than the fixed 50/50 mix on any measure that matters. Its realised CVaR was −7.7 per cent, slightly worse than the mix; its maximum drawdown was 41.5 per cent against 39.1; and its growth rate was lower, at 8.6 per cent a year against 9.3. Its Sharpe ratio of 0.04 was the lowest of the risky strategies. The bootstrap intervals for its difference from the 50/50 mix include zero for both CAGR (−2.9 to +1.6 points) and CVaR (−2.1 to +1.2 points). H2 cannot be rejected: the tail-risk rule offered no improvement over plain diversification.

Figure 2 shows why. When the rule first had enough history, in early 2008, the previous three years had been a period of strong and steady equity gains, and the historical CVaR of an equity-heavy portfolio looked modest. The rule therefore raised the equity weight to 0.85 in February 2008, at almost exactly the market peak. It began to cut exposure only as losses accumulated, to 0.60 in September 2008 and 0.35 in November 2008, and reached 0.20 in February 2009, by which time most of the damage had been done. It then stayed at low equity weights for years, because the crash months remained in its 36-month window, and so missed much of the subsequent recovery. In the 2023–2025 rally its average equity weight was only 0.60.

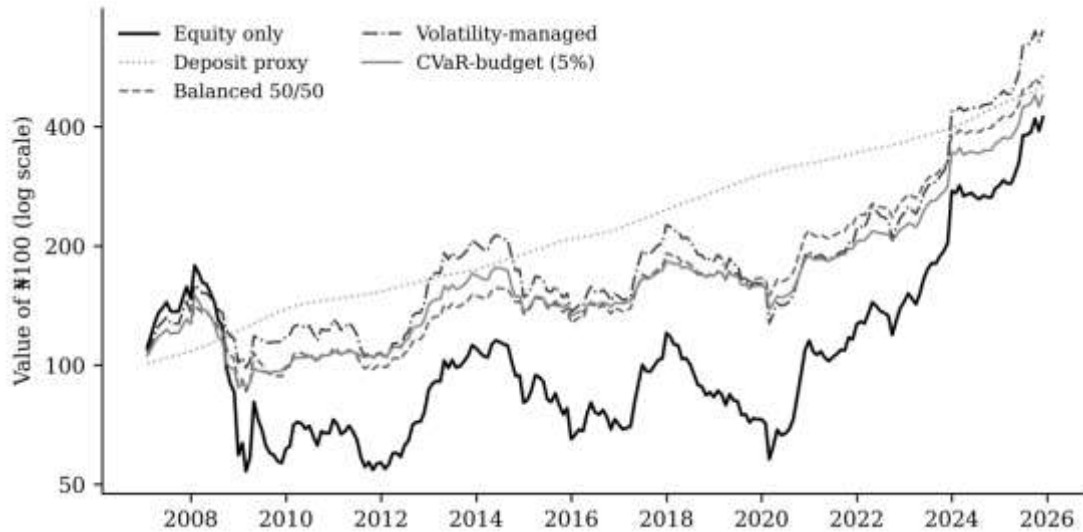


Figure 1. Value of ₦100 invested in February 2007 in each strategy (log scale), to December 2025. Source: author's calculations from Central Bank of Nigeria data.

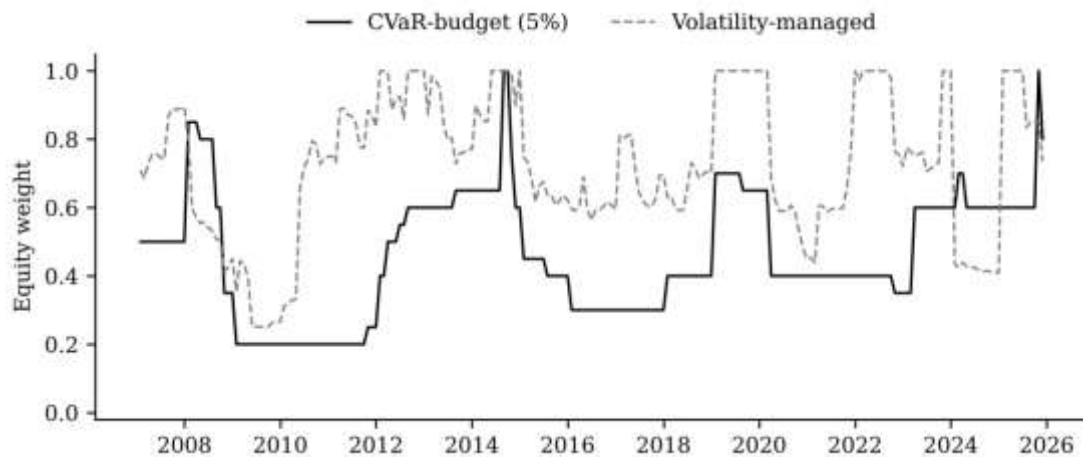


Figure 2. Equity weights chosen by the CVaR-budget and volatility-managed rules, February 2007 – December 2025. Both rules use only past returns. Source: author's calculations.

5.3 Crashes and recoveries

Table 2 shows cumulative returns over four episodes. During the 2008–2009 crash, the 50/50 mix lost 39 per cent and the volatility rule 38 per cent, compared with 70 per cent for equities alone; the CVaR rule lost 41 per cent. In the 2016 recession, the fixed mix and the CVaR rule were roughly flat. In the pandemic shock of early 2020, the volatility rule was fully invested after a calm 2019 and lost as much as equities (21 per cent), while the CVaR rule lost 13 per cent and the fixed mix 9 per cent. In the 2023–2025 rally, equities tripled in value. The volatility rule captured almost all of that gain, while the fixed mix and the CVaR rule roughly doubled.

Table 2 Cumulative returns in selected episodes (%)

Strategy	2008–09 crash	2016 recession	Covid shock	2023–25 rally
Equity only	–69.8	–6.2	–20.6	203.6
Deposit proxy	14.1	5.9	2.1	38.2
Balanced 50/50	–39.1	0.5	–9.5	109.1
Volatility-managed	–38.4	–0.3	–20.6	197.9
CVaR budget (5%)	–41.3	1.0	–12.9	118.9

Note. 2008–09 crash: March 2008 – March 2009; 2016 recession: January – December 2016; Covid shock: January – March 2020; 2023–25 rally: January 2023 – December 2025.

No dynamic rule protected investors consistently. Each did well in some episodes and badly in others, depending on whether the preceding period had been calm or turbulent. The fixed mix lagged badly in the 2023–2025 rally, but in each of the three downturns it was one of the two best-performing risky strategies.

5.4 Sensitivity of the CVaR rule

Table 3 shows how the CVaR rule depends on its parameters. Tighter loss limits reduce volatility, CVaR and drawdown, as they should. With a 3 per cent limit and a 36-month window, the rule produced a CAGR of 9.3 per cent, about the same as the fixed mix, with a maximum drawdown of only 25 per cent and a CVaR of –4.7 per cent. Looser limits behave increasingly like equities. Longer windows lower the average equity weight and, in most cases, the growth rate. The best-looking combination was not chosen in advance, and selecting it after seeing these results would be a form of data mining. What the table does show is that the outcome of a CVaR rule depends heavily on choices for which the investor has little objective guidance.

Table 3 Sensitivity of the CVaR-budget rule to the loss limit and look-back window

Loss limit	Look-back	CAGR (%)	Volatility (%)	Max drawdown (%)	CVaR, 5% (%)	Average equity weight
3%	24 months	9.26	9.68	–25.00	–5.20	0.39
3%	36 months	9.28	8.10	–25.00	–4.67	0.30
3%	60 months	8.75	7.21	–25.00	–4.11	0.26
5%	24 months	8.44	14.62	–41.47	–8.45	0.58
5%	36 months	8.64	12.59	–41.47	–7.71	0.46
5%	60 months	8.30	10.99	–41.47	–6.75	0.39
7%	36 months	8.52	16.52	–52.23	–10.09	0.62
10%	36 months	8.41	20.22	–59.87	–12.14	0.77

Note. The rule chooses the largest equity weight (in steps of 0.05) whose historical 95 per cent CVaR over the look-back window is no worse than the loss limit. The main specification is a 5% limit with a 36-month window.

5.5 Real returns

Every strategy lost purchasing power. Real CAGRs ranged from –3.2 per cent for the volatility rule to –5.7 per cent for equities alone, and the CVaR rule’s real loss was –5.1 per cent a year. US dollar returns were also negative for every strategy. Downside protection in nominal terms did not translate into protection of real wealth.

5.6 Alternative tail measures

With only about twelve months in the 5 per cent tail, the CVaR estimates are imprecise. Two alternative measures help. The 90 per cent CVaR, which averages the worst 10 per cent of months, gives the same ranking: –11.2 per cent for equities, –7.6 per cent for the volatility rule, –5.6 per cent for the CVaR rule and –5.2 per cent for the 50/50 mix. The Cornish–Fisher (modified) value at risk, which adjusts the normal quantile for the skewness and kurtosis of each return series, is –9.2 per cent for equities, –5.2 per cent for the volatility rule, –4.2 per cent for the 50/50 mix and –3.9 per cent for the CVaR rule. On this parametric measure the CVaR rule looks slightly better than the fixed mix, but its realised losses in the worst months were not smaller. The broad conclusion, that diversification halves tail risk and that the CVaR rule adds little to it, does not depend on the choice of tail measure.

6. DISCUSSION

The main lesson is that, in the Nigerian market over 2007–2025, plain diversification did most of the work of protecting investors from crashes. A fixed half-and-half split between equities and deposits halved the average loss in the worst months, cut the deepest drawdown by more than thirty points and raised the compound growth rate. These gains are statistically reliable. More sophisticated rules did not improve on them in a robust way.

The CVaR budget rule failed for a reason that is built into any rule that estimates tail risk from recent history. Tail events are rare and clustered. Before the 2008–2009 crash, the Nigerian market had gone through a long boom with few large losses, so the historical CVaR of an equity-heavy portfolio looked small and the rule increased exposure. Once the crash began, the historical CVaR rose only as the losses were realised, so the rule cut exposure late. After the crash, the large losses stayed in the 36-month window, so the rule remained defensive while the market recovered. This is a

sharper version of the estimation-error problem described by DeMiguel et al. (2009): the rule's inputs were least informative exactly when they mattered most.

Volatility management behaved differently because volatility is more persistent and easier to estimate than tail loss. It cut exposure early in 2008, when monthly volatility first rose, and it was fully invested during calm periods, which helped it capture the 2023–2025 rally. Its weakness showed in early 2020, when a calm 2019 left it fully invested just before the pandemic shock. For a growth-oriented investor, it was the best of the dynamic rules over this period; for an investor whose priority is to limit tail losses, the fixed mix was more reliable.

The degeneracy of the minimum-CVaR rule is also worth emphasising. When one asset never loses money in nominal terms, minimising tail loss means holding only that asset. This is not a useful investment rule for anyone who also cares about growth or real returns. A meaningful tail-risk rule must trade off tail loss against expected return, either through a budget, as here, or through a penalty, and the choice of budget or penalty then drives the result, as Table 3 shows.

6.1 Implications

For Nigerian investors, pension funds and asset managers, the results argue for a fixed strategic allocation with a substantial safe component as the first line of defence against crashes. Dynamic tail-risk rules based on short historical windows should be treated with caution: they can increase exposure before a crash and reduce it before a recovery. Where dynamic rules are used, volatility-based rules appear more dependable than CVaR-based ones in this market, but they still leave investors exposed to sudden shocks after calm periods. Risk managers who use historical CVaR for limits should supplement it with stress scenarios that include the 2008–2009 experience, rather than relying only on the most recent three years.

6.2 Limitations

The equity series excludes dividends, and the deposit return is a stylised accrual, so neither represents an investable total return. Transaction costs and taxes are ignored. The 5 per cent tail of 227 months contains only about twelve observations, so all CVaR estimates are imprecise, a fact reflected in the wide bootstrap intervals. The analysis covers one market and one period with a single great crash, and the conclusions may not hold in a market whose crashes are better anticipated by recent volatility. Only two assets are considered; a CVaR rule may perform better with a richer set of assets whose tail behaviour differs. Extensions could use dividend-inclusive returns, Treasury bill returns, offshore assets and parametric or extreme-value estimates of tail risk that rely less on the recent window.

7. CONCLUSION

Diversification was enough, or at least it was as good as anything more elaborate. Over 2007–2025, a fixed 50/50 mix of Nigerian equities and deposits halved the tail risk of equities, cut the maximum drawdown from 70 to 39 per cent and grew faster than either asset alone, and these improvements are statistically reliable. A rule designed to keep historical CVaR within a budget did no better, because it raised equity exposure after a calm period just before the 2008–2009 crash and stayed defensive during the recovery. A pure minimum-CVaR rule simply held deposits. Volatility management gave the best growth but less tail protection than the fixed mix. No strategy preserved purchasing power. For Nigerian investors, a disciplined strategic allocation remains the most reliable protection against crashes.

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