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Simple Heuristics on the Link Between Sharpe Ratio and Maximum Drawdowns

We review the algebra connecting two different ways of measuring risk-adjusted returns which can be used to estimate one from the other.

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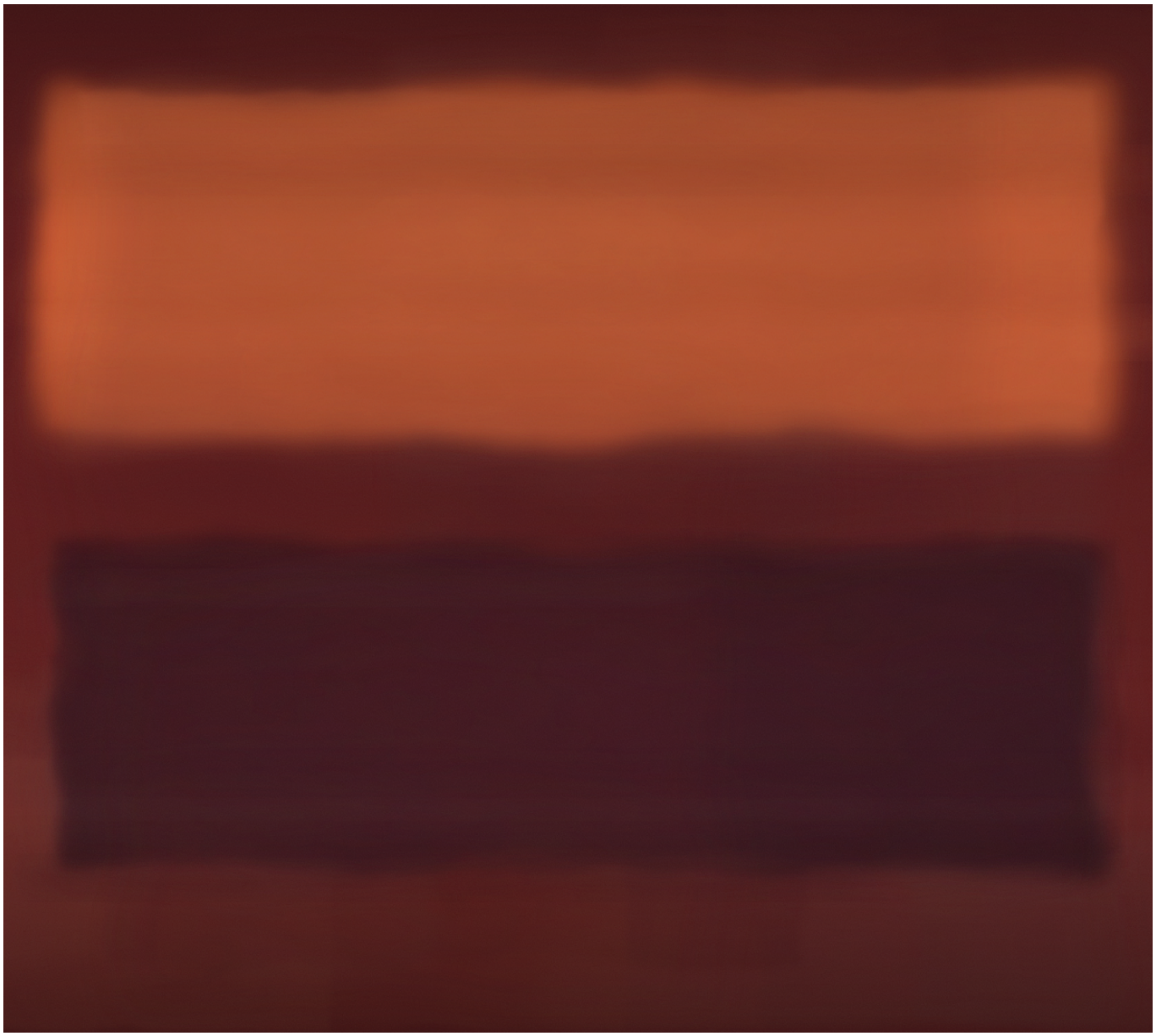

EXECUTIVE SUMMARY

Under a normality assumption **the Sharpe ratio determines both the depth and the duration of the drawdowns** a strategy should be expected to produce.

Depth is inversely proportional to Sharpe: the 5% worst-case drawdown runs at roughly 1.50 × σ/Sharpe. A 15% volatility strategy at a Sharpe of 1 should expect a drawdown of just over 20%, falling to 15% at a Sharpe of 1.5. Duration is inversely proportional to the *square* of Sharpe.

A modest shortfall in Sharpe translates into a disproportionately long wait. **A "normal" drawdown for a Sharpe 0.5 strategy can last close to a decade**.

When evaluating investment strategies, one metric stands above others in its widespread adoption: the Sharpe ratio. Its appeal lies in its elegant simplicity — a single number that provides a reasonably good (though not perfect) summary of a strategy's risk-adjusted performance. Another critical factor that investors and allocators scrutinize is the maximum drawdown of a strategy. Interestingly — though perhaps unsurprisingly — these two measures are mathematically intertwined in ways that provide powerful insights for risk management. We review below how these relationships can inform investment decisions (note that these assume normally distributed data and so if the strategy returns demonstrate a skewness or kurtosis different than a Normal distribution this will affect the results).

MAXIMUM DRAWDOWN DEPTH

The relationship between Sharpe ratio and maximum drawdown depth has been rigorously analyzed by Magdon-Ismail et al. (2004). For a profitable portfolio (μ > 0), they derive that the expected maximum drawdown follows:

$$E[MDD] \approx (\sigma^2/\mu) \times [0.63519 + 0.5 \log T + \log(\mu/\sigma)] \text{ for large } T$$

This formula reveals a fundamental insight: maximum drawdown depth scales inversely with the Sharpe ratio. More precisely:

$$E[MDD]/\sigma \approx (1/Sharpe) \times [0.63519 + 0.5 \log T + \log(Sharpe)]$$

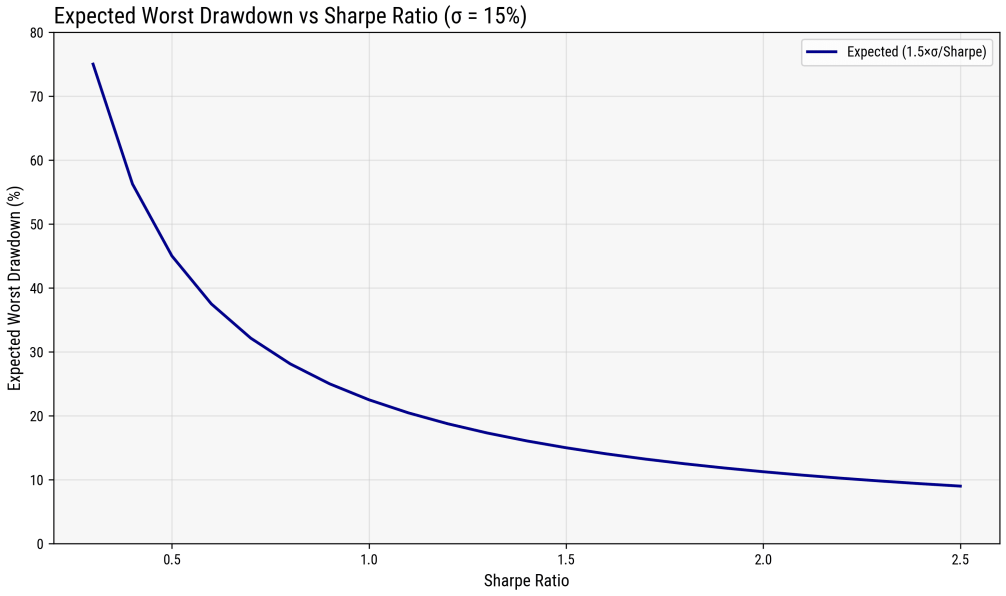

Figure 1: Maximum Drawdown vs Sharpe Ratio

Building on this theoretical foundation, empirical analysis by Rej, Seager, and Bouchaud (2017) provides a practical rule of thumb. Their numerical simulations show that the 5% worst-case drawdown (i.e. the drawdown exceeded only 5% of the time) follows:

5% worst drawdown depth ≈ 1.50 × σ/Sharpe

As the chart shows, this means that for a 15% vol strategy with a 1 Sharpe the expected max drawdown is just above 20%, while this moves to 15% for a Sharpe of 1.5 and 11.3% for a Sharpe of 2.

DRAWDOWN DURATION

Perhaps even more psychologically challenging than drawdown depth is drawdown duration — the length of time an investment remains underwater. Here, the mathematics deliver a sobering message: drawdown length scales inversely with the square of the Sharpe ratio.

Magdon-Ismail et al. identify the characteristic timescale as:

$T^* = \sigma^2/\mu^2 = 1/Sharpe^2$

The CFM research provides a practical formula for the 5% worst-case scenario:

5% worst drawdown length ≈ 2.14/Sharpe² (in years)

The quadratic relationship means that drawdown duration increases dramatically as Sharpe ratios decrease.

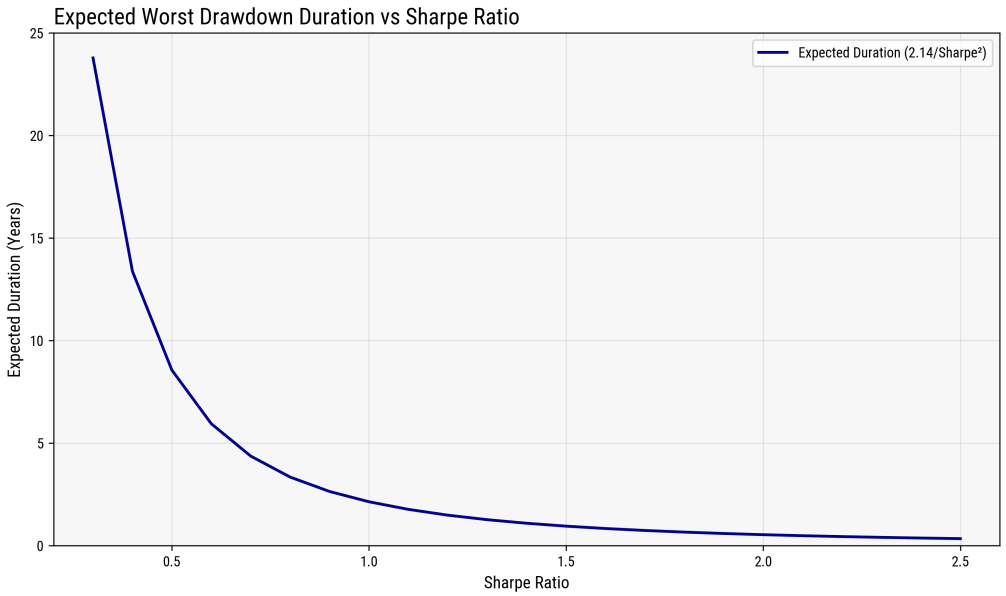

Figure 2: Drawdown Duration vs Sharpe Ratio

As we see in the chart, with a Sharpe of 1 the expected max drawdown duration is 2.14 years, which moves to 0.95 years for a Sharpe of 1.5 and then to 0.54 years for a Sharpe of 2.

THE CALMAR RATIO CONNECTION

The Calmar ratio, defined as annual return divided by maximum drawdown, provides another lens through which to view these relationships. Magdon-Ismail et al. show that:

Normalized Calmar Ratio ≈ Sharpe²/[0.63519 + log(Sharpe)]

For practical purposes, this approximates to:

Calmar ≈ 0.8 × Sharpe²

(for 1-year normalized periods)

Again, this quadratic relationship explains why strategies with higher Sharpe ratios are disproportionately more attractive from a drawdown perspective.

CONCLUSION

The Sharpe ratio contains more information than commonly appreciated — it effectively predicts both the depth and duration of expected drawdowns through these scaling laws. We also have shown how drawdown duration is particularly sensitive to Sharpe ratio changes, following a square law relationship which makes low-Sharpe strategies psychologically difficult to maintain. It is worth taking note that investors systematically underestimate drawdown risk, particularly duration. A "normal" drawdown for a Sharpe 0.5 strategy can last nearly a decade, while for a strategy with a Sharpe of 1.5 it can be a more moderate 1 year.

REFERENCES

Magdon-Ismail, M., Atiya, A. F., Pratap, A., & Abu-Mostafa, Y. S. (2004). On the maximum drawdown of a Brownian motion. *Journal of Applied Probability*, 41(1), 147–161.

Rej, A., Seager, P., & Bouchaud, J. P. (2017). You are in a drawdown. When should you start worrying? *Capital Fund Management*. arXiv:1707.01457v2