Downside Risk Management in Emerging Markets

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Motivation

- **The 2008 financial crisis and the subsequent Eurozone turmoil have had a tremendous impact on investors who were exposed to equity markets without proper risk management tools.**

- **Within a few weeks, a number of pension funds, university endowments and mutual funds suffered catastrophic capital losses, sometimes in excess of 50%.**

- **For example, the MSCI Emerging Markets Index experienced a 66% drawdown between October 2007 and October 2008.**

- **These events have renewed the interest of investors in risk mitigation tools for equity products.**

- **This is evidenced by the introduction of managed volatility or risk control indexes by major providers such as Dow Jones, MSCI, or S&P.**

- **We present Extreme Value Theory based techniques for downside risk control applied to dynamic asset allocation between EM equities and cash or bonds. We demonstrate that it is possible to significantly reduce both tail risk and maximum drawdown without a notable decrease in performance.**

Outline

1) Downside Risk Measurement

- Volatility based CVaR
- Extreme Value Theory based CVaR

2) Downside Risk Management

- Asset Allocation between Equities & Cash
- Asset Allocation between Equities & Bonds

3) Summary

Measuring Downside Risk

- **Necessity to accurately measure downside risk.**

Different tools are available:

- **Volatility: measures the standard deviation of daily returns without differentiating between positive and negative returns. Gives Value at Risk and Conditional Value at Risk assuming return distribution is Normal.**

- **Value at Risk: measures ~~maximum~~ minimum loss at a given confidence level (such as 95%). Does not give any indication on losses beyond this threshold.**

- **CVaR (Expected Shortfall): measures entire downside risk at a given confidence level; the CVaR is the average daily loss beyond the VaR threshold. Requires parametric modelling of return distribution such as normal or EVT.**

Measuring Conditional Value at Risk

- **For a normal distribution, VaR and CVaR can be computed from historical volatility.**

- **For example at the 95% confidence level, VaR = 1.65σ - μ and CVaR = 2.07σ - μ**

- **Otherwise, Extreme Value Theory shows that a Generalised Pareto Distribution can be fitted to the tail of almost any return distribution.**

- **Once the shape and scale parameters of the GPD have been estimated, the CVaR can be obtained easily.**

Generalised Pareto Distribution

- **The Generalised Pareto Distribution (GPD) for a given shape parameter ξ and scale parameter β is:**

$$G_{\xi,\beta}(y) = \begin{cases} 1 - (1 + \frac{\xi y}{\beta})^{-\frac{1}{\xi}}, & \text{for } \xi \neq 0; \\ 1 - \exp^{-\frac{y}{\beta}}, & \text{for } \xi = 0. \end{cases}$$

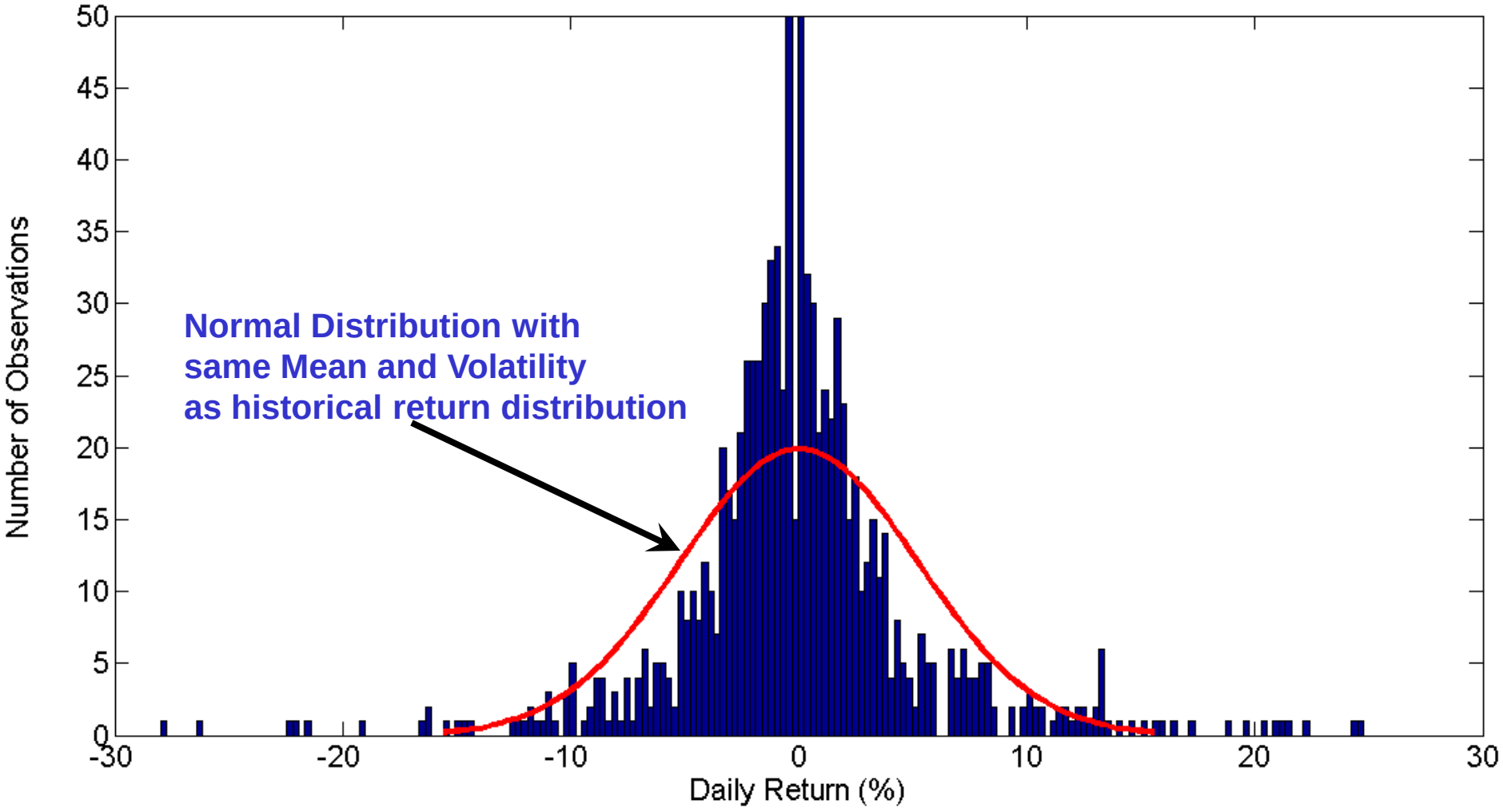
- **The VaR and CVaR can be obtained from ξ and β:**

$$\mathrm{VaR}_\alpha = u + \frac{\beta}{\xi}\left(\left(\frac{\alpha N}{N_u}\right)^{-\xi} - 1\right)$$

$$\mathrm{CVaR}_\alpha = \frac{\mathrm{VaR}_\alpha + \beta - \xi u}{1 - \xi}$$

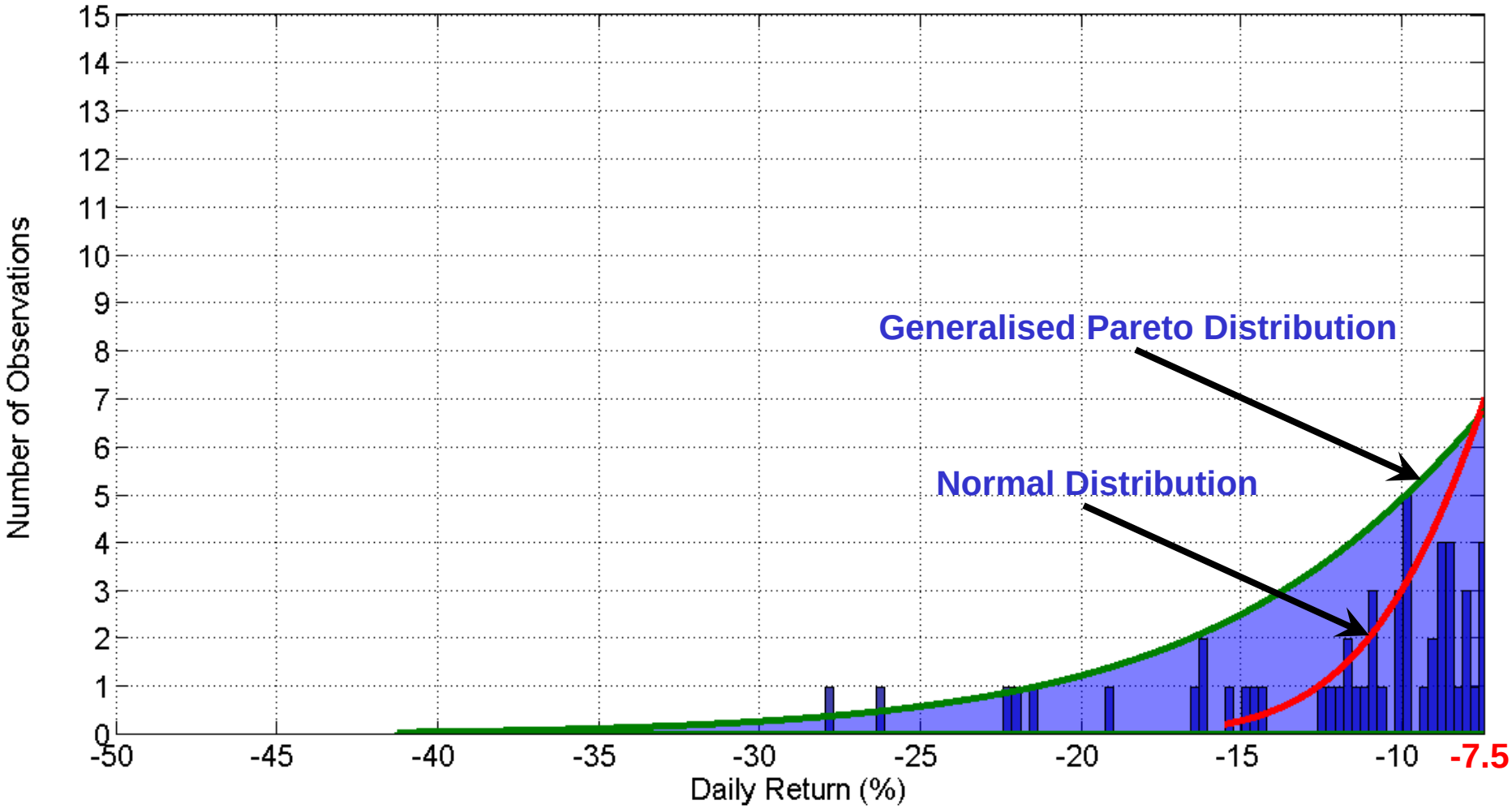
where α is the confidence level and u is the corresponding quantile value.

Normal Distribution Fitting



Generalised Pareto Distribution Fitting

• **The 95% CVaR is represented by the area under each curve to the left of the 95% VaR threshold. Significantly underestimated by the normal dist compared to GPD.**



Filtered Historical Simulation

- **For the GPD fitting to converge, the left tail of the return distribution should contain enough data.**
- **If the GPD is fitted directly to historical data, this requires a look back window of at least 2-3 years for 95% confidence level.**
- **Another solution is to fit the GPD to simulated returns.**
- **Several types of simulation methods are available:**
- **Monte Carlo simulations assume a specific distribution of returns, usually a normal distribution, which negates the advantage of using Extreme Value Theory.**
- **Historical simulations assume that daily returns are i.i.d. which is not usually the case for financial applications; they also require an extensive look back window to obtain a statistically significant distribution.**

Filtered Historical Simulation

- **The filtered historical simulation (FHS) method attempts to combine the advantages of historical and parametric methods.**
- **The FHS method relies on a model based approach such as GARCH for volatility, while remaining model free in terms of the distribution.**
- **In practice, we begin by filtering the returns in order to ensure they are i.i.d., then we sample with replacement from the standardised residuals.**
- **These simulations generate a number of return series which are then merged to form one return series.**
- **The CVaR of this return series is computed by fitting a GPD to its left tail.**

Downside Risk Management

- **We consider a long only portfolio of EM equities and assume that the portfolio manager can adjust the asset allocation between equities and cash to target a volatility of 15%.**

- **EM equities are represented by the MSCI Emerging Markets index and the equity allocation is computed weekly using the formula:**

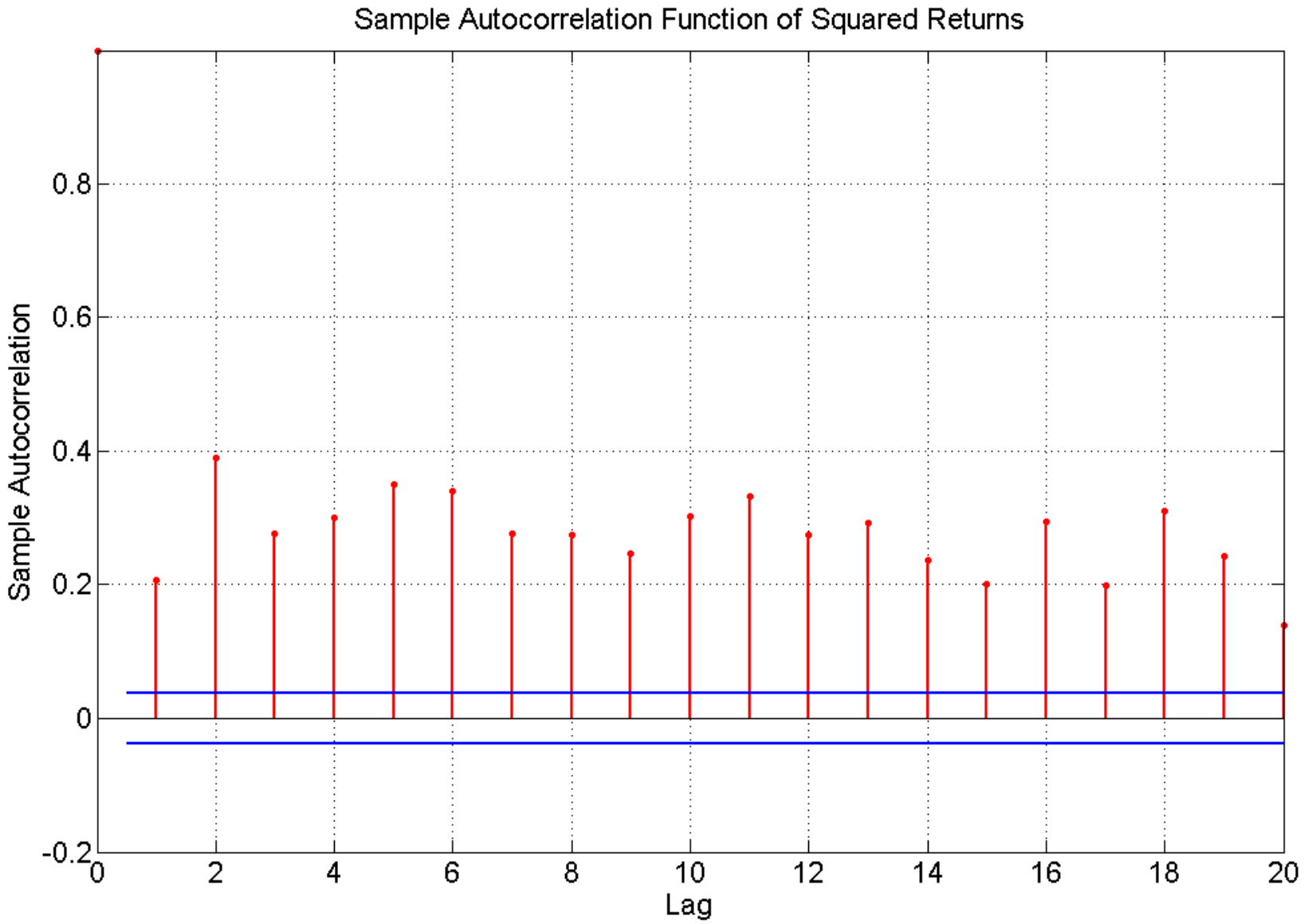
$$\text{Equity Allocation} = \frac{\text{Target CVaR}}{\text{Current CVaR}}$$

- **Target CVaR is the 95% CVaR corresponding to the targeted volatility level (15%) for a normal distribution:**

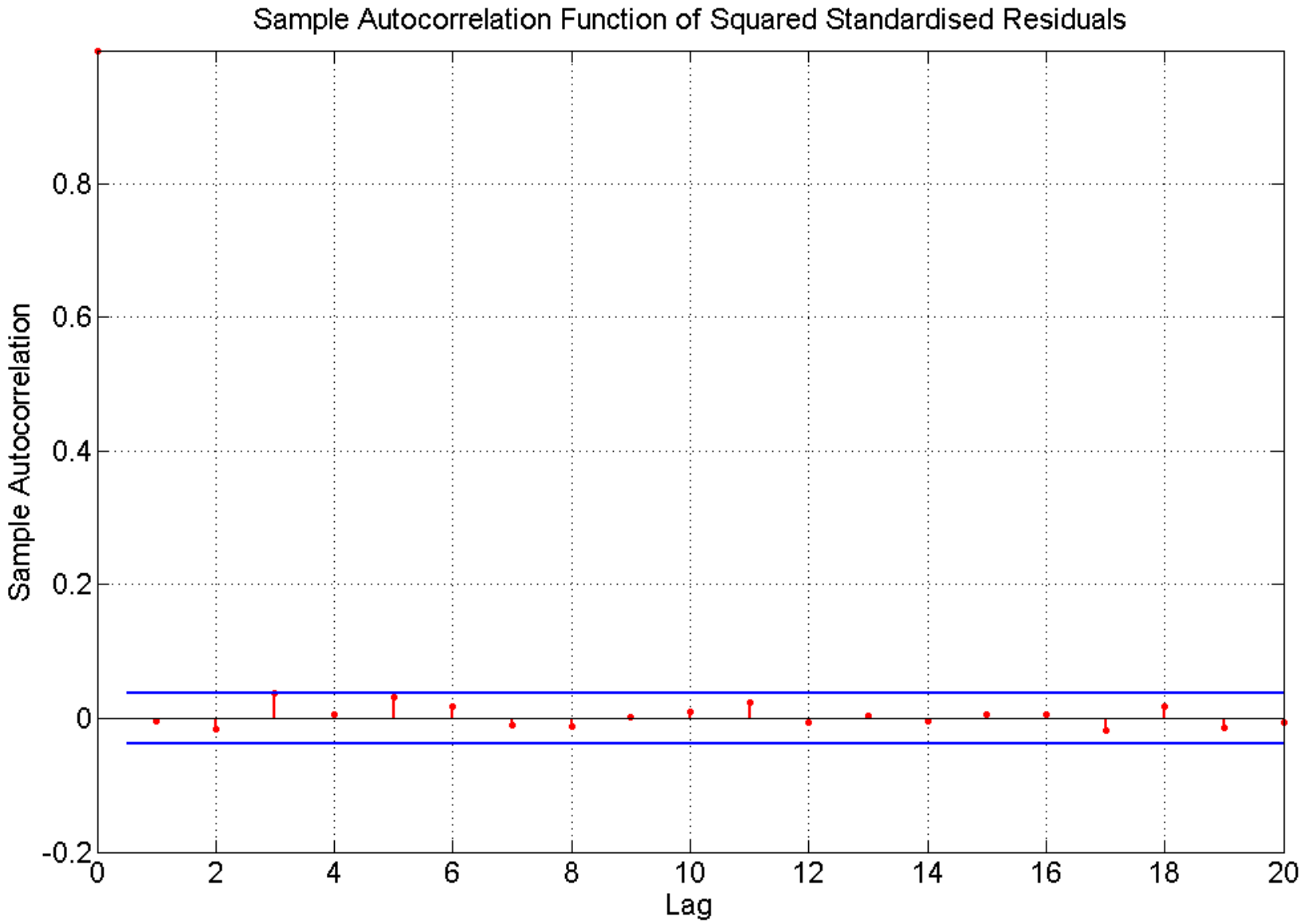
$$\text{Target 95\% CVaR} = 2.07 \times \frac{15\%}{\sqrt{260}} = 1.93\%$$

- **Current CVaR is computed from historical returns using Extreme Value Theory.**

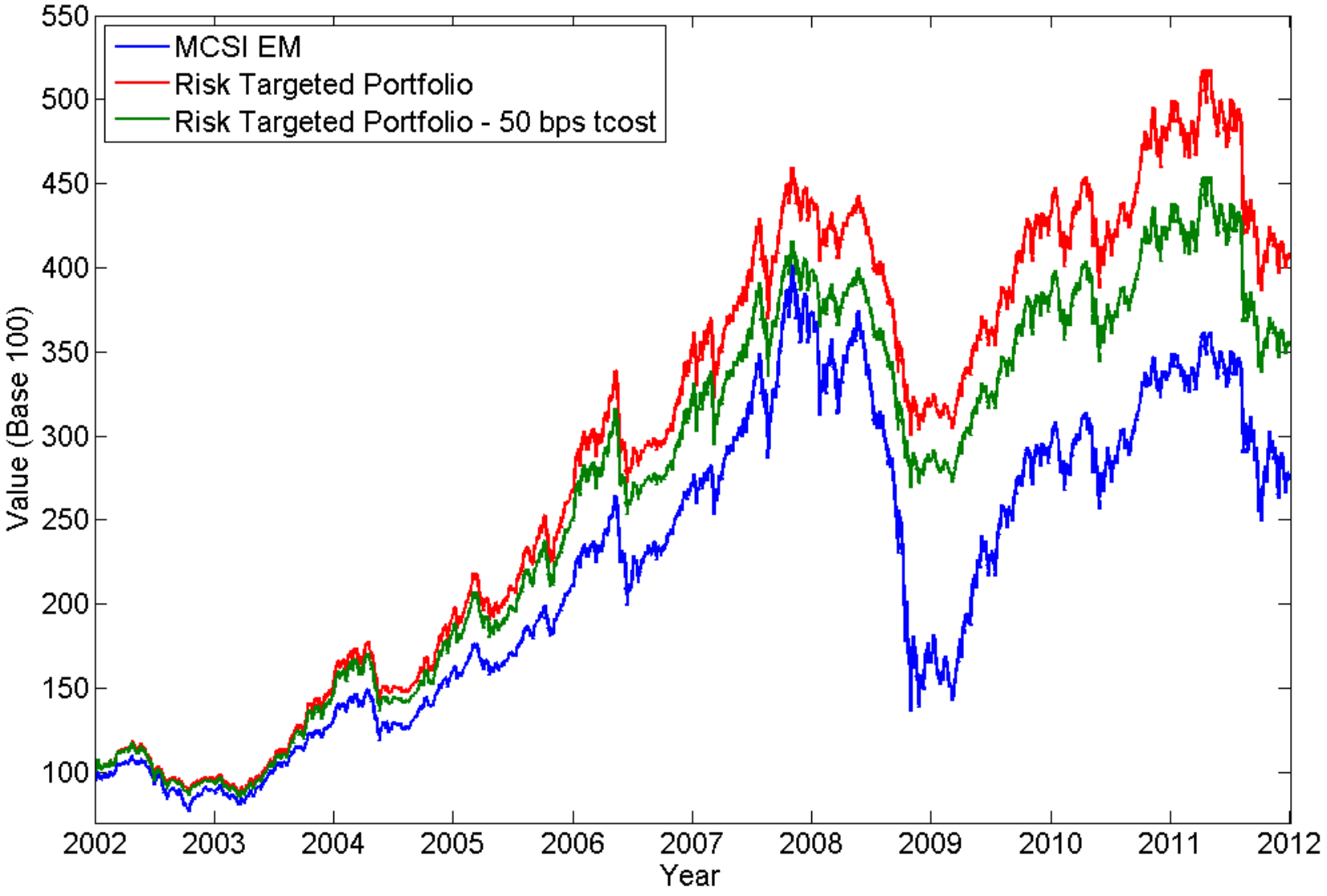
Autocorrelation in Returns



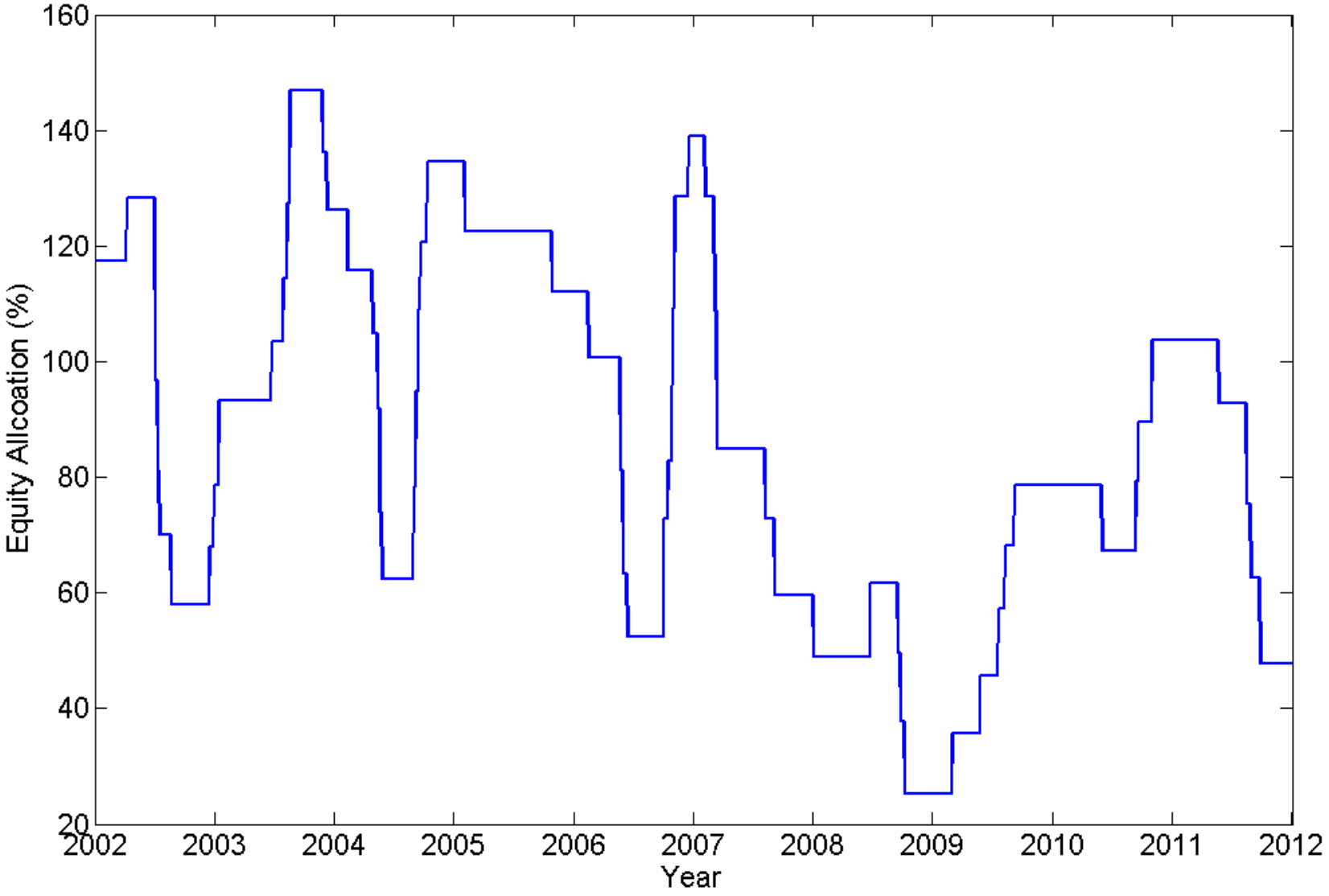
Autocorrelation in Filtered Returns



Asset Allocation between Equities and Cash



Asset Allocation between Equities and Cash



Asset Allocation between Equities and Cash

- **The risk targeted portfolios compared to the MSCI EM Index have:**

– lower volatility,

– lower Maximum Drawdown,

– higher Sharpe ratios.

- **Over the 2002-2011 period, the equity allocation varied between 25% and 150% with an average value of 0.87.**

	Annualised Return	Annualised Volatility	Maximum Drawdown	Sharpe Ratio
MSCI EM Index	11.19 %	21.91 %	66.06 %	0.51
Risk Targeted Portfolio	14.96 %	15.11 %	34.62 %	0.99
Risk Targeted Portfolio – 50 bps tcost	13.42 %	15.14 %	35.15 %	0.89

Performance Data

MSCI EM Index	Annualised Return	Annualised Volatility	Maximum Drawdown	Sharpe Ratio
2002	-7.97 %	16.57 %	30.02 %	-0.48
2003	51.59 %	13.56 %	12.43 %	3.80
2004	22.45 %	15.49 %	20.38 %	1.45
2005	30.31 %	11.95 %	10.58 %	2.54
2006	29.18 %	18.10 %	24.53 %	1.61
2007	36.48 %	20.53 %	17.73 %	1.78
2008	-54.48 %	40.74 %	63.64 %	-1.34
2009	74.50 %	26.68 %	21.78 %	2.79
2010	16.36 %	18.15 %	18.33 %	0.90
2011	-20.41 %	22.20 %	31.10 %	-0.92
2002-2011	11.19 %	21.91 %	66.06 %	0.51

Performance Data

Risk Targeted Portfolio – 50 bps tc	Annualised Return	Annualised Volatility	Maximum Drawdown	Sharpe Ratio
2002	-5.63 %	15.11 %	26.54 %	-0.37
2003	53.90 %	15.30 %	11.80 %	3.52
2004	25.62 %	15.74 %	20.41 %	1.63
2005	35.99 %	14.58 %	13.07 %	2.47
2006	26.09 %	15.27 %	19.77 %	1.71
2007	23.31 %	16.99 %	14.36 %	1.37
2008	-26.38 %	14.90 %	32.57 %	-1.77
2009	30.48 %	12.38 %	6.48 %	2.46
2010	11.50 %	14.42 %	14.73 %	0.80
2011	-16.40 %	16.33 %	25.67 %	-1.00
2002-2011	13.42 %	15.14 %	35.15 %	0.89

Performance Data

$$\text{Extreme Risk} = \frac{95\%\ \text{CVaR}}{1.26 \times 95\%\ \text{VaR}} - 1$$

Extreme Risk	MSCI EM	Risk Targeted Porfolio – 50 bps tc
2002	17.69%	3.98%
2003	1.21%	5.88%
2004	7.95%	6.76%
2005	5.95%	5.58%
2006	23.82%	25.26%
2007	19.61%	10.00%
2008	20.44%	-6.20%
2009	25.95%	28.53%
2010	1.71%	1.66%
2011	0.16%	5.04%
2002-2011	28.91%	7.96%

Asset Allocation between Equities and Cash

- **By construction, the risk targeted portfolio will have a higher (lower) equity allocation in times of low (high) market volatility.**

- **For an equity index, periods of low (high) volatility usually correspond to high (low) returns.**

- **For example in 2008, the MSCI EM index had a volatility of 40.65% and lost 54.48% while the risk targeted strategy lost 25.78% for a volatility of 14.87%.**

- **In 2003, the MSCI EM index had a volatility of 13.56% and gained 51.59% while the risk targeted strategy gained 56.8% for a volatility of 15.30%.**

- **The risk targeted strategy will tend to increase equity allocation in periods of positive returns and reduce it in periods of negative returns, which results in a higher Sharpe ratio and higher performance despite reducing volatility from 21.9% to 15.1%.**

Asset Allocation between Equities and Bonds

- **We now consider asset allocation between EM equities and EM bonds.**

- **The EM equities are still represented by the MSCI Emerging Markets index, the EM bonds by the JPM GBI EM index and we use as benchmark an equal weighted composite of the two indexes.**

- **Historically, EM bonds have had a higher correlation to EM Equities than US bonds. Between 2002 and 2011, the correlation of the MSCI EM index with the JPM GBI EM index is 0.63 while the correlation with US bonds is -0.13.**

- **However, this relationship has been changing during the last 2 years; EM bonds which tended to behave like high yield corporate bonds (high correlation to equity markets) are seen more and more as "risk off" assets such US Treasury bonds; this is due in part to improving economic and fiscal situations in many EM countries.**

- **In fact, while in 2008 the correlation between EM equities and EM bonds was 0.70, it was only 0.07 in 2011.**

Asset Allocation between Equities and Bonds

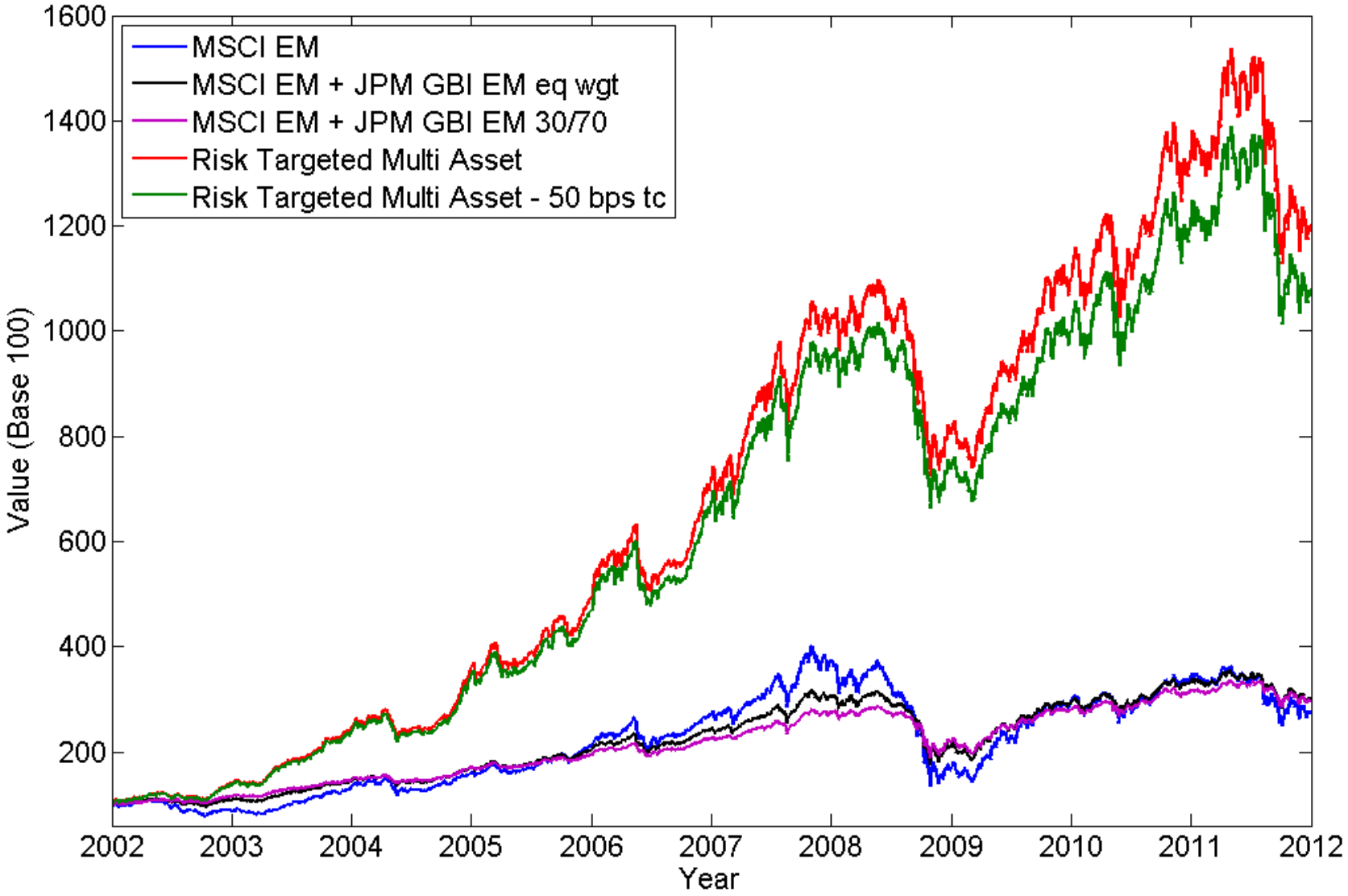
- **The asset allocation to bonds or stocks is computed weekly using a similar algorithm as before.**

- **The 95% CVaR for each index is computed using EVT and the allocation is then adjusted via a risk parity framework to a total 95% CVaR corresponding to a volatility of 15% for a normal distribution.**

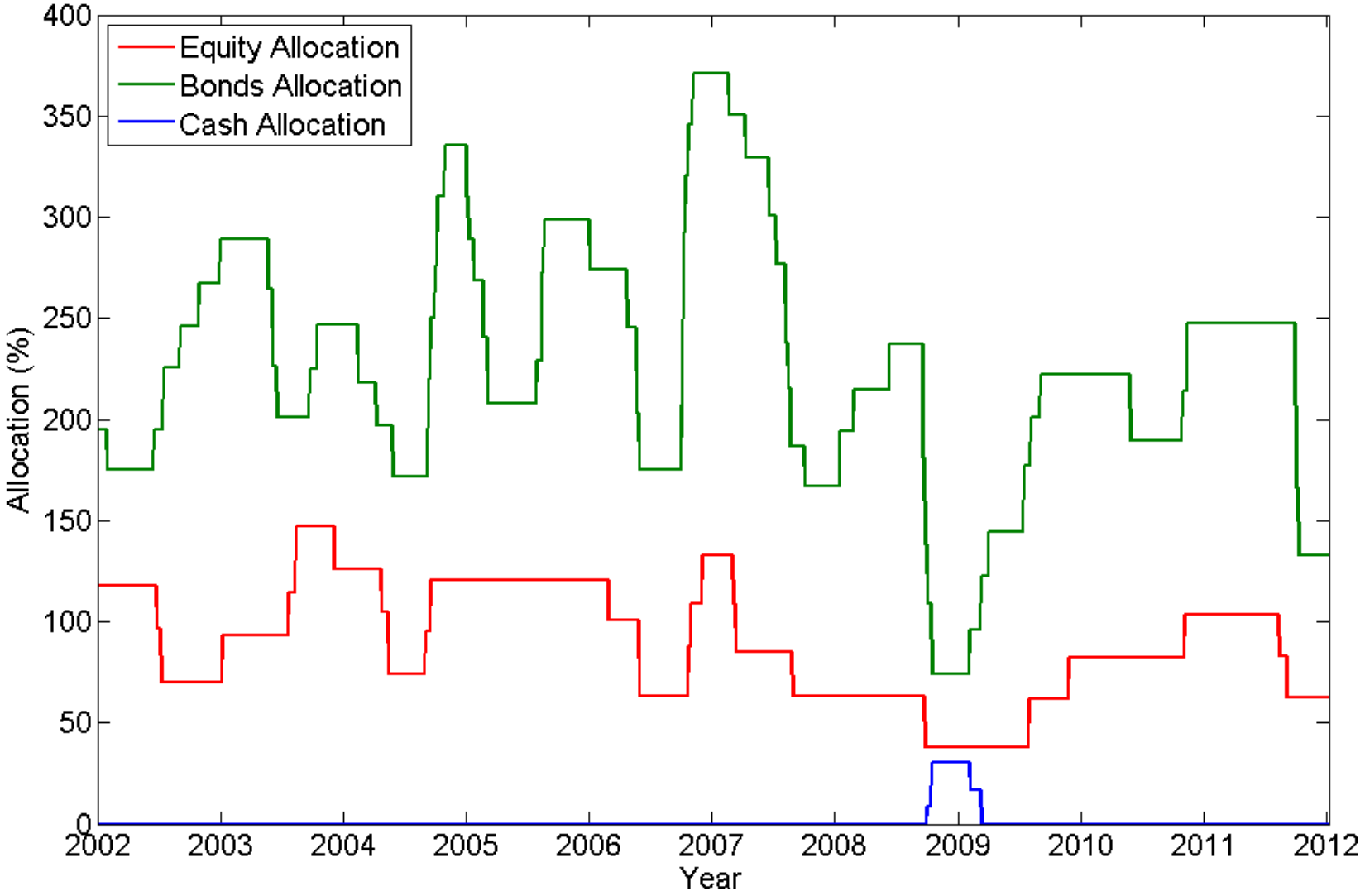
- **Since EM bonds have a volatility of about 7.4% over 2002-2011 compared to 21.9% for EM equities, the risk parity based portfolio has a bond allocation about 2.5 times greater than the equity allocation.**

- **Despite the lower equity exposure, the correlation of the multi asset portfolio to the MSCI EM index is 0.81 over 2002-2011 and the beta is 0.59, giving the investors some exposure to EM equities.**

Asset Allocation between Equities and Bonds



Asset Allocation between Equities and Bonds



Asset Allocation between Equities and Bonds

- **The risk targeted portfolios exhibit significantly higher returns and Sharpe ratios than the equal weighted composite and the 30/70 Equity/Bond portfolio.**

- **Adding EM bonds to the asset universe provides diversification and greatly improves performance compared to allocating only between equities and cash.**

	Annualised Return	Annualised Volatility	Maximum Drawdown	Sharpe Ratio
MSCI EM Index	11.19 %	21.91 %	66.06 %	0.51
Risk Targeted EM Equity - 50 bps tcost	13.42 %	15.14 %	35.15 %	0.89
EM Equity/EM Bond Equal Weighted	11.62 %	13.27 %	44.46 %	0.88
EM Equity/EM Bond 30/70	11.52 %	10.28 %	34.17 %	1.12
Risk Targeted Equity/Bond Portfolio	28.00 %	16.05 %	34.09 %	1.75
Risk Targeted Equity/Bond Portfolio - 50 bps tcost	26.64 %	16.04 %	34.64 %	1.66

Performance Data

Risk Targeted Equity/ Bond – 50 bps tcost	Annualised Return	Annualised Volatility	Maximum Drawdown	Sharpe Ratio
2002	36.86 %	11.90 %	11.26 %	3.10
2003	72.11 %	13.68 %	7.53 %	5.27
2004	44.27 %	14.89 %	19.62 %	2.97
2005	34.54 %	14.51%	12.11 %	2.38
2006	42.30 %	15.27 %	20.67 %	2.77
2007	39.78 %	16.38 %	17.45 %	2.43
2008	-18.99 %	19.80 %	34.64 %	-0.96
2009	30.26 %	14.72 %	10.92 %	2.06
2010	20.65 %	18.03 %	16.13 %	1.14
2011	-10.53 %	19.54 %	27.11 %	-0.54
2002-2011	26.64 %	16.04 %	34.64 %	1.66

Performance Data

Extreme Risk	MSCI EM	Equity/Bond Equal Weighted	Equity/Bond 30/70	Multi Asset Portfolio – 50bps tc
2002	17.69%	31.24%	15.39%	22.75%
2003	1.21%	-2.91%	1.86%	4.03%
2004	7.95%	10.44%	16.70%	21.32%
2005	5.95%	6.87%	8.64%	-0.43%
2006	23.82%	24.55%	23.03%	21.91%
2007	19.61%	23.52%	30.01%	20.07%
2008	20.44%	25.31%	30.34%	-0.88%
2009	25.95%	17.23%	11.79%	18.38%
2010	1.71%	6.26%	5.09%	3.50%
2011	0.16%	8.17%	7.93%	0.72%
2002-2011	28.91%	28.60%	28.27%	14.15%

Conclusion

- **A noticeable downside risk reduction can be obtained from an EVT based algorithm that allocates between equities and cash according to a target risk level.**

- **Downside risk can be even more significantly reduced by adding EM bonds to the asset universe. The resulting portfolios have a lower volatility and half the maximum drawdown of the equity index while returning more than twice as much.**

- **Focusing on tail risk rather than volatility leads to a reduction in left tail, as evidenced by the lower extreme risk of the risk targeted portfolios compared to the equity index and equity/bond composites.**

- **Risk targeted portfolios enable investors to benefit from an exposure to EM equities without suffering from the higher volatility and drawdowns associated with this asset class.**

- **They also limit the fluctuations in volatility observed in equities by maintaining tail risk around a fixed pre-specified level.**