Quantitative Portfolio Strategy
Research

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Risk-Based Asset Allocation for Money Market Portfolios

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Motivation and Outline

- Goals:
  - analyse the risk / return tradeoff in a money market fund
  - develop approaches to portfolio construction and asset allocation to help achieve manager objectives
- Portfolio return target: portfolio is expected to achieve a required return target
- Risk management: portfolio construction should aim to hit the return target while minimizing the probability / magnitude of adverse “tail” events
- Note: we focus only on the credit component of risk/return. Return measured as excess return over Euro govt curve; modeled risks are spread change, default

- Outline:
  - Describe our approach to risk modeling
  - Use some example model outputs to illustrate the effects of:
    - Portfolio concentration
    - Contagion effects

Modeling Risk in Money Market Portfolios

- Short duration means risk from spread change is limited
- Primary risk is default risk
- Defaults in money market securities are very rare; it is thus hard to estimate probabilities of default and recovery rates
- Diversification can provide protection from catastrophic risk, but:
  - The list of available names may be limited, forcing portfolio concentration;
  - The greater the number of issuers in the portfolio, the greater the probability that one of them will default (but the smaller the impact);
  - The risk of contagion can magnify the losses in case of a default if it is not seen as an isolated idiosyncratic event
- Our model represents a portfolio at a coarse level, and models risk at three levels:
  - Sector-level spread changes
  - Defaults
  - Contagion effects (spread changes in other bonds in case of default)

Key Modeling Assumptions

- Portfolio allocates among K asset classes, each defined by the following parameters:
  - N – number of issuers in the portfolio for the given asset class
  - S – average spread
  - P – probability of default (per issuer) on a 1-year horizon
  - R – recovery rate assumed in case of default
  - D – average duration
  - σ – relative spread volatility
  - P – probability of default (per issuer)

- In what follows, we present some hypothetical assumptions for these parameters and illustrate the return distributions that result. These do not represent our views on any specific assets or asset classes.

Example: Base Case Asset Class Assumptions

Asset Class	Spread (bp)	Recov Rate	Num Issuers	F *	Duration	Vol (%/mo)
Euro Core	7	80%	3	3%	1.0	15%
Italy	58	60%	1	3%	1.0	15%
Spain	45	60%	1	3%	1.0	15%
Ireland	23	60%	1	3%	1.0	15%
Covered Bonds	39	80%	20	3%	1.0	15%
Banks (Euro Core)	63	60%	20	3%	1.0	15%
Banks (US)	65	60%	10	3%	1.0	15%
Banks (Italy)	76	60%	15	3%	1.0	15%
Banks (Spain)	71	60%	5	3%	1.0	15%
Industrials (Euro Core)	65	60%	20	3%	1.0	15%
Industrials (US)	67	60%	10	3%	1.0	15%
Industrials (Italy)	74	60%	5	3%	1.0	15%
Industrials (Spain)	68	60%	5	3%	1.0	15%

- All asset classes are EUR-denominated (US asset classes are EUR debt of US-domiciled firms)
- Reported spread levels correspond to average OAS of 1-3y bonds in the Bloomberg Barclays Euro-Aggregate Index as of 29 Sep 2017
- Approximate relative spread volatility of 15%/month corresponds roughly to historical experience for these asset classes over the preceding five years

Source: Bloomberg, Barclays Research

Expected Default Loss per Unit of Spread

- For credit securities, part of the spread can be seen as compensation for expected default losses
- In a simple optimisation that minimises risk for a given spread level, this ratio can be a key statistic that will determine which asset class to favor
- Expected default loss: $E[loss] = P(1-R)$
- Fraction of spread due to expected default loss: $F = \dfrac{P(1-R)}{S}$
- However, it is very difficult to estimate these parameters consistently, because:
  - spread is an observable market variable that changes over time;
  - default probabilities & recovery rates also change over time but are not observable;
  - we have observed empirically that default rates increase with increasing spread.
- Therefore, we do not directly specify the probability of default P for each asset
- Instead, we specify the spread S, the recovery rate R, and F, the perceived fair value for how much of the spread should comprise compensation for expected default loss, and we then back out P as

$$P = \frac{FS}{1-R}$$

- For example: for S=60bp, R=60%, F=3%, annual default probability P=0.05%

Historical Default Rates

- Defaults in money market securities have been very rare events
- Moody's publishes historical studies only occasionally
- Even in these rare default events, recovery rates have been typically close to 100% (although with some delay)
- Worst case recovery: Lehman Brothers – around 50% according to 2014 resolution documents
- A Moody's study from 2013 includes the following historical default rates for commercial paper that Moody's rated P-1, at different horizons

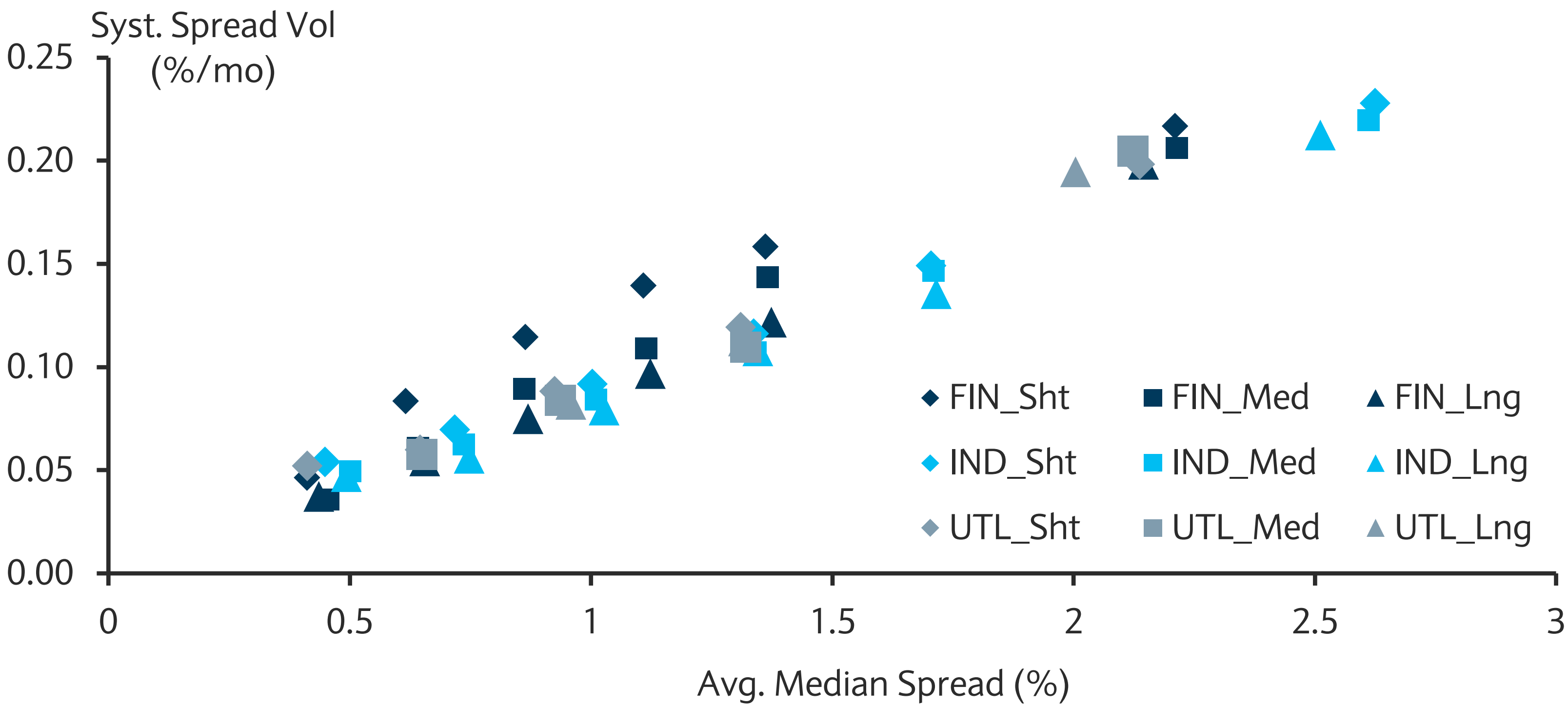
Average Commercial Paper Default Rates, Moody's P-1 Rating, 1972 – H1 2013

	30 days	90 days	1 year
All sectors	0.003%	0.010%	0.048%
Financial Institutions	0.005%	0.018%	0.080%
Non-Financial Corporations	0.002%	0.004%	0.027%

Source: Moody's

Spread Volatility is Proportional to Spread

Systematic Spread Volatility vs. Spread Level, US Corp IG, Dec89 – Apr16



- When modeling spreads change, we use relative spread volatility
- This implies that assets with higher spreads will experience greater spread volatility
- This assumption is supported by extensive empirical research across credit markets, and motivates the use of DTS (Duration Times Spread) as a risk measure for credit

Source: Barclays Research

Example Starting Portfolio

- We specify the initial weight of each asset class in the portfolio
- Equal weight is assumed among the specified number of issuers within each asset class
- Additional parameters provided to the model include the time horizon (here specified as three months), and a correlation matrix (not shown) for spread changes
- Analysis proceeds in two steps:
  - Analyse the risk of the starting portfolio
  - Optimise to find a portfolio that achieves the same expected return with less risk

Asset Class	Percent MV	Number of Issuers
Euro Core	20%	3
Italy	9%	1
Spain	9%	1
Ireland	2%	1
Covered Bonds	10%	20
Banks (Euro Core)	10%	20
Banks (US)	5%	10
Banks (Italy)	5%	15
Banks (Spain)	5%	5
Industrials (Euro Core)	10%	20
Industrials (US)	5%	10
Industrials (Italy)	5%	5
Industrials (Spain)	5%	5

Source: Barclays Research

Estimating the Portfolio Return Distribution by Simulation

- The simulation of portfolio return consists of three stages:
  - Spread change: we simulate a systematic relative spread change for each sector using an assumption of joint normal distribution with the specified volatilities and correlations
  - Default: we separately simulate the potential default of each issuer over the horizon
  - Contagion: in case of a default, we may apply a large additional spread change to all bonds in sectors deemed related. (For our first examples, we set this to 0.)
- We simulate a large number of such random outcomes, and tabulate the results.

Statistics of Starting Portfolio

Average Spread (bp)	48.9
Return Horizon (months)	3
Num Simulations	100,000
Mean Return (bp)	10.6
Stdev Return (bp)	9.6
95% VaR (bp)	-4.1
99% VaR (bp)	-13.6
95% CVaR (bp)	-11.5
99% CVaR (bp)	-27.2

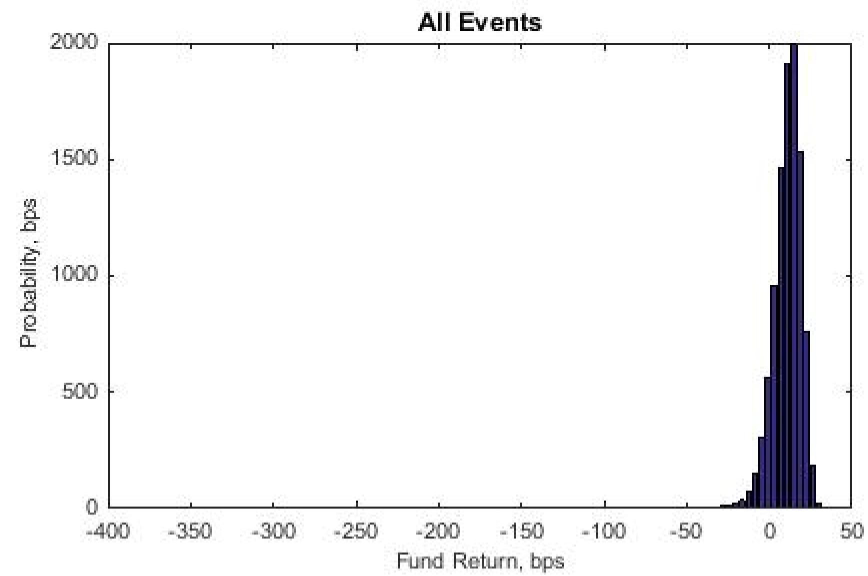
Conditional Statistics

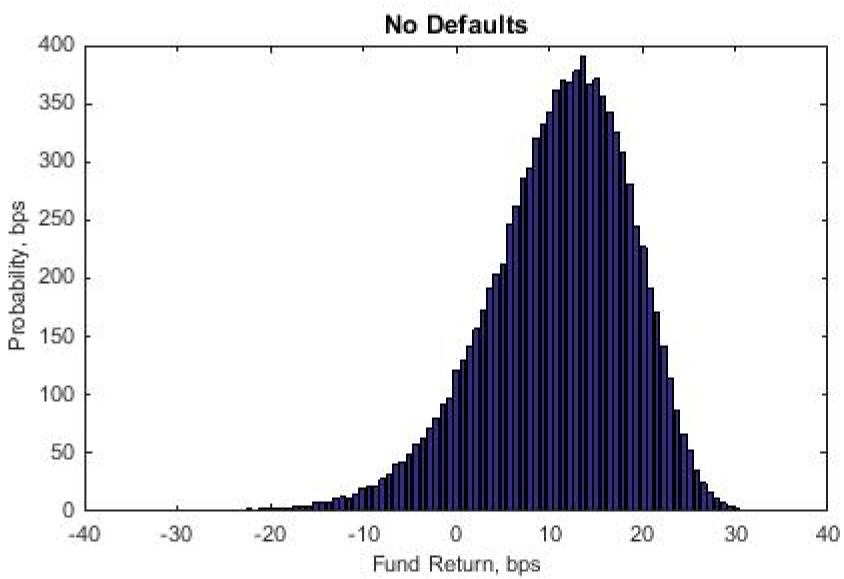
	Frequency	Mean Return (bp)
No Defaults	98.6%	11.0
Defaults	1.4%	-13.8

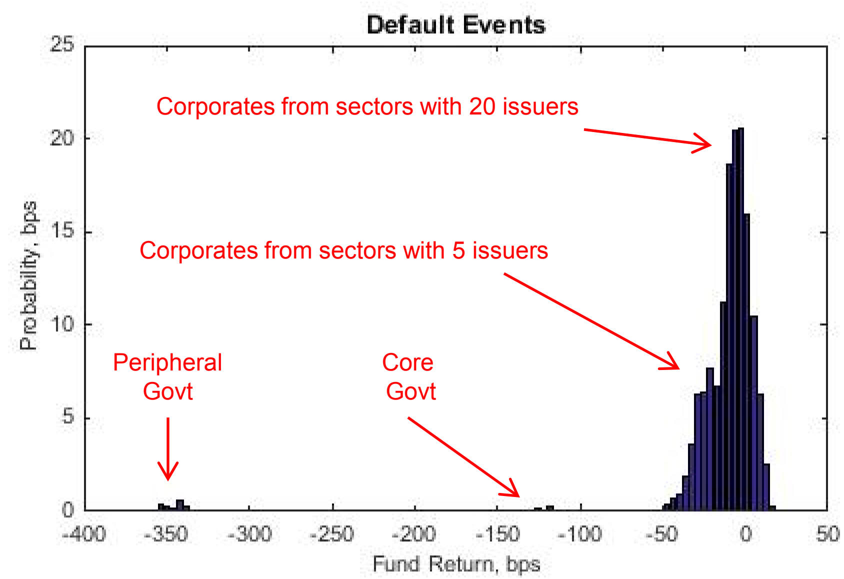
Source: Barclays Research

Simulated Return Distribution: Initial Portfolio, No Contagion

- We plot the distribution of expected excess returns over a 3m horizon for starting portfolio
- Results are clearer if we segregate the extreme outcomes (those with default events) from those with no defaults and examine the two distributions separately
- The "No Default" distribution follows a lognormal distribution over a small range
- The "Default Events" include events with different probabilities and loss levels







Source: Barclays Research

Evaluating the Effect of Portfolio Diversification

- We modify the initial portfolio assumptions to represent a more concentrated portfolio, which includes a smaller number of issuers (max. of five) in each sector
- The two portfolios have nearly identical expected returns, but different risks
- The more concentrated portfolio experiences a smaller number of default events in simulation; but when they occur, they cause greater losses

Overall Performance Statistics

Statistics	Starting Portfolio	Concentrated Portfolio
Number of Issuers	116	51
Average Spread (bp)	48.9	48.9
Return Horizon (months)	3	3
Num Simulations	100,000	100,000
Mean Return (bp)	10.6	10.6
Stdev Return (bp)	9.6	10.3
95% VaR (bp)	-4.1	-3.9
99% VaR (bp)	-13.6	-15.6
95% CVaR (bp)	-11.5	-13.6
99% CVaR (bp)	-27.2	-37.4

Conditional Statistics

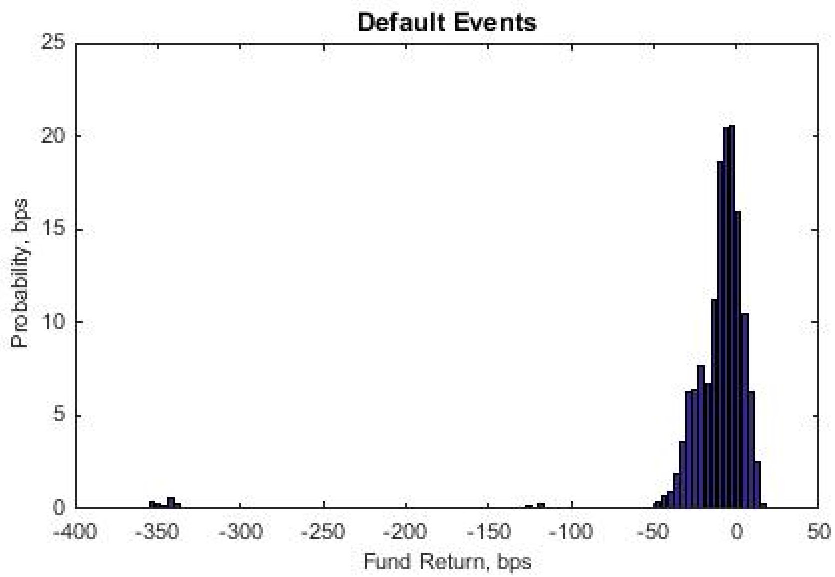
	Frequency	Mean Return (bp)
Original Portfolio		
No Defaults	98.6%	11.0
Defaults	1.4%	-13.8
Concentrated Portfolio		
No Defaults	99.4%	11.0
Defaults	0.6%	-47.8

Source: Barclays Research

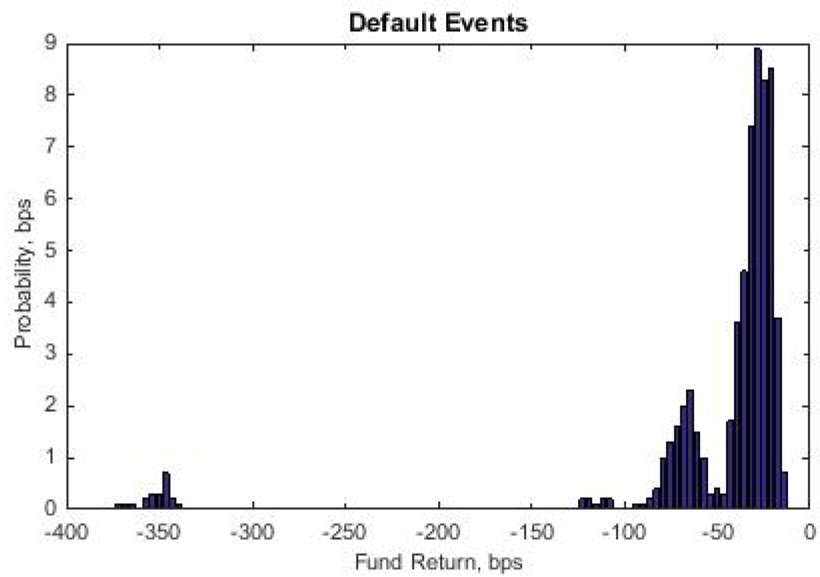
Effect of Portfolio Concentration on Tail of Return Distribution

- The return distribution for “no default” events remains unchanged
- We compare the 3mo return distributions for the case of “default events” in the two portfolios
- The more concentrated portfolio shows a greater occurrence of larger loss events (e.g. between -50 and -100bp), but a smaller overall frequency of loss events

Original Portfolio



Concentrated Portfolio



Source: Barclays Research

Modeling Contagion

- Any default in our portfolio universe could trigger large increases in spread throughout its sector and related sectors
- To model this, we introduce a contagion matrix $\mathbf{C}$
- Interpretation of $\mathbf{C}_{ij}$ is that a default of any bond in sector i will trigger a relative spread widening of this percentage in all bonds in sector j (e.g. $\mathbf{C}_{ij}$ =1 => spreads up 100%)
- For illustration, we use the below matrix, which was set on an ad hoc basis and not calibrated to any particular market event(s)

Asset Class	Euro Core	Italy	Spain	Ireland	Covered Bonds	Banks (Euro Core)	Banks (US)	Banks (Italy)	Banks (Spain)	Industrials (Euro Core)	Industrials (US)	Industrials (Italy)	Industrials (Spain)
Euro Core	3	3	3	3	3	3	3	3	3	3	3	3	3
Italy	1	3	3	3	2	2	2	3	2	1	0.5	3	1
Spain	1	3	3	3	2	2	2	2	3	1	0.5	1	3
Ireland	1	3	3	3	2	2	2	2	2	1	0.5	1	1
Covered Bonds	0	0	0	0	2	1	0	0.5	0.5	0	0	0	0
Banks (Euro Core)	1	1	1	1	1	2	0.5	1	1	0.5	0	0.5	0.5
Banks (US)	0	0	0	0	0	1	2	0.5	0.5	0	0.5	0	0
Banks (Italy)	1	3	1	1	0	2	0.5	3	2	0	0	1	0
Banks (Spain)	1	1	3	1	0	2	0.5	2	3	0	0	0	1
Industrials (Euro Core)	1	1	1	1	0	1.5	0	1	1	1	0.5	0.5	0.5
Industrials (US)	0	0	0	0	0	0.5	1.5	0	0	0.5	1	0.5	0.5
Industrials (Italy)	1	1	1	1	0	1	0	1.5	0.5	0.5	0.5	1	0.5
Industrials (Spain)	1	1	1	1	0	1	0	0.5	1.5	0.5	0.5	0.5	1

Source: Barclays Research

Evaluating the Effect of Contagion on Portfolio Tail Risk

- We redo the analysis of the original portfolio using the specified contagion matrix
- The return distribution in the “no default” case remains unchanged, but default events are now assumed to entail greater losses
- As a result, mean and standard deviation of expected return change mildly, but tail risk increases substantially: 99% CVaR nearly doubles, from -27bp to -54bp

Overall Performance Statistics

Statistics	No Contagion	With Contagion
Average Spread (bp)	48.9	48.9
Return Horizon (months)	3	3
Num Simulations	100,000	100,000
Mean Return (bp)	10.6	10.2
Stdev Return (bp)	9.6	11.5
95% VaR (bp)	-4.1	-4.7
99% VaR (bp)	-13.6	-24.5
95% CVaR (bp)	-11.5	-18.7
99% CVaR (bp)	-27.2	-53.8

Conditional Statistics

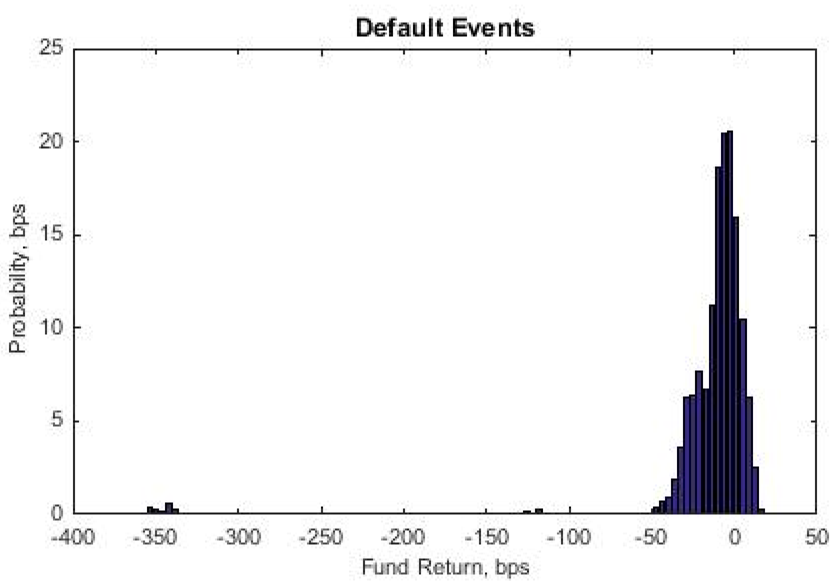
	Frequency	Mean Return (bp)
Original Portfolio (no contagion)		
No Defaults	98.6%	11.0
Defaults	1.4%	-13.8
Original Portfolio (with contagion)		
No Defaults	98.6%	11.0
Defaults	1.4%	-41.2

Source: Barclays Research

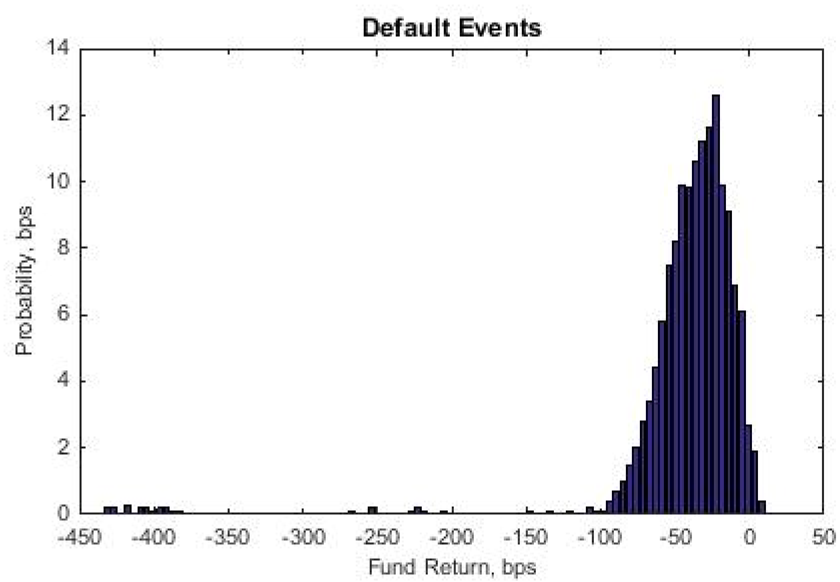
Effect of Contagion on Tail of Return Distribution

- Return distribution under the “No Default” case remains unchanged
- We compare the distributions of 3m excess returns for the original portfolio in the “default events” case with and without the contagion effect
- Contagion results in greater loss estimates for all default events

Original Portfolio – No Contagion



Original Portfolio – With Contagion



Source: Barclays Research

Portfolio Optimization

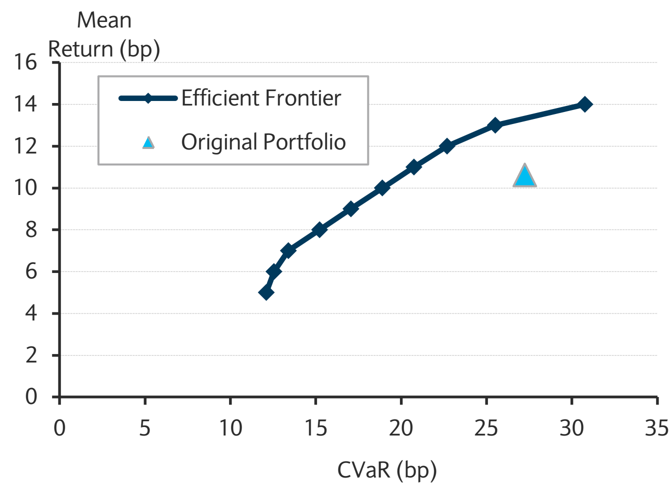
- Given the above risk modeling framework, we can set up a portfolio optimization to choose the allocation that best meets our objectives. For example:
- Minimize tail risk (99% CVaR) subject to
  - Expected excess return equal to a desired level (eg, equal to the original portfolio)
  - Long-only: all asset class weights positive and sum to 100%
  - Maximum allocations to each sector
  - Liquidity constraint – based on specified liquidity of each asset class and a portfolio minimum

Portfolio Optimization Results

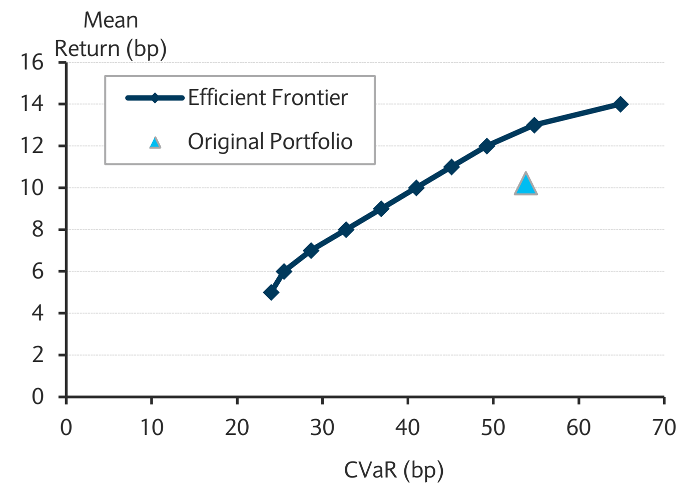
- Optimizer identifies asset shifts that can reduce portfolio tail risk
- We show results both with and without the modeling of contagion
- In both cases, optimal portfolio has lower CVaR for the same expected return
- Efficient frontier: risk achievable for different expected return targets in each case

	Without Contagion		With Contagion Model	
	Starting Portfolio	Optimal Portfolio	Starting Portfolio	Optimal Portfolio
Performance Statistics (3m horizon)				
Mean Return (bp)	10.6	10.6	10.2	10.2
99% VaR (bp)	-13.6	-14.8	-24.5	-22.3
99% CVaR (bp)	-27.2	-20.0	-53.8	-41.9

Efficient Frontier (no contagion)



Efficient Frontier (with contagion)



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Conclusion

- Return distributions and loss statistics shown above are a function of the illustrated input assumptions, and should not be considered as our projection for any actual fund or asset class
- Model can be easily modified to represent different asset classes and assumptions
- Can provide a framework for the top-down analysis of portfolio allocation decisions
- Contagion mechanism provides a way to express views on the inter-relationship between different market sectors in crisis scenarios

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