



Insurance Companies CIO Conference

Portfolio Risk Optimization for Total Return and Buy-and-Hold Investors

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Quantitative Portfolio Strategies

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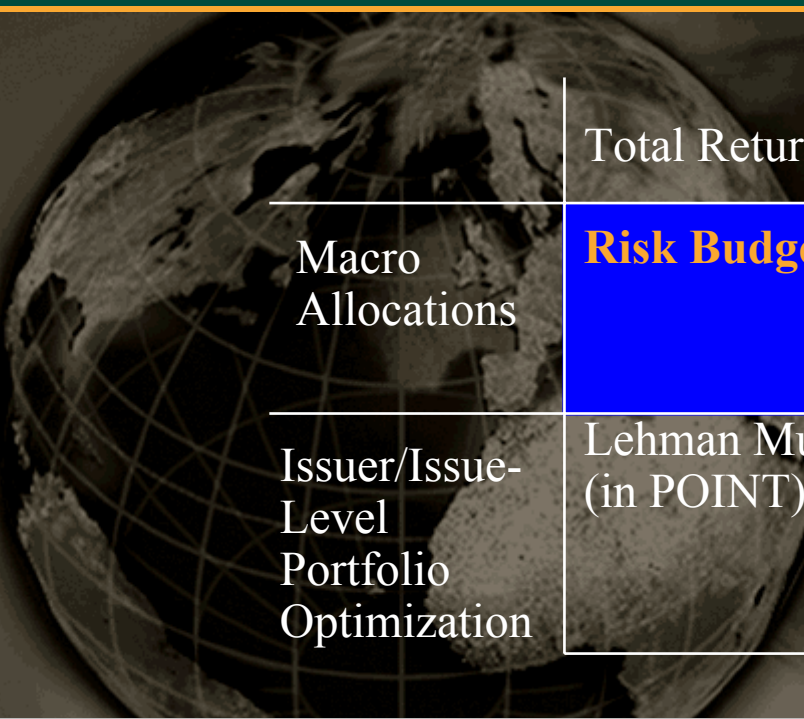
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Portfolio Risk Optimization

	Total Return Portfolios	Buy-and-Hold Portfolios
Macro Allocations	Risk Budgeting with Skill	Optimal Credit Allocation for Buy-and-hold investors
Issuer/Issue-Level Portfolio Optimization	Lehman Multi-factor Risk Model (in POINT)	COMPASS

- ♦ POINT (POrtfolio and INdex Tool) – Lehman Brothers tool for portfolio and benchmark analysis and management
- ♦ COMPASS (Credit OptiMized Portfolio Asset Selection System) – Lehman Brothers tool for constructing issuer-level portfolios of credit instruments and derivatives based on such portfolios for buy-and-hold investors

Risk Budgeting of Macro Strategies



	Total Return Portfolios	Buy-and-Hold Portfolios
Macro Allocations	Risk Budgeting with Skill	Optimal Credit Allocation for Buy-and-hold investors
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Arguments for Global Macro Strategies (“top-down” approach)

- ◆ Macro forces (rates, spreads, FX) largely determine index returns
 - ◆ Macro strategies involve changing exposures to the most basic drivers of index returns using the most liquid instruments
 - ◆ Ease of replication of index returns with derivatives demonstrates dominant role of macro positioning
 - ◆ A “bottom-up” approach across such diversified indices as the Global Aggregate would require a tremendous amount of resources and lead to many small and less liquid positions
- ✧ What combinations of macro strategies are the most risk-effective?

Strategy Simulation Example: FX Allocation, 20% skill

Asset	Ret (bp)	Long JPY	Long EUR	Long USD	Short JPY	Short EUR	Short USD
JPYcash	-24.5	4.5%	-2.7%	-2.4%	-4.5%	2.7%	2.4%
EURcash	27.7	-2.3%	5.4%	-2.4%	2.3%	-5.4%	2.4%
USDCash	-340.3	-2.3%	-2.7%	4.9%	2.3%	2.7%	-4.9%
Overall strategy:							
	Return (bp)	6.0	11.3	-16.6	-6.0	-11.3	16.6
Selection Probabilities for:							
	0% skill	16.7%	16.7%	16.7%	16.7%	16.7%	16.7%
	100% Skill	33.3%	33.3%	0.0%	0.0%	0.0%	33.3%
	20%	20.0%	20.0%	13.3%	13.3%	13.3%	20.0%
	(R-Mean)^2	13.9	80.9	356.5	68.1	182.5	206.4
	Mean Return	2.3					
	Variance	141.2					
	Volatility	11.9					

Performance Summary for Core Strategies (I)

January 1990 - December 2002

Skill Level	<i>Global Duration</i>			<i>Market Duration</i>			<i>FX Overlay in G3 currencies</i>		
	Mean			Mean			Mean		
	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio
0%	0.0	44.9	0.00	0.0	44.7	0.00	0.0	52.5	0.00
5%	6.2	44.8	0.14	6.0	44.7	0.13	6.8	52.5	0.13
10%	12.3	44.7	0.28	12.0	44.6	0.27	13.6	52.3	0.26
15%	18.5	44.6	0.41	18.0	44.4	0.41	20.4	52.2	0.39
20%	24.6	44.3	0.56	24.0	44.2	0.54	27.2	51.9	0.52
40%	49.3	42.6	1.16	48.0	42.5	1.13	54.4	50.1	1.09
60%	73.9	39.5	1.87	72.0	39.6	1.82	81.6	46.9	1.74
80%	98.5	34.8	2.83	96.0	35.1	2.73	108.9	42.1	2.59
100%	123.2	27.5	4.48	120.0	28.3	4.23	136.1	34.9	3.90

- ◆ Achieved volatilities are close to the targeted 50 bp/year
- ◆ IR increases more than linearly with skill, because in addition to increase in mean outperf., we also see lower vol. at high skills

Performance Summary for Core-Plus Strategies Long-Only, De-Meaned

Skill Level	<i>U.S. Credit</i>			<i>Euro Credit</i>			<i>Emerging Markets</i>			<i>U.S. High Yield</i>		
	<i>Aug 1988 - Dec 2002</i>			<i>Jan 1999 - Dec 2002</i>			<i>Jan 1993 - Dec 2002</i>			<i>Aug 1988 - Dec 2002</i>		
	Mean			Mean			Mean			Mean		
	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio	Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio
0%	0.0	7.0	0.00	0.0	3.4	0.00	0.0	53.4	0.00	0.0	25.4	0.00
5%	0.5	7.0	0.08	0.3	3.4	0.08	4.7	53.1	0.09	2.2	25.4	0.09
10%	1.0	6.9	0.15	0.6	3.4	0.17	9.5	52.8	0.18	4.4	25.3	0.17
15%	1.6	6.9	0.23	0.9	3.4	0.25	14.2	52.4	0.27	6.6	25.2	0.26
20%	2.1	6.9	0.31	1.1	3.4	0.34	18.9	51.9	0.36	8.7	25.1	0.35
40%	4.2	6.7	0.63	2.3	3.3	0.70	37.9	49.7	0.76	17.5	24.5	0.71
60%	6.3	6.4	0.98	3.4	3.1	1.09	56.8	46.8	1.21	26.2	23.7	1.11
80%	8.4	6.1	1.38	4.6	2.9	1.55	75.7	43.1	1.76	35.0	22.5	1.55
100%	10.5	5.7	1.84	5.7	2.7	2.10	94.7	38.2	2.48	43.7	20.9	2.09

- ♦ Long-only strategies exhibit a nonzero mean return at 0% skill. This represents the trend over the time period of the study, and has been subtracted out.
- ♦ Information ratios much lower than core strategies at given skill. For example, at 20% skill, all core strategies showed IR above 0.50
- ♦ Reason: “no shorts” constraint means inability to capitalize on negative views

Pair-Wise Performance Correlations Among Sample Pure Tilt Strategies

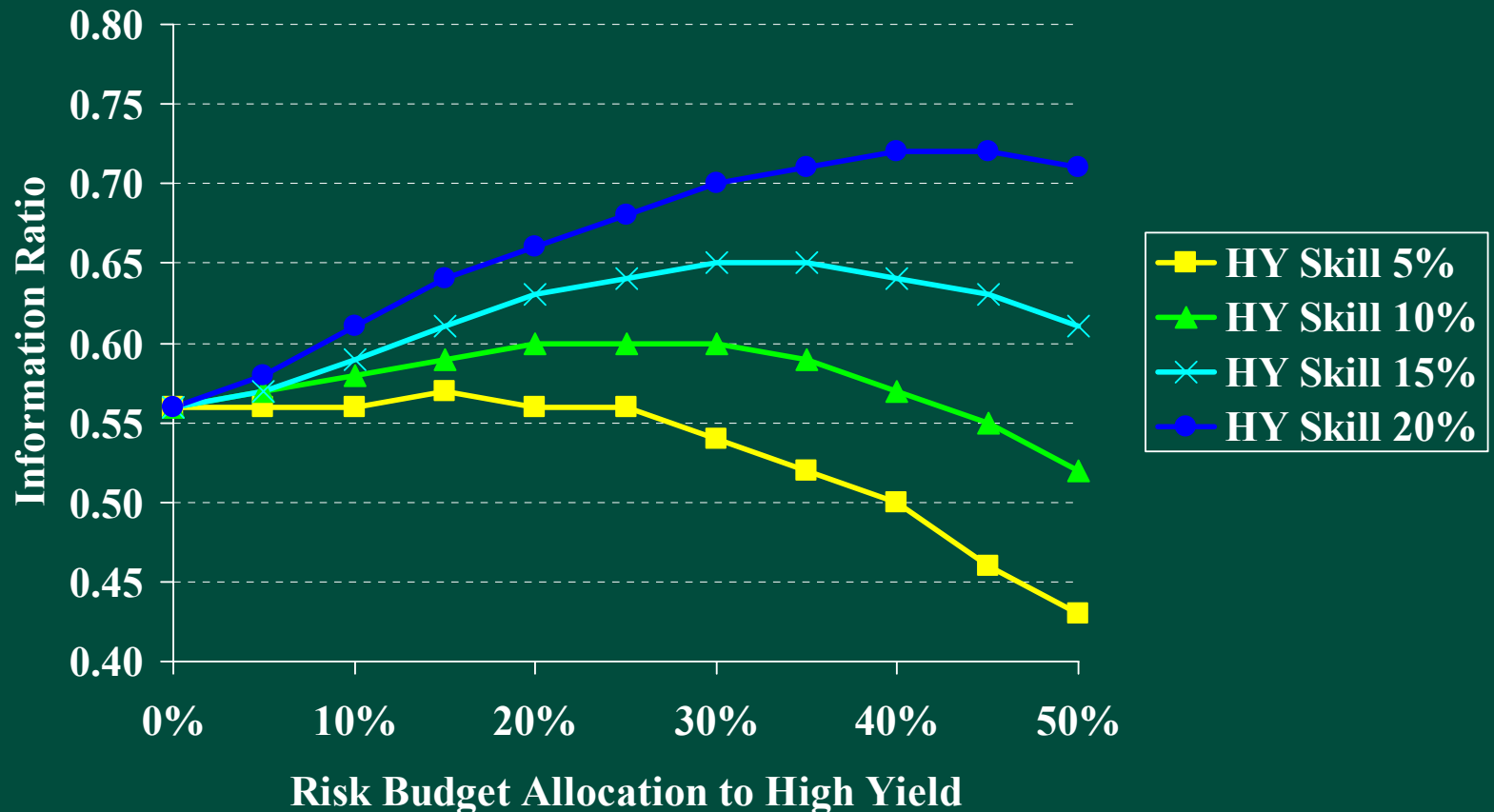
Market Duration Pairs		Pre-EMU	Post-EMU	Overall	Twist Pairs		Pre-EMU	Post-EMU	Overall
EUR-JPY	EUR-USD	0.29	-0.55	0.12	EUR Steepener	USD Steepener	0.04	0.53	0.23
EUR-JPY	EUR-GBP	0.10	-0.57	-0.01	EUR Steepener	JPY Steepener	0.09	-0.12	0.04
EUR-GBP	EUR-USD	0.33	0.53	0.37	USD Steepener	JPY Steepener	-0.03	-0.12	-0.06
EUR-CAD	EUR-USD	0.61	0.72	0.61	USD Steepener	USD-EUR	0.32	0.28	0.30
USD-JPY	USD-GBP	0.25	0.45	0.30	All 3 Steepeners	Long Glob Dur	0.10	0.23	0.14
Long Glob Dur	EUR-JPY	-0.32	0.47	-0.17	EUR Steepener	Long EUR FX	-0.22	0.14	-0.11
Long Glob Dur	EUR-USD	-0.51	-0.81	-0.59	USD Steepener	Long USD FX	-0.38	-0.28	-0.33
Long Glob Dur	EUR-GBP	-0.66	-0.64	-0.66	JPY Steepener	Long JPY FX	0.00	-0.05	-0.01
Long Glob Dur	USD-JPY	0.13	0.75	0.31	Core-Plus Pairs				
Long Glob Dur	USD-GBP	-0.20	0.32	-0.09			Pre-EMU	Post-EMU	Overall
FX Pairs		Pre-EMU	Post-EMU	Overall	Emerging Mkts	Long Glob Dur	0.24	-0.05	0.15
Long JPY FX	Long EUR FX	-0.55	-0.64	-0.56	High Yield	Long Glob Dur	0.33	-0.08	0.18
Long JPY FX	Long USD FX	-0.63	-0.50	-0.60	Euro Credit	Long Glob Dur	-1.00	-0.31	-0.31
Long USD FX	Long EUR FX	-0.30	-0.35	-0.32	Euro Credit	EUR Steepener	N/A	-0.38	-0.38
Long JPY FX	Long Glob Dur	0.07	0.04	0.06	High Yield	USD Steepener	0.10	-0.28	-0.08
Long EUR FX	Long Glob Dur	-0.07	0.17	0.00	Emerging Mkts	USD Steepener	0.01	-0.22	-0.07
Long USD FX	Long Glob Dur	0.01	-0.23	-0.05	Emerging Mkts	High Yield	0.63	0.51	0.49
Long JPY FX	JPY-EUR	-0.11	-0.08	-0.11	US Credit	Long Glob Dur	-0.09	-0.35	-0.18
Long EUR FX	EUR-USD	-0.23	-0.18	-0.22	US Credit	High Yield	0.55	0.77	0.67
Long USD FX	USD-EUR	-0.17	-0.34	-0.21	US Credit	Euro Credit	N/A	0.85	0.85
					US Credit	Long USD FX	0.31	0.20	0.24
					US Credit	USD-EUR	-0.19	-0.47	-0.30
					US Credit	USD Steepener	-0.26	-0.32	-0.29

Performance of a Combination Strategy with Unequal Skills

Strategy	Mean Outperf. (bp/yr)	Volat. (bp/yr)	Inform. Ratio
Global Duration (20% skill)	25.6	46.3	0.553
High Yield (10% skill)	14.6	60.9	0.240
Blend (75% Global Duration, 25% High Yield)	28.6	47.8	0.599

Performance of a Combination Strategy as a Function of Weight and Skill Level

20% skill at Global Duration strategy; High Yield skill as shown



- ◆ Optimal allocation to high yield depends on relative skill levels

The “Fundamental Law of Active Management”

- ◆ In previous “imperfect foresight” studies, we found performance to depend on the number of independent decisions in a strategy
- ◆ In *Active Portfolio Management* (1999, McGraw-Hill), Grinold and Kahn define the “fundamental law of active management”:

$$IR = IC \cdot \sqrt{BR}$$

- ◆ The “information coefficient” IC is defined as the correlation between forecast and realized returns, and corresponds roughly to our measure of skill
- ◆ The “breadth” BR of a strategy is defined as the number of independent decisions taken a year. For example, strategies that make a single decision each month have $BR=12$, and we should expect information ratio to equal $skill \cdot \sqrt{12}$

Lehman Brothers Risk Budgeting Tool

- ◆ What is outperformance (alpha) of a strategy?

$$IR = \frac{\alpha}{TE} \Rightarrow \alpha = TE \cdot SKILL \cdot \sqrt{BREADTH}$$

- ◆ The user provides skill levels for all strategies
- ◆ We set up an optimization process that maximizes the combined alpha subject to the overall risk budget (tracking error) constraint
- ◆ The optimization finds individual strategies' TE which in their turn determine position sizes in each strategy

Lehman Brothers Risk Budgeting Tool

Customized to the style of a U.S. Aggregate Index manager

- ◆ No pure duration positions – not viewed as efficient
- ◆ Yield curve view is a choice among many different bullet/barbell positions (2-5-10, 5-10-30, etc.)
- ◆ Long/short credit vs. Treasuries
- ◆ Long/short swap-based assets (agencies, MBS, ABS, CMBS) vs. Treasuries
- ◆ Long/short MBS vs. Agencies (within swaps-based assets)
- ◆ Long or neutral in various core-plus assets:
 - High yield
 - Emerging markets
 - Inflation-protected securities (TIPS)
 - Euro-denominated Treasuries



Lehman Brothers Risk Budgeting Tool

- ◆ Several factors help determine the optimal allocation
- ◆ Main inputs:
 - Set of directional views
 - Skill levels assigned to each view
 - Risk budget (target tracking error)
- ◆ Important behind-the-scenes data:
 - Historical volatilities and correlations of strategy returns (computed for specific views, based on asset class returns)
 - Constraints of various types

Example 1: Base Case

10% skill at all strategies, Risk budget 125 bp

Active Position		Skill/Confidence
U.S. Curve Exposure	Barbell 2-10-30 <input checked="" type="checkbox"/>	10 %
Investment Grade Credit	Long Credit <input type="checkbox"/>	10 %
Swap-Based Assets	Long Swap-Based Assets <input type="checkbox"/>	10 %
MBS vs. Agency	Long MBS vs. Agency <input type="checkbox"/>	10 %
Core-Plus Assets	HY Long High Yield <input type="checkbox"/>	10 %
	TIPS Long TIPS <input type="checkbox"/>	10 %
	EM Long Emerging Markets <input checked="" type="checkbox"/>	10 %
Euro Treasury Exposure	Long All <input type="checkbox"/>	10 %
Total Risk Budget (Tracking Error, bp/yr)		125
Maximize	Portfolio Alpha	
Total Portfolio TE (bp/yr)		125
Systematic	122	
Non-Systematic	27	
Portfolio Alpha	64	
Information Ratio	0.51	
Optimize		
Interactive Portfolio Positions Editor		
View Asset Correlation Matrix		
View Strategy Correlation Matrix		
View Pair Wise Combination Graph		
Print Summary Report		
Last optimization status:		OK

Asset	Active Position	Index %	Total Allocation	Chg vs. Current
USD Cash	0.00%	-	0.00%	-3.00%
Maturity cell 1-3	5.14%	18.04%	23.18%	17.44%
Maturity cell 3-7	0.00%	17.40%	17.40%	5.01%
Maturity cell 7-10	-10.96%	10.96%	0.00%	-27.48%
Maturity cell 10+	5.82%	15.10%	20.92%	12.92%
Investment Grade Credit	0.00%	27.46%	27.46%	8.89%
MBS	12.16%	34.17%	46.33%	24.33%
Agency	-12.16%	12.16%	0.00%	-14.84%
ABS/CMBS	0.00%	4.33%	4.33%	4.33%
High Yield	3.99%	0.00%	3.99%	-1.01%
TIPS	13.52%	0.00%	13.52%	13.52%
Emerging Markets	3.88%	0.00%	3.88%	-0.62%
EUR Trs 1-3	0.13%	0.00%	0.13%	-3.02%
EUR Trs 3-7	0.17%	0.00%	0.17%	-4.03%
EUR Trs 7-10	0.10%	0.00%	0.10%	-2.30%
EUR Trs 10+	0.09%	0.00%	0.09%	-2.05%

Strategy	Isolated TE (bp/yr)	R-squared	Contrib. to Var.
U.S. Curve Exposure	21.6	28.8%	9.7%
Investment Grade Credit	0.0	0.0%	0.0%
Swap-Based Assets	0.0	0.0%	3.3%
MBS vs. Agency	9.9	15.8%	
Long High Yield	43.4	60.7%	28.4%
Long TIPS	42.2	13.2%	12.9%
Long Emerging Markets	65.2	68.8%	45.4%
Euro Treasury Exposure	1.4	9.5%	0.4%

Broad Asset Allocation	Portfolio Benchmark	Difference
Treasuries	0.00%	21.88%
Credit	27.46%	27.46%
Swaps-based	50.66%	50.66%
Out-of-Benchmark Assets	21.88%	0.00%

Covariance matrix: Equal Weight 01/31/98 - 06/30/03

Example 2: Change Curve Strategy

More curve risk, less Core+ risk, better alpha and IR

Active Position		Skill/Confidence	Asset	Active Position	Index %	Total Allocation	Chg vs. Current																																		
U.S. Curve Exposure	Barbell 2-mid-30 <input checked="" type="checkbox"/>	10 %	USD Cash	0.00%	-	0.00%	-3.00%																																		
Investment Grade Credit	Long Credit <input type="checkbox"/>	10 %	Maturity cell 1-3	17.33%	18.04%	35.37%	29.63%																																		
Swap-Based Assets	Long Swap-Based Assets <input type="checkbox"/>	10 %	Maturity cell 3-7	-17.40%	17.40%	0.00%	-12.39%																																		
MBS vs. Agency	Long MBS vs. Agency <input type="checkbox"/>	10 %	Maturity cell 7-10	-8.54%	10.96%	2.42%	-25.06%																																		
Core-Plus Assets	HY Long High Yield <input type="checkbox"/>	10 %	Maturity cell 10+	8.61%	15.10%	23.71%	15.71%																																		
	TIPS Long TIPS <input type="checkbox"/>	10 %	Investment Grade Credit	0.00%	27.46%	27.46%	8.89%																																		
	EM Long Emerging Markets <input checked="" type="checkbox"/>	10 %	MBS	12.16%	34.17%	46.33%	24.33%																																		
Euro Treasury Exposure	Long All <input type="checkbox"/>	10 %	Agency	-12.16%	12.16%	0.00%	-14.84%																																		
Total Risk Budget (Tracking Error, bp/yr)		125	ABS/CMBS	0.00%	4.33%	4.33%	4.33%																																		
Maximize	Portfolio Alpha		High Yield	2.75%	0.00%	2.75%	-2.25%																																		
Total Portfolio TE (bp/yr)		125	TIPS	15.41%	0.00%	15.41%	15.41%																																		
Systematic	122		Emerging Markets	3.72%	0.00%	3.72%	-0.78%																																		
Non-Systematic	27		EUR Trs 1-3	0.00%	0.00%	0.00%	-3.15%																																		
Portfolio Alpha		66	EUR Trs 3-7	0.00%	0.00%	0.00%	-4.20%																																		
Information Ratio		0.53	EUR Trs 7-10	0.00%	0.00%	0.00%	-2.40%																																		
			EUR Trs 10+	0.00%	0.00%	0.00%	-2.14%																																		
<div>Optimize</div> <div>Interactive Portfolio Positions Editor</div> <div>View Asset Correlation Matrix</div> <div>View Strategy Correlation Matrix</div> <div>View Pair Wise Combination Graph</div> <div>Print Summary Report</div>			<table border="1"> <thead> <tr> <th>Strategy</th> <th>Isolated TE (bp/yr)</th> <th>R-squared</th> <th>Contrib. to Var.</th> </tr> </thead> <tbody> <tr> <td>U.S. Curve Exposure</td> <td>40.7</td> <td>36.6%</td> <td>20.6%</td> </tr> <tr> <td>Investment Grade Credit</td> <td>0.0</td> <td>0.0%</td> <td>0.0%</td> </tr> <tr> <td>Swap-Based Assets</td> <td>0.0</td> <td>0.0%</td> <td rowspan="2">3.5%</td> </tr> <tr> <td>MBS vs. Agency</td> <td>9.9</td> <td>17.6%</td> </tr> <tr> <td>Long High Yield</td> <td>30.0</td> <td>55.9%</td> <td>18.8%</td> </tr> <tr> <td>Long TIPS</td> <td>48.1</td> <td>15.2%</td> <td>15.7%</td> </tr> <tr> <td>Long Emerging Markets</td> <td>62.5</td> <td>62.4%</td> <td>41.3%</td> </tr> <tr> <td>Euro Treasury Exposure</td> <td>0.0</td> <td>11.2%</td> <td>0.0%</td> </tr> </tbody> </table>				Strategy	Isolated TE (bp/yr)	R-squared	Contrib. to Var.	U.S. Curve Exposure	40.7	36.6%	20.6%	Investment Grade Credit	0.0	0.0%	0.0%	Swap-Based Assets	0.0	0.0%	3.5%	MBS vs. Agency	9.9	17.6%	Long High Yield	30.0	55.9%	18.8%	Long TIPS	48.1	15.2%	15.7%	Long Emerging Markets	62.5	62.4%	41.3%	Euro Treasury Exposure	0.0	11.2%	0.0%
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Last optimization status: OK

Example 3: Low TE

Risk budget 60 bp; allocations don't hit 0 constraint in 7-10 year, Agency cells; better strategy diversification (bigger % of var to curve, swaps); higher IR

Active Position		Skill/Confidence
U.S. Curve Exposure	Barbell 2-10-30 <input checked="" type="checkbox"/>	10 %
Investment Grade Credit	Long Credit <input type="checkbox"/>	10 %
Swap-Based Assets	Long Swap-Based Assets <input type="checkbox"/>	10 %
MBS vs. Agency	Long MBS vs. Agency <input type="checkbox"/>	10 %
Core-Plus Assets	HY Long High Yield <input type="checkbox"/>	10 %
	TIPS Long TIPS <input type="checkbox"/>	10 %
	EM Long Emerging Markets <input checked="" type="checkbox"/>	10 %
Euro Treasury Exposure	Long All <input type="checkbox"/>	10 %
Total Risk Budget (Tracking Error, bp/yr)		60
Maximize	Portfolio Alpha	
Total Portfolio TE (bp/yr)		60
Systematic	55	
Non-Systematic	24	
Portfolio Alpha		34
Information Ratio		0.57
Optimize		
Interactive Portfolio Positions Editor		
View Asset Correlation Matrix		
View Strategy Correlation Matrix		
View Pair Wise Combination Graph		
Print Summary Report		
Last optimization status: OK		

Asset	Active Position	Index %	Total Allocation	Chg vs. Current
USD Cash	0.00%	-	0.00%	-3.00%
Maturity cell 1-3	3.71%	18.04%	21.75%	16.01%
Maturity cell 3-7	0.00%	17.40%	17.40%	5.01%
Maturity cell 7-10	-7.92%	10.96%	3.04%	-24.44%
Maturity cell 10+	4.20%	15.10%	19.30%	11.30%
Investment Grade Credit	0.00%	27.46%	27.46%	8.89%
MBS	6.52%	34.17%	40.69%	18.69%
Agency	-5.05%	12.16%	7.11%	-7.73%
ABS/CMBS	0.14%	4.33%	4.47%	4.47%
High Yield	0.00%	0.00%	0.00%	-5.00%
TIPS	10.66%	0.00%	10.66%	10.66%
Emerging Markets	1.13%	0.00%	1.13%	-3.37%
EUR Trs 1-3	2.27%	0.00%	2.27%	-0.88%
EUR Trs 3-7	2.97%	0.00%	2.97%	-1.23%
EUR Trs 7-10	1.72%	0.00%	1.72%	-0.68%
EUR Trs 10+	1.53%	0.00%	1.53%	-0.61%

Strategy	Isolated TE (bp/yr)	R-squared	Contrib. to Var.
U.S. Curve Exposure	15.6	29.0%	16.6%
Investment Grade Credit	0.0	0.0%	0.0%
Swap-Based Assets	1.6	16.2%	4.9%
MBS vs. Agency	4.4	17.9%	
Long High Yield	0.0	0.0%	0.0%
Long TIPS	33.3	27.0%	34.1%
Long Emerging Markets	18.9	27.5%	19.6%
Euro Treasury Exposure	24.2	27.2%	24.9%

Broad Asset Allocation	Portfolio Benchmark	Difference
Treasuries	0.00%	21.88%
Credit	27.46%	27.46%
Swaps-based	52.26%	50.66%
Out-of-Benchmark Assets	20.28%	0.00%

Covariance matrix: Equal Weight 01/31/98 - 06/30/03

LB Risk Budgeting Tool: Additional Options

History used, turnover constraint, idiosyncratic vols, index weights

Microsoft Excel - RiskBudgetingAgg3.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Index Weights and Curve Allocation Participation

Asset class	Index Weight	Maturity cells allocation				Total	
		1-3 yrs	3-7 yrs	7-10 yrs	10+ yrs		
USD Treasury	21.88%	7.45%	4.89%	2.40%	7.14%	21.88%	OK
Investment Grade Credit	27.46%	5.76%	8.63%	6.59%	6.48%	27.46%	OK
MBS	34.17%					0.00%	OK
Agency	12.16%	4.83%	3.88%	1.97%	1.48%	12.16%	OK
ABS/CMBS	4.33%					0.00%	OK
High Yield	0.00%					0.00%	OK
TIPS	0.00%					0.00%	OK
Emerging Markets	0.00%					0.00%	OK
EUR Treasury	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	OK
Total	100.00%						OK

Maturity cell 1-3: 18.04%

Maturity cell 3-7: 17.40%

Maturity cell 7-10: 10.96%

Maturity cell 10+: 15.10%

Manual input areas

Idiosyncratic Volatility

Asset class	Vol (bp/yr)
USD Treasury	0
Investment Grade Credit	60
MBS	40
Agency	40
ABS/CMBS	40
High Yield	120
TIPS	12
Emerging Markets	240
EUR Treasury	12

Covariance Matrix

Equal Weight

Half-Life (yr) n/a

Beginning Date: 01/31/92

Ending Date: 06/30/03

Edit Special Selections

Current Portfolio: Allocation Weights

		Maturity cells allocation				Total	
		1-3 yrs	3-7 yrs	7-10 yrs	10+ yrs		
USD Cash	3.00%						
USD Treasury	20.20%	1.88%	5.74%	9.47%	3.11%	20.20%	OK
Investment Grade Credit	18.57%	3.86%	2.13%	12.58%	0.00%	18.57%	OK
MBS	22.00%					0.00%	OK
Agency	14.84%	0.00%	4.52%	5.43%	4.89%	14.84%	OK
ABS/CMBS	0.00%					0.00%	OK
High Yield	5.00%					0.00%	OK
TIPS	0.00%					0.00%	OK
Emerging Markets	4.50%					0.00%	OK
EUR Treasury	11.89%	3.15%	4.20%	2.40%	2.14%	11.89%	OK
Total	100.00%						OK

Maturity cell 1-3: 5.74%

Maturity cell 3-7: 12.39%

Maturity cell 7-10: 27.48%

Maturity cell 10+: 8.00%

Current Portfolio: Active Positions and Turnover Limits

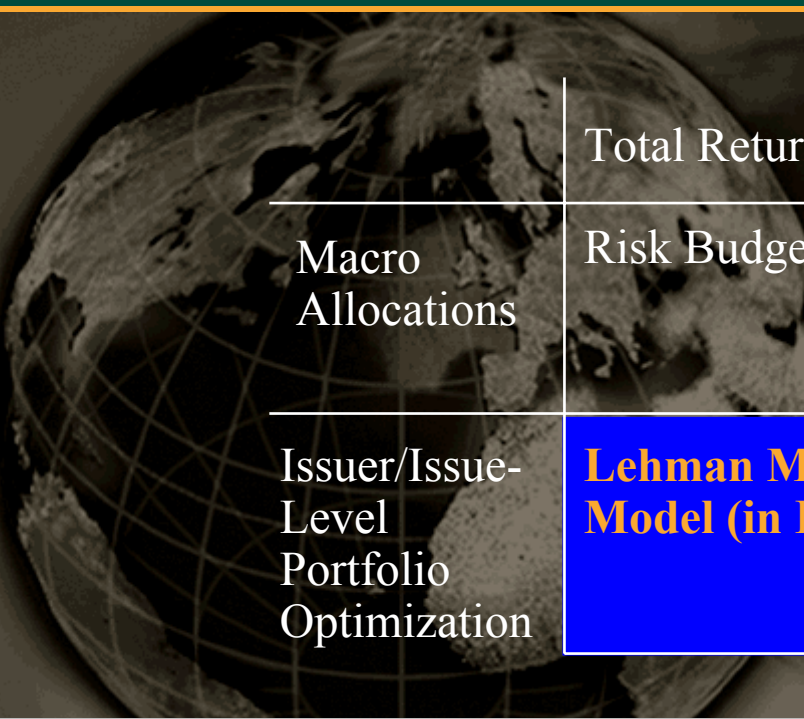
		Turnover Limit
Maturity cell 1-3	-12.30%	1000.00%
Maturity cell 3-7	-5.01%	1000.00%
Maturity cell 7-10	18.52%	1000.00%
Maturity cell 10+	-7.10%	1000.00%
EUR Trs 1-3	3.15%	1000.00%
EUR Trs 3-7	4.20%	1000.00%
EUR Trs 7-10	2.40%	1000.00%
EUR Trs 10+	2.14%	1000.00%
Investment Grade Credit	-8.89%	10.00%
MBS	-12.17%	15.00%
Agency	2.68%	15.00%
ABS/CMBS	-4.33%	10.00%
High Yield	5.00%	5.00%
TIPS	0.00%	1000.00%
Emerging Markets	4.50%	5.00%

Systematic TE: 51

Non-Systematic TE: 20

Total TE: 55

Global Risk Model



	Total Return Portfolios	Buy-and-Hold Portfolios
Macro Allocations	Risk Budgeting with Skill	Optimal Credit Allocation for Buy-and-hold investors
Issuer/Issue-Level Portfolio Optimization	Lehman Multi-factor Risk Model (in POINT)	COMPASS

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Why Do We Need a Risk Model?

- ♦ **Quantify the market risk embedded in a portfolio**
 - In absolute terms: expected volatility of the portfolio total returns
 - In relative terms: tracking error volatility
- ♦ **Attributes ex-ante risk to major decisions implemented by fund managers**
 - Currency allocation
 - Interest rate management: duration and yield curve exposure
 - Swap spreads
 - Interest rate volatility
 - Credit allocation
 - Name and security selection
- ♦ **Can be used in**
 - Monitoring active risk
 - Portfolio optimization
 - Risk Budgeting
 - Scenario analysis

Lehman's Model Framework

- ◆ The return of any particular fixed income security can be decomposed linearly:

$$R_{i,(t+1)} = \mu_{i,t} + L_{i,t} \cdot f_{(t+1)} + \varepsilon_{i,(t+1)}$$

Risk Loading

Risk Factor

- ◆ This general framework has been used in our risk modeling work since the early 90's and has proved robust, flexible, and intuitive

Categories of Risk factors

Category	Factor	Sensitivity
Currency	Change in spot exchange rate	Market value
Yield curve	Yield changes for key tenors of the respective Treasury par curve	Key rate duration
	Square of yield change	Convexity
Volatility	Change in Swaption volatility/latent factor	Volatility duration
Swap spreads	Changes in swap spreads for key tenors	Spread duration
Spread	Systematic change in spread across an entire sector/quality cell	Spread duration
	Change in spread curve slope	$\text{Sprd Durt} * \text{Norm Life}$
	Change in spread level premium	$\text{Sprd Durt} * \text{Norm OAS Level}$
	Geographic factors (US vs. Non-US issuers)	Spread duration
Non-systematic spread	Issue/issuer-specific spread change	Spread duration

Indicative Number of Systematic Risk Factors

Factor	All	USD	EUR	GBP	JPY	Other	Core
Currency	18	-	1	1	1	15	8
Curve	58	7	7	7	8	29	23
Volatility	8	6	1	1			3
Swap Spreads	26	6	4	4	7	5	8
IG Spread	148	75	37	24	12		16
HY Spread	18	18					
Totals	276	112	50	37	28	49	58

Yield Curve and Volatility Factors for Major Currencies

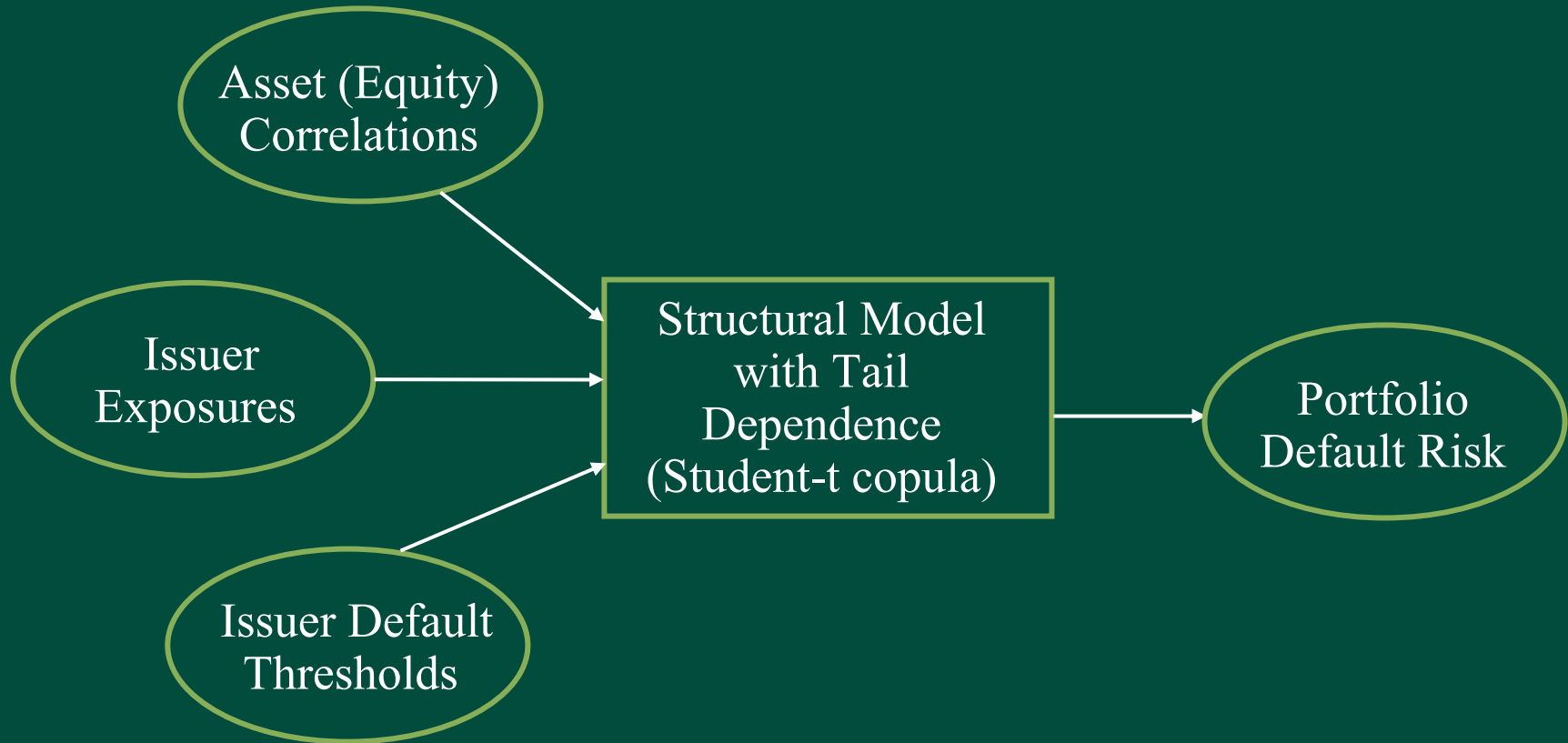
Currency	Yield Curve	Swap Spreads	Volatility
USD	6 Months 2, 5, 10, 20, 30 Years Convexity	6 Months 2, 5, 10, 20, 30 Years	6 Factors: Treasury, Agency, IG Corp, HY Corp, Short & Long MBS
EUR, GBP	6 Months 2, 5, 10, 20, 30 Years Convexity	2, 5, 10, 30 Years	5 x 5 Swaption
JPY	6 Months, 2, 5, 7, 10, 20, 30 Years Convexity	6 Months, 2, 5, 7, 10, 20, 30 Years	—

Spread Factors Dollar Risk Model

Gov	Other Spread Markets	Corporate Credit
Treasury Agy_farm Agy_fhlb Agy_fhlmc Agy_fnma Agy_other	10 MBS buckets 4 CMBS buckets 6 ABS buckets Non-Corp Aaa/Aa Non-Corp A Non-Corp Baa	24 IG buckets across 3 qualities and 8 sectors: Banking, Finance, Basic, Energy, Cyclical, Non-Cyclical, Communication, Utility 11 HY buckets, one for each of: Basic, Cyclical, ConsumerGoods, Communications, Energy, Finance, Medical, Non-Cyclical, Technology, Transport, Utility
	2 geographic factors	
2 Spread Slope Factors		Spread Slope Factor
2 Spread Level Factors		Spread Level Factor

Default Risk: Portfolio

- ◆ Default risk at the portfolio level considers correlations among issuer default events, which make default a systematic risk.



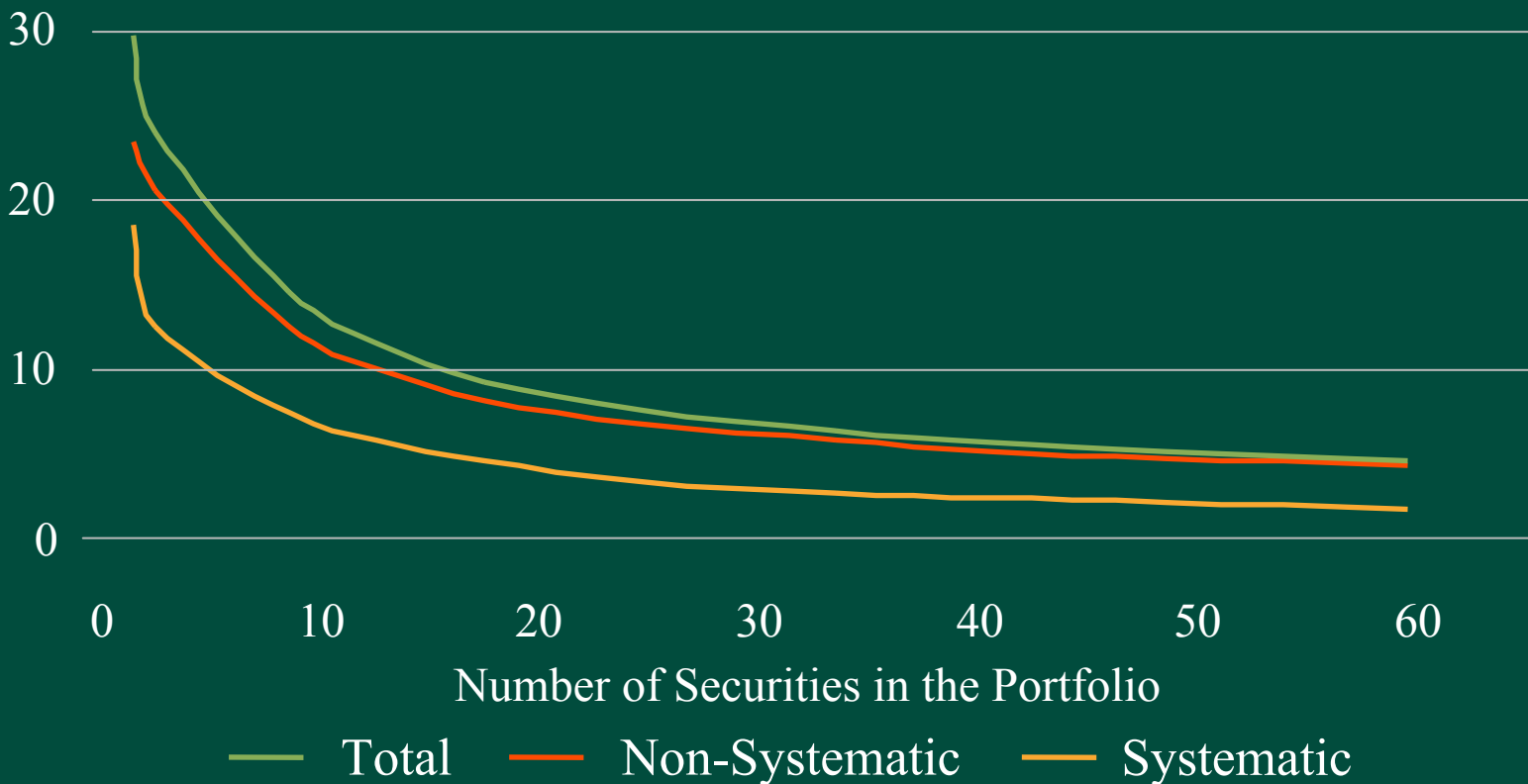
Calculation of Variance due to Special Risk (Issue-Specific Model)

	Portfolio Weights	Benchmark Weights	Contribution to Issue- Specific Risk
Issue 1	w_{P_1}	w_{B_1}	$(w_{P_1} - w_{B_1})^2 SD_1^2 \sigma_{\varepsilon_1}^2$
Issue 2	w_{P_2}	w_{B_2}	$(w_{P_2} - w_{B_2})^2 SD_2^2 \sigma_{\varepsilon_2}^2$
Issue N	w_{P_N}	w_{B_N}	$(w_{P_N} - w_{B_N})^2 SD_N^2 \sigma_{\varepsilon_N}^2$
Total Issue-Specific Risk			$\sum_{i=1}^N (w_{P_i} - w_{B_i})^2 SD_i^2 \sigma_{\varepsilon_i}^2$
Total Issuer-Specific Risk			$\sum_{i=1}^N \left\{ \sum_{j \in S_i} w_{P_j} SD_j \sigma_{\varepsilon_{i,j}} - \sum_{j \in S_i} w_{B_j} SD_j \sigma_{\varepsilon_{i,j}} \right\}^2$

Risk Model Application: Effect of Diversification on Index Tracking

Portfolio Tracking Error vs. LB Euro Aggregate Index

Tracking Error (bps / month)



POINT: Tracking Error Report

What are the sources of risk?

Global Risk Model				Glossary		
User-defined Parameters	Portfolio/Benchmark Comparison	Tracking Error	Factor Exposure - Full Details	Portfolio Issue-Specific Risk	Credit Tickers	Warnings & Exclusions
Tracking Error, 10/31/2003						
Portfolio : GRMRV			Benchmark : Global Agg			
Global Risk Factor	Isolated TEV	Cumulative TEV	Difference in cumulative	Percentage of tracking error variance	Portfolio beta	
Global:						

Currency	19.1	19.1	19.1	53.8	1.1	
Yield Curve	8.95	22.98	3.88	19.42	0.96	
Swap Spreads	0.99	22.73	-0.25	-0.9	1.04	
Volatility	0.15	22.74	0.01	0.06	1.05	
Investment-Grade Spreads	2.33	22.85	0.11	0.91	1.01	
~~ Treasury Spreads	1.14	22.66	-0.09	-0.28	1.44	
~~ Credit and Agency Spreads	1.61	22.85	0.2	1.04	1.02	
~~ MBS/Securitized	0.98	22.9	0.04	0.16	0.93	
~~ CMBS/ABS	0.37	22.85	-0.05	-0.01	1.75	
High Yield Spreads	6.97	25.61	2.76	11.82		
Systematic risk	25.61	25.61	0.0	85.1	1.05	
Idiosyncratic risk	8.38	26.94	1.34	9.11		
Default risk	6.68	27.76	0.82	5.79		
Total risk (bp/month)		27.76	0.0	100.0		
Portfolio volatility (bp/month)					127.93	
Benchmark volatility (bp/month)					119.34	

- ◆ Upper part of report shows Global Risk Factors
- ◆ Lower part shows Risk Factors grouped by currency bloc (not shown)

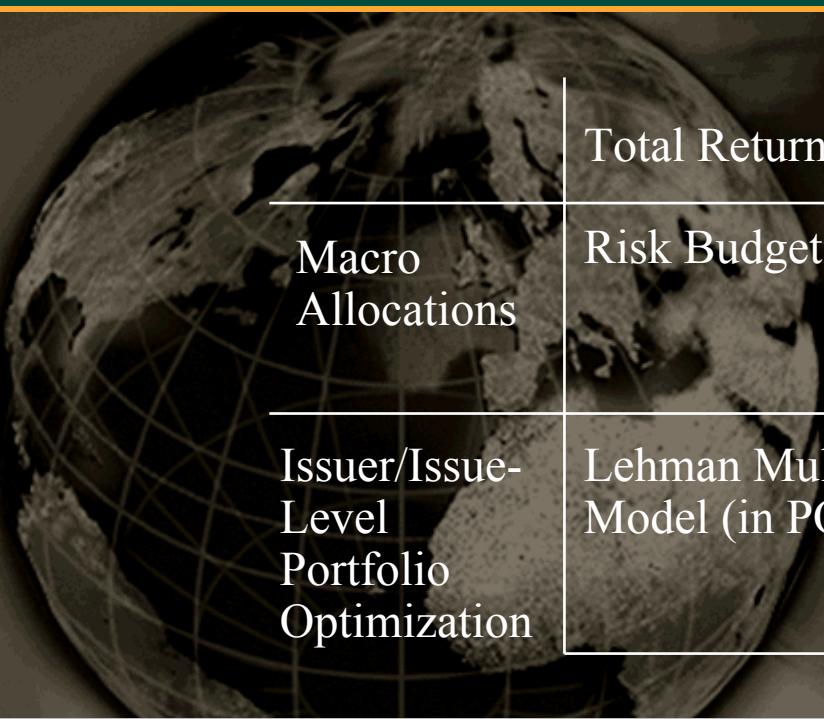
POINT: Tracking Error Report

What is the portfolio's sensitivity to risk factors?

Global Risk Model						Glossary			
User-defined Parameters	Portfolio/Benchmark Comparison		Tracking Error	Factor Exposure - Full Details		Portfolio Issue-Specific Risk	Credit Tickers	Warnings & Exclusions	
Factor Exposure - Full Details, 10/31/2003									
Portfolio : GRMRV				Benchmark : Global Agg					
Factor name	Sensitivity/exposure	Portfolio exposure	Benchmark exposure	Net exposure	Factor volatility	TE impact of an isolated 1 std. dev. up change	TE impact of a correlated 1 std. dev. up change	Marginal contribution to TEV	Percentage of tracking error variance
CURRENCY:									
USD Currency	MV%	37.66	42.2	-4.53	0.0	-0.0		0.0	-0.0
CAD Currency	MV%	2.6	1.8	0.8	2.12	1.69	11.47	0.243	2.52
EUR Currency	MV%	34.17	30.41	3.76	2.97	11.16	21.17	0.628	30.62
GBP Currency	MV%	3.7	4.16	-0.46	2.76	-1.26	17.8	0.49	-2.92
DKK Currency	MV%	0.68	0.53	0.15	3.44	0.52	20.38	0.7	1.36
SEK Currency	MV%	0.37	0.5	-0.13	3.21	-0.43	20.13	0.646	-1.12
NOK Currency	MV%	1.96	0.13	1.83	3.54	6.47	20.89	0.739	17.54
JPY Currency	MV%	16.52	18.82	-2.31	2.72	-6.29	4.26	0.116	-3.42
KEY RATES AND CONVEXITY:									
USD 6M key rate	KRD (Yr)	0.071	0.064	0.0060	19.67	-0.12	3.62	-0.712	-0.06
USD 2Y key rate	KRD (Yr)	0.19	0.268	-0.078	32.22	2.53	15.62	-5.032	5.13
USD 5Y key rate	KRD (Yr)	0.411	0.485	-0.074	40.44	2.99	18.08	-7.314	7.03
USD 10Y key rate	KRD (Yr)	0.459	0.56	-0.101	37.35	3.79	17.76	-6.632	8.72
USD 20Y key rate	KRD (Yr)	0.196	0.377	-0.18	31.39	5.66	16.7	-5.241	12.22
USD 30Y key rate	KRD (Yr)	0.153	0.173	-0.02	29.56	0.6	15.94	-4.713	1.22
USD Convexity	OAC (Yr^2/100)	-0.18	-0.094	-0.086	5.87	-0.51	3.15	0.185	-0.22
CAD 6M key rate	KRD (Yr)	0.0070	0.0010	0.0060	22.81	-0.14	8.01	-1.828	-0.14
CAD 2Y key rate	KRD (Yr)	0.021	0.0090	0.011	32.18	-0.37	12.15	-3.909	-0.51
CAD 5Y key rate	KRD (Yr)	0.0010	0.025	-0.024	29.89	0.7	13.08	-3.91	1.19
CAD 10Y key rate	KRD (Yr)	0.047	0.038	0.0090	25.32	-0.23	12.14	-3.073	-0.33

- Report lists sensitivities to all risk factors to which portfolio or benchmark are exposed.
- The volatility of each risk factor is shown. TE impact of risk factor =
Net exposure X Factor volatility

Optimal Credit Allocation for Buy-and-Hold Investors



	Total Return Portfolios	Buy-and-Hold Portfolios
Macro Allocations	Risk Budgeting with Skill	Optimal Credit Allocation for Buy-and-hold investors
Issuer/Issue-Level Portfolio Optimization	Lehman Multi-factor Risk Model (in POINT)	COMPASS

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A Case for Credit in Buy-&-Hold Portfolios

- ◆ Drivers of credit spreads:
 - default risk
 - spread volatility
 - liquidity premium
- ◆ Hypothesis
 - “Efficient market” is controlled by mark-to-market investors, who set credit spreads based on all of the above risks
 - To justify these spreads purely based on default risk, would have to assume very high default rates
 - For buy-and-hold investors subject only to default risk, these high spread levels may offer good fundamental value

Simple Holding Period Return Assumptions

- ◆ Portfolio of N bonds, characterized by:
 - yield y
 - realized portfolio default rate D , average recovery rate R
- ◆ Assume non-defaulted part of portfolio earns its yield, defaulted bonds earn nothing but recovery rate (no coupons, reinvestment)
- ◆ Total terminal value V per \$1 of starting value is given by

$$V = (1-D)(1+y)^{10} + D R$$

- ◆ Terminal value of a riskless 10-year Treasury portfolio is

$$V_{treas} = (1+y_{treas})^{10}$$

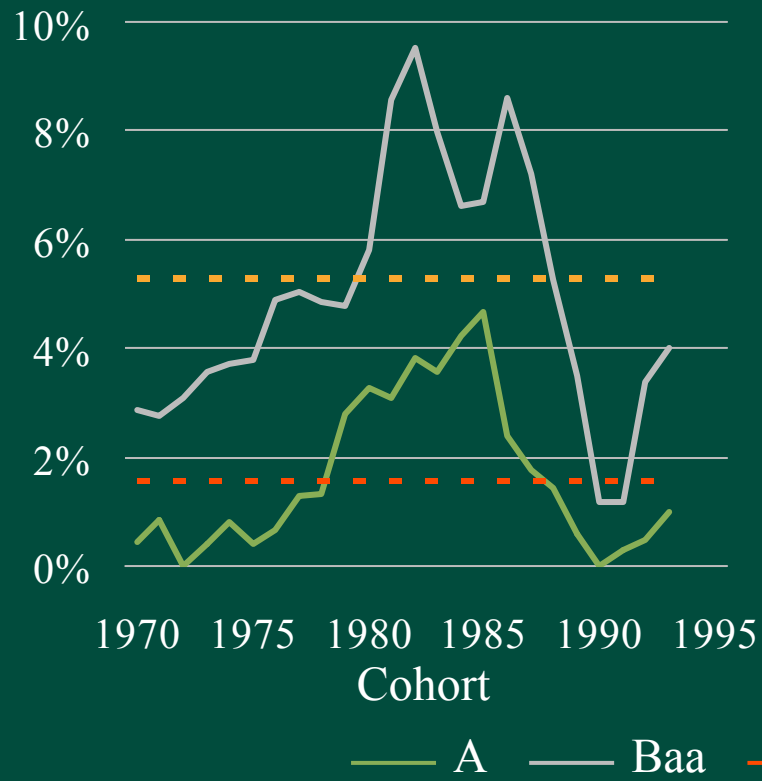
- ◆ What default assumptions give break-even ($V=V_{treas}$)?

Worst-case Default Assumptions

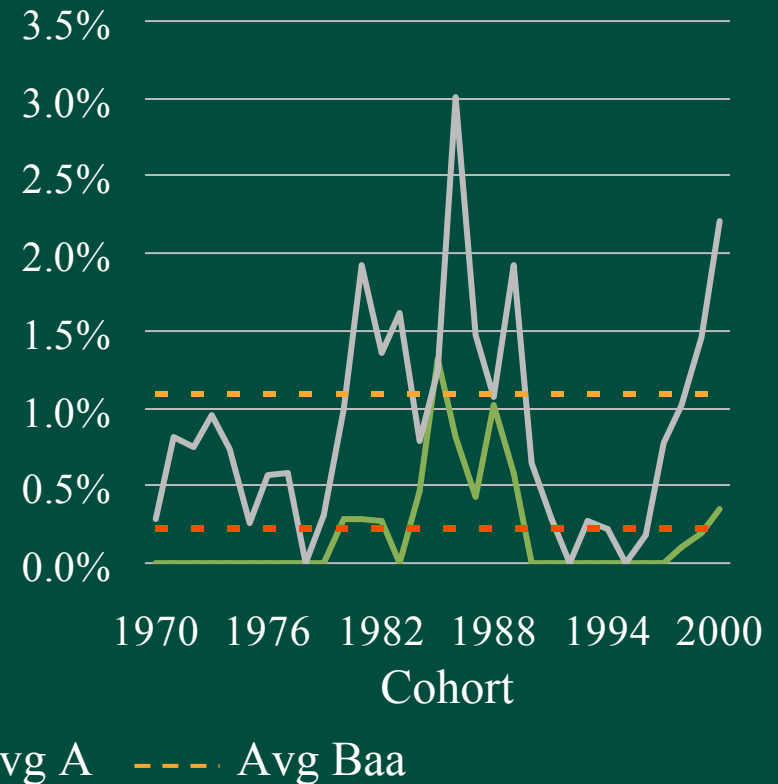
- ◆ Two approaches:
 - assume independence of individual bond defaults, conditioned on a pessimistic overall market default rate p
(choose worst observed cumulative 10-year default rate)
 - assume correlations among defaults of issuers
(choose the average observed cumulative 10-year default rate)
- ◆ Realized portfolio default rate $(D = n / N)$
 - use binomial model for number of defaults n in a portfolio
 - each of N bonds defaults with probability p (in a correlated model p is random)
- ◆ Recovery rate
 - long-term average has been 40%
 - we assume 40%, 20%, or 0%

Cumulative Default Rates by Annual Cohort

Moody's 10-Year Cohort Default Rates



Moody's 3-Year Cohort Default Rates



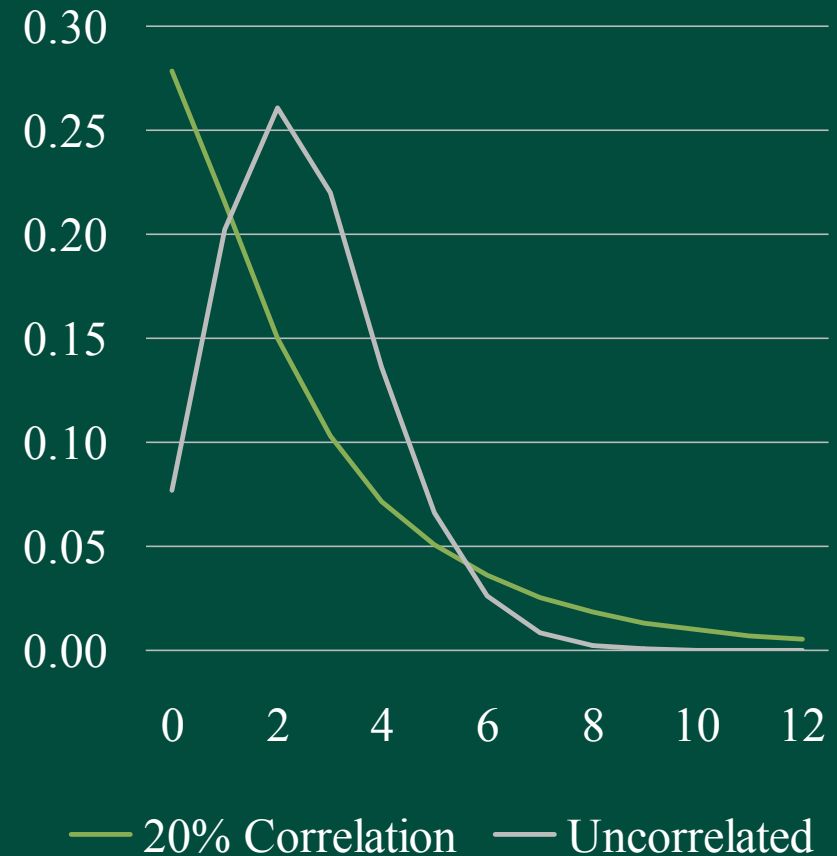
Source: Moody's Investors Service

Introducing Issuer Correlations

- ◆ Merton model (firm value approach)
- ◆ An issuer defaults when firm value is less than outstanding debt
- ◆ Changes to firm value of each issuer (asset returns) have correlation β with a “market return” variable
- ◆ Assume all issuers start with same firm value, same amount of debt, same β
- ◆ Asset correlation between any two issuers is β^2 . In reality default correlations are lower than asset correlations.
- ◆ Large negative market returns will increase default probabilities for all issuers

Effect of Correlations on Distribution of Cumulative Number of Defaults

- ◆ Number of defaulted bonds in a 50-bond portfolio, 5% cumulative default probability, with 0% or 20% correlations
- ◆ Correlations of firm values with a “market” variable increase likelihood of either very few or very many defaults



“Worst Case” Realized Portfolio Default Rates with and without Correlations, Baa portfolios

20 bonds 50 bonds

95% Confidence

Uncorrelated, 10% default prob.	20%	18%
20% correlation, 5% default prob.	20%	18%

99% Confidence

Uncorrelated, 10% default prob.	30%	20%
20% correlation, 5% default prob.	30%	28%

- ◆ Uncorrelated Case: expected default rate set to that of worst cohort
 - tail risk is diversifiable - comes down quickly as portfolio grows
- ◆ Correlated Case: expected default rate set to historical average
 - the 99% tail is mostly a systematic risk - goes down much less as portfolio grows from 20 to 50 bonds!

Risk/Return Characteristics Under Different Default Rate and Correlation Assumptions

Corp. Yield 6.59%, Treas. Yield 4.22%, Recovery 20%, 10-year holding period

Prob. of Default	10%	5%	10%	5%
Correlation	0%	20%	20%	30%
Mean Outperformance (%/yr)	1.37%	1.87%	1.33%	1.86%
Stdev of Outperformance (%/yr)	0.44%	0.64%	1.06%	0.82%
Information Ratio	3.08	2.91	1.25	2.26
Probability of Outperformance	99.7%	98.0%	90.3%	96.4%
Worst Case No. Defaults, 95% conf.	9	9	14	10
Worst Case Outperform., 95% conf.	0.52%	0.52%	-0.66%	0.29%
Worst Case No. Defaults, 99% conf.	10	14	21	17
Worst Case Outperform., 99% conf.	0.29%	-0.66%	-2.53%	-1.42%

- ◆ Pessimistic assumptions: high default rate **and** high correlations
 - still high probability of outperforming Treasuries, high IR
 - tail risk: larger losses are possible, with small probability

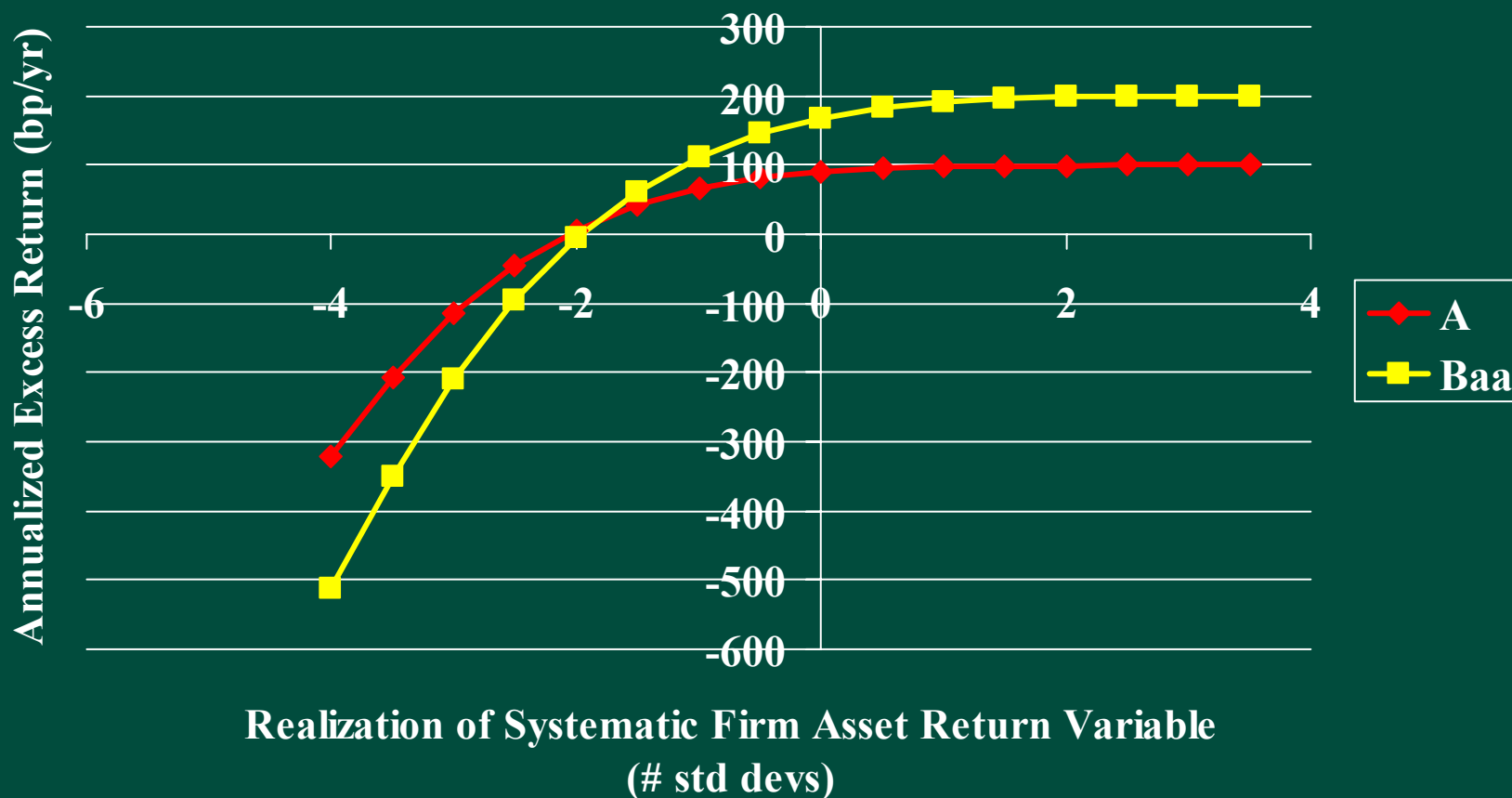
Macro Decision: Allocation Between Single-A & Baa Credits

- ◆ Apply our analysis to asset allocation
- ◆ Large Homogeneous Portfolio (LHP) approximation - assume:
 - large numbers of bonds of each quality
 - portfolio experiences market default rates in each quality
 - distribution of market default rates given by correlated model
- ◆ Assume market default rates in the two qualities are driven by the same systematic market variable, so are perfectly correlated
- ◆ For any given blend of A and Baa credits, project distributions of cumulative 10-year defaults, cumulative excess return
- ◆ Find the blend that maximizes expected return subject to a constraint on tail risk

Idealized Representation of A and Baa Credit

Quality	Spread (bp)	Expected 10-year Cumulative Default Probability	Correlation Among Issuer Asset Returns	Recovery Rate
A	100	2%	20%	20%
Baa	200	5%	20%	20%

Conditional Excess Returns: A and Baa Credits

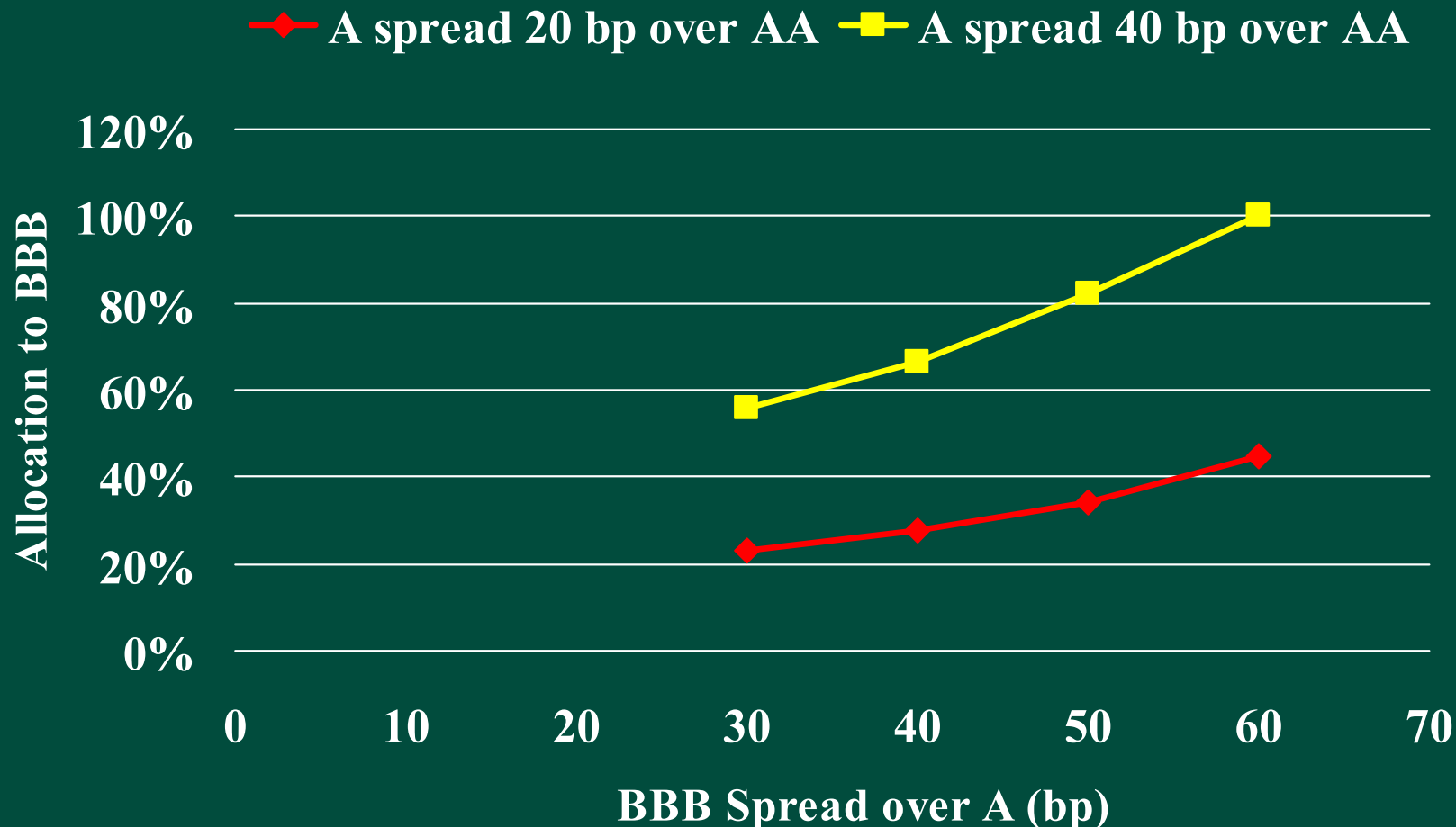


Projected Performance Measures for Various Blends of A and Baa Credits

A Weight	100%	75%	50%	25%	0%
Baa Weight	0%	25%	50%	75%	100%
Mean Annualized Excess Return (bp)	81	99	116	133	151
Stdev Annualized Excess Return (bp)	26	33	40	47	55
95% VAR	33	36	39	42	44
99% VAR	-25	-34	-44	-53	-63
Breakeven Probability	98.1%	97.9%	97.7%	97.6%	97.5%
IR	3.15	3.00	2.89	2.82	2.76

Example 2: AA Insurer

Optimal Allocation Depends on Spreads



- ♦ Optimization Criteria: Maximize expected return subject to worst case excess return of -50 bp/year vs. AA liabilities at 95% confidence

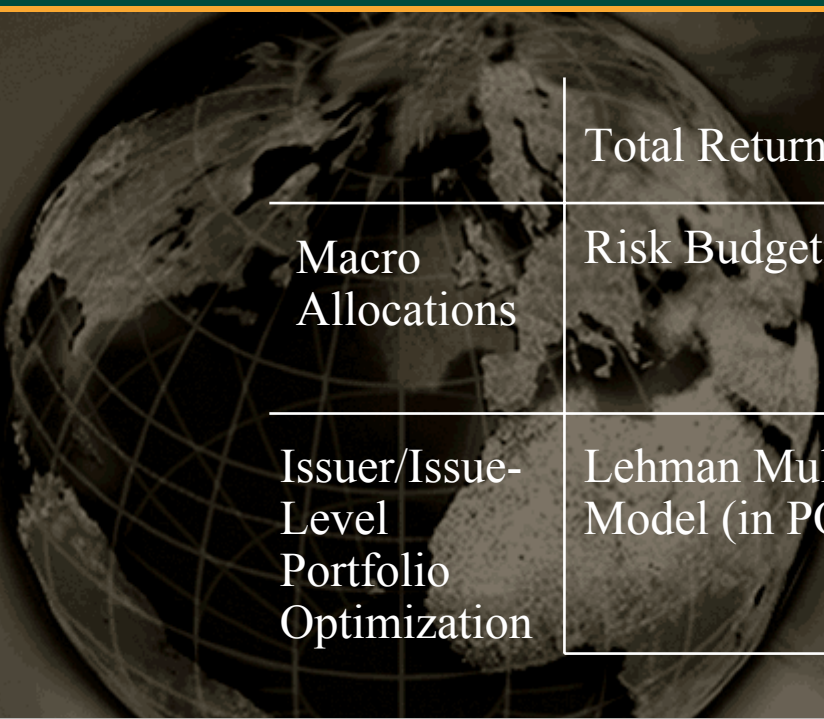


Conclusions

- ◆ Are there any pure buy-and-hold investors?
- ◆ Model can be used for allocation among credit sectors, subject to specific limits on acceptable underperformance
- ◆ Easy to see effects of different assumptions (spread, expected default rate, recovery rate, correlation) on risk/return tradeoff between asset classes
- ◆ Next level – security selection – issuer-specific analysis – COMPASS

COMPASS

Constructing an Optimal Buy & Hold Credit Portfolio



	Total Return Portfolios	Buy-and-Hold Portfolios
Macro Allocations	Risk Budgeting with Skill	Optimal Credit Allocation for Buy-and-hold investors
Issuer/Issue-Level Portfolio Optimization	Lehman Multi-factor Risk Model (in POINT)	COMPASS

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What is COMPASS?

- ◆ COMPASS is the **C**redit **O**pti**M**ised **P**ortfolio **A**sset **S**election **S**ystem
- ◆ COMPASS is a tool for analysing the risk-return properties of a buy & hold credit portfolio
- ◆ COMPASS incorporates the risk of multi-name default which is an approach most suitable for illiquid/buy-and-hold portfolios
- ◆ COMPASS also incorporates an *optimisation tool* to determine the optimal portfolio that minimizes risk for a given portfolio return goal
- ◆ COMPASS allows the investor to quantitatively determine the efficiency of his portfolio and how to improve the portfolio's efficiency

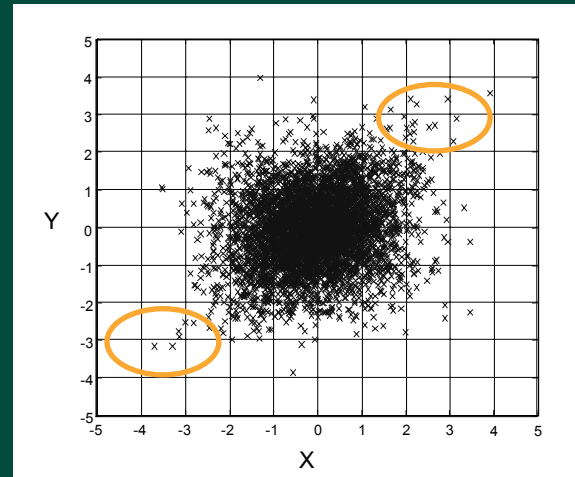
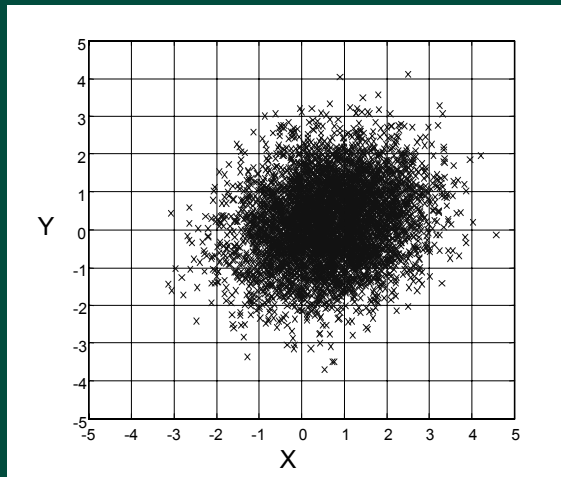
Modelling Issuer Default Correlations: Normality and “Tail” Behavior

- ◆ We model default correlation through the correlation of firms’ asset values
- ◆ We use *equity return correlations* to determine the asset return correlation between firms
- ◆ There is an extensive literature - going back to the 1960’s - documenting the observed fat tails of univariate equity returns
- ◆ Recent studies indicate that equity returns display *fat joint tails*, i.e., we observe more joint extreme realizations than if equity returns were joint normally distributed
- ◆ If asset returns also display joint fat tails, assuming normality in multi-name default models will underestimate the likelihood of having multiple defaults within a given portfolio

“Fat Joint Tails”

- ◆ If the joint default distribution has “fat joint tails” then there is greater likelihood of simultaneous outlier (i.e., default) events compared to a joint Normal distribution with correlation

Normal
Distribution
with 20%
correlation



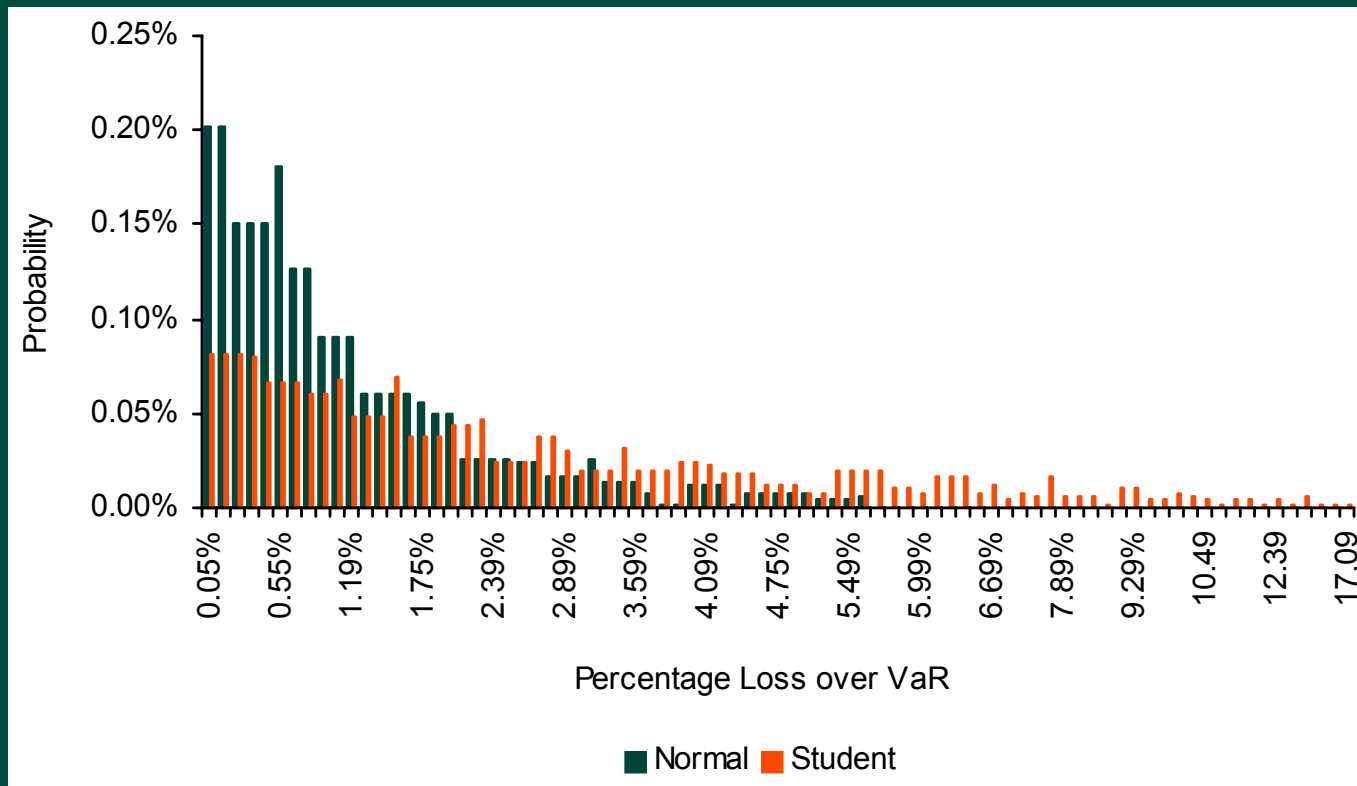
Distribution with
20% correlation
and joint fat tails

- ◆ The greater chance of extreme co-movements is often referred to as “tail dependence”
- ◆ This is the probability of one extreme event conditional on another

The Difference is in the Tail!

Here are two simulated portfolio loss distributions with differing assumptions about the joint default distribution:

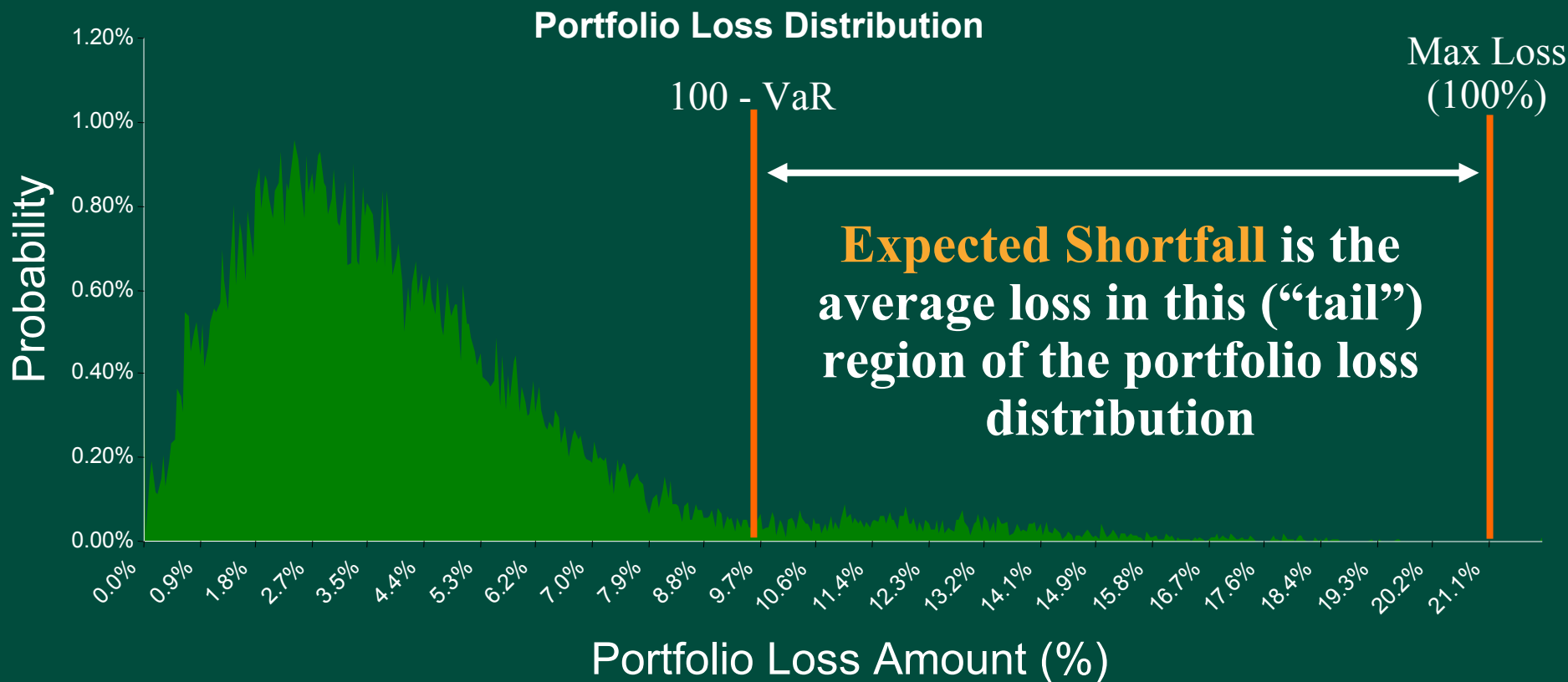
- Case 1: Assume Normal distribution
- Case 2: Assume a distribution with “joint fat tails”



Buy & Hold Portfolio Risk Measure: *Expected Shortfall* (a.k.a. “C-VaR”)

Expected Shortfall is a better risk measure than Value-at-Risk (VaR):

- Expected Shortfall considers the shape of the tail risk
- VaR only considers where the tail risk begins



Finding the Optimal Portfolio

Definition of an Optimal Portfolio

	<u>objective</u>		<u>risk</u>
Total Return Investor	Max Exp Ret	↔	Min Ret Volatility

Buy & Hold Investor (COMPASS)	Max Cur. Spread	↔	Min Exp Shortfall
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How COMPASS Works

Step 1: Specify Eligible Universe of Issuers



ISSUER UNIVERSE

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Each issuer is mapped to a rating and a sector

223	Entity	Hazard Rates				0	Dependence Tags	
		Rating	Lookup	User	Used		Sector	Country
1	AA	A-	0.1244%		0.1244%	0	Materials	United States
1	AAB	A+	0.0942%		0.0942%	0	Financials	United States
1	ABBEY	A+	0.0942%		0.0942%	0	Financials	United States
1	ABS	BBB	0.4531%		0.4531%	0	Consumer Staples	United States
1	ABT	AA	0.0661%		0.0661%	0	Health Care	United States
1	AEP	BBB	0.4531%		0.4531%	0	Financials	United States
1	AHC	BBB	0.4531%		0.4531%	0	Energy	United States
1	AIG	A+	0.0942%		0.0942%	0	Financials	United States
1	AL	A-	0.1244%		0.1244%	0	Materials	United States
1	ALL	A+	0.0942%		0.0942%	0	Financials	United States
1	AMBEV	BBB-	0.8644%		0.8644%	0	Consumer Staples	United States
1	AMR	A-	0.1244%		0.1244%	0	Consumer Discretionary	United States
1	ANZ	A+	0.0942%		0.0942%	0	Financials	United States
1	APC	BBB+	0.3633%		0.3633%	0	Energy	United States
1	AT	A	0.1365%		0.1365%	0	Telecommunication Services	United States
1	AWE	BBB	0.4531%		0.4531%	0	Telecommunication Services	United States
1	AXP	A+	0.0942%		0.0942%	0	Financials	United States
1	BA	A	0.1365%		0.1365%	0	Industrials	United States
1	BAC	A+	0.0942%		0.0942%	0	Financials	United States
1	BBT	A-	0.1244%		0.1244%	0	Financials	United States
1	BLS	A+	0.0942%		0.0942%	0	Telecommunication Services	United States

How COMPASS Works

Step 2: Specify Eligible Set of Bonds



MY PORTFOLIO

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Date	7-Nov-03
Total Assets	666
Recovery Rate Errors	0

User inputs spreads
and recovery assumptions

Average Recovery Rate

ISIN / UniqueID	Issuer	Description	Price	Spread	Maturity	Internal
A_05946NAC	BRADES	BANCO BRADESCO SA	102.7500	353.1	24-Oct-13	35.00%
A_20441XAC	AMBEV	CIA BRASILEIRA DE BEBIDAS	103.0000	350.6	15-Sep-13	35.00%
A_02378JBH	AMR	AMERICAN AIRLINES	101.0000	322.7	1-Oct-11	35.00%
A_345220AB	F	FORD CAPITAL B.V.	111.3460	318.5	1-Jun-10	35.00%
A_370424FV	GM	GENERAL MOTORS ACPT CORP	110.3181	299.2	1-Jun-10	35.00%
A_71646FAD	PETBRA	PETROBRAS INTL FINANCE-GLOBAL	109.5000	295.1	1-Feb-07	35.00%
A_247367AP	DAL	DELTA AIR LINES	102.5000	285.2	18-Nov-10	35.00%
A_428040BQ	F	HERTZ CORP-GLOBAL	101.9827	272.3	1-Mar-11	35.00%
A_345397SM	F	FORD MOTOR CREDIT-GLOBAL	103.3183	271.4	28-Oct-09	35.00%
A_428040BS	F	HERTZ CORP-GLOBAL	102.0580	271.2	1-Jun-12	35.00%
A_345397ST	F	FORD MOTOR CREDIT-GLOBAL	105.4990	268.7	15-Jun-10	35.00%
A_345397TS	F	FORD MOTOR CREDIT-GLOBAL	102.5063	261.8	1-Feb-11	35.00%
A_345370BQ	F	FORD MOTOR	104.1980	263.1	1-Oct-08	35.00%
A_345397SG	F	FORD MOTOR CREDIT-GLOBAL	97.6148	258.1	12-Jan-09	35.00%
A_345397TY	F	FORD MOTOR CREDIT-GLOBAL	101.5279	252.8	25-Oct-11	35.00%
A_345397RR	F	FORD MOTOR CREDIT-GLOBAL	105.0263	256.6	15-Jun-07	35.00%
A_247367AT	DAL	DELTA AIR LINES	101.0000	249.2	18-Sep-11	35.00%
A_3454024U	F	FORD MOTOR CREDIT	106.8482	251.2	15-Feb-07	35.00%
A_345397UA	F	FORD MOTOR CREDIT-GLOBAL	98.0265	246.0	1-Oct-08	35.00%
A_718154CJ	MO	PHILIP MORRIS COS. INC-GLOBAL	104.0000	249.7	15-Jul-05	35.00%

How COMPASS Works

Step 3: Modeling Default Risk

There are three components to modeling default risk:

- (A) Probability of Default.
- (B) Correlation of Issuer Defaults.
- (C) “Tail Dependence.”

(A) Probability of Default

COMPASS assigns a default rate to each issuer based on the issuer’s credit rating.

E.g., COMPASS gives Alcoa, rated A-, a default probability of 0.62% over the assumed 5-year investment horizon (which is converted to a hazard rate). This value is based on Moody’s historical 5-year cumulative default rate for A- rated issuers over the 1983-2002 period (see mapping on the next slide). The user is free to use his own default probabilities. So, too, for recovery rate assumptions.

How COMPASS Works

Step 3: Modeling Probability of Default



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MAPPINGS

HAZARD RATE MAP

Horizon (Y): 5

Rating	Def Prob
AAA	0.1700%
AA+	0.1700%
AA	0.3300%
AA-	0.2900%
A+	0.4700%
A	0.6800%
A-	0.6200%
BBB+	1.8000%
BBB	2.2400%
BBB-	4.2300%
BB+	7.6100%
BB	9.4200%
BB-	20.7000%
B+	27.5600%
B	34.4900%
B-	44.4000%
CCC+	60.9900%
CCC	60.9900%
CCC-	60.9900%
CC	60.9900%
C	60.9900%
D	60.9900%
NR	60.9900%

RATINGS MAP

Moody	S&P	Simple
A1	A+	A
A2	A	A
A3	A-	A
AA1	AA+	AA
AA2	AA	AA
AA3	AA-	AA
AAA	AAA	AAA
B1	B+	B
B2	B	B
B3	B-	B
BA1	BB+	BB
BA2	BB	BB
BA3	BB-	BB
BAA1	BBB+	BBB
BAA2	BBB	BBB
BAA3	BBB-	BBB
C	C	C
CA	CC	CC
CAA1	CCC+	CCC
CAA2	CCC	CCC
CAA3	CCC-	CCC

- ◆ This example assumes: Moody's 5-year cumulative corporate default rate over the period 1983 – 2002.

- ◆ Recovery rate assumption: 35.0%
- ◆ Other default/recovery scenarios could be used instead (e.g., worst 5-yr period over past twenty-three years).

How COMPASS Works

Step 3: Modeling Default Correlation

(B) Correlation of Issuer Defaults.

The risk for a buy & hold investor is that several issuers held in his portfolio may default simultaneously. COMPASS models the correlation of issuer defaults using the historical correlation of returns for the issuers' respective sectors.

For example, BAC, WFC and C all belong to the same sector (“financials”). Consequently, COMPASS assumes that BAC has the same default correlation with WFC as it does with C. This correlation value is based on historical equity market correlations among financial firms.

The issuer correlation matrix is updated regularly. See sample correlation matrix on the next slide.

How COMPASS Works: Issuer Correlations



ISSUER CORRELATION MATRIX

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223	AA	AAB	ABBEY	ABS	ABT	AEP	AHC	AIG	AL	ALL	AMBEV
AA	100.00%	15.72%	15.72%	16.23%	9.42%	15.72%	22.53%	15.72%	27.99%	15.72%	16.23%
AAB	15.72%	100.00%	13.98%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	13.98%	12.72%
ABBEY	15.72%	13.98%	100.00%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	13.98%	12.72%
ABS	16.23%	12.72%	12.72%	100.00%	8.97%	12.72%	13.80%	12.72%	16.23%	12.72%	17.72%
ABT	9.42%	7.09%	7.09%	8.97%	100.00%	7.09%	7.69%	7.09%	9.42%	7.09%	8.97%
AEP	15.72%	13.98%	13.98%	12.72%	7.09%	100.00%	14.18%	13.98%	15.72%	13.98%	12.72%
AHC	22.53%	14.18%	14.18%	13.80%	7.69%	14.18%	100.00%	14.18%	22.53%	14.18%	13.80%
AIG	15.72%	13.98%	13.98%	12.72%	7.09%	13.98%	14.18%	100.00%	15.72%	13.98%	12.72%
AL	27.99%	15.72%	15.72%	16.23%	9.42%	15.72%	22.53%	15.72%	100.00%	15.72%	16.23%
ALL	15.72%	13.98%	13.98%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	100.00%	12.72%
AMBEV	16.23%	12.72%	12.72%	17.72%	8.97%	12.72%	13.80%	12.72%	16.23%	12.72%	100.00%
AMR	19.57%	13.27%	13.27%	13.92%	8.64%	13.27%	16.01%	13.27%	19.57%	13.27%	13.92%
ANZ	15.72%	13.98%	13.98%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	13.98%	12.72%
APC	22.53%	14.18%	14.18%	13.80%	7.69%	14.18%	34.08%	14.18%	22.53%	14.18%	13.80%
AT	10.77%	8.54%	8.54%	9.56%	6.53%	8.54%	5.96%	8.54%	10.77%	8.54%	9.56%
AWE	10.77%	8.54%	8.54%	9.56%	6.53%	8.54%	5.96%	8.54%	10.77%	8.54%	9.56%
AXP	15.72%	13.98%	13.98%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	13.98%	12.72%
BA	22.32%	15.56%	15.56%	16.06%	9.46%	15.56%	18.78%	15.56%	22.32%	15.56%	16.06%
BAC	15.72%	13.98%	13.98%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	13.98%	12.72%
BBT	15.72%	13.98%	13.98%	12.72%	7.09%	13.98%	14.18%	13.98%	15.72%	13.98%	12.72%

How COMPASS Works

Step 3: Modeling Default “Tail Dependence”

(C) “Tail Dependence”

Tail dependence is the likelihood that correlated defaults are more likely than if joint issuer defaults followed a joint Normal “bell-shaped” distribution. COMPASS models tail dependence by using a joint issuer default distribution that has “fat tails.”

With these inputs COMPASS now has enough information to specify the joint default distribution and the portfolio loss distribution for any combination of issues.

How COMPASS Works

Step 4: Specify Optimization Constraints

COMPASS can produce an optimized portfolio to minimize/maximize some target (e.g., expected return over LIBOR) subject to a variety of constraints.

For example, COMPASS can be set up to:

Minimize: Expected shortfall

Subject to:

- Achieving an expected return of 100bp over LIBOR
- Investing no more than 2% in any single issuer
- No short positions permitted

COMPASS then samples from the joint default distribution using Monte Carlo simulation and optimizes using standard techniques. The portfolio that best meets the objective is then displayed (see next slide).

How COMPASS Works

Optimization Results: COMPASS Output



OPTIMIZATION

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OK

Investment Size

10,000,000,000

Scaling

100%

Tail Parameter

1.00%

Notional Lower Bound

0.00%

Notional Upper Bound

1.00%

OK

Optimiser Switch:

ON

Expected Loss

52,069,751

Value At Risk

577,643,737

Expected Shortfall

794,267,400

Asset ID

Entity

Description

Optimal Notional

666

A_00077QAD

AAB

ABN-AMRO BANK NV - GLOBAL

0

A_00077QAG

AAB

ABN-AMRO BANK NV - GLOBAL

100,000,000

A_00184AAA

TWX

AOL TIME WARNER-GLOBAL

0

A_00184AAB

TWX

AOL TIME WARNER-GLOBAL

0

A_00184AAD

TWX

AOL TIME WARNER-GLOBAL

94,387,037

A_00184AAE

TWX

AOL TIME WARNER-GLOBAL

0

A_00184AAF

TWX

AOL TIME WARNER-GLOBAL

0

A_001957AV

T

AT&T CORP - GLOBAL

0

A_001957BB

T

AT&T CORP - GLOBAL

0

A_001957BC

T

AT&T CORP - GLOBAL

44,981,583

A_00209AAD

AWE

AT&T WIRELESS SVCS INC-GLOBAL

0

A_00209AAE

AWE

AT&T WIRELESS SVCS INC-GLOBAL

88,461,522

A_00209AAG

AWE

AT&T WIRELESS SVCS INC-GLOBAL

100,000,000

A_00209AAH

AWE

AT&T WIRELESS SVCS INC-GLOBAL

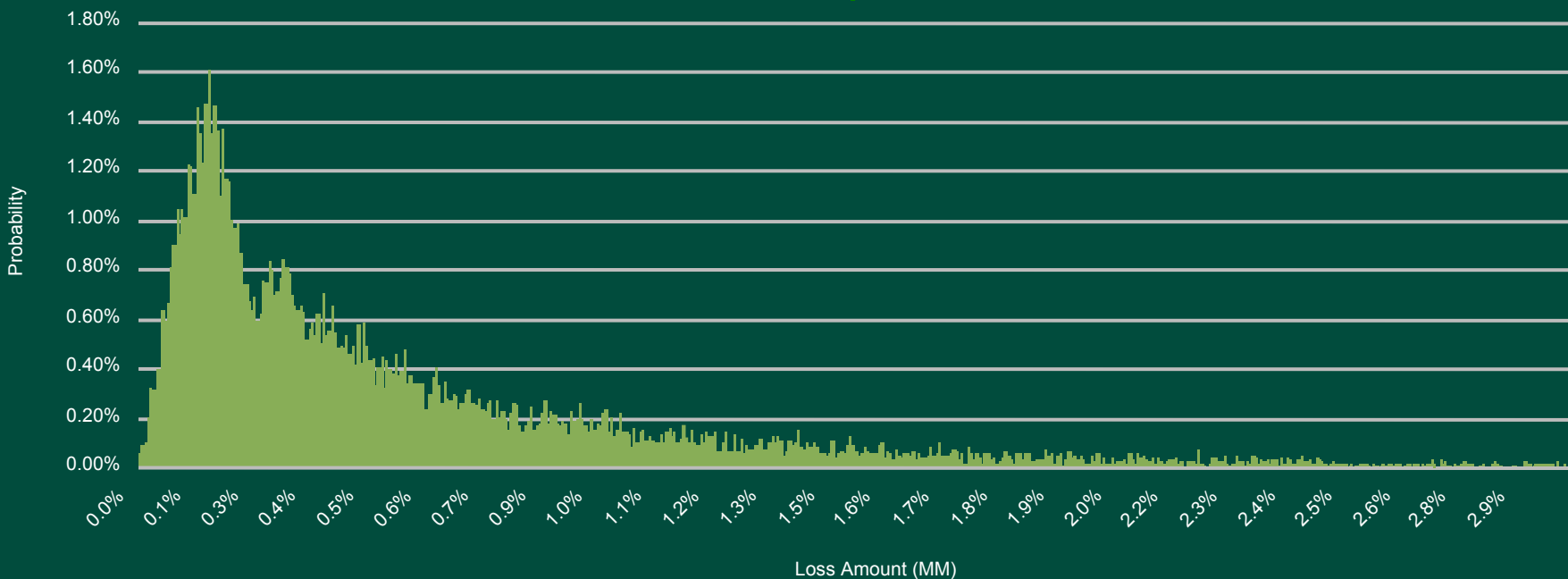
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How COMPASS Works Before Optimization

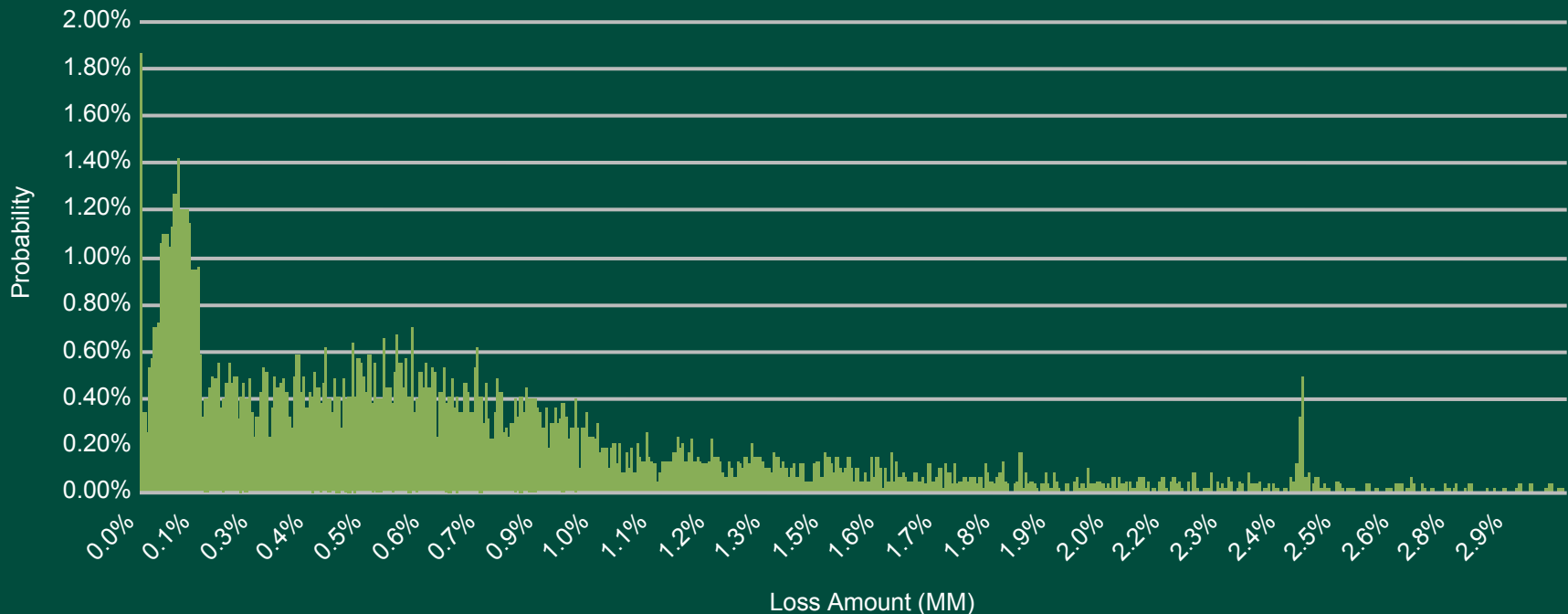
<u>Measure</u>	<u>Value</u>
Number of Issuers	415
Expected Return over LIBOR	160 bps
Expected Loss	0.50%
1% Expected Shortfall	5.95%
99% VaR	3.96%

Optimization Goal:
Minimize ES subject
to a lower bound on
expected return over
LIBOR

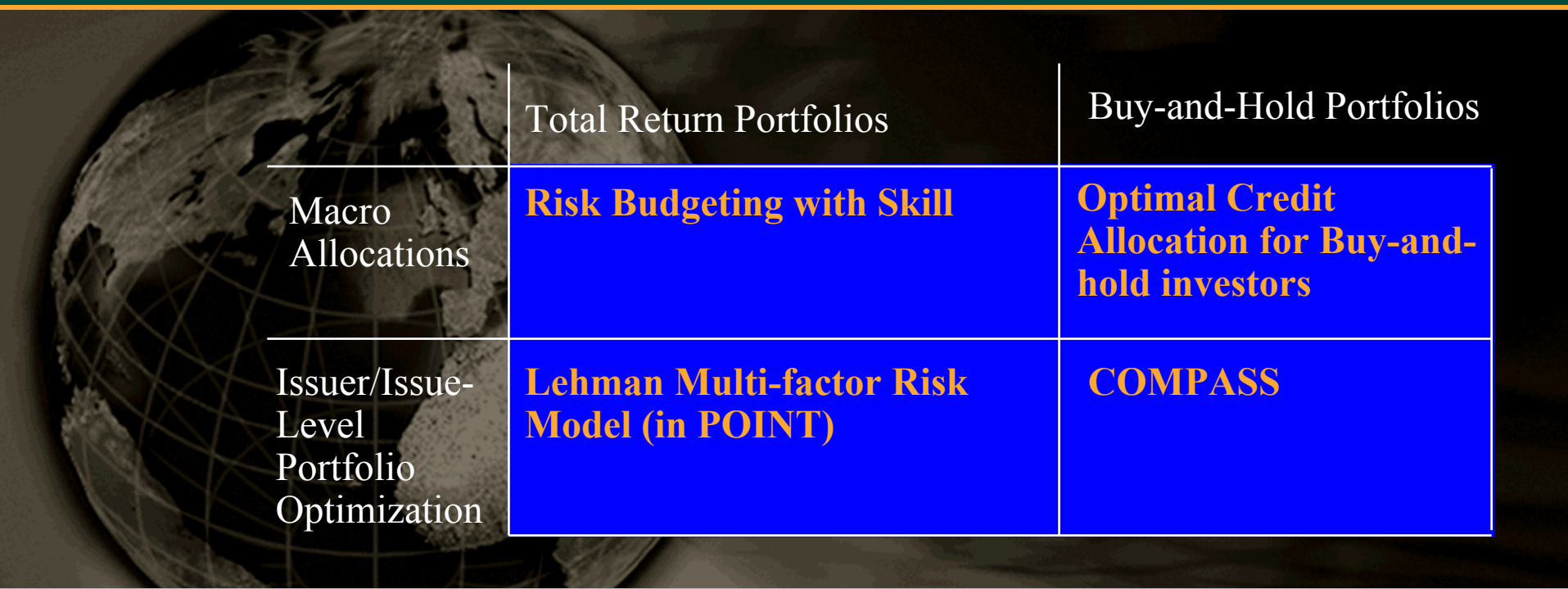


How COMPASS Works After Optimization (with return constraint)

<u>Measure</u>	<u>Value</u>
Number of Issuers	93
Expected Return over LIBOR	354 bps (was 160 bps)
Expected Loss	0.21%
1% Expected Shortfall	3.39% (was 5.95%)
99% VaR	2.44%




Portfolio Risk Optimization for Insurance Companies - Summary



	Total Return Portfolios	Buy-and-Hold Portfolios
Macro Allocations	Risk Budgeting with Skill	Optimal Credit Allocation for Buy-and-hold investors
Issuer/Issue-Level Portfolio Optimization	Lehman Multi-factor Risk Model (in POINT)	COMPASS

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