

Insurance Industry CIO Conference

Portfolio Optimization Techniques for Long-Horizon Investors

Quantitative Portfolio Strategies

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Outline

- ◆ Measuring Relative Performance of Long-Horizon Portfolios
 - BOOKINs
- ◆ Risk Measures for Long-Horizon Investors
 - Asymmetric Credit Excess Returns
 - Default risk
 - Correlated default risk
- ◆ Portfolio Risk Optimization for Long-Horizon Investors
 - ALPS: Top-down asset allocation
 - COMPASS: Bottom-up portfolio construction
 - Global Risk Model: Identify short-term risks (Tracking Error)
 - ORBS: Optimal allocation of risk budget across various strategies

Measuring Performance of Long-Horizon Investors – BOOKINs

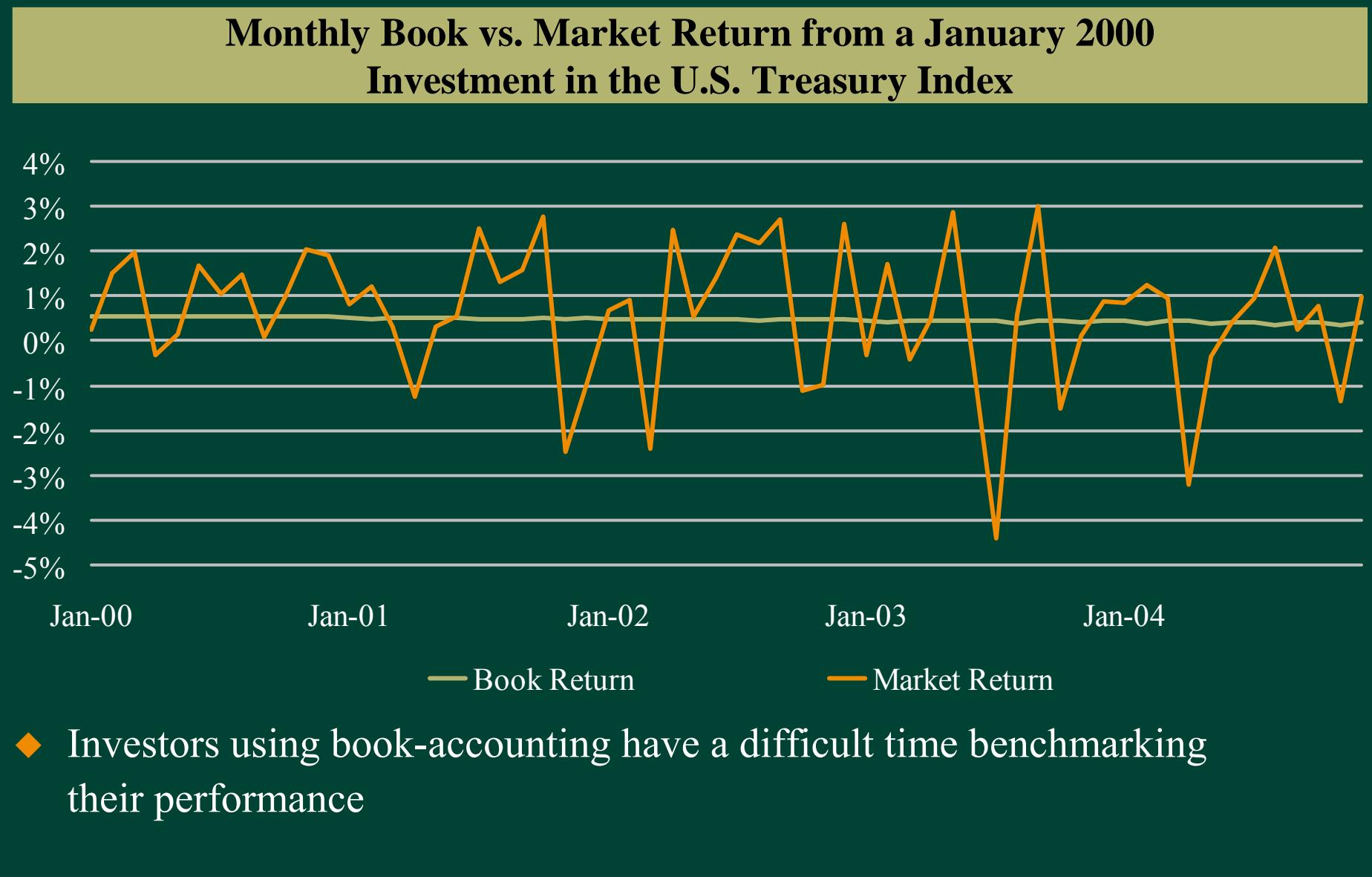
Problems Using Total Return Indices to Measure Long-Horizon Investors' Performance

- ◆ Assets are purchased for their promised yield and held until maturity
 - The composition of Total Return Indices changes constantly over time
- ◆ Portfolio performance is often measured using book-accounting methods
 - The performance of Total Return Indices is market based: monthly mark-to-market
- ◆ Portfolio sales are not always at the portfolio manager's discretion
 - Many managers benchmarked against a total return index have full discretion on buy and sell decision
- ◆ Today's portfolio performance is determined by manager and corporate decisions of long ago
 - Today's performance of Total Return Indices determined by today's returns and current market composition

Bond-Level Book Accounting Methodology

- ◆ A bond's book yield depends on date of purchase
 - The book yield is not recalculated unless
 - Bond downgraded to sub-investment grade
 - Assumed amortization schedule changes (e.g., MBS)
- ◆ Different purchase dates → Different book yields → Different book returns for the same bond!
 - So, positions in the same bond acquired at different times must be tracked separately
- ◆ Book return = Book Income/Beginning Book Value
- ◆ Monthly Book Return \neq Monthly Market Return

Book Return vs. Total Return: Difficult to Compare



Book Accounting-Based Benchmarks: Could be Helpful

- ◆ Identify value-added of investment decisions for long-horizon portfolios
 - Compare actual performance vs. a pure passive investment approach
 - What would be our book-yield today if we had simply invested in the index?
 - An impartial, quantitative approach to performance evaluation
- ◆ Identify sources of value-added performance
 - Is our book yield higher than expected due to good credit picks over the years? Or, was it due to identifying slower-prepaying mortgages?
- ◆ Perform empirical analysis studies
 - Compare performance of various investment strategies
 - How would our portfolio have performed if we had a 5% allocation to high-yield vs. a 2% allocation?

Introducing BOOKINs: Book Accounting-Based Indices

- ◆ BOOKINs are rules-based indices
- ◆ BOOKINs measure the performance (using standard book accounting) of a passive investment in various standard or custom indices.
 - Multiple investment inflows into a portfolio are handled by constructing a composite BOOKIN
 - Investment outflows (e.g., raising cash) can be handled to mimic what the manager must do in the actual portfolio
- ◆ A BOOKIN is identified by its vintage month
 - Unlike standard market-based indices, a BOOKIN's book performance in January 2005 depends on when the investment was made
 - The **SEP-03 Aggregate BOOKIN** refers to an investment in the Aggregate Index in September 2003. All cash flows generated by this investment are re-invested in the contemporaneous Aggregate Index
 - The January 2005 performance of the SEP-03 BOOKIN may differ from that of the DEC-03 BOOKIN

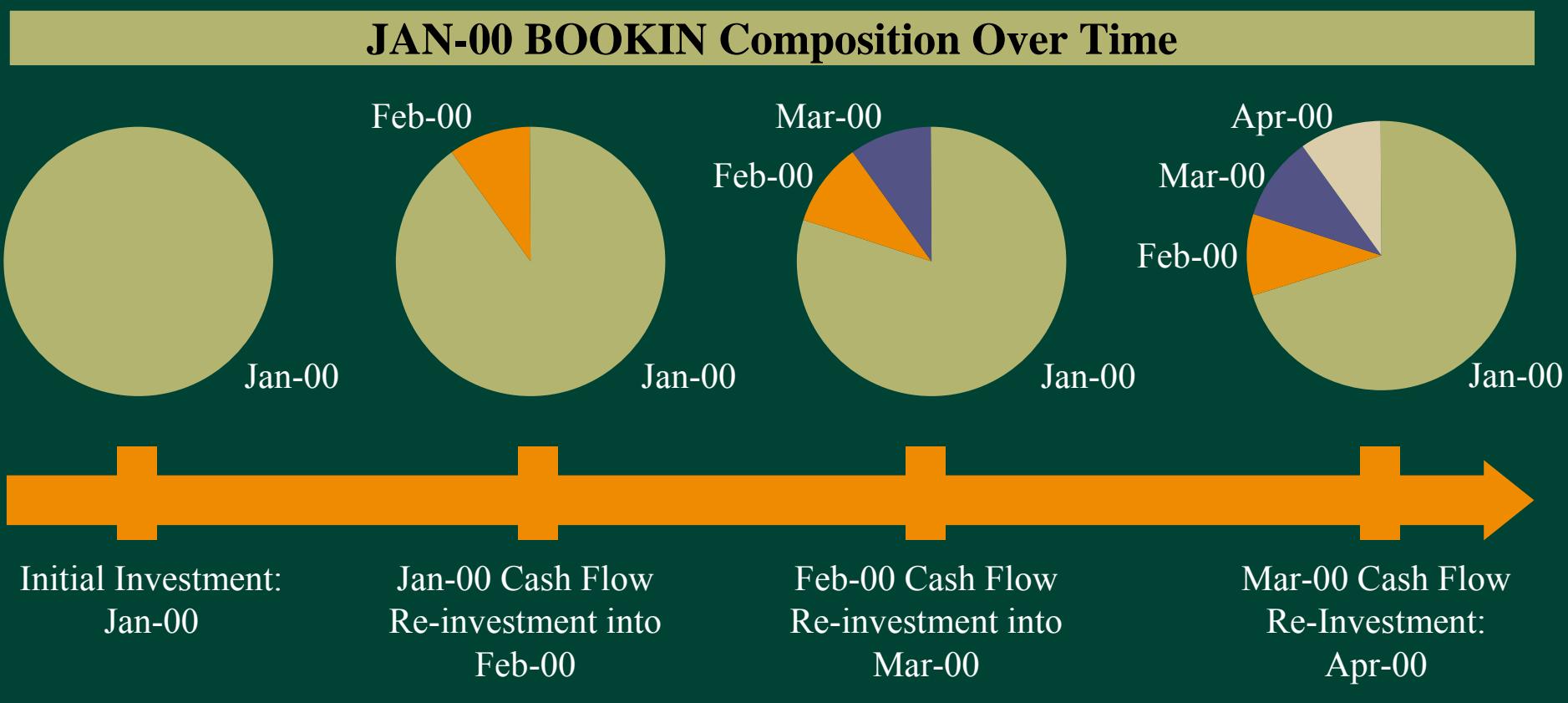
Example: BOOKINs for the U.S. Treasury Index

		Return Month for each BOOKIN							
		Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04
BOOKIN Vintage (i.e., investment month)	JAN-04	0.28	0.28	0.28	0.28	0.27	0.28	0.28	0.28
	FEB-04		0.27	0.27	0.27	0.27	0.27	0.27	0.27
	MAR-04			0.26	0.26	0.25	0.26	0.26	0.26
	APR-04				0.25	0.24	0.25	0.25	0.25
	MAY-04					0.30	0.30	0.30	0.30
	JUN-04						0.32	0.32	0.32
	JUL-04							0.32	0.32
	AUG-04								0.32

- ◆ An investment in the U.S. Treasury Book Yield Index in March 2004 is reflected by the MAR-04 BOOKIN. The July 2004 monthly book return for the MAR-04 BOOKIN was 26bp

BOOKINs: More Complex than Traditional Indices

- ◆ Handling of cash flows
 - A vintage BOOKIN (e.g., JAN-00 Aggregate BOOKIN) begins with an initial investment in the January 2000 Aggregate Index
 - Subsequent cash flows are then invested in the contemporaneous Aggregate Index
 - Over time, a vintage BOOKIN becomes a portfolio of vintage BOOKINs



BOOKINs: More Complex than Traditional Indices

- ◆ Handling of callable securities (yield-to-worst vs. yield-to-maturity)
- ◆ Handling of credit impairments
 - BOOKINs recognize credit impairments if a bond is downgraded below investment grade
- ◆ Handling of mortgage/ABS/CMBS prepayments
 - Prepayments are estimated at time of purchase
 - Every month, actual prepayments and revised prepayment estimates are compared to last month's estimates
 - Amortization schedule is revised back to time of purchase
 - Book loss/gain is recognized this period
 - Book yield is adjusted going forward

BOOKINs: Involve a High Degree of Customization

- ◆ BOOKINs are a **benchmark methodology**, not a set of standard published indices
- ◆ Investors construct a set of BOOKINs that match their accounting and portfolio management practices
 - The underlying index is likely to be a customized index (e.g., issuer capped index)
 - When to recognize credit impairments?
 - When to recognize changes in MBS prepayments?
 - Which accounting treatment to use for callable bonds?
 - How to handle portfolio cash outflows (e.g., recognition of gains/losses; and book yield targets)

Outperforming a BOOKIN: With What Risk?

- ◆ A book yield advantage can be obtained by buying high spread securities in their peer groups
- ◆ The risk of concentrating in high spread securities may not manifest itself for long periods of time
- ◆ Observed portfolio outperformance on a book yield basis has to be adjusted by the amount of risk taken to obtain it
- ◆ Risk measures differ depending on investment horizon
- ◆ Long-horizon investors are often sensitive to large short-term performance fluctuations
- ◆ Investors require a combination of BOOKINs for performance measurement with both long- and short-horizon risk models

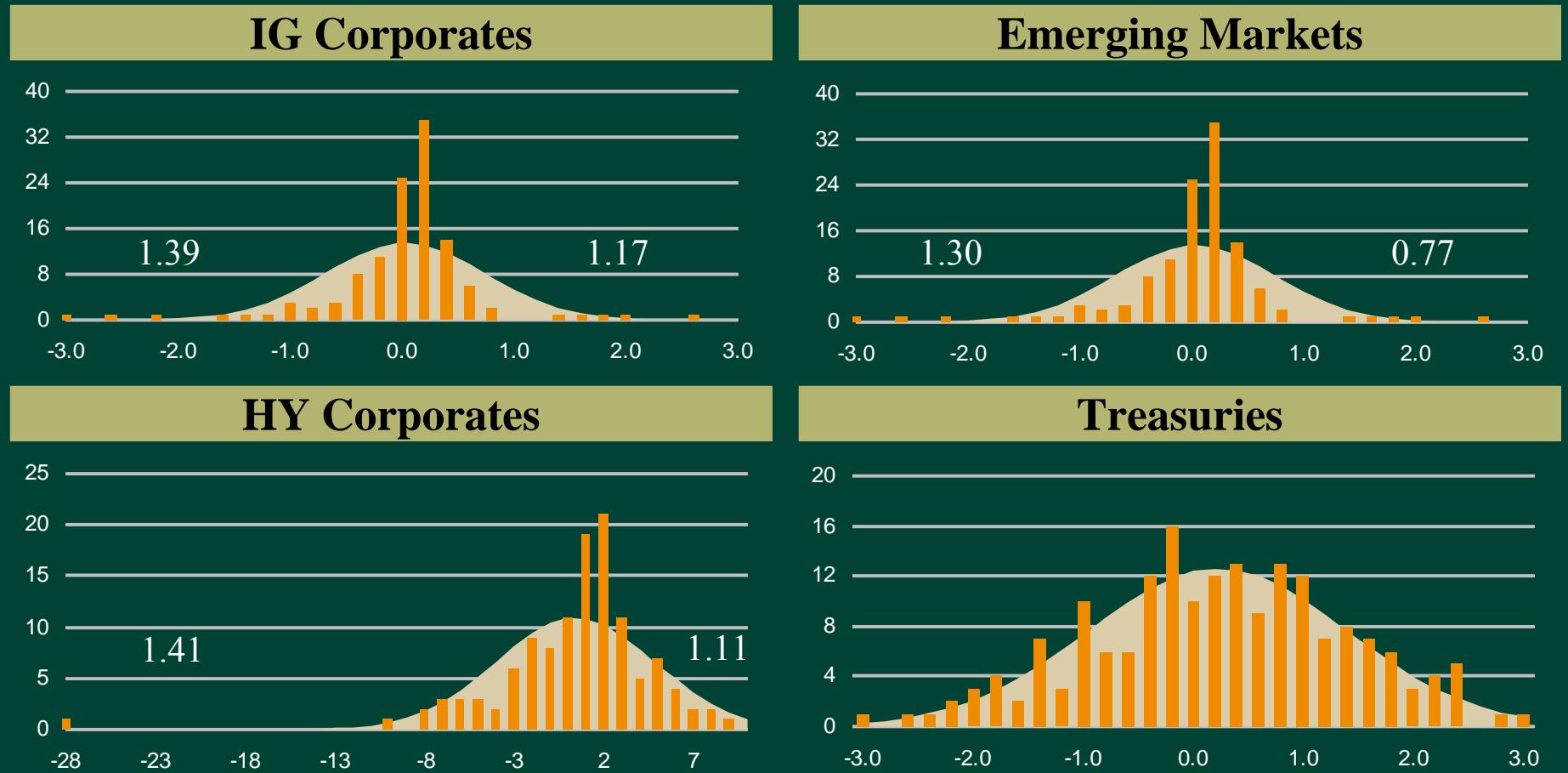
Portfolio Risk Optimization for Long-Horizon Investors

Defining an Optimal Portfolio

Short- vs. Long-Horizon Investors

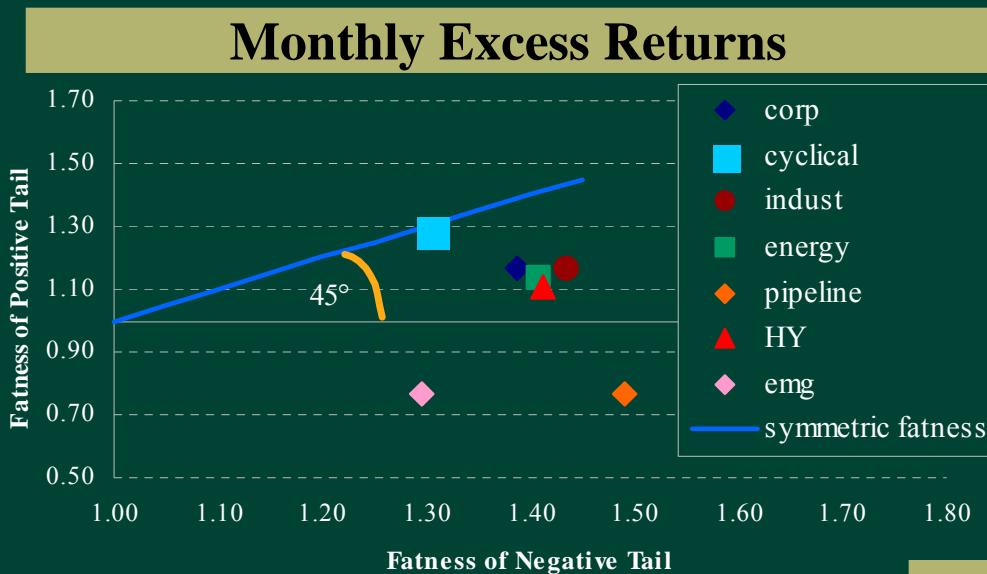
- ◆ Over a short horizon, credit excess returns are roughly symmetrical
 - Spreads are as likely to widen as tighten
 - Consequently, short-horizon credit investors optimize as follows
 - Maximize expected return
 - Minimize monthly tracking error
- ◆ Over a long horizon, credit excess returns are asymmetrical
 - Credit assets either earn a narrow spread with high probability or suffer a large loss due to default with low probability
 - Consequently, long-horizon credit investors optimize as follows
 - Maximize expected spread
 - Minimize probability of large losses due to defaults (“tail risk”)
- ◆ Performance comparisons vs. BOOKINs must be adjusted by some blend of short- (tracking error) and long-horizon (expected shortfall) risk measures.
What risk is taken to earn the extra book yield?

Distributions of Monthly Index Excess Returns with Fatness of Positive and Negative Tails

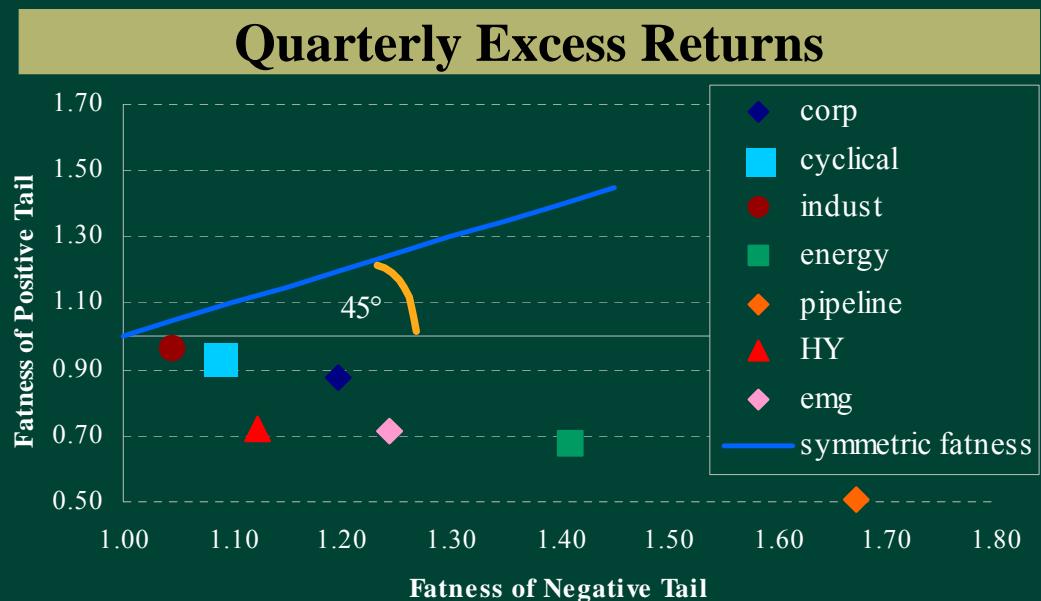


- ◆ Excess returns of IG and HY Corporates show fat tails, modest negative skew
- ◆ “Fatness” is average excess return in 5% tails relative to Normal

Symmetry of Positive vs. Negative Tails: Credit Excess Returns: Monthly & Quarterly

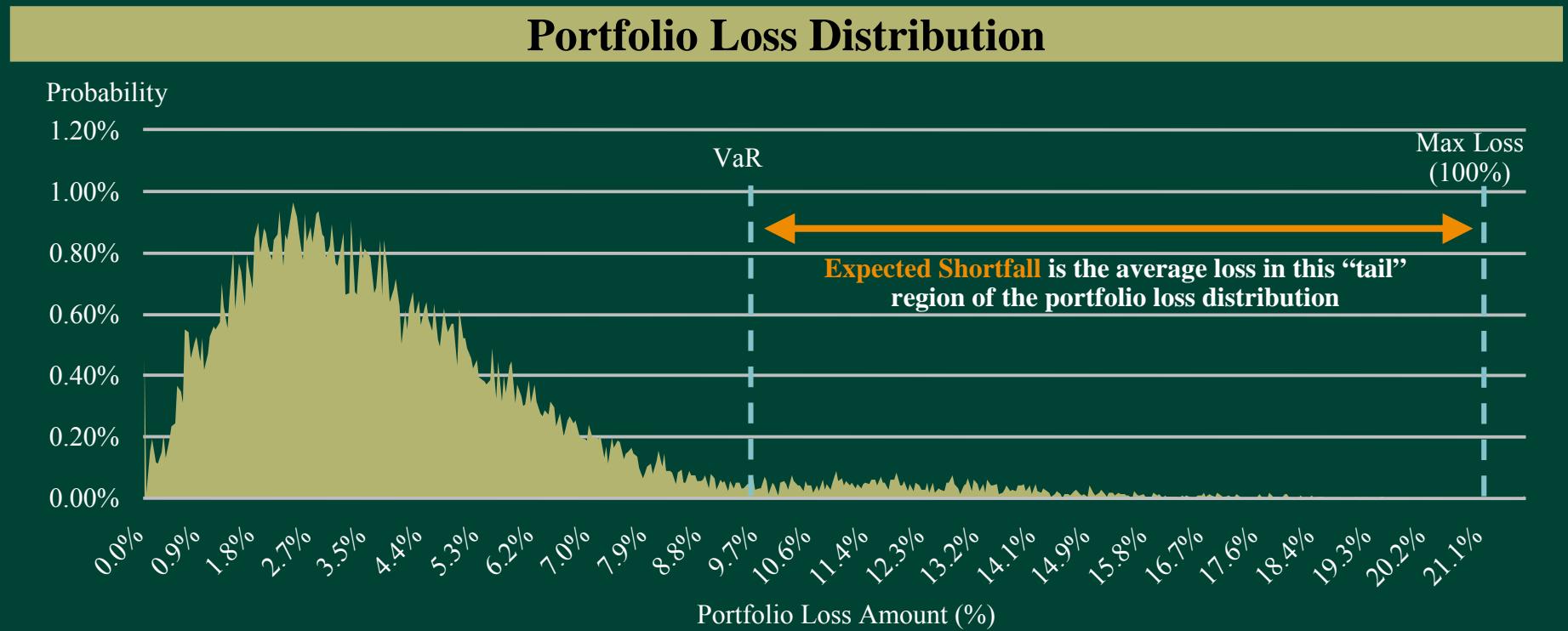


In the distribution of credit excess returns, tails become more asymmetric as the holding-period increases



Buy & Hold Portfolio Risk Measure: Expected Shortfall

- ◆ Expected Shortfall is a better “tail” risk measure than Value-at-Risk (VaR)
 - Expected Shortfall considers the shape of the tail risk (probability-weighted average loss in the worst X% of the outcomes)
 - VaR only considers where the tail risk begins (the portfolio will not lose more than VaR with (1-X)% confidence)

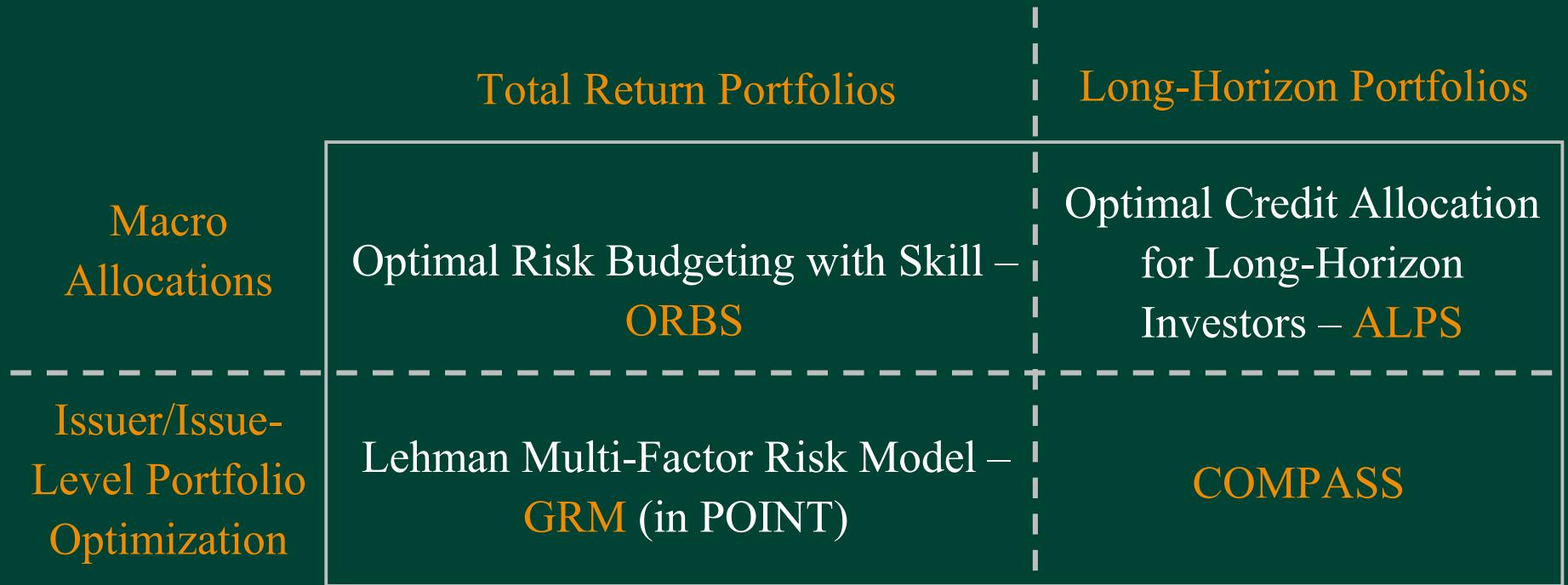


Defining an Optimal Portfolio: Short- vs. Long-Horizon Investors

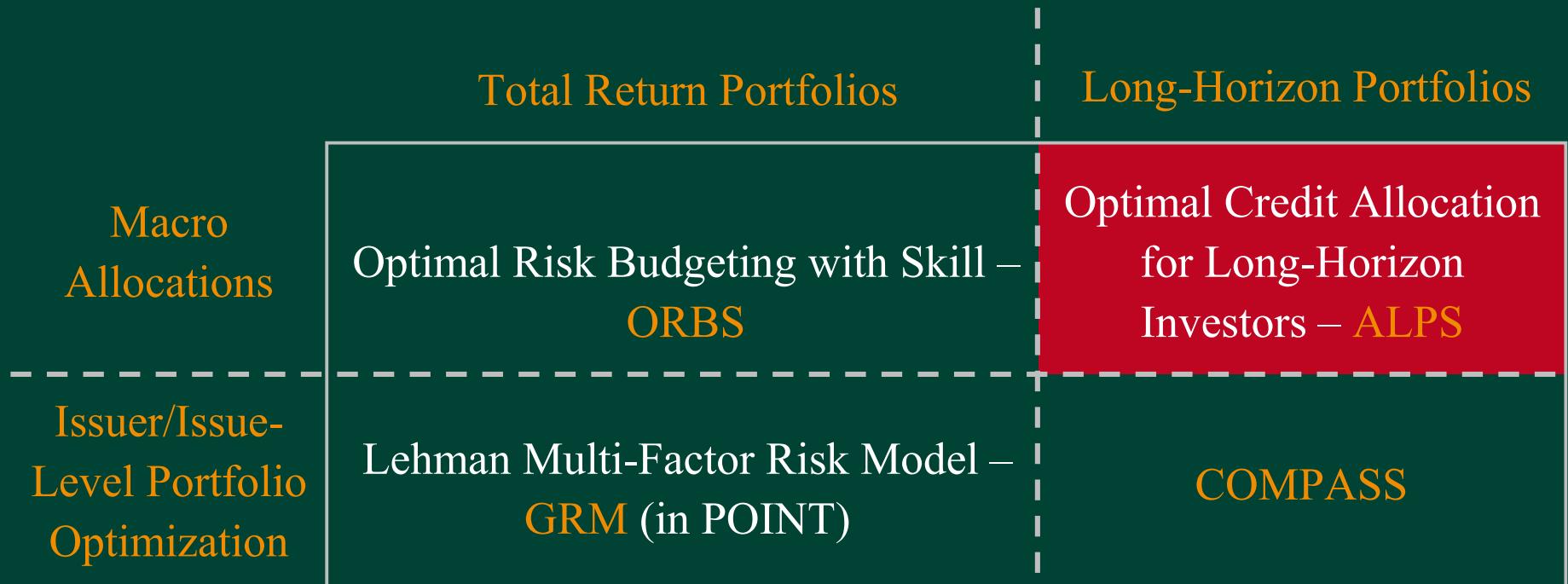
	Objective		Risk
Total Return Investor	Max. Exp. Return		Min. Ret. Volatility
Buy & Hold Investor	Max. Cur. Spread		Min. Exp. Shortfall

- ◆ In practice, many long-horizon investors fall somewhere in between

Portfolio Risk Optimization for Long-Horizon Investors – Optimization Frameworks



Optimal Credit Quality Allocation for Long-Horizon Investors

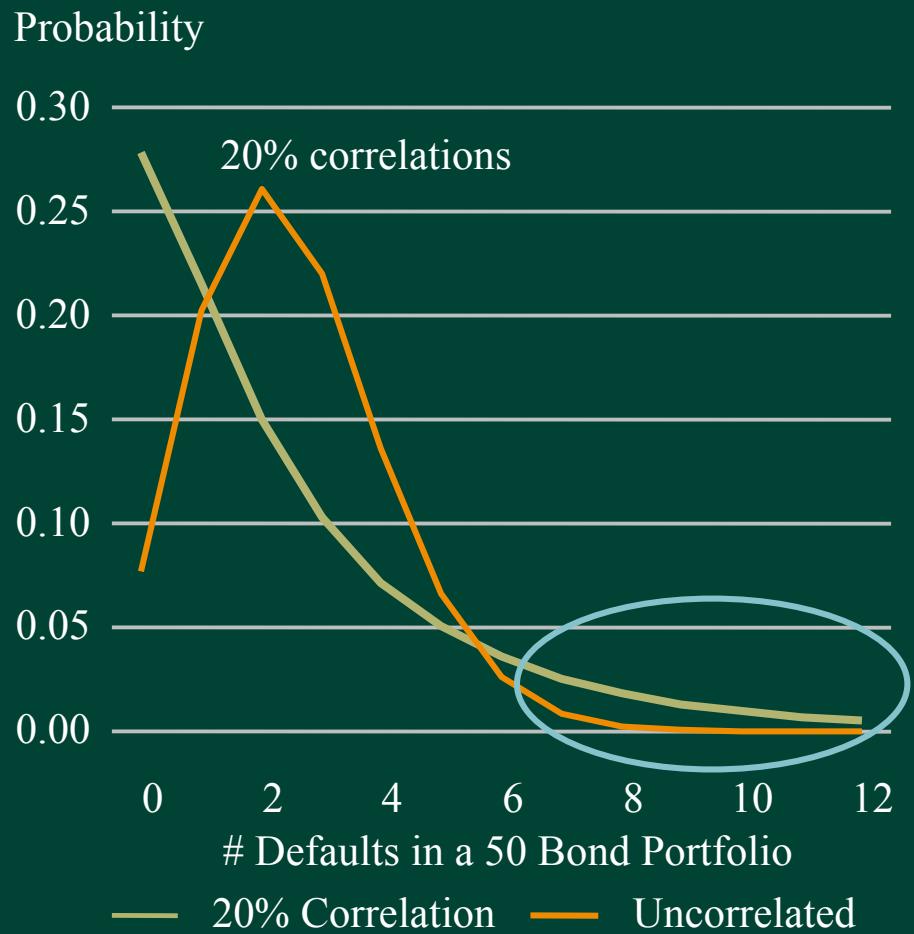


A Case for Credit in Buy & Hold Portfolios

- ◆ 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
- ◆ Risk for a Buy & Hold Investor
 - Defaults exceeding some threshold level
 - Recoveries less than expected

Effect of Correlations on Distribution of Cumulative Number of Defaults

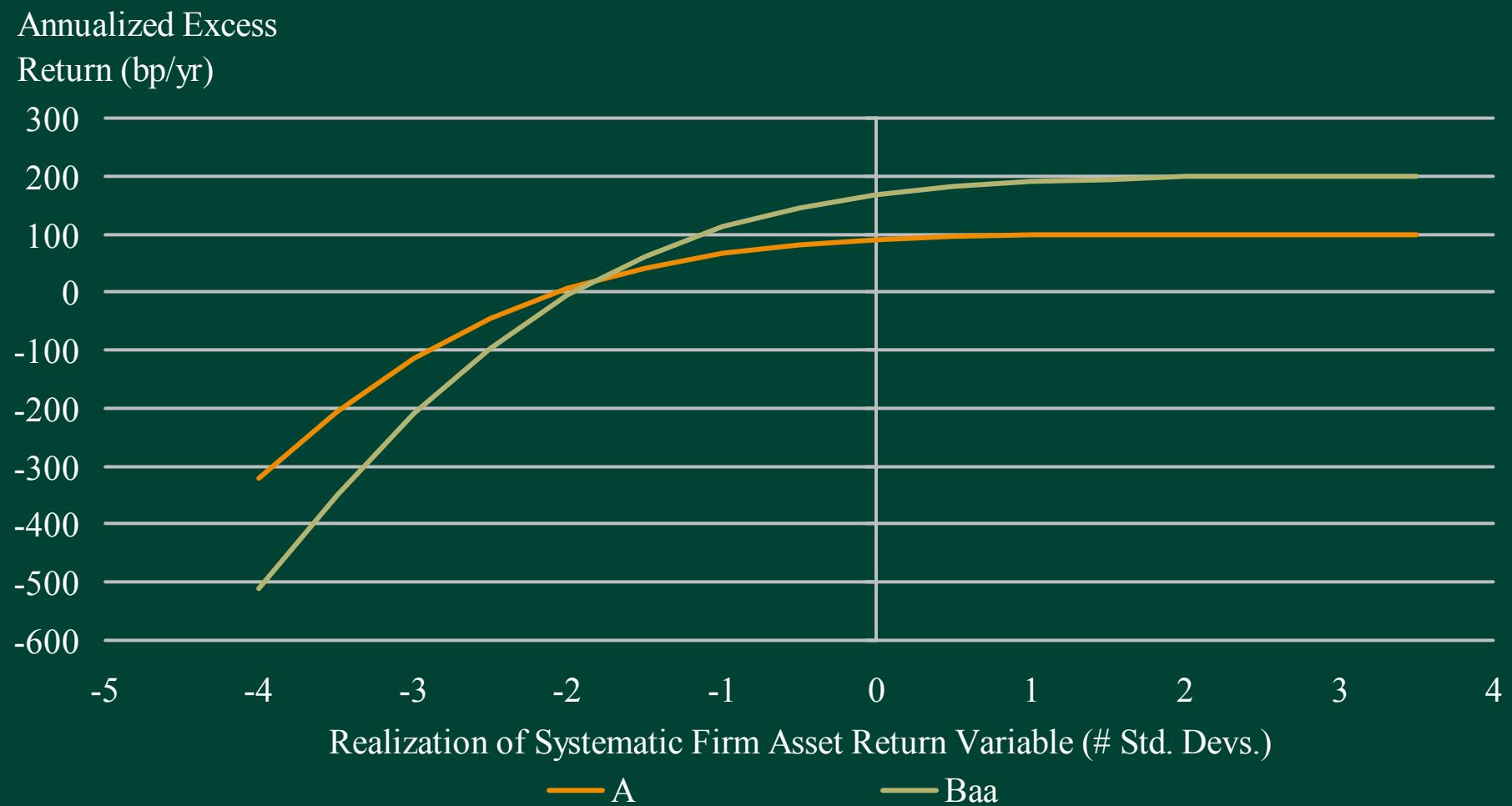
- ◆ Number of defaulted bonds in a 50-bond portfolio, 5% cumulative default probability, with 0% or 20% correlations
- ◆ Correlations of firm values with a “market” variable increase likelihood of either very few or very many defaults



Sample Representation of A and Baa Credits

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%

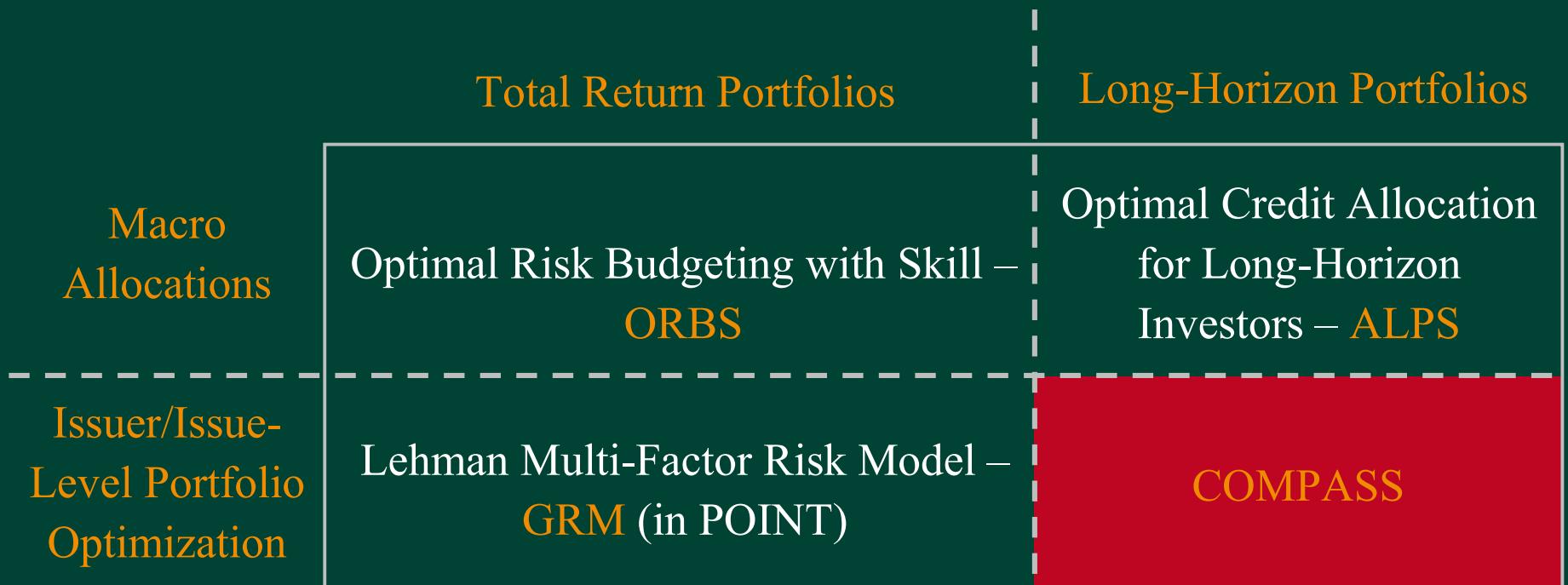
Conditional Excess Returns: A and Baa Credits



Projected Performance Measures for Various Blends of A and Baa Credits

	100%	70%	50%	30%	0%
A Weight					
Baa Weight	0%	30%	50%	70%	100%
Mean Annualized Excess Return (bp)	81bp	102bp	116bp	130bp	151bp
Std. Dev. Annualized Excess Return (bp)	26bp	34bp	40bp	46bp	55bp
95% Exp. Shortfall	-4bp	-9bp	-13bp	-17bp	-23bp
99% Exp. Shortfall	-70bp	-89bp	-103bp	-116bp	-136bp
Break-even Probability	98.1%	97.9%	97.7%	97.6%	97.5%
Information Ratio	3.15	2.97	2.89	2.83	2.76

Credit Decision at Portfolio Level: Building Optimal Long-Horizon Portfolios



What is COMPASS?

- ◆ COMPASS = Credit OptiMized Portfolio Asset Selection System
- ◆ COMPASS is a tool for analyzing 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 optimization tool to determine the optimal portfolio that minimizes risk for a given portfolio return goal
- ◆ COMPASS allows the investor to optimize the portfolio efficiency defined as a tradeoff between current spread and expected shortfall due to defaults

Modeling Issuer Default Correlations

- ◆ We model default correlation through the correlation of firms' asset values
- ◆ We use **equity return correlations** to determine the asset return correlation between firms

How COMPASS Works

Step 1: Specify Universe of Eligible Issuers



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ISSUER UNIVERSE

Each issuer is mapped to a rating and a sector

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

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How COMPASS Works

Step 2: Specify and Price a Set of Eligible Bonds

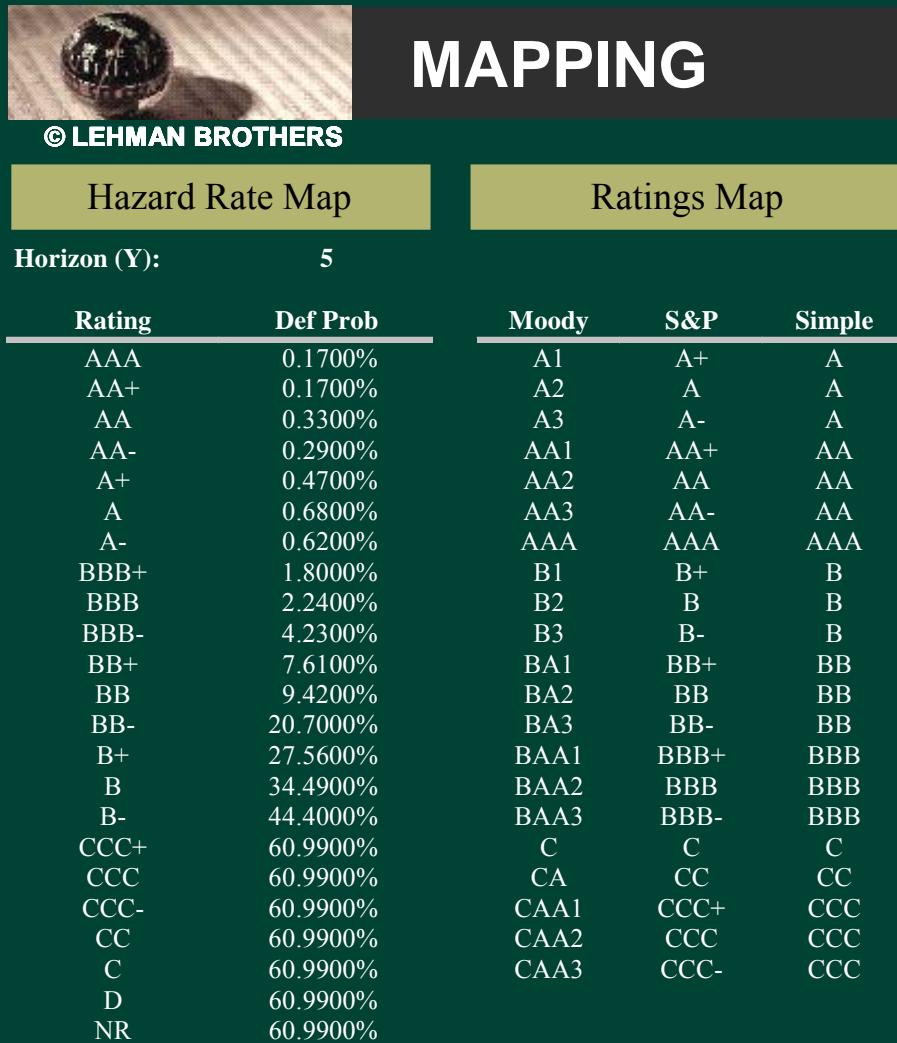
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MY PORTFOLIO

Date	7-Nov-03	User inputs spread and recovery assumptions				Average
Total Assets	666					
Recovery Rate Errors	0					
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



- ◆ 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-year period over past 23 years)

How COMPASS Works

Issuer Correlations



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ISSUER CORRELATION MATRIX

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		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 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



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OPTIMIZATION

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 666	Entity	Description	Optimal Notional
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	0

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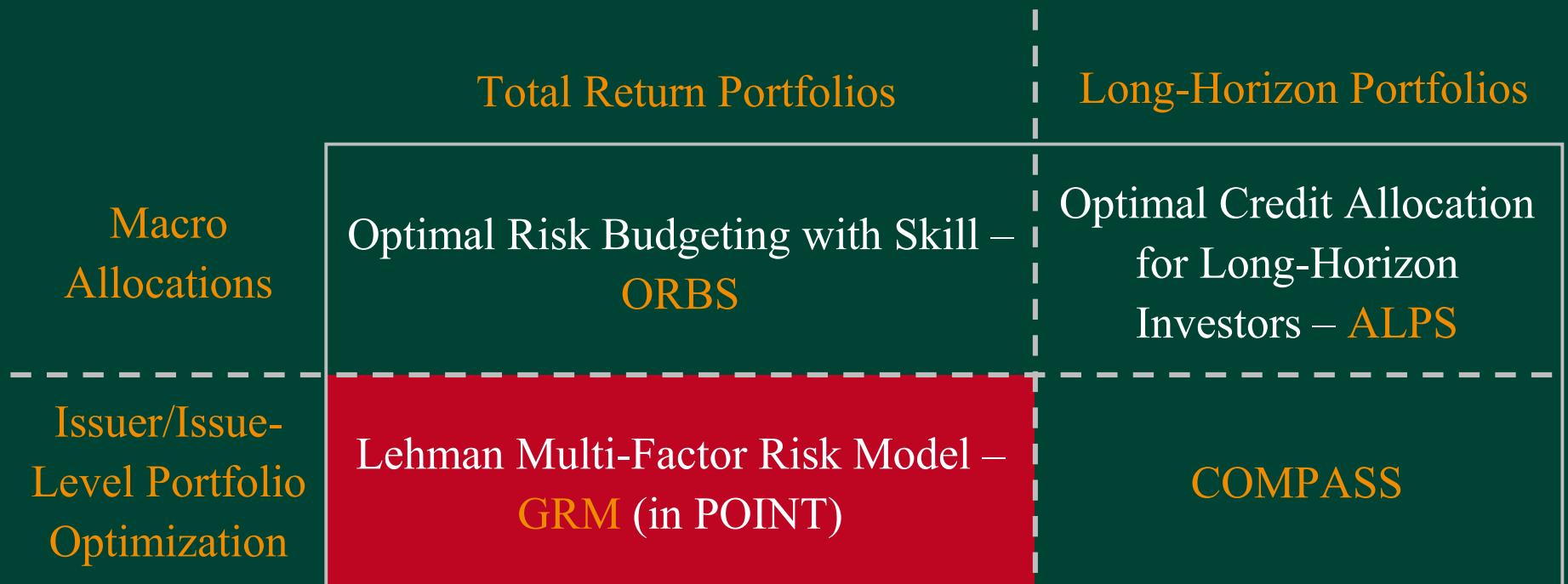
Optimization Results: Example



Optimization Results: Example

CUSIP	Description	Rating	OAS	Cur. Alloc.	COMPASS – Optimized Portfolios								
					ExShortfall ==>	8.8%	5.23%	5.54%	6.2%	6.9%	7.9%	8.9%	10.1%
				ExSpread ==>	72.8	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0
A_31359MF	FEDERAL NATL MTG ASSN – GLOBAL	AAA+	17.1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
A_298785CZ	EUROPEAN INVESTMENT BANK – GLOBAL	AAA	18.5	3.6%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_748148PU	QUEBEC PROV CANADA	A+	27.9	5.1%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_172967BA	CITIGROUP, INC. – GLOBAL	AA-	28.6	0.6%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_36962GVM	GENERAL ELECTRIC CAPITAL – GLOBAL	AAA	29.3	0.7%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_500630AY	KOREA DEVELOPMENT BANK – GLOBAL	A-	30.6	0.8%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_CTRRB01-1:A3	CONNECTICUT RRB SPECIAL PURPOS	AAA	32.1	1.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_381317AM	GOLDEN WEST FIN. CORP. (DEL)	A+	34.5	0.5%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_CCIMT99-5:A	CITIBANK CREDIT CARD MASTER TR	AAA	35.6	0.6%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_449218AC	IBM CANADA CREDIT	A+	36.6	1.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_929903AA	WACHOVIA CORP.	A	37.7	0.3%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_524908BY	LEHMAN BROTHERS HOLDINGS, INC.	A	38.5	0.6%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_369550AH	GENERAL DYNAMICS CORP. – GLOBAL	A	39.9	0.4%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_925524AN	VIACOM INTERNATIONAL, INC. – GLOBAL	A-	41.0	0.2%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_3128X17C	FEDERAL HOME LN MTG CORP. – GLOBAL	AAA+	43.3	0.5%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
A_31359MQP	FEDERAL NATL MTG ASSN – GLOBAL	AAA+	43.8	0.4%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_25243QAB	DIAGEO CAPITAL PLC – GLOBAL	A	44.4	0.9%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
A_842434CE	SOUTHERN CALIF GAS	A+	44.5	0.4%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_3136F5PH	FEDERAL NATL MTG ASSN	AAA+	45.9	10.2%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_3128X2TM	FEDERAL HOME LN MTG CORP – GLOBAL	AAA+	46.1	4.9%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_428236AE	HEWLETT PACKARD CO. – GLOBAL	A-	46.1	0.2%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
A_025816AP	AMERICAN EXPRESS CO. – GLOBAL	A+	46.5	0.2%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_87612EAL	TARGET CORP. – GLOBAL	A+	47.6	0.1%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_46625HAP	JP MORGAN CHASE & CO. – GLOBAL	A+	47.7	0.4%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_49337WAA	KEYSPAN CORP.	A	48.0	0.2%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_748148QR	QUEBEC PROV CANADA – GLOBAL	A+	50.0	0.4%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
A_94975CAF	WELLS FARGO FINANCIAL – GLOBAL	AA-	52.6	0.4%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_40049JAP	GRUPO TELEVISA S.A. DE CV	BBB-	53.2	0.3%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
A_00184AAD	AOL TIME WARNER – GLOBAL	BBB+	55.6	0.2%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_172967BJ	CITIGROUP, INC. – GLOBAL	AA-	55.6	0.5%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_50075NAA	KRAFT FOODS, INC. – GLOBAL	BBB+	56.6	0.4%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
A_69512EGL	PACIFICORP.	A	57.4	0.7%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
A_8447HBAB	SOUTHTRUST BANK BIRM	A-	58.0	1.0%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
A_71654QAT	PETROLEOS MEXICANOS – GLOBAL	BBB-	58.9	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
A_524908FD	LEHMAN BROTHERS HOLDINGS, INC.-G	A	59.0	0.4%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
A_202795GX	COMMONWEALTH EDISON	BBB+	59.5	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%

Long-Horizon Investors Can Benefit from Total Return Risk Tools



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

POINT: Tracking Error Report

What are the Sources of Risk?

LEHMAN BROTHERS POINT		Global Risk Model			
Tracking Error		12/31/2003			
Portfolio : Aggregate_active(2)					
Benchmark : US Aggregate					
Global Risk Factor	Isolated TEV	Cumulative TEV	Difference in cumulative	Percentage of tracking error variance	Systematic beta
Global					
Yield Curve	10.88	10.88	10.88	43.53	1.08
Swap Spreads	1.23	10.94	0.06	0.03	1.05
Volatility	0.79	11.29	0.36	1.0	0.82
Investment-Grade Spreads	8.85	12.51	1.22	25.95	1.28
Treasury Spreads	0.4	11.23	-0.06	-0.17	1.15
Credit and Agency Spreads	8.61	12.36	1.12	24.68	1.46
MBS/Securitized	1.73	12.57	0.22	1.55	0.81
CMBS/ABS	0.7	12.51	-0.06	-0.1	1.61
High Yield Spreads	1.34	12.94	0.43	2.77	
Systematic risk	12.94	12.94	0.0	73.29	1.07
Idiosyncratic risk	7.73	15.07	2.13	26.16	
Credit default risk	1.13	15.11	0.04	0.56	
Total risk (bp/month)		15.11	0.0	100.0	
Portfolio volatility (bp/month)					122.2
Benchmark volatility (bp/month)					113.62

POINT: Tracking Error Report

What is the Portfolio's Sensivity to Risk Factors?

LEHMAN BROTHERS POINT								Global Risk Model	
Factor Exposure - Full Details								12/31/2003	
Portfolio : Aggregate_active(2)		Benchmark : US Aggregate							
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%	100.0	100.0	0.0	0.0	0.0		0.0	0.0
KEY RATES AND CONVEXITY									
USD 6M key rate	KRD (Yr)	0.159	0.154	0.0040	24.25	-0.11	-1.35	2.164	0.06
USD 2Y key rate	KRD (Yr)	0.535	0.635	-0.101	29.21	2.94	-4.14	7.997	-5.33
USD 5Y key rate	KRD (Yr)	0.962	1.127	-0.165	30.59	5.06	-5.96	12.063	-13.21
USD 10Y key rate	KRD (Yr)	1.786	1.311	0.474	27.47	-13.03	-7.75	14.09	44.25
USD 20Y key rate	KRD (Yr)	1.088	0.889	0.198	23.64	-4.69	-8.53	13.346	17.51
USD 30Y key rate	KRD (Yr)	0.415	0.41	0.0050	22.67	-0.12	-8.62	12.935	0.46
USD Convexity	OAC (Yr^2/100)	-0.119	-0.295	0.176	3.94	0.69	-0.69	-0.181	-0.21
SWAP SPREADS									
USD 6M swap spread	SSKRD (Yr)	0.143	0.166	-0.023	12.02	0.28	-0.51	0.407	-0.06
USD 2Y swap spread	SSKRD (Yr)	0.531	0.528	0.0030	5.85	-0.02	-2.71	1.048	0.02
USD 5Y swap spread	SSKRD (Yr)	0.906	0.911	-0.0050	6.38	0.03	-1.02	0.429	-0.01
USD 10Y swap spread	SSKRD (Yr)	1.018	0.988	0.03	7.07	-0.21	0.13	-0.062	-0.01
USD 20Y swap spread	SSKRD (Yr)	0.53	0.496	0.034	8.19	-0.28	-0.05	0.025	0.01
USD 30Y swap spread	SSKRD (Yr)	0.404	0.293	0.111	7.34	-0.82	-0.26	0.127	0.09
TREASURY SPREAD & VOL.									
USD Treasury Volatility	Volatility Duration	0.01	0.04	-0.03	0.93	0.03	3.63	-0.224	0.05
USD Treasury spread	OASD (Yr)	1.474	1.225	0.249	1.44	-0.36	4.22	-0.401	-0.66
USD Treasury Spread Slope	OASD*(TTM-AvgTTM) (Yr^2)	0.099	0.077	0.022	4.34	-0.09	-5.57	1.599	0.23
USD Treasury Liquidity	OASD*(OAS-AvgOAS) (Yr^2/Yr)	0.0	-0.018	0.019	14.43	-0.27	-2.19	2.088	0.26

How a Long-Horizon Investor Can Use COMPASS & Risk Model Together

- ◆ Buy & Hold Portfolio
 - US\$ credit assets
 - Issuer exposure caps
 - 5.3 year duration
- ◆ However, also total return oriented
 - Benchmarked against a Custom Benchmark
 - Issuer-capped credit index
 - Maturity 2–20 years
 - Performance measured regularly against benchmark
- ◆ Also, portfolio characteristics are compared to benchmark
 - Spread (OAS)
 - Capital cost (rating agency)
 - “Are we generating spread in an efficient manner compared to our benchmark?”

An Investor's Ideal Rebalanced Portfolio

- ◆ Rebalanced Portfolio
 - Has improved risk properties (VaR or ExpShortfall)
 - Has a lower capital requirement
 - Has a higher book yield
 - Transactions generate desired P&L
 - Has good tracking error with the benchmark
- ◆ Use COMPASS
 - Look for more efficient portfolios
 - Better risk capital efficiency?
- ◆ Use Risk Model
 - How do the optimized portfolios compare to the benchmark?
 - Identify any unanticipated short-term risks

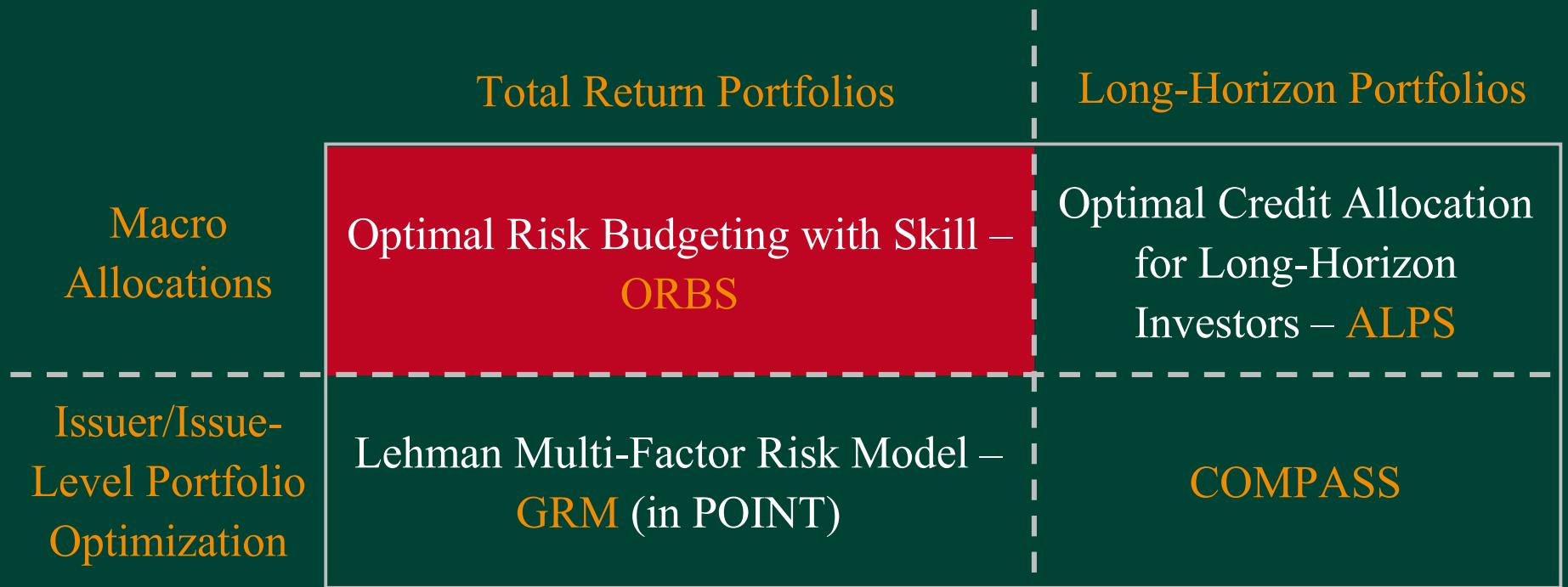
Summary: COMPASS Results

	SUMMARY		COMPASS Portfolios						Lehman Brothers
	Current Portfolio	Custom Benchmark							
spread	84	94	80	85	90	100	110		
#issuers	251	542	119	114	120	114	114		
#issues	428	1881	122	119	123	116	115		
Exp Shortfall(1%)	9.34%	8.70%	5.33%	5.65%	6.08%	7.32%	9.32%		
<i>diff</i>			-4.01%	-3.69%	-3.26%	-2.02%	-0.02%		
VaR(1%)	6.54%	6.24%	3.53%	3.77%	4.09%	5.16%	6.73%		
<i>diff</i>			-3.01%	-2.77%	-2.45%	-1.38%	0.19%		
OAD	5.17	5.33	5.12	5.12	5.12	5.12	5.12		
book yield	5.52%	n.a.	4.87%	4.94%	5.03%	5.15%	5.25%		
<i>diff</i>			-0.66%	-0.58%	-0.50%	-0.38%	-0.27%		
S&P capital charge	\$7.2		\$3.6	\$4.1	\$4.8	\$6.1	\$8.5		
%	2.06%		1.65%	1.18%	1.38%	1.76%	2.43%		
<i>diff</i>			-1.04%	-0.88%	-0.68%	-0.30%	0.37%		
recognized book g/l	\$38.15	n.a.	\$37.26	\$38.11	\$32.52	\$32.65	\$32.46		
%	unrecognized		1.07%	1.09%	0.93%	0.94%	0.93%		

Summary: Risk Model Results

TRACKING ERROR ANALYSIS								Lehman Brothers
		Benchmark, Current Portfolio, and COMPASS Portfolios						
	Custom Benchmark	Current Portfolio	80	85	90	100	110	
TEV (bp/mo)		10.9	16.3	15.2	14.3	15.1	18.7	
Yield Curve Isolated TEV		8.6	12.7	11.9	10.9	9.8	9.3	
Credit Spreads Isolated TEV		6.3	11.5	8.6	6.5	5.4	10.5	
Systematic TEV		9.6	14.6	13.1	12.0	12.5	16.4	
Idiosyncratic TEV		5.2	7.2	7.7	7.7	8.4	9.0	
Systematic Vol	146.3	138.4	136.4	136.2	136.5	136.6	136.8	
Idiosyncratic Vol	4.6	6.3	7.3	8.2	8.4	9.4	10.4	
Total Vol	146.4	138.5	136.5	136.4	136.7	136.9	137.2	

Risk Budgeting of Macro Strategies



Optimal Risk Allocation to Macro Strategies

- ◆ For broad indices, macro forces (rates, spreads, FX) largely determine returns
- ◆ Macro strategies change exposures to basic drivers of index returns, using the most liquid instruments or derivatives
- ◆ How to determine the optimal “bet size” – allocation to a specific strategy given the manager’s view?

Traditional approach:

- ◆ The manager provides explicit forecasts in basis points of changes in yield curves, spreads, etc.
- ◆ Expected return for each asset is computed given these forecasts
- ◆ Risk is computed using historical volatilities and correlations of assets

ORBS:

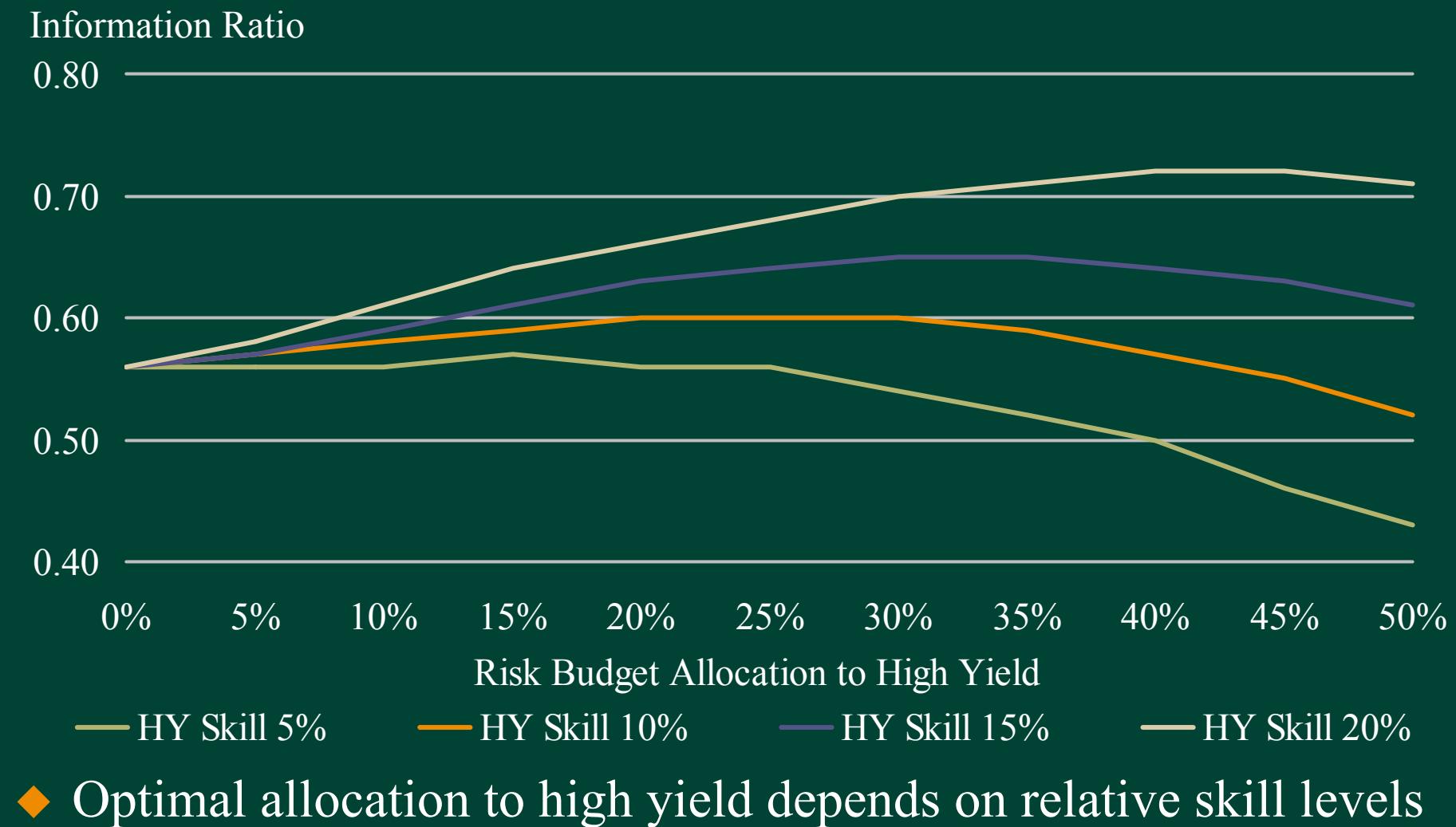
- ◆ The manager provides only directional market outlooks
- ◆ Skill at making directional calls is used to generate strategies’ expected returns
- ◆ Optimal allocation to active strategies is found using historical volatilities and correlations of strategy returns

Performance of a Combination Strategy with Unequal Skills

Strategy	Mean Outperf. (bp/yr)	Volat. (bp/yr)	Information 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



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

Market Views: Long Bets on IG and HY Credit (with different skill); Short Duration Bet

Microsoft Excel - ORBS-Demo.xls

RiskBudget

Strategy Skill Exposure

Overall Risk Budget (bp/yr) **150**

Optimize

Using 'Equal Weight' matrix, 01/31/93 - 12/31/04 (144 mo)

Category	Strategy	Score	Skill	Exposure
Yield Curve Strategies	Duration	5	<input checked="" type="checkbox"/>	Short
	0-2 Slope	5	<input checked="" type="checkbox"/>	Neutral
	2-5 Slope	5	<input checked="" type="checkbox"/>	Neutral
	5-10 Slope	5	<input checked="" type="checkbox"/>	Neutral
	10-30 Slope	5	<input checked="" type="checkbox"/>	Neutral
Core Strategies	IG Credit vs. Govt	20	<input checked="" type="checkbox"/>	Long
	MBS vs. Govt	10	<input checked="" type="checkbox"/>	Neutral
	ABS/CMBS vs. Govt	10	<input checked="" type="checkbox"/>	Neutral
Core-Plus Strategies	High Yield (+split) vs. Govt	5	<input checked="" type="checkbox"/>	Long
	EMD vs. Govt	5	<input checked="" type="checkbox"/>	Neutral
	TIPS vs. Govt	5	<input checked="" type="checkbox"/>	Neutral
Derivative Strategies	10-yr Swaps vs. 10-yr Govt	10	<input checked="" type="checkbox"/>	Neutral
	Non-Dollar Strategies			
EUR Treasuries vs USD Treasuries	5	<input checked="" type="checkbox"/>	Neutral	
JGB Treasuries vs USD Treasuries	5	<input checked="" type="checkbox"/>	Neutral	

Checked: Block view override

Control Output Parameters Optimizer Interface CovMatrix YieldCurve Other USDTRS EURTRS JPYTRS FX

Parameters Setting: Idiosyncratic Risk and Alpha; Covariance Matrix; Constraints

Microsoft Excel - ORBS-Demo.xls

Index Weights This format = user input
Lehman U.S. Aggregate Index as of 12/31/04

		2yr	5yr	10yr	30yr
Treasuries	24.68%	8.45%	6.32%	3.55%	6.36%
Agencies	11.01%	4.86%	3.73%	1.60%	0.82%
Credit	24.80%	5.53%	8.45%	5.18%	5.64%
MBS	35.08%	0.91%	18.59%	15.59%	0.00%
ABS/CMBS	4.43%	1.35%	2.12%	0.94%	0.02%
	100.00%	100.00%	21.10%	39.21%	26.86%
					12.84%
TIPS	100.00%	7.67%	30.26%	35.02%	27.04%
High Yield + Split	100.00%	8.05%	42.92%	35.24%	13.78%
Emerging Markets	100.00%	9.59%	31.34%	17.35%	41.71%
Treasury Durations		2yr	5yr	10yr	30yr
		1.75	3.88	6.74	10.82
Duration Constraints					
Index Duration			4.34		
Max Shortening			50%		
Max Extension			25%		
Governments		2yr	5yr	10yr	30yr
Maturity cells allocation	35.69%	13.31%	10.05%	5.15%	7.18%
Duration		1.75	3.88	6.74	10.82
Hedge EUR Treasuries?			no		
Hedge JPY Treasuries?			no		
Treasury Futures Limit (+/-)			100%		
3-mo Eurodollar Limit (+/-)			100%		

Idiosyncratic Volatility and Name-Selection Alpha

Asset class	Vol (bp/yr)	Alpha (bp)
Cash	50	25
IG Credit	50	25
MBS	25	10
ABS/CMBS	25	10
High Yield	150	50
Emerging Markets	250	50

Covariance Matrix

Total s
1/31/
2/28/
3/31/
4/30/
5/31/
6/30/
7/31/
8/31/
9/30/
10/31/
11/30/
12/31/
1/31/
2/29/
3/31/
4/30/
5/31/
6/30/
7/31/
8/31/
9/30/
10/31/
11/30/
12/31/
n/a

Half-Life (yr) n/a

Beginning Date 01/31/93

Ending Date: 12/31/04

Sample size: 144 months

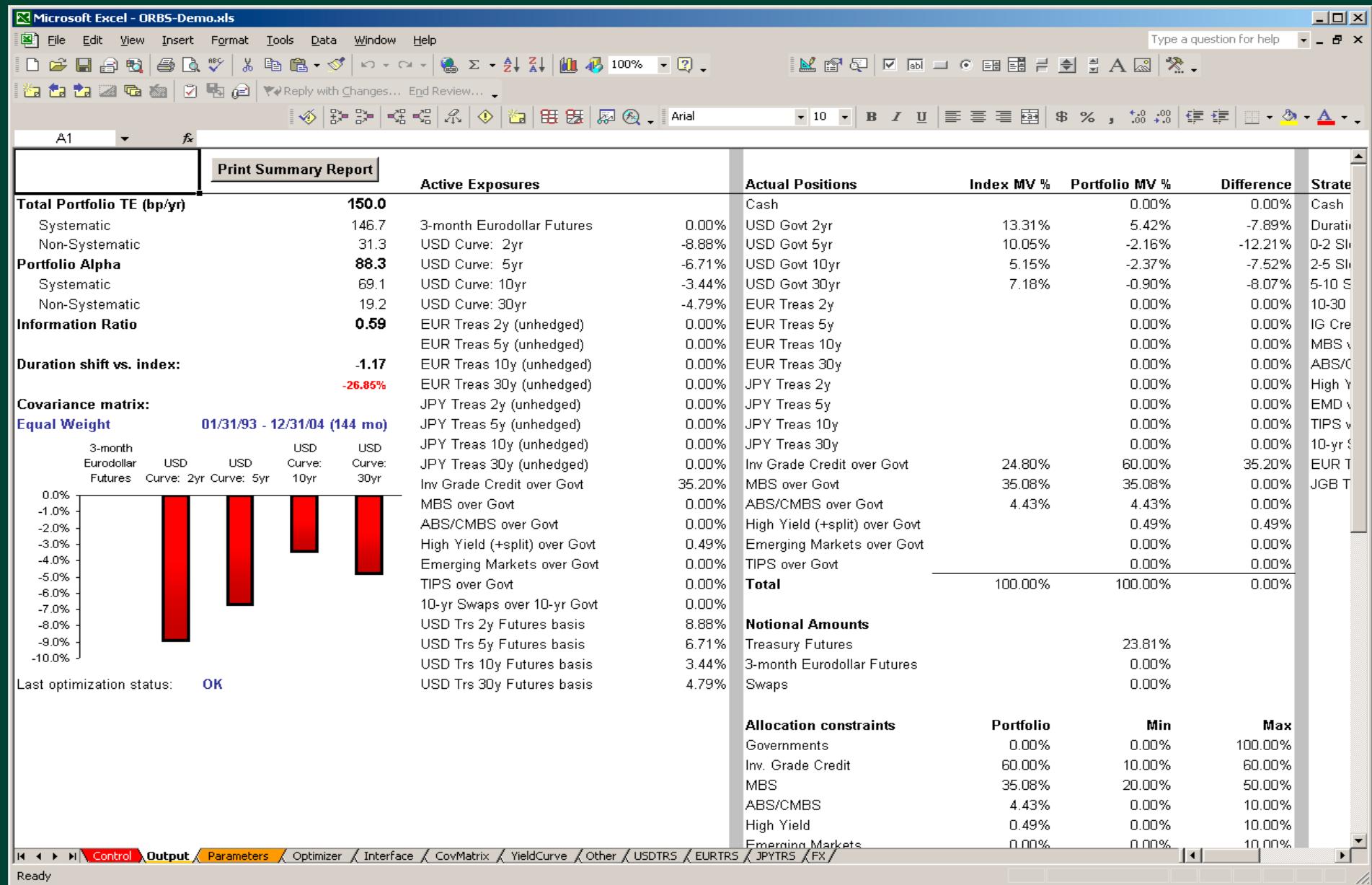
Matrix Selection

- Equal Weight 1
- Time Decay
- Special 1
- Special 2
- Special 3

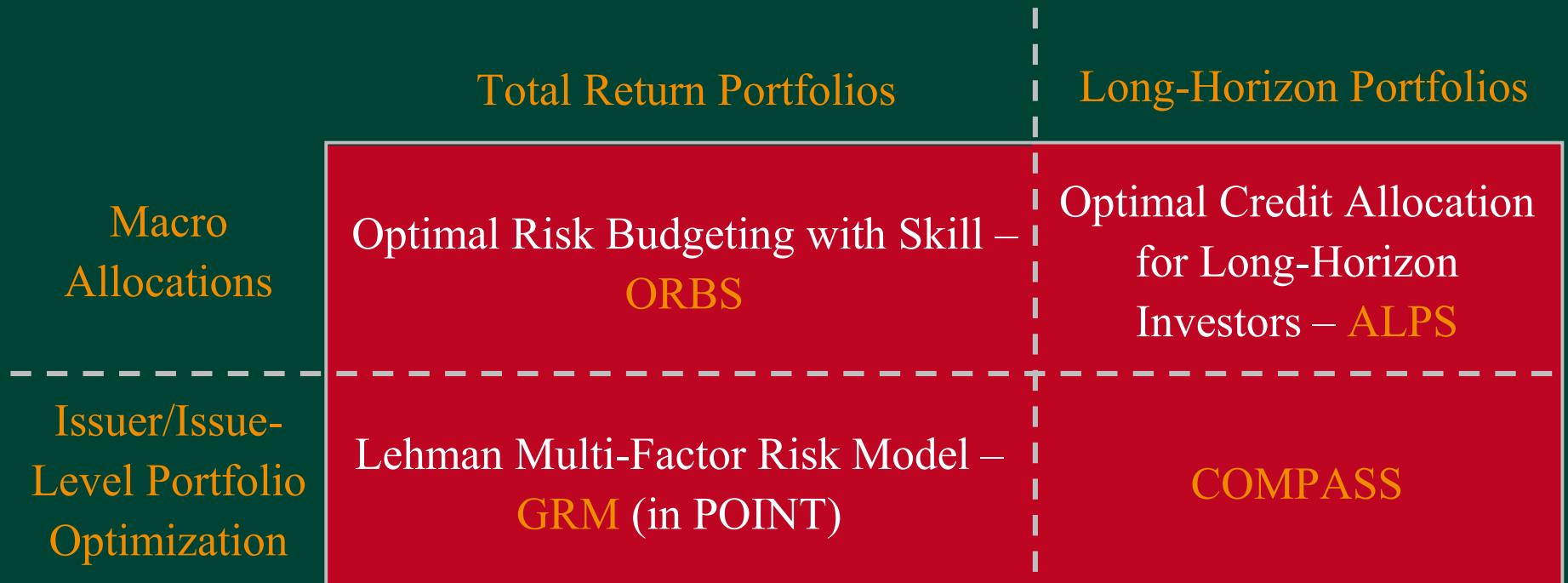
Half-Life Selection

- n/a 1
- n/a

Solution: More Risk to IG Despite Alpha Potential of HY; IG Allocation and Total TEV Constraints Met



Portfolio Risk Optimization for Insurance Companies – Summary



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