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FICC Research
Quantitative Portfolio Strategy

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Is Credit a Redundant Asset Class?

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Motivation

Question: Is credit a redundant asset class in the presence of equities and treasuries?

- In the Merton model, a corporate bond is represented by a risk-free bond and a short put position on the underlying asset of the firm
- Consequently, some argue that a corporate bond may be replaced by a combination of treasuries and the company's stock

We examine this issue in two steps

Step 1: At issuer level, to what extent can corporate debt be replicated by the issuer's equity combined with treasuries?

Step 2: In the context of an asset allocation framework, would including credit improve the risk-adjusted performance of an equities/treasuries portfolio?

Key Results

I. Corporate credit is not a redundant asset class

II. Corporate bonds (IG and HY) achieved better risk-adjusted performance than a combination of treasuries and equity of the same companies with similar systematic exposures regardless of the weighting scheme used

III. The outperformance of corporate bonds was evident irrespective of time period, rating, sector, geography, and risk matching approach

IV. In an asset allocation framework, the inclusion of credit improved equities/treasuries benchmarks irrespective of the initial mix. The improvement was more pronounced during crisis periods

Can corporate bonds of an issuer be replicated by a combination of its equity and treasuries?

Answering the question "To what extent can corporate bonds be replicated by treasuries and stocks?"

- **Approach 1 (easier but incorrect):**
  comparing aggregate bond vs. equity index returns

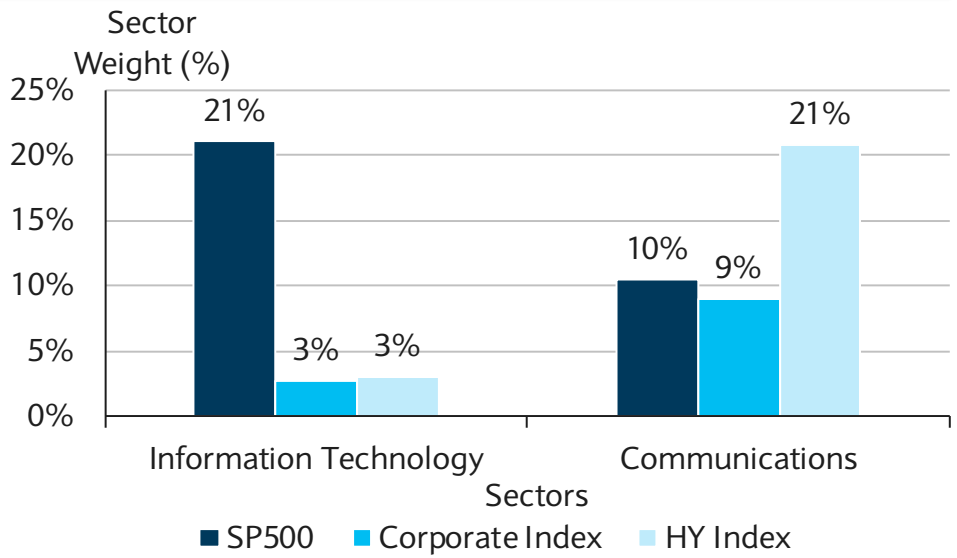
- **Inappropriate** due to the following three issues

  I. Constituent difference

  II. Weights mismatch (issuer and sector)

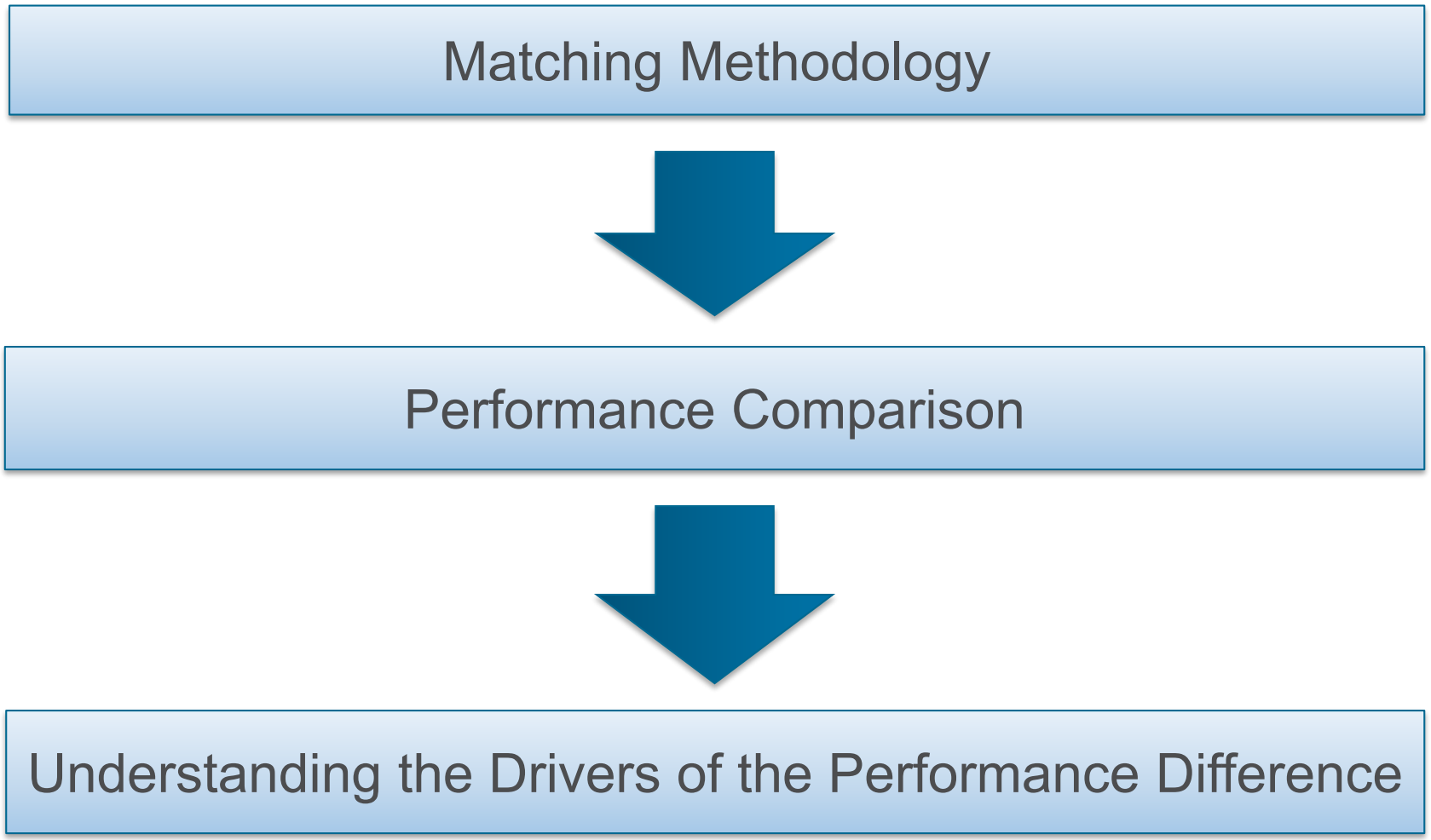
  III. Risk mismatch

Sector Weight of Technology and Communication Sectors in Equity and Bond Indices (as of December 2019)



- **Approach 2**
  Using a carefully matched sample of bonds to stocks at company level

Outline


Matching Methodology
Performance Comparison
Understanding the Drivers of the Performance Difference

Matching Methodology

Bond – Equity Sample Construction

- All issuers in the US credit (Jan 1990 – Dec 2017) and Pan Euro credit indices (May 2002 – Dec 2017) were linked to accounting and equity data from COMPUSTAT
- **Key challenges: Lack of common firm identifiers and corporate events**
- Mapping is based on methodology used in BEAM (Bonds in Equity Asset Momentum)*

Results

- Mapping success (IG and HY) increased consistently over time
- In recent years, mapped sample covered 90% in market cap, almost 100% for US IG
- Most unmapped HY issuers had no identifiers (private firms)

Matching of Corporate and High Yield Index Constituents to COMPUSTAT

Year End Market Value	US ($ Bln)						Pan Euro (Euro Bln)				
	1994	1999	2004	2009	2013	2017	2003	2007	2011	2014	2017
Corporate Index	560	914	1,697	2,555	3,727	5,192	1,003	1,205	1,607	1,930	2,330
Mapped	85%	87%	94%	98%	97%	98%	77%	90%	86%	87%	88%
HY Index	144	351	610	747	1,270	1,339	63	77	154	348	330
Mapped	68%	65%	83%	82%	80%	85%	56%	67%	66%	74%	73%
Agg. Universe (IG+HY)	704	1,265	2,307	3,302	4,996	6,531	1,065	1,282	1,761	2,279	2,660
Mapped	82%	81%	91%	94%	93%	96%	76%	89%	84%	85%	86%

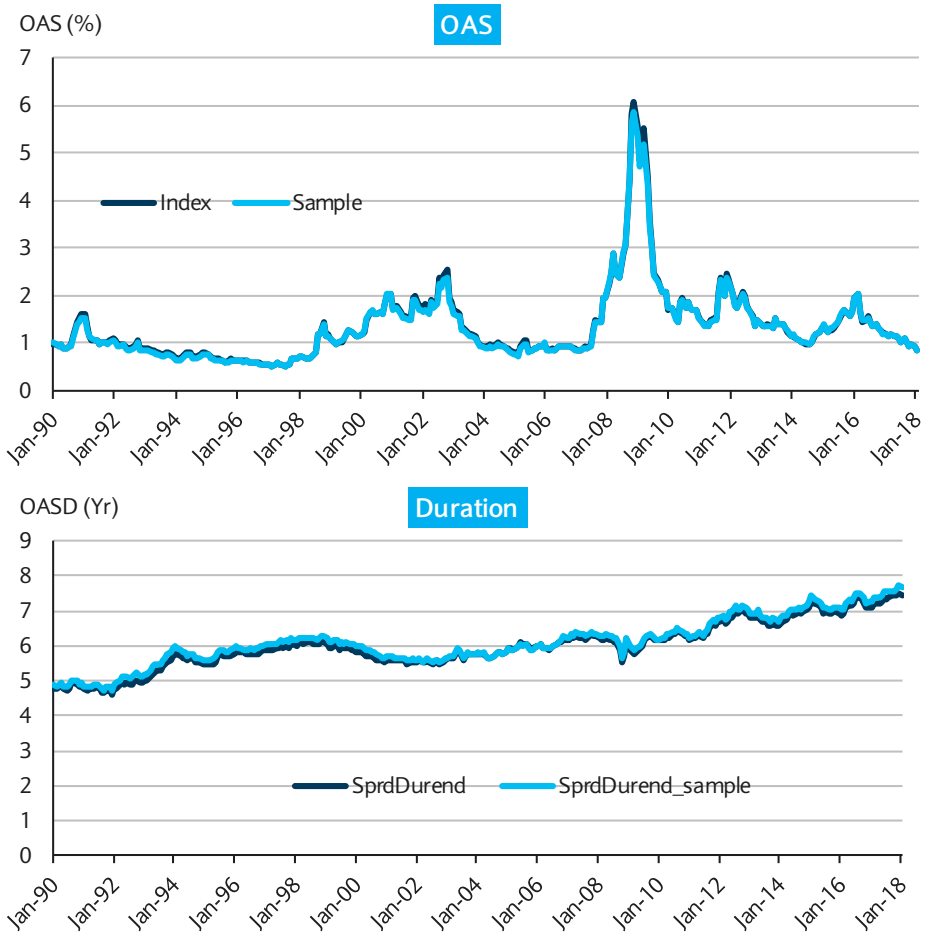
Source: Bloomberg, Compustat, Barclays Research

*Ben Dor, A., and Xu, J., BEAM (Bonds in Equity Asset Momentum) Value of Bond Market Information in Equity Momentum Strategies, Barclays Capital, 5 June 2014

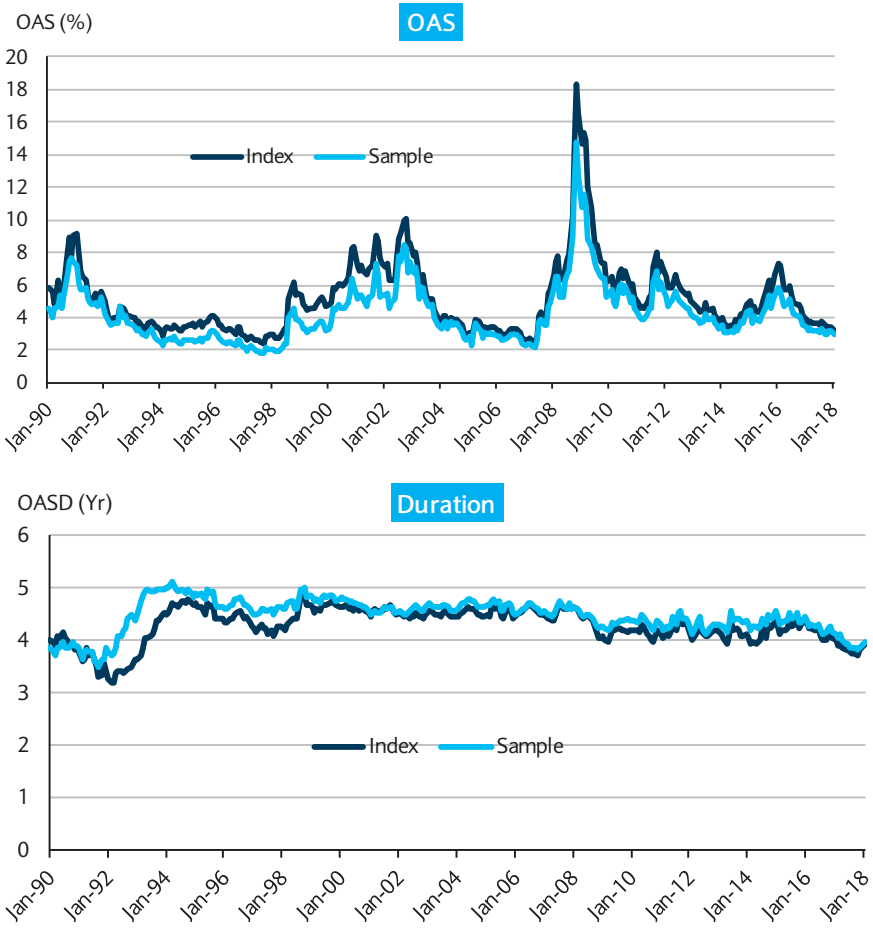
Mapped Samples Are Similar to IG and HY Indices

- Our mapped bond universe was similar to the IG and HY indices in terms of spread and duration

Mapped Univ. vs. Index – US IG



Mapped Univ. vs. Index – US HY



Source: Bloomberg, Compustat, Barclays Research

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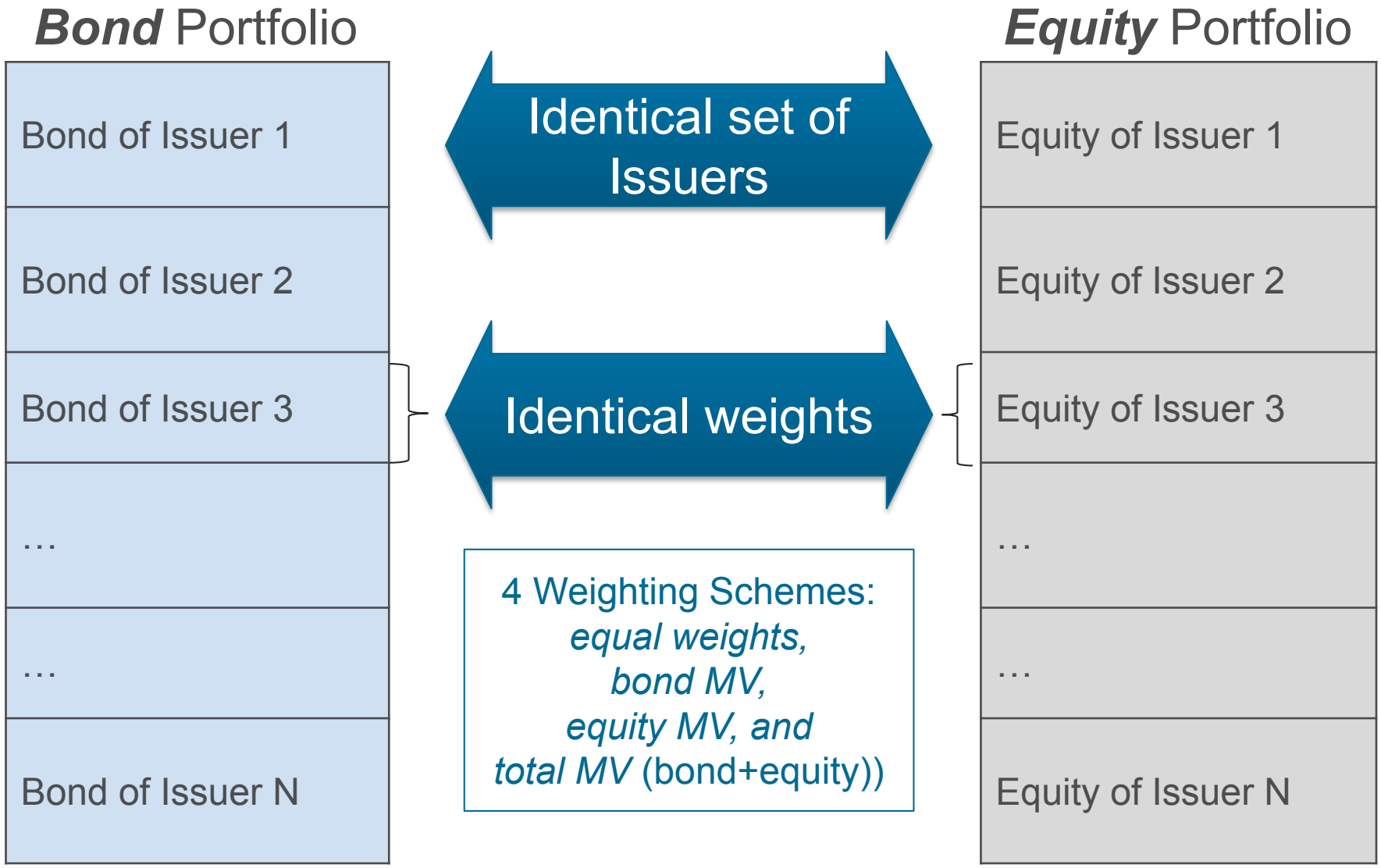
Step 1: Construct Mapped Bond and Equity Portfolios

Each month, we construct two portfolios (*Bond* and *Equity*) with



Source: Barclays Research

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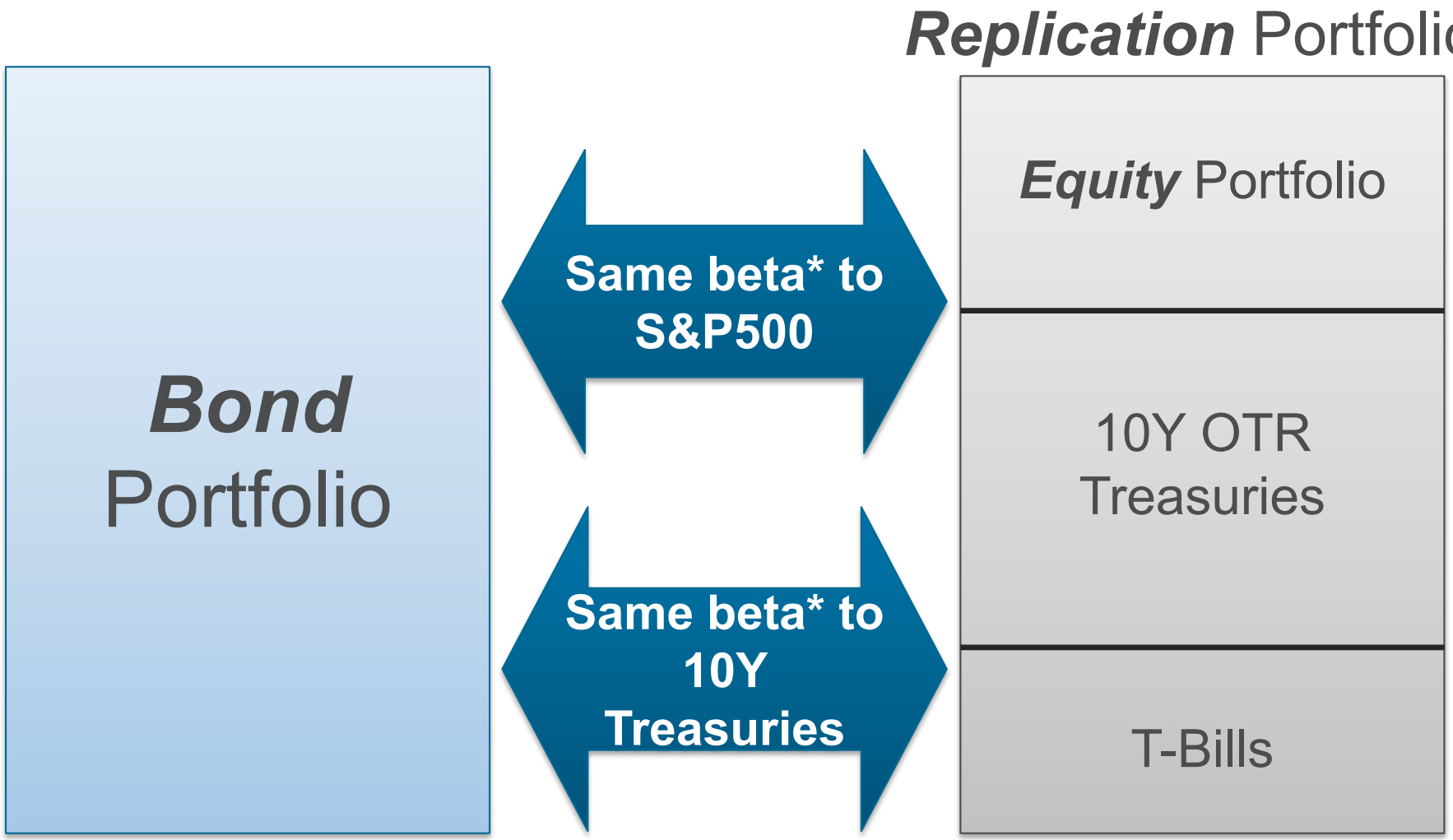
Step 2: Multi-Dimension Risk Matching

Each month, we construct a replicating portfolio (comprised of the Equity portfolio, Treasuries, and T-bills) that matches the two factor sensitivities of the Bond portfolio



*: Betas estimated from trailing 36m data using exponentially decayed weighting to give more focus on recent data (half-life 9 months)

Source: Barclays Research

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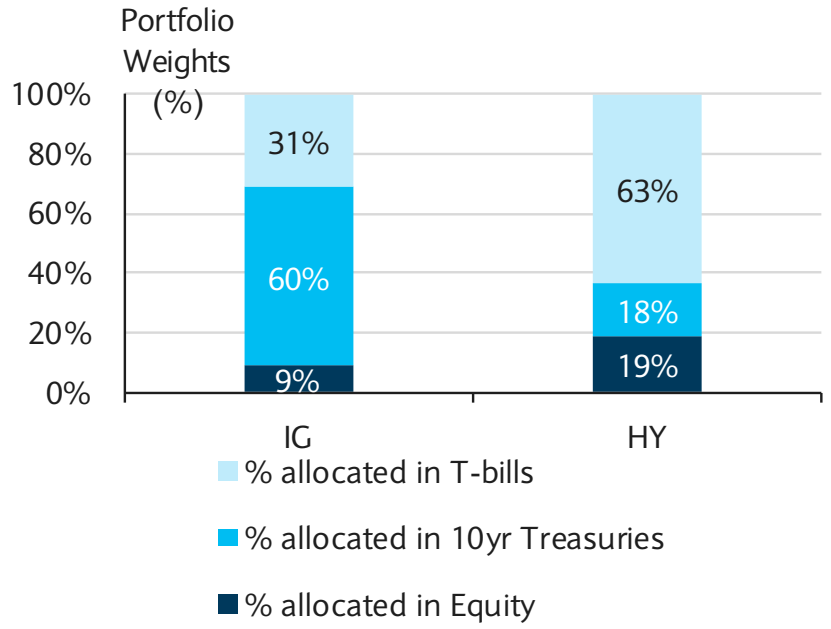
Matching Portfolios by Factor Sensitivities

- Factor sensitivities were calculated using trailing 36m data
- Ex-ante sensitivities were similar across all the weighting schemes

Pre-Formation Avg. Sensitivities
(Trailing 36m Regression, Avg. across time series from Jan 1993 – Jan 2018, EW, total returns used)

	Portfolio	β_S&P 500	% of month with 5%-sig.	β_10y Treasury ret.	% of month with 5%-sig.	Average Adj. R2
IG	Bond	0.09	70%	0.60	97%	75%
	Equity	0.94	100%	0.00	12%	85%
HY	Bond	0.25	83%	0.09	44%	42%
	Equity	1.28	100%	-0.40	31%	67%

Average Portfolio Weights
(Jan 1993 – Jan 2018, EW)



Source: Bloomberg, Compustat, Barclays Research

Post-Formation, Bond, and Replication Portfolios Had Same Exposure

- Post-formation, the *bond* and *replication* portfolios had no difference in their factor exposures
- Similar results across weighting schemes and in both IG and HY

Post-Formation Portfolio Return Sensitivities
(Jan 1993 – Jan 2018, EW, total returns used)

	Portfolio	Intercept (ann. %/Yr)	T-Stat	β_S&P500	T-Stat	β_10y Treasury ret.	T-Stat	adj. R2
IG	**Bond-over-Replication**	**1.72**	**2.31**	**-0.01**	**-0.39**	**-0.03**	**-0.68**	**-0.2%**
	Bond	0.12	1.84	0.12	4.08	0.56	14.05	60%
	Sensitivity-matched Replication Portfolio	-0.02	-0.59	0.13	7.86	0.59	21.83	84%
HY	**Bond-over-Replication**	**3.51**	**2.54**	**-0.01**	**-0.21**	**-0.01**	**-0.17**	**-0.6%**
	Bond	0.29	2.38	0.28	5.02	0.03	0.37	31%
	Sensitivity-matched Replication Portfolio	0.00	-0.03	0.28	10.30	0.04	0.81	53%

Source: Bloomberg, Compustat, Barclays Research

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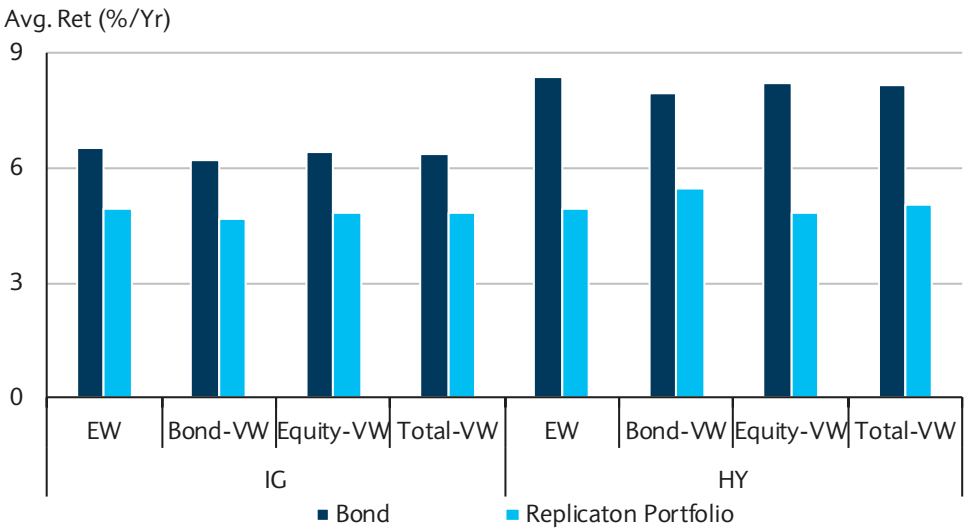
Performance Comparison

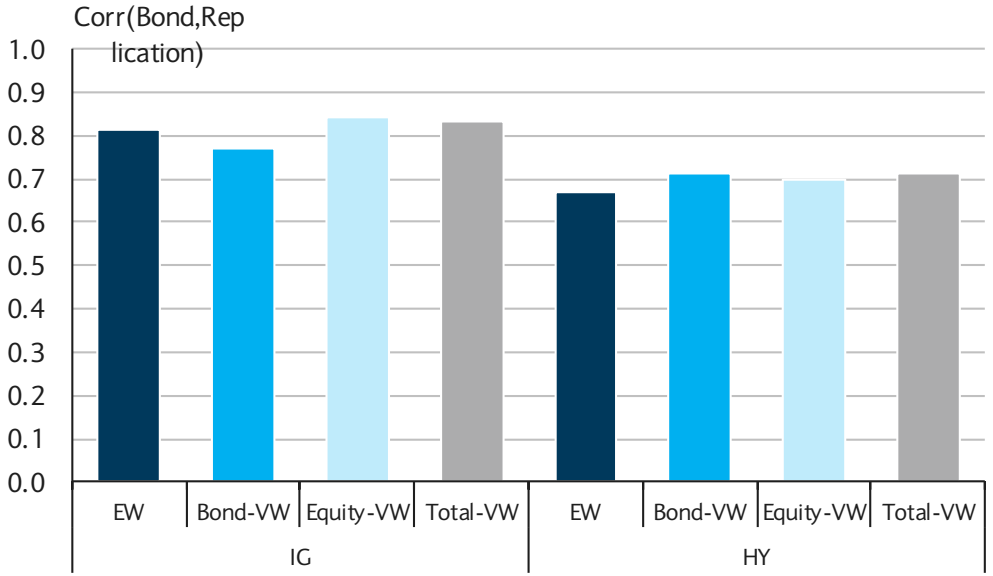
Bonds Had Higher Average Returns Than Replication Portfolio

- Replication portfolios had factor exposures almost identical to the bond portfolios post-formulation but produced much lower average returns, regardless of the weighting scheme, in both IG and HY
- Regardless of the difference in average returns, the correlations were high for both IG and HY among all weighting schemes

Avg. Return of Bond vs. Replication Portfolio
(Jan 1993 – Jan 2018, total returns)



Post-Formation Correlation b/w Bond and Replication Portfolios
(Jan 1993 – Jan 2018)

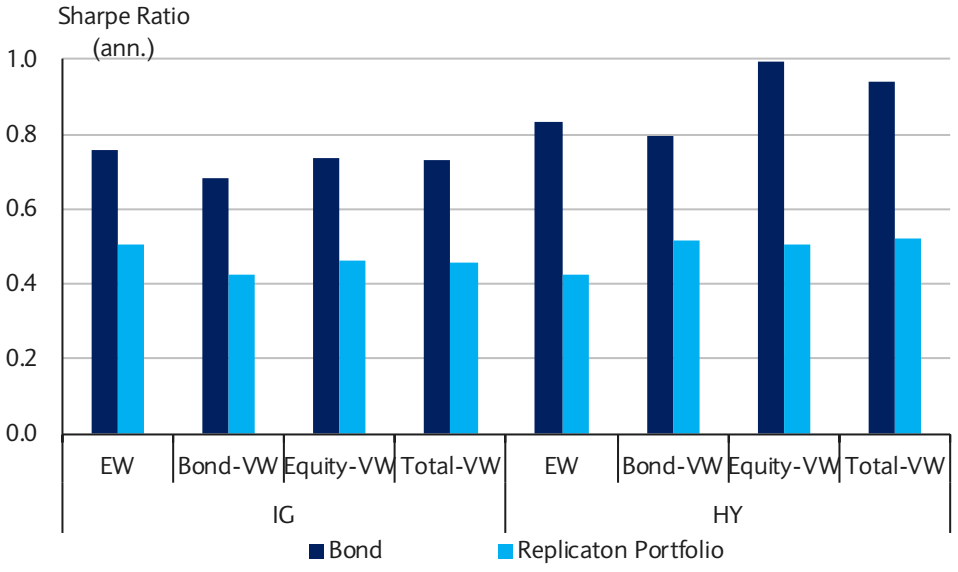


Note: The mapped bond universe has a price filter of $40 to exclude bonds traded on recovery. Results were similar using no price filter
Source: Bloomberg, Compustat, Barclays Research

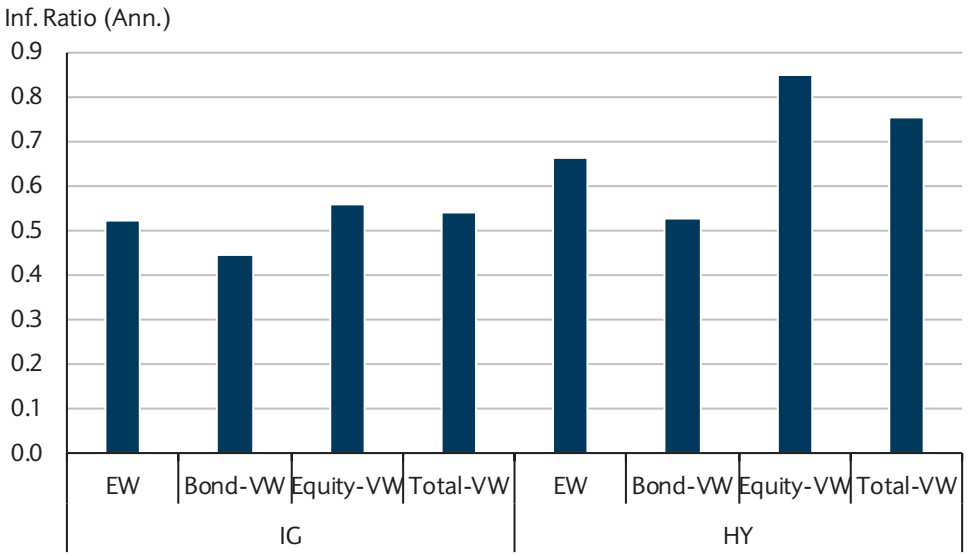
Bond Portfolios Had Higher S.R. than Sensitivity-Matched Port.

- Regardless of the weighting scheme, bond portfolios had higher S.R. on average than the replication portfolios of the same companies in both IG and HY
- The I.R. of bonds over replication portfolios ranged from 0.45 to 0.85 with different weighting schemes

Sharpe Ratios of Bond vs. Replication Portfolio (Jan 1993 – Jan 2018)



Inf. Ratios of Bond over Replication Portfolio (Jan 1993 – Jan 2018)



Source: Bloomberg, Compustat, Barclays Research

Results Remained Consistent across Multiple Dimensions

1. Time periods
2. Ratings
3. Sectors
4. Geographies
5. Including and excluding fallen angels

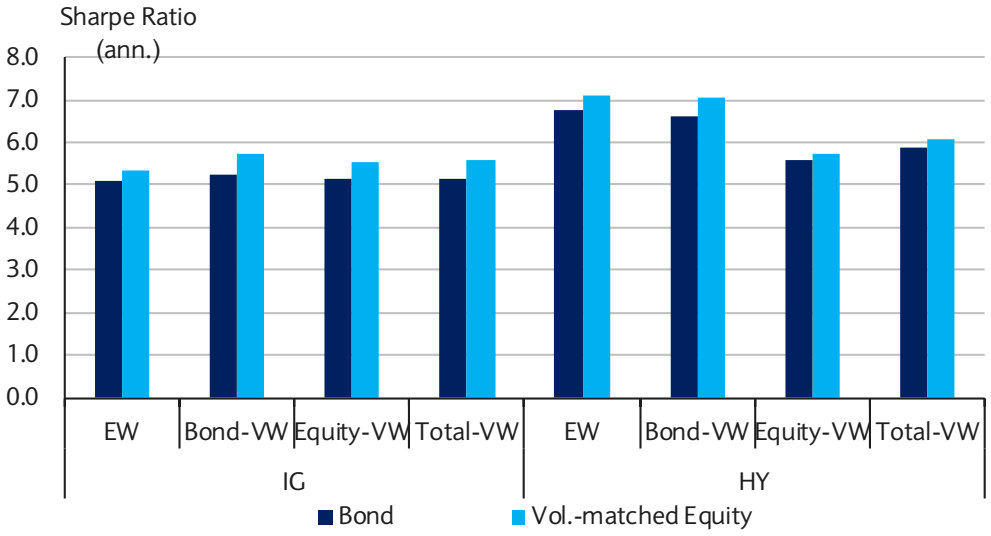
All detailed results are in Appendix 1 (pg. 43)

Risk Matching Using Alternative Approaches

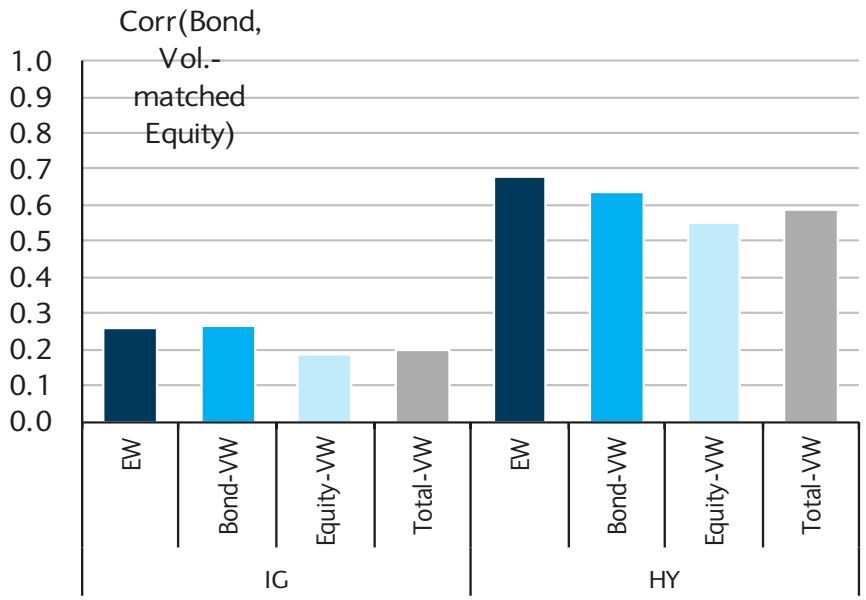
Alternative Approach 1: Matching by Total Volatility

- Simple and intuitive. Equity weights were scaled by relative historical volatility of bond to equity*
- Works well for HY
- For IG, total volatility is matched, but correlation is low. The approach is sensitive to risk mismatch. IG bonds have significant treasury risk exposure, which is not included in equity vol.

Vol of Bonds vs. Vol-matched Equity (Jan 1993 – Jan 2018)



Correlation of Bonds with Vol-matched Equity (Jan 1993 – Jan 2018)



Source: Bloomberg, Compustat, Barclays Research

* Note: trailing vol. was calculated using a 36m window. Any excess weight is allocated to T-bills

HY Bonds Outperformed Vol-Matched Portfolios

- HY bond portfolios outperformed vol-matched equity portfolios
- In IG, performance of bond and vol-matched portfolios are not directly comparable because they had very low correlations (0.26). When risk were matched properly as in the sensitivity-matching case, IG bond outperformed the replication portfolio
- Results were similar across weighting schemes

Performance of Bond-over-Matched Portfolios
(EW, Jan 1993 – Jan 2018)

	Matching Method	Avg. Ret (%/Yr)	Vol. (%/Yr)	Inf. Ratio (Ann.)	Worst Monthly Ret (%)	Max. DD (%)	Corr (Bond, Matched Equity)
IG	Vol.-Matched	-0.12	6.37	-0.02	-5.00	-34.37	0.26
	Sensitivity-Matched	1.58	3.01	0.52	-3.21	-13.86	0.81
HY	Vol.-Matched	2.77	5.56	0.50	-6.74	-14.47	0.68
	Sensitivity-Matched	3.40	5.14	0.66	-6.65	-16.07	0.67

Source: Bloomberg, Compustat, Barclays Research

Alternative Approach 2: Using Merton Model

- Forward-looking risk measures, but sensitive to model assumption
  (eg, Merton model assumes that HR is directly related to leverage ratio, but not profitability. In reality, for certain companies such as Netflix, which may have low leverage but low profitability at an early stage, their HR will be higher than what's predicted by leverage alone)
- **Hedge Ratio for Treasuries**: analytical duration(bond)/analytical duration(treasury)
- **Hedge Ratio for Equities:** based on the Merton Model $\left(\frac{1}{\frac{\partial E}{\partial V}} - 1\right)\frac{E}{D}$, (derivations on pg. 51)

- Research has shown that the analytical hedge ratio makes reasonably accurate predictions of how corporate bond returns vary from the corresponding equity returns (Schaefer and Strebulaev 2008)

Equity Hedge Ratios Implied by the Merton Model
(Jan 1993 – Jan 2018)

Rating	Mean	Median	Average Empirical HR (EW) from Sensitivity Matching
Aaa/Aa	1.9%	0.0%	7.4%
A	3.1%	0.5%	8.0%
Baa	5.3%	1.8%	9.9%
Ba	9.6%	6.9%	16.5%
B	16.4%	15.3%	20.7%
Caa and below	27.7%	24.7%	27.4%
IG	4.2%	1.0%	9.0%
HY	15.0%	13.1%	19.0%

Note: more detailed distribution statistics of the equity HRs are available on pg. 52. Source: Bloomberg, Compustat, OptionMetrics, Barclays Research

The Merton Model Generated Similar Results to the Original Approach

- Using the Merton model generated similar bond outperformance over the replication portfolio as using the original approach (OLS)
- The replication portfolio using analytical HR had lower correlations with the bond portfolio than using empirical HR

Portfolio Performance using Analytical
(EW, Jan 1993 – Jan 2018)

			Using Analytical HR (Merton Model)		Using Empirical HR (OLS-based)	
		Bond Portfolio	Replication Portfolio	Bond-over-Replication	Replication Portfolio	Bond-over-Replication
IG	Avg. Ret (%/Yr)	6.63	5.15	1.49	4.98	1.65
	Vol. (%/Yr)	5.15	5.50	3.45	4.62	3.01
	Sharpe (Inf.) Ratio (ann.)	0.78	0.46	0.43	0.52	0.55
	Corr. with Bond Portfolio Ret	1.00	0.79		0.82	
	Avg. Weights in Equities		4%		9%	
	Avg. Weights in 10Y Treasury		78%		60%	
HY	Avg. Ret (%/Yr)	8.40	6.17	2.23	5.21	3.20
	Vol. (%/Yr)	6.93	6.56	5.84	5.86	5.29
	Sharpe (Inf.) Ratio (ann.)	0.83	0.54	0.38	0.44	0.60
	Corr. with Bond Portfolio Ret	1.00	0.63		0.67	
	Avg. Weights in Equities		15%		19%	
	Avg. Weights in 10Y Treasury		53%		18%	

Source: Bloomberg, Compustat, OptionMetrics, Barclays Research

Replication Portfolios Ex Post Factor Exposures

- Constructing replication portfolios using Merton HR + analytical duration overweight treasuries, as evidenced by the significant exposure to the treasury factor of the bond-over-replication-portfolio (Merton) returns
- Bond portfolio still demonstrated outperformance over equities

Portfolio Ex Post Exposures Using Analytical vs. Empirical Hedge Ratios (EW, Jan 1993 – Jan 2018)

	Dependent Variables	Intercept	beta on S&P500	beta on 10Y Treasury	Adj. R2
IG	Bond - Replication Ret (using Merton HR)	1.743**	0.035	-0.197***	20.10%
	Bond - Replication Ret (using OLS)	1.784**	-0.009	-0.023	-0.30%
HY	Bond - Replication Ret (using Merton HR)	3.589***	-0.027	-0.429***	25.63%
	Bond - Replication Ret (using OLS)	3.41**	-0.023	-0.011	-0.29%

Source: Bloomberg, Compustat, OptionMetrics, Barclays Research

Understanding the Drivers of the Performance Difference

Are Results Affected by Outliers?

- For each company, we looked at the difference in avg. return between its bond and sensitivity-matched returns using both empirical hedge ratios (applying the **same weights across the board for IG/HY**)* and analytical HRs based on the Merton model
- More than 70% of companies in both IG and HY had higher average returns with their bonds than with their sensitivity-matched equities/treasury during 1993-2018

% of Companies with Bond outperforming Risk-Matched Equities (EW)

		Using Empirical Hedge Ratios (OLS based)		Using Analytical Hedge Ratios (Merton Model)	
	Period	IG	HY	IG	HY
Whole Sample	Jan. 1993 - Jan. 2018	78%	74%	84%	73%
Sub-Period	Jan. 1993 - Dec. 1997	82%	79%	84%	68%
	Jan. 1998 - Dec. 2002	71%	55%	65%	55%
	Jan. 2003 - Dec. 2007	55%	71%	71%	68%
	Jan. 2008 - Dec. 2012	87%	88%	78%	70%
	Jan. 2013 - Jan. 2018	68%	64%	93%	83%

Note: The OLS weights on equity, 10y treasury, and T-bills calculated monthly from EW bond and equity portfolios using sensitivity matching of two factors (S&P 500 and 10y Treasury Ret). Source: Bloomberg, Compustat, Barclays Research

Are We Underweighting Equity Risk?

- With the empirical HRs, we applied the same weights to all individual equities (in IG/HY) every month. In reality, different companies might need different weights for their equities to have the same factor sensitivities as the bonds
- The positive diff in return could be driven by bonds having higher risk (proxied by vol)
- Cross-sectional regressions show that bonds with higher volatility than sensitivity-matched E/T did not have higher returns

Cross-Sectional Regression of Pair-Wise Return Diff. on Pair-Wise Vol. Ratio
(Bond over Matched-Equity/Treasury, Jan 1993 – Jan 2018, EW)

Independent Variables	Using Empirical Hedge Ratios (OLS based)		Using Analytical Hedge Ratios (Merton Model)	
	IG	HY	IG	HY
Intercept	0.224***	0.653***	0.193***	0.298***
Vol Ratio (Bond/Risk-Matched Equity)	-0.095**	-0.4***	-0.058	-0.046
Adj. R2	4%	13%	1%	0%

Note: The empirical weights on equity, 10y treasury, and T-bills are calculated monthly from EW bond and equity portfolios using sensitivity matching of two factors (S&P 500 and 10y Treasury Ret). Source: Bloomberg, Compustat, Barclays Research

What About the Effect of Liquidity?

We tested the effect of liquidity in three ways:

1. Using a liquid sub-sample (S&P 500 firms)
2. Dividing all issuers into low and high bond liquidity categories (measured by LCS)
3. Incorporating transaction costs for bonds

- In all cases, results are similar (detailed results are in Appendix 3 pg. 54)

Gross and Net Performance of Bonds-over-Replication Portfolios
(EW, Jan 2007* – Jan 2018,
transaction costs approximated by LCS, incorporated at sales)

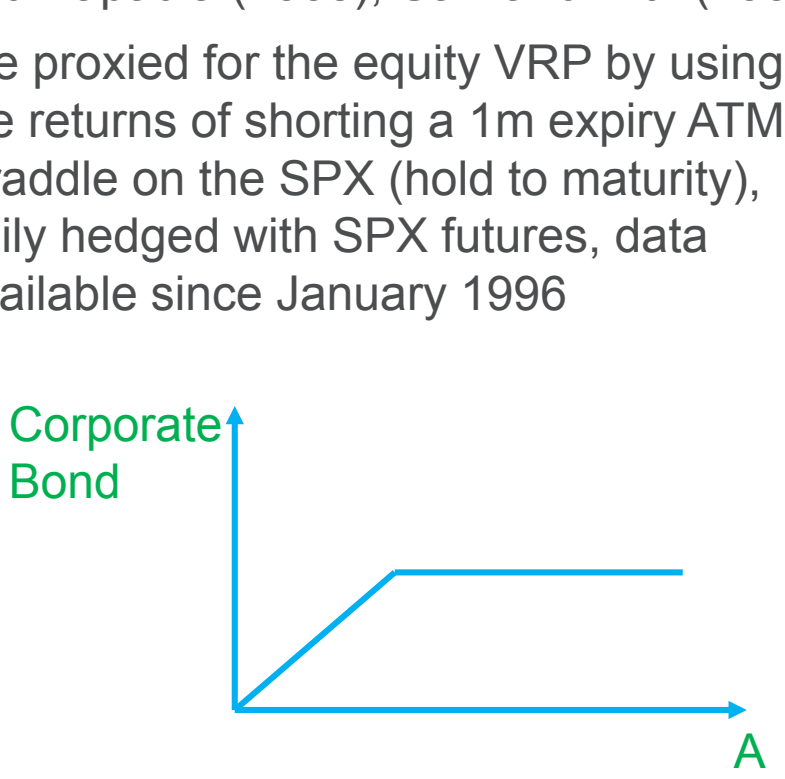
	IG			HY		
	Avg. Ret (%/Yr)	Vol. (%/Yr)	Inf. Ratio (Ann.)	Avg. Ret (%/Yr)	Vol. (%/Yr)	Inf. Ratio (Ann.)
Gross	2.06	3.98	**0.52**	4.75	6.10	**0.78**
Net of Transaction Costs	1.89	3.97	**0.48**	4.11	6.13	**0.67**

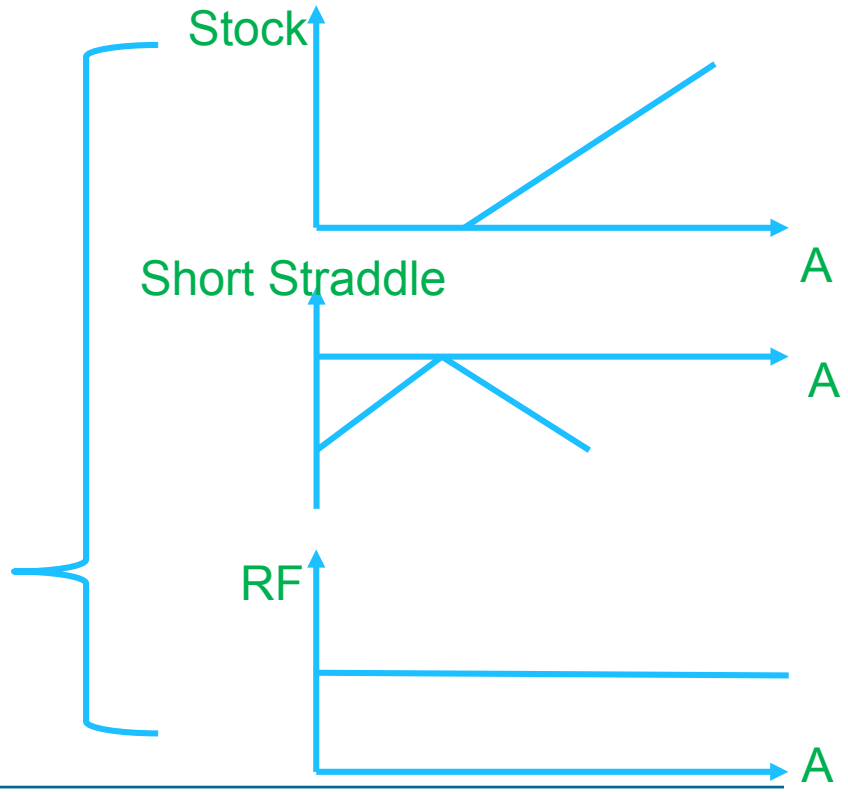
Note: Analysis starts in 2007 due to availability of LCS data. Source: Bloomberg, Compustat, Barclays Research

What Explains the Bond Outperformance?

Bond Returns May Have Exposures to Equity Variance Risk Premium (VRP) Factor

- In the Merton Model, a corporate bond is a short put on the underlying asset plus a risk-free asset, while the company's stock is a call option on the underlying asset
- A corporate bond can also be thought as of the stock + short straddle (a call and a put ATM) + risk free bond
- Holding a corporate bond creates an exposure to shorting volatility on the underlying asset, similar to a straddle on the stock. Previous research shows that shorting volatility on equities generates a premium (ie, Equity Variance Risk Premium, Bakshi and Kapadia (2003), Carr and Wu (2009))
- We proxied for the equity VRP by using the returns of shorting a 1m expiry ATM straddle on the SPX (hold to maturity), daily hedged with SPX futures, data available since January 1996





Source: Barclays Research

Bond Returns May Have Exposures to Bond Variance Risk Premium (VRP) Factor

- **Rationale**:
  1. A considerable fraction of corporate bonds have **callable provisions** that allow issuer to repurchase the bonds at a preset redemption price, which is an optionality that allows the issuer to benefit from declining interest rate

     For bond holder, the call features is similar to selling an option on interest rate
  2. Due to **convexity mismatch** between the bond portfolio and the treasuries, the bond-over-replication portfolio might have an exposure to interest rate vol. as well

- Similar to equity VRP, there is a bond VRP, that is, an investor can collect a premium by selling a straddle on ATM treasury futures (Choi, Mueller, and Vedolin 2017)

- We proxied for the bond VRP by using two separate short volatility strategies that sell ATM 1m expiry puts and calls respectively (hold to maturity) on the US 10y Treasury futures with delta hedging using US 10y Treasury futures

- The strategy selling puts captures the effect of the callable feature because the issuers only benefit from the callable feature from declining interest rate

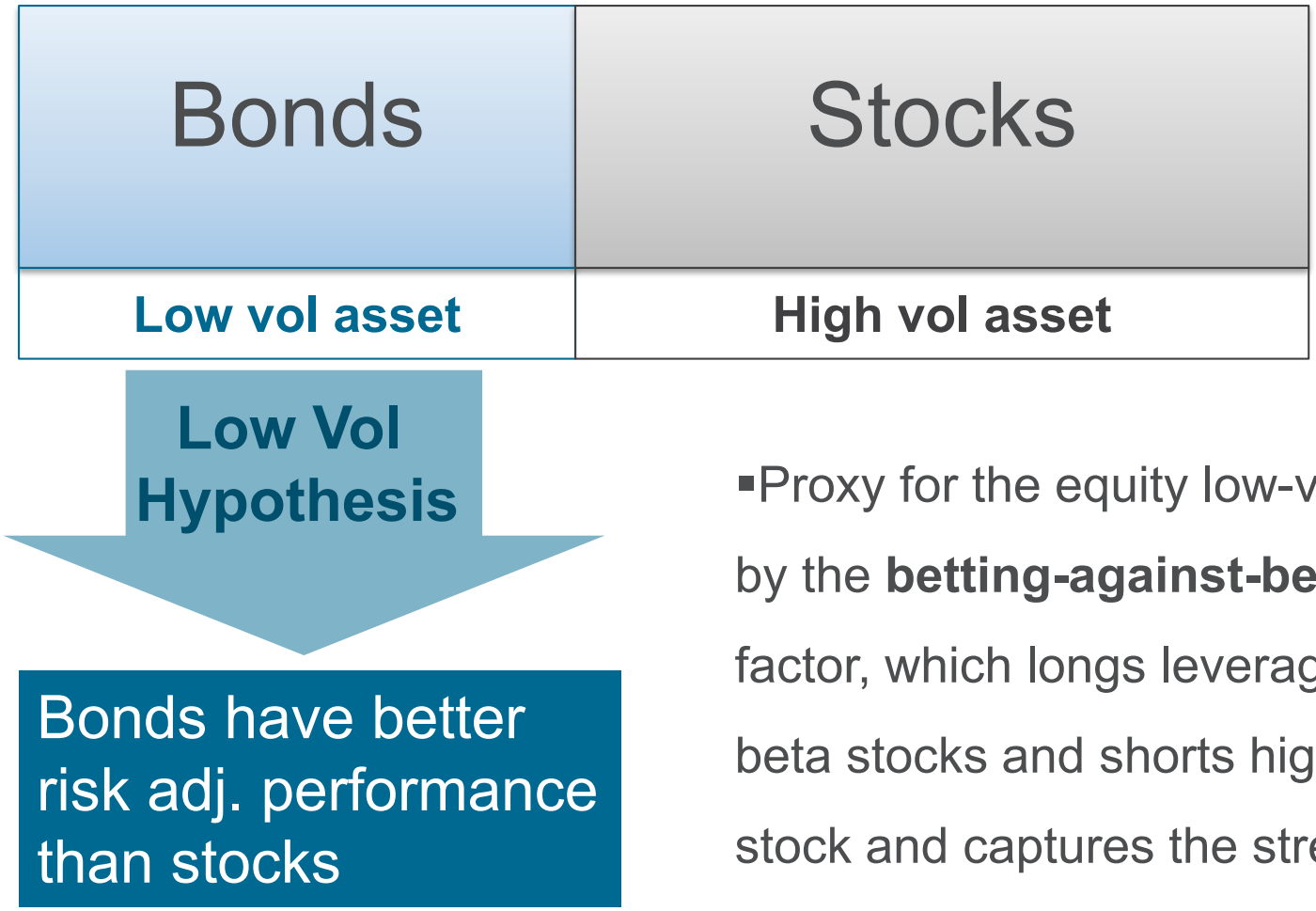
- The strategy selling puts and calls together captures the convexity mismatch.

Is the Bond Outperformance Related to the Low-Vol Phenomenon?

- The ‘Low Vol” phenomenon – the tendency of **lower-risk stocks to outperform high-risk stocks** on a risk-adjusted basis – is widely documented (Ang, Hodrick, Xing, and Zhang 2006; Frazzini and Pedersen 2014)
- A similar pattern was also detected within credit: **Short-maturity bonds had better risk-adjusted and unadjusted performance than long-maturity bonds** (Ambastha, Ben Dor, Dynkin, and Hyman 2008, Desclée, Dubois, and Polbennikov 2019)
- Underlying theory: Investors with leverage constraints chase risky assets as a form of taking on leverage and, thus, bid up the prices and drive down the expected returns of risky assets (Frazzini and Pedersen 2014)

Is Bond Outperformance a Manifestation of the Low-Vol Phenomenon *across* Asset Classes?

- Bonds and stocks represent the two extremes of a company's capital structure



- Proxy for the equity low-vol. effect by the **betting-against-beta (BAB)** factor, which longs leveraged low-beta stocks and shorts high-beta stock and captures the strength of low-vol phenomenon in equities

Source: Barclays Research

Bond Outperformance Has Exposures to Equity- and Bond-VRP and BAB

Regression of Bond over Replication Portfolios on FF, Momentum, **Equity VRP, Bond VRP, and BAB** Factors (EW, Jan 1993 – Jan 2018)

	IG					HY				
Specification	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Variables	**Baseline**	**+ FF5 + MMT**	**+Equity VRP**	**+Bond VRP**	**+BAB (Low Vol Factor)**	**Baseline**	**+ FF5 + MMT**	**+Equity VRP**	**+Bond VRP**	**+BAB (Low Vol Factor)**
Intercept	1.745**	2.125**	1.538*	0.895	0.608	3.403**	4.138**	3.188**	2.225	1.830
S&P 500 over rf	-0.013	-0.021	-0.02	-0.028	-0.025	-0.014	-0.032	-0.031	-0.042	-0.038
Treasury over rf	-0.04	-0.039	-0.027	-0.028	-0.011	-0.025	-0.044	-0.034	-0.035	-0.012
SMB (size)		0.014	0.015	0.022	0.022		-0.036	-0.035	-0.024	-0.025
HML (value)		-0.056	-0.055	-0.036	-0.037		-0.087	-0.086	-0.059	-0.06
RMW (profitability)		-0.012	-0.013	-0.02	-0.02		-0.015	-0.017	-0.027	-0.027
CMA (investment)		-0.005	-0.005	-0.03	-0.027		-0.045	-0.045	-0.082	-0.077
MMT (momentum)		-0.029*	-0.029**	-0.038**	-0.038**		-0.015	-0.015	-0.028	-0.027
Equity VRP			0.23**	0.198**	0.136**			0.372***	0.323**	0.238**
Bond VRP (puts)				1.63***	1.492***				2.348***	2.158***
Bond VRP (calls)				0.003	-0.129				0.098	-0.085
BAB (low vol.)					0.113***					0.155***
adj. R-Squared	0.2%	6%	11%	17%	31%	-0.6%	3%	8%	13%	22%
Δ in adj. R-Squared from previous model		6%	5%	7%	14%		4%	5%	5%	9%
Δ in Intercept from previous model (%/Yr)		0.38	-0.59	-0.64	-0.29		0.74	-0.95	-0.96	-0.40

Note: For clear interpretation of coefficients, the MMT factor is orthogonized against the FF5 factors, and the BAB and Equity VRP factors are orthogonized against the FF5+MMT factors. Source: AQR, Bloomberg, Compustat, Ken French Data Library, OptionMetrics, Barclays Research

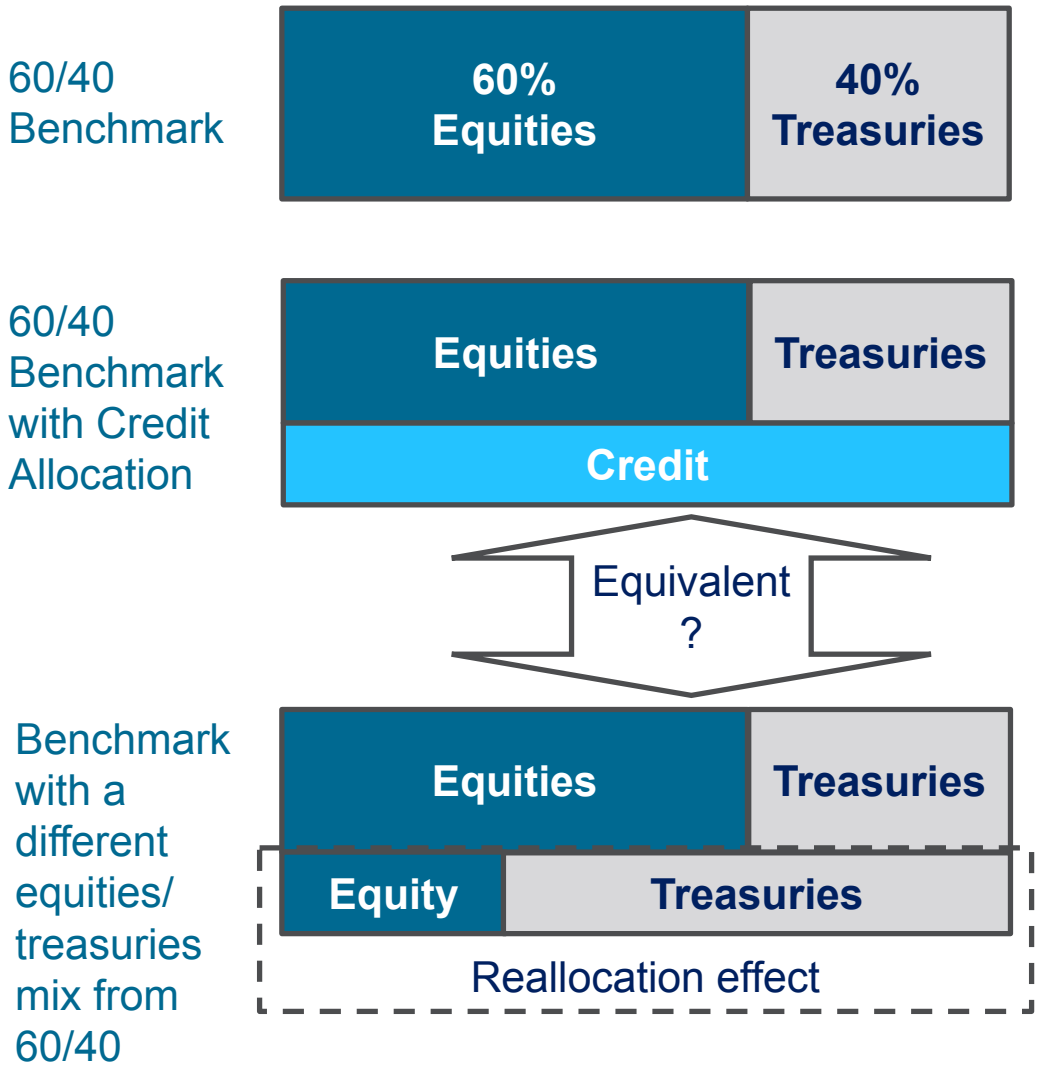
Would inclusion of credit improve the risk-adj. performance of an equities/treasuries portfolio?

Effect of Credit in the Context of Asset Allocation – Are we done?

- Is Part I enough to argue that at the asset-class level, credit is not redundant?
- In asset-allocation decisions, most investors have to allocate between equity/treasury/credit **indices**
- Security-level and index-level comparisons may yield different results due to
  - Constituent mismatch
  - Industry weight mismatch
- As a result, we look at whether investing in a credit index increases the performance of an equities/treasuries benchmark

The Inclusion of Credit Has Several Aspects

1. **Reallocation effect:** Credit introduces more/less treasuries into the benchmark (can be achieved by changing existing mix of E/T)
2. **Unique benefit from credit** (credit risk premium)
3. **Name diversification** (names unique to each asset class, small magnitude)



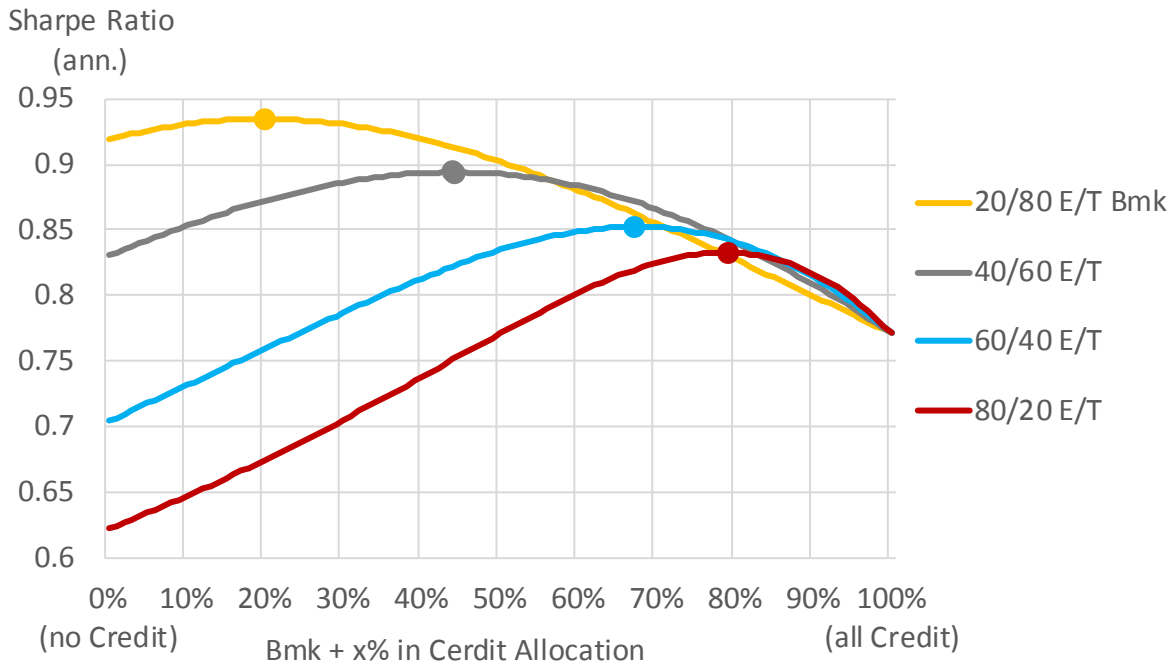
Source: Barclays Research

Benefit of Credit Varies Due to Reallocation Effect

- **Benchmark**: Equities (S&P500) and Treasuries (Bloomberg Barclays Treasury Index) total returns
- **Credit Portfolio**: MV-weighted Bloomberg Barclays IG/HY Corporate Bond Index total returns

- Allocating to the credit portfolio increases the Sharpe ratio regardless of the benchmarks
- The magnitude of the benefit depends on the mix of E/T of the benchmark → the reallocation effect depends on what credit replaces
- How to disentangle the unique benefit of credit vs. the reallocation effect?

Sharpe Ratio with x% in Credit Allocation for Different E/T Benchmarks (Jan 1993 – Jan 2018)



Note: The dots indicate optimal credit allocation for each benchmark mix. Credit replaces the benchmark mixes of E/T. Source: Bloomberg, Compustat, Barclays Research

A Replication Portfolio Allows Us to Isolate the True Impact of Credit

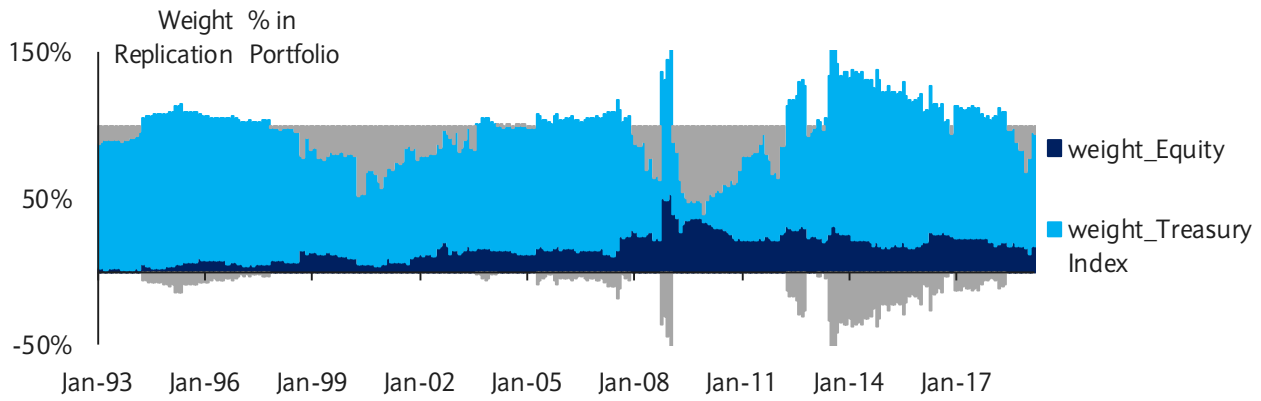
- **Replication Portfolio**
  A mix of equities/treasuries/T-bills with the same systematic exposures to equity and treasuries as the credit portfolio
- Unique effect of Including credit = Perf.(bmk+Credit) – Perf. (bmk+Replication Port.)
- **Construction Methodology**
  Each month, we use a regression to estimate the mix of equities/treasuries (W_E, W_T) that has most closely replicated the fluctuations in the credit allocation (trailing 36m)

$$\text{Credit ret}_t = \text{Intercept} + W_E * \text{Equity Ret}_t + W_T * \text{Treasury index ret}_t + e_t$$

W_E and W_T estimated using data in a trailing 36 month window

Historical Weights of Equities/Treasuries in the Replication Portfolio

- On average W_E =16%, W_T =79%, with the excess allocated in cash (3m T-bill, avg. 4%)



Source: Bloomberg, Compustat, Barclays Research

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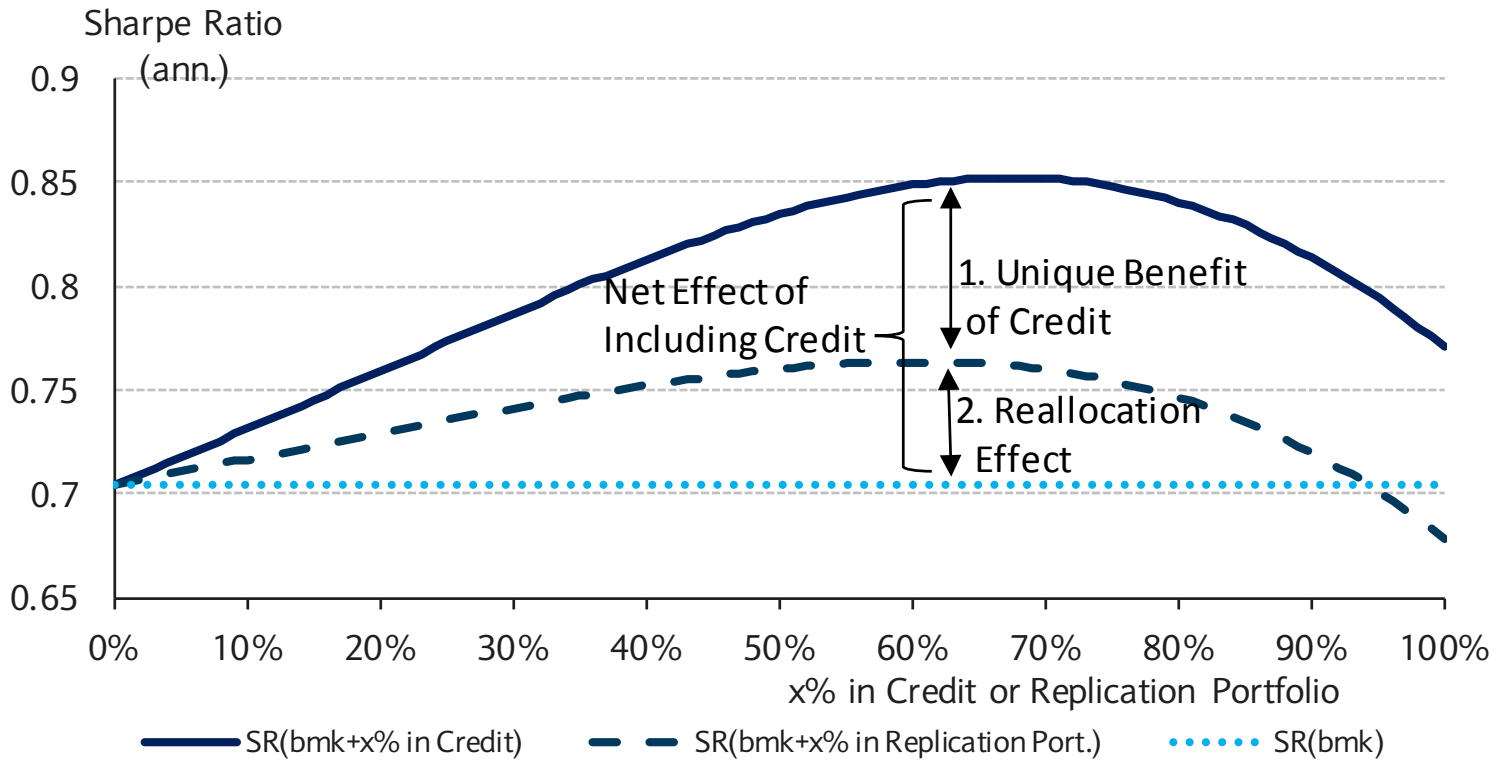
Credit Increased Benchmark's Sharpe Ratio More Than the Replication Portfolios

- For the 60/40 E/T benchmark, allocating to the credit portfolio increased S.R. over the benchmark
- Credit provided unique benefits beyond the replication portfolio

Sharpe Ratio with x% in Credit Allocation vs with x% in Replication Portfolio
(60/40 E/T Benchmark, Credit = VW IG/HY, Jan 1993 – Jan 2018)

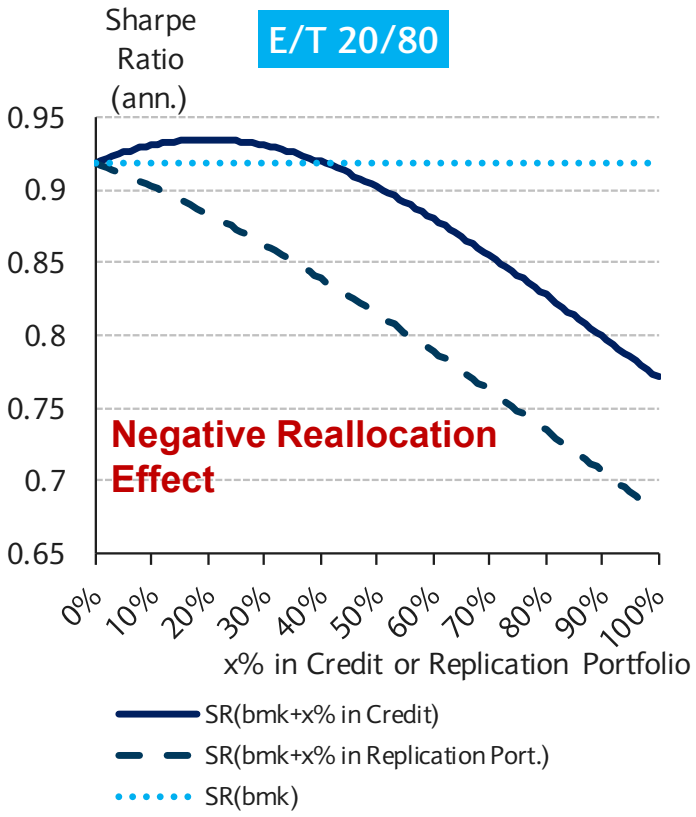


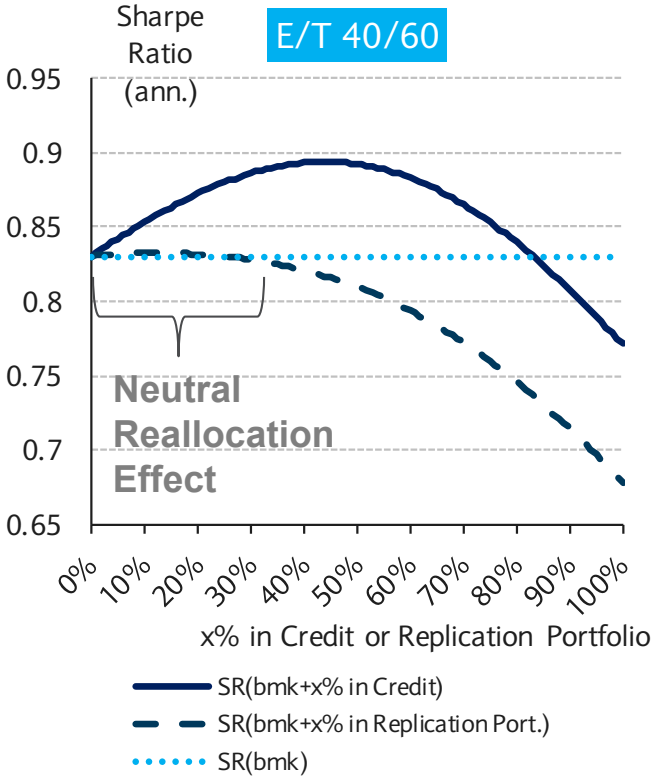
Source: Bloomberg, Compustat, Barclays Research

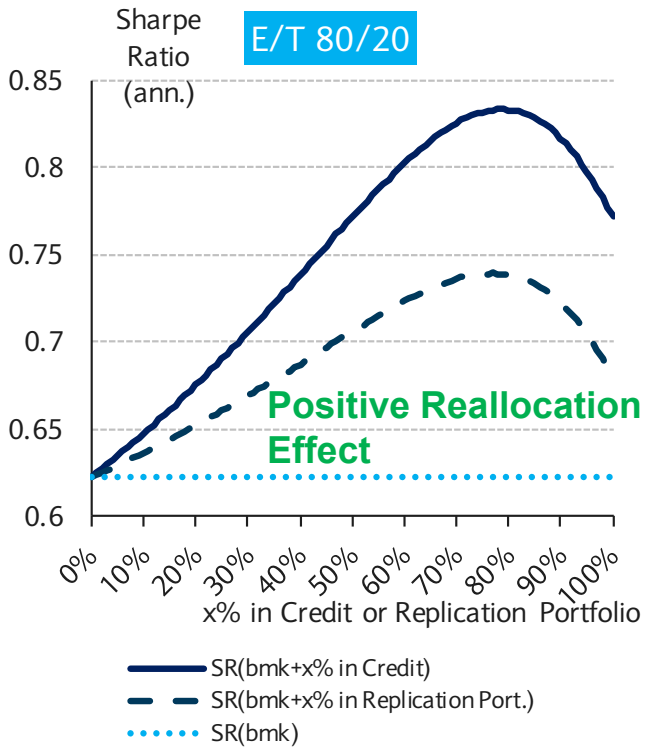
Credit Offered Unique Benefit Regardless of the Benchmark

- The reallocation effect may be positive or negative depending on the original benchmark
- Credit offers unique benefits regardless of the original benchmark mix of E/T

Sharpe Ratio with x% in Credit Allocation vs with x% in Replication Portfolio for other E/T Benchmarks (Credit = VW IG/HY, Jan 1993 – Jan 2018)







Source: Bloomberg, Compustat, Barclays Research

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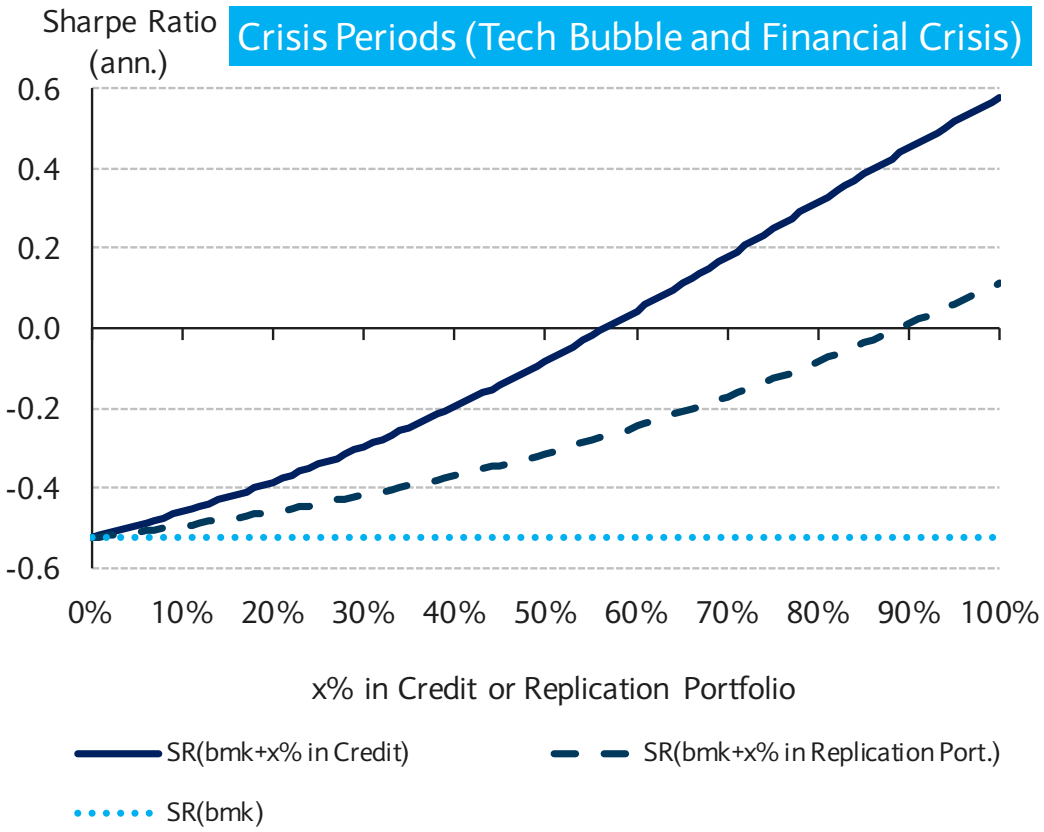
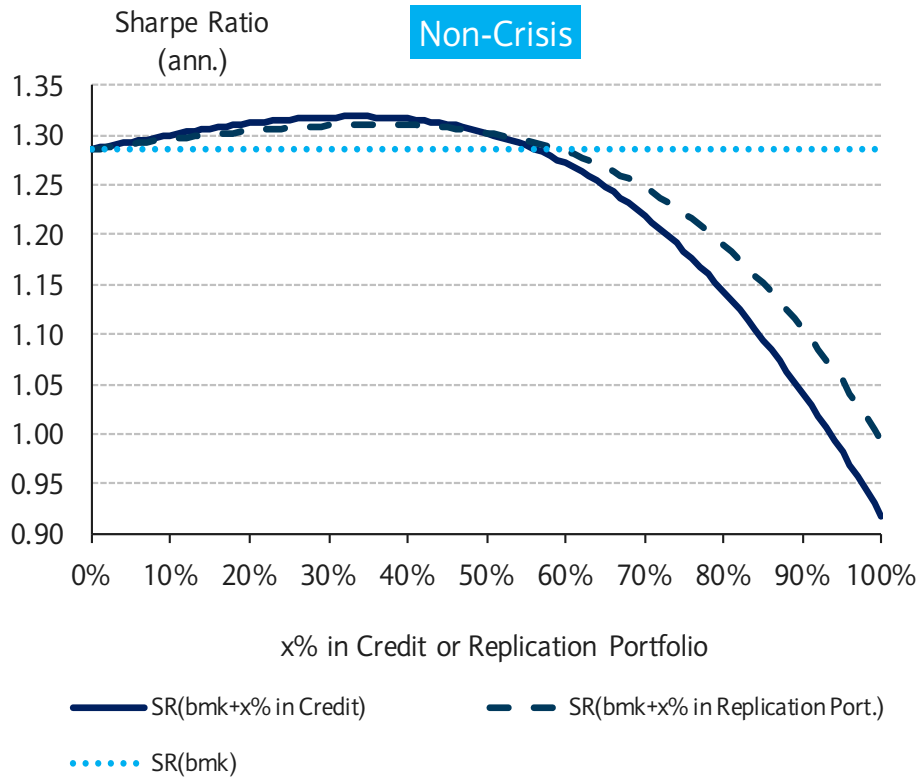
Including Credit Increased Sharpe Ratio during Crisis Periods

- Allocating to credit increased S.R. substantially in the two crises (tech bubble and financial crisis) during our sample period
- The benefit of credit was much smaller during the non-crisis periods

Sharpe Ratio with x% Credit Allocation for 60/40 E/T Benchmarks in Crisis and Non-Crisis Periods(Credit = VW IG/HY, Jan 1993 – Jan 2018)





Note: The crisis periods include the tech bubble (Jan. 2000 – Dec. 2002) and the financial crisis (Jan. 2008 to Dec. 2009). Expansions are the rest of the sample periods.
Source: Bloomberg, Compustat, Barclays Research

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Key Takeaways

I. Credit is not a redundant asset class. It cannot be fully replicated by a combination of equities and treasuries at the issuer level and is additive at the asset-class level

II. Having “flexible” mandates that allow combining credit and equities may be beneficial by adding another source of alpha for portfolio managers

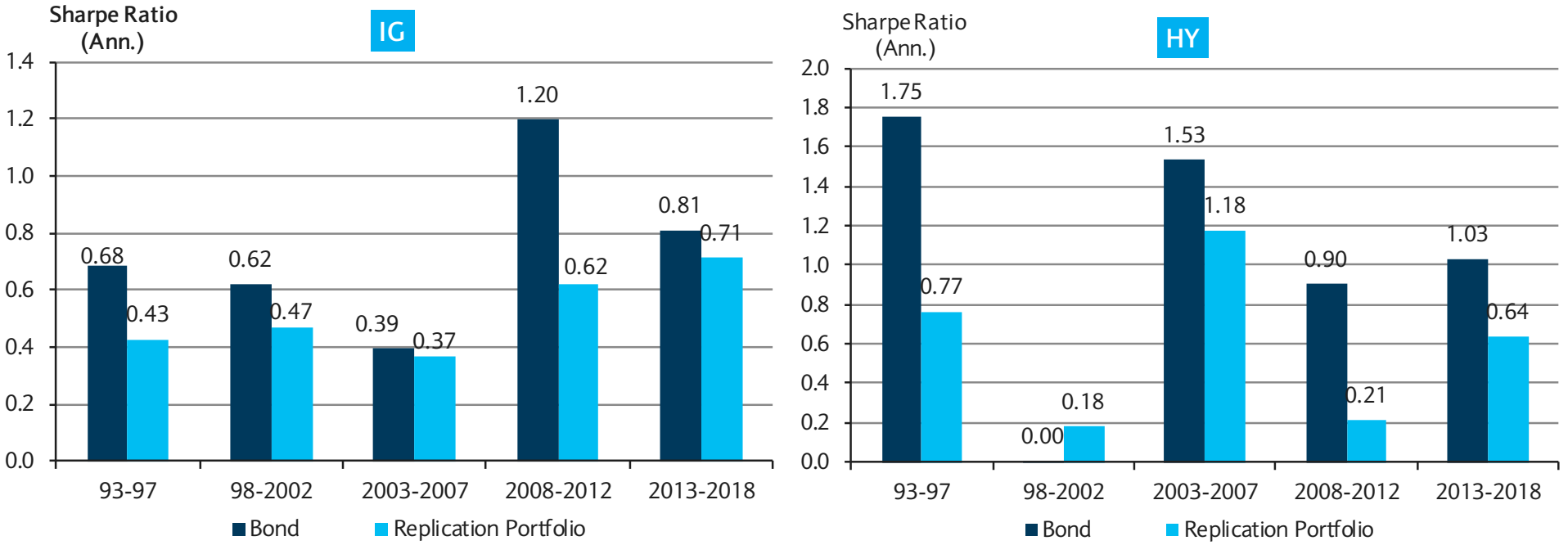
Appendix 1

Portfolio Analysis in Sub-Periods and Sub-Samples

Bond Outperformance Was Not Limited to a Single Period

- Bond portfolios had higher S.R. than sensitivity-matched portfolios in most sub-periods except 2003-2007 for IG and 1998-2002 for HY
- Sub-period performance comparison were similar in all weighting schemes

Sharpe Ratios of Bond vs. Sensitivity-matched Portfolios in Sub-Periods (EW)

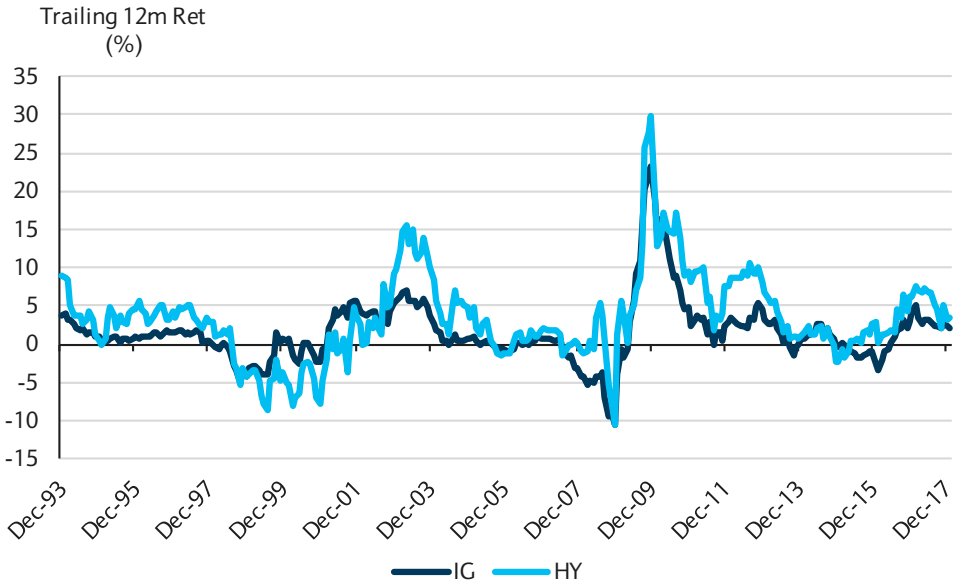


Source: Bloomberg, Compustat, Barclays Research

But in Some Periods, Stocks Did Outperform Bonds

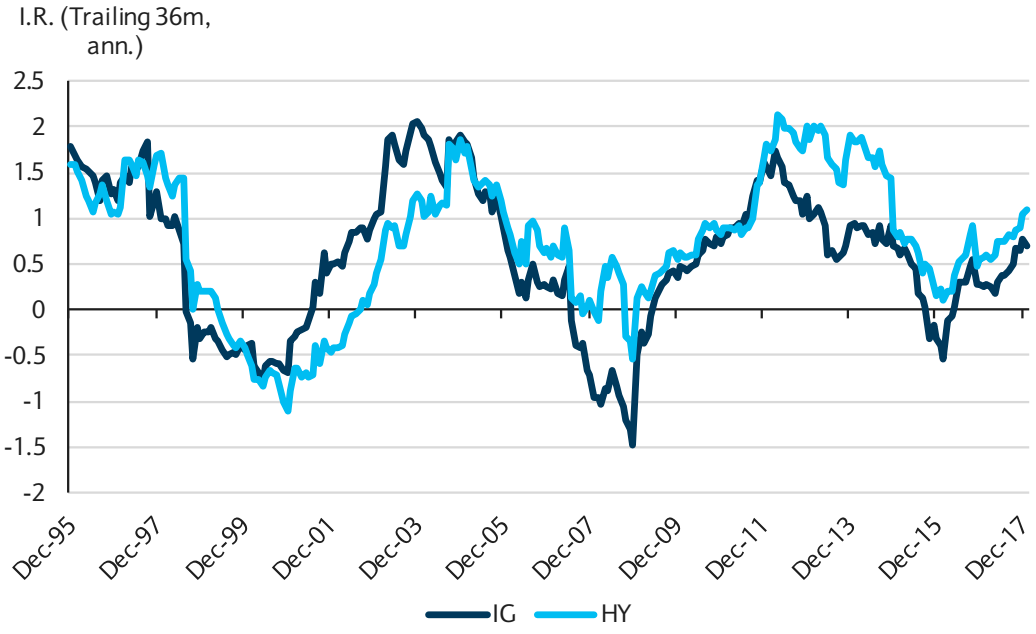
- Similar dynamics with all weighting schemes

Trailing 12m Return Diff of Bond over Replication Portfolio (EW)



Corr(IG,HY) = 0.83

Trailing 36m Inf. Ratio of Bond over Replication Portfolio (EW)



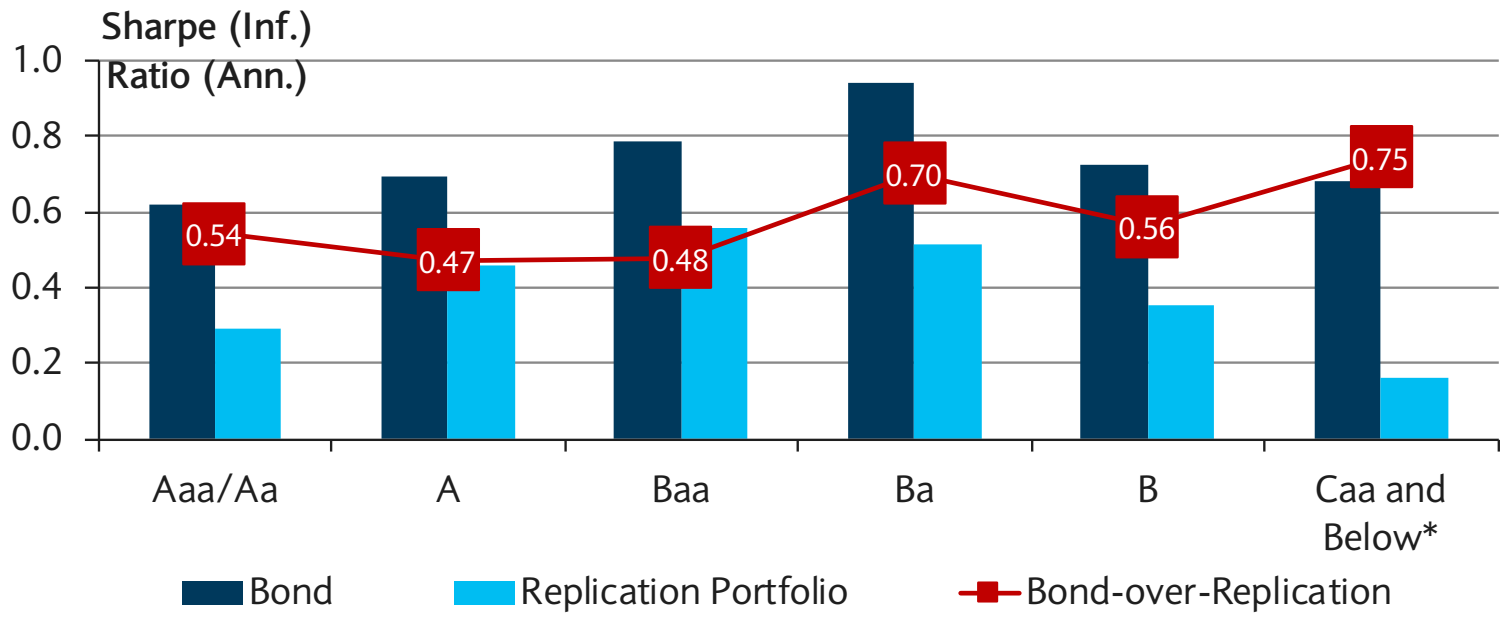
Corr(IG,HY) = 0.76

Source: Bloomberg, Compustat, Barclays Research

Bonds Had Higher S.R. Than Replication Port. across All Ratings

- In all rating categories
  - ✓ Bonds had higher S.R. than their sensitivity-matched equity and treasury counterparts
  - ✓ The bond over replication portfolio return diff. also had positive I.R ranging from 0.47 to 0.75
- Results hold regardless of weighting schemes

Sharpe (Inf.) Ratios (Ann.) of Bond vs. Replication Portfolios in Each Rating (Jan 1993 – Jan 2018, EW)

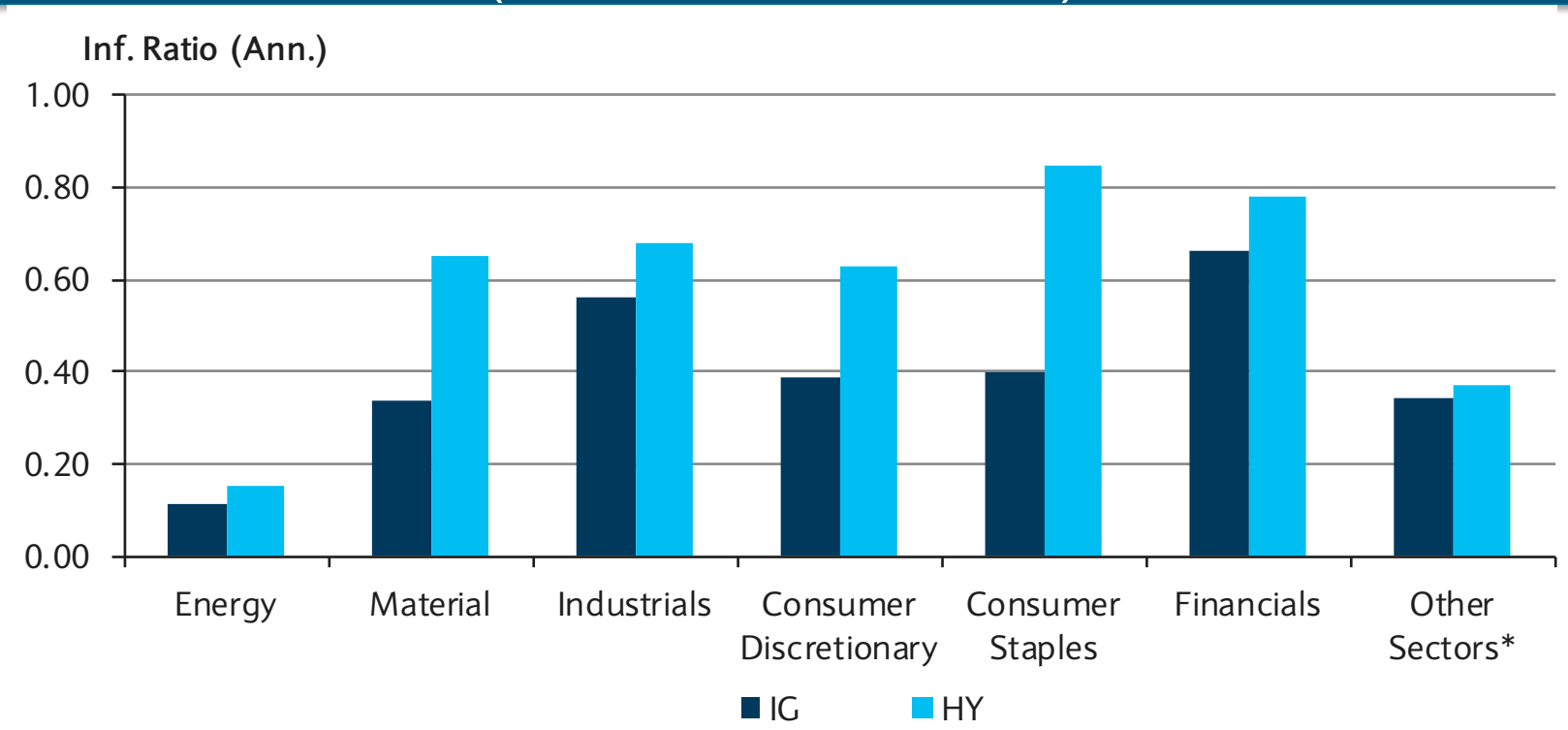


Note: The statistics shown for Caa and below are from Jan 2002 – Jan 2018 due to lack of observation in this rating bucket from 1993-2001.
Source: Bloomberg, Compustat, Barclays Research

Bonds Outperformed Sensitivity-Matched Portfolios in all Sectors

- In all GICS sectors, the bond portfolios outperformed corresponding sensitivity-matched equity/treasury portfolios in both IG and HY
- The results are similar regardless of weighting scheme

Inf. Ratio of Bond over Sensitivity-Matched Portfolios (EW, Jan 1993 – Jan 2018)

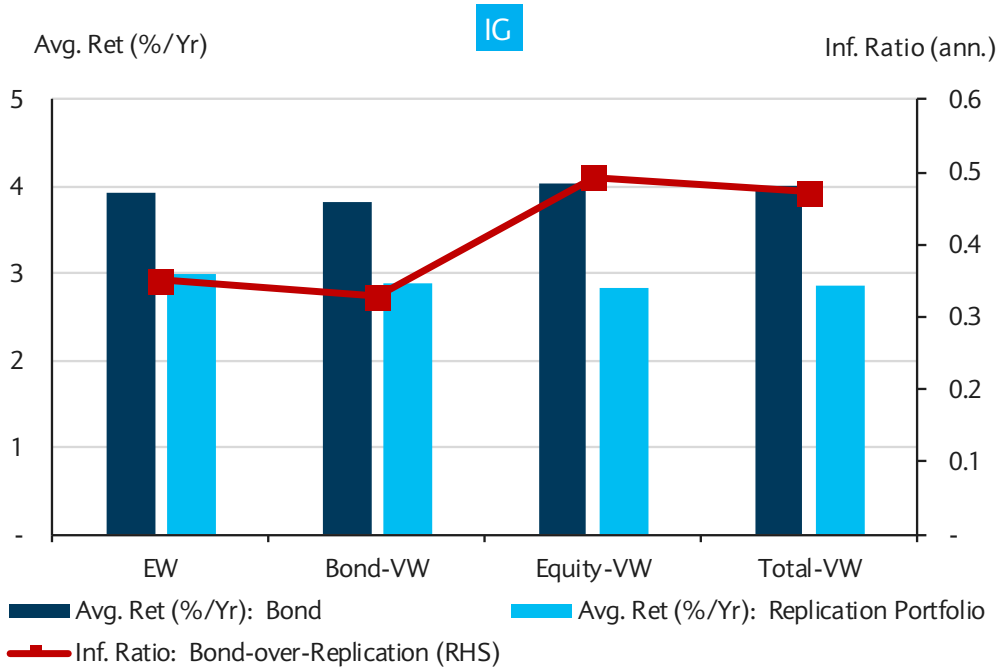


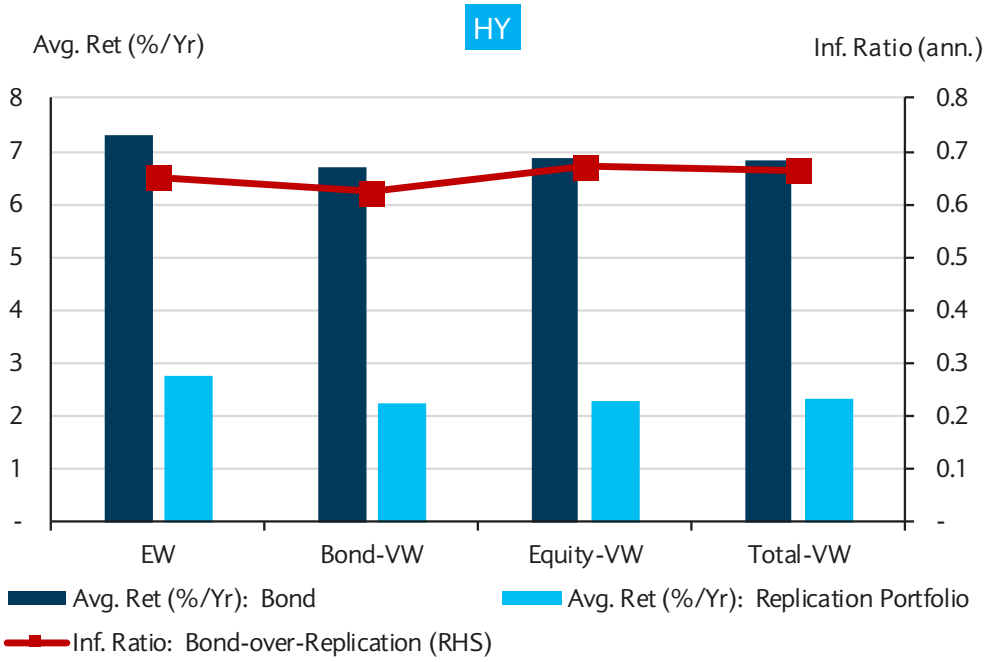
Note Other sectors include utilities, health care, information technology, and telecommunications. These sectors did not have enough observations on their own, so they were grouped together. Source: Bloomberg, Compustat, Barclays Research

Similar Bond Outperformance in European Markets

- Similarly, in European markets, bond portfolios had higher average returns and Sharpe ratios than the replication portfolios
- The Information ratios of bond over replication portfolios are about 0.4 for IG and 0.65 for HY
- The results are consistent across different weighting schemes

Bond vs. Sensitivity-Matched Equity/Treasury Portfolio Performance in European Markets (May 2005 – Jan 2018)





Source: Bloomberg, Compustat, Barclays Research

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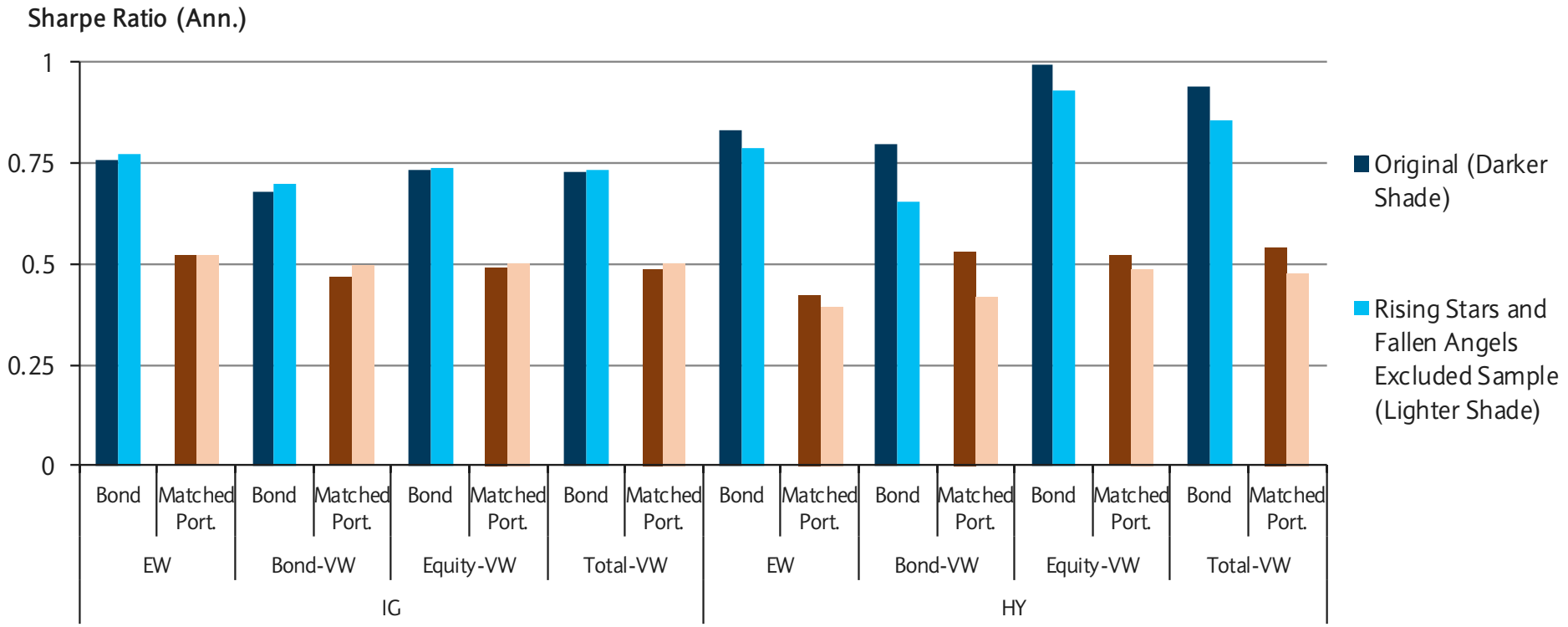
Were Higher Bond Returns Driven by Rising Stars or Fallen Angels?

- No. Excluding rRising stars (IG bonds that were in HY in any month during previous 24m) and fallen angels (HY bonds that were in IG in any month during previous 24m-period) had **no material effect** on the outperformance of bonds over sensitivity-matched portfolios

Sharpe Ratios of Original Sample vs. Sample excluding Fallen Angels and Rising Stars (Jan 1993 – Jan 2018)



Source: Bloomberg, Compustat, Barclays Research

Appendix 2

Risk Matching Using the Merton Model

Derivation of Equity Hedge Ratio Using Merton Model

- A corporate bond (D) is short a put on the underlying asset (A) plus a risk-free asset, while the equity (E) is equivalent to a call option on A. Thus,

$$Hedge\ Ratio_{equity} = \frac{\frac{\partial D}{D}}{\frac{\partial E}{E}} = \left(\frac{\frac{\partial D}{\partial V}}{\frac{\partial E}{\partial V}}\right)\frac{E}{D} = \left(\frac{1-\frac{\partial E}{\partial V}}{\frac{\partial E}{\partial V}}\right)\frac{E}{D} = \left(\frac{1}{\frac{\partial E}{\partial V}} - 1\right)\frac{E}{D}$$

where $\frac{\partial E}{\partial V} = N(d1), N(.) is\ the\ normal\ cdf\ function,$

and $d1 = \frac{ln\left(\frac{V}{book\_debt}\right)+(rf+\sigma^2/2)T}{\sigma\sqrt{T}}$

book_debt : long-term debt from Compustat

D: market value of debt, calibrated as $\frac{\text{MV\_index bonds}}{\text{AmtOutstanding\_index bonds}}$* *book_debt*

E: market value of equity

V = D+E

rf: 3m libor

σ^2: asset volatility = $\left(\frac{E}{V}\right)^2 \sigma^2_{E(option\ implied)} + \left(\frac{D}{V}\right)^2 \sigma^2_{D(DTS)} + 2\left(\frac{E}{V}\right)\left(\frac{D}{V}\right) Corr_{DE}\sigma_E\ \sigma_D$

Summary Statistics of Merton Bond-to-Equity Hedge Ratios

On average, the Merton-Model implied HRs were smaller than those calibrated through trailing regressions for both IG and HY

Equity Hedge Ratios Implied by the Merton Model (Jan 1993 – Jan 2018)

Rating	Mean	Median	Std.	Q1	Q3	5%-tile	95%-tile	Average Empirical HR (EW) from Sensitivity Matching
Aaa/Aa	1.9%	0.0%	4.6%	0.0%	1.1%	0.0%	11.5%	7.4%
A	3.1%	0.5%	5.2%	0.0%	3.9%	0.0%	14.7%	8.0%
Baa	5.3%	1.8%	7.4%	0.1%	7.8%	0.0%	21.1%	9.9%
Ba	9.6%	6.9%	9.4%	1.8%	15.1%	0.0%	27.1%	16.5%
B	16.4%	15.3%	12.6%	7.2%	22.8%	1.0%	35.8%	20.7%
Caa and below	27.7%	24.7%	17.4%	17.4%	33.4%	7.2%	58.4%	27.4%
IG	4.2%	1.0%	6.6%	0.0%	5.8%	0.0%	18.6%	9.0%
HY	15.0%	13.1%	13.3%	4.8%	21.9%	0.3%	36.2%	19.0%

Source: Bloomberg, Compustat, OptionMetrics, Barclays Research

Appendix 3

Testing Whether Liquidity Is the Driver of Bond Outperformance

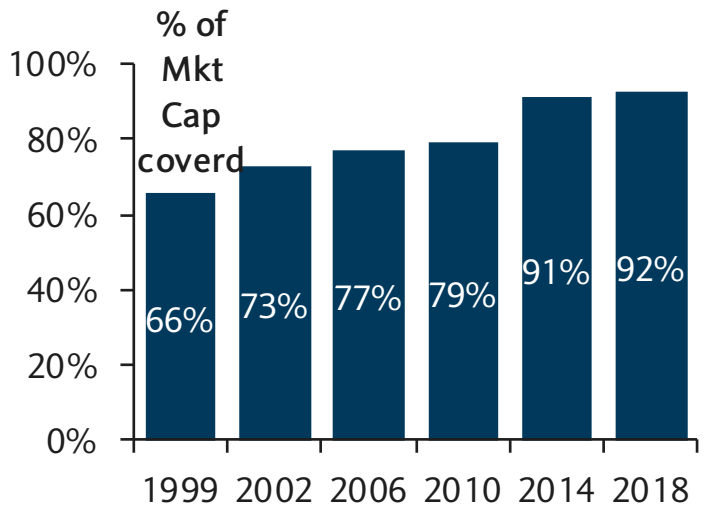
Bond Outperformed Replication Port. in S&P 500 Sub-Sample

- We focus on a sub-sample with liquid bonds and equities: S&P 500 companies with publicly traded bonds included in the Bloomberg Barclays Corporate and HY index
- Bonds outperformed matched portfolios in a pattern similar to that in IG
  - ✓ Sensitivity-matched portfolios had high correlation with bond portfolios
  - ✓ EW *Bond* portfolio outperformed sensitivity-matched portfolio by 1.89%/year with an I.R. of 0.54
  - ✓ Results were similar across weighting schemes

S&P 500 Sample: Performance of Bond over Sensitivity-matched Equity/Treasury Portfolios
(EW, Dec 1997 – Jan 2018 due to availability on S&P500 constituent data)

Weighting Scheme	Avg. Ret (%/Yr)	Vol. (%/Yr)	Inf. Ratio (Ann.)	Worst Monthly Ret (%)	Max. DD (%)	Corr(Bond, Replication Portfolio)
EW	1.89	3.48	0.54	-2.92	-10.83	0.72
Bond-VW	1.90	3.94	0.48	-5.68	-8.63	0.69
Equity-VW	1.79	3.14	0.57	-3.68	-7.93	0.79
Total-VW	1.82	3.27	0.56	-4.00	-7.78	0.77

% Mkt Cap of S&P 500 Stocks Having Mapped Index Bonds



Source: Bloomberg, Compustat, Barclays Research

Note: the coverage data are of January for each year listed.

Another Approach: Quantifying Bonds' Liquidity Using *LCS*

Liquidity as Cost of Trading:

- Liquidity Cost Score (LCS) measures the cost of an *immediate, institutional-size, round-trip* transaction, expressed as a percent of the bond's price:
  - OASD × (Bid spread – Ask spread) *if quoted on spread*
  - (Ask price – Bid price) / Bid price *if quoted on price*

- Launched in October 2009 for USD IG and HY corporate bonds, with history available from January 2007. Currently, LCS is computed for ~20,000 bonds
- Based on bond-level information, and published by Barclays QPS Research (see Konstantinovsky, Ng, and Phelps, 2015; Konstantinovsky, 2018; for more details)

LCS Ranking Had Little Effect on Bond Outperformance

- Each month, we divided all issuers into low and high LCS categories and tracked their performance in a similar way
- In low and high LCS buckets, bond-over-sensitivity-matched portfolios had similar I.R. in both IG and HY and across weighting schemes
- Similar bond outperformance across LCS rankings indicates that liquidity is not a reason for bonds' outperformance over equities

Performance of Bonds over Sensitivity-matched Portfolios **by LCS Ranking**
(EW, Jan 2010* – Jan 2018)

		LCS Ranking	Avg. Ret (%/yr)	Vol. (%/Y)	Inf. Ratio (Ann.)	Worst Monthly Ret (%/m)	MaxDD (%)
IG	IG	Low LCS (High Liquidity)	1.48	1.81	**0.82**	-1.45	-2.21
		High LCS (Low Liquidity)	2.43	3.07	**0.79**	-1.87	-6.93
HY	HY	Low LCS (High Liquidity)	3.83	2.99	**1.28**	-1.88	-3.40
		High LCS (Low Liquidity)	5.55	5.22	**1.06**	-4.41	-6.32

Note: Analysis starts in 2010 due to availability of LCS data, which starts in Jan. 2007. Need the first 3 years to calibrate weights in the replication portfolios.
Source: Bloomberg, Compustat, Barclays Research

Bond Outperformance Remained Strong after Transaction Costs

- Transaction costs account for only a small part of bonds' returns, due to their long holding periods

	Annualized Bond Transaction Cost (%)	Average LCS (%)	Average Bond Holding Period (Yr)
IG	0.16	1.07	5.5
HY	0.64	1.65	3.3

- As a result, incorporating transaction costs in bonds made only a very small difference on the bond outperformance over equities
  - ✓ The I.R. of **net** bond over sensitivity-matched portfolios remained strong at 0.48 for IG and 0.74 for HY
  - ✓ Results were similar across weighting schemes and (for HY) risk-matching methods

Gross and Net Performance of Bonds over Sensitivity-matched Portfolios
(EW, Jan 2007* – Jan 2018, transaction costs approximated by LCS, incorporated at sales)

	IG						HY					
	Bond			Bond-over-Replication Portfolio			Bond			Bond-over-Replication Portfolio		
	Avg. Ret (%/Yr)	Vol. (%/Yr)	Sharpe Ratio (Ann.)	Avg. Ret (%/Yr)	Vol. (%/Yr)	Inf. Ratio (Ann.)	Avg. Ret (%/Yr)	Vol. (%/Yr)	Sharpe Ratio (Ann.)	Avg. Ret (%/Yr)	Vol. (%/Yr)	Inf. Ratio (Ann.)
Gross	5.86	5.24	**0.94**	2.06	3.98	**0.52**	7.88	8.49	**0.82**	4.75	6.10	**0.78**
Net of Transaction Costs	5.70	5.26	**0.91**	1.89	3.97	**0.48**	7.24	8.62	**0.74**	4.11	6.13	**0.67**

Note: Analysis starts in 2007 due to availability of LCS data. Source: Bloomberg, Compustat, Barclays Research

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We, Arik Ben Dor and Jingling Guan, hereby certify (1) that the views expressed in this research report accurately reflect our personal views about any or all of the subject securities or issuers referred to in this research report and (2) no part of our compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this research report.

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