



Alternative

Thinking

Exploring Rates Sensitivity
Online Appendix

This document accompanies *Exploring Rates Sensitivity*. It presents additional results for multi-asset styles and a hypothetical real return strategy, and analysis of sensitivity to financing spreads. It also contains some methodological details for interested readers.

Second Quarter 2017

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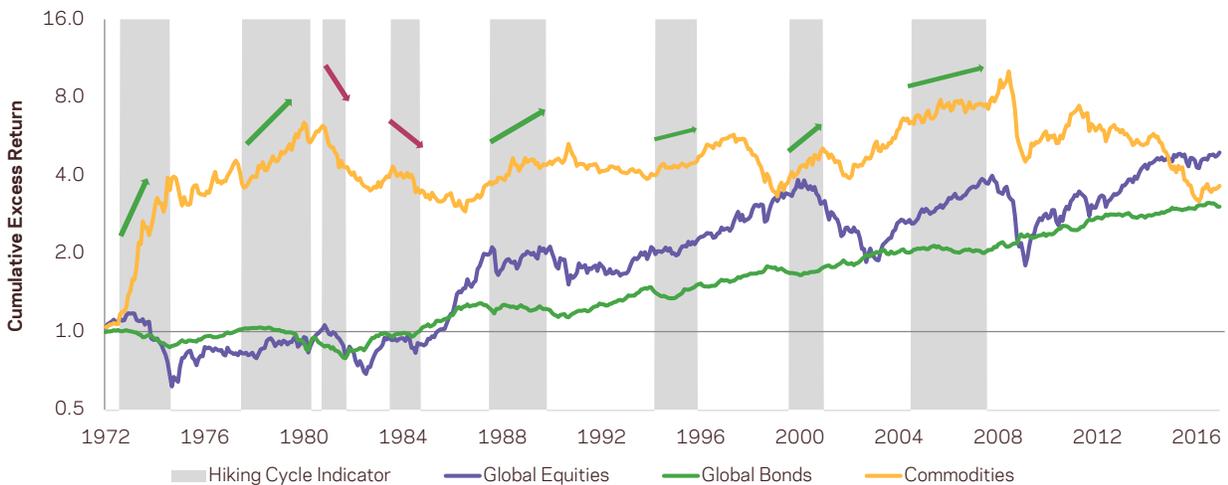
Additional Results

Short-term Interest Rates

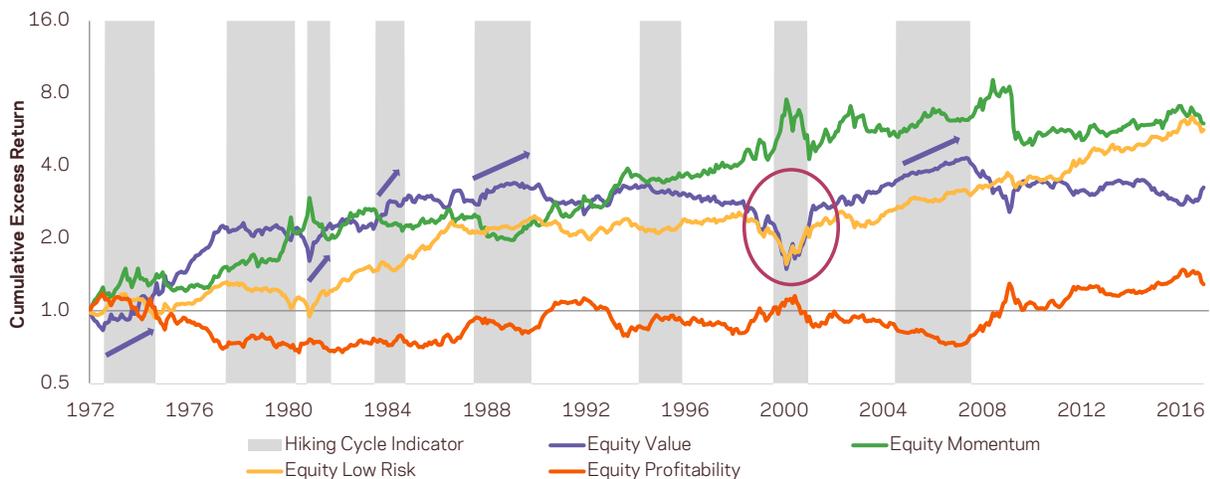
Exhibit 3 in the main article showed, for various investments, the difference between average Sharpe ratios during hiking and non-hiking periods from 1972 to 2016. **Exhibit A1** shows cumulative excess returns for selected investments, highlighting the 8 hiking periods. Commodities performed especially strongly during the early 70s Bretton-Woods collapse and associated currency devaluation, but also did well in 6 of the 8 hiking periods (see arrows). Among equity styles, value performed well in 5 of the 8 periods (purple arrows). Low risk (non-industry-neutral) underperformed during hiking periods on average, but this tended to be due to lackluster rather than sharply negative returns. The Tech Bubble and bust (highlighted) caused a sharp reversal of equity style fortunes during the 1999-2000 hiking cycle.

Exhibit A1 | Cumulative Excess Returns for Selected Investments, 1972-2016

a. Major Asset Classes



b. Long/Short Equity Styles (non-industry-neutral)



Sources: Federal Reserve, Bloomberg, Global Financial Data and AQR. Hypothetical returns excess of 3-month T-Bills, gross of t-costs and fees. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see Appendix for an explanation of the universe and methodology used to create the asset classes and hypothetical strategies.



Exhibit A2 shows average Sharpe ratios during hiking and non-hiking periods for hypothetical multi-asset styles and a hypothetical real return strategy. Unlike the asset classes we examined in the main article, all the multi-asset styles earned positive excess returns in both regimes. The real return strategy earned most of its excess returns on average during hiking periods. It includes allocations to commodities, inflation breakevens and trend-following, and is net short duration (see Appendix for full strategy details).

Exhibit A2 | Hypothetical Sharpe Ratios During Hiking and Non-Hiking Periods, 1972-2016

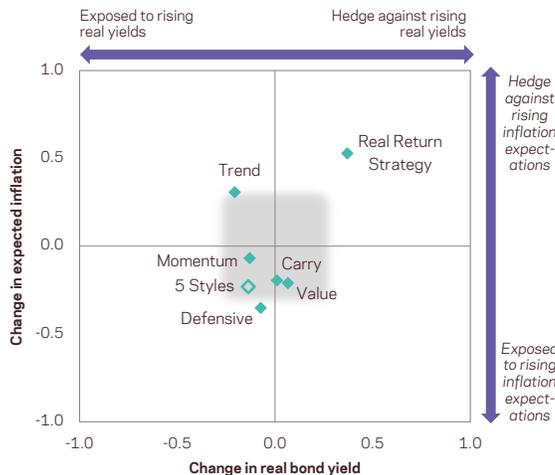


Sources: Federal Reserve, Bloomberg, Global Financial Data and AQR. Hypothetical Sharpe ratios based on arithmetic returns excess of 3-month T-Bills, gross of transaction costs and fees. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see Appendix for an explanation of the universe and methodology used to create the hypothetical strategies.

Long-term Interest Rates

Exhibit 4 in the main article mapped investments according to their partial correlations to changes in ex ante real yields and changes in expected inflation (based on monthly overlapping year-on-year periods). In **Exhibit A3** below we show the same results for the hypothetical multi-asset styles and real return strategy. Multi-asset styles have exhibited near-zero long-term correlations to both components, while the real return strategy has shown strong positive sensitivities to both components.

Exhibit A3 | Decomposing Correlations to Changes in Nominal Bond Yields 1972-2016

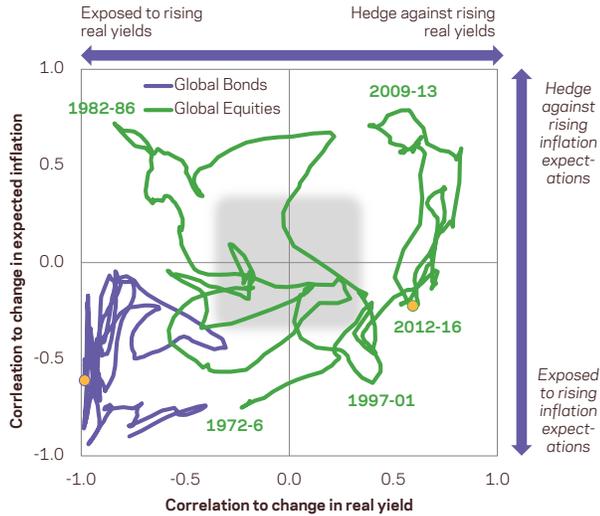


Source: AQR. Please see Appendix for details of backtest methodology. Based on monthly year-on-year yield changes and returns excess of cash, gross of transaction costs and fees. Shaded area is indicative of correlations not statistically significant at the 95% confidence level, adjusting for overlapping observations. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see Appendix for an explanation of the universe and methodology used to create the hypothetical strategies

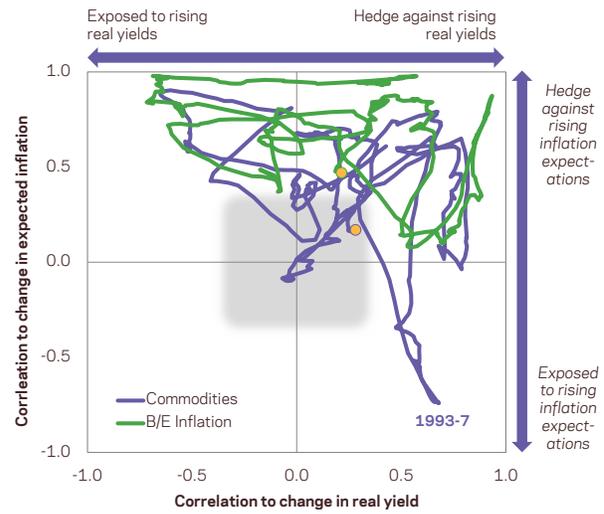


Exhibit A4 | Tracing Correlations to Changes in Nominal Bond Yields Through Time 1972-2016

a. Global Equities and Bonds



b. Inflation Protection Assets



Sources: Bloomberg, Global Financial Data and AQR. Rolling 5-year partial correlations based on monthly year-on-year yield changes and returns excess of cash, gross of transaction costs and fees. Shaded area is indicative of correlations not statistically significant at the 95% confidence level, adjusting for overlapping observations. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see Appendix of main article for an explanation of the universe and methodology used to create the asset classes and hypothetical strategies.

Exhibit A4 plots the evolution of the same correlations through time for four of the investments, based on a rolling 5-year window. For bonds (tightly bunched purple line in chart A4a) the relations are very persistent, not surprisingly. Equities, by contrast, have wandered to all four quadrants of the chart, exhibiting sensitivities in both directions to both risk factors at different times. Equities tended to reside on the left-hand side of the chart in the 1970s and 80s, drifting across to the right-hand side in the 90s - this reflects the switch from a positive to a negative stock-bond correlation. The most recent observation for each asset class is highlighted yellow.

Among inflation protection assets (chart A4b), the long/short inflation breakeven trade shows the most reliable positive exposure (staying in the top half of the chart), but commodities also show persistent positive exposure (the brief foray into the bottom right quadrant was during the mid 1990s).

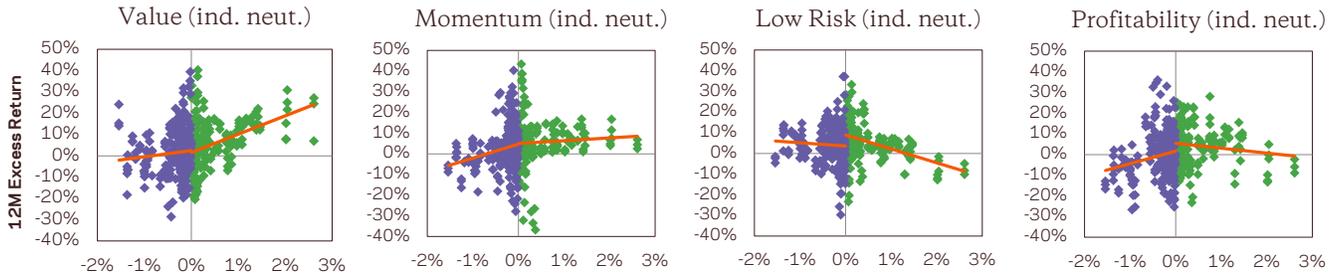
Exhibit 6 in the main article showed separately sensitivities to rising and falling inflation expectations for selected asset classes. **Exhibit A5** shows the same analysis for dynamic strategies. Among equity styles, value and low risk have offsetting upside sensitivities. The multi-asset, multi-style strategy shows no upside inflation sensitivity, while the real return strategy shows strong sensitivity to both rising and falling expectations.

Market-Based Decomposition of Nominal Yields

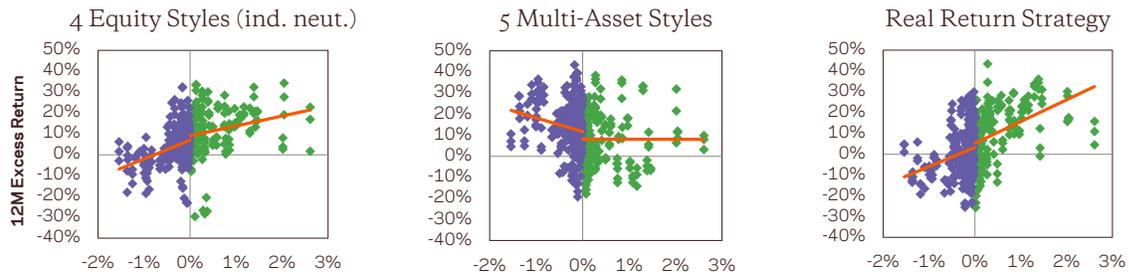
All yield and inflation analysis in the main article and in this appendix so far has used survey-based inflation expectations to decompose the nominal bond yield to two parts. In the main article we mentioned an alternative decomposition, into TIPS (U.S. inflation-linked government bonds) yield and breakeven inflation. For this decomposition we have a shorter history, starting in 1997 when TIPS were first issued, and we should recognize that changes in TIPS yields sometimes (e.g., in 2008) reflect technical, liquidity-driven elements rather than changes in inflation expectations. **Exhibit A6** shows, for selected investments,

Exhibit A5 | Upside and Downside Sensitivity to Change in Expected Inflation

a. Long/Short Equity Styles



b. Multi-Style Portfolios and Real Return Strategy



Source: AQR. Based on monthly year-on-year expected inflation changes and returns excess of cash, gross of transaction costs and fees. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see Appendix for an explanation of the universe and methodology used to create the hypothetical strategies.

Exhibit A6 | Decomposing Nominal Yield Correlations: Different Periods and Different Decompositions

Asset Classes	1. Survey-based 1972-2016		2. Survey-based 1997-2016		3. Market-based 1997-2016	
	Ex Ante Real Yield	Exp. Inflation	Ex Ante Real Yield	Exp. Inflation	TIPS Yield	B/E Inflation
Global Equities	-0.01	-0.20	0.56	0.29	0.34	0.57
Global Bonds	-0.85	-0.75	-0.92	-0.36	-0.91	-0.87
Commodities	0.09	0.50	0.30	0.41	-0.24	0.64
US Real Estate	-0.03	-0.31	0.21	0.39	-0.10	0.39
Long/Short Equity Styles						
Value	0.04	0.05	-0.02	0.16	-0.18	0.13
Value (ind. neut.)	0.07	0.32	0.10	0.18	-0.05	0.20
Momentum	-0.15	0.11	0.05	-0.04	0.17	-0.09
Momentum (ind. neut.)	-0.03	0.19	-0.03	-0.17	0.18	-0.22
Low Risk	-0.40	-0.43	-0.41	0.16	-0.35	-0.31
Low Risk (ind. neut.)	-0.17	-0.14	-0.50	-0.13	-0.32	-0.50
Trend	-0.21	0.31	-0.31	-0.37	0.03	-0.48

Sources: Bloomberg, Global Financial Data and AQR. Partial correlations based on monthly year-on-year yield changes and returns excess of cash, gross of transaction costs and fees. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see the Appendix for an explanation of the universe and methodology used for creating the asset classes and hypothetical strategies.



partial correlations as reported in Exhibit 4 in the main article (panel 1), and then two variants. First we use the same survey-based decomposition over the shorter period 1997-2016 (panel 2), then we use the TIPS decomposition over this period (panel 3).

Simply shortening the period changes the results markedly. This is a period during which inflation has been low and the stock/bond correlation has been negative, so it is not surprising that equities exhibit positive correlations to yield changes. Real estate shows a similar shift. Equities' strong positive correlation to B/E inflation is partly due to the sharp, liquidity-related fall in B/E inflation during 2008, when equity returns were also sharply negative. The positive inflation sensitivity of commodities is robust across both periods and both decompositions.

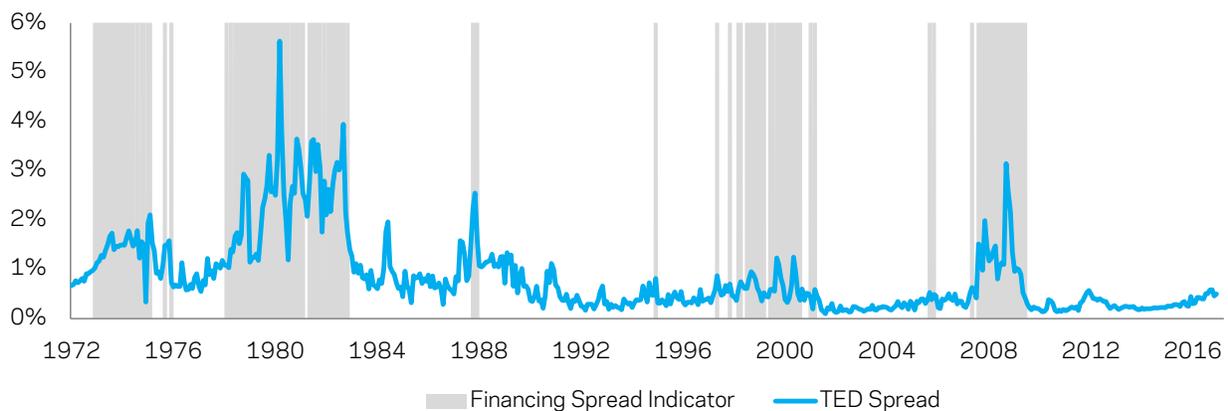
For equity styles, most sensitivities remain small. The bond-like negative sensitivities of the low risk style are fairly persistent, and during the more recent period this includes the industry-neutral version. Trend-following has exhibited bond-like sensitivities during this period, probably because it has tended to hold long bond positions.

Financing Spreads

Changes in short-term interest rates directly impact the total returns of long/short strategies as well as long-only investments. The impact on excess-of-cash returns of long/short strategies is limited by the offsetting nature of the long and short positions. Levered long-short strategies are, however, directly impacted by changes in the financing spread between the rate earned on the proceeds of short sales, and the rate payable to finance long positions.

Our proxy for the financing spread is the difference between 3-Month LIBOR and 3-Month T-Bill rates, known as the TED spread. This spread has tended to remain narrow for long periods and then suffer periods of significant widening at times of market distress and elevated counterparty and credit risk. We therefore create a regime-based factor that identifies periods of widening financing spreads, as shown in **Exhibit A7**. Some of the financing stress periods coincide with Fed hiking periods, while others do not (e.g. central bank rates and bond yields were falling during the Financial Crisis, but financing spreads were very wide).

Exhibit A7 | Regime Indicator to Identify Elevated and Rising Financing Spreads, 1972-2016



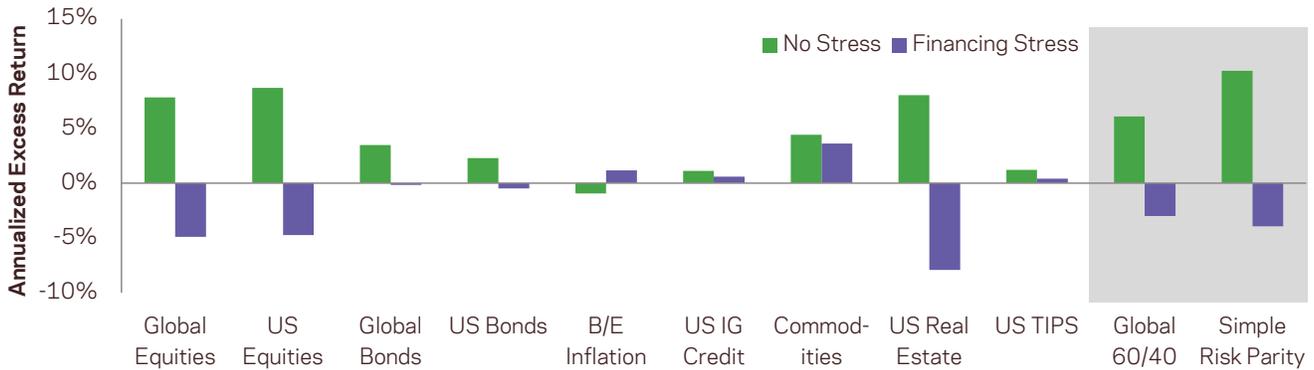
Source: Bloomberg and AQR. The Financing Spread Indicator is defined as the average of TED spread level and 12-month change (each expressed as a z-score with expanding sample window). A financing stress period is triggered when this indicator is in the top quartile, based on the full sample.



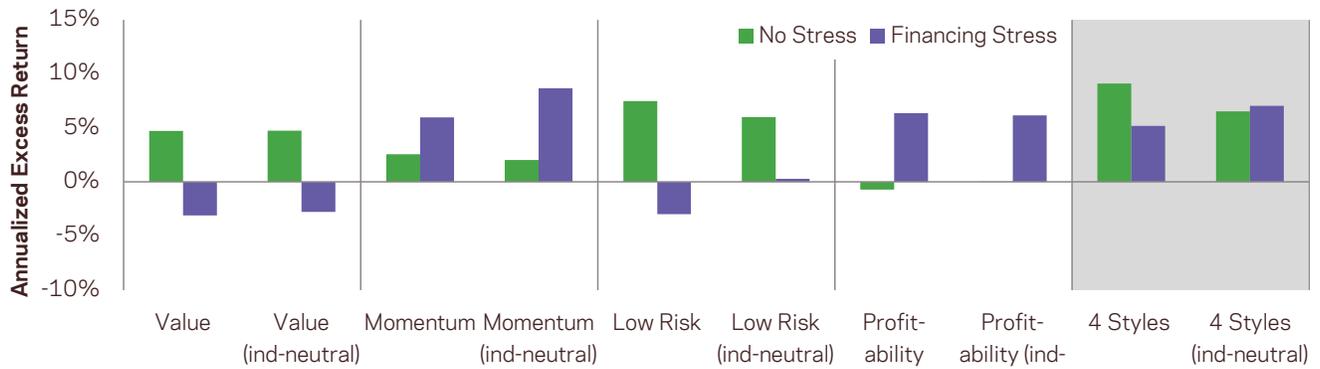
Exhibit A8 shows excess returns averaged over financing stress and non-stress periods. Periods of high and/or rising financing spreads tend to coincide with episodes of market distress, and so it is not surprising that all the investments we study experienced higher volatility during such periods (not shown), and most traditional asset classes underperformed cash (top chart). Out of the asset classes, commodities, credit and TIPS proved the most resilient.

Exhibit A8 | Hypothetical Impact of Financing Spreads on Various Performance Metrics, 1972-2016

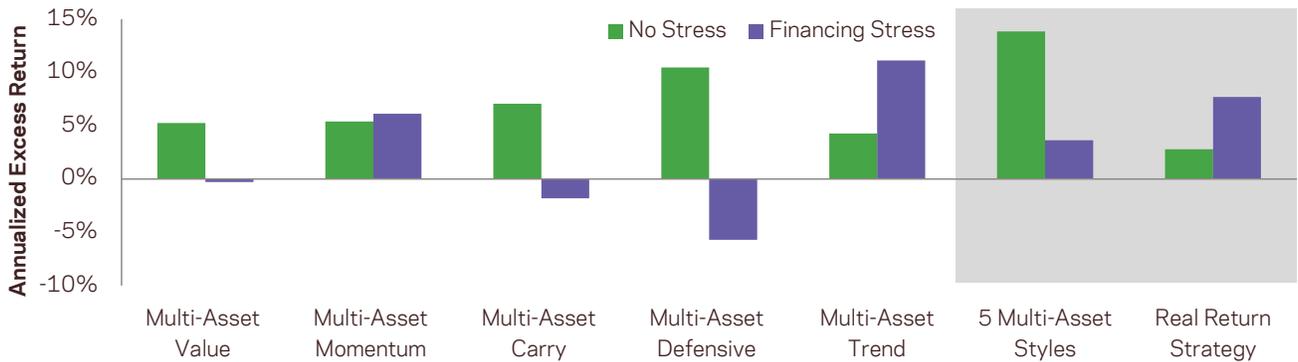
a. Asset Classes



b. Long/Short Equity Styles



c. Multi-Asset Styles and Real Return Strategy



Sources: Bloomberg, Global Financial Data, Asvanunt and Richardson (2015) and AQR. Hypothetical arithmetic returns excess of cash, gross of transaction costs and fees. 'B/E/ Inflation' is long TIPS, short Treasuries. 'US IG Credit Excess' is the return of IG corporate bonds in excess of duration-matched Treasuries. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see Appendix of main article for an explanation of the universe and methodology used to create the asset classes and hypothetical strategies.

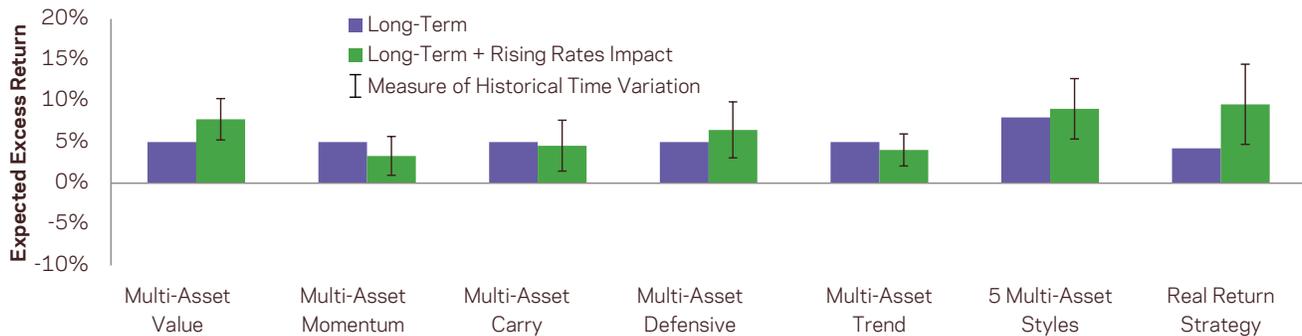


Among long/short equity styles, momentum and profitability outperformed during stress periods (the dollar-neutral profitability factor tends to have negative equity beta), while value and low risk underperformed. The multi-style, industry-neutral portfolio benefited from this diversification and was relatively insensitive to financing stress. A portfolio of five multi-asset styles underperformed during financing stress periods (value, carry and defensive styles sharing the responsibility) but excess returns remained positive. Trend-following and the real return strategy actually performed better in such periods.

Economic Significance

Exhibit 7 in the main article showed the estimated impact on expected returns of a defined ‘rising rates event’ amounting to a 1.8% increase in nominal 10-year Treasury yields over a 12-month period. **Exhibit A9** shows the same results for multi-asset styles and the real return strategy. Based on historical sensitivities, the expected returns of multi-asset styles would be only mildly affected by such an event. The real return strategy would be expected to deliver above-average returns with relatively high conviction (this is not surprising as it includes inflation breakeven trades and is net short duration).

Exhibit A9 | Estimated Impact of Rising Rates Event on One-Year Expected Returns



Source: AQR. Impact is based on beta estimate using average of correlations over the full sample and the past 10 years, with full-sample volatility. ‘Measure of Historical Time Variation’ is based on the interquartile range of the rolling 10-year beta throughout the sample. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Please see the Appendix for an explanation of the universe and methodology used for creating the hypothetical strategies.

Methodological Details

Construction of Hiking Cycle Indicator

Our hiking cycle indicator (Exhibit 2 in the main article) is designed to identify Fed hiking cycles systematically without the benefit of hindsight,¹ and without many false or short-lived triggers. It combines two inputs for robustness, signaling a hiking cycle when there is a large increase in the 3-month T-Bill rate, or a smaller increase combined with an increase in the Fed Funds Rate.

Specifically, a new hiking cycle is triggered when the following conditions are met: *3-month T-Bill rate exceeds prior 12-month average by 0.40% AND Fed Funds Rate is higher than prior 12-month average, OR 3-month T-Bill rate exceeds prior 12-month average by 0.80%*. The hiking cycle then continues until the following opposite conditions are met to trigger its end: *3-month T-Bill rate is less than prior 12-month average by 0.40% AND Fed Funds Rate is lower than prior 12-month average OR 3-month T-Bill rate is less than prior 12-month average by 0.80%*.

¹ Though our parameter choices were guided by a desire to capture sustained hiking cycles over the full sample, while ignoring short-term fluctuations.



We repeated our analysis using different definitions of hiking cycles. Asset class results were very similar, while the sensitivities of long/short styles were more variable. For the latter, where macro exposures of the long and short sides are offsetting, empirical sensitivities are more likely to be sample-specific or specific to the parameters of the analysis.

Investment Returns Data Sources

Investment	Proxy	Source
Global Equities	MSCI World Index USD	Bloomberg
US Equities	S&P500 Index	Bloomberg
Global Bonds	GDP-weighted portfolio of G6 10-year government bonds (hedged to USD)	GFD
US Bonds	10-year U.S. Treasury	GFD
B/E Inflation	Long 10-year U.S. TIPS, short 10-year U.S. Treasury	Bloomberg, GFD
US IG Credit Excess	Barclays U.S. IG Credit Excess Return Index (Barclays U.S. IG Corporate Bond Index minus duration-matched Treasuries)	Barclays
Commodities	From 1991, Bloomberg Commodity Index. Before 1991, equal weighted portfolio of available commodity futures	Bloomberg, GFD
US Real Estate	Average of FTSE EPRA/NAREIT US Index and NCREIF Index	Bloomberg
US TIPS	From 1997, U.S. 10-year TIPS. Before 1997, synthetic returns based on nominal Treasury yields and survey-based expected inflation.	Bloomberg, inflation as above
Global 60/40	60% Global Equities, 40% Global Bonds as defined above	Bloomberg, GFD
Simple Risk Parity	Hypothetical strategy that allocates equal volatility to 3 asset classes: developed equities (GDP-weighted), government bonds (GDP-weighted) and commodities (equal-weighted). Allocations are based on rolling 12-month volatility.	AQR
Single Equity Styles	Hypothetical long-short factors use the methodology of Fama and French (1993) but include only a large-cap U.S. stock universe. Each factor is cap-weighted long the 1/3 best stocks and short the 1/3 worst stocks, and rebalanced annually every January. Value is based on book-to-price as described in Asness and Frazzini (2013). Momentum is based on 12-month price momentum excluding the most recent month. Low risk is a beta-neutral factor that is cap-weighted long the 1/3 lowest-beta and short the 1/3 highest-beta stocks, with the long side levered to make the portfolio ex-ante beta-neutral as described in Frazzini and Pedersen (2014). Profitability is based on gross profits-to-assets.	AQR
4 Equity Styles	1/3 Value, 1/3 Momentum, 1/6 Low Risk and 1/6 Profitability, as described above	AQR
Multi-Asset Styles	Hypothetical long/short strategies as described below and in Ilmanen, Maloney and Ross (2014). Hypothetical returns are discounted by 50% for the period January 1972 to August 2012, and by 25% for the period September 2012 to December 2016.	AQR
5 Multi-Asset Styles	Equal-dollar-weighted composite of the five multi-asset styles	AQR
Real Return Strategy	Hypothetical multi-strategy real return portfolio designed to perform strongly during periods of high or rising inflation. It allocates 2/3 risk to strategic exposure to inflation-sensitive assets, and 1/3 risk to active strategies. The strategic risk allocation is as follows: 36% commodities, 9% commodity-related equities (beta-hedged), 9% real estate-related equities (beta-hedged), 9% inflation-sensitive currencies, 15% inflation breakevens, 20% short U.S. Treasuries, 3% options on U.S. Treasuries. The active risk allocation includes managed futures and relative value strategies in fixed income, commodities and currencies. Hypothetical returns are net of estimated transaction costs and gross of fees. The hypothetical returns of the active strategies are discounted by 50%. Investment universe is given below.	AQR



Further details on multi-asset styles

The four market-neutral multi-asset style premia (Value, Momentum, Carry and Defensive) are hypothetical long/short strategies applied in stock selection, industry allocation, country allocation in equity, fixed income and currency markets, and commodities. Each style allocates 50/50 risk weights to stock and industry selection (SS) and asset allocation (AA) strategies. For AA we use the following risk weights: 33% equity country allocation, 25% fixed income, 25% currencies, 17% commodities. We combine several data sources to produce a sufficiently long dataset:

- Since 1990, we use style premia strategies as described in “Investing With Style” (AQR white paper, 2012, available upon request). For SS value, momentum and carry we use 50/50 risk weights between stock selection within industries and across industries. For SS carry we use the dividend yield strategy returns in Ken French’s data library.
- For 1972-1989, we source value and momentum style returns from “Value and Momentum Everywhere” (Journal of Finance, 2013), defensive style returns from “Betting Against Beta” (Journal of Financial Economics, 2013), and SS carry from the dividend yield strategy returns in Ken French’s data library. We construct the AA carry style premia before 1990 as well as some early histories of AA value, momentum and defensive styles using AQR in-house backtests. These backtests are similar to those described above, but over a narrower universe.

While the SS style premia proxies we use since 1990 are beta-neutral, the value and momentum premia before 1990, and the SS carry premium throughout, are ‘only’ dollar-neutral and may contain moderate empirical beta exposures. The defensive style premia are beta-neutral throughout.

The multi-asset trend strategy applies 12-month trend-following strategies in four asset classes: equities, fixed income, currencies and commodities. From 1985, we use “Time Series Momentum” (Journal of Financial Economics, 2012). For 1972-1984, we use in-house backtests based on the same asset classes, but including 1-, 3- and 12-month momentum, and starting with a smaller asset universe that grows during the period as more assets become available.

Further details on real return strategy

The investment universe for each asset class is based on a customized basket of securities designed with the objective of achieving inflation sensitivity. Commodity exposure is represented by a customized basket of Aluminum, Brent Oil, Copper, Crude Oil, Gas Oil, Gold, Heating Oil, Lead, Lean Hog, Live Cattle, Natural Gas, Nickel, Platinum, Silver, Soy Oil, Sugar, Unleaded Gas securities. Hedged Equities exposure is represented by a customized basket of Metal and Mining, Oil, Gas and Consumable Fuels, Energy, Equipment and Services, and REIT securities. Fixed Income exposure is represented by a customized basket of United States Short Bonds, United States Long Bond Futures Put Options, and Inflation Breakevens in France, United Kingdom, and United States. Currency exposure is represented by a customized basket of Australian Dollar, Canadian Dollar, Swiss Franc, Euro, United Kingdom Pound, Japanese Yen, Norwegian Krone, New Zealand Dollar, Swedish Krona, United States Dollar, Brazilian Real, Israeli Shekel, South Korean Won, Mexican Peso, New Taiwan Dollar, Singapore Dollar, Turkish Lira, South African Rand securities:



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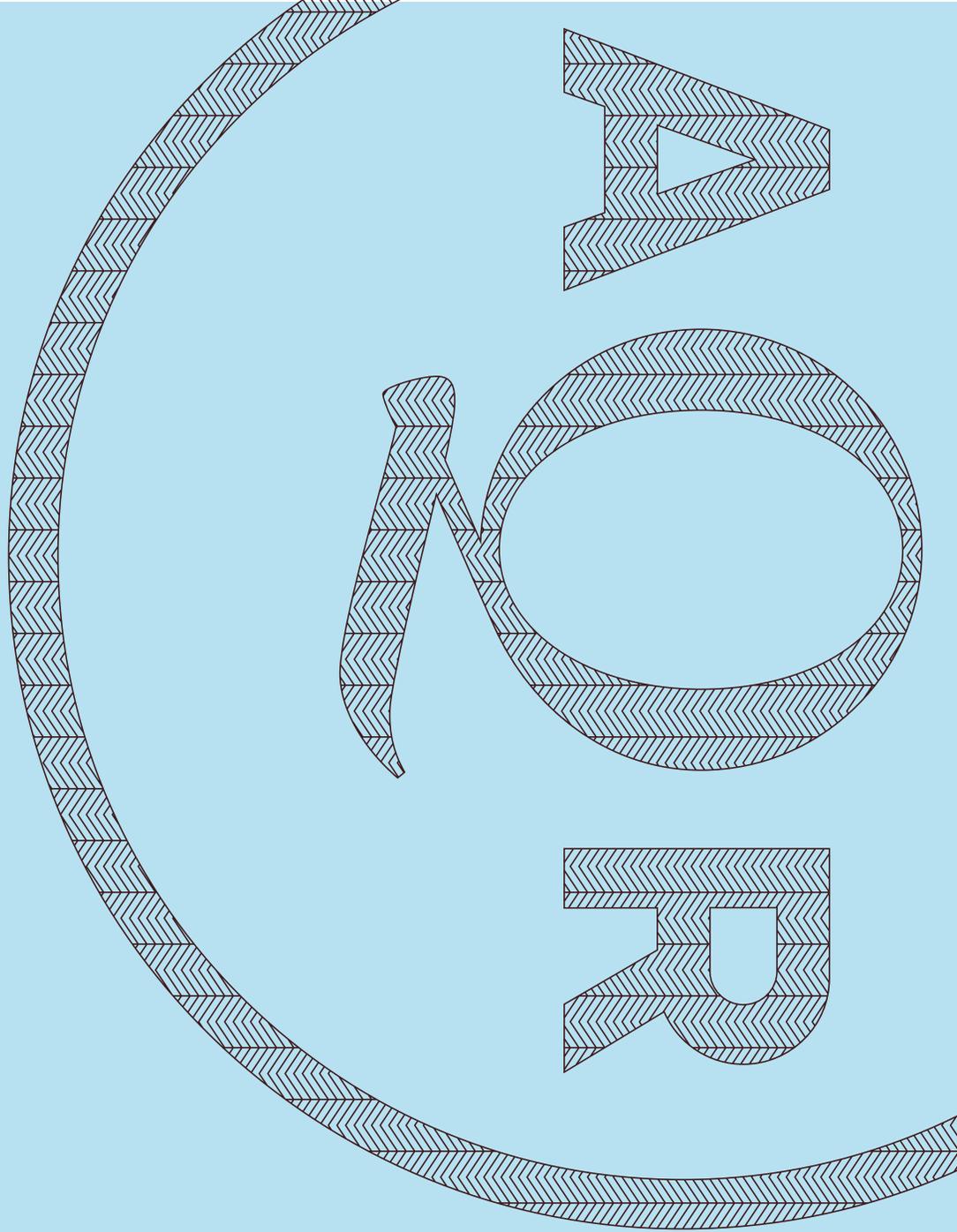
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There is a risk of substantial loss associated with trading commodities, futures, options, derivatives and other financial instruments. Before trading, investors should carefully consider their financial position and risk tolerance to determine if the proposed trading style is appropriate. Investors should realize that when trading futures, commodities, options, derivatives and other financial instruments one could lose the full balance of their account. It is also possible to lose more than the initial deposit when trading derivatives or using leverage. All funds committed to such a trading strategy should be purely risk capital.





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