Alternative Thinking

Exploring Rates Sensitivity

Many investors are currently interested in risks related to monetary policy, rising yields and inflation. In this article we interpret 'rates' broadly – encompassing short term interest rates, real bond yields and expected inflation – and explore the historical sensitivities of a range of asset classes and strategies.

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Executive Summary

In this article we explore the historical rates sensitivities of a range of asset classes and hypothetical strategies,[1] over the past 45 years. We separately consider the impact of monetary policy cycles, changes in real bond yields and changes in expected inflation. We also try to gauge the economic significance of these relationships by estimating the impact of a hypothetical 'rising rates event' where 10-year Treasury yields rise by 1.8% over 12 months.

During this extreme event, we estimate negative expected excess-of-cash returns for nominal bonds, TIPS and non-industry-neutral defensive equity factors, while above-average returns might be expected for commodities, based on past experience. Other investments' expected returns would be subject to smaller and/or less confident adjustments. Both traditional 60/40 and risk parity portfolios are estimated to retain positive expected returns during the scenario that we describe. This is a useful reminder that rising rates may not be the most damaging of the many tail risks investors face.[2] Moreover, rising yields might appear outright benign from an asset-liability perspective as they would reduce the value of liabilities.

Our publishing of this analysis should not be interpreted as an active forecast of sharp rises in policy rates, bond yields or inflation in the near future. Nor do we advocate aggressive tactical allocation changes, even for investors who do expect such outcomes. Rather, we hope to provide investors with one more tool to help ensure their portfolios are sufficiently diversified to meet their objectives across a range of macroeconomic environments.

Other notable findings:

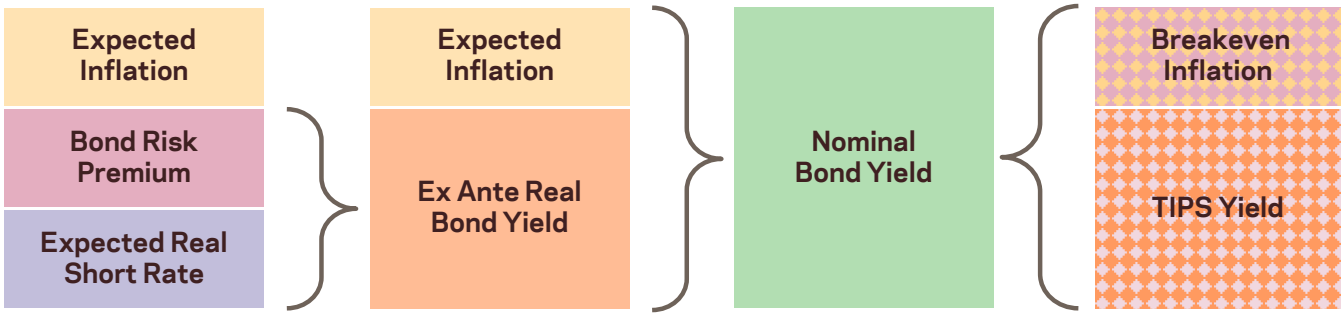
- The rates sensitivities of equities vary through time, and depend on other interacting factors. Equities have, on average, underperformed during hiking cycles and shown some negative long-term average sensitivity to changes in expected inflation. But in recent decades, when rising yields have often been associated with higher growth expectations, equities have tended to outperform.
- All the asset classes we study have performed worse during Fed hiking periods than non-hiking periods, with the clear exception being commodities.
- Risk parity has outperformed a traditional 60/40 portfolio in both hiking and non-hiking periods (the greater rates sensitivity of its bond allocation is offset by its commodities allocation).
- 60/40 and risk parity portfolios have similar inflation sensitivity (risk parity's additional bond and commodity exposures are again offsetting), but risk parity is the more sensitive to real yield changes.
- Among long/short equity styles, value has performed better during hiking periods, while other styles have slightly underperformed. When industry exposure is removed, the sensitivity of defensive styles (low risk and profitability) is much milder.
- The low risk style has exhibited sensitivity to both real yields and inflation, but, over our sample period, these sensitivities are again milder when industry exposure is removed. Other styles show little long-term sensitivity.

Introduction

Even before last year's U.S. presidential election, many investors expected rate hikes and rising bond yields in the medium term and were considering the potential impact on their portfolios. For some, the election result has moved rising rates higher up on their list of macroeconomic concerns, though the economic implications of the new administration remain uncertain at the time of writing.

1 See Appendix for description of asset class proxies and hypothetical strategies. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix.
2 More damaging tail events could include deep or prolonged recessions and/or financial crises, as many portfolios are dominated by equity risk.

Exhibit 1 | *Underlying Drivers of Default-Free Government Bond Yields*



Source: AQR. For illustrative purposes only.

Economic growth remains the preeminent macroeconomic risk factor for many portfolios, and ***inflation*** has historically been the second most important, though it has been low and fairly stable across developed markets for several decades. ***Real yields*** may be the third key macroeconomic risk factor (though related to the first two). This could refer to real short rates (closely related to monetary policy) or to real bond yields, which also include the bond risk premium. The bond risk premium comprises both inflation uncertainty and CAPM-related components, and nominal bond yields are the sum of real bond yields and expected inflation.

Phew! So sensitivities to short term interest rates, bond yields and expected inflation are all intimately connected. In this article we disentangle these underlying risk factors, and explore the historical sensitivity of various asset classes and long/short factors or styles. We are of course not the first to examine such patterns.[3] We hope our approach is distinctive in balancing the length and breadth of the dataset to give the most insightful results (we include the important inflationary 1970s, but limit our study period to that for which we have a broad, relevant and reliable dataset of assets and dynamic strategies to test). This article presents a summary of our results, while further analysis is included in an online appendix.

Theory and Its Limitations

In theory, all assets are priced according to the present value of their expected future cash flows. At the time of writing, U.S. Treasury yields (and the government bond yields of other major developed markets) remain within 1% of the all-time lows they hit in mid-2016. Since the default-free yield is the common element of all assets' discount rates, and since low discount rates produce high valuations, it's not surprising that, across the full menu of traditional investments, valuations appear unattractive compared to history.

Exhibit 1 illustrates, on the left, three fundamental components of default-free bond yields. Since 2000, the main driver of falling yields has been falling expected real short rates.[4] Going forward, uncertainty surrounds all three components. The fate of real short rates will be partly determined by the pace of central bank rate hikes, while renewed inflation uncertainty and/or a higher stock-bond correlation could lead to a change in the bond risk premium.

Duration measures the sensitivity of investments to changes in nominal bond yields. What is the duration of equities, real estate or long/short styles? If future cash flows were certain (or if the

3 Dimson, Marsh and Staunton (2016) are one recent example, and include a useful literature survey. Ilmanen, Maloney and Ross (2014) explored a range of macroeconomic sensitivities.

4 See, for example, AQR Alternative Thinking 2014 Q2. Our simple decomposition can be written as: $Y_M = (E[R_f]_M - E[I]_M) + (Y_M - E[R_f]_M) + E[I]_M$ where $E[R_f]_M$ and $E[I]_M$ are expected risk-free and inflation rates averaged over the maturity of the M-year bond. We use survey-based estimates.

impact of changing cash flow expectations could be considered separately), equities would have a very long duration. However, when these interacting factors are considered in aggregate, variations in cash flow and growth expectations (the numerator in the discounted value) often overwhelm changes in the discount rate (the denominator), and the relation between equity prices and bond yields is complex.

In this article we focus on empirical, rather than theoretical sensitivities. Empirical data has the advantage of reflecting all the real world's moving parts, but empirical relationships should only be projected into the future with caution. They may be specific to the period of study, or spurious statistical alignments without economic substance. However, they are also one useful input to the investment decision process.

Risk Factors

Short term interest rates: Monetary policy strongly influences expected real short rates (the purple building-block in Exhibit 1), though it cannot control them directly.[5] We measure sensitivity to short rates using an explicit monetary policy factor – specifically, a factor that systematically identifies Fed hiking cycles. Monetary policy tends to be applied in discrete regimes of tightening and loosening, so a regime-based factor may be best-suited to measuring the sensitivity of investments to changes in short term interest rates. Our 'hiking cycle' regime indicator is shown in **Exhibit 2a**. Eight hiking cycles account for approximately one third of our 45-year sample.[6]

Long term interest rates: During 2016, both nominal and real Treasury yields revisited the all-time lows they made in 2012, before rebounding slightly. **Exhibit 2b** shows the nominal 10-year Treasury yield decomposed into two components. Most of the yield volatility has been driven by changes in the *ex ante real bond yield* (comprising both the real short rate and bond risk premium).

The *expected inflation* component (based on survey data with a 10-year horizon) is slower moving - it reached a peak of about 8% in 1980, declined steadily to 2.5% by 2000, and has remained stable near that level ever since. In our analysis, we separately consider investments' sensitivities to changes in these two components of Treasury yields.[7,8]

Investments

We explore the sensitivities of 8 traditional and alternative asset classes, 4 long/short U.S. equity styles and a multi-asset trend-following strategy. We also include 3 simple portfolios to examine the possible benefits of diversification (60/40 stocks/bonds, simple risk parity and a combination of long/short equity styles). For each of our equity styles, we consider versions with and without industry exposure.[9]

Our dataset spans the 45-year period from 1972 to 2016. Details of our investment proxies are provided at the end of this article. In the online appendix, we also show results for multi-asset long/short styles, and for a hypothetical diversified inflation-protection ('real return') strategy.

5 Central banks control nominal short rates. Since the Financial Crisis, they have effectively targeted negative real short rates as well as attempting to directly influence the bond risk premium through asset purchases (QE).

6 Our indicator registered the most recent hiking cycle only in March 2017, beyond the end of our sample, even though the first hike occurred in December 2015. The indicator requires a meaningful rise in short rates, to avoid registering many false triggers (full description in the online appendix). At the time of writing we are 'officially' in a hiking cycle for the first time in a decade.

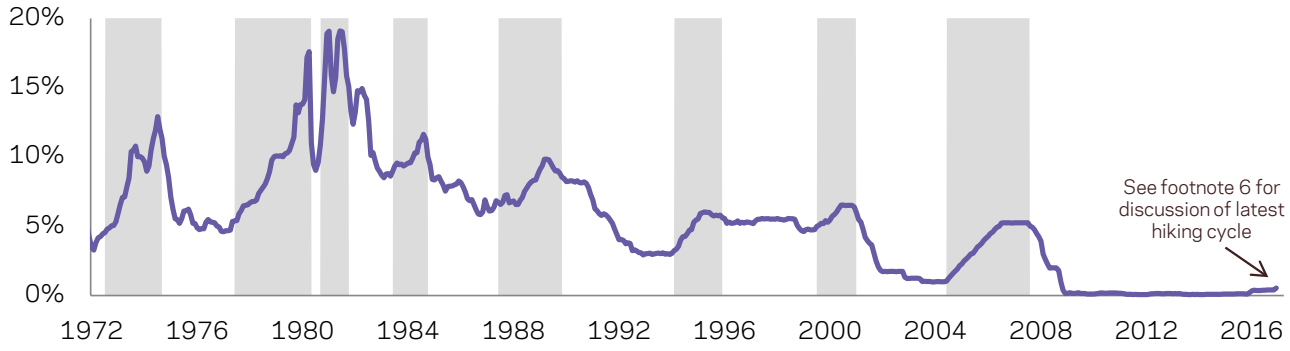
7 As noted in Exhibit 1, another way to decompose nominal yields is into TIPS yield and breakeven inflation rate (with each component including part of the bond risk premium) . We prefer survey-based inflation expectations because technical, liquidity-driven elements have sometimes (e.g., in 2008) dominated TIPS yield moves, and because we have only synthetic TIPS data before 1997.

8 In the online appendix we explore an additional risk factor: financing spreads. The impact of interest rate changes on excess-of-cash returns of long/short strategies is limited by the offsetting nature of the long and short sides. 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.

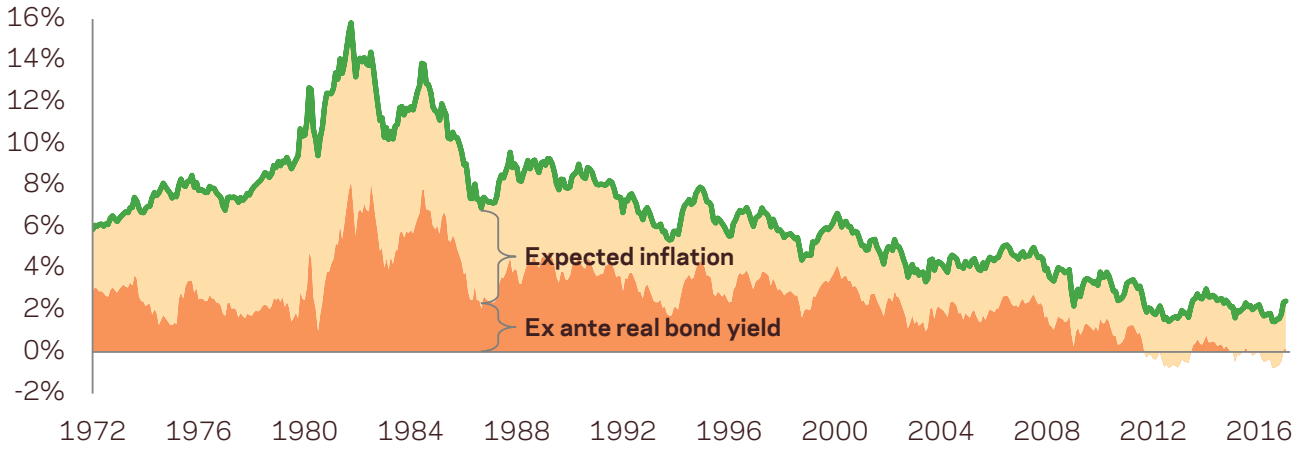
9 The equity styles and trend-following strategy all target 10% volatility. Returns are gross of transaction costs and fees as we focus on relative performance in different environments rather than absolute performance.

Exhibit 2 | *Short-Term and Long-Term U.S. Interest Rates, 1972-2016*

a. Fed Funds Rate and a Regime Indicator Based on Fed Hiking Cycles



b. 10-Year Treasury Nominal Yield and Its Components



Sources: Federal Reserve, Blue Chip Economic Indicators, Consensus Economics, Federal Reserve Bank of Philadelphia, Bloomberg, AQR. Hiking Cycle Indicator (chart a.) is triggered when current Fed Funds and T-Bill rates over- or undershoot their 12-month averages by a given margin (full methodology in online appendix). Ex ante real bond yield (chart b.) is defined as nominal yield minus survey-based expected long-term inflation.

Results

Short term interest rates

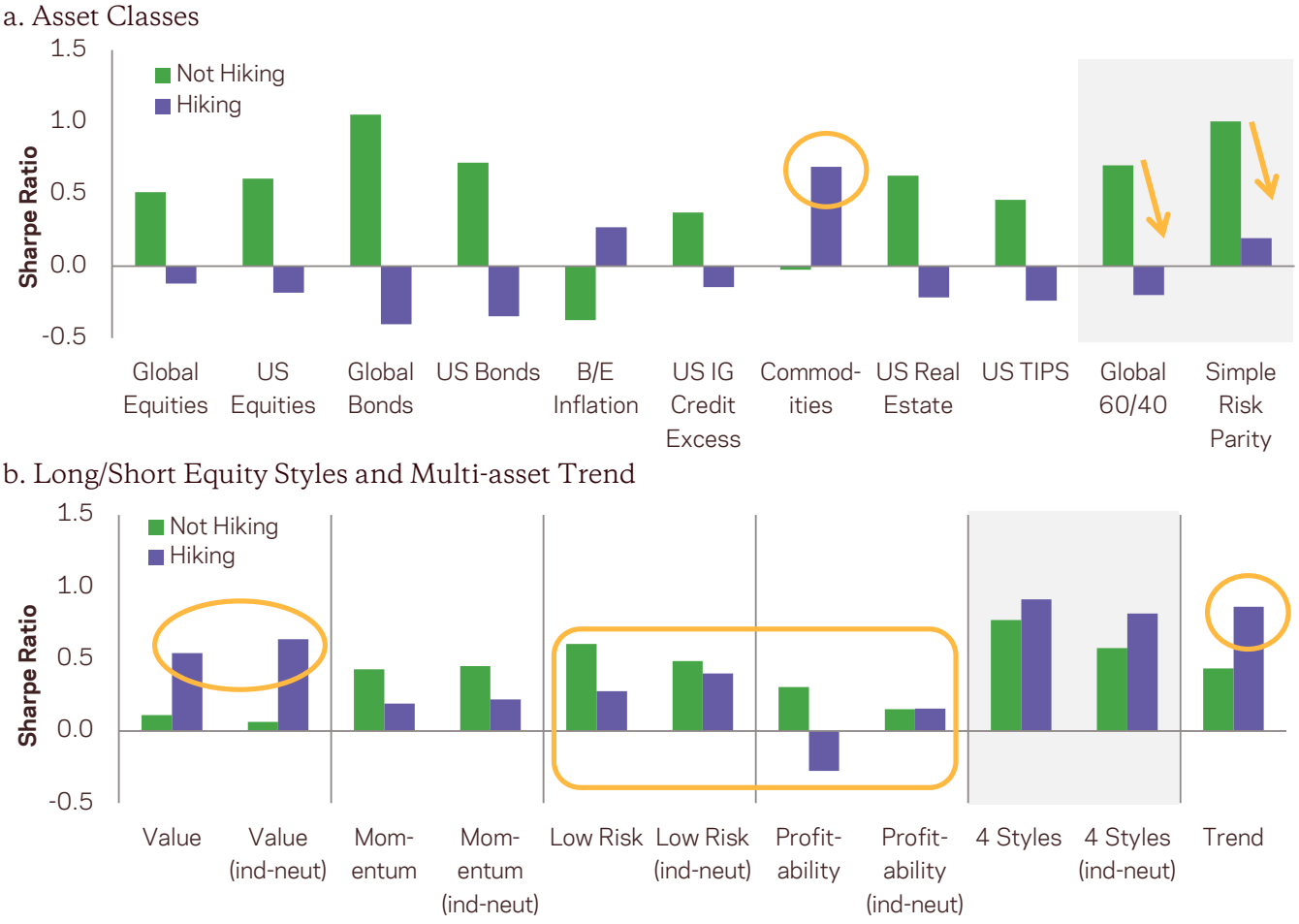
Exhibit 3a summarizes the risk-adjusted return sensitivity of 8 asset classes and 2 portfolios (plus a long/short inflation breakeven trade) to the monetary policy environment. For each investment it shows the average Sharpe ratios earned during non-hiking and hiking periods.

Most asset classes have tended to underperform during hiking periods, with bonds suffering the most. Not only have most asset classes underperformed their non-hiking averages, but they have actually underperformed cash on average. Commodities, by contrast, have on average earned all their excess returns during hiking periods. Interestingly, the hypothetical risk parity portfolio is no more sensitive to hiking cycles than the 60/40 portfolio (yellow arrows). The negative sensitivity of its larger fixed income exposure is offset by the positive sensitivity of its commodity allocation, highlighting the benefit of extending strategic diversification beyond stocks and bonds.[10]

We show the impact on Sharpe ratios, which are based on excess-of-cash returns. Total nominal

10 We repeated this analysis over a longer period from 1954, for the major asset classes and portfolios. Commodities retain their positive sensitivity to hiking cycles, while the negative sensitivity of equities is slightly milder. The sensitivities of 60/40 and risk parity portfolios are again comparable.

Exhibit 3 | *Hypothetical Sharpe Ratios During Non-Hiking and Hiking Periods, 1972-2016*



Sources: Federal Reserve, Bloomberg, Global Financial Data, Asvanunt and Richardson (2015) and AQR. Hypothetical Sharpe ratios based on arithmetic returns excess of 3-month T-Bills, 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 the Appendix for an explanation of the universe and methodology used for creating the asset classes and hypothetical strategies.

returns during hiking periods enjoy a cushioning effect of 4% higher cash returns on average, while real returns enjoy a cushion of only 1% (inflation tends to be 3% higher during hiking periods). These effects are the same for all asset classes.

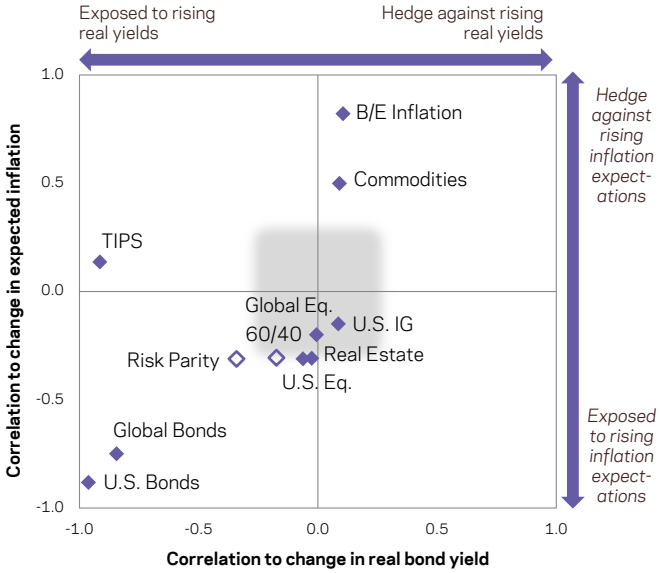
Exhibit 3b shows the equivalent results for dynamic strategies: long/short U.S. equity styles and multi-asset trend-following. Unlike the asset classes, most of these have earned positive excess returns in both regimes. Value has performed better during hiking periods, while the other three styles have not performed as well in such periods. However, note that by eliminating industry exposure, we greatly reduce the sensitivity of the two defensive styles (low risk and profitability). Interestingly, trend-following has tended to outperform during hiking periods.[11]

One possible (but tentative) intuition for value's stronger performance during hiking cycles is that growth stocks may have a longer effective duration (their expected cash flows are further out) and

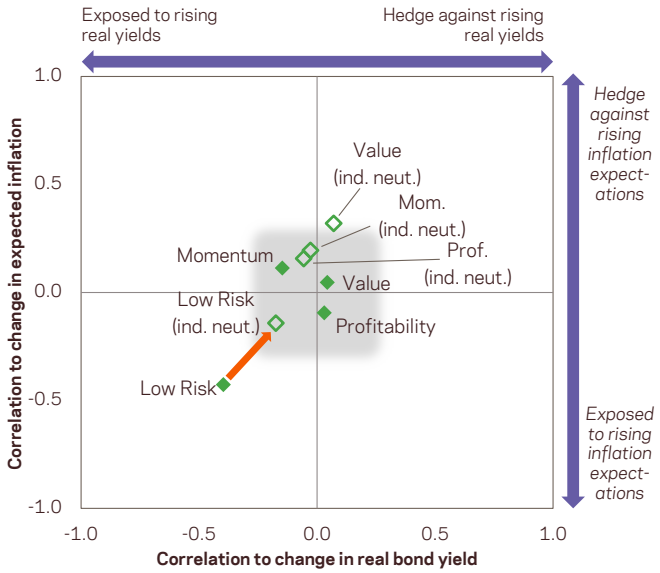
11 One explanation could be that Fed hiking tends to coincide with (or be in response to) sustained market trends, though trend's strongest performance was during the collapse of the Bretton Woods system in 1973, rather than a sustained and orderly hiking regime.

Exhibit 4 | *Decomposing Correlations to Changes in Nominal Bond Yields, 1972-2016*

a. Asset Classes



b. Long/Short Equity Styles and Trend



Sources: Bloomberg, Global Financial Data, Asvanunt and Richardson (2015) and AQR. 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 the Appendix for an explanation of the universe and methodology used for creating the asset classes and hypothetical strategies.

therefore experience a greater drag from rising rates.[12] We also note that value has performed poorly during the past decade, a prolonged non-hiking period.

The underperformance of industry-unconstrained defensive factors may be due to the more bond-like characteristics of defensive sectors such as utilities. This pattern (and the benefit of controlling industry exposure) is seen again in the next section.

In addition to the sensitivity of Sharpe ratios, we studied the sensitivity of returns, volatilities and correlations to hiking cycles. As equity risk dominates most investor portfolios, the equity correlation may be of particular interest. We found that while most equity correlations are relatively insensitive to monetary policy cycles, commodities, TIPS and trend-following may be particularly useful diversifiers of equity risk during hiking cycles.

Long-term interest rates

We turn now to long-term interest rates, i.e., bond yields, and start by examining long-term average relationships between year-on-year changes in 10-year Treasury yields and year-on-year investment returns. **Exhibit 4** decomposes these correlations into the two components we highlighted in Exhibit 2b.[13] The shaded area indicates correlations not statistically significant at the 95% confidence level.

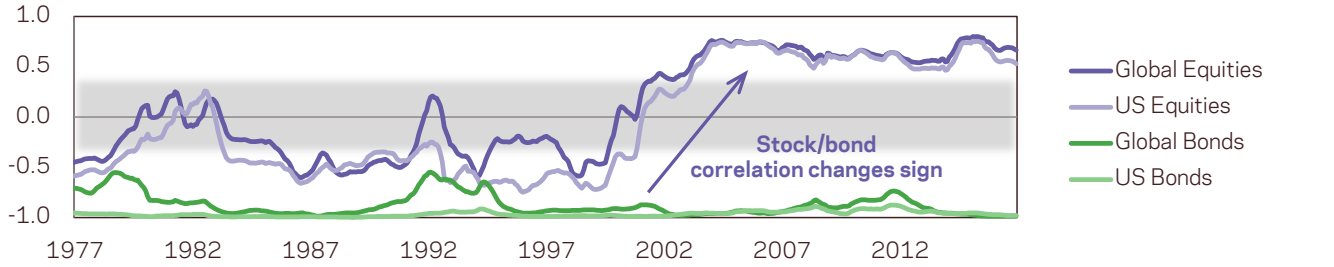
By construction bond yields, and hence bond returns, are sensitive to changes in both real yields and expected inflation. Rising yields imply negative bond returns, placing bonds firmly in the bottom left of chart 4a. TIPS are exposed to changes in real yields but not inflation. Equities and commodities have exhibited more long-term sensitivity to inflation (negative and positive respectively) than

12 See for example Dechow et al (2004) and Lettau and Wachter (2007).

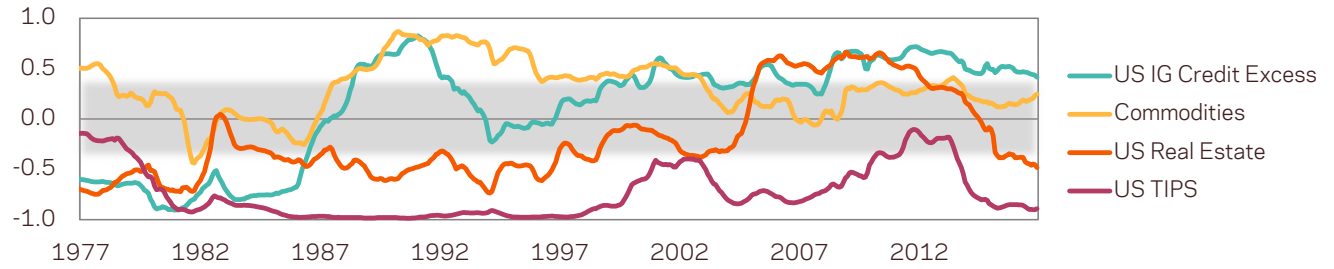
13 Specifically, it maps each investment according to its partial correlation to arithmetic changes in ex ante real yields and in expected inflation, based on monthly overlapping year-on-year periods. Partial correlations control for the effect of correlation between the risk factors themselves. Over the full period, the correlation between changes in real yields and changes in expected inflation was low (-0.1), so this interaction has little effect on full-period results. Using year-on-year rather than monthly correlations may identify relationships that are more robust and more relevant to investors concerned about the possibility of a sustained rise in yields.

Exhibit 5 | *Rolling 5-Year Correlations to Changes in Nominal Bond Yields 1972-2016*

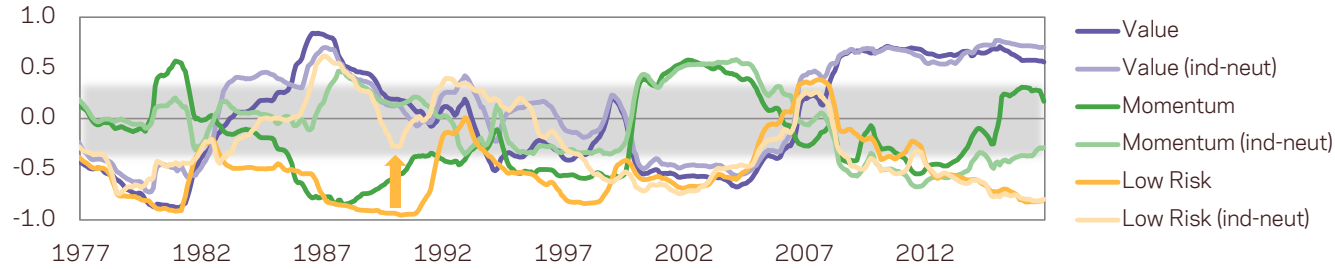
a. Equities and Bonds



b. Other Asset Classes



c. Long/Short Equity Styles



Sources: Bloomberg, Global Financial Data and AQR. Rolling 5-year 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 the Appendix for an explanation of the universe and methodology used for creating the asset classes and hypothetical strategies.

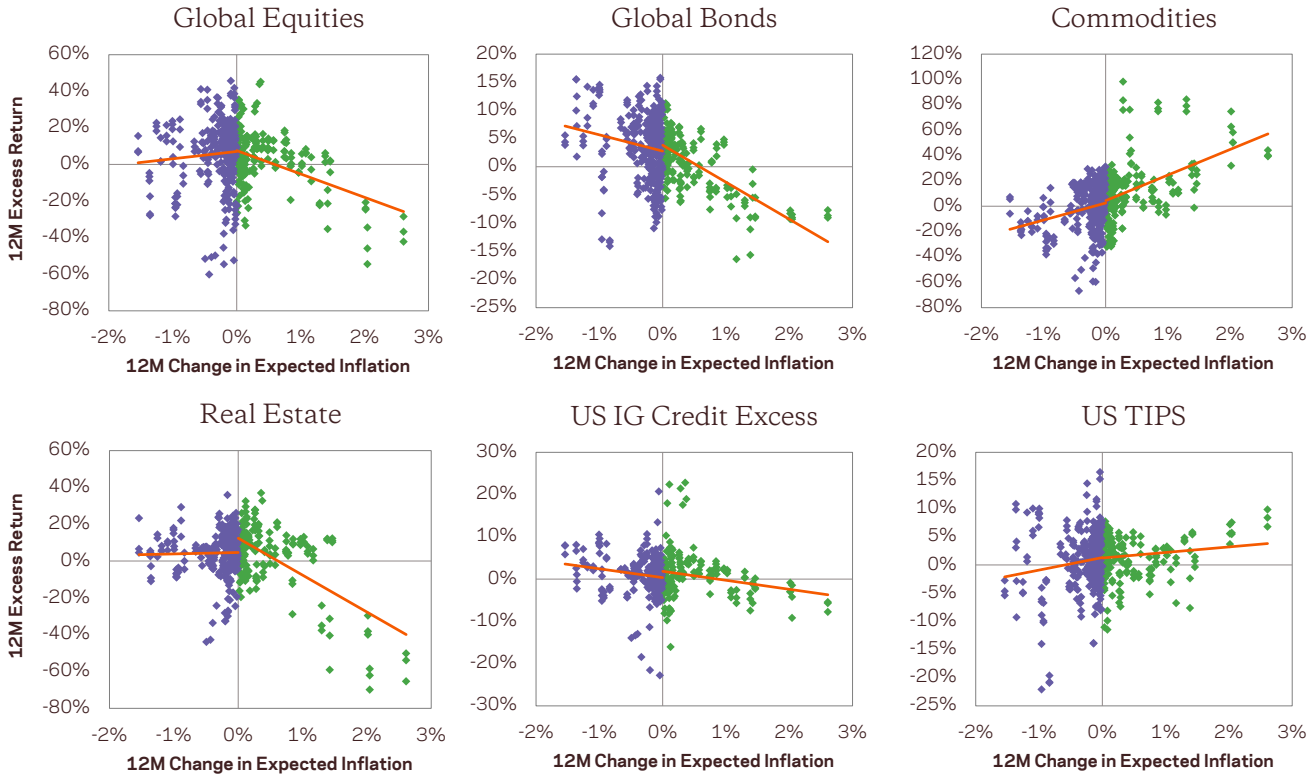
to real yields.[14] It follows that 60/40 and risk parity portfolios have similar inflation sensitivity (risk parity's additional bond and commodity exposures are offsetting), but risk parity is slightly more sensitive to real yields.

Equity styles (chart 4b) have exhibited milder exposures than most asset classes: exposures of longs and shorts are offsetting, and most correlations are not statistically significant. Low risk has exhibited some negative (bond-like) sensitivity to both real yields and inflation, but these sensitivities are again milder when industry exposure is removed (see orange arrow). Industry-neutral value and trend-following have offered some inflation protection, while other styles show very little long-term sensitivity.

Long-term averages tell us nothing about the stability of these relationships through time. **Exhibit 5** plots rolling 5-year correlations to changes in nominal 10-year Treasury yields (the sum of ex ante real yields and expected inflation). In the upper chart, equities are seen to undergo a change from

14 Gold (often considered an inflation hedge, but not shown here) resides a little up and left of this broader portfolio of commodities. In other words, it has stronger senstivitity to inflation but negative sensitivity to real yields. In recent years, gold and bond returns have been positively correlated.

Exhibit 6 | *Upside and Downside Sensitivity to Change in Expected Inflation*



Sources: Bloomberg, Global Financial Data, Asvanunt and Richardson (2015) and 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 the Appendix for an explanation of the universe and methodology used for creating the asset classes and hypothetical strategies.

negative to positive correlation around 20 years ago (i.e., positive to negative stock/bond correlation – loosely speaking, as inflation uncertainty abated and growth uncertainty became dominant). The middle chart shows that commodities and credit excess returns have exhibited positive sensitivities to bond yields for most of the past three decades.

The lower chart (5c) shows that the sensitivities of equity styles have frequently changed sign, with value and momentum often having offsetting exposures. The chart also shows that the moderating impact of removing industry exposure for the low risk style (yellow arrow) occurred mainly in the 1980s and 90s. In recent years, both versions have been negatively correlated to yield changes.

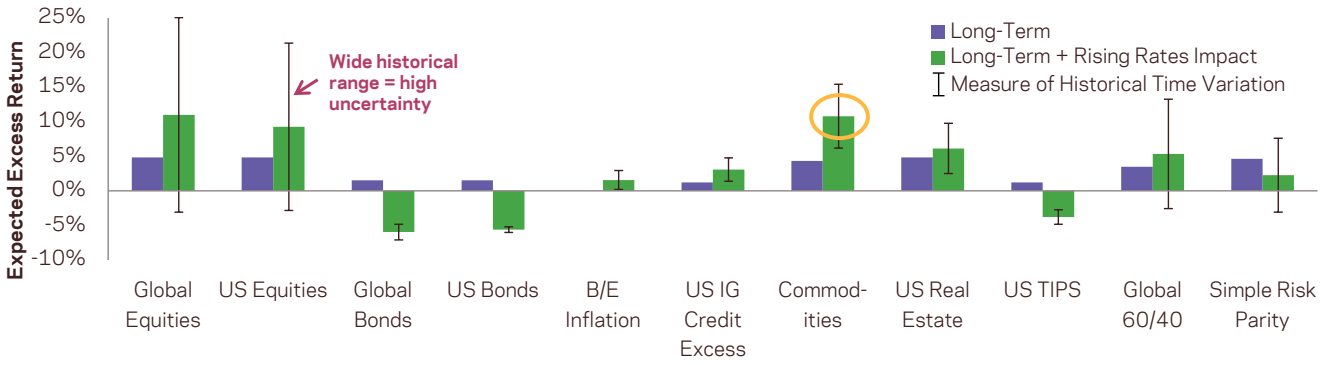
Finally, we can separately measure sensitivities to rising and falling real yields and expected inflation. **Exhibit 6** shows the latter for six asset classes. The top-left chart confirms the well-known result that equities favor stable inflation expectations: they are vulnerable to sharp increases but don't see commensurate benefits from sharp falls (high inflation and deflation are both harmful; real estate shows a similar non-linear pattern). Commodities and TIPS appear to offer useful upside protection. Among equity styles, value and low risk have offsetting upside sensitivities (see online appendix).

Economic Significance

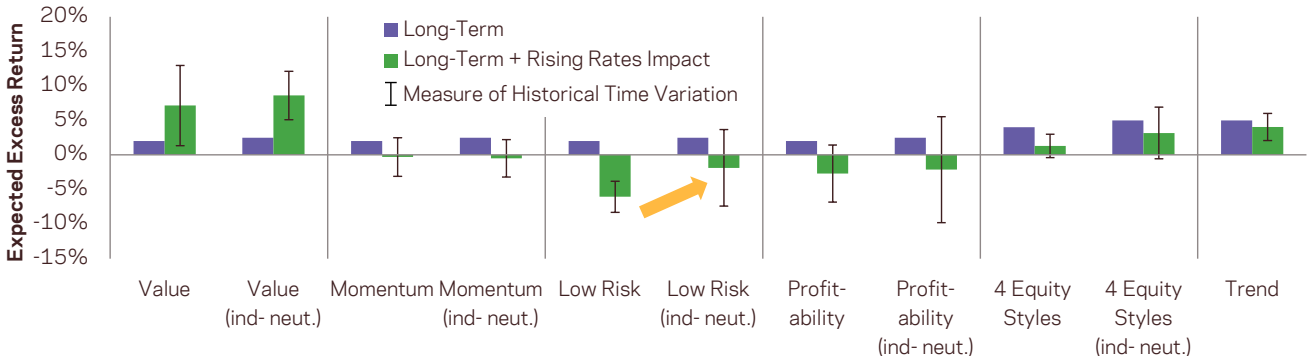
Correlations are useful for comparing the strength of relationships across investments or across time periods. However, they tell us nothing about the economic significance of those relationships. If real yields or inflation expectations were to rise by a given amount over, say, 12 months, what impact

Exhibit 7 | *Estimated Impact of Rising Rates Event on One-Year Expected Returns*

a. Asset Classes



b. Long/Short Equity Styles and Trend (each at 10% volatility)



Sources: Bloomberg, Global Financial Data, Asvanunt and Richardson (2015) and AQR. Illustrative expected returns excess of cash, net of transaction costs and fees. '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 asset classes and hypothetical strategies.

would we expect based on historical data? Would expected returns be significantly different for that period? That is the question we turn to now.

Investments' betas to changes in real yields or inflation expectations (and their sum, nominal yields) vary widely through time and in different environments, due to changing correlations (as we have seen above) and also changing volatilities. Which is the correct beta to use? The long-term average? The most recent? To estimate the potential beta in the event of a rising rates outcome, we take the average of the correlations over the full sample and the past 10 years (i.e., we give some weight, but not full weight, to persistent recent patterns such as the negative stock-bond correlation), and then use full-sample volatility to estimate the beta. This is our "best guess" point estimate, but we also measure variation through time.

We then define a "rising rates event" as a two-standard deviation 12-month change in the 10-year U.S. Treasury yield, which over our 45-year sample amounts to a rise of 1.8%.[15] For historical context, 10-year Treasury yields rose 1.6% during 2009 and 1.3% during 2013. The most recent 12-month rise as large as our hypothetical +1.8% event occurred in 1999.

Exhibit 7 shows the estimated impact on expected returns of such an outcome, based on our beta estimates. To give a sense of economic significance, we first show a long-term expected excess return

15 One way this could occur would be a 90th percentile 12-month change in real yields (+1.2%) coinciding with a 90th percentile change in expected inflation (+0.6%) – or it could be some other combination. As noted earlier, we do not predict this outcome but present it as an extreme risk scenario.

for each investment (purple bars). These estimates are themselves highly uncertain and can be derived in many ways with many different answers. Ours are based on simple long-term Sharpe ratio and volatility assumptions (details at the end of this article). They are rough illustrative assumptions.

Beside this long-term expected return assumption, we show the expected return adjusted for the estimated impact of our rising rates event (green bars). We also show 'whiskers' to indicate the degree of historical time variation in each investment's sensitivity to yield changes.[16]

For equities, our expected impact is positive (the recent negative stock-bond correlation outweighs longer-term negative inflation sensitivity). However, the range of historical variation has been very wide. We are therefore not confidently predicting a benign outcome for equities if such a year of rising rates were to occur, but rather noting that the historical data don't give us clear guidance to the contrary.

Bonds would be expected to underperform cash, of course, with the impact dictated by duration. Commodities would be expected to deliver above-average returns, with some uncertainty but less than for equities. TIPS would be protected against any rise in inflation expectations but would still suffer from a rise in real yields. A simple risk parity portfolio would be expected to underperform a 60/40 portfolio, but its expected return would remain positive.[17] The performance of the 60/40 portfolio would be largely dictated by how equities performed.

Among equity styles, value would be expected to outperform, while the expected returns of the other styles might see enough negative impact to offset their expected long-term premium during such an event (though with low conviction). Low risk would be expected to suffer negative return, but this loss would be much milder for an industry-neutral version of the style (yellow arrow). The expected returns of trend-following and multi-asset styles (see online appendix) would be only mildly affected.

Concluding Thoughts

If, as many expect, the Fed continues to hike rates over a long period, most traditional investments can be expected to underperform their long-term averages during the hiking cycle. This is one empirical perspective on the common observation that we are in a low expected returns world.

A sharp rise in real yields and inflation expectations, which may or may not occur during the cycle, would clearly result in losses for bonds, but other investments and wider portfolios may be more mildly affected (and liabilities would also shrink). Equities have experienced very mixed fortunes. Commodities have tended to outperform during rising rates environments, and may provide especially useful diversification to traditional portfolios.

Long/short styles have not exhibited significant exposure to rising rates, with the exception of defensive or low risk portfolios with unconstrained industry exposures. This is a useful reminder that active strategies should carefully allocate to the best-compensated risks, for example by favoring within-industry style exposures. Styles will of course continue to experience their own ups and downs, and diversified combinations are likely to deliver the most consistent performance regardless of the macroeconomic environment.

16 These are based on the interquartile (i.e., 75th – 25th percentile) range of the rolling 10-year beta throughout the sample.
17 We noted in AQR Alternative Thinking Q2 2014 that risk parity tends to underperform 60/40 during episodes of sharply rising real yields. However, Hurst, Mendelson and Ooi (2013) showed that risk parity has outperformed 60/40 during periods of more gradually rising yields.

Appendix

Expected Inflation Data Sources

Period	Source
1972-1978	Statistical estimate of long-term inflation expectations by Kozicki-Tinsley (2006).
1978-1989	Average of 2-3 available surveys: Hoey, Livingston, Survey of Professional Investors, Blue Chip Economic Indicators, Consensus Economics (all conduct surveys at different times).
1990-2016	Consensus Economics (average of 1-10-year forecasts)

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
Trend-following	Hypothetical Time Series Momentum strategy from Moskowitz, Ooi and Pedersen (2012) (12-month trend-following strategies applied to futures for equity indices, government bonds, currencies and commodities)	AQR Data Library

Long-Term Expected Return Assumptions

Long-term expected return assumptions (purple bars in Exhibit 7) are derived from simple long-term Sharpe ratio and volatility assumptions as shown in the table below.

Investment	Long-term Sharpe Ratio	Long-term Volatility	Long-term Excess Return
Global Equities	0.30	16.0%	4.8%
US Equities	0.30	16.0%	4.8%
Global Bonds	0.30	5.0%	1.5%
US Bonds	0.30	5.0%	1.5%
B/E Inflation	0.00	5.0%	0.0%
US IG Credit Excess	0.24	5.0%	1.2%
Commodities	0.24	18.0%	4.3%
US Real Estate	0.40	12.0%	4.8%
US TIPS	0.24	5.0%	1.2%
Global 60/40	0.35	10.0%	3.5%
Simple Risk Parity	0.46	10.0%	4.6%
Single Equity Style (industry unconstrained)	0.20	10.0%	2.0%
Single Equity Style (industry neutral)	0.24	10.0%	2.4%
4-Style Portfolio (industry unconstrained)	0.40	10.0%	4.0%
4-Style Portfolio (industry neutral)	0.50	10.0%	5.0%
Trend-following	0.50	10.0%	5.0%

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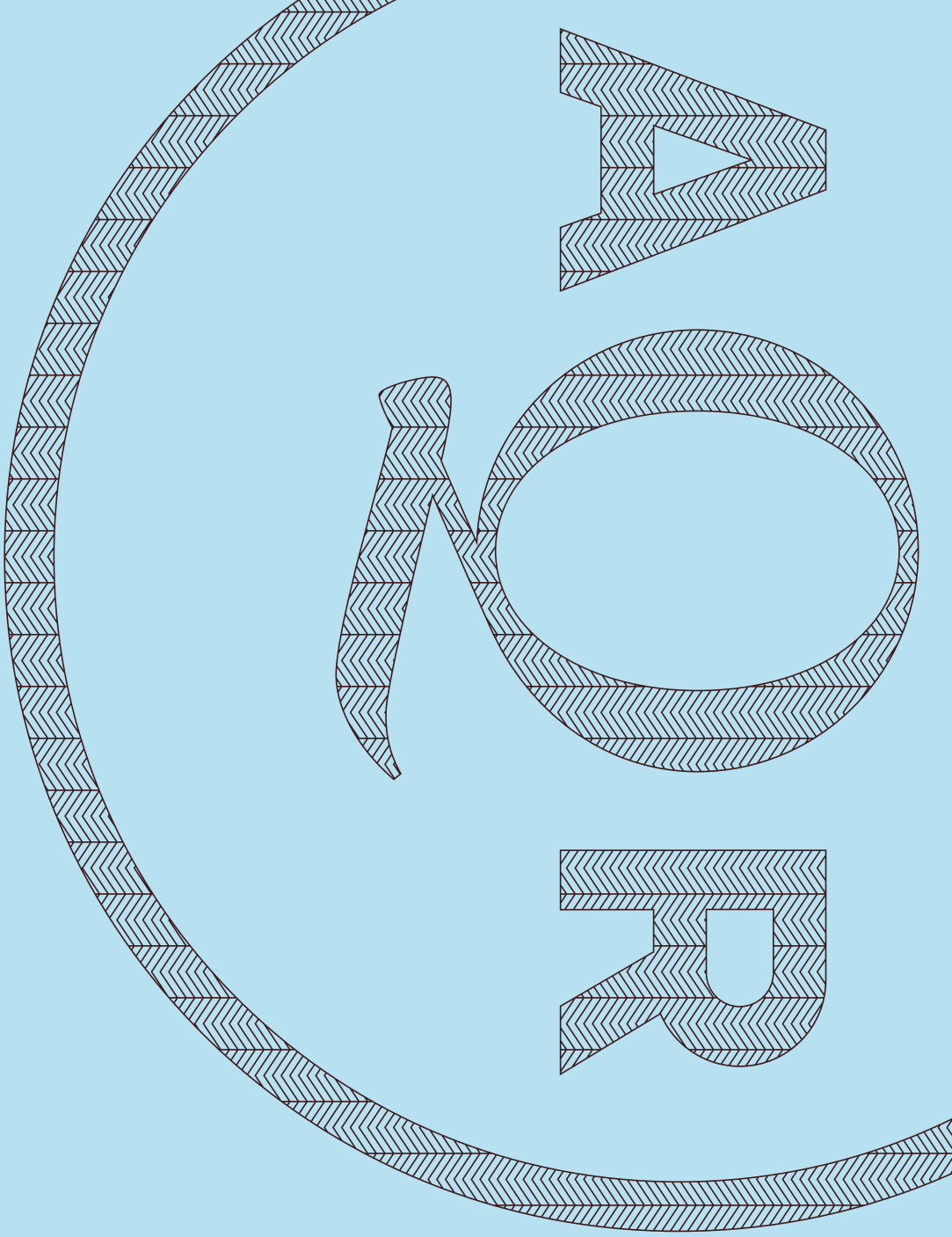

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