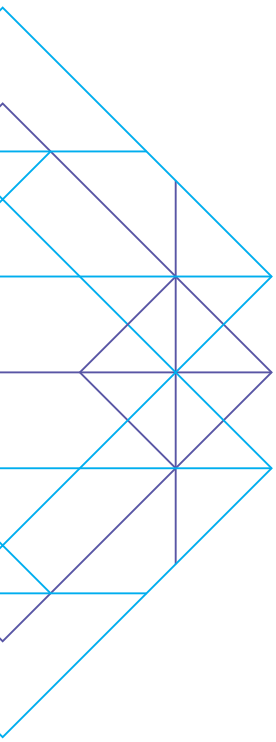
Alternative Thinking | Q4 2020

Fire and Ice: Confronting the Twin Perils of Inflation and Deflation



Some say the world will end in fire,
Some say in ice.
From what I've tasted of desire
I hold with those who favor fire.
But if it had to perish twice,
I think I know enough of hate
To say that for destruction ice
Is also great
And would suffice.

— **Robert Frost**, Fire and Ice

Executive Summary

The COVID-19 pandemic and the responses to it by governments, central banks and consumers have unleashed both (clearly) disinflationary and (potentially) inflationary forces. We do not know whether inflationary or disinflationary forces will win over the longer term. But despite credible central banks and well-anchored near-term expectations, many investors feel that medium-term inflation uncertainty has risen. How should they respond?

In this article we explore the historical inflation sensitivities of a range of different investments, and present the benefits of both risk-balanced asset allocations and dynamic directional strategies to prepare for uncertain times.

PSG
Portfolio Solutions Group

Contents

About the Portfolio Solutions Group

The Portfolio Solutions Group (PSG) provides thought leadership to the broader investment community and custom analyses to help AQR clients achieve better portfolio outcomes.

We thank Alfie Brixton, Jordan Brooks, Thomas Maloney and Ashwin Thapar for their work on this paper. We also thank Pete Hecht, Antti Ilmanen, Michael Katz, Christopher Palazzolo and Scott Richardson for their helpful comments.

Inflation Environment and Outlook

During the 2010s, inflation remained stubbornly low. The first half of the decade saw record low interest rates and quantitative easing, and the second half was characterized by sustained positive growth and tightening labor markets. But inflation was nowhere to be seen in major economies.

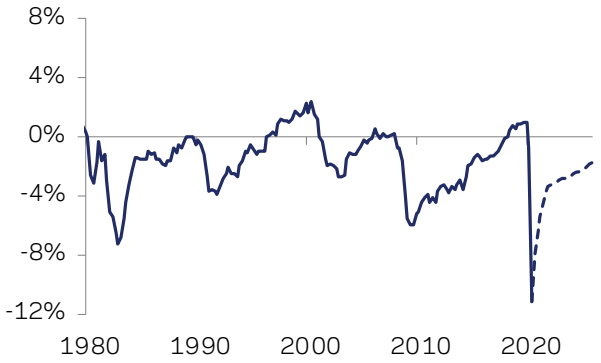
At least two secular disinflationary forces played a role. Firstly, increased globalization reduced both production costs and worker bargaining power. Secondly, technological advances drove cost savings that extended far beyond the tech sector itself.[1] More specifically to the 2010s, most commodity prices fell after a boom in the previous decade.

In early 2020, the COVID-19 pandemic and associated lockdowns and consumer responses unleashed substantial disinflationary forces in the shorter term: plummeting demand and employment across many sectors. The large output gap shown in **Exhibit 1a** is projected to take several years to close. A related collapse in the oil price was exacerbated by a price war between producers, and as of late 2020 it remains near the previous decade's lows.

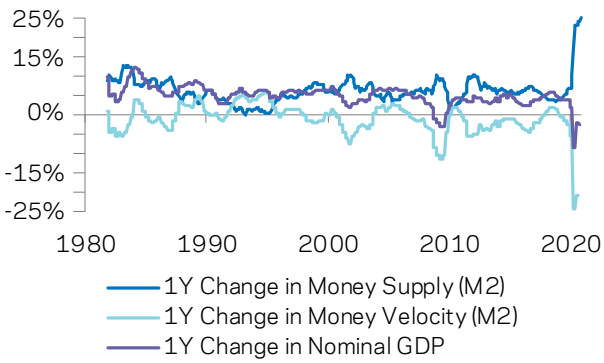
Meanwhile, central banks and governments have enacted a raft of stimulative policies that may be inflationary over the longer term. According to the quantity theory of money, an increase in the money supply can cause inflation unless it is matched by output growth or offset by a slowing of the circulation of money. The year 2020 saw an increase in money supply exceeding anything seen during the Global Financial Crisis (**Exhibit 1b**). However, this was tempered by a reduction in the velocity (circulation) of money, and the eventual net effect is unclear. Another source of uncertainty is the possibility that globalization, which was already meeting resistance in the late 2010s in the form of escalating trade wars, could face further barriers as a result of the pandemic even if vaccines are successfully deployed.

Exhibit 1: The pandemic unleashed disinflationary forces and (potentially) inflationary responses

a. U.S. Output Gap
January 1, 1980 – December 31, 2025



b. Change in Money Supply, Velocity and GDP
November 1, 1981 – October 31, 2020



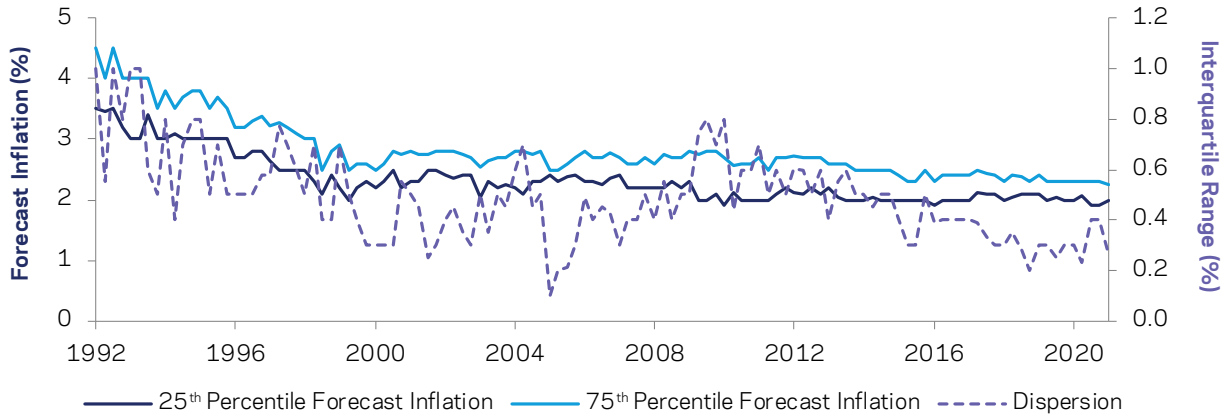
Source: Congressional Budget Office (CBO), Federal Reserve Economic Data. Dashed line is CBO projected data as of July 2020.

1 Shifting demographics are also sometimes cited, though their impact is more ambiguous.

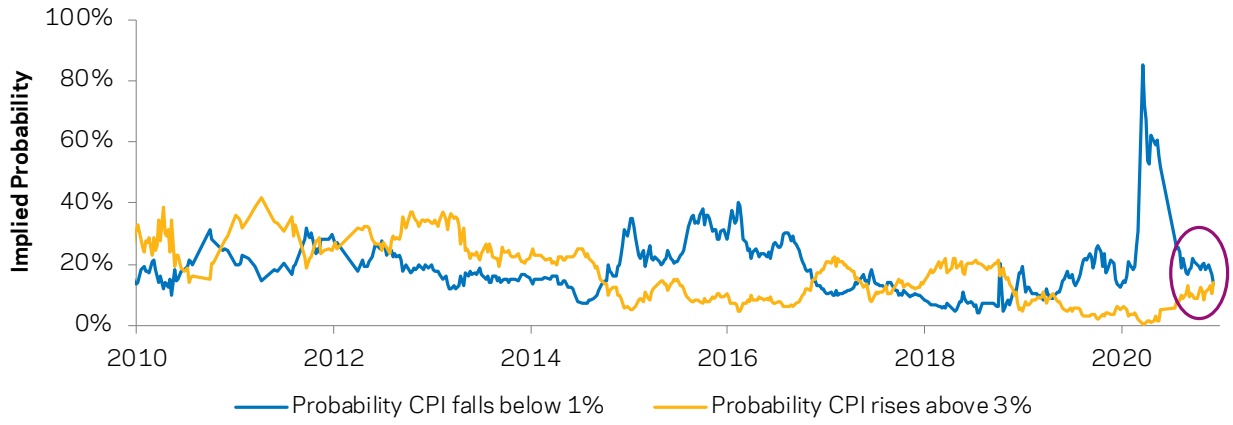
Some investors believe the net result of these events is heightened uncertainty for inflation's medium-term prospects. However, at the end of 2020, economists' forecast data shows little evidence of this — expectations for the next decade remain firmly anchored around 2% (**Exhibit 2a**). We can also attempt to extract the distribution of inflation expectations from CPI cap and floor option pricing. **Exhibit 2b** shows that the implied probability of higher U.S. inflation has risen noticeably but remains low. It is substantially lower than it was either in the years after the GFC, or more recently in 2017-2018.[2]

Exhibit 2: Little sign of upside inflation risks in economists' forecasts or options pricing

a. 10-Year U.S. Inflation Forecasts and Dispersion, Q4 1991 – Q4 2020



b. Estimating U.S. Inflation Uncertainty from Options (5-Year Horizon), Jan 2010 – Dec 2020



Source: Survey of Professional Forecasters, Federal Reserve Bank of Minneapolis, AQR. Chart (a) shows cross-sectional dispersion in quarterly forecasts for annual average CPI over the next 10 years. Chart (b) shows risk-neutral probabilities implied by CPI caps and floors, from Federal Reserve Bank of Minneapolis website.

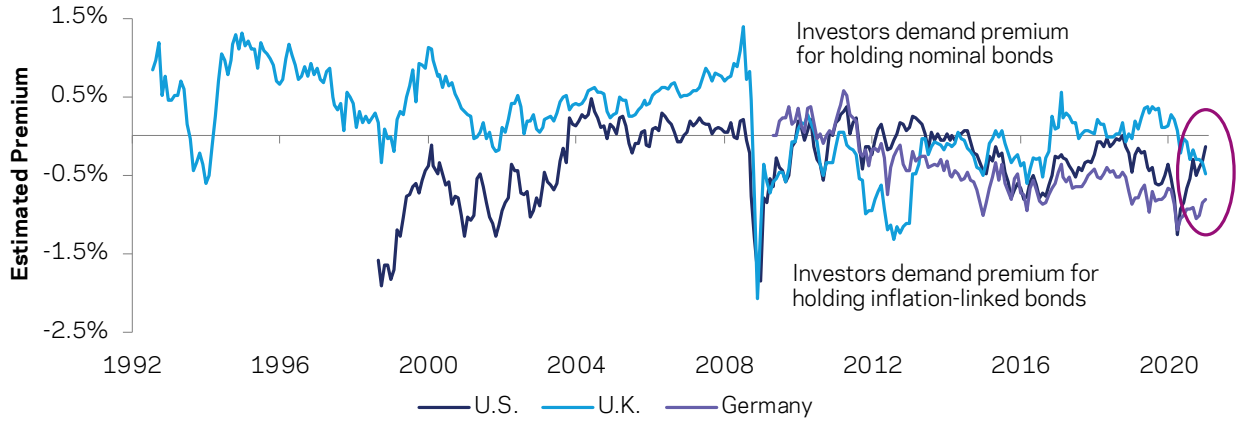
Finally, we can look at bond markets. The *inflation risk premium* is the premium demanded by nominal bond investors for bearing inflation risk. A crude estimate of this premium is the amount by which TIPS breakeven inflation exceeds survey-based

2 Care should be taken when interpreting these risk-neutral probabilities, as discussed in Nagel (2016). They embed risk premia as well as expected probability, and may reflect some combination of uncertainty and disagreement among market participants.

expected inflation over the same horizon, as plotted in **Exhibit 3**.[3] At the end of 2020 these estimates were negative for both U.S. and eurozone bonds (though becoming less negative in the U.S., see red oval), suggesting investors may be more averse to *deflation risks* than *inflation risks*, and are willing to pay a premium to own nominal bonds. This makes sense in that a deflationary recession (the Global Financial Crisis) was the most damaging recent event for most portfolios. We believe investors who are deallocating from bonds in the expectation of higher inflation should keep such alternative outcomes in mind.

Exhibit 3: Estimating the Inflation Risk Premium

July 1992 – December 2020



Source: Consensus Economics, Bloomberg, AQR. Estimated inflation risk premium calculated as 10-year breakeven inflation rate from Bloomberg minus Consensus Economics average 1-10-year inflation forecast. U.K. inflation forecast is for RPI, in line with U.K. inflation-linked bonds, whereas U.S. and German forecasts use CPI.

With expectations well-anchored, central banks have the tools to bring inflation down (pushing it up from low levels has proved more challenging). Therefore, sustained future inflation is likely to require their policy sponsorship. This pro-inflation bias could come from explicit changes to monetary policy frameworks — the Federal Reserve already announced in August 2020 a policy change towards average inflation targeting — or from cyclical leniency in interpreting mandates to maintain low and stable inflation.

In summary, as of late 2020 the likelihood of an upside inflation surprise seems small in the short term, but in the medium term there may be larger uncertainties. The 2010s cast doubt on traditional models that wrongly predicted rising inflation. On the other hand, there are plausible arguments that the present wave of stimulus may (eventually) be more inflationary than the responses to the Financial Crisis of 2008. Are prudent investors obliged to choose a side in this battle of fire and ice, or is there another way?

3 Breakeven inflation is nominal yield minus TIPS yield at a given maturity, and in theory equates to expected inflation plus required premia. The simple difference in Exhibit 3 should be interpreted with caution, as it reflects not only the inflation risk premium but also time-varying liquidity premia in TIPS and other supply/demand forces. For example, the chart shows that early investors in U.S. TIPS in the late 1990s demanded a substantial liquidity premium. The difference may also reflect the fact that survey forecasts may be baseline (median) estimates, while market-implied expectations may represent a probability-weighted mean.

How Should Investors Respond to Medium-Term Inflation Uncertainty?

Some investors and asset managers have suggested a decisive shift in asset allocation is justified in this environment. For them, the combination of unattractive bond yields, lower bounds that may constrain nominal more than real bond yields, and perceived upside inflation risks over the medium term, implies a tilt away from nominal bonds and towards inflation-linked bonds, precious metals and other real assets.

For this strategy to be profitable, investors must believe the market has underestimated inflation risks, and must act before higher inflation expectations are reflected in asset prices.[4] This is a defensible approach but we advise investors to be wary of overconfidence. The implications of other outcomes must also be considered — for example, such a tilt is likely to perform poorly in a prolonged disinflationary recession. In recent decades globally, secular stagnation — weak growth accompanied by low inflation — has been much more prevalent than stagflation. Tactical tilts should be sized according to conviction.

An alternative (or complementary) approach is to adjust your portfolio to be more resilient to a range of outcomes. To be effective, this approach is likely to require financial tools such as prudent leverage and the use of derivatives (directly or delegated to managers). Two examples are listed in **Exhibit 4.**

Exhibit 4: Candidate strategies for improving inflation resilience

Better risk balance across asset classes, including inflation-sensitive assets	• Uses leverage to improve macro diversification • Nominal bonds are retained for disinflationary outcomes • Sizeable allocation to commodities and other inflation-sensitive assets for inflationary scenarios • Equities for growth exposure
Dynamic strategies: • **Trend following** • **Global macro**	• Respond to changing macro environment by following trends in prices and in macro fundamentals • Can go long or short bonds and inflation sensitive assets • Can perform well in both inflationary and deflationary environments (especially if extreme or sustained)

Whether an investor wishes to position a portfolio in expectation of a particular inflation outcome, or increase resilience to a range of possible outcomes, he or she will need to understand how different asset classes and sectors can be expected to respond to inflation news. We turn to this subject now, before returning to the above candidate strategies in the final section.

4 There may also be opportunities to profit from initial underreaction to inflationary news (trends and macro momentum effects) but this is best achieved with a well-diversified dynamic strategy, as we discuss later.

Measuring Historical Inflation Sensitivities

Challenges, Caveats and Metrics

The sensitivities of different investments to inflation can vary through time and can be hard to disentangle from sensitivities to other variables such as economic growth. Some assets that suffer when inflation rises may offer more resilient real returns over the longer term. Others may fare best when inflation is moderate and stable, and suffer at extremes. Different metrics and different periods can lead to very different results.

The choice of **sample period** is a difficult one. Long histories of inflation data exist, but span different monetary systems and so may give results that are not fully applicable to the current era. Any post-war analysis tends to be dominated by outcomes during the Great Inflation of the mid-70s to early-80s, raising the risk of sample-specific results. And inflation-linked bonds have only existed since 1981 (U.K.), 1997 (U.S.), and 2006 (Germany); none were available during major inflationary episodes. More recent periods have the advantages of broader data availability and consistent monetary systems, but inflation expectations have been extremely well-anchored since the late 1990s. Shorter samples will contain no major inflationary episodes. Also, analysis of longer-horizon sensitivities is limited by the small number of independent observations. We show our main results for two different periods.

Because of the above challenges, we favor a **broad metric** that combines several different measures to produce more stable and robust results. Specifically, we combine three different approaches to measuring asset responses to unexpected inflation, and related changes in inflation expectations.[5] Each is designed to control for concurrent changes in the growth environment, to better isolate inflation sensitivity.

Results

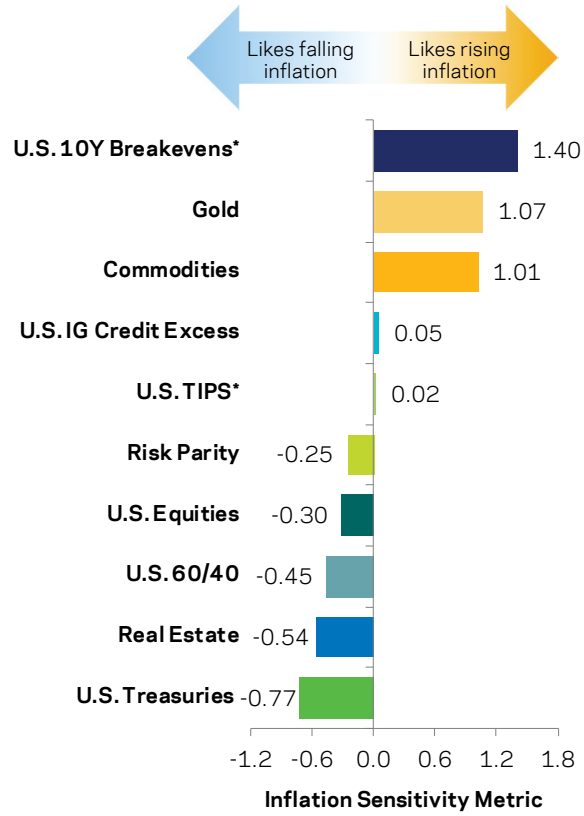
Exhibit 5a shows our broad metric for major asset classes since 1972 (with TIPS and breakevens extended back using synthetic data). Stocks, bonds and real estate all exhibit negative sensitivity, which is a reminder that an unanchoring of inflation expectations could have grave consequences for many investors. Credit and TIPS have sensitivities near zero, while breakevens, commodities and gold exhibit strong positive sensitivity and therefore offer protection in inflationary scenarios. A simple risk parity portfolio shows noticeably more resilience than a traditional stock/bond portfolio.[6]

Exhibit 5b shows the same analysis over the shorter period since TIPS were first introduced. It also includes a basket of emerging market currencies, which have offered inflation protection comparable with that of breakevens. The sensitivity of equities is slightly positive over this more recent period, consistent with demand-driven inflation shocks and the complete absence of severe inflationary episodes.

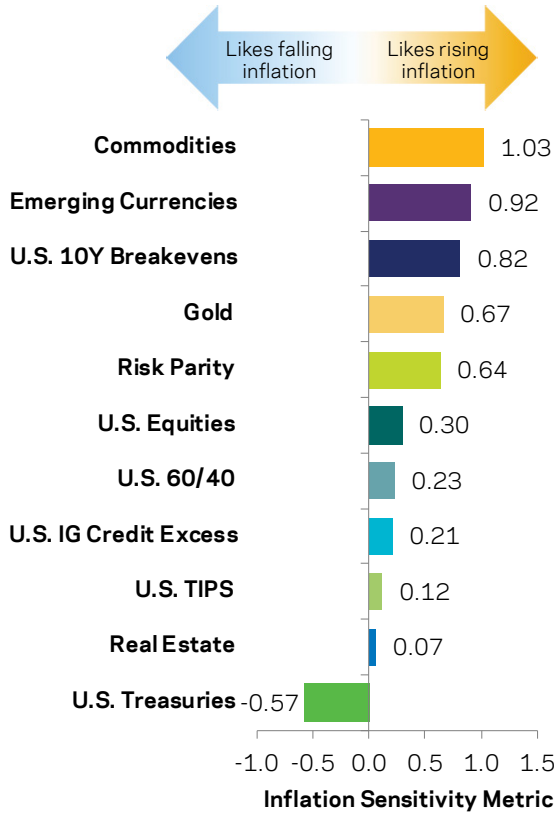
5 These are described in the Appendix and were developed from measures first outlined in Katz and Palazzolo (2010).
6 This metric measures the sensitivity of excess-of-cash performance, so cash itself has a sensitivity of zero by definition. But note that cash currently delivers negative real returns in most markets.

Exhibit 5: U.S. Inflation Sensitivity Metric for Major Asset Classes

a. January 1972 – June 2020



b. March 1997 – June 2020



* Before March 1997, TIPS and Breakevens are synthetic series built using survey-based inflation expectations.

Source: AQR, Bloomberg, Survey of Professional Forecasters, U.S. Bureau of Labor Statistics. Inflation sensitivity metric controls for growth exposure. See Appendix for details of metric and asset class proxies.

Non-Linearities

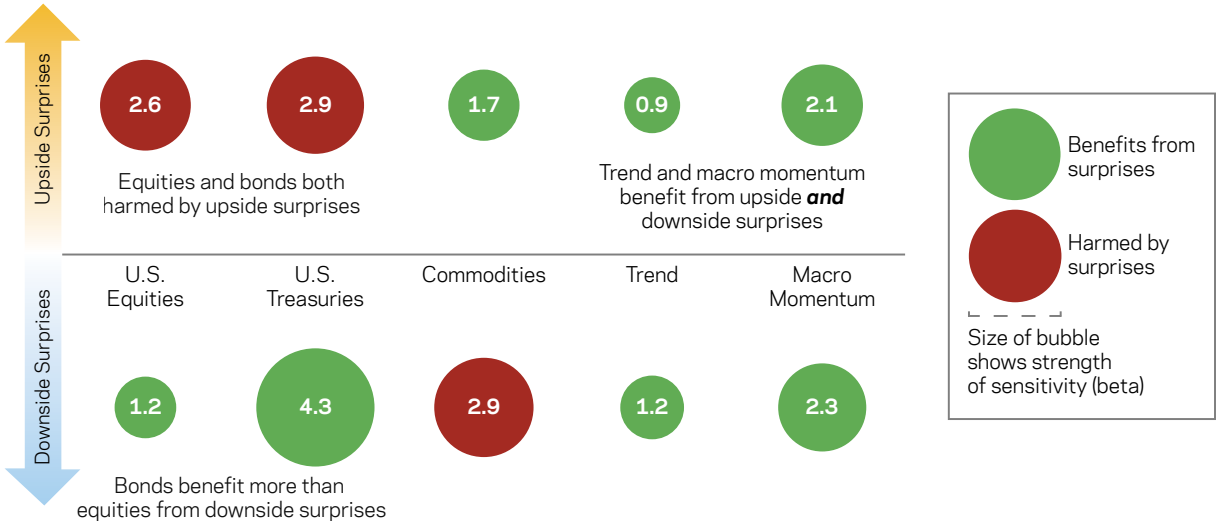
So far, we have reported a broad summary measure of inflation sensitivity. But do investments exhibit similar sensitivities to upside and downside inflation shocks? In **Exhibit 6** we show risk-adjusted betas to positive and negative 1-year inflation surprises, controlling for growth surprises. The size of each bubble is the beta, and the color indicates the sign: green means the investment benefits from surprises of that sign, while red means it tends to underperform.

The relationships for the first three asset classes are approximately linear after we control for growth exposure. However, while equities and bonds have tended to suffer fairly equally when inflation surprises on the upside, bonds have benefitted much more from downside surprises. In other words, equity markets tend to favor a stable inflation environment and are not guaranteed to perform well in a disinflationary scenario, especially if it is accompanied by slow or negative growth. In an environment of two-sided inflation risks, this result supports the case for maintaining an allocation to nominal

bonds. As expected, commodities have the opposite sensitivities to equities and bonds, offering upside inflation protection.

We also show results for a hypothetical **trend following** strategy (harnessing price trends in many instruments across several asset classes), and a hypothetical **macro momentum** strategy that seeks to exploit trends in fundamentals such as inflation, international trade, monetary policy and risk sentiment. Both strategies exhibit modest average inflation sensitivities over our full sample, which is no surprise as they are designed to be uncorrelated to traditional markets over the long term. But in Exhibit 6 they are seen to benefit from inflation surprises in either direction (i.e., they exhibit positive beta to upside surprises and negative beta to downside surprises). These dynamic strategies tend to thrive in environments of large or persistent upside or downside inflation surprises, which may be a useful trait in the current environment of two-sided risks.

Exhibit 6: Sensitivities to Upside and Downside 1-Year Inflation Surprises
January 1972 – June 2020

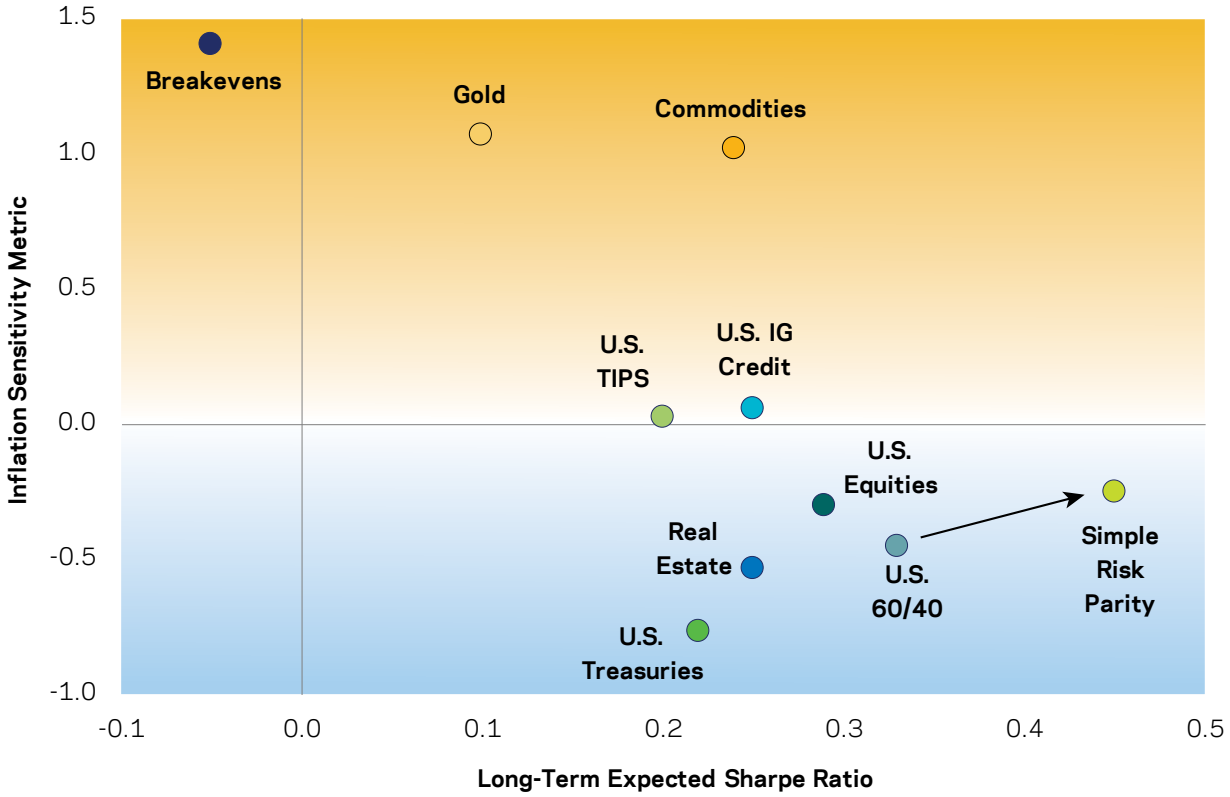


Source: AQR, Bloomberg, Survey of Professional Forecasters, U.S. Bureau of Labor Statistics. Asset returns scaled to 10% volatility to aid comparison. Sample divided into positive and negative inflation surprise samples, then quarterly overlapping 1-year asset returns regressed on contemporaneous inflation and growth surprises. Inflation surprise betas reported in chart. See Appendix for proxies and construction of hypothetical portfolios. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix.

Inflation Sensitivity vs. Long-Term Expected Return

For constrained investors, it is important to consider long term expected return trade-offs when adjusting the inflation sensitivity of a portfolio. **Exhibit 7** shows plausible long-term expected Sharpe ratio assumptions on the x-axis and the inflation sensitivity metric on the y-axis. Commodities have offered inflation protection comparable with breakevens, but with a positive expected return. And a risk parity portfolio not only has less sensitivity to inflation than a stock/bond portfolio, but also a higher expected risk-adjusted return (black arrow).

Exhibit 7: Fire and Ice — an Inflation Sensitivity Frontier



Source: AQR, Bloomberg, Survey of Professional Forecasters, U.S. Bureau of Labor Statistics. See Appendix for asset class proxies. Long-term expected Sharpe ratios are based on the assumption of equal Sharpe ratios for major asset classes, adjusted for breadth. Negative Sharpe ratio for Breakevens assumes positive inflation risk premium over the long term.

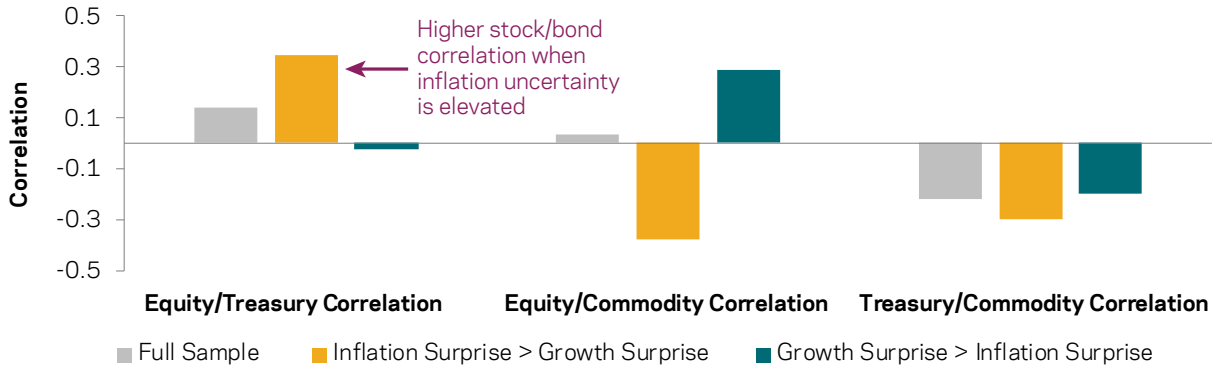
Putting It All Together

The 2010s was an exceptional decade for stock/bond portfolios: an unusually long bull market for stocks, falling yields for bonds *and* a strong negative correlation between the two asset classes. Risk-balanced multi-asset portfolios struggled to keep up with traditional stock/bond allocations in that environment, hampered by sustained falls in commodity prices.

If inflation were to move up the news agenda, it is likely that equities and bonds would become more positively correlated, as they were for much of the twentieth century. In **Exhibit 8** we divide the last half-century into two sub-samples by comparing the size of inflation and growth surprises, as a measure of relative uncertainty. The stock/bond correlation has tended to be higher during periods when inflation uncertainty is heightened relative to growth uncertainty. Rising inflation would probably be bad for both asset classes. The chart also shows that commodities have tended to be strong diversifiers in these environments, and this is why most risk parity portfolios include a substantial allocation to commodities and other assets that offer inflation protection.

Exhibit 8: Major Asset Class Correlations for Different Inflation vs. Growth Surprise Periods

January 1972 – June 2020



Source: Bloomberg, Global Financial Data, Survey of Professional Forecasters, AQR. Correlations are for U.S. equities and Treasuries and are based on contemporaneous 12-month returns and surprises, at overlapping quarterly frequency. Surprise is defined as realized 12-month CPI or real GDP growth minus SPF starting forecast. Sample is divided into periods when magnitude of inflation surprise was bigger/smaller than growth surprise (ignoring sign of surprise), as a proxy for relative uncertainty. See Appendix for asset class proxies.

But risk parity also includes a substantial bond allocation. If inflation is coming, would it not be better simply to shift capital from bonds to real assets? Well, yes, but that was a very big 'if'. The great benefit of a risk parity strategy that includes both real assets and nominal bonds is that it has the potential to outperform a traditional portfolio in both inflationary and deflationary scenarios. Both present formidable risks to investors.

Our last analysis uses a different method to assess macroeconomic resilience at the portfolio level.[7] **Exhibit 9** shows how four portfolios have performed in different growth and inflation environments over the past 50 years, compared to their full-sample average performance. As we would expect, the traditional 60/40 portfolio (chart a) performs strongly in benign 'growth up' / 'inflation down' environments like the 2010s, but suffers in 'growth down' or 'inflation up' scenarios. The risk parity portfolio has much milder sensitivities (chart b), due to the better macro diversification across its three asset classes.

Chart (c) shows even milder sensitivities for a combination of trend following and macro momentum strategies. These dynamic absolute return strategies follow trends in prices and/or macro fundamentals, and can adopt long or short exposures in inflation sensitive assets depending on the unfolding macro scenario. Importantly, their dynamic exposures are expressed across a large number of globally diversified assets. An allocation to such strategies may be preferable to the concentrated macro timing bet implied by a tactical shift in asset allocation to express a view on future inflation. The dynamic market exposure they deliver may help increase resilience to a range of different macroeconomic outcomes — particularly the extreme inflationary or deflationary outcomes that would be most challenging for equity-dominated portfolios.

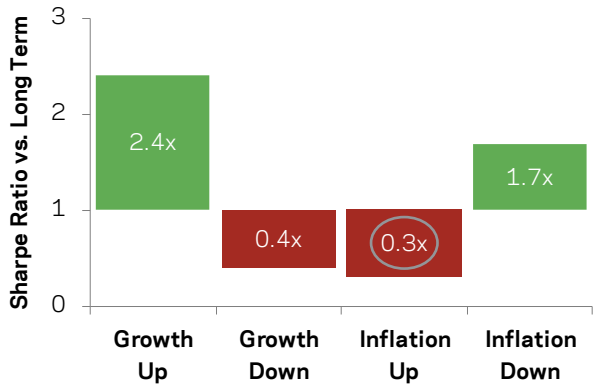
Finally, chart (d) shows the sensitivities of a sample portfolio that starts from global 60/40, then allocates 20% to risk parity and 10% each to trend following and macro momentum strategies. This gives a sense of how much the resilience of a traditional portfolio can be increased by a moderate reallocation. Relative performance during 'inflation up' environments is noticeably improved (gray circles), from a lackluster 0.3x to a more creditable 0.6x.

7 Based on the framework set out in Ilmanen, Maloney and Ross (2014).

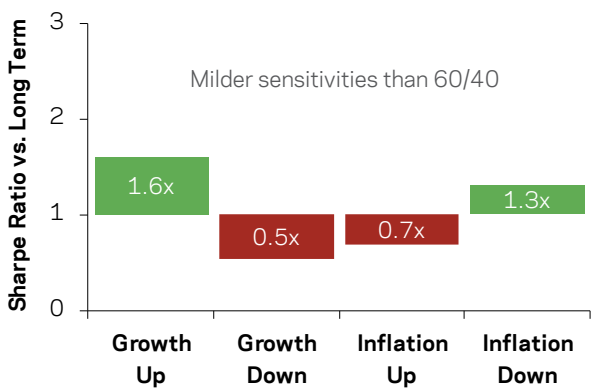
Exhibit 9: Hypothetical Relative Performance across Growth and Inflation Environments

January 1972 – December 2019

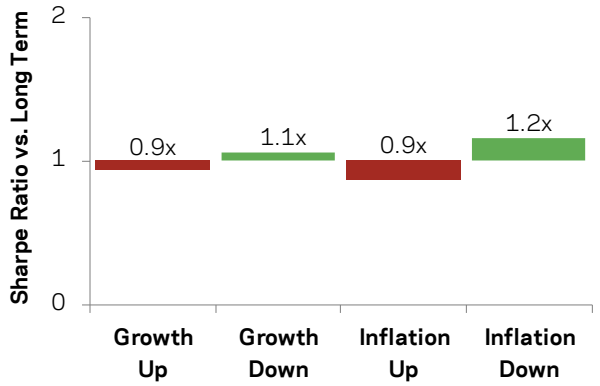
a. Global 60/40



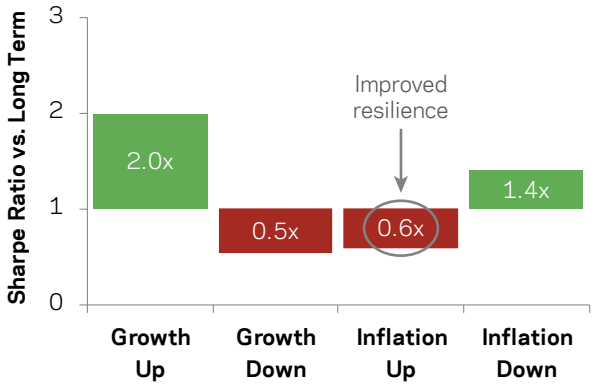
b. Simple Risk Parity



c. 50/50 Trend and Macro Momentum



d. 60/40 + 20% RP, 10% Trend, 10% M. Mom.



Source: Bloomberg, AQR. Global 60/40 is 60% Global Equities and 40% Global Bonds. Simple Risk Parity is an equal risk-weighted combination of Global Equities, Global Bonds and Commodities, discounted to match our expected long-term Sharpe ratio for the strategy. Trend and Macro Momentum are hypothetical strategies described in the Appendix. Chart (d) shows a portfolio that starts from Global 60/40, then allocates 20% to Simple Risk Parity, 10% to Trend and 10% to Macro Momentum, funded pro rata from rest of the portfolio and rebalanced monthly. Please see Appendix for details on the construction of the macroeconomic environmental indicators. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix.

Final Thoughts

At the beginning of this article we very briefly sketched out plausible arguments for both long-term inflationary and disinflationary outcomes of the current environment, that other commentators have covered in much greater detail. We presented analysis to help investors prepare their portfolios for a future of heightened (but we believe two-sided) inflation uncertainty. Even investors with a strong view on the inflation outlook may wish to consider the benefits of allocating to a truly risk-balanced portfolio and/or to dynamic, systematic directional strategies, to mitigate the tail risks of an unexpected outcome.

References

Boudoukh, J. and M. Richardson, 1993, "Stock returns and inflation: A long-horizon perspective," *American Economic Review*.

Brooks, J., 2017, "A Half Century of Macro Momentum," AQR white paper.

Hurst, B., Y. H. Ooi and L. Pedersen, 2014, "Time Series Momentum," *Journal of Financial Economics*, 104(2).

Ilmanen, A., 2011, "Expected Returns," Wiley.

Ilmanen, A., T. Maloney and A. Ross, 2014, "Exploring Macroeconomic Sensitivities", *Journal of Portfolio Management*, 40(3).

Katz, M., H. Lustig and L. Nielsen, 2017, "Are stocks real assets? Sticky discount rates in stock markets," Review of Financial Studies.

Katz, M. and C. Palazzolo, 2010, "Inflation in 2010 and Beyond? Practical Considerations for Institutional Asset Allocation," AQR white paper in two parts.

Levine, A., Y. Ooi, M. Richardson and C. Sasseville, 2018, "Commodities for the Long Run," *Financial Analysts Journal*, 74(2).

Nagel, S., 2016, "Long-run Inflation Uncertainty," *International Journal of Central Banking*, September issue.

Appendix

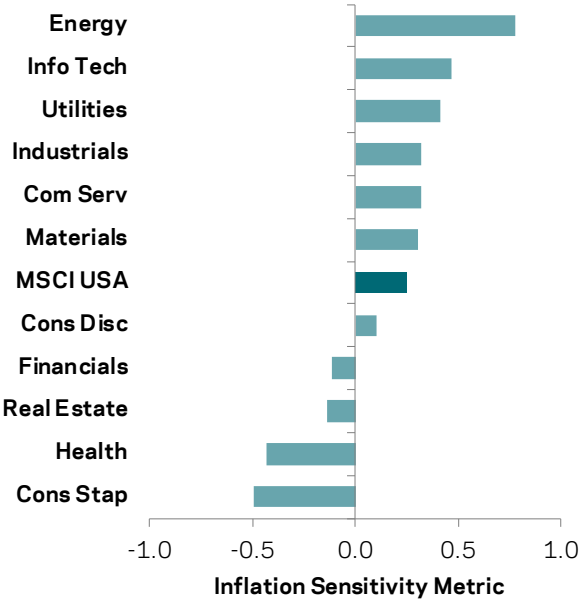
Inflation Sensitivity of Equity Sectors and Commodity Sectors

The broad patterns outlined in Exhibit 5a highlight the inflation hedging credentials of commodities, and the vulnerability of equities. But within each of these asset classes we find considerable variation. **Exhibit A1a** shows our sensitivity metric for U.S. equity sectors since 1995. The stand-out sectors are energy, tech, energy-related utilities, industrials (especially capital goods), communications and materials (especially metals and mining). Analysis of European equity sectors' sensitivities to eurozone inflation gives similar results.

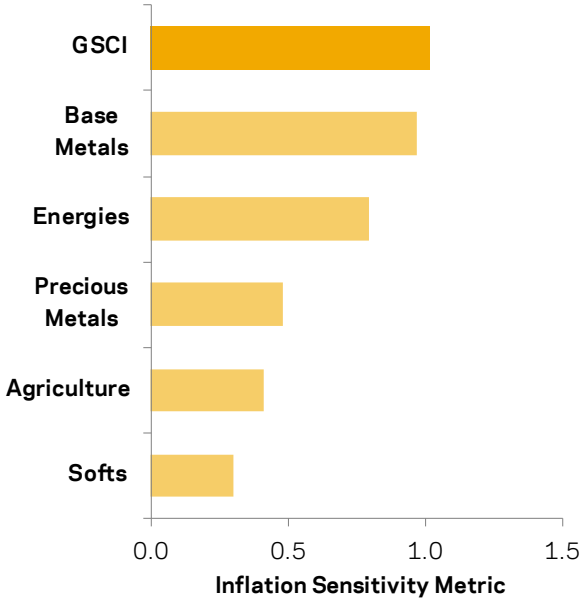
Among commodity sectors (**Exhibit A1b**), energy and base metals have the highest scores, but importantly a basket of commodities has stronger sensitivity than any of its components. This may be because sector-specific exposures are reduced by diversification, allowing the common inflation sensitivity clearer expression. Or the basket may protect against more different types of inflation shocks, such as oil supply shocks (energies), demand-pull shocks (energies, base metals) and monetary shocks (precious metals). A diversified basket has also delivered the highest long-term risk-adjusted return,[8] though it is likely to suffer when inflation expectations fall.

Exhibit A1: U.S. Inflation Sensitivity Metric for Equity and Commodity Sectors

a. U.S. Equity Sectors 1995 – 2020



b. Commodity Sectors 1983 – 2020



Source: AQR, Bloomberg, Survey of Professional Forecasters, U.S. Bureau of Labor Statistics. GICS sector indices are designed to track major sectors of the U.S. equity market. Sub-indices of the GSCI are designed to track individual commodities, components and sectors. Sample periods are determined by data availability.

8 See Levine, Ooi, Richardson and Sasseville (2018).

Methodology for Inflation Sensitivity Metric

The metric combines three measures of changing inflation expectations.

1. Relative risk-adjusted performance in positive versus negative 12-month inflation surprise periods. Surprises imply realizations that were not already reflected in prices, and coincide with changes in expectations. To control for growth exposure, within each of the inflation surprise categories we average results for positive and negative growth surprise sub-periods.

2. Relative risk-adjusted performance in decreasing versus increasing inflation regimes. Inflation trends tend to impact prices, as expectations are anchored to previous realizations. To control for growth exposure, within each of the inflation regime categories we average results for positive, flat and negative growth regime sub-periods.

3. Realized correlation of monthly excess returns to subsequent 12-month inflation. Changes in expectations tend to be reflected in subsequent realized inflation. To control for growth exposure we use partial correlations, adjusting for the inflation/growth correlation over the period.

The measures are combined as follows, to give roughly equal volatility weights: Inflation Sensitivity Metric = ((difference in Sharpe ratio in positive vs. negative inflation surprise periods) + (0.5 * (difference in Sharpe ratio in increasing vs. decreasing inflation regime)) + (5 * (correlation with future inflation))) / 2. A positive score indicates stronger performance when inflation expectations are rising.

Asset Class Proxies for Inflation Sensitivity Analysis

Investment	Proxy	Source
U.S. Equities	MSCI US Net TR Index	Bloomberg
U.S. Bonds	10-year U.S. Treasury	GFD
U.S. 60/40	60% US Equities, 40% US Treasuries as defined above	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
B/E Inflation	Long 10-year U.S. TIPS, short 10-year U.S. Treasury	Bloomberg, GFD
U.S. 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
Real Estate	50% FTSE Nareit All REITs Index (listed), 50% NCREIF Property Index (unlisted)	Bloomberg
Commodities	S&P GSCI Total Return Index	Bloomberg
Gold	S&P GSCI Gold Total Return Index	Bloomberg
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
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). Discounted by 50% until Aug 2012, then 25% thereafter and scaled to 8% volatility.	AQR Data Library
Macro Momentum	Hypothetical long/short and directional strategies in equity indices, fixed income and currencies, with signals based on the following macro momentum themes as described in Brooks (2017): Business Cycle, International Trade, Monetary Policy, Risk Sentiment. Discounted by 50% until Dec 2011, then 25% thereafter.	AQR

Methodology for Growth and Inflation 'Up' and 'Down' Analysis

Each of our macro indicators combines two series, which are first normalized to Z-scores: that is, we subtract a historical mean from each observation and divide by a historical volatility. When we classify our quarterly 12-month periods into, say, 'growth up' and 'growth down' periods, we compare actual observations to the median so as to have an equal number of up and down observations. The underlying series for our **growth** indicator are the Chicago Fed National Activity Index (CFNAI) and the "surprise" in industrial production (IP) growth over the past year. CFNAI combines 85 monthly indicators of U.S. economic activity. The other series – the difference between actual annual IP growth and the forecast a year earlier – is narrower but more directly captures the surprise effect. We use median forecasts from the Survey of Professional Forecasters data as published by the Philadelphia Fed. Our **inflation** indicator is also an average of two normalized series. One series measures the level of inflation (CPIYOY minus its mean, divided by volatility), while the other measures the surprise element in realized inflation (CPIYOY minus consensus economist forecast a year earlier). For further detail and discussion see Ilmanen, Maloney and Ross (2014).

Disclosures

This document has been provided to you solely for information purposes and does not constitute an offer or solicitation of an offer or any advice or recommendation to purchase any securities or other financial instruments and may not be construed as such. The factual information set forth herein has been obtained or derived from sources believed by the author and AQR Capital Management, LLC ("AQR"), to be reliable, but it is not necessarily all-inclusive and is not guaranteed as to its accuracy and is not to be regarded as a representation or warranty, express or implied, as to the information's accuracy or completeness, nor should the attached information serve as the basis of any investment decision. This document is not to be reproduced or redistributed without the written consent of AQR. The information set forth herein has been provided to you as secondary information and should not be the primary source for any investment or allocation decision.

Past performance is not a guarantee of future performance.

This presentation is not research and should not be treated as research. This presentation does not represent valuation judgments with respect to any financial instrument, issuer, security, or sector that may be described or referenced herein and does not represent a formal or official view of AQR.

The views expressed reflect the current views as of the date hereof, and neither the author nor AQR undertakes to advise you of any changes in the views expressed herein. It should not be assumed that the author or AQR will make investment recommendations in the future that are consistent with the views expressed herein, or use any or all of the techniques or methods of analysis described herein in managing client accounts. AQR and its affiliates may have positions (long or short) or engage in securities transactions that are not consistent with the information and views expressed in this presentation.

The information contained herein is only as current as of the date indicated and may be superseded by subsequent market events or for other reasons. Charts and graphs provided herein are for illustrative purposes only. The information in this presentation has been developed internally and/or obtained from sources believed to be reliable; however, neither AQR nor the author guarantees the accuracy, adequacy, or completeness of such information. Nothing contained herein constitutes investment, legal, tax, or other advice, nor is it to be relied on in making an investment or other decision.

There can be no assurance that an investment strategy will be successful. Historic market trends are not reliable indicators of actual future market behavior or future performance of any particular investment, which may differ materially, and should not be relied upon as such. Target allocations contained herein are subject to change. There is no assurance that the target allocations will be achieved, and actual allocations may be significantly different from those shown here. This presentation should not be viewed as a current or past recommendation or a solicitation of an offer to buy or sell any securities or to adopt any investment strategy.

The information in this presentation might contain projections or other forward-looking statements regarding future events, targets, forecasts, or expectations regarding the strategies described herein and is only current as of the date indicated. There is no assurance that such events or targets will be achieved and might be significantly different from that shown here. The information in this presentation, including statements concerning financial market trends, is based on current market conditions, which will fluctuate and may be superseded by subsequent market events or for other reasons. Performance of all cited indices is calculated on a total return basis with dividends reinvested.

The investment strategy and themes discussed herein may be unsuitable for investors depending on their specific investment objectives and financial situation. Please note that changes in the rate of exchange of a currency might affect the value, price, or income of an investment adversely. Neither AQR nor the author assumes any duty to, nor undertakes to update forward-looking statements. No representation or warranty, express or implied, is made or given by or on behalf of AQR, the author, or any other person as to the accuracy and completeness or fairness of the information contained in this presentation, and no responsibility or liability is accepted for any such information. By accepting this presentation in its entirety, the recipient acknowledges its understanding and acceptance of the foregoing statement. Diversification does not eliminate the risk of experiencing investment losses.

Information contained on third party websites that AQR may link to are not reviewed in their entirety for accuracy and AQR assumes no liability for the information contained on these websites.

Broad-based securities indices are unmanaged and are not subject to fees and expenses typically associated with managed accounts or investment funds. Investments cannot be made directly in an index

Index Definitions:

The **MSCI US Index** is a free float-adjusted market capitalization index that is designed to measure the performance large and mid cap equities in the United States.

The **MSCI World Index** is a free float-adjusted market capitalization index that is designed to measure the large and mid cap equity market performance of 23 developed countries.

The **Bloomberg Barclays US Corporate Bond Credit Excess Return Index** represents the corporates portion of the Bloomberg Barclays Global Aggregate index grouping, and subtracts the returns of duration-matched U.S. Treasuries.

The **FTSE Nareit All REITs Index** is a market capitalization-weighted index that and includes all tax-qualified real estate investment trusts (REITs) that are listed on the New York Stock Exchange, the American Stock Exchange or the NASDAQ National Market List.

The **NCREIF Property Index** measures the performance of real estate investments on a quarterly basis and evaluates the rate of returns in the market. The NPI covers properties that are acquired in place of institutional investors that are exempted from taxes in the fiduciary environment.

The **S&P GSCI®** is a composite index of commodity sector returns representing an unleveraged, long-only investment in commodity futures that is broadly diversified across the spectrum of commodities.

HYPOTHETICAL PERFORMANCE RESULTS HAVE MANY INHERENT LIMITATIONS, SOME OF WHICH, BUT NOT ALL, ARE DESCRIBED HEREIN. NO REPRESENTATION IS BEING MADE THAT ANY FUND OR ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN HEREIN. IN FACT, THERE ARE FREQUENTLY SHARP DIFFERENCES BETWEEN HYPOTHETICAL PERFORMANCE RESULTS AND THE ACTUAL RESULTS SUBSEQUENTLY REALIZED BY ANY PARTICULAR TRADING PROGRAM. ONE OF THE LIMITATIONS OF HYPOTHETICAL PERFORMANCE RESULTS IS THAT THEY ARE GENERALLY PREPARED WITH THE BENEFIT OF HINDSIGHT. IN ADDITION, HYPOTHETICAL TRADING DOES NOT INVOLVE FINANCIAL RISK, AND NO HYPOTHETICAL TRADING RECORD CAN COMPLETELY ACCOUNT FOR THE IMPACT OF FINANCIAL RISK IN ACTUAL TRADING. FOR EXAMPLE, THE ABILITY TO WITHSTAND LOSSES OR TO ADHERE TO A PARTICULAR TRADING PROGRAM IN SPITE OF TRADING LOSSES ARE MATERIAL POINTS THAT CAN ADVERSELY AFFECT ACTUAL TRADING RESULTS. THERE ARE NUMEROUS OTHER FACTORS RELATED TO THE MARKETS IN GENERAL OR TO THE IMPLEMENTATION OF ANY SPECIFIC TRADING PROGRAM, WHICH CANNOT BE FULLY ACCOUNTED FOR IN THE PREPARATION OF HYPOTHETICAL PERFORMANCE RESULTS, ALL OF WHICH CAN ADVERSELY AFFECT ACTUAL TRADING RESULTS. The hypothetical performance results contained herein represent the application of the quantitative models as currently in effect on the date first written above, and there can be no assurance that the models will remain the same in the future or that an application of the current models in the future will produce similar results because the relevant market and economic conditions that prevailed during the hypothetical performance period will not necessarily recur. Discounting factors may be applied to reduce suspected anomalies. This backtest's return, for this period, may vary depending on the date it is run. Hypothetical performance results are presented for illustrative purposes only. In addition, our transaction cost assumptions utilized in backtests, where noted, are based on AQR Capital Management LLC's, ("AQR's") historical realized transaction costs and market data. Certain of the assumptions have been made for modeling purposes and are unlikely to be realized. No representation or warranty is made as to the reasonableness of the assumptions made or that all assumptions used in achieving the returns have been stated or fully considered. Changes in the assumptions may have a material impact on the hypothetical returns presented. Actual advisory fees for products offering this strategy may vary.

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 whether 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.

AQR Capital Management, LLC, is exempt from the requirement to hold an Australian Financial Services License under the Corporations Act 2001 (Cth). AQR Capital Management, LLC, is regulated by the Securities and Exchange Commission ("SEC") under the United States of America laws, which differ from Australian laws. Please note that this document has been prepared in accordance with SEC requirements and not Australian laws.

Canadian recipients of fund information: These materials are provided by AQR Capital Management (Canada), LLC, Canadian placement agent for the AQR funds.

Please note for materials distributed through AQR Capital Management (Asia): This presentation may not be copied, reproduced, republished, posted, transmitted, disclosed, distributed, or disseminated, in whole or in part, in any way without the prior written consent of AQR Capital Management (Asia) Limited (together with its affiliates, "AQR") or as required by applicable law.

This presentation and the information contained herein are for educational and informational purposes only and do not constitute and should not be construed as an offering of advisory services or as an invitation, inducement, or offer to sell or solicitation of an offer to buy any securities, related financial instruments, or financial products in any jurisdiction.

Investments described herein will involve significant risk factors, which will be set out in the offering documents for such investments and are not described in this presentation. The information in this presentation is general only, and you should refer to the final private information memorandum for complete information. To the extent there is any conflict between this presentation and the private information memorandum, the private information memorandum shall prevail.

The contents of this presentation have not been reviewed by any regulatory authority in Hong Kong. You are advised to exercise caution, and if you are in any doubt about any of the contents of this presentation, you should obtain independent professional advice.

The information set forth herein has been prepared and issued by AQR Capital Management (Europe), LLP, a UK limited liability partnership with its registered office at Charles House 5–11 Regent Street, London, SW1Y 4LR, which is authorized by the UK Financial Conduct Authority ("FCA").

AQR, a German limited liability company (Gesellschaft mit beschränkter Haftung; "GmbH"), is authorized by the German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, „BaFin") to provide the services of investment advice (Anlageberatung) and investment broking (Anlagevermittlung) pursuant to the German Banking Act (Kreditwesengesetz; "KWG"). The Complaint Handling Policy for German investors can be found here: https://ucits.aqr.com/.

Request ID: 319639

www.aqr.com