Risk Parity Strategy

Prepared Exclusively for the Employees' Retirement Fund of the City of Dallas

September 14, 2017

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AQR Capital Management, LLC
Two Greenwich Plaza
Greenwich, CT 06830
p: +1.203.742.3600 | w: aqr.com

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AQR Overview

AQR Presenters

Michael A. Mendelson

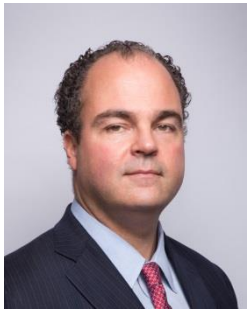
Principal, Portfolio Management

Michael is portfolio manager of AQR's risk parity strategies and a member of both the firm's strategic planning and risk committees. Prior to AQR, Michael was a managing director at Goldman Sachs & Co., where he founded the quantitative trading group. He has been a member of the Managed Funds Association's board of directors and Chairman of its Trading and Markets Committee and is currently Chairman of its Government Affairs Committee. Michael earned an S.B. in mathematics, an S.B. in management, an S.B. in chemical engineering and an S.M. in chemical engineering, all from the Massachusetts Institute of Technology, and an M.B.A. from the University of California at Los Angeles.

Gregor M. Andrade, Ph.D.

Principal, Client Strategies

Gregor runs AQR's international business development team, overseeing client relations in Europe, the Middle East, Asia, Australia and Latin America. Prior to joining AQR in 2003, Gregor was an assistant professor of finance at Harvard Business School after having worked as a mergers and acquisitions analyst at Wasserstein Perella. He is on the Advisory Council of the AQR Asset Management Institute at London Business School, has been published in academic journals and won an Amundi Smith Breeden Award for an article in The Journal of Finance. Gregor earned a B.S. in economics from the Massachusetts Institute of Technology and a Ph.D. in finance from the University of Chicago's Graduate School of Business.



Our Firm and Risk Parity

At a Glance

- AQR takes a systematic, research-driven approach to managing alternative and traditional strategies
- Our clients include institutional investors, such as pension funds, defined contribution plans, insurance companies, endowments, foundations, family offices and sovereign wealth funds, as well as RIAs, private banks and financial advisors
- The firm has 30 principals and 815 employees; nearly half of employees hold advanced degrees
- AQR is based in Greenwich, Connecticut, with offices in Boston, Chicago, Hong Kong, London, Los Angeles, and Sydney
- Approximately $194.9 billion in assets under management as of June 30, 2017*
  - AQR has managed Risk Parity strategies as a core business since 2006
  - We are one of the largest managers of Risk Parity

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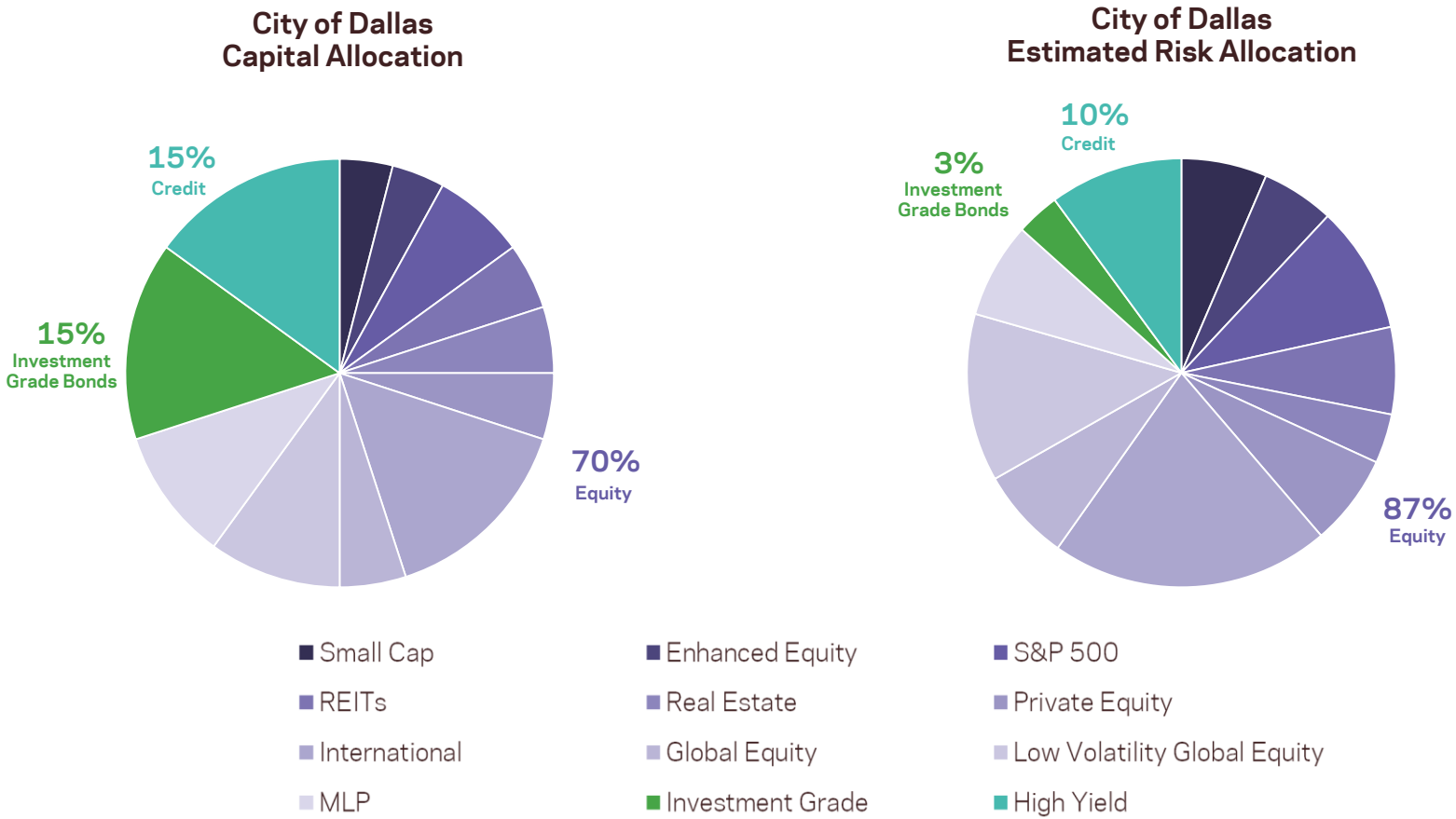
* Approximate as of 6/30/2017, includes assets managed by AQR and its advisory affiliates

Why Risk Parity?

Traditional Allocations Are Risk Concentrated…

Equity Risk Concentration Is a Primary Issue for Many Investors

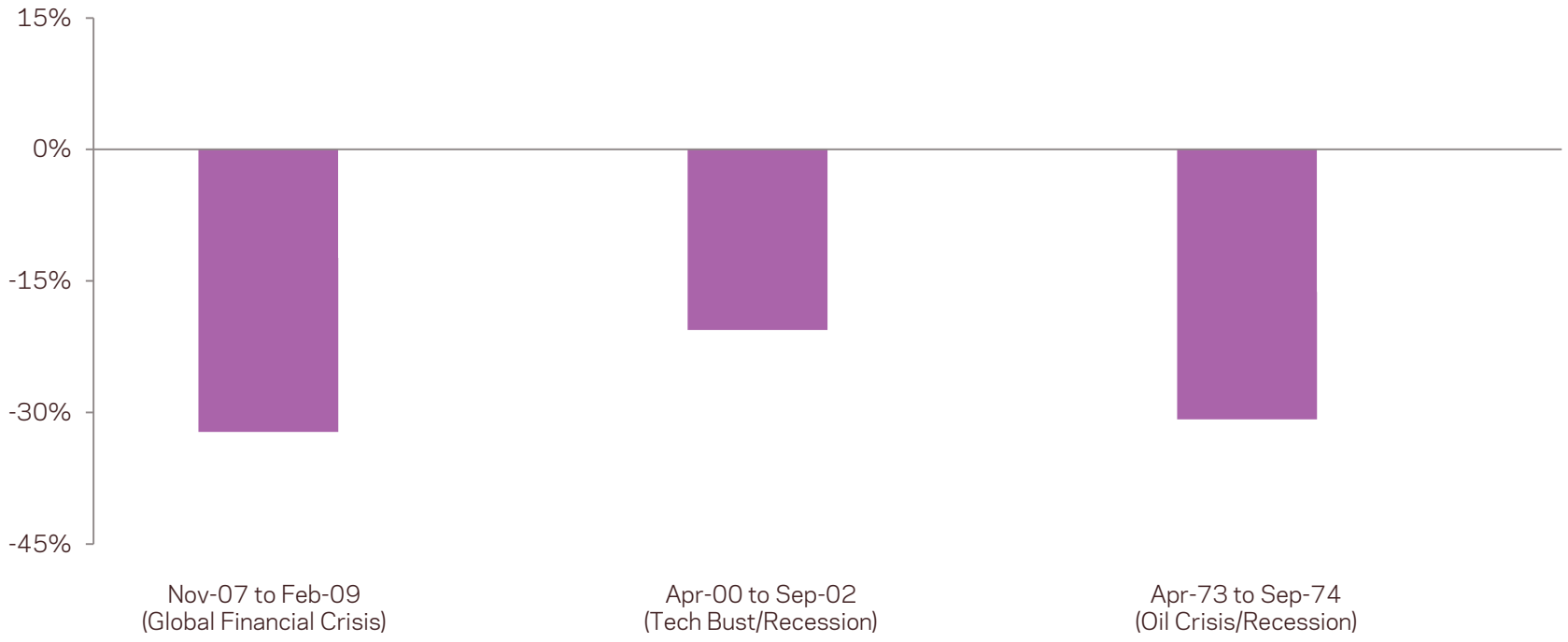


Sources: AQR, City of Dallas, Bloomberg, Barclays, Datastream, Alerian, Citibank, Bank of America, NAREIT, NCREIF, Cambridge. This analysis was performed at the specific request of City of Dallas. No representation is being made that any investment will achieve performance similar to those shown. All information is for educational and illustrative purposes only and not based on an actual portfolio AQR manages. Capital and Risk allocation charts are for illustrative purposes only and are intended to illustrate an asset class allocation and corresponding risk allocation/exposure. City of Dallas Estimated Risk Allocation is calculated based on volatility and correlation estimates from January 1972-December 2016. "Traditional Allocations" and "Traditional Portfolios" are defined as those with 60% equity exposure and 40% bond exposure by capital. Hypothetical data has inherent limitations, some of which are disclosed in the Appendix. Please read important disclosures in the Appendix.

...So Bad Times for the Economy and the Fund Can Coincide

When Stocks Fall, Traditional Portfolios Tend to Suffer

Global 60/40 during Worst 3 Drawdowns for Global Equities
January 1970 – December 2016



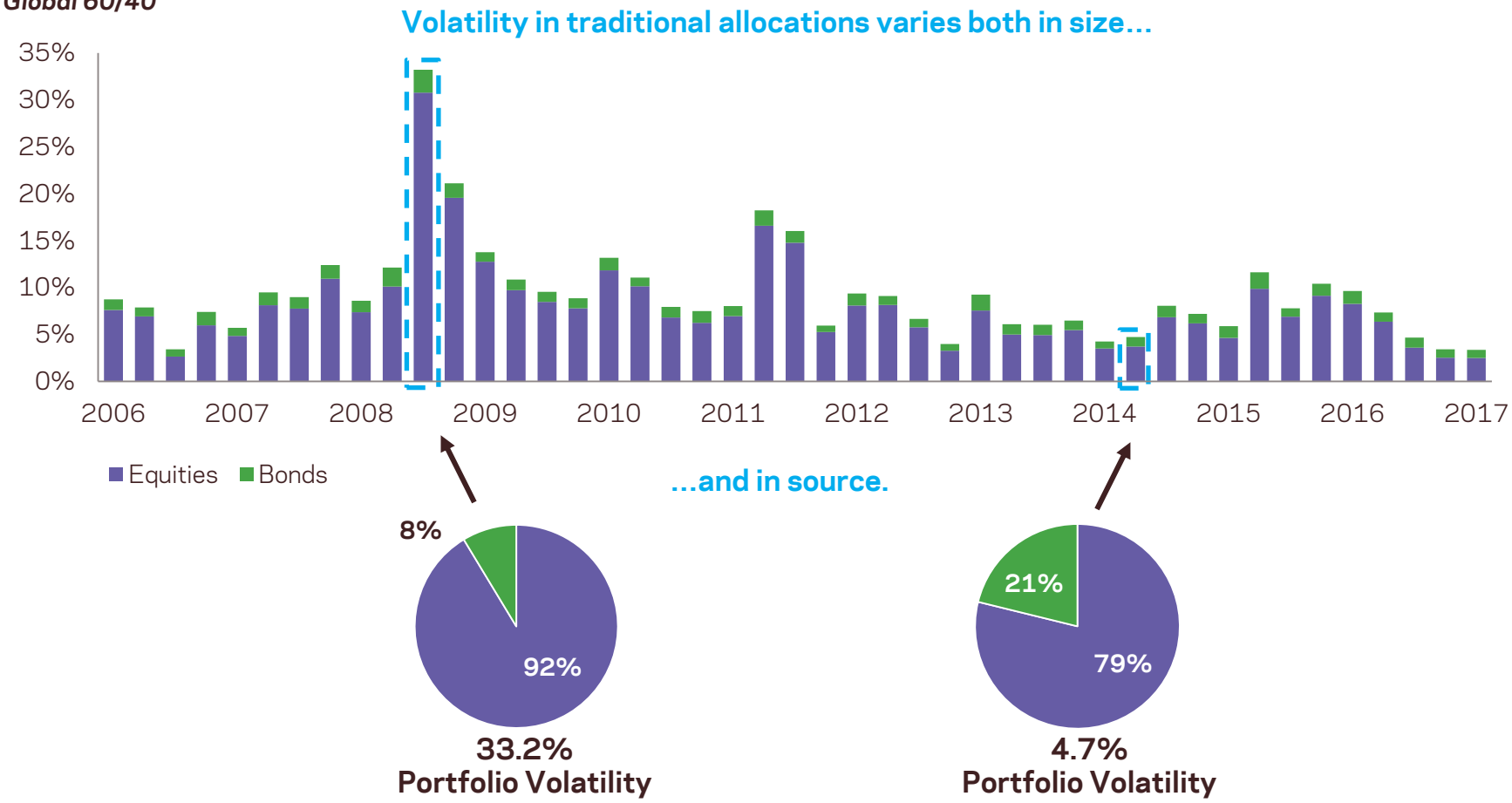
Source: AQR, Bloomberg. "Global Equities" here defined as the MSCI World Index. Global 60/40 Portfolio is based on 60% MSCI World Index and 40% Barclays Capital Global Aggregate Bond Index. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Traditional Portfolios Are Not Risk Targeted

Portfolio Volatility Levels and Risk Allocations Vary a Lot

Quarterly Realized Volatility

Global 60/40



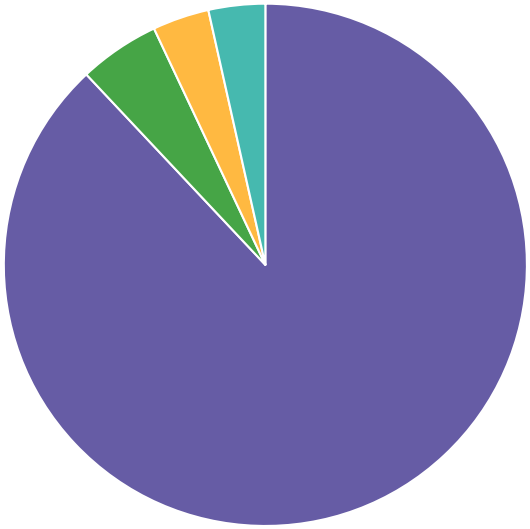
Source: AQR, Bloomberg. Data uses 3-day returns from January 1, 2006 to June 30, 2017. 60/40 Portfolio is based on 60% "Equities" (MSCI World Index) and 40% "Bonds" (Barclays Capital Global Aggregate Bond Index) by Capital Weight from January 1, 2006, through June 30, 2017. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Risk Parity Is Not Risk Concentrated...

Risk Parity Targets a Meaningful Allocation of Risk to Each Asset Class

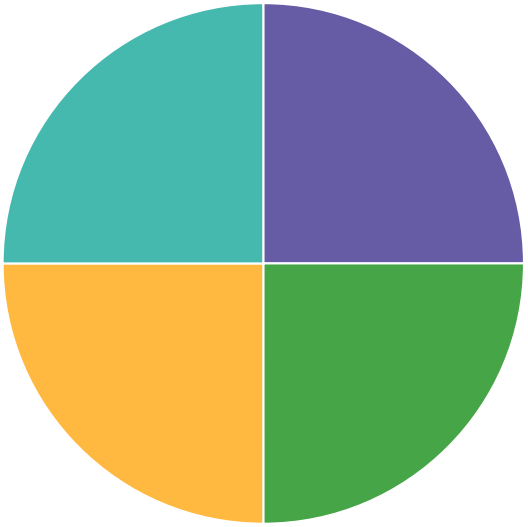
Risk Allocation

Traditional Portfolio



- Equities
- Bonds
- Inflation-Sensitive Assets
- Credit/Currencies

Example Risk Parity Portfolio

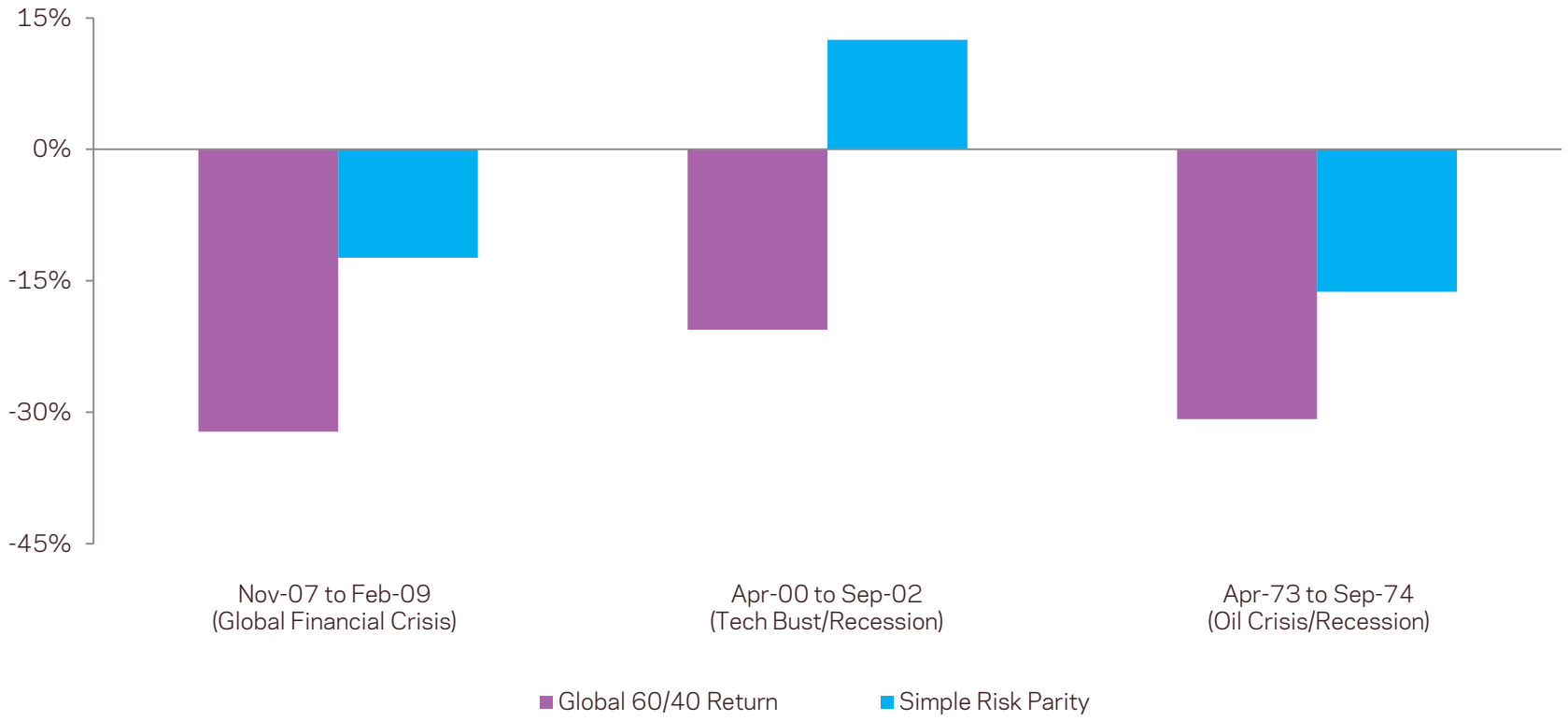


Source: AQR. Charts are for illustrative purposes only. The illustrative allocation above does not represent the actual allocation of any AQR client account, fund or strategy.

...So Risk Parity Returns Are Less Driven by Equity Markets

When Stocks Perform Poorly, Risk Parity Can Be a Diversifier

Global 60/40 and Simple Risk Parity Returns during Worst 3 Drawdowns for Global Equities
January 1970 – December 2016



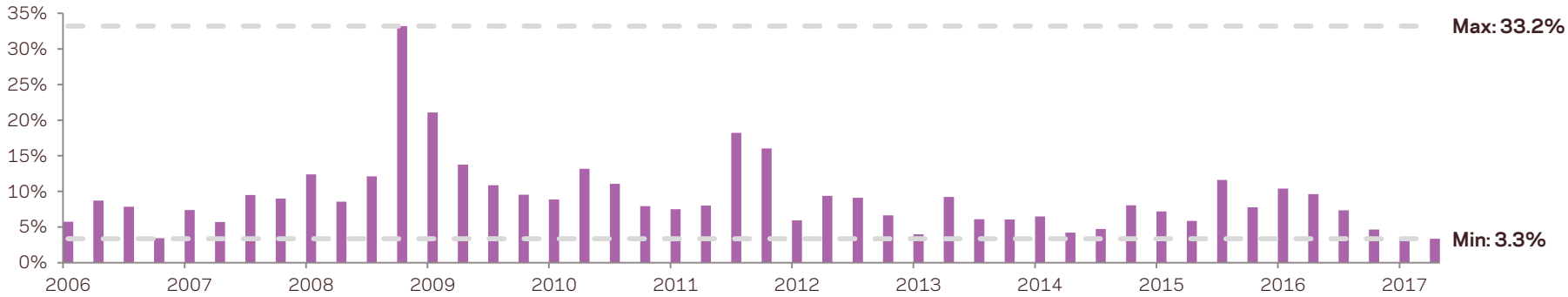
Source: AQR, Bloomberg. "Global Equities" here defined as the MSCI World Index. Global 60/40 Portfolio is based on 60% MSCI World Index and 40% Barclays Capital Global Aggregate Bond Index. Hypothetical Simple Risk Parity is constructed by AQR by allocating equal risk, rebalanced monthly, across three asset classes (equities, bonds and commodities) based on each asset class' previous 12 month realized volatility to target a total annualized portfolio volatility of 10%. Please see Appendix for detailed construction methodology. Please read important disclosures in the Appendix. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix.

Risk Parity Can Be Risk Managed

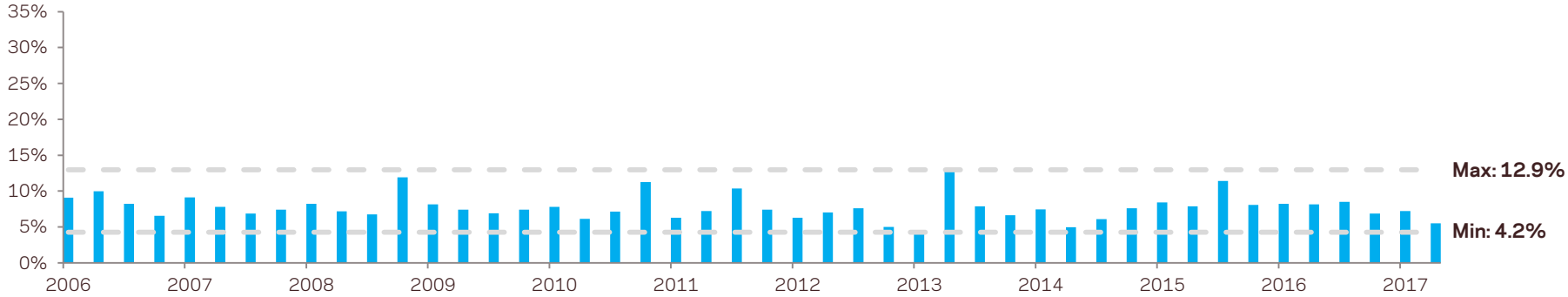
Which May Provide Steadier Portfolio Volatility and Risk Allocation

Quarterly Realized Volatility

Global 60/40



Simple Risk Parity Example (10% Volatility)



Source: AQR, Bloomberg, Morgan Markets, MSCI, Barclays Live, Datastream, Reuters, Markit, Credit Suisse, Citi Velocity. Data using 3-day returns, from January 1, 2006 to June 30, 2017. 60/40 Portfolio is based on 60% MSCI World Index and 40% Barclays Capital Global Aggregate Bond Index. The above example is based on a hypothetical 3-asset class risk parity strategy, which is not representative of an actual AQR strategy, and are for illustrative purposes only. The hypothetical asset class exposures are calculated using the volatility forecasts and volatility targets of three asset classes (developed equities, developed bonds and commodities). The volatility targets are sized using asset class correlation forecasts such that the risk contribution across asset classes is equal and the hypothetical strategy targets 10% annualized volatility, as asset class volatility forecasts evolve across the different periods, so do the exposures. The methodology used to calculate the asset class volatility and correlation forecasts are commensurate with those used in all AQR risk parity strategies, and the data reflects the historical data represented by the securities for the respective asset classes. Developed equities data includes the broad market-cap weighted indices which are sufficiently liquid to trade in each of the following countries/regions: Australia, Canada, France, Germany, Hong Kong, Italy, Japan, Netherlands, Spain, Switzerland, United Kingdom, United States, and continental Europe. Developed bonds data includes GDP-weighted government bonds from the following countries: Australia, Canada, Germany, Japan, United Kingdom, United States. Commodities data includes individual futures consistent with the weighting and composition of the Bloomberg Commodity Index. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Past performance is not a guarantee of future performance.

Key Reasons to Consider Risk Parity

A Commonly-Used Tool *within* Traditional Allocations

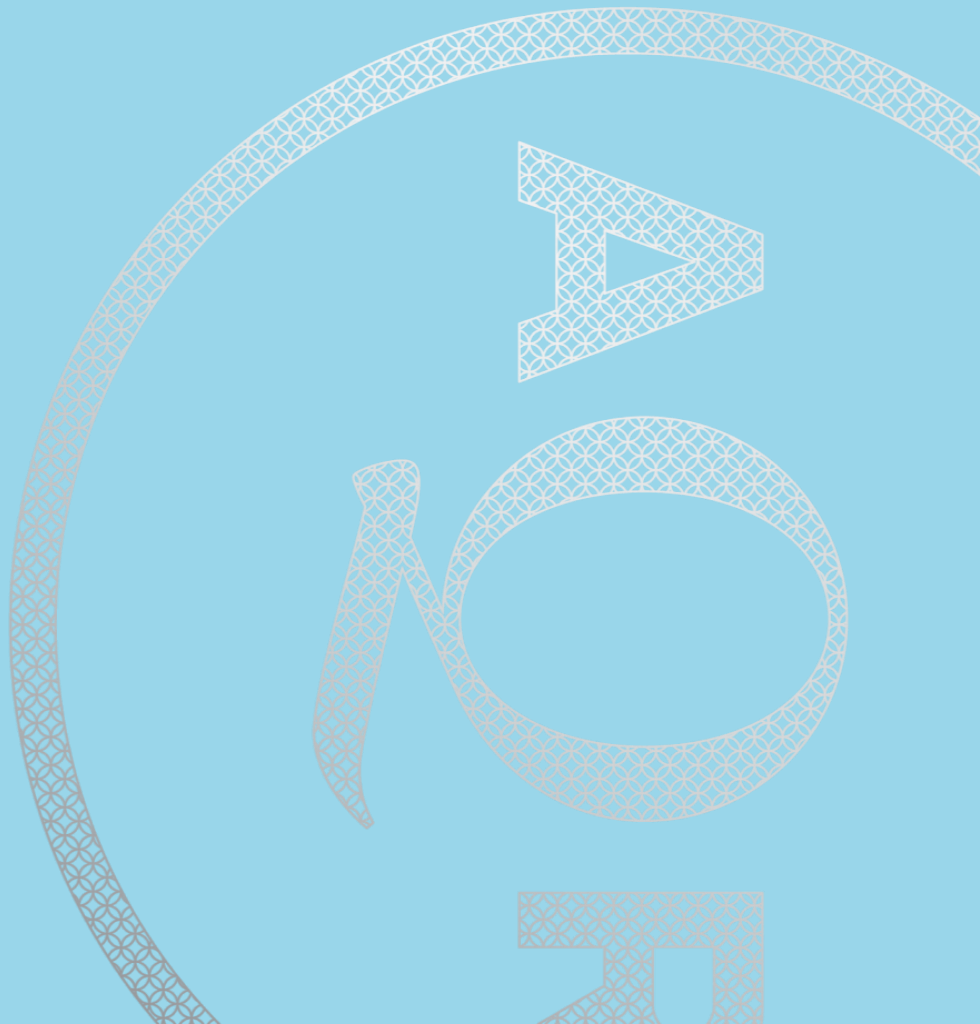
1. **Helps reduce equity risk concentration**

2. **Adds diversifying assets**

3. **Should improve the risk-adjusted return of a traditional portfolio**

Diversification does not eliminate the risk of experiencing investment losses. "Traditional Allocations" and "Traditional Portfolios" are defined as those with 60% equity exposure and 40% bond exposure by capital. Please read important disclosures in the Appendix.

The Roads to Risk Parity



There's More Than One Conceptual Framework for Risk Parity

The Parsimonious, the Statistical, and the Mechanistic

Minimum Assumption	Don't assume that any one asset class is "better" than another
Mean-Variance Optimization (MVO)	Perform mean-variance portfolio optimization without the no-leverage constraint
Environmental Balance	Balance portfolio performance across economic environments

Please read important disclosures in the Appendix.

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But Each Path Reaches the Same Destination

Different Concepts, All of Which Highlight the Value of Risk Balancing

Minimum Assumption

Environmental Balance

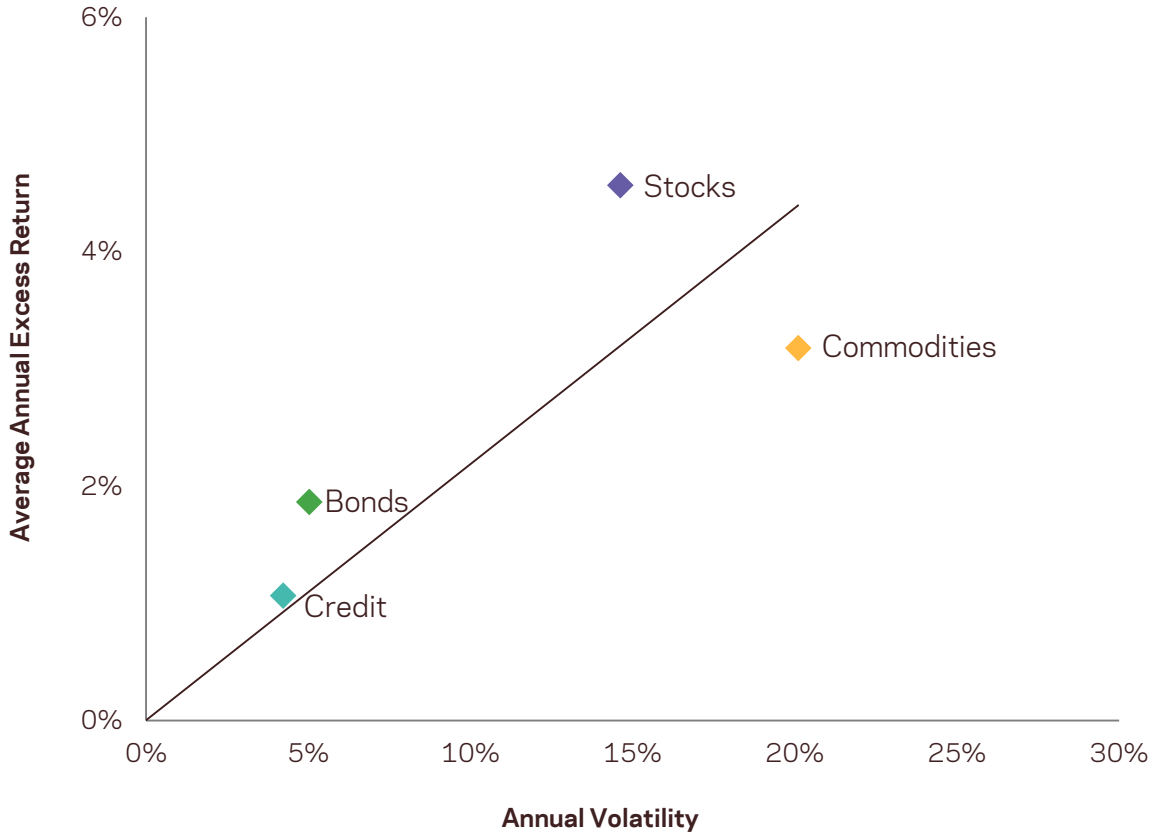
Mean-Variance Optimization

Source: AQR. For illustrative purposes only. Photo source: 123RF.

Minimum Assumption: Three Premises for Risk Parity

Risk-Adjusted Returns Are Similar, so Risk Allocations Should Be Too

Historical Asset Class Risk and Return Scatter Plot
January 1971 – June 2017

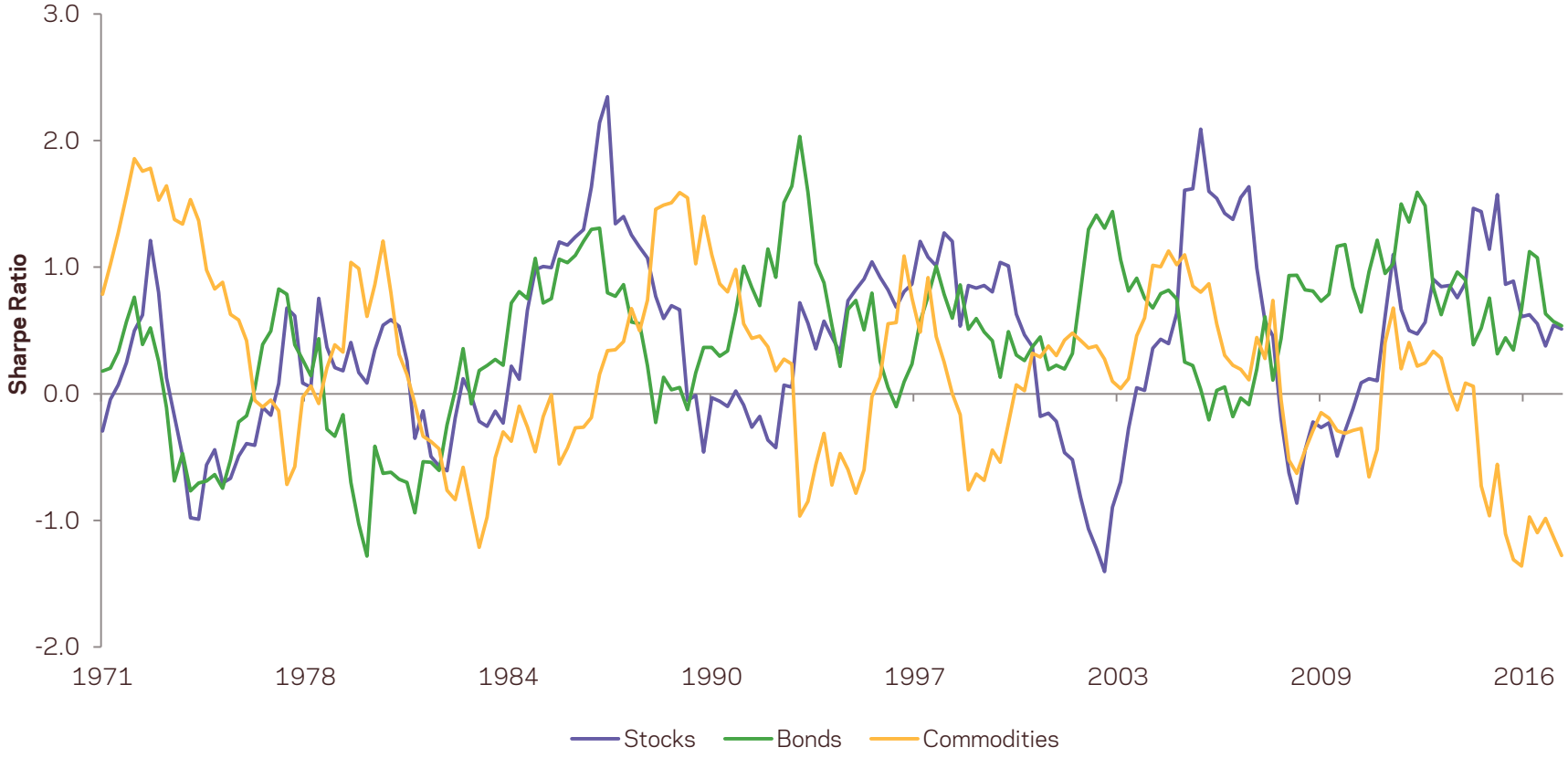


Source: AQR, Barclays Live, Bloomberg, Ibbotson Associates (Morningstar). Excess returns are in excess of cash proxied by the Merrill Lynch 3-Month T-Bill Index. Stocks are defined as the MSCI World Index. Bonds are defined as the Barclays Capital U.S. Government Index and, prior to 1973, the Ibbotson U.S. Intermediate Government Bond Index. Commodities are defined as the S&P GSCI Total Return Index. Credit is defined as the Barclays U.S. Corporate Index minus key-rate duration matched treasury returns and, prior to 1988, the Ibbotson's Long-term Corp Bond Index minus duration matched long-term government bonds total returns. Please read important disclosures in the Appendix.

Minimum Assumption: Three Premises for Risk Parity

Assets Pay Off at Different Times, so Diversification Has a Benefit

Rolling 3-Year Asset Class Sharpe Ratios
January 1971 – June 2017



Source: AQR, Barclays Live, Bloomberg, Ibbotson Associates (Morningstar). Stocks are defined as the MSCI World Index. Bonds are defined as the Barclays Capital U.S. Government Index and, prior to 1973, the Ibbotson U.S. Intermediate Government Bond Index. Commodities are defined as the S&P GSCI Total Return Index. The risk free rate is assumed to be the U.S. 3-month Treasury Bill in Sharpe ratio calculations. Please read important disclosures in the Appendix.

Minimum Assumption: Three Premises for Risk Parity

Market Timing Is Hard, so We Shouldn't Stray from Being Risk-Balanced

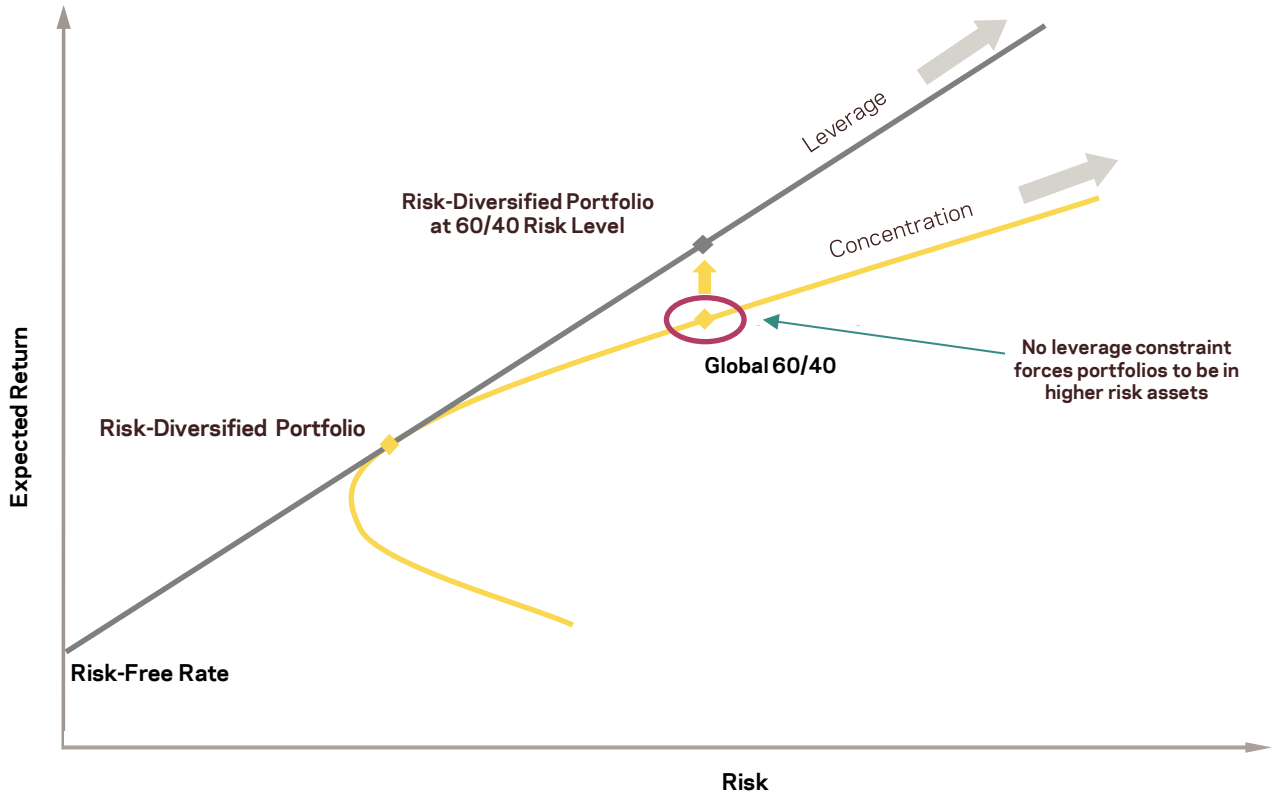
U.S. Treasury Historical 10-Year Yield versus Economists' Forecasts
January 1993 – June 2017

Source: AQR, Consensus Economics, Bloomberg. Economists' forecasts are based on linear extrapolation of beginning of 12 month forecast at the start of each calendar year. Estimate error in Economists' forecasts is the difference in yields. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Mean-Variance Optimization: Risk Parity Can Be "Optimal"

The Traditional No-Leverage Constraint Leads to Risk Concentration

Investors can seek to meet their risk/return objectives with large allocations to high risk assets, but may improve upon that by applying leverage to a lower risk, but higher risk-adjusted return portfolio

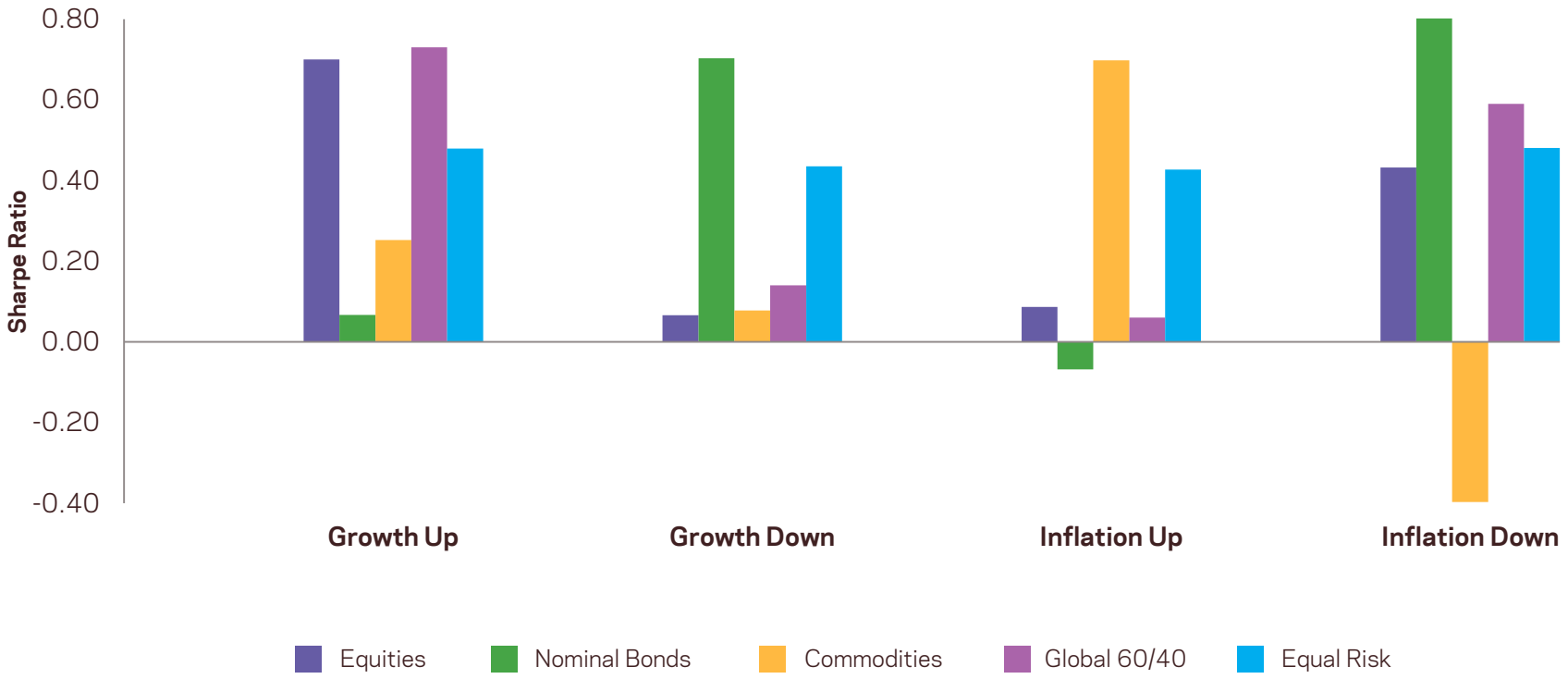


Source: AQR. Chart is for illustrative purposes only. Diversification does not eliminate the risk of experiencing investment losses.

Environmental Balance: Less Sensitive to Economic Conditions

Build a Portfolio More Resilient to Surprises in Growth and Inflation

Asset Class and Portfolio Risk-Adjusted Returns in Different Macro Environments
January 1972 – December 2016



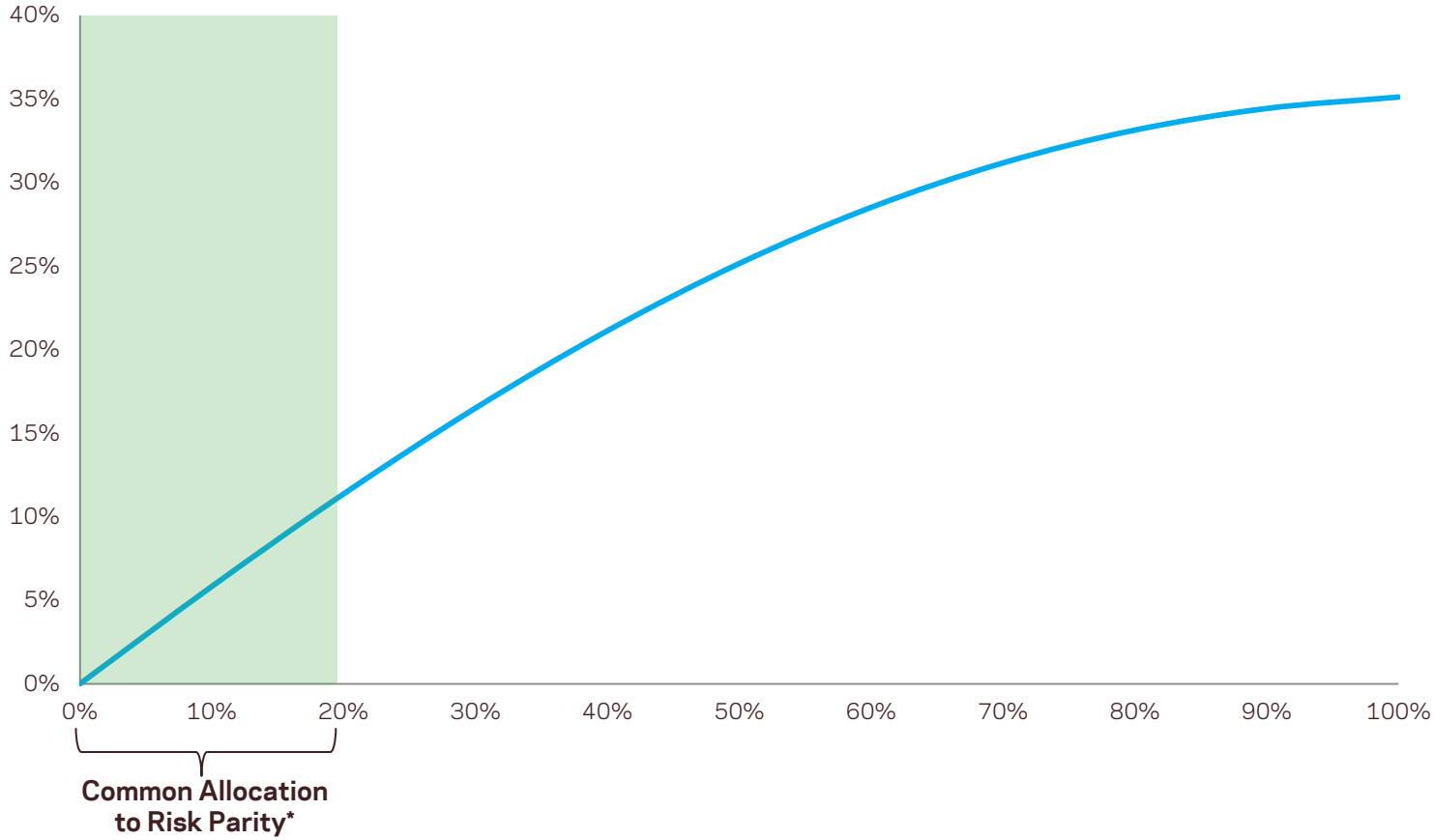
Source: AQR, Barclays Live, Bloomberg, Ibbotson Associates (Morningstar). The *Equal Risk Weight Strategy* is constructed by allocating equal risk, rebalanced monthly, across three asset classes based on the previous 12 month realized volatility to target a total annualized portfolio volatility of 10%. Stocks are defined as the MSCI World Index. Bonds are defined as the Barclays Capital U.S. Government Index and, prior to 1973, the Ibbotson U.S. Intermediate Government Bond Index. Commodities are defined as the S&P GSCI Total Return Index. The risk free rate is assumed to be the U.S. 3-month Treasury Bill in Sharpe ratio calculations. Global 60/40 Portfolio is based on 60% MSCI World Index and 40% Barclays Capital Global Aggregate Bond Index. Please see the Appendix for more details on the macroeconomic environmental indicators. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Adding Risk Parity to a Traditional Portfolio

Meaningful Expected Performance Benefits with Only Modest Allocations

Hypothetical Sharpe Ratio Improvement

Adding Risk Parity to a 60/40 Portfolio



Source: AQR. For illustrative purposes only. Expected Sharpe ratio improvement is based on a hypothetical equal risk contribution risk parity strategies, which consist of stocks, bonds, inflation-sensitive assets and, in the case of 4-asset class risk parity, credit. Assumptions are consistent with our long-term static asset class correlations and volatilities, and assert equal risk adjusted returns of 0.3 for each asset class. The traditional 60/40 portfolio consists of a hypothetical capital-weighted portfolio of 60% equities and 40% bonds. There is no guarantee, express or implied, that long-term return targets will be achieved. Realized returns may come in higher or lower than expected.

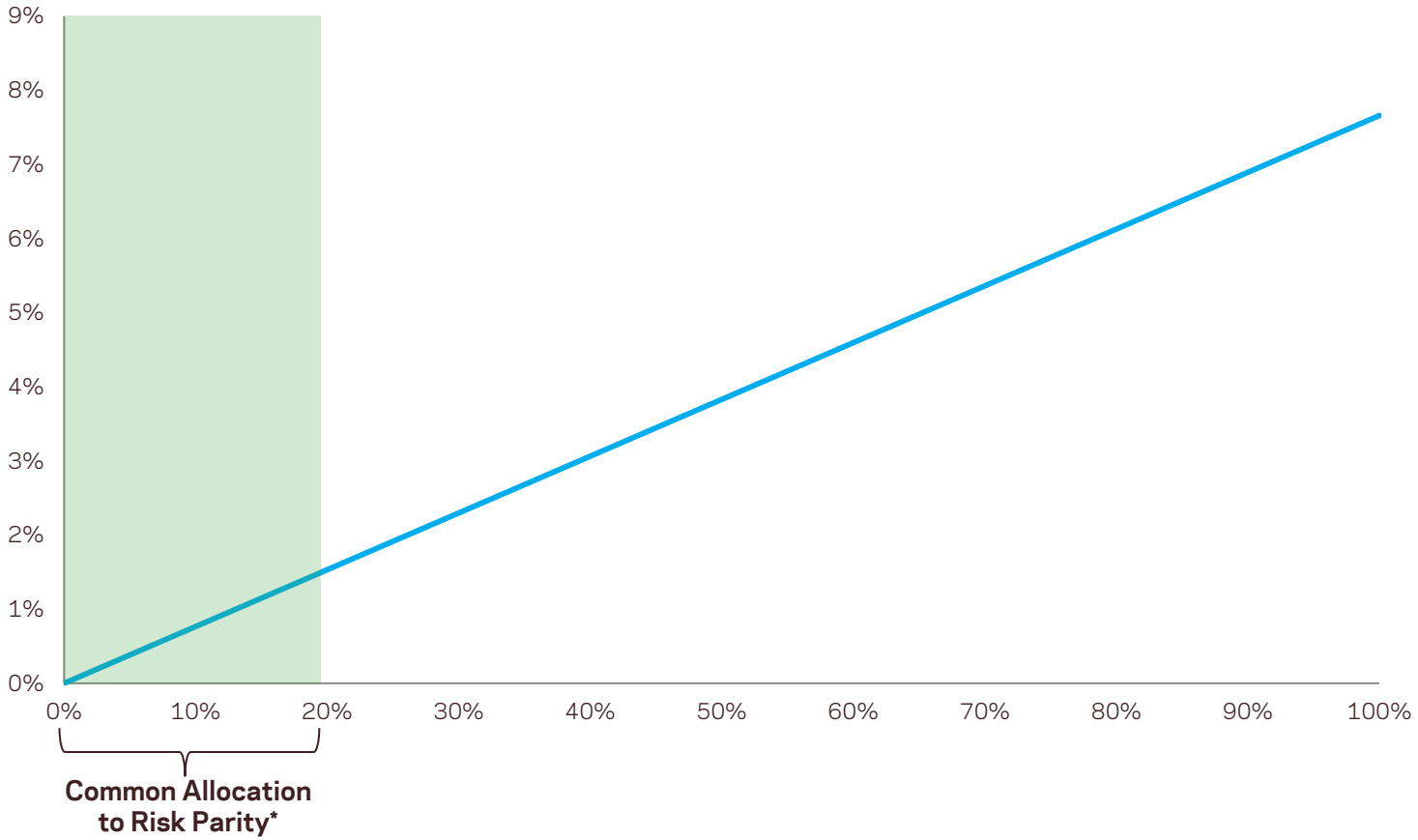
* Based on survey of top 30 clients from S&P Money Market Directories (MMD) as of December 31, 2015.

Adding Risk Parity to a Traditional Portfolio

But Expected Performance Improvement Comes with Tracking Error

Hypothetical Tracking Error to a 60/40 Portfolio

Adding Risk Parity to a 60/40 Portfolio



Source: AQR. For illustrative purposes only. Expected tracking error is based on a hypothetical equal risk contribution risk parity strategies, which consist of stocks, bonds, inflation-sensitive assets and, in the case of 4-asset class risk parity, credit. Assumptions are consistent with our long-term static asset class correlations and volatilities, and assert equal risk adjusted returns of 0.3 for each asset class. The traditional 60/40 portfolio consists of a hypothetical capital-weighted portfolio of 60% equities and 40% bonds. There is no guarantee, express or implied, that long-term return targets will be achieved. Realized returns may come in higher or lower than expected.

* Based on survey of top 30 clients from S&P Money Market Directories (MMD) as of December 31, 2015.

Investment Process

What Is in Risk Parity?

Risk Parity Is Diversified across and within Asset Classes

Instruments Used: Futures, Government Bonds, Swaps, and Currency Forwards

Equity Risk

Developed

Australia
Canada
Eurostoxx
France
Germany
Hong Kong
Italy
Japan
Netherlands
Spain
Switzerland
United Kingdom
United States

Mid Cap

United States

Small Cap

United States

Emerging

Brazil
China
India
Russia
South Africa
South Korea
Taiwan

Nominal Interest Rate Risk

Developed

Australia
Canada
Germany
Japan
United Kingdom
United States

Emerging

Czech Republic
Hong Kong
Hungary
Poland
Singapore
South Africa
South Korea

Inflation Risk

Inflation-Linked Bonds

France
Germany
United Kingdom
United States

Commodities

Aluminum
Brent Oil
Cocoa
Coffee
Copper
Corn
Cotton
Crude Oil
Feeder Cattle
Gas Oil
Gold
Heating Oil
KC Wheat
Lead
Lean Hogs
Live Cattle
Natural Gas
Nickel
Silver
Soybeans
Soy Meal
Soy Oil
Sugar
Unleaded Gas
Wheat
Zinc

Credit/Default Risk

Credit Spreads

Emerging Sovereign
Europe – High Yield
Europe – Investment Grade
North America – High Yield
North America – Investment Grade

Emerging Currencies

Brazil
China
Hungary
India
Mexico
Poland
South Africa
South Korea
Turkey

Diversification does not eliminate the risks of experiencing investment losses.

How Are Assets Weighted to Create "Risk Parity"?

Target Risk Exposures, Then Create the Positions Needed to Achieve Them

Volatility and Exposures Example for a 4-Asset Class Risk Parity

	Sample Asset Volatility Target		Volatility Forecast for Asset		Position Size as % of Strategy
Total Portfolio	10%				269%
Stock Weight	3.5%	÷	12.4%	=	28%
Bond Weight	4.6%	÷	5.2%	=	88%
Inflation Weight	3.6%	÷	6.8%	=	53%
Credit Weight	3.5%	÷	3.5%	=	100%

Risk forecasts can change frequently

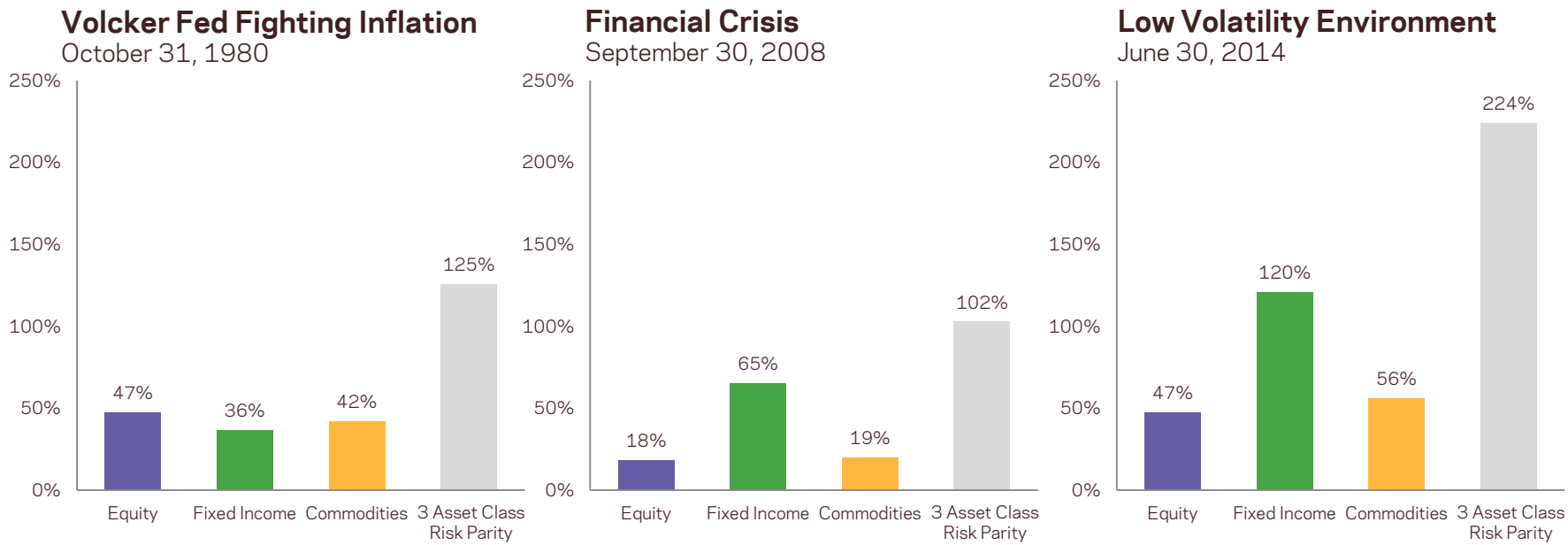
Asset class weights change as risk forecasts change

Source: AQR. Volatility targets, forecasts and position sizes are presented for illustrative, informational purposes. This chart is not intended to forecast or predict future events, but rather to demonstrate AQR's investment process. The illustrations above do not represent the actual or target volatility or allocation of any AQR client account, fund or strategy, and do not represent AQR's actual volatility forecast for any asset class.

In Some Risk Parity Strategies, Exposures Change over Time

A Changing Risk Environment May Induce Changes in Positioning

Hypothetical Exposures for 3 Asset Class Risk Parity Portfolio at 10% Volatility



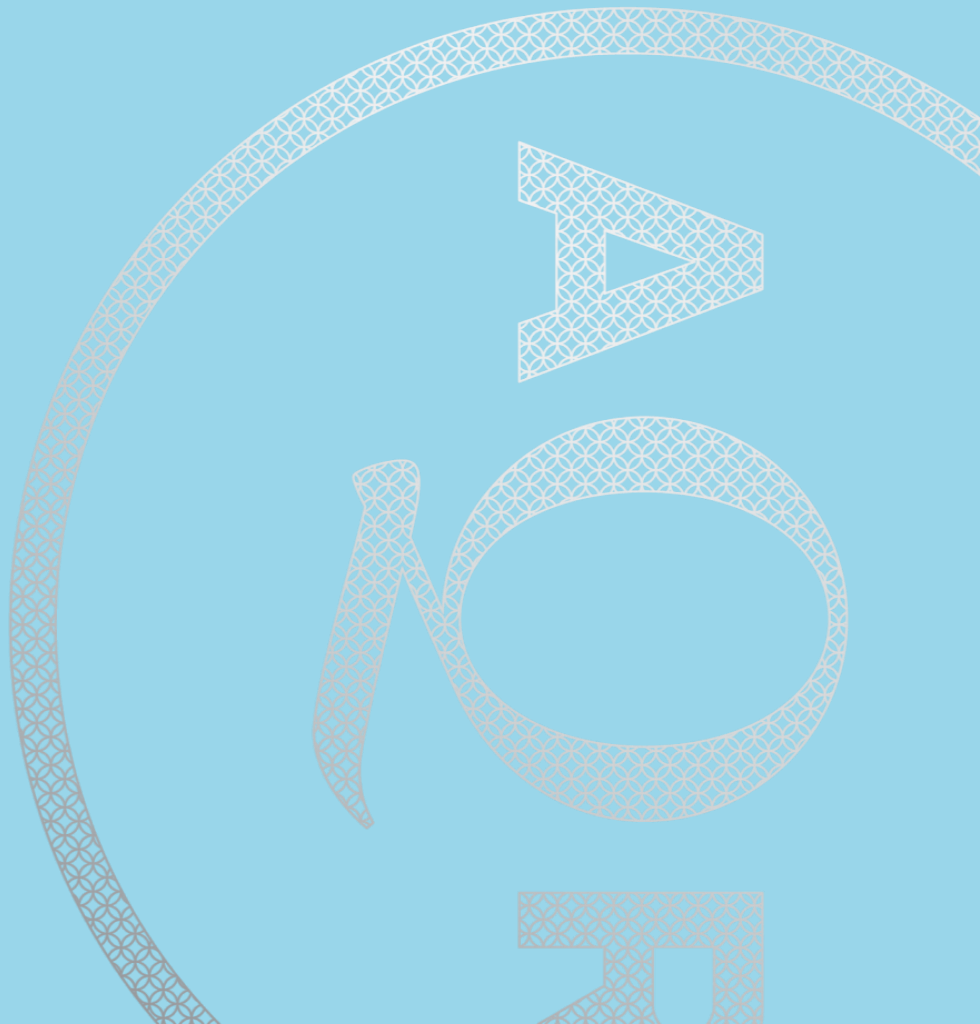
It's possible for bond volatility to be higher than equity volatility — and bond exposures to be relatively small

Risk spiked in the GFC, especially in equities and commodities, so all exposures could be much smaller, but bonds relatively less so

In a period of below average volatility, like mid-2014, exposures could be higher than average

Source: AQR. Morgan Markets, Bloomberg, MSCI, Barclays Live, Datastream, Reuters, Markit, Credit Suisse, Citi Velocity. The above exposure examples are based on a hypothetical 3-asset class risk parity strategy, which is not representative of an actual AQR strategy, and are for illustrative purposes only. The hypothetical asset class exposures shown are calculated using the volatility forecasts and volatility targets of three asset classes (developed equities, developed bonds and commodities). The volatility targets are sized using asset class correlation forecasts such that the risk contribution across asset classes is equal and the hypothetical strategy targets 10% annualized volatility, as asset class volatility forecasts evolve across the different periods, so do the exposures. The methodology used to calculate the asset class volatility and correlation forecasts are commensurate with those used in all AQR risk parity strategies, and the data reflects the historical data represented by the securities for the respective asset classes. Developed equities data includes the broad market-cap weighted indices which are sufficiently liquid to trade in each of the following countries/regions: Australia, Canada, France, Germany, Hong Kong, Italy, Japan, Netherlands, Spain, Switzerland, United Kingdom, United States, and continental Europe. Developed bonds data includes GDP-weighted government bonds from the following countries: Australia, Canada, Germany, Japan, United Kingdom, United States. Commodities data includes individual futures consistent with the weighting and composition of the Bloomberg Commodity Index. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix.

Risk Management Policies



Managing the Risk of Leverage

Risk Parity Should Be Designed to Make That Risk Manageable

Volatility target	Manage portfolio volatility to target a consistent level
Exposure limits	Employ sensible constraints to manage tail risk
Liquid holdings	Maintain a portfolio of liquid assets
Ample cash	Hold ample cash to maintain financing
Drawdown control	Have a plan for reducing risk targets if returns are very poor

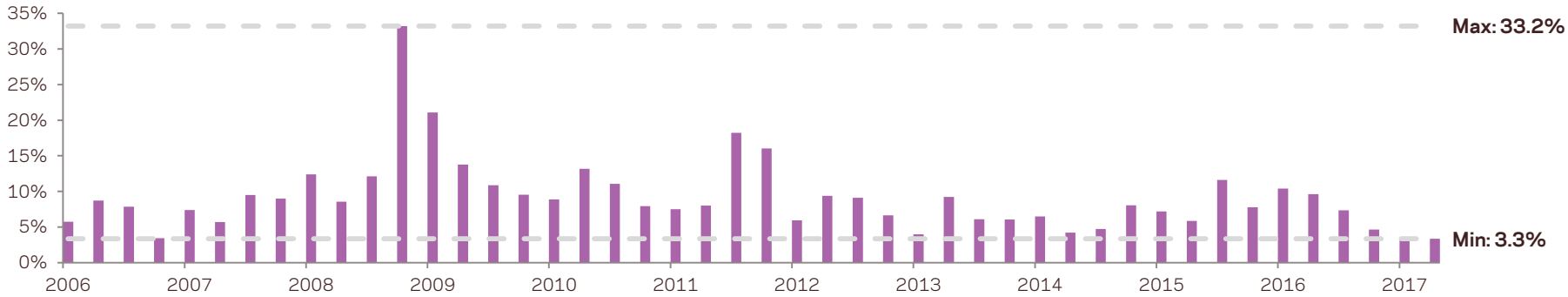
Please read important disclosures in the Appendix.

Managing the Risk of Leverage

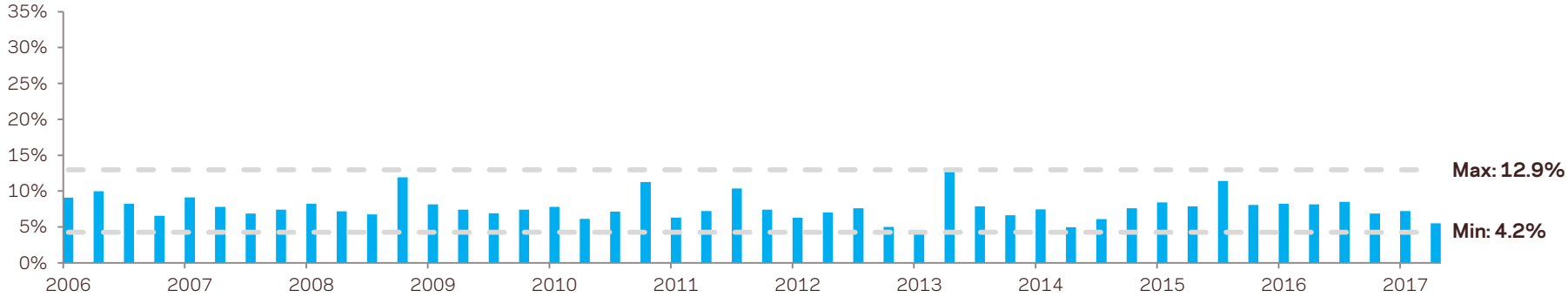
Risk Targeting Reduces the Likelihood of Realizing Very High Volatility

Quarterly Realized Volatility

Global 60/40



Simple Risk Parity Example (10% Volatility)



Source: AQR, Bloomberg, Morgan Markets, MSCI, Barclays Live, Datastream, Reuters, Markit, Credit Suisse, Citi Velocity. Data using 3-day returns, from January 1, 2006 to June 30, 2017. 60/40 Portfolio is based on 60% MSCI World Index and 40% Barclays Capital Global Aggregate Bond Index. The above example is based on a hypothetical 3-asset class risk parity strategy, which is not representative of an actual AQR strategy, and are for illustrative purposes only. The hypothetical asset class exposures are calculated using the volatility forecasts and volatility targets of three asset classes (developed equities, developed bonds and commodities). The volatility targets are sized using asset class correlation forecasts such that the risk contribution across asset classes is equal and the hypothetical strategy targets 10% annualized volatility, as asset class volatility forecasts evolve across the different periods, so do the exposures. The methodology used to calculate the asset class volatility and correlation forecasts are commensurate with those used in all AQR risk parity strategies, and the data reflects the historical data represented by the securities for the respective asset classes. Developed equities data includes the broad market-cap weighted indices which are sufficiently liquid to trade in each of the following countries/regions: Australia, Canada, France, Germany, Hong Kong, Italy, Japan, Netherlands, Spain, Switzerland, United Kingdom, United States, and continental Europe. Developed bonds data includes GDP-weighted government bonds from the following countries: Australia, Canada, Germany, Japan, United Kingdom, United States. Commodities data includes individual futures consistent with the weighting and composition of the Bloomberg Commodity Index. Hypothetical performance results have certain inherent limitations, some of which are disclosed in the Appendix. Past performance is not a guarantee of future performance.

Managing the Risk of Leverage

Enforce Exposure Limits

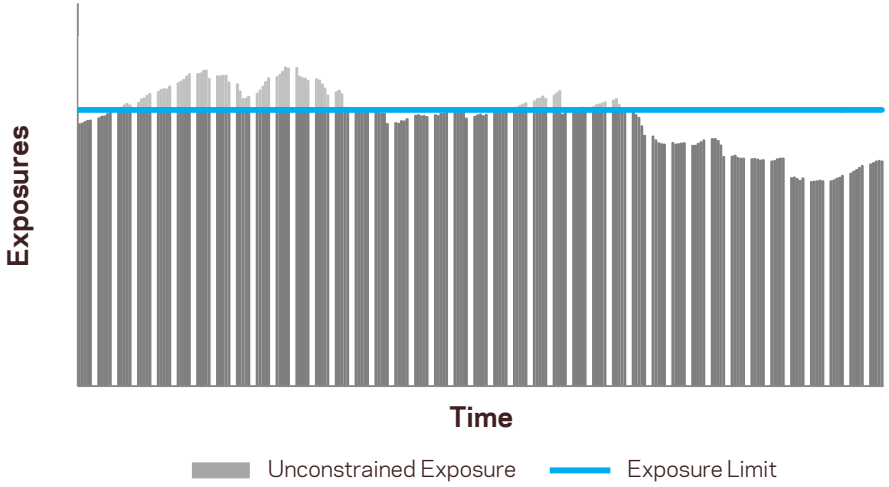
Exposures should be capped because risk levels can jump

Asset class exposure limits should be established to mitigate the risks of leverage and fat-tailed return distributions

- Stress tests are useful for setting position limits
- We believe it is best to make position limits independent of risk forecasting process

Further limitations, like a portfolio-wide exposure limit also may be useful

Illustrative Exposure Limits



Source: AQR. The illustrative chart above does not represent the actual or target exposures of any AQR client account, fund or strategy, or that of any other adviser. Please read important disclosures in the Appendix.

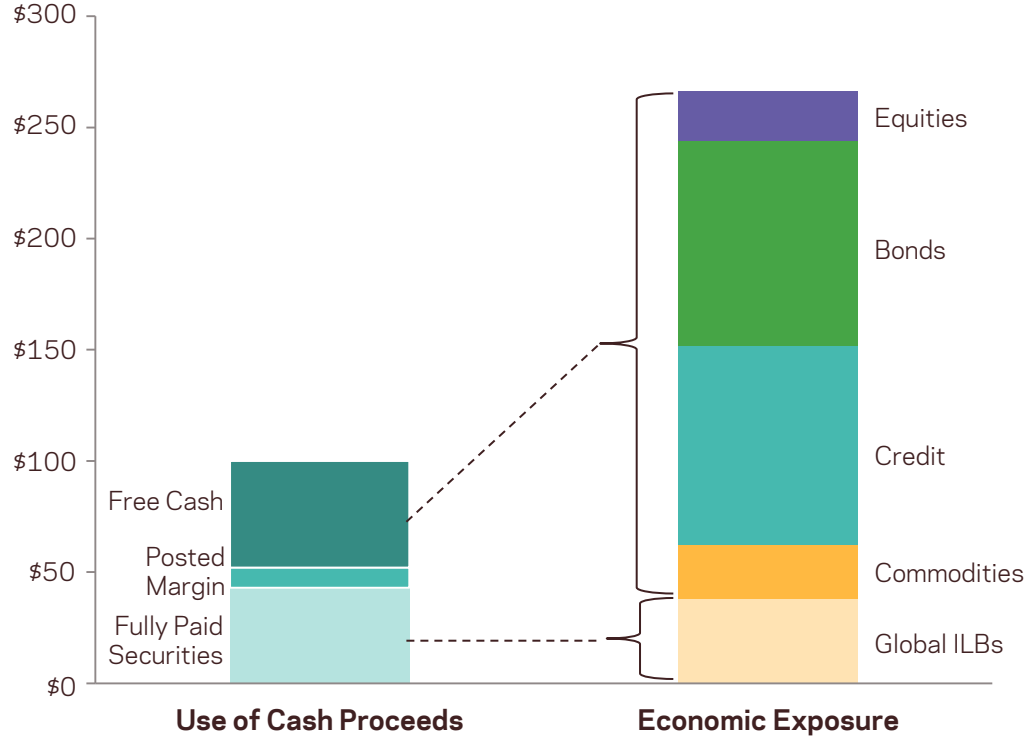
Managing the Risk of Leverage

High Levels of Cash, Even Though RP Portfolios Are "Fully Invested"

Detailed Breakdown of Sample Cash Usage

Net Asset Value	**$100**
Fully Paid Securities	**$43**
Posted Margin	**$7**
Futures Exchange	$5
OTC Counterparty	$2
Free Cash	**$50**
Money Market Funds	$36
U.S. Treasury Bills	$13
Deposits	$1

Sample Risk Parity Notional Exposures and Cash Usage
For Sample 10% Target Volatility Portfolio



Source: AQR. Charts are for illustrative purposes only and are not based on an actual portfolio AQR manages. This simulated portfolio targets an equal amount of volatility from each asset class every month. Hypothetical data has inherent limitations, some of which are disclosed in the Appendix hereto.

Managing the Risk of Leverage

Risk Parity Funds Can Employ a Systematic Drawdown Control Process

We believe that portfolio risk management should reflect the reality that investor risk aversion often increases as wealth declines

When faced with large losses, we prefer a pre-planned approach to controlling risk and declining risk tolerance that gradually reduces total portfolio risk target as loss "triggers" are hit

Process should be designed to be transparent, explicit, and as objective as possible

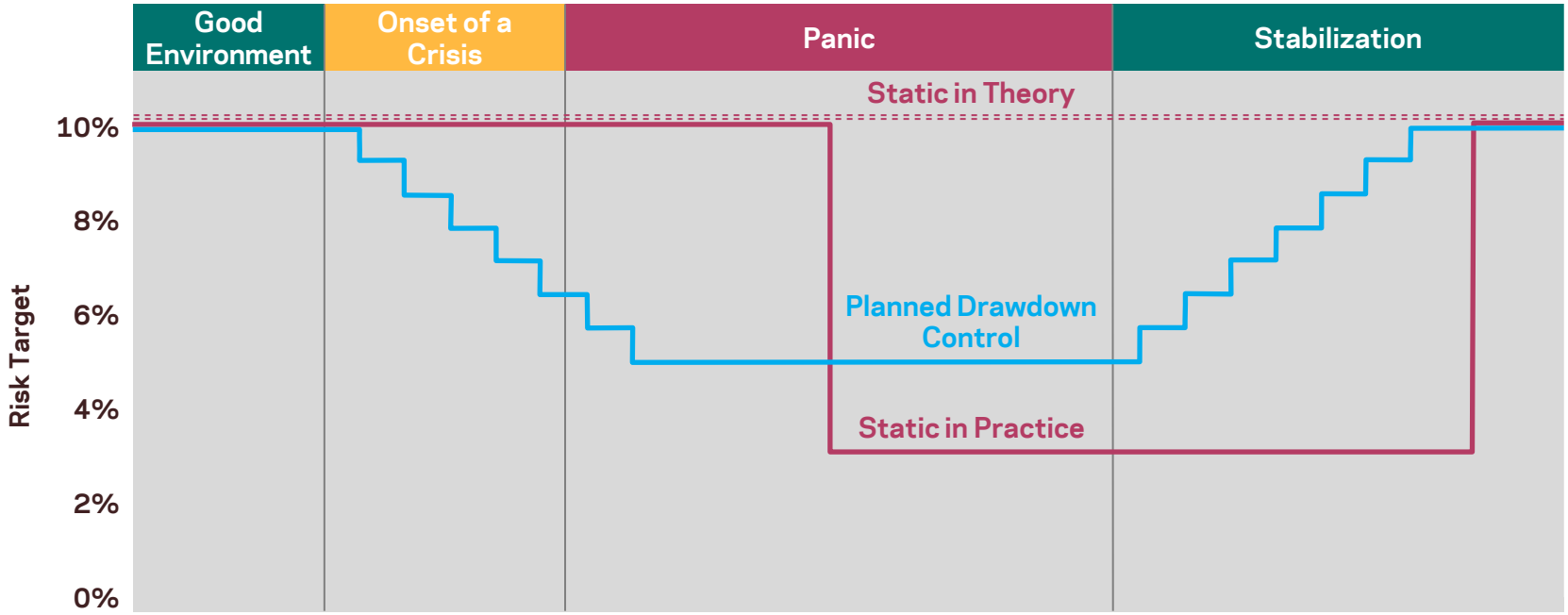
Source: AQR. A drawdown control policy may not always be successful at controlling risk or limiting portfolio losses. Investment process is subject to change at any time. Please read important disclosures in the Appendix.

Managing the Risk of Leverage

Risk Parity Funds Can Employ a Systematic Drawdown Control Process

Under substantial stress, investor risk tolerance will be reduced — it's best to have a process to manage this

Two Types of Risk Management in a Crisis



Source: AQR. For illustrative purposes only. A drawdown control policy may not always be successful at controlling risk or limiting portfolio losses. Please read important disclosures in the Appendix.

Benchmarking Risk Parity and the Sources of Performance Differences

Benchmarking Risk Parity

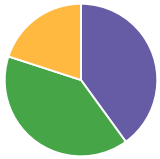
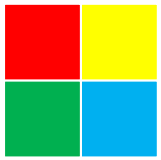
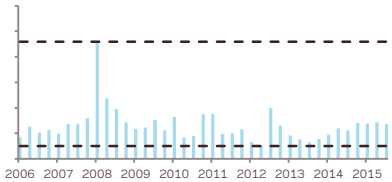
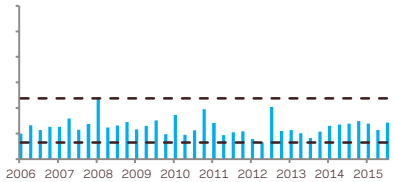
A Nagging Problem for Investors

	Traditional Allocation (e.g. 60/40)	Cash + 5%	Leveraged Risk-Balanced Index	Risk Parity Peer Index
Purpose	Opportunity cost	Absolute return	Comparison to a long-term risk-balanced portfolio	Peer comparison
Pros	Investible and well understood	Long-term comparison to return goals	Measures manager value added	Measures manager relative performance
Cons	Tracking error too high for useful comparisons	Not investible, unrealistic return without risk	Leveraged benchmark without an accepted standard for risk parity	Doesn't address most common investor questions
Expectations vs. Benchmark (10% volatility)	Approx. 0.15 Sharpe ratio improvement with 7%-9% tracking error	Expected returns similar, but with 10% tracking error	Similar expected returns with moderate tracking error	Similar expected returns with moderate tracking error

Source: AQR. The assumptions used to express these views are subject to change and there is no guarantee, express or implied, that long-term return and/or volatility expectations will be achieved.

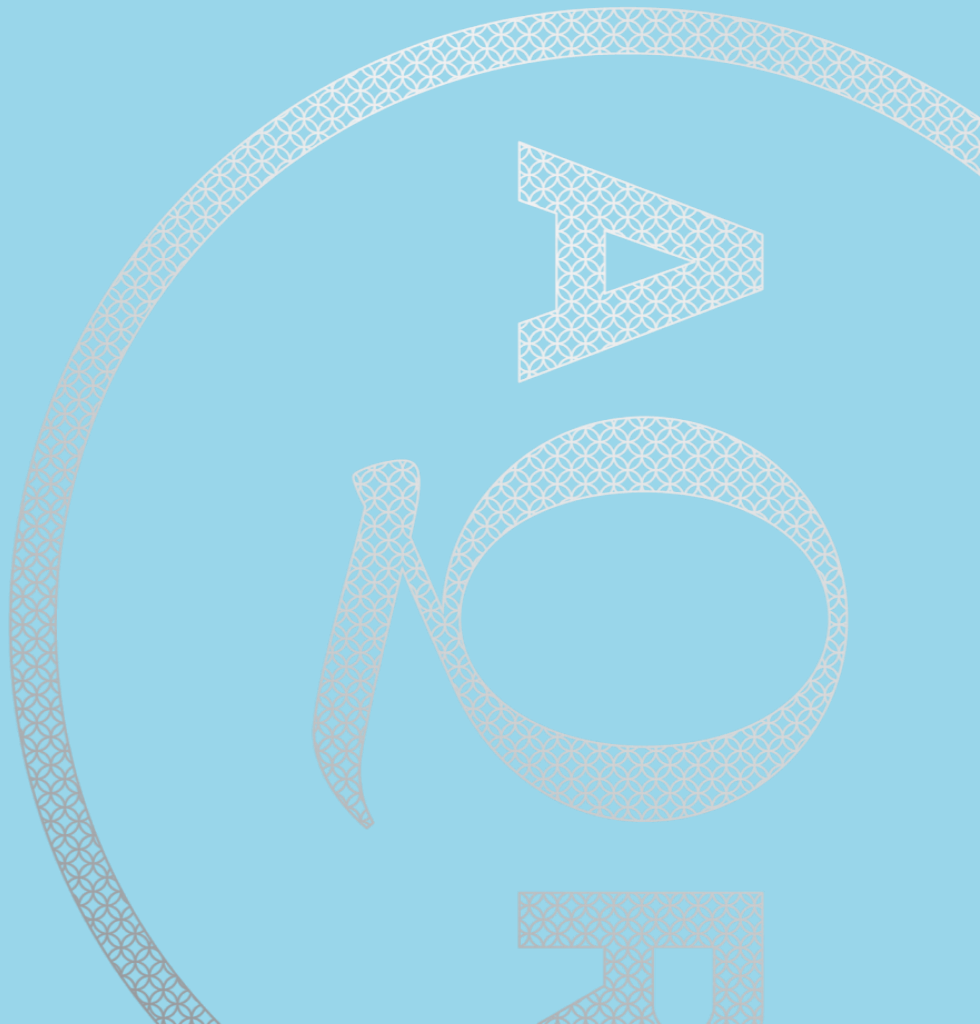
Design Choices Can Lead to Large Return Gaps in Any Year

Many "Flat-Surface" Decisions Create Short- to Medium-Term Noise

Design Pillars	Design Choices		
Allocation across Asset Classes	Equal Risk Contribution	Not-Quite-Balanced Risk Allocation 	Balanced across Economic Environments 
Allocation within Asset Classes	Market-Cap-Weighted • Market index weighted	Alternative Weighting • GDP weighted • Risk weighted • Valuation weighted	Liquidity-Weighted • Production weighted • Trading-volume weighted
Risk Targeting	Static Risk Model 	Dynamic Risk Model 	

Source: AQR. Charts are for illustrative purposes only and are not based on an actual portfolio AQR manages.

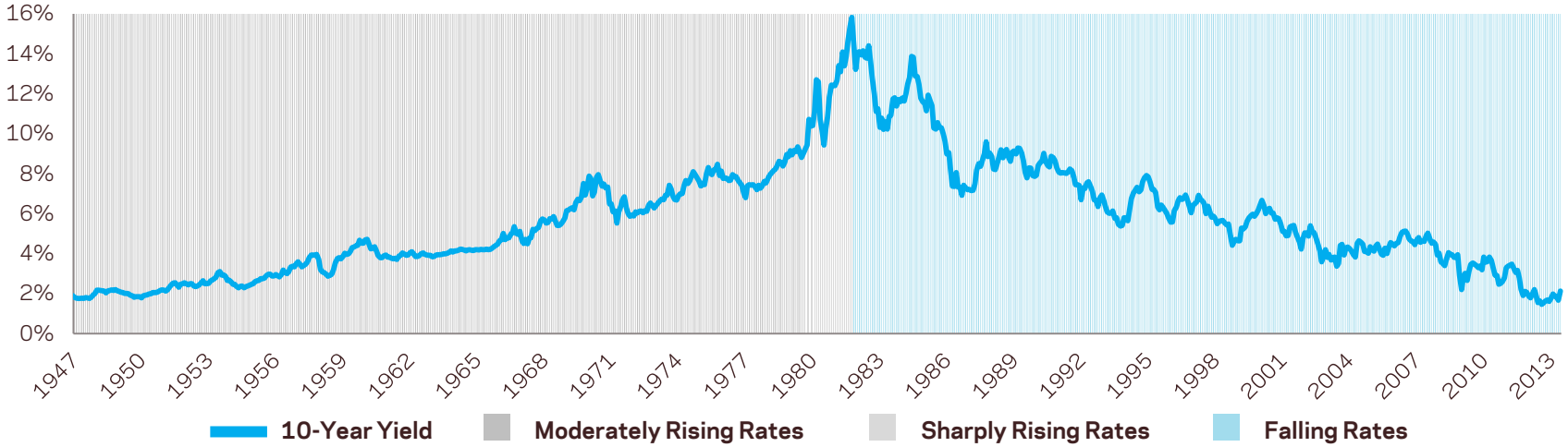
A Study of Risk Parity in a Historical Rising Rate Environment



Simple Risk Parity in a Rising Rate Environment

How Might Risk Parity Perform in a Sustained Rising Rate Environment?

Yield on a 10-Year U.S. Treasury Note



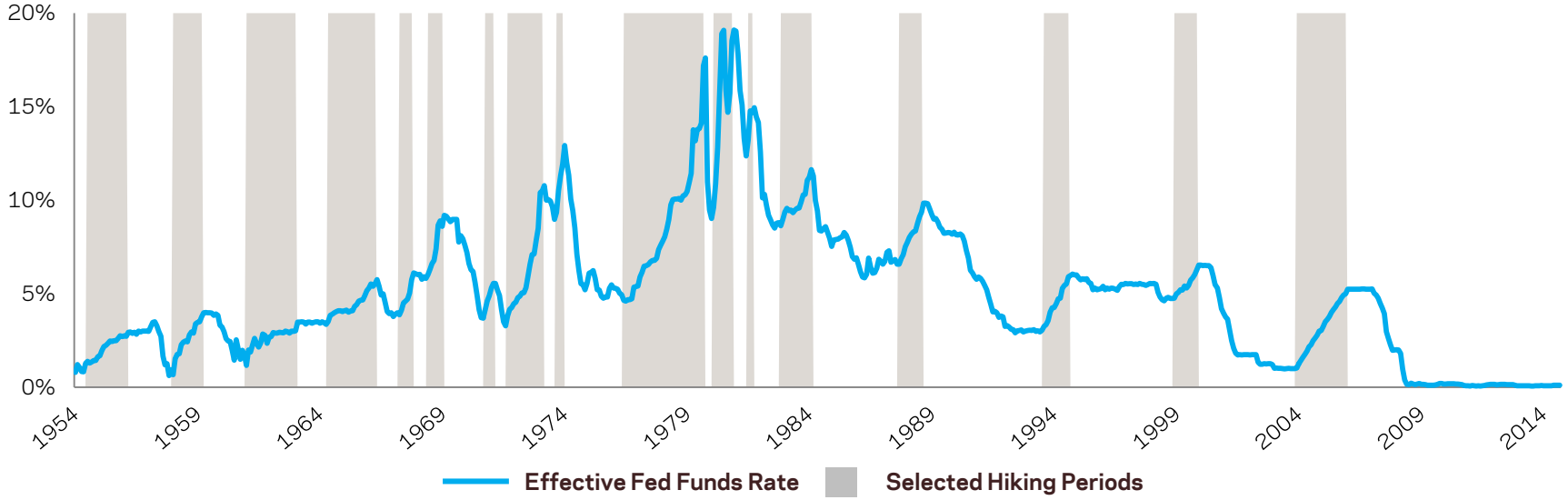
	Total Annualized Gross Returns			Sharpe Ratios		
	60/40 U.S.	60/40 Global	Risk Parity	60/40 U.S.	60/40 Global	Risk Parity
By Subperiod:						
Rising Rates: *1947–1981*	7.8%	8.0%	10.9%	**0.38**	**0.49**	**0.62**
▪ Moderately Rising Rates: *August 1947–September 1979*	8.0%	8.2%	11.9%	0.47	0.63	0.80
▪ Sharply Rising Rates: *October 1979–September 1981*	4.9%	3.8%	-5.6%	-0.65	-0.83	-1.26
Falling Rates: *1981–2013*	10.8%	9.7%	13.9%	0.62	0.52	0.97
Full Sample	9.3%	8.8%	12.3%	**0.50**	**0.50**	**0.77**

Source: AQR. Data from August 1947-June 2013. Simple Risk Parity is constructed by AQR by allocating equal risk, rebalanced monthly, across three asset classes (stocks, bonds and commodities) based on each asset class' previous 12 month realized volatility to target a total annualized portfolio volatility of 10%. Please see the Appendix for more details regarding the asset class construction. Global 60/40 is based a 60% monthly exposure to GDP-weighted global equities prior to 1970 and the MSCI World Index thereafter and a 40% monthly exposure to GDP-weighted global USD hedged bonds as defined in the Appendix. The risk free rate is assumed to be the U.S. 3-month Treasury Bill in Sharpe ratio calculations. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Simple Risk Parity in a Rising Rate Environment

How Might Risk Parity Perform When the Fed Raises Interest Rates?

Effective Fed Funds Rate over Various Selected Policy Cycles



	Total Annualized Gross Returns			Sharpe Ratios*		
	60/40 U.S.	60/40 Global	Risk Parity	60/40 U.S.	60/40 Global	Risk Parity
Month of First Hike	-0.6%	6.5%	-0.6%	-0.64	0.39	-0.51
6 Months Before First Hike	7.2%	6.7%	9.1%	**0.89**	**0.88**	**1.05**
6 Months Beginning with First Hike*	1.0%	1.9%	3.2%	**-0.43**	**-0.24**	**0.15**

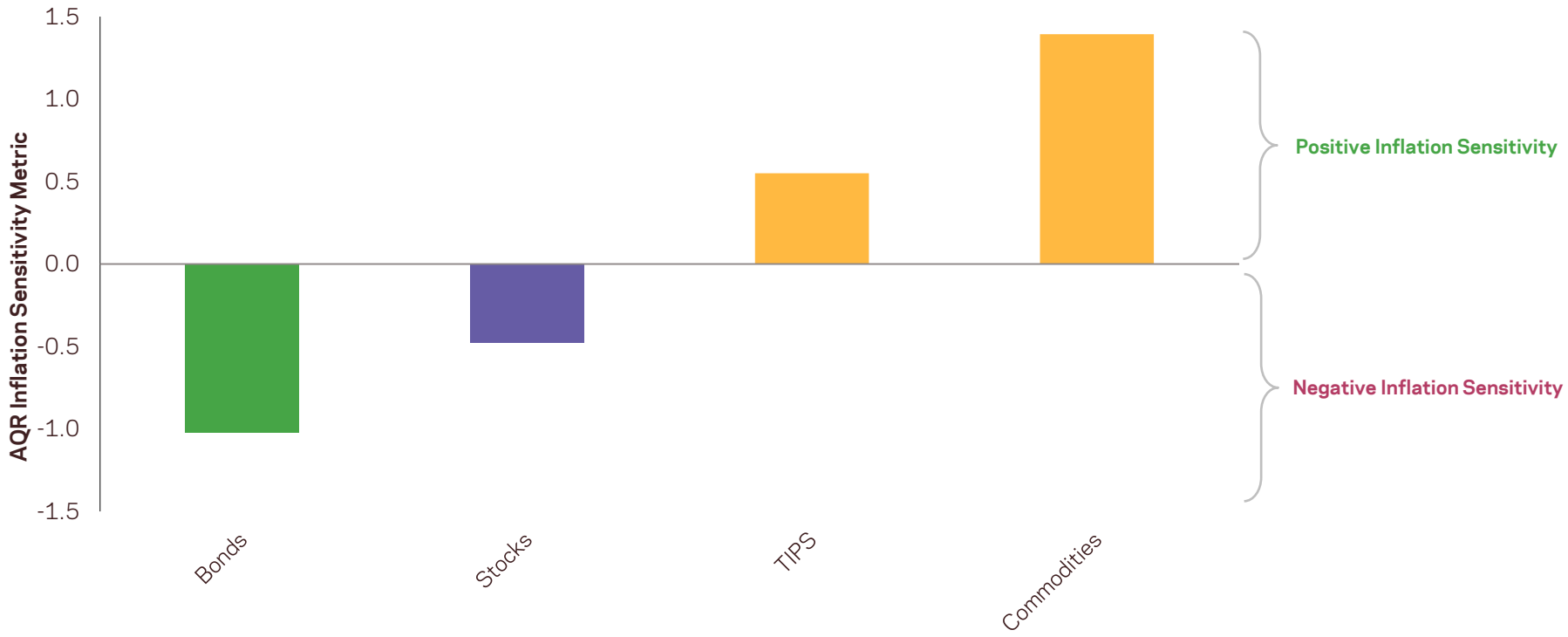
Source: AQR, Federal Reserve Economic Data. * Annualized Sharpe ratios. ** 6 Months After First Hike data is inclusive of the Month of First Hike. Data from July 1954-March 2015. Simple Risk Parity is constructed by AQR by allocating equal risk, rebalanced monthly, across three asset classes (stocks, bonds and commodities) based on each asset class' previous 12 month realized volatility to target a total annualized portfolio volatility of 10%. Please see the Appendix for more details regarding the asset class construction. Global 60/40 is based a 60% monthly exposure to GDP-weighted global equities prior to 1970 and the MSCI World Index thereafter and a 40% monthly exposure to GDP-weighted global USD hedged bonds as defined in the Appendix. The risk free rate is assumed to be the U.S. 3-month Treasury Bill in Sharpe ratio calculations. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Risk Parity in Perspective

Risk Parity in Perspective

Commodities Have Hurt, but Investors Need the Inflation Sensitivity

Inflation Sensitivity to Stocks, Bonds, TIPS, and Commodities
January 1970-March 2017

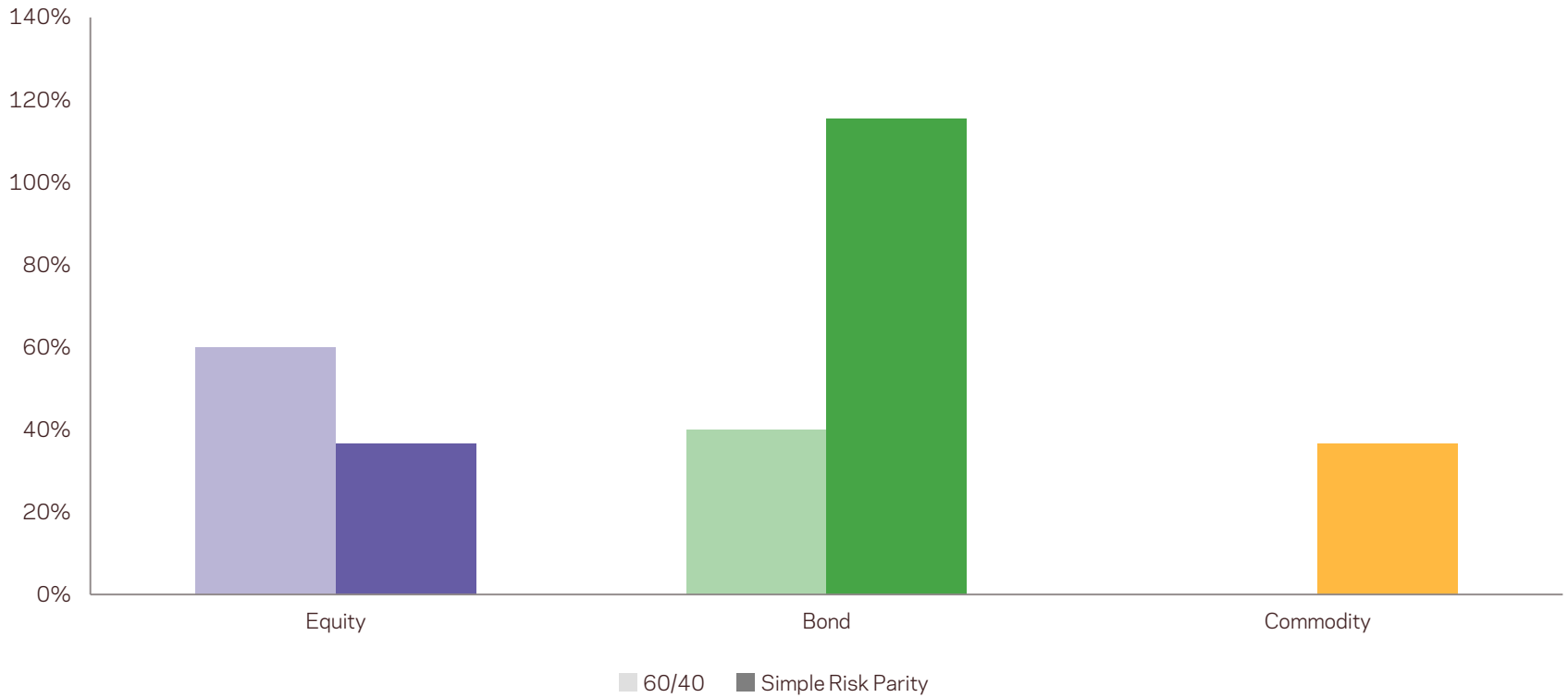


Sources: AQR, Bloomberg, Datastream. Data using the following sources: 10 year U.S. Treasury securities scaled to a constant duration (Bonds); S&P 500 Index (Equities); 10 year U.S. TIPS (TIPS); S&P GSCI Index (Commodities). Inflation data utilized in the metric is sourced from the U.S. Bureau of Labor Statistics, while inflation expectations are sourced from the Survey of Professional Forecasters. AQR's Inflation Sensitivity Measure combines three measurements to analyze the inflation properties of assets and strategies: relative performance of assets in positive versus negative inflation surprise periods; relative performance of assets in various inflation regimes (Decreasing / Flat / Increasing Inflation) and realized correlation of an asset's excess returns to subsequent annual inflation. Inflation Measure: U.S. seasonally adjusted CPI. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Risk Parity in Perspective

Why Is Tracking Error of Risk Parity to 60/40 So High?

Notional Portfolio Asset Allocations

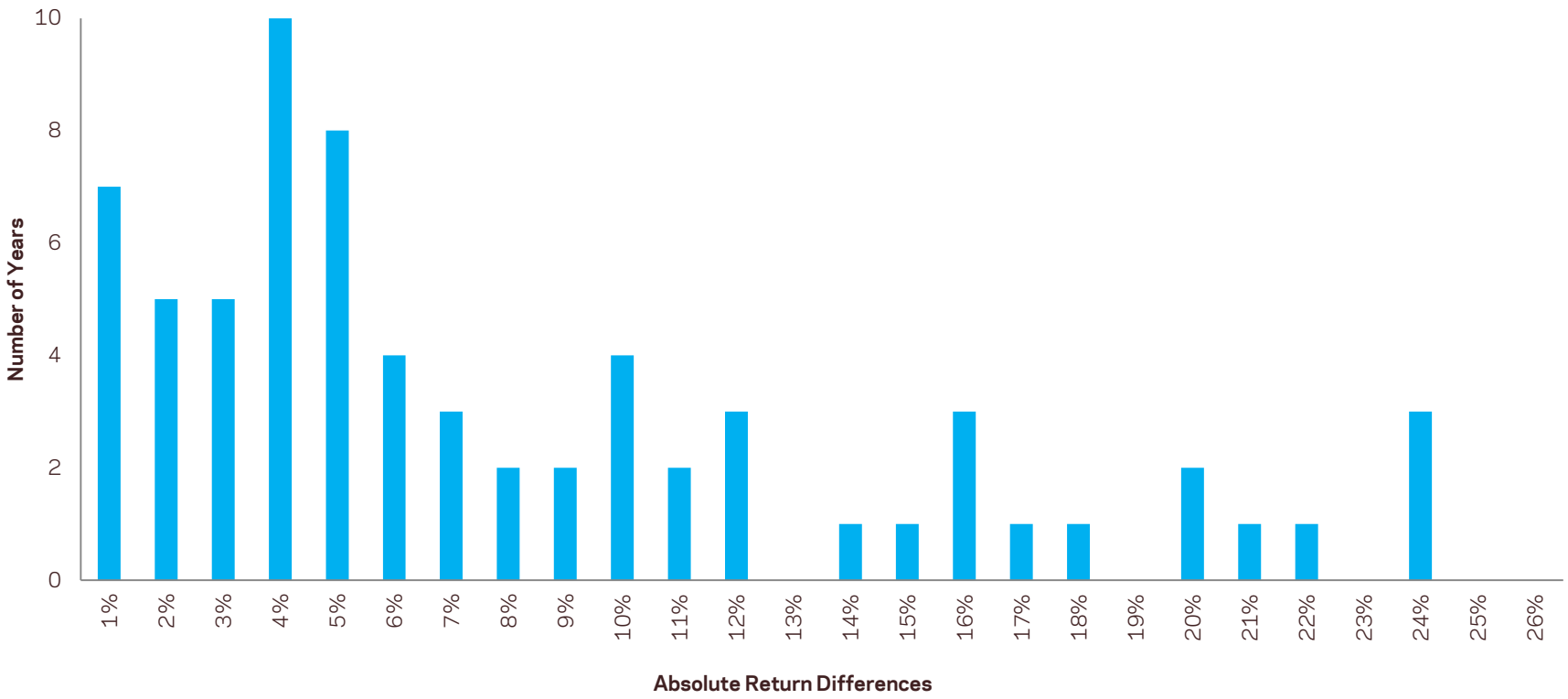


Source: AQR. Charts are for illustrative purposes only and are not based on an actual portfolio AQR manages. Simple Risk Parity is constructed by allocating equal risk, rebalanced monthly, across three asset classes (stocks, bonds and commodities) based on each asset class' previous 12 month realized volatility to target a total annualized portfolio volatility of 12%. Please see the Appendix for more details regarding the asset class construction. 60/40 is based a 60% monthly exposure to GDP-weighted global equities as defined in the Appendix prior to 1970 and the MSCI World Index thereafter and a 40% monthly exposure to GDP-weighted global USD hedged bonds as defined in the Appendix. Hypothetical data has inherent limitations, some of which are disclosed in the Appendix. Please read important disclosures in the Appendix.

Risk Parity in Perspective

High Tracking Error Can Lead to Large Differences in Individual Years

Frequency of Absolute Return Differences between a 60/40 and a Simple Risk Parity Portfolio
January 1948–December 2016



Source: AQR. Charts are for illustrative purposes only and are not based on an actual portfolio AQR manages. Simple Risk Parity is constructed by allocating equal risk, rebalanced monthly, across three asset classes (stocks, bonds and commodities) based on each asset class' previous 12 month realized volatility to target a total annualized portfolio volatility of 12%. Returns are gross of fees. Please see the Appendix for more details regarding the asset class construction. 60/40 is based a 60% monthly exposure to GDP-weighted global equities as defined in the Appendix prior to 1970 and the MSCI World Index thereafter, and a 40% monthly exposure to GDP-weighted global USD -hedged bonds as defined in the Appendix. Hypothetical data has inherent limitations, some of which are disclosed in the Appendix. Please read important disclosures in the Appendix.

Appendices

AQR Risk Parity Research Timeline

We Continue to Refine the Theory of Risk Parity

2016	Bollerslev, Hood, Huss and Pedersen discuss **risk modeling and forecasting** in their working paper "Risk Everywhere: Modeling and Managing Volatility"	
2015	Asness demonstrates the benefit of **risk parity as part of a traditional allocation** in "Risk Parity Is Even Better Than We Thought" Huss and Mendelson describe **the importance of risk targeting** in "Taking Control of Your Risk Allocation" Dhillon, Ilmanen and Liew discuss the benefits of **risk balancing within target-date funds** in "Balancing on the Life Cycle: Target Date Funds Need Better Diversification"	
2013	Hurst, Mendelson, and Ooi explore historical data to answer the question "**Can Risk Parity Outperform If Yields Rise**? – Risk Parity in a Rising Rate Environment"	
2012	Asness, Frazzini, and Pedersen show that **leverage aversion creates structural opportunities** for investors who embrace risk diversification in "Leverage Aversion and Risk Parity" Ilmanen, Palazzolo, and Mendelson discuss the **benefit of risk balancing** in "Risk Parity: A Supplement to Traditional Portfolios, Not Their Replacement"	
2011	Mendelson, Berger, and Villalon recommend **dynamic risk controls** and highlight capacity limitations in "Risk Parity, Risk Management, and the Real World"	
2010	Hurst, Johnson, and Ooi highlight the **benefits of diversification** in "Understanding Risk Parity – So You Think You're Diversified..." Asness, Kabiller, and Mendelson discuss the **do's and don'ts of using leverage and derivatives** in "Where the Wild Things Aren't"	
2006	Global Risk Premium Fund (GRP) launched Global Risk Premium Tactical Fund (GRPT) launched	
1998	**AQR Founding Principals began managing investments**	**AQR founded** by Asness, Kabiller, Krail, and Liew
1996		Asness demonstrates that the higher risk-adjusted return of a **diversified portfolio beats an all equity portfolio** in "Why Not 100% Equities"

Source: AQR.

Principal Biographies

Clifford S. Asness, Ph.D., *Managing and Founding Principal*
Cliff is a Founder, Managing Principal and Chief Investment Officer at AQR Capital Management. He is an active researcher and has authored articles on a variety of financial topics for many publications, including *The Journal of Portfolio Management*, *Financial Analysts Journal* and *The Journal of Finance*. He has received five Bernstein Fabozzi/Jacobs Levy Awards from *The Journal of Portfolio Management*, in 2002, 2004, 2005, 2014 and 2015. *Financial Analysts Journal* has twice awarded him the Graham and Dodd Award for the year's best paper, as well as a Graham and Dodd Excellence Award, the award for the best perspectives piece, and the Graham and Dodd Readers' Choice Award. In 2006, CFA Institute presented Cliff with the James R. Vertin Award, which is periodically given to individuals who have produced a body of research notable for its relevance and enduring value to investment professionals. Prior to cofounding AQR Capital Management, he was a managing director and director of quantitative research for the Asset Management Division of Goldman, Sachs & Co. He is on the editorial board of *The Journal of Portfolio Management*, the governing board of the Courant Institute of Mathematical Finance at NYU, the board of directors of the Q-Group and the board of the International Rescue Committee. Cliff received a B.S. in economics from the Wharton School and a B.S. in engineering from the Moore School of Electrical Engineering at the University of Pennsylvania, graduating *summa cum laude* in both. He received an M.B.A. with high honors and a Ph.D. in finance from the University of Chicago, where he was Eugene Fama's student and teaching assistant for two years (so he still feels guilty when trying to beat the market).

David G. Kabiller, CFA, *Founding Principal*
David Kabiller is co-founder and the Head of Business Development at AQR, overseeing client relationships, business development and strategic initiatives. In this role, he has helped foster AQR's tradition of innovation by initiating AQR's international expansion into Europe and Asia and spearheading its introduction of mutual funds. In addition to these corporate milestones, David is dedicated to investor education and fostering young research talent. To that end, he was instrumental in creating the "AQR University" symposia series for financial advisors and the Master Class program for institutional investors. For the academic community, David helped create the AQR Insight Award for outstanding innovation in applied academic research and was a founding member of the LBS AQR Asset Management Institute. David has co-authored papers on topics including derivatives, enhanced indexation, securities lending, insurance-linked securities, hedge funds and the secret of Warren Buffett's investing acumen. He is a member of Northwestern University's Board of Trustees and chairman of the Executive Council of the university's International Institute for Nanotechnology (IIN). He is also a member of the Advisory Council of the AQR Asset Management Institute at London Business School and has served on the Board of Trustees for the Terra Foundation for American Art. Prior to AQR, David was a vice president at Goldman, Sachs & Co., where he established and maintained relationships with the chief investment officers of many of the largest pension and endowment funds in North America. He earned a BA in economics and an MBA from Northwestern, where he received an athletic scholarship to play tennis and was named to the Big Ten's Academic All-Conference team. At Northwestern, David founded the Kabiller Prize and the Kabiller Young Investigator Award for researchers in nanoscience and nanomedicine, and established NU for Life, a program dedicated to the professional development of Northwestern student-athletes. He is a CFA charterholder.

John M. Liew, Ph.D., *Founding Principal*
John is a Founder and the head of the Global Asset Allocation team at AQR, where he oversees the research, portfolio management and trading associated with that strategy. Prior to AQR, he worked at Goldman, Sachs & Co. as a portfolio manager in the Asset Management Division where he developed and managed quantitative trading strategies. He began his career at Trout Trading, developing quantitative market-neutral stock-selection strategies. John has published articles in *The Journal of Portfolio Management* and *Financial Analysts Journal*, and has received the Bernstein Fabozzi/Jacobs Levy award and the Graham and Dodd award for his articles. John is a member of the University of Chicago's Board of Trustees and sits on the university's investment committee. He earned a B.A. in economics from the University of Chicago, where he was elected a member of Phi Beta Kappa, and went on to earn an M.B.A. and a Ph.D. in finance, also from Chicago.

Principal Biographies

Michele L. Aghassi, Ph.D., CFA, *Principal*
Michele is co-head of research in AQR's Global Stock Selection group. She played a key role in launching the firm's emerging equities strategy in 2008 and is responsible for oversight of emerging-market stock selection. Michele has contributed to the advancement of our investment process in a variety of areas, and developed the proprietary robust optimization technology that AQR uses to build portfolios. In addition, Michele serves on the Editorial Advisory Board of the *Journal of Portfolio Management*. Michele graduated *magna cum laude* from Brown University with a B.Sc. in applied mathematics. She also earned a Ph.D. in operations research from the Massachusetts Institute of Technology, where she was a National Science Foundation Graduate Research Fellow and an MIT Presidential Graduate Fellow. Between Brown and MIT, Michele worked as a quantitative analyst in the proprietary equities department of D.E. Shaw & Co.

Gregor M. Andrade, Ph.D., *Principal*
Gregor runs AQR's international business development team, overseeing client relations in Europe, the Middle East, Asia, Australia and Latin America. Prior to joining AQR in 2003, Gregor was an assistant professor of finance at Harvard Business School after having worked as a mergers and acquisitions analyst at Wasserstein Perella. He is on the Advisory Council of the AQR Asset Management Institute at London Business School, has been published in academic journals and won an Amundi Smith Breeden Award for an article in The Journal of Finance. Gregor earned a B.S. in economics from the Massachusetts Institute of Technology and a Ph.D. in finance from the University of Chicago's Graduate School of Business.

Bradley D. Asness, J.D., *Principal*
Brad is AQR's Chief Legal Officer, overseeing the firm's legal department as it deals with matters ranging from fund creation to corporate finance to new rules and regulations. Prior to AQR, which he joined at its inception in 1998, Brad worked at Donaldson, Lufkin & Jenrette on public and private debt and equity offerings, asset sales and merger and acquisition transactions for real estate investment trusts and home-building companies. Brad earned a B.A. from Brandeis University, a J.D. from New York Law School, where he was a member of the law review, and an M.B.A. with distinction from New York University's Stern School of Business. He is a member of the New York State Bar.

William Cashel, *Principal*
Bill leads the distribution team for AQR's Advisor Solutions Group (ASG) within Business Development, which works with financial advisors across national and regional broker-dealers, bank trust departments and registered investment advisors. Prior to AQR, Bill was a Vice President at Natixis Asset Management where he was responsible for distribution in the Registered Investment Advisor channel. Before that, Bill worked at Wachovia in their private client group. He began his career at Brown Brothers Harriman & Co. Bill earned a B.A. from Denison University and an M.B.A. from Pepperdine University.

Jeffrey Dunn, *Principal*
Jeff heads AQR's Australia business, focused on building the firm's presence in the region. Prior to AQR, Jeff was the research manager for the international equity division at QIC, one of Australia's largest institutional investment managers, where he was responsible for researching external asset management firms and developing portfolio and risk management infrastructure. While at QIC, Jeff also worked in a secondment role with the quantitative strategies group at Goldman Sachs Asset Management in New York. Jeff earned a B.Sc. (mathematics) and a B.Bus. (banking and finance) from the Queensland University of Technology.

Principal Biographies

Andrea Frazzini, Ph.D., *Principal*
Andrea is a Principal on AQR's Global Stock Selection team, focusing on research and portfolio management of the Firm's Long/Short and Long-Only equity strategies. He is also an Adjunct Professor of Finance at New York University's Stern School of Business. He has published in top academic journals and won several awards for his research, including the Smith Breeden Award, the Fama-DFA award, the BGI best paper award, several Bernstein Fabozzi/Jacobs Levy Awards, and the PanAgora Crowell Memorial Prize. Prior to AQR, Andrea was an associate professor of finance at the University of Chicago's Graduate School of Business and a Research Associate at the National Bureau of Economic Research. He also served as a consultant for DKR Capital Partners and J.P. Morgan Securities and on the board of directors of the Center for Research in Security Prices at the University of Chicago. He earned a B.S. in economics from the University of Roma Tre, an M.S. in economics from the London School of Economics and a Ph.D. in economics from Yale University

Jacques A. Friedman, *Principal*
Jacques is a Principal and head of AQR's Global Stock Selection team. In this role, he is involved in all aspects of research, portfolio management and strategy development for the firm's equity products and strategies. He is also a member of both the firm's Strategic Planning and Risk Committees. Prior to joining AQR at its inception in 1998, Jacques was with Goldman, Sachs & Co., where he developed quantitative stock-selection strategies within the asset management division. Before joining Goldman, he was pursuing a Ph.D. in applied mathematics at the University of Washington, where his research interests ranged from mathematical physics to quantitative methods for sports handicapping. Jacques earned a B.S. in applied mathematics from Brown University and an M.S. in applied mathematics from the University of Washington.

Jeremy M. Getson, CFA, *Principal*
Jeremy leads AQR's North America institutional team within Business Development, working with and advising clients throughout the United States and Canada. Prior to AQR, Jeremy was a vice president of Allstate Financial and a consultant with Mercer Investment Consulting, advising pension plans on asset allocation and investment-manager selection. He earned an A.B. in politics from Princeton University, graduating cum laude, and an M.B.A. with high honors from the University of Chicago's Graduate School of Business, where he was named a Siebel Scholar as one of the top 25 M.B.A. students annually. He is a CFA charterholder.

Marco Hanig, Ph.D., *Principal*
Marco is President of AQR Funds, leading the firm's entry into the mutual funds business. In this role, he is responsible for oversight of AQR's mutual funds and executing the firm's distribution strategy. Prior to AQR, Marco was a principal with William Blair & Company, where he served as President of William Blair Funds and Chief Operating Officer of the Investment Management Department. Before that, he worked at First Chicago Corporation as managing director for mutual funds. He began his career as a management consultant with Bain & Company. Marco earned a B.A. in mathematics from the University of Chicago, graduating *cum laude*, and a Ph.D. in economics from the Massachusetts Institute of Technology.

John B. Howard, CPA, *Principal*
John is AQR's Chief Operating Officer and Chief Financial Officer. In those roles, he oversees much of the firm's infrastructure functions. Earlier in his career, John was Chief Financial Officer of the global asset management firm AllianceBernstein and before that he held various senior financial positions at Knight Capital Group, including group controller and chief financial officer of Knight Equity Markets International Ltd. based in London; he ultimately was CFO of the entire firm. John began his career at Price Waterhouse, rising to become a senior manager in the securities industry practice. He earned a B.S. in accounting from Lehigh University and is a Certified Public Accountant.

Principal Biographies

Brian K. Hurst, *Principal*
Brian is a portfolio manager for two of AQR's macro strategies — managed futures and risk parity — and is Co-head of Trading. He has more than 20 years of experience managing money for institutional investors in both traditional and alternative investment strategies, and has been at AQR since its founding. He was named Alternatives Fund Manager of the Year by Morningstar in 2013 for his work on managed futures. He has written a number of papers on Risk Parity and Managed Futures, including "Demystifying Managed Futures" in the Journal of Investment Management, and spoken at a host of industry conferences. Before AQR, he was an original member of the quantitative research group in the Asset Management Division of Goldman, Sachs & Co. He began his career as a sell-side investment banking analyst at Donaldson, Lufkin & Jenrette. Brian earned a B.S. in economics from the Wharton School at the University of Pennsylvania.

Antti Ilmanen, Ph.D., *Principal*
Antti manages AQR's Portfolio Solutions Group, which advises institutional investors and sovereign wealth funds, and develops the firm's broad investment ideas. Before AQR, Antti spent seven years as a senior portfolio manager at Brevan Howard, a macro hedge fund, and a decade in a variety of roles at Salomon Brothers/Citigroup. He began his career as a central bank portfolio manager in Finland. Antti earned M.Sc. degrees in economics and law from the University of Helsinki and a Ph.D. in finance from the University of Chicago. Over the years, he has advised many institutional investors, including Norway's Government Pension Fund Global and the Government of Singapore Investment Corporation. Antti has published extensively in finance and investment journals and has received a Graham and Dodd award and Bernstein Fabozzi/Jacobs Levy awards for his articles. His book *Expected Returns* (Wiley, 2011) is a broad synthesis of the central issues in investing. Antti recently scored a rare double in winning the best-paper and runner-up award for best articles published in 2012 in *The Journal of Portfolio Management* (co-authored articles "The Death of Diversification Has Been Greatly Exaggerated" and "The Norway Model").

Ronen Israel, *Principal*
Ronen's primary focus is on portfolio management and research. He was instrumental in helping to build AQR's Global Stock Selection group and its initial algorithmic trading capabilities, and now runs the Global Alternative Premia group, which employs various investing styles across asset classes. He has received an Outstanding Article award as part of the 17th Annual Bernstein Fabozzi/Jacobs Levy Awards from *The Journal of Portfolio Management* in 2015 and the Special Distinction Award as part of the Harry M. Markowitz Prize for the best paper published in the *Journal of Investment Management* in 2015. He is on the executive board of the University of Pennsylvania's Jerome Fisher Program in Management and Technology, is an adjunct professor of finance at New York University, has been a guest speaker at Harvard, Columbia, the University of Pennsylvania and the University of Chicago, and is a frequent conference speaker. Prior to AQR, he was a senior analyst at Quantitative Financial Strategies Inc. Ronen earned a B.S. in economics from the Wharton School at the University of Pennsylvania, a B.A.S. in biomedical science from the University of Pennsylvania's School of Engineering and Applied Science, and an M.A. in mathematics, specializing in mathematical finance, from Columbia.

Michael Katz, Ph.D., *Principal*
Michael is a Principal on AQR's Global Asset Allocation team. In this role, he oversees macro, fixed income and inflation research. He is also part of the portfolio management teams for multi-strategy hedge funds, macro and long-only equity products. Prior to AQR, Michael was a teaching fellow and research assistant at Harvard University, a teaching and research assistant at Tel Aviv University and a consultant for Trigger Ltd. (now Trigger-Foresight Ltd.). He also served as an intelligence officer in the Israeli Defense Forces, achieving the rank of Major. His research has been published in the Financial Analysts Journal and the Review of Financial Studies. Michael earned a B.A. in economics and Middle East history, with honors, from Tel Aviv University, and a Ph.D. and an A.M. in economics from Harvard University.

Principal Biographies

Hoon Kim, Ph.D., CFA, *Principal*
Hoon is the head of equity portfolio management in AQR's Global Stock Selection group, responsible for the day-to-day portfolio management decisions for all long-short and long-only equity strategies. He has contributed to advancements in various areas of investment strategy and process, including alpha signal research, portfolio construction, performance attribution and portfolio analytics. He also played a key role in building AQR's defensive equity strategies. Prior to AQR, he was the head of quantitative equity research at Mellon Capital Management in San Francisco. Hoon earned a B.A. in business administration from Yonsei University in South Korea, and an M.B.A. and a Ph.D. in business/accounting from Carnegie Mellon University. He is a CPA (in Korea) and a CFA charterholder.

Oktay Kurbanov, *Principal*
Oktay is a key member of AQR's Global Asset Allocation group, where he runs the portfolio management team that applies the firm's strategies to each portfolio. He also oversees development of research and optimization software and works with other departments to streamline account management. Prior to AQR at its inception, Oktay was a quantitative analyst in the Asset Management Division of Goldman, Sachs & Co. He earned a B.S. in physics and mathematics from the University of Michigan and an M.B.A. with concentration in finance and statistics from New York University's Stern School of Business.

Ari Levine, *Principal*
Ari is a portfolio manager for AQR's commodities and managed futures strategies, leading research efforts in both areas. His research on trend following techniques has been published in the Financial Analysts Journal. Ari earned a B.S. in finance and a B.S.E. and M.S.E. in electrical engineering from the Jerome Fisher Program in Management and Technology at the University of Pennsylvania.

Stephen J. Mellas, *Principal*
Steve oversees both firm-wide operations and client administration at AQR. Prior to the firm, Steve was a managing director at Goldman Sachs & Co., where he was responsible for the Investment Management Division's asset management operations worldwide. Before that, he managed fixed-income trading operations at Morgan Stanley. Steve was a founding member of the Securities Industry and Financial Markets Association's Asset Managers Forum and currently teaches management-communications courses at New York University's Stern School of Business and Stanford University's Graduate School of Business. Steve earned a B.A. in economics from Villanova University and an M.B.A. from Pace University.

Michael A. Mendelson, *Principal*
Michael is portfolio manager of AQR's risk parity strategies and a member of both the firm's strategic planning and risk committees. Prior to AQR, Michael was a managing director at Goldman Sachs & Co., where he founded the quantitative trading group. He has been a member of the Managed Funds Association's board of directors and Chairman of its Trading and Markets Committee and is currently Chairman of its Government Affairs Committee. Michael earned an S.B. in mathematics, an S.B. in management, an S.B. in chemical engineering and an S.M. in chemical engineering, all from the Massachusetts Institute of Technology, and an M.B.A. from the University of California at Los Angeles.

Principal Biographies

Tobias J. Moskowitz, *Ph.D., Principal and Dean Takahashi Professor of Finance, Yale University*
Toby contributes to research on asset pricing and investment issues related to domestic and international strategies for AQR's Global Alternative Premia team. He currently holds the Dean Takahashi Chaired Professorship in Finance at Yale University, is a research associate at the National Bureau of Economic Research, and was formerly the Fama Family Professor of Finance at the University of Chicago Booth School of Business from 1998 to 2016. He has won numerous awards for his academic research, including the 2015 Bernstein Fabozzi/Jacobs Levy Award for the best article in The Journal of Portfolio Management. In 2007, he was awarded the Fischer Black Prize by the American Finance Association, which recognizes the best financial economist under the age of 40, and the Kauffman Prize Medal for Distinguished Research in Entrepreneurship in 2012 by the Kauffman Foundation, which recognizes the largest contribution to entrepreneurial research under the age of 40. His work has been cited in numerous print media, television appearances, and in a 2005 speech by former Federal Reserve Chairman Alan Greenspan. Toby earned a B.S. in industrial management/industrial engineering with honors and an M.S. in finance from Purdue University, as well as a Ph.D. in finance from the University of California at Los Angeles.

Lars N. Nielsen, *Principal*
Lars is the Chief Risk Officer of AQR. Previously, Lars oversaw research in AQR's Global Stock Selection and Global Asset Allocation teams, and was part of the portfolio management teams for a number of AQR's multistrategy hedge funds and long-only equity portfolios. His research has been published in the Review of Financial Studies, the Financial Analysts Journal, the Journal of Portfolio Management and the Journal of Investing. Prior to AQR, he was a quantitative equity analyst at Danske Invest. Lars earned a B.Sc. and an M.Sc. in economics from the University of Copenhagen.

Yao Hua Ooi, *Principal*
Yao Hua is a Principal on AQR's Global Asset Allocation team, focusing on research and portfolio management of macro-related strategies that include commodities, risk parity and managed futures. His research has been published in the *Journal of Financial Economics* and the *Journal of Investment Management*. He was named the 2013 Alternatives Fund Manager of the Year by Morningstar for his work on managed futures, and shared the 2013 Whitebox Prize for his work on time series momentum. Yao Hua is an alumnus of the Jerome Fisher Program in Management and Technology at the University of Pennsylvania, where he earned a B.S. in economics and a B.S. in engineering, graduating *summa cum laude* in both.

Christopher Palazzolo, CFA, *Principal*
Christopher heads AQR's business development and client service in Europe. Prior to AQR, he worked as a Business Development Manager and Consultant for the Palladium Group and as an analyst at Goldman Sachs in the Investment Management Division's Product Management group. Christopher earned a B.A. in political science with a concentration in economics from Amherst College, an M.B.A. from Harvard Business School and an M.P.A. from the Harvard University Kennedy School of Government. He is co-author of several published articles, including "Risk Parity: A Supplement to Traditional Portfolios, Not Their Replacement," "Inflation in 2010 and Beyond (Parts I and II)," "Eurozone Inflation Update: Will ECB Actions Match its Rhetoric?," "QE2: Not Just Another QE1," "The Convertible Bond Dislocation of 2008" and "The Limits of Convertible Bond Arbitrage." He is a CFA charterholder.

Neal Pawar, *Principal*
Neal is AQR's Chief Technology Officer. Prior to AQR, he was a managing director and Chief Information Officer of UBS's global wealth management business in Switzerland, and a partner and co-Chief Information Officer at D.E. Shaw & Co. He began his career at Swiss Bank / O'Connor in Chicago. Neal earned a B.Sc. in computer science from Brown University.

Principal Biographies

Lasse H. Pedersen, Ph.D., *Principal*
Lasse is a Principal on AQR's Global Asset Allocation team, leading research on proprietary quantitative forecasting models to identify opportunities in equities, fixed income, currencies and commodities. He is also a finance professor at Copenhagen Business School and New York University's Stern School of Business. He has served on the board of the American Finance Association, the Economic Advisory Boards of NASDAQ OMX and FTSE, and the Federal Reserve Bank of New York's Monetary Policy Panel. Lasse has been awarded the Bernácer Prize for the best European economist under 40 and an Elite Research Prize, the Danish government's most prestigious scientific honor. His research has been published in leading journals and cited by central bank governors. Lasse has served on the editorial boards of several journals, including *The Journal of Finance*, and as a research associate at the National Bureau of Economic Research and the Centre for Economic Policy Research. He earned a B.S. and an M.S. in mathematics-economics from the University of Copenhagen and a Ph.D. in finance from Stanford University.

Scott Richardson, Ph.D., *Principal*
Scott is a researcher and portfolio manager in AQR's Global Alternative Premia group, overseeing research in credit and fixed-income markets. He is also involved with the equity research for the firm's Global Stock Selection group. Prior to AQR, he was a professor at London Business School, where he still teaches M.B.A. and Ph.D. classes. He has held senior positions at BlackRock (Barclays Global Investors), including head of Europe equity research and head of global credit research, where he oversaw research and investment decisions at BGI for both total return and absolute return products across credit and equity markets. He began his career as an assistant professor at the University of Pennsylvania. He is an editor of the Review of Accounting Studies and has published extensively in leading academic and practitioner journals. In 2009 he won the Notable Contribution to Accounting award for his work on earnings quality and accruals. Scott earned a B.Ec. with first-class honors from the University of Sydney and a Ph.D. in business administration from the University of Michigan.

H.J. Willcox, J.D., *Principal*
H.J. is a Principal and AQR's Chief Compliance Officer, overseeing the firm's compliance program. Prior to AQR, he was Global Head of Compliance and Counsel at KKR & Co., and before that was Chief Compliance Officer and Senior Counsel at Silver Point Capital LP. Earlier, he was a lawyer at Wilmer Cutler Pickering Hale and Dorr, and Schulte Roth & Zabel, and was a branch chief in the U.S. Securities and Exchange Commission Northeast Regional Office. H.J. earned a B.A. in English at Bucknell University and a J.D. from Brooklyn Law School. He is a member of the New York State Bar.

Principal Biographies

CNH Partners

CNH Partners is an affiliate of AQR

Mark L. Mitchell, Ph.D., *Co-Founder and Principal, CNH Partners*
Mark is a co-founder and principal at CNH Partners, the arbitrage affiliate of AQR that trades merger arbitrage, convertible arbitrage and other strategies related to corporate events. Prior to CNH, he was a finance professor at Harvard University and the University of Chicago. In the late 1980s, he worked in the Office of the Chief Economist at the Securities and Exchange Commission, where he wrote several research papers on mergers and acquisitions. Mark publishes frequently and has won four paper-of-the-year awards from research journals: an Amundi Smith Breeden Award, a Merton Miller Prize, a Graham and Dodd Scroll and a Roger F. Murray Prize. Mark also received five teaching awards at the University of Chicago. He joined the board of directors at TD-Ameritrade in 1996 and currently chairs its risk committee. Mark earned a B.B.A. in economics from the University of Louisiana at Monroe, and an M.A. in economics and a Ph.D. in applied economics from Clemson University.

Todd C. Pulvino, Ph.D., *Co-Founder and Principal, CNH Partners*
Todd is a co-founder and principal at CNH Partners, the arbitrage affiliate of AQR that trades merger arbitrage, convertible arbitrage and other strategies related to corporate events. Prior to CNH, Todd was a tenured associate professor of finance at Northwestern University's Kellogg School of Management, where his research focused on the risks and returns in event arbitrage. Earlier, he was a consultant at two fund-of-fund firms, Collins Associates and Grosvenor Capital Management, and a visiting professor at Harvard Business School. He began his career as an aerospace engineer. He has published in finance journals, winning two Amundi Smith Breeden Awards for his research, and he still teaches at the Kellogg School. Todd earned a B.Sc. in mechanical engineering from the University of Wisconsin-Madison, an M.S. in the same field at the California Institute of Technology, and an A.M. and a Ph.D. in business economics from Harvard University.

Rocky Bryant, *Principal, CNH Partners*
Rocky heads the event-driven desk at CNH Partners, the arbitrage affiliate of AQR. His team invests in opportunities created by corporate actions like mergers and other market events. He developed a database of convertible bonds issued since 1984 and maintains CNH's legacy merger arbitrage data going back to 1963, and he has used those tools to help develop several new strategies. Prior to CNH, Rocky was a research associate at Harvard Business School, where he worked with finance professors Erik Stafford and Lisa Meulbroek. He earned a B.S. in computer science and electrical engineering from the Massachusetts Institute of Technology.

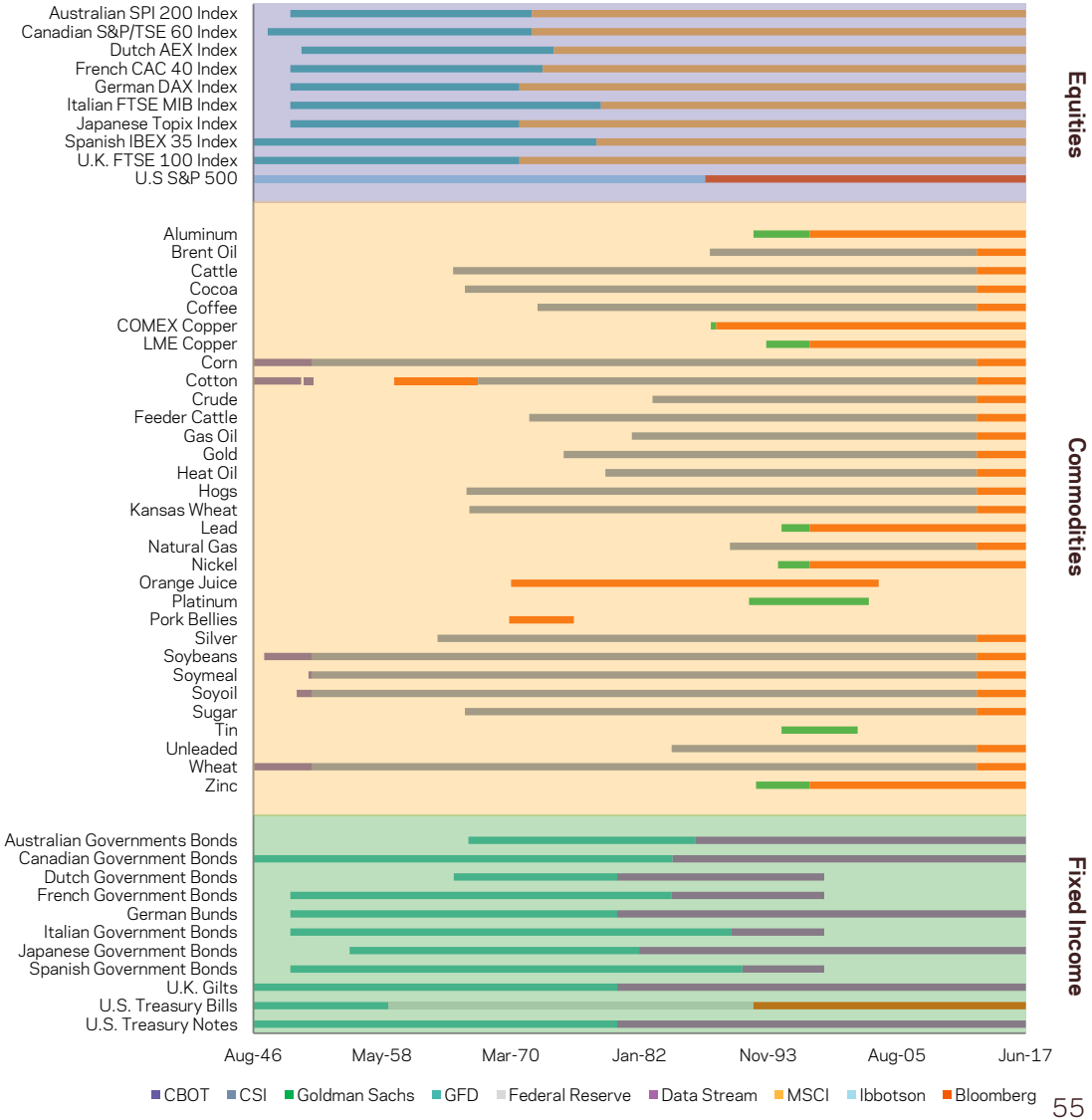
Simple Risk Parity

Description of Simple Risk Parity hypothetical portfolio

- Assumes equal volatility targets across global equities, global bonds and commodities
- The equal volatility targets are determined such that the volatility of overall portfolio averages 10% over the complete history
- Volatility estimates are calculated using rolling 12-month annualized standard deviation
- The exposure for each asset is adjusted as the volatility estimates evolve such that the portfolio targets 10% volatility overtime
- There are no leverage constraints and the model makes no explicit assumptions about correlation between asset classes

Asset class weighting

- Global equities are GDP-weighted for the primary equity index for 10 developed countries
- Global bonds are GDP-weighted across government bonds for 10 developed countries
- Commodities are an equally weighted basket of futures which currently consists of 31 contracts



Building Macro Indicators / Investment Return Series

Macro Indicators

Our first choice was to decide which macro dimensions are most relevant. We chose economic growth and inflation. Monetary policy was another candidate; it is closely related to real yields.

We choose to construct macro indicators, or risk factors, mainly based on fundamental economic data, and not based on asset market returns (which are "too close" to the patterns we try to explain). For example, potential market-based proxies of economic growth include equity market returns, the relative performance of cyclical industries, dividend swaps, and estimates from cross-sectional regressions of asset returns on growth surprises. This choice brings its own problems, notably timing challenges as macroeconomic data are backward-looking, published with lags and later revised, while asset prices are clearly forward-looking. The impact of publication lags and the mismatch between backward- and forward-looking perspectives can be mitigated by using longer windows. Thus, we use contemporaneous annual economic data and asset returns through our analysis (past-year data with quarterly overlapping observations). Arguably composite growth surprise indices are the best proxies of economic growth news, but such composites are available at best going back to 1990s. Forecast changes in economist surveys as well as business and consumer confidence surveys may be the next best choices because they are reasonably forward-looking and timely. In a globalized world, it is not clear whether we should focus only on domestic macro developments, but data constraints make us focus on U.S. data. Finally, it is not clear how real economic growth ties to expected corporate cash flow growth (e.g., earnings per share) that influence stock prices or to real yields that influence all asset prices but especially those of bonds.

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. We use rolling 10-year windows for means and volatilities when normalizing the last three macro indicators. However, for growth and inflation indicators we use in-sample 1972-2013 means and volatilities because we do not have long histories of economist forecasts needed to construct the surprise series below. This choice does not seem to change any major results. 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 (because we are not trying to create an investable strategy where data should be available for investors in real time, we use the full sample median).

The underlying series for our growth indicator are the Chicago Fed National Activity Index (CFNAI) and the "surprise" in industrial production growth over the past year. Since there is no uniquely correct proxy way to capture "growth"; averaging may make the results more robust and signals appropriate humility. CFNAI takes this averaging idea to extremes as it combines 85 monthly indicators of U.S. economic activity. The other series – the difference between actual annual growth in industrial production and the consensus economist forecast a year earlier – is narrower but more directly captures the surprise effect in economic developments. We use median forecasts from the Survey of Professional Forecasters data as published by the Philadelphia Fed. While data surprises a priori have a zero mean, this series has exhibited a downward trend in recent decades, reflecting the (partly unexpected) relative decline of the U.S. manufacturing sector.

Our inflation indicator is also an average of two normalized series. One series measures the de-trended 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).

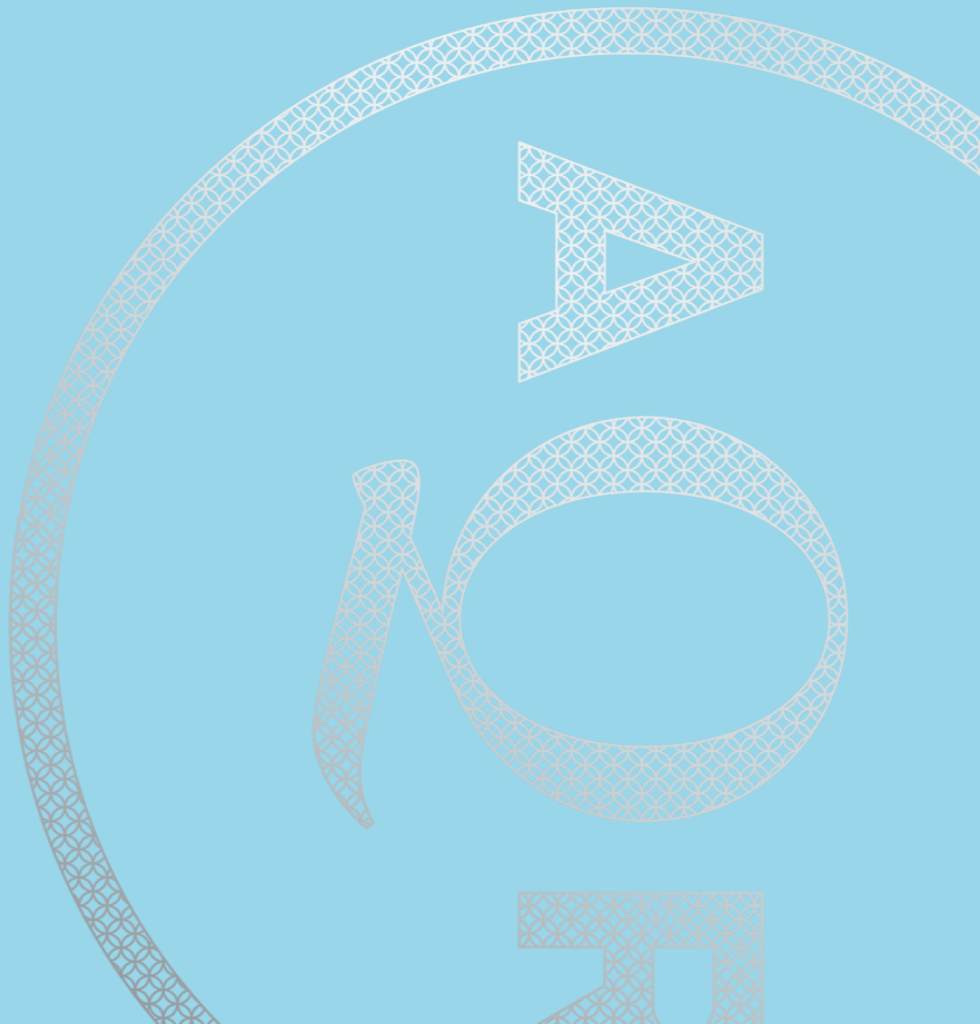
Performance Disclosures

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 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 intended exclusively for the use of the person to whom it has been delivered and it is not to be reproduced or redistributed to any other person.

All performance figures contained herein reflect the reinvestment of dividends and all other earnings and represent unaudited estimates of realized and unrealized gains and losses prepared by AQR Capital Management, LLC (AQR). There is no guarantee as to the above information's accuracy or completeness. There is no guarantee, express or implied, that long-term return and/or volatility targets will be achieved. Realized returns and/or volatility may come in higher or lower than expected. **PAST PERFORMANCE IS NOT A GUARANTEE OF FUTURE PERFORMANCE.** Diversification does not eliminate the risk of experiencing investment losses.

The Drawdown Control System described herein will not always be successful at controlling risks or limiting portfolio losses.

Hypothetical performance results (e.g., quantitative backtests) 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 adhere to a particular trading program in spite of trading losses are material points 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. 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. 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. n addition, our transaction cost assumptions utilized in backtests, where noted, are based on 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.

Gross performance results do not reflect the deduction of investment advisory fees, which would reduce an investor's actual return. For example, assume that $1 million is invested in an account with the Firm, and this account achieves a 10% compounded annualized return, gross of fees, for five years. At the end of five years that account would grow to $1,610,510 before the deduction of management fees. Assuming management fees of 1.00% per year are deducted monthly from the account, the value of the account at the end of five years would be $1,532,886 and the annualized rate of return would be 8.92%. For a 10-year period, the ending dollar values before and after fees would be $2,593,742 and $2,349,739, respectively. AQR's asset based fees may range up to 2.85% of assets under management, and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate. Where applicable, performance fees are generally equal to 20% of net realized and unrealized profits each year, after restoration of any losses carried forward from prior years. In addition, AQR funds incur expenses (including start-up, legal, accounting, audit, administrative and regulatory expenses) and may have redemption or withdrawal charges up to 2% based on gross redemption or withdrawal proceeds. Please refer to AQR's ADV Part 2A for more information on fees. Consultants supplied with gross results are to use this data in accordance with SEC, CFTC, NFA or the applicable jurisdiction's guidelines.

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