

Street View

How Design Choices Impact Low Risk Factor Performance

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Executive summary

When it comes to the construction of risk factors, seemingly innocuous specification details can have a surprisingly large impact on the factor's performance. During the COVID market crisis earlier this year, "Low Risk" factors and strategies* exhibited meaningfully different performance depending on the design choices made by various providers. In this Street View, we explore five such design choices and measure their impact on the Low Risk factor's performance. We find that one particular design choice had significant performance impact because of its persistent relationship with another risk factor. This has important implications for asset allocators that use Low Risk factors to analyze the performance of their portfolios and/or investment managers.

* Low Risk factors and strategies are those that buy or overweight low risk stocks and sell or underweight high risk stocks.

Introduction

When it comes to the construction of risk factors, the devil is in the details.¹ It is one thing to define a general theme for a risk factor, for example one that captures Momentum,² but when it comes to the design and actual construction of the factor, there are many specification choices that need consideration, and that is where the value can lie. For example, while the theme behind a Value³ factor is generally well understood and documented in the academic literature, how one defines whether a stock is under- or overvalued is not necessarily straightforward. Our 2016 paper, “[Risk Factors Are Not Generic](#),” demonstrated that Value factors with varying definitions of value were only 14% correlated on average—and that’s just definitional differences. There is also dispersion that can occur from different approaches to what data sets and techniques are utilized in factor construction. Long story short: when building factors for practical use cases, such as portfolio analysis and risk modeling, definitional and constructional choices matter. In this Street View, we’ll analyze five such choices and their impact on factor performance and risk analysis.

A recent, stark example of seemingly small specification details having a surprisingly large impact is the performance of Low Risk during the COVID-19 equity market selloff in the first quarter of 2020. At a high level, Low Risk factors intend to capture the phenomenon that lower risk stocks tend to outperform higher risk stocks on a risk-adjusted basis. The performance of funds and long-short factors attempting to capture the same Low Risk phenomenon varied greatly over this period. In fact, performance was often directionally different depending on the factor provider or asset manager: some delivered positive returns, while others saw notable losses.

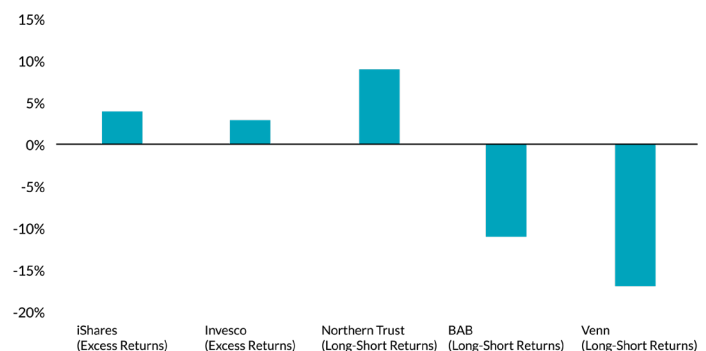
For example, as reflected in Exhibit 1, on the positive side, the largest Low Risk factor-based ETF by assets, BlackRock’s iShares Edge MSCI Min Vol USA ETF (ticker USMV), delivered positive excess returns relative to the S&P 500 Index. The same can be said for Invesco’s S&P 500 Low Volatility ETF (ticker SPLV). Both USMV and SPLV are long-only U.S. funds, hence our comparison relative to the S&P 500 Index. Additionally, some asset managers’ Low Risk long-

short factors, such as Northern Trust’s Low Volatility factor, posted meaningfully positive returns during the market rout, with top-quintile low volatility stocks outperforming their higher-risk counterparts by nearly 10%.⁴

Compare that to very poor performance of other Low Risk factors over the same period. The long-short Betting Against Beta (BAB) factor, which was part of the original research on the Low Risk phenomenon, delivered double digit negative returns during the COVID market meltdown in the U.S. universe.⁵ Similarly, our Low Risk factor in Venn suffered even worse losses, down closer to -20%. A summary of this recent performance dispersion is in Exhibit 1.

Exhibit 1: Cumulative Returns of Various Low Risk Factors and ETFs

Time period: February 19, 2020 - March 17, 2020.



These factor-based funds and factors aim to provide exposure to the same investment theme, but performance was all over the map. Such surprising differences in performance can create confusion for asset allocators trying to understand the true performance of Low Risk over this period and how it may have contributed to the performance of their portfolio(s).

It turns out that there are various design choices that can have meaningful performance implications for a factor like Low Risk that could have contributed to this dramatically disparate performance across the industry. In this Street View, we’ll walk through five such design choices and compare how they impacted the performance of the Low Risk factor during the COVID market crisis period. We’ll then demonstrate the implications for asset allocators,

¹ For example, read “The Devil in HML’s Details” (Asness and Frazzini, 2013) in which the authors show the performance improvement of a simple book-to-price Value factor by updating the denominator (i.e., price) more frequently.

² Momentum is the phenomenon whereby stocks that have recent positive price momentum tend to continue their outperformance.

³ The idea behind Value is that stocks that are priced cheaply, relative to some fundamental measure, tend to outperform those that are relatively expensively priced over time.

⁴ <https://www.northerntrust.com/united-states/insights-research/2020/investment-management/finding-value-in-volatility>

⁵ AQR Capital Management, LLC. <https://www.aqr.com/Insights/Datasets/Betting-Against-Beta-Equity-Factors-Daily>

specifically those that outsource all or some of their investment management to external managers. While this group of investors may be less concerned with building their own factor portfolios, they may be impacted by factor design choices of others to the extent they use factors to analyze whether their managers are delivering the factor exposures they expect.

Factor Construction and Explanation of Design Choices

Before we outline the five design choices that we consider in this Street View, we will first provide a very brief summary of some high-level steps in constructing a long-short equity style risk factor such as Low Risk.

Step 1: Choose a universe or group of stocks from which you'll construct your factor.

Step 2: Define a metric that you will use to determine a stock's exposure to the factor (e.g., book-to-price for Value, or a stock's standard deviation for Low Risk).

Step 3: Calculate that metric for every stock in your universe, normalize the metrics,⁶ and then sort the stocks into long and short portfolios based on their values (stocks with positive values in the long portfolio, and negative values in the short portfolio).

Step 4: Multiply the returns of the stocks by their weights in the long and short portfolios, and sum up all the values to arrive at your factor return for the day.

Each of these seemingly simple steps comes with a host of important choices behind it, which can fundamentally affect the factor's performance. In this Street View, we'll analyze five such choices that go into a long-short Low Risk equity style factor designed in this way.

1. Universe We'll construct two Low Risk factors using two different universes:

- **MSCI World:** A global developed universe⁷
- **S&P 500:** A US universe

2. Definition In order to create a Low Risk factor, we need to define "low risk." We'll explore two different definitions of

risk, all calculated over the same lookback period of one year:

- **Volatility:** The negative⁸ of a stock's total volatility
- **Beta:** The negative⁹ of a stock's univariate equity market beta, calculated relative to the market-cap weighted portfolio of all stocks in the factor's universe

3. Weighting After we've calculated the "risk" of each stock in our universe in Step 2, we need to determine how we weight the stocks within the factor's long and short portfolios. In this Street View, we'll explore two different weighting schemes:

- **Quintiles:** Factor constructed by going long (short) an equi-weighted portfolio of stocks in the top (bottom) quintile of the chosen low risk measure, with quintiles computed over the chosen universe. Note that this scheme would give weights to stocks in the most extreme quintiles and ignore stocks in the middle.
- **Loadings:** Factor constructed using all stocks in the universe with each stock's weight being the z-score¹⁰ of its value for the chosen risk measure

4. Neutrality The factor should be constructed in a way that isolates its unique risk and removes the impact of the overall stock market. We'll analyze two neutrality options:

- **"Dollar"-neutral:** Factor constructed with equal dollar amounts allocated to the factor's long and short portfolios
- **Beta-neutral:** Factor constructed to be equity beta neutral (i.e., equal amount of equity risk in the factor's long and short portfolios)

5. Sector Tilts The final factor design choice we'll consider is how we handle sector tilts. We will explore two variations:

- **Sector-neutral:** Factor with sector neutrality, wherein we construct separate long-short Low Risk factors for each sector, and then combine them in a liquidity¹¹-weighted fashion to get the final Low Risk factor
- **Sector-tilts:** Factor with sector tilts, wherein no sector neutralization is performed

In the next section, we will analyze how these design specifications impacted Low Risk factor performance during the COVID market crisis.

⁶ For example, convert all the metrics, such as book-to-price values, for all the stocks into z-scores.

⁷ The factors with an MSCI World universe are region-neutralized by building factors within each region and then combining the regional factor portfolios in a liquidity-weighted fashion. Our measure of a stock's liquidity is the square root of its average daily dollar volume.

⁸ We use the negative of the stock's volatility because we want long exposure to lower volatility stocks and short exposure to higher volatility stocks.

⁹ We use the negative of the stock's equity market beta because we want long exposure to lower beta stocks and short exposure to higher beta stocks.

¹⁰ Z-score is calculated as (the stock's low risk value [i.e., -1 * the volatility or beta] - the average low risk value across all stocks in the universe) / the standard deviation of the low risk values across all stocks in the universe.

¹¹ Our measure of a stock's liquidity is the square root of its average daily dollar volume.

Low Risk Factor Performance During the COVID Market Crisis

Exhibit 2 summarizes the risk-adjusted performance for all the factor variations based on the design choices discussed above for the COVID market crisis period (see Appendix 1 for a longer-term analysis), and Exhibit 3 averages the Sharpe ratios across all the variations for a particular design choice.¹² We chose to display Sharpe ratios primarily to normalize risk and allow for performance comparability across the factor variations.

Three of the five design choices (Definition, Weighting, and Sector Tilts) didn't appear to matter much to performance over this period. The Universe design choice did make some difference, with the S&P 500 factors performing better than the MSCI World factors. The Neutrality design choice had by far the largest impact on factor returns.

In fact, not only did the performance differ depending on whether the factor was constructed dollar or beta neutral, but the sign of the performance differed. Dollar-neutral factors posted positive risk-adjusted returns, while beta-neutral factors posted negative risk-adjusted returns. This result held true regardless of the other design choices. In other words, every dollar-neutral specification we tried was positive, and every beta-neutral specification was negative.

Exhibit 2: Sharpe Ratios Over COVID Market Crisis Period

Time period: February 20, 2020 - March 23, 2020, using daily data.

Definition	Weighting	Neutrality	Sector Tilt	Universe	
				MSCI World	S&P 500
Volatility	Quintiles	Dollar-neutral	Yes	0.38	0.39
			No	0.26	0.30
	Beta-neutral	Yes	Yes	-0.40	-0.20
			No	-0.44	-0.23
	Loadings	Dollar-neutral	Yes	0.32	0.32
			No	0.26	0.33
Beta	Beta-neutral	Yes	Yes	-0.47	-0.23
			No	-0.44	-0.20
	Quintiles	Dollar-neutral	Yes	0.39	0.42
			No	0.35	0.36
	Beta-neutral	Yes	Yes	-0.50	-0.25
			No	-0.51	-0.25
Loading	Dollar-neutral	Yes	Yes	0.40	0.39
			No	0.38	0.35
	Beta-neutral	Yes	Yes	-0.48	-0.25
			No	-0.47	-0.26

Exhibit 3: Differences in the Average Sharpe Ratios Across All Other Factor Specifications During the COVID Market Crisis Period

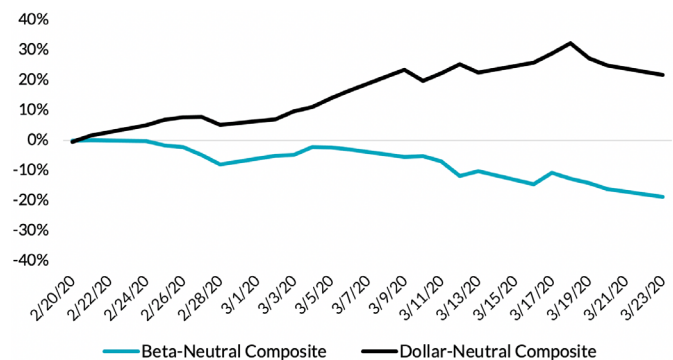
Time period: February 20, 2020 - March 23, 2020, using daily data.

Choice		Avg. Sharpe	Absolute Difference
Universe	MSCI World	-0.06	0.12
	S&P 500	0.06	
Definition	Volatility	0.00	0.01
	Beta	0.00	
Weighting	Quintiles	0.00	0.01
	Loading	0.00	
Neutrality	Dollar-neutral	0.35	0.70
	Beta-neutral	-0.35	
Sector Tilts	Yes	0.01	0.03
	No	-0.01	

The exhibit below shows the cumulative performance over the COVID market crisis period for the beta-neutral and dollar-neutral factors by averaging the daily returns across all other factor specifications. Dollar-neutral variations performed very well, while beta-neutral versions suffered.

Exhibit 4: Cumulative Performance of Beta-Neutral vs. Dollar-Neutral Low Risk Factors¹³

Time period: February 20, 2020 - March 23, 2020, using daily data.



What explains the directionally different performance of Low Risk factors depending on the Neutrality design choice? Neutrality is an important consideration for all factors, but notably for Low Risk because Low Risk stocks tend to have betas less than 1. In the dollar-neutral factor variations, where equal capital is allocated to the long and short portfolios, the beta of the long leg is typically less than 1, while it's typically greater than 1 for the short leg. This results in a risk imbalance such that the factor is negatively

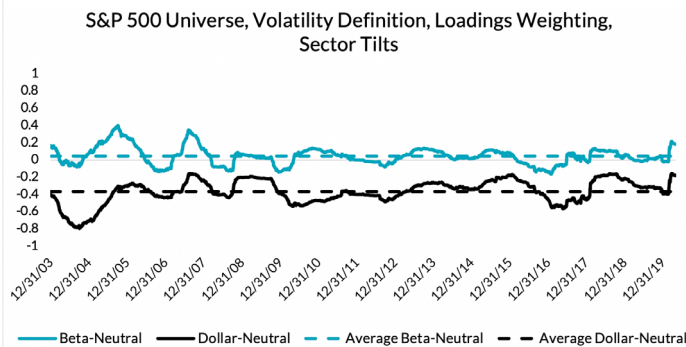
¹² We define the dates for the COVID market crisis period as starting with the first day of losses in the Two Sigma Factor Lens™ Equity factor (February 20th) and ending at the factor's peak losses on March 23rd. It is intended to represent the hardest and sharpest part of the equity market decline due to the global pandemic as of this writing (August 2020).

¹³ The factor returns were volatility-scaled for comparability.

exposed to equity market movements. In other words, the dollar-neutral versions have a static short equity beta bet, as seen in the rolling beta chart below, which may or may not be intentional.¹⁴ Therefore, when equity markets sell off in crises such as the COVID market crisis period, this short beta positioning benefits. However, this also means that dollar-neutral Low Risk factors are fighting the equity risk premium over the long-term (Appendix 1 shows how this short equity positioning negatively impacts the factor's long-term performance).

Exhibit 5: Rolling 1 Year Betas of Low Risk Factors Relative to the S&P 500 Index

Time period January 1, 2003 - April 30, 2020, using daily data. Sector tilts start on June 5, 2008.



The beta-neutral factor variations by design do not have any meaningful market tilt because these factors intend to balance the risk of the long and short portfolios by allocating more capital to the long portfolio than the short. The long portfolio needs more dollars to achieve the same amount of risk as the short portfolio.

Implications for Asset Allocators

Exhibit 5 showed that the dollar-neutral versions of Low Risk carry a persistent short equity beta, as opposed to their beta-neutral counterparts, which tend to be more orthogonal to the equity market. This has important implications for asset allocators that are trying to assess the factor exposures of their managers or portfolio(s).

For example, let's take the point of view of an asset allocator who wanted to understand the factor exposures of one of their managers that they specifically hired to provide defensive long-only equity exposure. Factor analysis might

be one way for this allocator to understand if their manager is following through on their desired exposure.

Say the manager was Fidelity's Advisor Consumer Staples Fund (ticker FDIGX). The fund seeks to outperform the market through an actively managed portfolio of less than 60 primarily U.S.-based stocks (as of 9/30/2020). The fund is considered to be defensive in nature, as it is focused on the consumer staples sector.¹⁵ In fact, the fund's long-term equity beta has been ~0.7, according to Fidelity's website.¹⁶

The allocator employs a set of returns-based regressions to attempt to explain the risk of the ETF using two different versions of the same factor risk model: one with a beta-neutral version of the Low Risk factor, and another with a dollar-neutral version.¹⁷ For simplicity, we use only two factors from the Two Sigma Factor Lens™, Equity and Local Equity, as our factor risk model.¹⁸ Equity attempts to capture the risk of global equity markets, while Local Equity intends to capture the extra risk of the U.S. equity market in particular.

Given what we know about the fund — it's long-only, focused on U.S. stocks in the consumer staples sector, and is meant to be defensive — we would expect to see the following factor exposures:

- Positive Equity beta that is ~0.7
- Positive Local Equity beta
- Positive Low Risk beta

Exhibit 6: Factor Exposures¹⁹ for FDIGX

Time period January 1, 2003 - April 30, 2020, using daily data. Sector tilts start on June 5, 2008.

	With Beta-Neutral Low Risk Factor	With Dollar-Neutral Low Risk Factor
Equity	0.67	0.79
Local Equity	0.53	0.65
Low Risk	0.34	0.37

14 The chart compares dollar-neutral and beta-neutral factors in the S&P 500 universe, with the Volatility definition, the Loadings weighting scheme, and sector tilts (see Appendix 2 for other factor variations). The factors are scaled to the same volatility.
15 <https://institutional.fidelity.com/app/fund/sasid/details/1783.html>
16 <https://institutional.fidelity.com/app/fund/sasid/details/1783.html>
17 We use factors in the S&P 500 universe, with the Volatility definition, the Loadings weighting scheme, and sector tilts. The factors are scaled to the same volatility.
18 The Two Sigma Factor Lens™ is a group of risk factors that intends to explain the risk of multi-asset class portfolios. For more information on the lens, please refer to our white paper “Introducing the Two Sigma Factor Lens” (Duncombe and Kay, 2018). While research on the Two Sigma Factor Lens™ plays a foundational role in the development of the Venn® Platform, any use by Venn of the Two Sigma Factor Lens™ can differ materially from the content, research, or methodologies discussed herein.
19 All of the factor exposures for both analyses were statistically significant.

While the results for the beta-neutral Low Risk factor are in line with what the allocator would expect, the dollar-neutral version paints a different picture. The fund, through this lens, appears ~20% riskier relative to the market (i.e., its beta to the Equity factor is 0.79 versus 0.67). Collinearity, or the strong -0.58 correlation between the dollar-neutral Low Risk factor and the Equity factor, has distorted the factor analysis results, as the regression has a hard time discerning how much risk to allocate between the Equity factor and the dollar-neutral Low Risk factor because of their high (negative) correlation. The analysis with the beta-neutral Low Risk factor does not run into this issue because it is naturally more orthogonal to the two other factors in the analysis due to its construction (0.03 correlation to Equity and 0.17 correlation to Local Equity).

This example showcases how differences in factor construction can directly impact allocators' analyses of third-party managers and lead to confusing and potentially misleading conclusions. We'd recommend that allocators use orthogonal factors when analyzing the factor risks of their managers and portfolios, making the beta-neutral version of the Low Risk factor, with its lower correlation to Equity risk, the superior option for this use case.

Finally, we should note that other design choices, while not necessarily "wrong", could potentially lead to differing conclusions when used in factor analysis. For example, using a U.S.-only Low Risk factor might miss exposure that a fund gained internationally. Additionally, the Sector Tilts design choice could be important if analyzing funds that derive their performance by taking a lot of sector risk. Again, allocators should be aware of which design choices are being made and how they impact their portfolios and analyses.

Conclusion

In this Street View, we tried to make sense of the dramatically dissimilar performance of Low Risk factors and funds during the COVID market crisis by analyzing the impact of various design choices. We found that Neutrality was the most impactful consideration in the recent market environment where equity markets dropped precipitously and subsequently posted a strong recovery, so any residual beta in the Low Risk factor led to meaningful performance

differences between the two neutrality options. The dollar-neutral Low Risk factors exhibited short equity bets that paid off during this market crisis, but otherwise are expected to underperform because of the equity risk premium drag on factor returns, as observed in Appendix 1. Additionally, these bets may or may not be intentional on the part of the investor and/or the factor provider.

All of this is to say that it's important for the asset allocator to be aware of how factors are constructed, especially when using them to analyze the performance of portfolios or investment managers. These intricate factor construction details could materially impact the conclusions drawn from returns-based factor analyses, thereby leading to potentially better-informed manager hire/fire decisions.

Appendix 1: Long-Term Performance of the Five Low Risk Factor Design Choices

Sharpe Ratios Over the Long-Term

Time period: January 1, 2003 - April 30, 2020, using daily data. Sector tilts start on June 5, 2008.

Definition	Weighting	Neutrality	Sector Tilt	Universe	
				MSCI World	S&P 500
Volatility	Quintiles	Dollar-neutral	Yes	-0.27	-0.23
			No	-0.19	-0.12
	Beta-neutral		Yes	0.95	0.38
			No	1.05	0.49
	Loadings	Dollar-neutral	Yes	-0.23	-0.15
			No	-0.21	-0.11
Beta		Beta-neutral	Yes	1.19	0.53
			No	0.94	0.45
	Quintiles	Dollar-neutral	Yes	-0.26	-0.18
			No	-0.18	-0.08
		Beta-neutral	Yes	1.33	0.58
			No	1.29	0.57
	Loading	Dollar-neutral	Yes	-0.23	-0.18
			No	-0.19	-0.11
		Beta-neutral	Yes	1.39	0.61
			No	1.27	0.57

Differences in the Average Sharpe Ratios Across All Other Factor Specifications

Time period: January 1, 2003 - April 30, 2020, using daily data. Sector tilts start on June 5, 2008.

Choice		Avg. Sharpe	Absolute Difference
Universe	MSCI World	0.48	0.29
	S&P 500	0.19	
Definition	Volatility	0.28	0.11
	Beta	0.39	
Weighting	Quintiles	0.32	0.03
	Loading	0.35	
Neutrality	Dollar-neutral	-0.18	1.03
	Beta-neutral	0.85	
Sector Tilts	Yes	0.33	0.01
	No	0.34	

The exhibits above summarize the risk-adjusted performance for all the factor variations based on the design choices discussed in this Street View for the period spanning January 1, 2003 to April 30, 2020. There were two design choices that resulted in statistically significantly different long-term returns: Neutrality and Universe.

The beta-neutral implementations posted higher risk-adjusted returns over the long-term compared to their dollar-neutral equivalents. In fact, the difference in signs we observed over the COVID market crisis period (beta-neutral negative; dollar-neutral positive) is the opposite over the

long-term (beta-neutral positive; dollar-neutral negative). This is because the dollar-neutral versions have a short equity position that detracts from returns long-term, as equity market risk has a positive return premium.

The global universe (MSCI World) appeared to result in higher Sharpe ratios than for the universe that was constrained to the US only (i.e., S&P 500 universe). A hypothesis for this result is that the cross-section of stocks to implement the factor using the MSCI World is broader. We confirmed this hypothesis by expanding the US universe from the 500 stocks in the S&P 500 to the 3,000 stocks in the Russell 3000 Index. The Russell 3000 universe indeed exhibits higher Sharpe ratios across the various factor implementations when compared to the S&P 500 universe over this long-term period.

The other three design choices didn't have a material impact on the long-term performance of the factor.

Finally, the long-term correlations among the various factors were generally positive across the board, though varied significantly. The average pairwise correlation across the MSCI universe was 0.47; 0.66 for S&P 500. The dispersion of pairwise correlation values was quite high though. The standard deviation of correlation values for all specifications using the MSCI universe was 0.37. The standard deviation was 0.22 for specifications under the S&P 500 universe. These results show that correlations among these factors can be meaningfully far from 1 even over the long-term.

A key observation that immediately sticks out from the correlation matrices is the evidence of clusters driven by the Neutrality design choice. Factors were more correlated if they followed the same neutrality construction (beta-neutral or dollar-neutral), confirming again that this design choice is a particularly important one.

Factor Correlations

Time period: January 1, 2003 - April 30, 2020, using daily data. Sector tilts start on June 5, 2008.

	MSCI-Beta-BN-SN-Q	MSCI-Beta-BN-SN-L	MSCI-Beta-BN-ST-Q	MSCI-Beta-BN-ST-L	MSCI-Beta-DN-SN-Q	MSCI-Beta-DN-SN-L	MSCI-Beta-DN-ST-Q	MSCI-Beta-DN-ST-L	MSCI-Vol-BN-SN-Q	MSCI-Vol-BN-SN-L	MSCI-Vol-BN-ST-Q	MSCI-Vol-BN-ST-L	MSCI-Vol-DN-SN-Q	MSCI-Vol-DN-SN-L	MSCI-Vol-DN-ST-Q	MSCI-Vol-DN-ST-L
MSCI-Beta-BN-SN-Q	1.00	0.96	0.98	0.96	0.06	0.06	0.03	0.03	0.47	0.46	0.44	0.44	0.02	0.02	0.00	-0.01
MSCI-Beta-BN-SN-L	0.96	1.00	0.93	0.98	0.09	0.10	0.06	0.06	0.58	0.58	0.53	0.55	0.06	0.07	0.03	0.03
MSCI-Beta-BN-ST-Q	0.98	0.93	1.00	0.95	0.00	0.00	0.00	-0.01	0.41	0.39	0.40	0.41	-0.04	-0.04	-0.05	-0.06
MSCI-Beta-BN-ST-L	0.96	0.98	0.95	1.00	0.02	0.03	0.01	0.02	0.51	0.52	0.50	0.53	-0.02	-0.01	-0.02	-0.03
MSCI-Beta-DN-SN-Q	0.06	0.09	0.00	0.02	1.00	0.99	0.97	0.97	0.32	0.31	0.26	0.27	0.92	0.91	0.92	0.89
MSCI-Beta-DN-SN-L	0.06	0.10	0.00	0.03	0.99	1.00	0.97	0.98	0.33	0.34	0.28	0.29	0.91	0.92	0.93	0.91
MSCI-Beta-DN-ST-Q	0.03	0.06	0.00	0.01	0.97	0.97	1.00	0.98	0.27	0.27	0.26	0.26	0.87	0.86	0.92	0.88
MSCI-Beta-DN-ST-L	0.03	0.06	-0.01	0.02	0.97	0.98	0.98	1.00	0.30	0.30	0.28	0.29	0.89	0.89	0.94	0.92
MSCI-Vol-BN-SN-Q	0.47	0.58	0.41	0.51	0.32	0.33	0.27	0.30	1.00	0.96	0.95	0.94	0.39	0.42	0.37	0.41
MSCI-Vol-BN-SN-L	0.46	0.58	0.39	0.52	0.31	0.34	0.27	0.30	0.96	1.00	0.92	0.96	0.39	0.47	0.38	0.44
MSCI-Vol-BN-ST-Q	0.44	0.53	0.40	0.50	0.26	0.28	0.26	0.28	0.95	0.92	1.00	0.96	0.33	0.36	0.36	0.39
MSCI-Vol-BN-ST-L	0.44	0.55	0.41	0.53	0.27	0.29	0.26	0.29	0.94	0.96	0.96	1.00	0.34	0.40	0.36	0.43
MSCI-Vol-DN-SN-Q	0.02	0.06	-0.04	-0.02	0.92	0.91	0.87	0.89	0.39	0.39	0.33	0.34	1.00	0.96	0.96	0.94
MSCI-Vol-DN-SN-L	0.02	0.07	-0.04	-0.01	0.91	0.92	0.86	0.89	0.42	0.47	0.36	0.40	0.96	1.00	0.95	0.97
MSCI-Vol-DN-ST-Q	0.00	0.03	-0.05	-0.02	0.92	0.93	0.92	0.94	0.37	0.38	0.36	0.36	0.96	0.95	1.00	0.97
MSCI-Vol-DN-ST-L	-0.01	0.03	-0.06	-0.03	0.89	0.91	0.88	0.92	0.41	0.44	0.39	0.43	0.94	0.97	0.97	1.00

	S&P 500-Beta-BN-SN-Q	S&P 500-Beta-BN-SN-L	S&P 500-Beta-BN-ST-Q	S&P 500-Beta-BN-ST-L	S&P 500-Beta-DN-SN-Q	S&P 500-Beta-DN-SN-L	S&P 500-Beta-DN-ST-Q	S&P 500-Beta-DN-ST-L	S&P 500-Vol-BN-SN-Q	S&P 500-Vol-BN-SN-L	S&P 500-Vol-BN-ST-Q	S&P 500-Vol-BN-ST-L	S&P 500-Vol-DN-SN-Q	S&P 500-Vol-DN-SN-L	S&P 500-Vol-DN-ST-Q	S&P 500-Vol-DN-ST-L
S&P 500-Beta-BN-SN-Q	1.00	0.98	0.89	0.89	0.46	0.47	0.38	0.39	0.89	0.85	0.78	0.75	0.40	0.44	0.35	0.38
S&P 500-Beta-BN-SN-L	0.98	1.00	0.87	0.90	0.46	0.48	0.38	0.40	0.90	0.89	0.79	0.77	0.40	0.46	0.35	0.40
S&P 500-Beta-BN-ST-Q	0.89	0.87	1.00	0.97	0.37	0.37	0.40	0.40	0.77	0.73	0.83	0.80	0.31	0.35	0.34	0.39
S&P 500-Beta-BN-ST-L	0.89	0.90	0.97	1.00	0.37	0.39	0.40	0.42	0.80	0.78	0.86	0.86	0.33	0.38	0.36	0.42
S&P 500-Beta-DN-SN-Q	0.46	0.46	0.37	0.37	1.00	0.99	0.94	0.94	0.53	0.50	0.47	0.46	0.90	0.91	0.87	0.86
S&P 500-Beta-DN-SN-L	0.47	0.48	0.37	0.39	0.99	1.00	0.94	0.95	0.54	0.54	0.49	0.48	0.89	0.92	0.86	0.87
S&P 500-Beta-DN-ST-Q	0.38	0.38	0.40	0.40	0.94	0.94	1.00	0.99	0.45	0.43	0.49	0.48	0.84	0.86	0.89	0.89
S&P 500-Beta-DN-ST-L	0.39	0.40	0.40	0.42	0.94	0.95	0.99	1.00	0.47	0.47	0.52	0.52	0.84	0.88	0.89	0.92
S&P 500-Vol-BN-SN-Q	0.89	0.90	0.77	0.80	0.53	0.54	0.45	0.47	1.00	0.95	0.89	0.86	0.56	0.62	0.51	0.56
S&P 500-Vol-BN-SN-L	0.85	0.89	0.73	0.78	0.50	0.54	0.43	0.47	0.95	1.00	0.86	0.89	0.54	0.65	0.51	0.60
S&P 500-Vol-BN-ST-Q	0.78	0.79	0.83	0.86	0.47	0.49	0.49	0.52	0.89	0.86	1.00	0.96	0.52	0.58	0.59	0.64
S&P 500-Vol-BN-ST-L	0.75	0.77	0.80	0.86	0.46	0.48	0.48	0.52	0.86	0.89	0.96	1.00	0.50	0.60	0.56	0.67
S&P 500-Vol-DN-SN-Q	0.40	0.40	0.31	0.33	0.90	0.89	0.84	0.84	0.56	0.54	0.52	0.50	1.00	0.94	0.93	0.88
S&P 500-Vol-DN-SN-L	0.44	0.46	0.35	0.38	0.91	0.92	0.86	0.88	0.62	0.65	0.58	0.60	0.94	1.00	0.91	0.94
S&P 500-Vol-DN-ST-Q	0.35	0.35	0.34	0.36	0.87	0.86	0.89	0.89	0.51	0.51	0.59	0.56	0.93	0.91	1.00	0.93
S&P 500-Vol-DN-ST-L	0.38	0.40	0.39	0.42	0.86	0.87	0.89	0.92	0.56	0.60	0.64	0.67	0.88	0.94	0.93	1.00

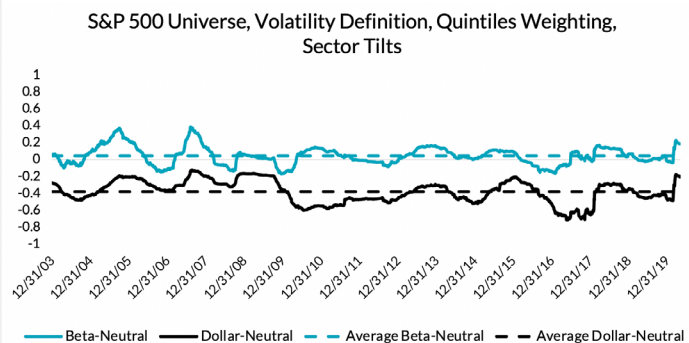
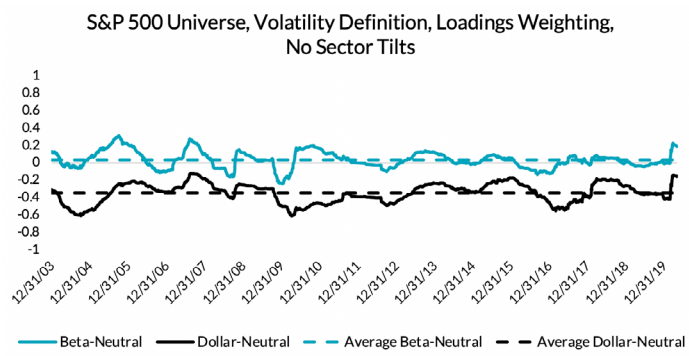
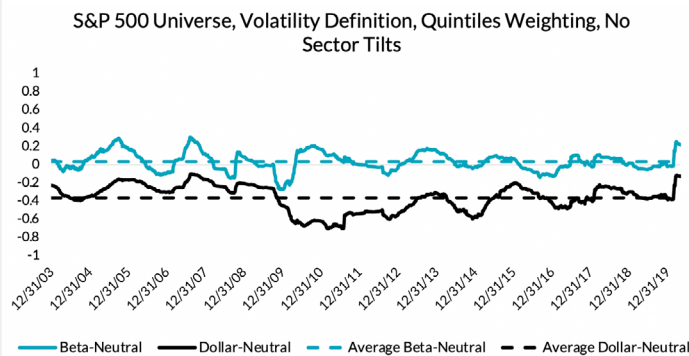
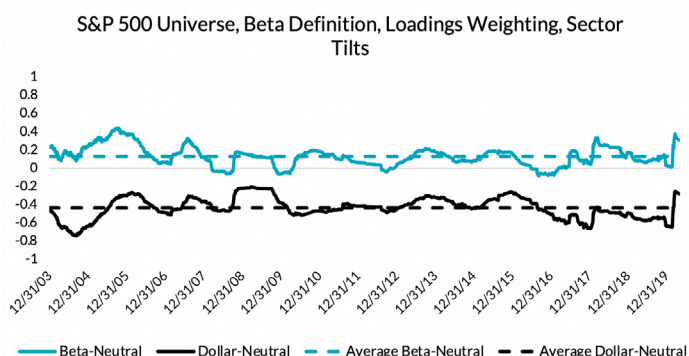
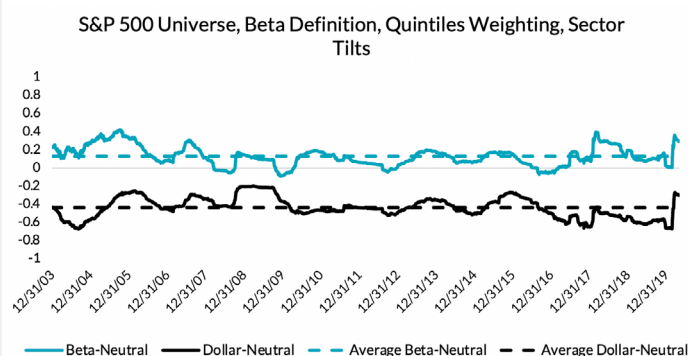
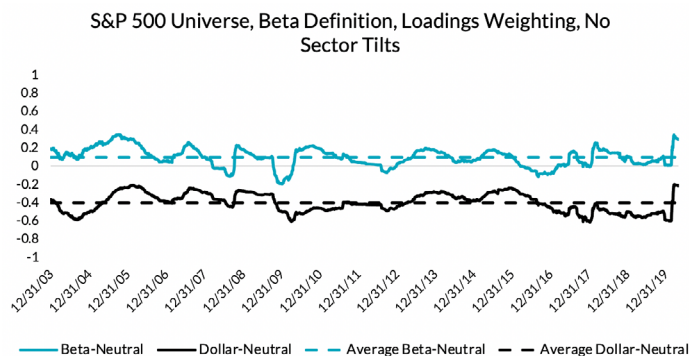
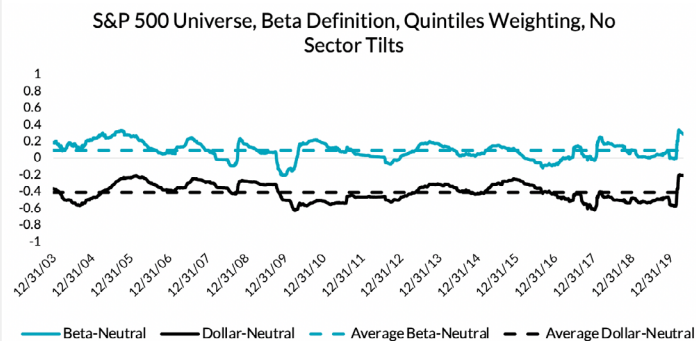
Legend:

Universe	MSCI or S&P 500
Definition	Beta or Vol (Volatility)
Neutrality	BN (Beta-Neutral) or DN (Dollar-Neutral)
Sector Tilts	SN (Sector-neutral) or ST (Sector-tilts)
Weighting	Q (Quintiles) or L (Loadings)

Example:

S&P 500-Vol-BN-SN-L S&P 500 universe, Volatility definition, beta-neutral, sector-neutral, and loadings-based weighting scheme

Appendix 2: More Rolling 1 Year Betas of Low Risk Factors Relative to the S&P 500 Index²⁰



²⁰ Sector tilts start on June 5, 2008.

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