Extending Rules-Based Factor Portfolios to a Long-Short Framework

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Why Extend Factor Investing to Long-Short?

While long-short strategies are commonplace in the arena of hedge funds, they are relatively new in the world of factor investing. (This includes our own definition of advanced beta and many forms of smart beta, systematic investing, risk premia investing, etc.) Advanced beta involves capturing well-known factors in simple rules-based ways typically in long-only portfolios; see [Ang et al. [2009], Bender et al. [2013]. By construct, we choose not to employ optimization or other well-known techniques since these portfolios are meant to be simple, rules-based, and transparent—in other words, a benchmark that any active strategy should be able to improve upon.

Why extend factor investing to long-short portfolios in the first place? Depending on whom you speak to, shorting is either a boon to investing or the devil in disguise. Jacobs and Levy [1993] pointed out that "investors who are able to overcome short-selling restrictions and have the flexibility to invest both long and short can benefit from winners and losers." Using a neat analogy about a hypothetical Yankees fan with perfect foresight, clearly he or she would benefit from being able to bet on the Mets losing, not just the Yankees winning.

Similarly, factor investing is based on faith or belief in the power of the risk premia captured by that set of attributes. Harnessing the full risk premium requires shorting. If an investor has a view that undervalued stocks will generally outperform, the corollary is that overvalued stocks will generally underperform. In a long-only portfolio, the investor can overweight the low valuation stocks but the most he can do is choose to not hold the high valuation stocks. The long-short framework allows the investor to more fully express the Value factor by actually shorting the high valuation stocks.

Building Long-Short Factor Portfolios: Simple Quintiles

Factor portfolios can be built using a simple methodology. First, a universe of stocks is ranked or sorted based on the security attribute in question. In long-short space, one would then go long the securities that are most attractive along that attribute and short the securities that are unattractive. Specifically, within some pre-defined universe:

- Value: Long lower valuation securities, short higher valuation securities
- Low Volatility: Long lower volatility securities, short higher volatility securities
- Quality: Long higher quality securities, short lower quality securities
- Size: Long smaller cap securities, short larger cap securities
- Momentum: Long higher momentum securities, short lower momentum securities

A pitfall of such a simple approach is that the resulting portfolio may have certain biases, such as at the sector or country level. Also, there may be a bias towards another factor; for instance if Value and Size are correlated at the time of construction, the Value portfolio will partially be a Size portfolio and vice versa. The advantage of such an approach is that it is clear how a portfolio is formed; that is, the resulting holdings in the portfolio are easy to explain.

Exhibit 1 shows the results of sorting the securities and forming quintiles (in which securities are equally weighted), where quintile 1 (Q1) consists of securities that are most attractive along the attribute in question, and quintile 5 (Q5) consists of the securities that are most unattractive. (We acknowledge that the choice of quintiles over quartiles or any other unit of segmentation is somewhat arbitrary here.) Returns shown are gross of assumed transactions costs. We use broadly accepted definitions of the factors.[1]

Given that these are factors that have been shown by a swath of academics to have a premium over the long run, it should come as no surprise that Q1 securities invariably have had higher returns over the last 25 years than Q5 securities. Interestingly, there are differences across the factors; Value and Quality for instance are factors where Q1 securities have much larger returns than Q5 securities, but Q2 through Q4 returns are rather flat (and not differentiated).

We construct long-short portfolios by going long the Quintile 1 portfolios and short the Quintile 5 portfolios in Exhibit 1. The annualized average return and volatilities, gross of transactions costs, are shown for these long-short portfolios in Exhibit 2.[2] The Value portfolio earns the highest returns historically by far, followed by Momentum, Quality, and Volatility. While all four portfolios have earned positive historical returns, Quality and Volatility have not outperformed the US 1-Month T-bill (which along with Libor is generally the benchmark for long-short strategies).

	Value	Quality	Volatility	Momentum
Q1	13.05%	10.16%	10.78%	11.67%
Q2	9.91%	9.04%	9.63%	10.49%
Q3	8.69%	8.83%	8.79%	8.42%
Q4	7.49%	8.02%	7.61%	6.68%
Q5	2.70%	6.08%	4.53%	3.90%

Exhibit 1: Annualized Returns (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	Value	Quality	Volatility	Momentum	US 1M T-Bill	MSCI World Index
Annualized Returns	9.30%	2.30%	1.50%	3.27%	2.97%	7.06%
Annualized Volatility	15.82%	9.38%	18.79%	20.23%	0.62%	15.24%
Sharpe Ratio*	0.59	0.24	0.08	0.16	0.00	0.27

Exhibit 2: Performance of Long-Short Portfolios (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.
Note that because the long-short portfolio returns do not include the cash return, the Sharpe Ratio shown here is calculated as: (portfolio return + cash return – cash return)/(portfolio return volatility).
*Note: To compute annualized returns, we do not subtract the annualized return of Q5 from Q1. Instead we compute monthly spreads (return difference) between the Q1 and Q5 portfolios, and take the annualized geometric mean of this time series. Asset base is adjusted monthly in all figures. All portfolios are notional neutral.

Notional Neutral versus Beta Neutral

So far we have assumed that the weight in the long portfolio is 100% and the weight in the short portfolio is 100%. This is the same as a notional-neutral or dollar-neutral strategy in which the long and short portfolios have equal dollar amounts. Specifically, we assume we have $100 in the long portfolio, $100 is shorted in the short portfolio, and we hold $100 in cash. Leverage is fixed for a notional-neutral portfolio so if the strategy is long one dollar and short one dollar for every dollar of invested capital, as in our framework, the leverage is 2:1. Note that leverage is fixed at the time of rebalancing but can drift in between rebalancing dates.[3] We do not include the cash return in any of the results shown for the remainder of the paper though in practice, an investor would earn some amount of interest on that amount. Unless otherwise stated, all returns are gross of transaction costs.

We showed results for notional neutral portfolios previously. However, as we show in Exhibit 3, they all have historically exhibited significantly non-zero beta.[4] Most factor portfolios have had negative beta on average (the long portfolios have generally had lower beta than the short portfolios have).[5] This significant negative beta reflects a sizable exposure to market risk; the returns to the portfolios are effectively penalized by the fact that the market has generally gone up during the two-decades in question. In addition, constructing the portfolios such that they are beta neutral (or market neutral) may have the merit of potentially being employed as a diversified uncorrelated source of return when layered onto an existing equity portfolio.

We examine the impact of beta-neutralizing the portfolios each month by forcing the beta of the long portfolio to be the same as the short portfolio. Specifically we calculate the weighted average beta of the final long and final short portfolios using historical 60-month betas to the MSCI World.[6] We then assign a weight of 100% to the portfolio (long or short) with the lower relative beta, and assign a weight to the higher beta portfolio proportional to their betas:

$$w_{low\_beta} = 100\% \tag{1}$$

$$w_{high\_beta} = \frac{\beta_{low\_beta}}{\beta_{high\_beta}} \tag{2}$$

Why would beta neutralizing the portfolios be desirable? A portfolio with a beta of zero will be completely uncorrelated with the market and thus attractive if the investor's objective is to offset losses to the existing equity portfolio when there are equity market drawdowns.

Exhibit 4 shows the results of beta neutral factor portfolios. Ex post betas are reasonably close to zero and compared to the dollar-neutral portfolios, exhibit lower annualized volatility and improved risk-adjusted returns. Returns are meaningfully higher in the case of Quality, Volatility, and Momentum.

	Value	Quality	Volatility	Momentum	US 1M T-Bill	MSCI World Index
Annualized Returns	9.30%	2.30%	1.50%	3.27%	2.97%	7.06%
Annualized Volatility	15.82%	9.38%	18.79%	20.23%	0.62%	15.24%
Sharpe Ratio	0.59	0.24	0.08	0.16	0.00	0.27
Beta vs MSCI World	0.001	-0.30	-0.81	-0.44	0.00	1.00

Exhibit 3: Long-Short Portfolios (December 31, 1989 to August 31, 2014, Rebalanced Monthly Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	Value	Quality	Volatility	Momentum	US 1M T-Bill	MSCI World Index
Annualized Returns	9.54%	5.13%	8.44%	6.49%	2.97%	7.06%
Annualized Volatility	14.99%	6.59%	8.32%	13.67%	0.62%	15.24%
Sharpe Ratio	0.64	0.78	1.02	0.47	0.00	0.27
Beta vs MSCI World	0.13	(0.04)	0.07	0.03	0.00	1.00

Exhibit 4: Long-Short Portfolios, Beta Neutral, Netted (Monthly Rebalancing, December 31, 1989 to August 31, 2014, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	Value	Low Volatility	Quality	Momentum
Value	1.00			
Low Volatility	0.06	1.00		
Quality	-0.43	0.56	1.00	
Momentum	-0.35	0.56	0.48	1.00

Exhibit 5A: Correlation of Long-Short Portfolios, Notional Neutral (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	Value	Low Volatility	Quality	Momentum
Value	1.00			
Low Volatility	0.22	1.00		
Quality	-0.45	0.23	1.00	
Momentum	-0.36	0.31	0.35	1.00

Exhibit 5B: Correlation of Long-Short Portfolios, Beta Neutral (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

Combining Multiple Factors

The analysis so far has focused on individual factor portfolios. What if we were to combine multiple factors in a single portfolio? Exhibit 5 shows the long-term correlations between the factor portfolios, both notional neutral and beta neutral. Combining multiple factors can provide the benefit of diversification, as an investor could take advantage of the low, sometimes negative correlations, between factor portfolios to achieve more consistency in performance. Correlations can of course vary substantially over time but over the long term, there have been significant diversification opportunities across the factors.

Factors also behave differently depending on the market or macro regime. Gupta et al. [2014] find that Momentum and Size have historically performed best in high growth regimes, while Low Volatility has historically done well in low growth and high inflation periods. Furthermore, Quality has historically done well as economic growth slows. Exhibits 6A and 6B highlights these patterns with the cumulative returns of both the dollar-neutral and beta-neutral factor portfolios over time.

We next combine the individual factor portfolios using equal weights. Unlike typical hedge fund strategies where securities are specifically selected for the long and short portfolios, multiple factor portfolios can have overlapping names in the combined long and short portfolios. For instance, a security can show up in the long portfolio for Value and in the short portfolio for Momentum. We "net" these trades out. The netted portfolio return is different from the combined, non-netted portfolio, due to compounding effects. Netting also can meaningfully impact turnover and transaction costs, which are discussed in the next section.

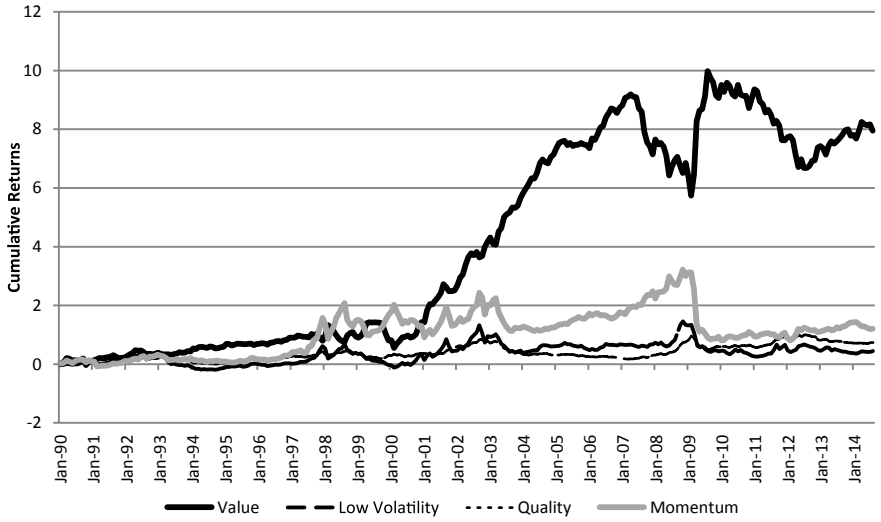

Exhibit 6A: Cumulative Returns of Long-Short Portfolios, Dollar Neutral (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

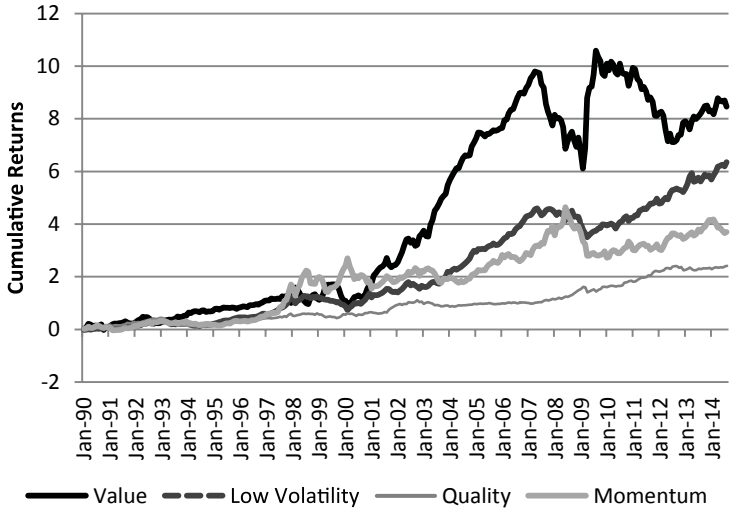

Exhibit 6B: Cumulative Returns of Long-Short Portfolios, Beta Neutral (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and Authors' calculations.

The equally weighted combination of the four factor portfolios is shown in Exhibit 7. Only the notional neutral version is shown here for illustration (a beta-neutral version using a modified rebalancing scheme is later shown in Exhibit 12).[7] Combining the four portfolios results in a portfolio with 7.61% annualized returns, which is notably higher than the average return of the individual four factor portfolios of 4.09%. This result is due to netting, and the compounding effects that arise.[8]

There are of course other ways we can build long-short multi-factor portfolios besides combining individual factor portfolios. One reasonable and intuitive way is to take into account all factor attributes simultaneously when selecting the securities for the long and short portfolios. To illustrate, we create normalized scores ranging from -3 to 3 for each security and each factor. We average the four factor scores for each security and bucket them into quintiles. We then go long the top quintile (using the average score) and short the lower quintile. Exhibit 8 compares the results of this method with Exhibit 7. The annualized returns improve from 7.61% to 8.31%; however the annualized volatility increases, the Sharpe Ratio decreases, and the beta also decreases.

Exhibits 7 and 8 illustrate the power of combining factors using dollar-neutral portfolios. The combined portfolio by construction is dollar neutral as well and likewise exhibits a large negative beta. The power of diversification is equally compelling for beta-neutral portfolios. Later in Exhibit 12 we show the results of combining the notional-neutral portfolios and beta neutralizing the combined portfolio.

Rebalancing Mechanisms to Mitigate Turnover

Last but not least, we address the challenge of turnover. Exhibit 9 displays two-way annual turnover for the long-short factor portfolios along with the estimated drag on returns incurred under a range of transaction cost assumptions (20 to 50 bps). (Details on how we calculate turnover appear in Appendix A.) Note that for transaction costs, we not include borrow costs for the short positions, which we address later in Section 6.[9]

The turnover numbers in Exhibit 9 are orders of magnitude higher than the 6-10% turnover for the market cap weighted index and the 30-50% two-way turnovers that long-only factor portfolios generally experience. On the other hand, it is not uncommon to see two-way annual turnover for long-only active strategies between 150-300% and long-short strategies 3 to 4 times higher.

Subtracting the estimated drag from the annualized returns shown in the first row of Exhibit 9 would give us the transaction-cost-adjusted return. Transaction costs would clearly erode a

	Value	Quality	Volatility	Momentum	Combined Four Factor	US 1M T-Bill	MSCI World Index
Annualized Returns	9.30%	2.30%	1.50%	3.27%	7.61%	2.97%	7.06%
Annualized Volatility	15.82%	9.38%	18.79%	20.23%	15.72%	0.62%	15.24%
Sharpe Ratio	0.59	0.24	0.08	0.16	0.48	0.00	0.27
Beta vs MSCI World	0.001	-0.30	-0.81	-0.44	-0.64	0.00	1.00

Exhibit 7: Performance of Long-Short Factor Portfolios, Notional Neutral, Netted (December 31, 1989 to August 31, 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.
Note: Individual factor portfolios use simple quintiles (long Q1, short Q5). The combined four factor portfolio combines these in equal weight and nets out positions.

	Value	Quality	Volatility	Momentum	Combined Four Factor	Combined Four Factor (Security-Level)	US 1M T-Bill	MSCI World Index
Annualized Returns	9.30%	2.30%	1.50%	3.27%	7.61%	8.31%	2.97%	7.06%
Annualized Volatility	15.82%	9.38%	18.79%	20.23%	15.72%	18.47%	0.62%	15.24%
Sharpe Ratio	0.59	0.24	0.08	0.16	0.48	0.45	0.00	0.27
Beta vs MSCI World	0.001	-0.30	-0.81	-0.44	-0.64	-0.75	0.00	1.00

Exhibit 8: Performance of Long-Short Portfolios, Notional Neutral, Netted (December 1989 to August 2014, Rebalanced Monthly, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

significant amount of the return across all factors. The question remains whether there are ways to reduce the turnover of the strategies while still preserving the returns.

First we explore whether rebalancing quarterly would solve the problem. As shown in Exhibit 10, the turnover can be reduced significantly; however, the returns for Quality, Volatility, and Momentum are greatly diminished. Unlike long-only tilted portfolios, in which Quality and Volatility can be captured using annual rebalancing and Momentum can be captured using quarterly rebalancing, the use of a more concentrated stock universe (quintiles) and their weightings require more frequent rebalancing.

Second we explore whether we can maintain the monthly rebalancing frequency but mitigate the turnover with buffer rules. Specifically, we allow stocks that have previously been in Q1 but drop to the top half of Q2 to remain in the long portfolio; these securities stay in the long portfolio indefinitely until they fall below the top half of Q2.[10] Similarly, securities that have previously been in Q5 but move to the bottom half of Q4 continue to be shorted, and held indefinitely unless they move above the bottom half of Q4. While this does introduce an element of path dependency to the long-short portfolios, we believe it is the lesser of necessary evils if one wants to capture the factors. Effectively the buffer rules find a half-way point between monthly and quarterly rebalancing.

Exhibit 11 shows the results with the buffer rules in place. We find that turnover can be mitigated by using simple buffer rules while still preserving some of the excess returns. After subtracting the estimated drag, the returns to Value, Quality, Volatility, and Momentum would have been 8.08%, 0.62%, 0.48%, and 0.33% respectively. These annualized returns are all positive, though with the exception of Value, are quite small.

Similar to the dollar neutral portfolios shown in Exhibit 11, the rebalancing buffer is equally helpful in reducing the turnover of beta neutral portfolios (Exhibit 12). Because the annualized returns are historically higher for beta-neutral Quality, Volatility, and Momentum portfolios, the returns (after costs have been accounted for) are far more compelling than the dollar-neutral portfolios. After subtracting the estimated drag, the returns to Value, Quality, Volatility, and Momentum would have been 6.50%,

	Value	Quality	Volatility	Momentum
Annualized Returns	9.30%	2.30%	1.50%	3.27%
Annualized Volatility	15.82%	9.38%	18.79%	20.23%
Sharpe Ratio	0.59	0.24	0.08	0.16
Beta vs MSCI World	0.00	-0.30	-0.81	-0.44
Two-Way Annual Turnover (Monthly Rebalancing)	603%	381%	424%	1339%
Estimated Drag in bps (Assuming 20 bps one way)	121	76	85	268
Estimated Drag in bps (Assuming 30 bps one way)	181	114	127	402
Estimated Drag in bps (Assuming 40 bps one way)	241	152	170	536
Estimated Drag in bps (Assuming 50 bps one way)	303	190	213	670

Exhibit 9: Turnover for Long-Short Portfolios, Dollar Neutral, Netted (Monthly Rebalance, December 31, 1989 to August 31, 2014, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	Value	Quality	Volatility	Momentum
Monthly Rebalance				
Annualized Returns	9.30%	2.30%	1.50%	3.27%
Two-Way Annual Turnover (Monthly Rebalancing)	603%	381%	424%	1339%
Estimated Drag in bps (Assuming 30 bps one way)	181	114	127	402
Annualized Return Minus Drag	7.49%	1.16%	0.23%	-0.75%
Quarterly Rebalance				
Annualized Returns	8.81%	1.58%	-0.08%	0.32%
Two-Way Annual Turnover (Monthly Rebalancing)	358%	264%	271%	744%
Estimated Drag in bps (Assuming 30 bps one way)	107	79	81	223
Annualized Return Minus Drag	7.74%	.79%	-0.89%	-1.91 %

Exhibit 10: Turnover for Long-Short Portfolios, Dollar Neutral, Netted (Monthly Rebalance vs. Quarterly Rebalance, December 31, 1989 to August 31, 2014, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

3.53%, 7.44%, and 2.25% respectively. When combined together, an equally weighted, beta-neutral combination of the Value, Quality, Volatility and Momentum factor portfolios would have earned 8.42% after subtracting the estimated drag of 161 bps from the 10.03% return.

The Costs and the Risks of Shorting

It is well known that one of the biggest challenges to managing a long-short strategy is the cost of shorting. So far we have looked at transaction costs but have not included additional costs related to shorting such as borrowing costs. Historical shorting costs are difficult to obtain and may not necessarily be indicative of current or future costs.

That said, to get a sense of shorting costs, we look next at short scores. In the portfolios we have shown, the long and short portfolios for each factor have roughly 300 names each. This is a relatively diversified portfolio (not concentrated) but because the securities are equally weighted, there is a bias in both the short and long portfolios towards smaller more illiquid names. And in the short portfolio, these names may have very high shorting costs. Utilizing shorting scores from Data Explorer, we analyze whether the cost of shorting for our portfolios is significantly higher than the underlying universe or not. Data Explorer assigns each security in the universe a short score ranging from 0 to 5, where 0 being the least expensive to short and 5 the most expensive. The following table and charts show the score distribution of the MSCI World universe versus our

	US 1M T-Bill	MSCI World Index	Value	Quality	Volatility	Momentum	Combined Four Factor (Equally Weighted)
Monthly Rebalance with Buffer (Notional Neutral)							
Annualized Returns	2.97%	7.06%	8.59%	1.55%	1.42%	2.84%	6.45%
Annualized Volatility	0.62%	15.24%	15.07%	8.94	17.49%	19.84%	15.36%
Sharpe Ratio	0.00	0.27	0.57	0.17	0.08	0.14	0.42
Beta vs MSCI World	0.00	1.00	-0.08	-0.28	-0.74	-0.40	-0.61
Two-Way Annual Turnover (Monthly Rebalancing)			338%	311%	313%	837%	553%
Estimated Drag in bps (Assuming 30 bps one way)			101	93	94	251	166
Annualized Return Minus Drag			7.58%	0.62%	0.48%	0.33%	4.79%

Exhibit 11: Performance and Turnover for Long-Short Portfolios, Dollar Neutral, Netted (Monthly Rebalance with Buffer, December 31, 1989 to August 31, 2014, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	US 1M T-Bill	MSCI World Index	Value	Quality	Volatility	Momentum	Combined Four Factor (Equally Weighted)
Monthly Rebalance with Buffer (Beta Neutral)							
Annualized Returns	2.97%	7.06%	7.50%	4.42%	8.15%	4.82%	10.03%
Annualized Volatility	0.62%	15.24%	12.90%	6.38%	8.15%	13.03%	8.17%
Sharpe Ratio	0.00	0.27	0.58	0.69	1.00	0.37	1.23
Beta vs MSCI World	0.00	1.00	-0.02	-0.03	-0.09	-0.04	0.01
Two-Way Annual Turnover (Monthly Rebalancing)			333%	295%	237%	855%	537%
Estimated Drag in bps (Assuming 30 bps one way)			100	89	71	257	161
Annualized Return Minus Drag			6.50%	3.53%	7.44%	2.25%	8.42%

Exhibit 12: Performance and Turnover for Long-Short Portfolios, Beta Neutral, Netted (Monthly Rebalance with Buffer, December 31, 1989 to August 31, 2014, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

	MSCI World	Value	Quality	Volatility	Momentum
0 (Lowest)	36.64%	30.00%	33.29%	28.37%	29.02%
1	45.39%	49.11%	44.91%	45.91%	45.37%
2	12.52%	14.34%	14.26%	16.22%	15.74%
3	3.44%	4.00%	4.85%	5.84%	5.97%
4	1.17%	1.42%	1.70%	2.32%	2.39%
5 (Highest)	0.85%	1.13%	0.99%	1.34%	1.50%
Mean	0.90	1.01	1.00	1.12	1.12
Standard Deviation	0.93	0.96	0.99	1.04	1.06

Exhibit 13: Weight of Portfolios in Various Short Score Categories Reflecting Shorting Costs (Portfolio Averages, 2006 to 2014)
Source: SSgA, Factset, Data Explorer

short portfolios. In the bottom two rows of Exhibit 13, the average short score of each of the short portfolios over the period 2006 to 2014 is shown as well as the standard deviation across scores. These average scores are all higher than the universe (suggesting that it is more expensive to short the portfolio compared with the universe) however not meaningfully higher.

Also shown in Exhibit 13 is the percentage of each factor portfolios' short portfolio in each category. The weights of all four factors in the most expensive category (Category 5) are not significantly higher than the MSCI World's percentage of 0.85%. To the extent that the MSCI World Index as a portfolio remains relatively easy and not too expensive to short, we would expect the short sides of the factor portfolios to be similar and within a narrow range.

If we assume that shorting costs for the factor portfolios are generally around the shorting costs for an MSCI World universe (cap-weighted), we can assume the costs of shorting might be in the range of 20 to 50 bps. Returning to Exhibit 12, we could further adjust the returns as shown in Exhibit 14 using the conservative estimate of 50 bps. The potential performance benefits of the beta-neutral factor portfolios do in fact remain viable.

That said, shorting costs do not capture the dangers of shorting. These include the potential for infinite losses, the risks of shares being recalled, inability by the investor to meet margin requirements, and the potential that counterparties may just stop lending out securities to short altogether. If the strategy underperforms significantly, margin calls may force positions to be liquidated. Short squeezes may occur, when prices of appreciating shorted securities further rise as existing short sellers buy shares to cover their short positions. Losses may be limited on the long side but they are infinite on the short side. These risks are difficult to quantify but are critical to manage. This paper does not claim to address these important risks but they are nevertheless paramount to the viability of long/short factor investing.

Conclusion

The idea of extending factor portfolios to a long-short framework has the merit of allowing investors to more fully express their factor beliefs by being able to short names that are less desirable along the relevant attribute. Here we explore the implications of

	US 1M T-Bill	MSCI World Index	Value	Quality	Volatility	Momentum	Combined Four Factor (Equally Weighted)
Annualized Returns	2.97%	7.06%	7.50%	4.42%	8.15%	4.82%	10.03%
Estimated Drag from Transaction Costs in bps (Assuming 30 bps one way)			100	89	71	257	161
Estimated Drag from Shorting Costs in bps (Assuming 50 bps)			50	50	50	50	50
Annualized Returns Minus Drag from Both Transaction and Shorting Costs			6.00%	3.03%	6.94%	1.75%	7.92%

Exhibit 14: Estimated Costs for Long-Short Portfolios, Beta Neutral, Netted (Monthly Rebalance with Buffer, December 31, 1989 to August 31, 2014, Universe = MSCI World Index)
Source: MSCI World Index and authors' calculations.

extending the simple rules based framework to portfolios that can employ leverage. These portfolios could be used as potential benchmarks for long-short strategies, particularly factor-based active strategies which should in theory add value over these simple rules-based portfolios. These portfolios could also serve as investable solutions, either as candidates for alternatives mandates or to complement existing long-only portfolios.

Our results show that long-short factor portfolios have historically provided compelling performance even after costs are accounted for. Not all factors are created equal--some factors are more compelling than others in terms of their historical returns and volatility. Importantly, the choice to construct portfolios as dollar neutral versus beta neutral has a significant impact on the historical returns. Dollar neutral portfolios, particularly for Low Volatility, have historically exhibited large negative betas, exposing them to market risk. Factors such as Low Volatility and Quality are thus less compelling when captured in a dollar neutral framework versus a beta neutral framework. Ways to mitigate turnover can be introduced such that the potential performance benefits of these strategies are still compelling even after costs are accounted for.

Moreover, combining factors yields strong benefits as the factors diversify each other over time. Netting trades that overlap from one factor to another has a large impact in the long/short framework, producing sizable reductions in turnover relative to the collection of individual standalone portfolios.

That said, there are two main challenges. First, it is well-known that factors are cyclical and can experience periods of underperformance. Implementing long-short versions of the factors means these periods of underperformance will generally be magnified. Second, shorting itself entails significant risks. However, for investors willing to bear the risks associated with shorting, our results indicate that long-short factor investing can be viable.

Endnotes

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1. Valuation is measured by the equally weighted average of price-to-fundamental ratios where the fundamentals are Earnings, Cash Flow, Sales, Dividend, and Book Value. Volatility is measured by 12-month variance of USD return. Size is measured by free-float adjusted USD market capitalization. Momentum is measured by the trailing 12 month's local return minus the last month's return. Quality is measured by the equally weighted average score across return-on-assets, earnings-per-share variability, and long-term debt-to-equity. These are equally weighted

2. It should be noted that the return of the long/short portfolio is the difference (or spread) between the the Q1 and Q5 portfolios, for which we show the annualized geometric mean in Exhibit 2. This return figure can differ significantly from subtracting the annualized Q5 return from the annualized Q1 return shown in Exhibit 1. For instance, the annualized return for Quality is 2.3% but the difference between the Q1 and Q5 annualized returns in Exhibit 1 was 10.16% minus 6.08% which is 4.08 percentage points. This is primarily due to compounding. For Low Volatility, where the difference is even more stark, the difference between the two is also due to beta.

3. The rebalancing mechanics are simply illustrated as follows: Suppose we hold $100 in the long portfolio,-$100 in the short portfolio and an equivalent amount in cash. Within a given month, the dollar amount of each portfolio will vary with returns such that the portfolio will not be perfectly notional neutral, but at the end of each month, we rebalance back to notional neutral. Specifically, if the long portfolio outperforms the short portfolio (say the long portfolio now is now worth $110, while the short portfolio is worth $90),

we sell a proportional amount of the short holdings ($30) and reinvest $20 into cash, and $10 into the long portfolio. So now both the long, the short and the cash are at $120. Rebalancing the beta neutral portfolios follows the same process as above except that instead of rebalancing back to $100 long, $100 short in the above example, we would rebalance back to the beta neutral amounts, for example $100 long, $70 short.

4. Beta of the notional-neutral portfolios are computed as the beta of the long-short spread against MSCI World Index returns. Beta of the beta-neutral portfolios are computed as the beta of the beta-neutral portfolio returns relative to the MSCI World Index returns.

5. We highlight that Momentum counterintuitively has a negative beta of -0.44 in Exhibit 3. This is because the long portfolio has a beta of 0.93 while the short portfolio has a beta of 1.37. The low momentum losers tend to exhibit significantly greater volatility than the high momentum winners.

6. We tested alternative versions with 36-month historical beta, Axioma predicted beta, and Axioma historical beta. The results, while different depending on the factor, were qualitatively similar. 60-Month Historical beta was chosen for simplicity.

7. For the beta-neutral version, the notional neutral portfolios are first combined and the beta neutralization applied afterwards.

8. Readers may note that combining long-only factor portfolios produces a portfolio with characteristics that generally average the individual portfolios (with diversification between factor portfolios lowering the overall volatility and improving the Sharpe and Information Ratios). Here, there are much greater differences that arise when factors are combined and this is both due to factor diversification and netting but largely the result of the latter. For example, in each single factor long-short portfolio, we only select stocks that reflect the best/worst of that dimension. Then when we combine the portfolios, securities that are desirable in one dimension but undesirable in another dimension will be netted out. Only securities that are desirable simultaneously across all dimensions will be held in the final long portfolio. Similarly, only securities that are undesirable simultaneously across all dimensions will be held in the final short portfolio.

9. For instance, if we assume the transaction cost is 20 basis points, the 20 basis points would apply to a one-way trade, such that trading $100 of any security either on the long or short side would incur 2 cents.

10. Note that securities that have previously been in Q1 and remain in Q1 in subsequent months are held indefinitely in the long portfolio. To preserve the number of securities in the long portfolio to be 1/5 of the universe, securities that are the lowest ranked in Q1 are not held in lieu of those names in Q2 that remain because of the buffer rule. Similarly, securities that have previously been in Q5 and remain in Q5 in subsequent months are held indefinitely in the short portfolio. And again, to preserve the number of securities in the short portfolio to be 1/5 of the universe, securities that are the highest ranked in Q5 are not held in lieu of those names in Q4 that remain because of the buffer rule.

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Appendix A: Turnover Calculation

The turnover for the long-short portfolio from period t to t+1 will be the total changes of security values at the beginning of period t+1 versus the end of period t, as well as the notional amount changes in the long and short portfolio and the resulting security value changes, divided by the average of the long and the short portfolio values at the end of period t. Further details on the turnover calculation may be obtained upon request from the authors.

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