

WRDS Quant Alpha Report*

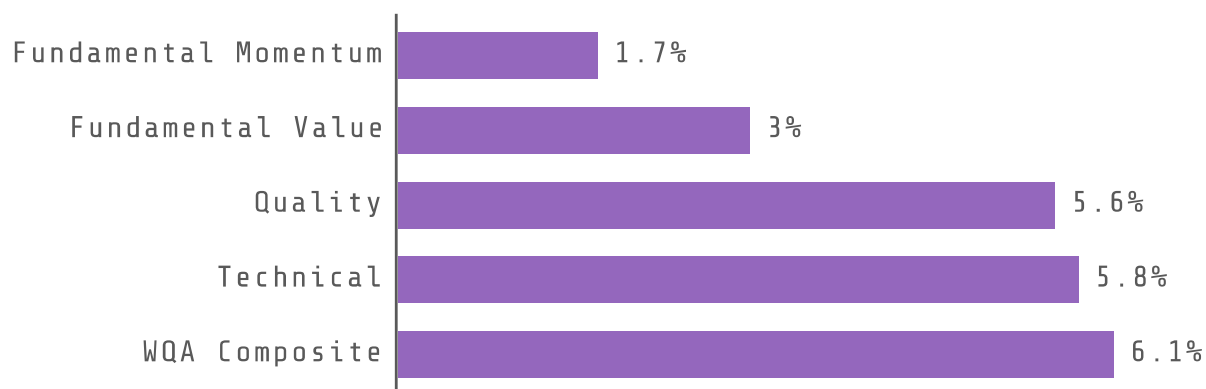
Number 6 | November 2014

Executive Summary

The third quarter of 2014 saw strong long-short performance for quantitative strategies, with the broad **WQA Composite LS** reporting a 6.1% return (8.9% YTD). In fact, all of the various WQA Composites generated impressive long-short returns in this quarter, from 0.2% (WQA UnCorrelated, 5.1% YTD) to 8.6% (WQA Novel, 13.8% YTD). Among the individual signals in our newly expanded library, more than 75% showed long-short returns outperforming the risk-free benchmark. At the theme level, **Technical** showed the highest long-short return at 5.8% (4.8% YTD), followed by 5.6% for the **Quality** theme (5.2% YTD).

Q3 Performance

Long-Short Returns



During the last quarter, the WRDS alpha signal library underwent a major enhancement. The number of strategies were effectively doubled to over 130 after reviewing additional academic literature in accounting and finance. In addition, a rigorous signal-validation mechanism was incorporated in the backtesting procedure, ensuring that only *predictive* and *additive* signals are included in the final theme and composite calculations.

In the last section of this report, we review additivity analysis as applied to traditional quant strategies. Before expanding an investment menu, portfolio managers need to know how much incremental value an additional individual strategy brings to an existing strategy mix. It does not always follow that individual strategies with high IR provide the most improvement in the IR of overall strategies. We will show specific signals that most help (or hurt) the overall IRs of various quant investment themes.

1. Recent Performance

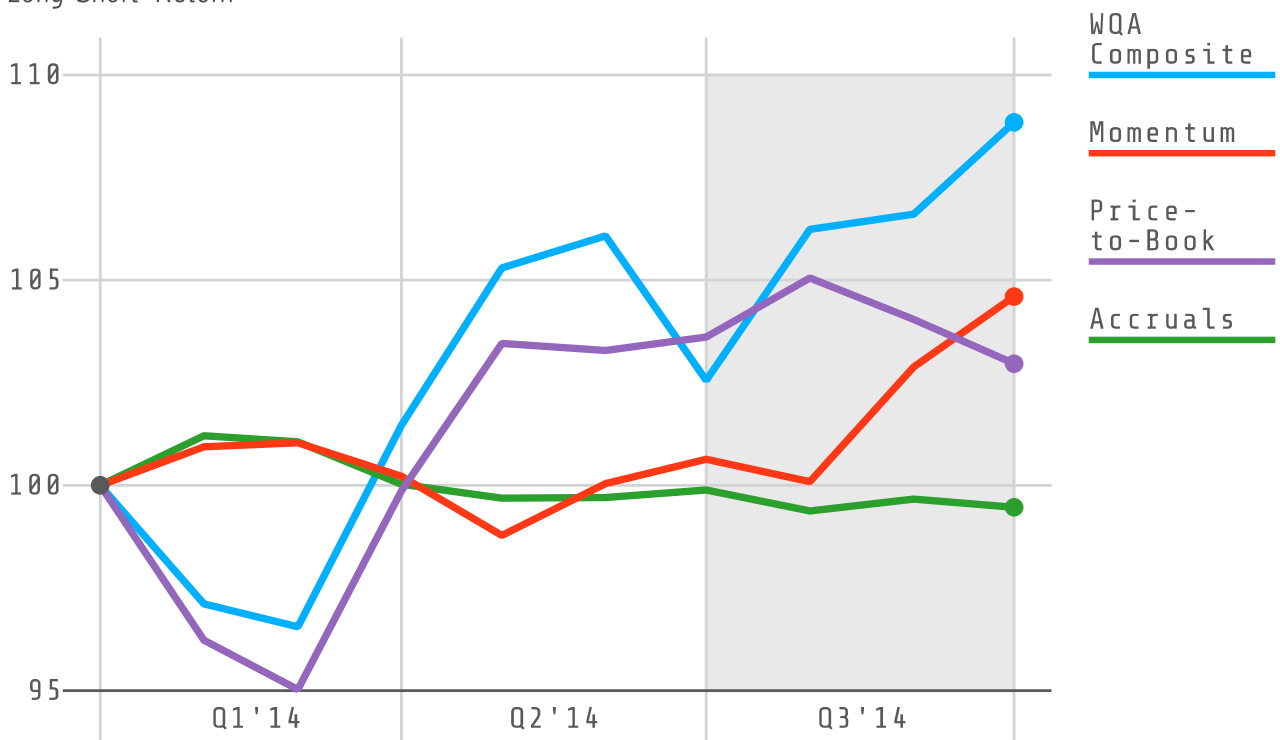
1.1 Traditional Strategies

Year-to-date, among traditional strategies, *Price-Momentum* displays the strongest long-short (LS) return, with a 4.6% return through Q3. *Price-to-Book* also reports a 3.0% YTD LS return. After a strong start for the year Accruals has been flat, generating a -0.5% LS return for the first nine months of 2014.

WQA Composite strategy shows solid long short return of 8.9% for the first 9 months of the year, and more specifically, it shows a strong Q3 performance of 6.1% LS return. The strong return in Q3 recovers losses suffered during the first two months as well as in June of this year.

Figure 1. Recent Performance of WQA Composite & Traditional Strategies

Long-Short Return



1.2 WQA Composites

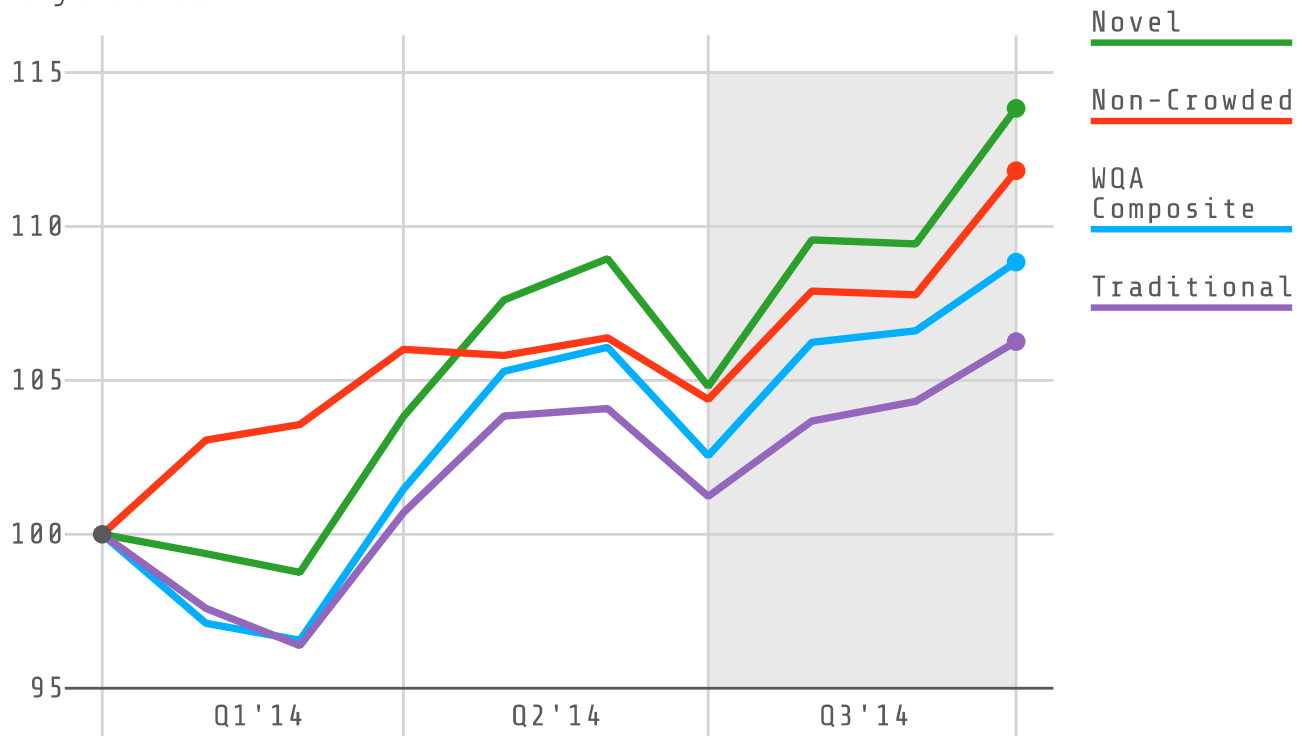
Q3 proves to be quite a strong quarter for long short quant strategies. As shown by **WQA Traditional** strategy,¹ the LS return is 5.0%, counting for approximately 80% of the YTD return of 6.3%.

Among various WQA Composites, **WQA Novel**, a dynamically updated blended signal of strategies with strong past performance,² generates the best YTD LS return (13.8%). More than half of that is obtained in a strong Q3, where **WQA Novel** generated an 8.6% long-short return.

WQA Non-Crowded, which reflects strong strategies having low ex-ante correlation with the traditional quant space, also shows solid performance: 11.8% year-to-date long-short return and 7.1% for Q3 alone.

Figure 2. Recent Performance of WQA Composite Strategies

Long-Short Return



¹ A blended signal of 9 commonly implemented quant strategies, including Value (proxied by Price-to-Book), 6-month Momentum, Accruals of Sloan (1996), Earnings Surprise, P/E Ratio, Net Stock Issuance, Gross Profitability, At-The-Money Put Volatility Skewness and Sale-to-Price.

² WQA Novel is a weighted strategy that contains the top 20 individual signals (excluding the traditional strategies) with the highest IRs in the prior 5 years.

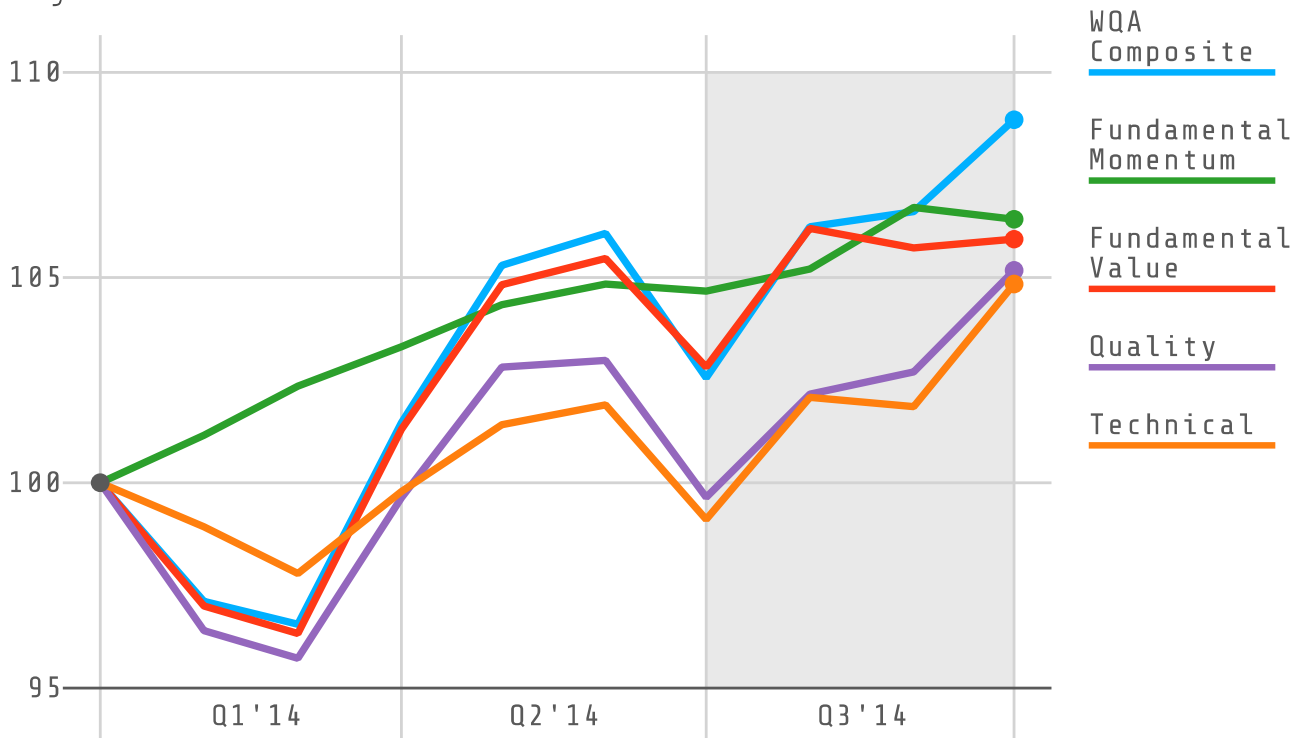
1.3 WQA Themes

In terms of the four WQA Themes, both **Technical** and **Quality** rebound strongly in Q3 after the dip in June, generating long-short returns of 5.8% and 5.6% respectively. In fact, 4 out of the top 10 performing individual signals of Q3 belong to the **Technical** theme (*Modified Short Interest* 12.5%, *Short Interest Ratio* 7.4%, *Cash Flow Margin Volatility* 6.2%, and *Net Stock Issuance* 6.0%), and the other 4 come from the **Quality** theme (*Cash Flow Margin* 7.6%, *Free Cash Flows* 7.4%, *Operating Profitability* 6.3% and *Asset Usage Efficiency* 6.0%),

Fundamental Momentum and **Fundamental Value** themes, while having less impressive quarterly long-short returns (1.7% and 3.0% respectively), show strong year-to-date performance: 6.4% for **Fundamental Momentum** and 5.9% for **Fundamental Value**. Notice that both the Fundamental Momentum and Fundamental Value display return patterns similar to their traditional signal counterparts, namely *Price-Momentum* and *Price-to-Book* strategies, but with stronger performance. This showcases the power of quantitative investing in a wide spectrum of strategies compared to less diverse single signal.

Figure 3. Recent Performance of WQA Themes

Long-Short Return



1.4 Long Only Strategies

For conventional long-only (LO) strategies, 2014 has been a challenging period. Compared to the 7.0% year-to-date return of the Russell 3000 Index benchmark, our **WQA Composite** LO shows a low return of 0.7%. In particular, it suffers a 5.1% loss in Q3 compared to the benchmark breakeven return of 0%. In fact, among the 80+ individual strategies within our library, even the best performing long-only strategy (Modified Short Interest, 5.0%) fails to outperform the Russell 3000 benchmark. It proves to be particularly challenging for long-only strategies to outperform given the extremely bullish market environment for the first three quarters of the year.

Table 1. Historical Returns on Quant Portfolios & Respective Benchmarks

QTD and Annualized Average Returns

THEME	Q3	YTQ3	1Y	3Y	5Y	10Y	Since Inception
<i>Long-Short Returns</i>							
Composite	6.1%	8.8%	12.2%	13.4%	15.6%	18.2%	26.1%
Risk-Free Rate	0.0	0.0	0.0	0.0	0.0	1.5	3.1
Fundamental Momentum	1.7	6.4	6.9	9.7	10.5	11.0	19.1
Fundamental Value	3.0	5.9	9.4	11.8	12.0	14.1	16.0
Quality	5.5	5.2	6.4	6.7	8.3	10.6	17.4
Technical	5.8	4.8	7.9	7.2	9.8	9.9	11.5
Novel	8.6	13.8	17.7	14.8	16.4	20.0	28.7
Non-Crowded	7.1	11.8	15.0	12.0	11.9	16.4	24.8
Traditional	5.0	6.3	7.8	8.4	10.1	11.1	17.7
<i>Long-Only Returns</i>							
Composite	-5.1%	0.7%	12.8%	30.0%	21.2%	17.6%	22.9%
Russell 3000	0.0	7.0	17.8	23.1	15.8	8.5	10.0
Fundamental Momentum	-6.3	-1.6	11.3	31.1	20.3	16.8	20.1
Fundamental Value	-6.1	-1.3	11.6	31.2	20.3	16.9	20.1
Quality	-4.2	0.8	11.4	26.3	18.2	14.0	18.2
Technical	-3.5	1.7	13.5	27.9	19.6	14.0	15.9
Novel	-4.6	2.5	14.6	29.3	21.1	17.7	22.6
Non-Crowded	-4.5	3.1	15.2	29.7	19.8	16.2	20.6
Traditional	-5.1	0.1	11.2	28.1	19.2	14.7	19.3

Portfolio inception: January, 1990.

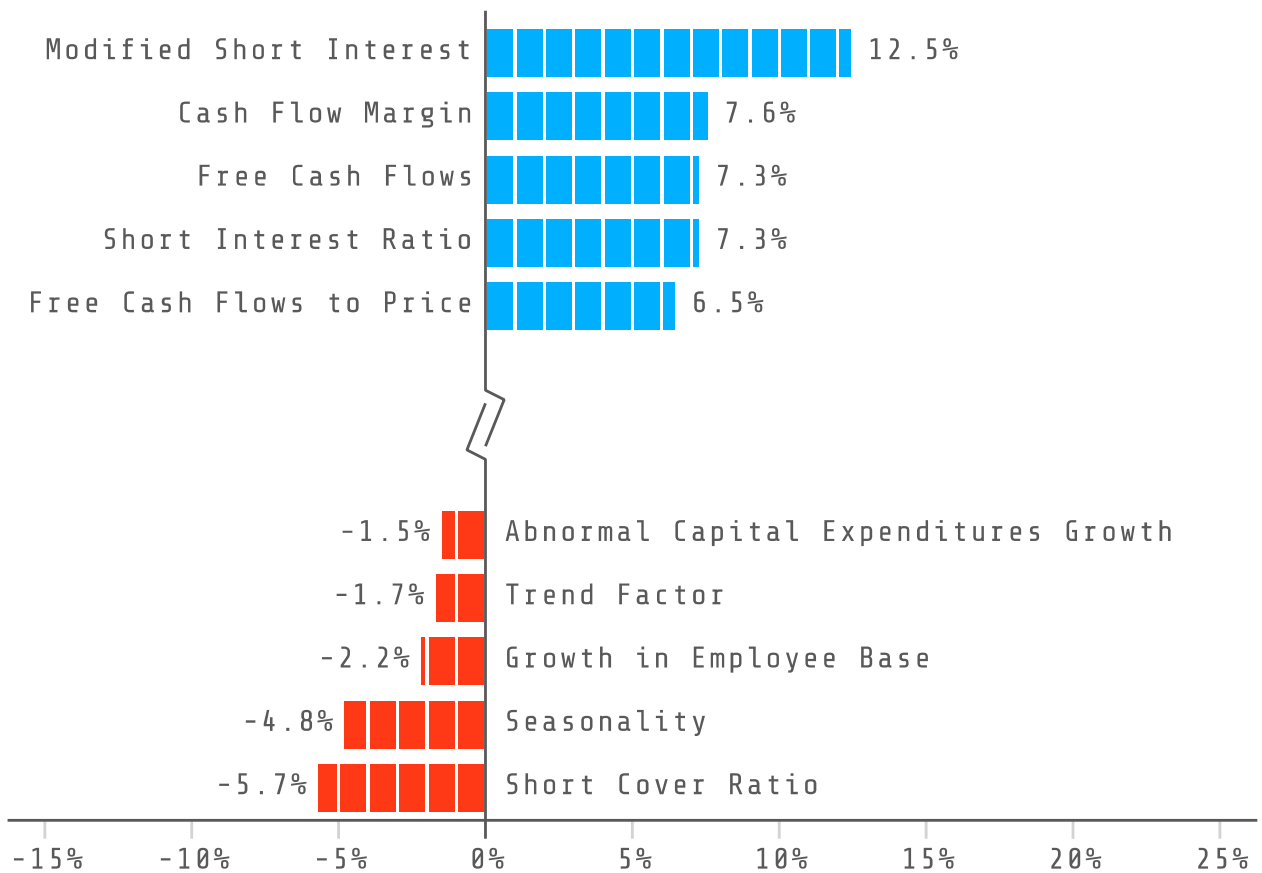
On the other hand, if we observe slightly longer run performance record, our long-only **WQA Composite** outperforms the Russell 3000 benchmark in all investment horizons that of three years or more. For example, for the past three years the **WQA Composite** LO return generates an annualized return of 30.0%, compared to a 23.1% from the benchmark, and an annualized return of 21.2% for the past 5 years (15.8% for the benchmark). As quant strategies are generally positioned for the long run, the short term losses of the past 12 months will most likely be recovered in the long term.

1.5 Individual Strategies

Among the 80+ individual strategies, *Modified Short Interest* (Technical theme) and *Cash Flow Margin* (Quality theme) have the strongest Q3 performance, with long-short returns of 12.5% and 7.6% respectively. SIO is also among the best year-to-date strategies, generating a LS return of 22.4% for the first 9 months of the year. On the other hand, *Short Cover Ratio* (Technical theme) and *Seasonality* (Fundamental Momentum theme) are the two worst performing signals in this quarter, losing 5.7% and 4.8% respectively.

Figure 4. Best- & Worst-Performing Strategies

2014 Q3 Long-Short Return



1.6 Industry Heat Map

Among the large cap space, represented by Russell 1000 Index, Health Care sector continues to be the sector with the strongest signal strength, measured by WQA Composite strategy. This strikes a remarkable contrast to the sector's signal strength within the small cap space, as it is the sector with the weakest signal strength among the 10 GICS sectors. Financials and Utilities are the two sectors that experience deterioration in the signal strength within the large cap space when compared to the previous quarters.

Table 2. WQA Composite by Sector

R1K Market Cap-Weighted Average Signal by GICS Industry Sector

SECTOR	2013	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14
	Energy	0.18	0.18	0.23	0.12	0.23	0.16	0.30	0.19	0.21	0.27
Materials	0.03	0.02	0.00	0.14	0.17	0.11	0.16	0.13	0.08	0.17	0.08
Industrials	-0.15	-0.05	-0.06	0.03	0.08	-0.02	-0.02	-0.01	-0.07	-0.05	-0.09
Consumer Discretionary	-0.06	-0.07	-0.03	0.04	0.15	0.02	-0.07	-0.06	-0.13	-0.10	-0.08
Consumer Staples	-0.05	-0.04	-0.08	-0.14	-0.16	-0.17	-0.23	-0.22	-0.22	-0.22	-0.26
Health Care	0.75	1.02	0.85	0.72	0.73	0.91	0.87	0.80	0.75	0.82	0.84
Financials	0.21	0.18	0.17	0.34	0.32	0.37	0.32	0.33	0.38	0.15	0.14
Information Technology	0.22	0.27	0.29	0.33	0.16	0.15	0.24	0.34	0.19	0.17	0.04
Telecom	0.32	0.57	0.68	0.68	0.50	0.50	0.12	0.11	0.06	0.17	0.02
Utilities	-0.15	0.07	-0.01	0.15	0.29	0.25	0.40	0.28	0.35	0.14	0.13

Table 3. WQA Composite by Sector

R2K Market Cap-Weighted Average Signal by GICS Industry Sector

SECTOR	2013	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14
	Energy	-0.30	-0.11	-0.13	-0.26	-0.24	-0.20	-0.18	-0.24	-0.15	-0.19
Materials	-0.09	-0.27	-0.19	-0.16	-0.15	-0.15	-0.05	0.01	0.05	0.04	0.03
Industrials	-0.03	-0.06	-0.04	0.00	0.05	0.00	0.03	0.06	0.05	0.09	0.14
Consumer Discretionary	0.09	-0.03	0.03	0.05	0.11	0.03	-0.06	0.06	0.07	0.08	0.05
Consumer Staples	0.15	0.09	0.14	0.16	0.02	0.05	-0.03	0.00	0.00	0.03	0.02
Health Care	-0.18	-0.13	-0.21	-0.29	-0.23	-0.15	-0.08	-0.28	-0.26	-0.30	-0.19
Financials	-0.07	-0.08	-0.07	-0.07	-0.08	-0.03	-0.16	-0.14	-0.10	-0.13	-0.12
Information Technology	0.05	0.01	0.00	0.01	0.01	0.00	0.14	0.23	0.26	0.20	0.19
Telecom	0.26	0.27	0.26	-0.01	-0.12	-0.01	0.25	0.12	-0.06	0.02	0.06
Utilities	0.06	-0.13	-0.17	-0.17	-0.13	-0.12	0.16	0.14	0.21	-0.03	-0.01

2. Enhancement in the Signal Library

2.1 Signal Library Expansion

In Q3, the WRDS signal library was expanded from 60+ to over 130.³ The new signals cover various aspects of quantitative investment, including 15+ new signals for the **Quality** theme and 10+ for the **Fundamental Momentum** theme. Newly added signals include Piotroski's F-score (Piotroski, 2000 JAR),⁴ Shiller's Price-to-Average Cash Flow (Campbell and Shiller, 1988 JF),⁵ Debt Capacity-to-Firm Tangibility (Hahn & Lee, 2009 JF), among others.

We also introduced a suite of *SEC Filing* based quantitative strategies, including the Coleman Readability Index,⁶ Loughran-McDonald Modal Strong Word Proportion (Loughran and McDonald, 2014 JF),⁷ to the **Technical** theme. These signals reflect the underlying complexity and sentiment of firms' SEC Filings (10-K only at this point), and researchers have found these indicators carry predicative power for future returns.

2.2 Additivity Restriction

In addition to signal library expansion, the signal inclusion criterion was tightened, raising the bar for individual signals to be considered "value-additive". The basic procedure follows:

- For an individual signal to be considered predictive, we require an IR of 0.2 or higher to pass the "primary candidate test". This prerequisite shrinks the eligible signal library to 80+.
- Among the 80+ primary candidates, an Additivity Analysis is conducted to determine which signals add value to the corresponding theme.⁸ Only those that improve the IR of the existing theme will be added to the theme.
- The same additivity test is also performed among the signals that have low (IR<0.2) yet positive IRs ("secondary candidates"), even though they might initially appear less likely to be additive. However, if a signal is found to add value to the IR of the corresponding theme, it is then added to the final signal library in spite of poor stand-alone performance.⁹
- As a last step, we then form various WQA Composites as well as investment Themes using the final signal library constructed through the first three steps. We believe this new procedure guarantees that all signals that enter into the composites and themes calculation indeed carry meaningful information on future equity returns.

³ We referenced Green, Hand and Zhang (2014), "The Remarkable Multidimensionality in the Cross-Section of Expected U.S. Stock Returns, Working Paper, for the list of additional strategies.

⁴ Piotroski F-score is a composite score of nine individual dummy variables, each reflecting different aspects of firms' financial strength. Firms with high P-score is expected to have better future performance and hence higher returns.

⁵ Shiller's Price-to-Average Cash Flow measures the cyclically adjusted ratio of price to average of past 5 years of cash flow.

⁶ Coleman-Liau Readability Index was first developed in 1967 to gauge the readability of a document based on inputs such as character, word, and sentence counts.

⁷ Loughran-McDonald Modal Strong Word proportion reflects the fraction of financial-modal-strong words in the document based on the Loughran-McDonald financial dictionary.

⁸ See the second part of the report for detailed discussion on the Additivity Analysis.

⁹ All individual signals, regardless of IR, are kept in our overall signal library. Knowing a signal does not work is useful information for investors.

As high individual signal IRs in general help improve IRs of weighted portfolio themes, we do see higher fraction of signals from the *primary* group entering the final signal library compared to the *secondary* group. For example, out of the 20+ individual signals from the *primary* group for the **Fundamental Momentum** theme, only four are dropped due to the fact that they do not improve theme level performance (*Current Ratio Growth, Quick Ratio Growth, Growth in Return on Assets* and *12 month Price Momentum*). In contrast, only one signal (*Cash Turnover Growth*) from the *secondary* pool is added to the final signal library.

The enhancement procedure produces significant improvements. The table below highlights various strategies' IR pre- versus post-enhancement. All four investment themes experience increased IRs, with the **Technical** theme showing the strongest improvement (from 1.5 pre-enhancement to the current level of 2.5).

The **Technical** theme improvement has three components:

- i) Individual signals with low IRs (<0.2), such as *Dispersion in Analysts' Opinion* (IR=0.15), are no longer included in the corresponding theme calculation.
- ii) Signals that weaken the theme-level return, in spite of high stand-alone IRs, are also excluded. For instance, the *Active Flow* signal is excluded from the Technical theme calculation as additivity analysis reveals that including this signal subtracts 4.2% from the theme IR, even though its stand-alone IR is a reasonably high 0.4.
- iii) New individual signals with strong predictive power are added to the theme. For example, *Coleman Readability Index* (IR=0.96), a technical signal that reflects the level of complexity of firms' 10-K filings, is now part of the theme.

The same logic applies to the improvement in IRs in all three other themes. With stronger-performing themes, various quant alpha composites accordingly see higher IRs. Our broad strategy, **WQA Composite**, has its IR increased from 2.5 to 2.9. The most striking improvement comes from the **WQA Non-Crowded** and **WQA Novel** strategies, with IRs improving from 2.5 to 3.4, and from 2.6 to 3.5 respectively.

Table 4. IR Comparison of Pre- and Post- Enhancement Process

IR Comparison	Pre-Enhancement	Post-Enhancement
<i>Theme</i>		
Fundamental Momentum	2 . 7	2 . 8
Fundamental Value	1 . 0	1 . 3
Quality	2 . 3	2 . 4
Technical	1 . 5	2 . 5
<i>Composite</i>		
WQA Composite	2 . 5	2 . 9
WQA Non-Crowded	2 . 5	3 . 4
WQA Novel	2 . 6	3 . 5
WQA Traditional	2 . 1	2 . 3

3. How Much Value Does a Quant Signal Add: Additivity Analysis

3.1 Motivation and Empirical Framework

Every now and then, every investment manager asks herself whether a new investment strategy with appealing back-tested risk-adjusted performance is worth adding to the portfolio of existing strategies. How likely is the new signal to bring value above and beyond what the manager already trades on? Is an attractive signal-level Information Ratio (IR) or Sharpe Ratio enough to justify adding the candidate to an existing portfolio and what is the appropriate framework for evaluating the additivity of new signals?

In this section of the report, we reassess the additivity of our previously back-tested signals as well as the signals newly added to the WRDS Quant Alpha Library in Q3/2014¹⁰. There are two primary motivations for this analysis. First it provides an empirical framework for evaluating quant signal additivity at both the aggregate and theme composite levels. Second, it tests whether a signal-specific performance attribute (e.g. Information Ratio, Information Coefficient, and Sharpe Ratio) is adequate for deciding whether to add a signal vs evaluating the interaction of the candidate signal with standing strategies. The primary goal is to provide investment professionals an analytical quantitative tool to help strike the right balance between the number of quantitative signals and their “additivity”, i.e. the incremental risk-adjusted performance a particular strategy brings to an existing portfolio.

Before describing our methodology and results, it is worth defining more clearly what we mean by “additivity”. In this analysis, a signal is considered additive if, when added to a specified set of signals, it produces a statistically significant increase in strategy IR under back-testing. A signal is designated value-destructive if its inclusion produces a statistically significant IR reduction, even if its individual IR might be positive and attractive on a stand-alone basis.

Methodological framework. We compute the difference composite strategy IRs including and excluding a particular signal during Jan 1990-Sep 2014 time period and use this approach to evaluate the IR change along seven related but distinct dimensions:

- WRDS Quant Alpha Market Neutral Composite (35%)
- WRDS Quant Alpha Long-Only Composite (15%)
- WRDS Traditional Quant Alpha Composite (15%)
- Theme Market Neutral Composite (15%)
- Theme Long-Only Composite (10%)
- Plain Vanilla Value strategy (Price/Book) (5%)
- Plain Vanilla 6-month Momentum (5%)

For example, for our broad composite, **WRDS Quant Alpha Market Neutral (MN)**, the algorithm evaluates the percentage change in IR attributable to a particular signal by looking at the IR difference between two signal-weighted portfolios, each formed using equal-weighted means of N (first portfolio) and N+1 (second portfolio) individual standardized signals as portfolio weights. The same logic is applied when computing

¹⁰ See the appendix of WRDS Alpha Report #1 for Q2/2013 for the full list of 65+ individual signals which were initially a part of WRDS Quantitative Alpha library prior to being expanded in Q3/2014. The current version of Alpha Factor Library features 130+ individual signals spanning investment ideas based on textual analysis of SEC filings as well as fundamental, market, options-related, and other financial and accounting data.

IR change for the Long-Only portfolio. If the signal is already a part of a theme or WRDS Traditional composite, we then compare IR of the theme/composite with and without this signal, keeping the rest of the member signals intact¹¹. The last two criteria were specifically designed to assess the value added by combining a given signal with conventional **Value** (defined as price/book) and **Price Momentum** (defined as return over the past 6 months and skipping a month before portfolio formation), given the prominent status these two strategies occupy in the portfolios of many investors.

Since IR changes are subject to sampling and estimation errors, we need to gauge whether an IR difference is statistically distinguishable from zero. To this end, we calculate the time-series of the difference between 24-month rolling IRs of the composite strategy both with and without a signal, and consider the mean IR difference to be significant if its absolute t-value is greater than 3.00¹². We then combine IR changes (Δ IR) in each of these dimensions into an overall **weighted additivity score (WAS)** by taking the sum of respective weights and Δ IRs across all seven criteria only when Δ IR is statistically significant¹³. Clearly, when Δ IR is statistically insignificant, it does not affect WAS. While the advantage of WAS is that it is continuous by construction (thereby allowing more refined ranking of individual signals) it is sensitive to large IR changes. Such changes are more likely to occur when blended with simple Price/Book and 6-month price momentum strategies. To alleviate this concern, we also construct an **indicator-based additivity score (IAS)** calculated as the sum of seven {0,1} binary indicators taking value of 1 when t-value of Δ IR is greater than +3.00 or 0 otherwise.

3.2 Additivity to WQA Themes and Aggregate Alpha Composite

We use this methodology to compute IR changes (and t-values) along each of seven dimensions as well as aggregated WAS and IAS for all 132 signals in WRDS Alpha Factor Library. Table 5 presents the overall top 10 quant signals in terms of WAS. These most additive signals come primarily from Quality and Fundamental Momentum themes, with cash flow-based, price trend-based and profitability signals performing particularly well at improving risk-adjusted performance of the **WRDS Quant Alpha** composite. For a similar table based on IAS, see Table 13 in the appendix. In comparing IAS and WAS rankings, it is noteworthy that price-trend signals such as **modified Short-Term Reversal** of Da et al. (2012), **Extreme Returns** of Bali et al. (2011) and **Seasonality** of Heston and Sadka (2008) tend to come out on top in IAS-based rankings, suggesting that these signals' additivity is more balanced across the board and less likely to be driven by a single criterion.

¹¹ As a reminder, Traditional Quant composite is an equal-weighted mean across 8 individual signals, namely, Price/Book, 6-month Momentum, Accruals, Earnings Surprise, Price/Earnings Ratio, Net Stock Issuance, Gross Profitability and At-The-Money Put Volatility Skewness. For the full list of signals comprising theme portfolios, see WQA Report #1 (Q2/2013).

¹² It is important to note that we blend strategies at the signal level (prior to portfolio construction) to determine new weights rather than combining them at the portfolio return level. This allows to take into account covariance among portfolio holding weights rather than among portfolio returns as the latter are more likely to be more affected by market-wide factors such as sentiment, liquidity, etc. Furthermore, since the difference in 24-month rolling IRs is serially correlated, we adjust the standard errors of this difference using Newey-West (1987) correction with up to 24 lags.

¹³ Weights assigned to each criterion were chosen based on the relative hurdle a given signal needs to cross in order to add incremental alpha. For instance, improving risk/return profile of WQA Composite and a Theme is a more difficult task than adding value to plain vanilla value or momentum strategy. Weights were assigned with this in mind.

Trend Factor comes out on top as the most additive signal (as measured by WAS), increasing IRs of both WRDS Alpha Long-Short (Table 6) and Long-only Composite (Table 9) by nearly 3%, a remarkable improvement considering that it is just one of 132 signals included in the overall composite. This strategy is based on the paper by Han, Zhou and Zhu (2014) and is built to capture cross-section short-, intermediate-, and long-term stock trends. This signal is found to be additive within its own theme, **Fundamental Momentum**, as well as to traditional quant strategies such as value and momentum.

On the surface, it appears that **Trend Factor** might be subsumed by a combination of **Short-Term Reversal** (Jegadeesh, 1990; Da et al., 2013), intermediate **Price Momentum** (Jegadeesh and Titman, 1993) and **Long-Term Reversal** (DeBondt and Thaler, 1985). However, correlations of **Trend Factor** with each of these signals never exceeds 20% (in the case of **Price Momentum**, it is essentially zero). Since Jan 1990, long-short signal-weighted Trend Factor portfolio delivered an alpha of 0.72% per month after controlling for Fama-French factors augmented by the three above-mentioned price-trend factors. In fact, **Trend Factor** has an R-Squared of just 11% with these signals, suggesting that it quantifies distinct aspects of existing price trends not captured by short-/long-term reversals and intermediate momentum.

Table 5. Top 10 most additive quant signals based on weighted additivity score, selected LS dimensions

MN stands for the market neutral signal-weighted portfolio

Signal Name	Theme	Overall weighted additivity	WRDS		Theme MN		WRDS	
			Alpha MN Δ IR	T value	Δ IR	T value	Traditional Δ IR	T value
Trend Factor	FundMom	0.220	2.81%	3.38	14.49%	3.75	14.93%	2.98
Free Cash Flow/Assets	Quality	0.203	0.61%	1.25	-0.33%	1.12	3.69%	1.99
Modified Short-Term Reversal	FundMom	0.191	1.83%	5.34	10.29%	5.21	10.29%	4.07
Piotroski F-Score	Quality	0.190	0.58%	1.82	2.36%	2.67	3.19%	2.44
Net Operating CF/Assets	Quality	0.175	0.47%	0.50	-0.89%	-0.40	1.76%	0.50
Extreme Returns	FundMom	0.164	0.71%	5.01	4.77%	6.61	5.13%	5.50
Free Cash Flow/Price	FundValue	0.160	-0.68%	-0.41	10.90%	4.47	-2.84%	0.88
Operating Profitability	Quality	0.155	0.46%	1.23	-1.58%	-2.83	0.16%	-0.16
Growth in Net Operating Assets	Quality	0.152	0.45%	2.86	2.29%	5.35	2.25%	4.30
Earnings Surprises	FundMom	0.149	0.48%	1.06	0.35%	0.62	3.16%	0.93

Among newly added signals, only **Piotroski F-score** makes it to the overall top 10 most additive signals, while the rest have been a part of WRDS Alpha library since its launch. **Piotroski's F-score** represents a composite measure garnered from a set of nine simple financial statement indicator variables (e.g., an increase in return on assets or asset turnover). Its components are commonly used in financial statement analysis and this score was found to forecast returns and profitability even after accounting for other known predictors such as size, price/book and asset growth (Piotroski, 2000; Piotroski and So, 2013), consistent with the explanation that F-score proxies for expected profitability.

We further analyze additivity along specific dimensions. Table 6 below is meant to show that the signals most additive for the **WRDS Quant Alpha** composite are do not necessarily have the highest WAS values, and more importantly, need not exhibit the highest individual IRs.

Table 6. Top 10 most additive signals to the WRDS Quant Alpha MN Composite

Signal Name	Theme	Overall weighted additivity	IR of WRDS Alpha MN Composite		WQA MN Δ IR, %	T-Value of Δ IR	Signal IR
			without signal	with signal			
Trend Factor	FundMom	0.220	2.29	2.35	2.81%	3.38	1.44
Net Operating Assets	Quality	0.032	2.3	2.35	2.14%	7.48	1.06
R&D/Price	FundValue	0.076	2.31	2.35	2.06%	6.37	0.67
Firm Tangibility	Quality	0.027	2.31	2.35	1.89%	6.18	0.57
Modified Short Term Reversal	FundMom	0.191	2.31	2.35	1.83%	5.34	1.55
Accruals	Quality	0.123	2.32	2.35	1.45%	4.83	0.94
Probability of Dividend Increase	Technical	0.022	2.32	2.35	1.32%	9.71	0.08
Growth in Inventory Turnover	FundMom	0.016	2.33	2.35	1.14%	4.72	0.25
Seasonality	FundMom	0.141	2.33	2.35	1.11%	3.67	1.04
Cash Flow Margin	Quality	0.015	2.33	2.35	1.06%	4.25	0.71

Given that WRDS Quant Alpha composite is comprised of 130+ signals, adding alpha to it is a particularly high hurdle, generating particular interest for the signals in table 6. Again, we see that Quality and Fundamental Momentum occupy most of the top spots, accompanied by just one Technical and one FundValue signal. Note that this degree of high additivity would be difficult to foresee by simply looking at stand-alone IRs. For example, **Firm Tangibility** (Hahn and Lee, 2009) robustly adds nearly 2% to the overall composite IR, but its individual IR is in the middle of the pack.

Firm Tangibility serves as a proxy for the firm’s debt capacity, i.e. the expected asset liquidation value of a firm net of existing debt book value. A higher Firm Tangibility is essentially an indicator of higher collateral value for lenders (i.e. debt capacity) and consequently higher future returns via increased exposure to the risk associated with changes in availability of internal and external funds for investment. Another interesting case is **Probability of Dividend Increases** (Bessembinder and Zhang, 2014), a strategy using the observation that announcements of corporate actions (and dividend increases, in particular) is quite predictable, mainly because they tend to recur at regular calendar intervals. The market fails to fully appreciate the implications of current distributions for future distributions and stock returns, so betting on firms with high predicted probabilities of dividend increases earns significant abnormal returns.

3.3 Additivity to Traditional Quant Strategies

Aside from analyzing quant signals based on WAS and IAS, additivity analysis proves to be a valuable tool for selecting quant signals most beneficial to traditional value and momentum strategies, as many money managers might tilt towards these strategies in their portfolio. There is evidence that combining value and momentum at the signal level allows investors to achieve better risk/return tradeoff than pure plays on value or momentum alone (Stivers and Sun, 2009; Asness, Moskowitz and Pedersen, 2012; Fisher, Shah and Titman, 2014). Our results suggest that even though momentum does indeed provide a powerful “ally” for

value, there are quite a few Quality-related signals that interact with plain vanilla value at least as well as momentum, while keeping the turnover nearly the same.

In fact, a disproportionate number of signals that blend well with value come from the Quality theme as demonstrated in Table 7. The fact that Quality and Value enhance each other has been also highlighted in some previous research (see, e.g., Kalesnik and Kose, 2014). Such quality signals as **Net Operating Cash Flow/Assets**, **Piotroski's F-Score**, **Operating profitability** (Ball, Gerakos, Linnainmaa, Nikolaev, 2014), and **Ohlson (1980) O-score** are particularly powerful in improving risk-adjusted performance when combined with plain vanilla value strategy proxied by **Price/Book**. For example, blending value with one of the best-performing quality signals (**Free Cash Flow/Assets**) more than triples the IR of a simple long-short Price/Book-based portfolio and provides an informative example of how two relatively slowly moving strategies can be combined together to offer higher active return per unit of active risk than pure play strategies. The only Technical theme signal which made it to the top 10 is **Net Stock Issuance** (Loughran and Ritter, 1995) suggesting that a value manager can significantly enhance the risk-adjusted performance of her portfolio by focusing on value stocks of firms which repurchase their stock and more aggressively shorting growth stocks of firms which recently issued additional equity.

Our results also suggest that, in general, signals which are relatively more additive to traditional value and momentum strategies also tend to have relatively high individual IRs: the correlation between individual IRs and additivity to plain vanilla value is 88% using the entire cross-section of 132 signals. Yet price momentum provides an illustration where a strategy with a middling IR turns out to be one of the most additive strategies when combined with value.

Table 7. Top 10 Most Additive Signals to Price/Book (Value) strategy

Signal Name	Theme	IR of Price/Book		Price/Book ΔIR, %	T-Value of ΔIR	Signal IR
		without signal	with signal			
Free Cash Flow/Assets	Quality	0.37	1.56	316.5%	6.69	2.00
6-month price momentum	FundMom	0.37	1.49	297.3%	3.71	0.74
Piotroski F-Score	Quality	0.37	1.43	280.9%	6.58	2.03
Net Operating Cash Flow/Assets	Quality	0.37	1.38	268.3%	7.42	1.88
Operating Profitability	Quality	0.37	1.26	237.2%	6.03	1.67
Ohlson Score	Quality	0.37	1.25	234.5%	3.90	0.90
Earnings Surprise	FundMom	0.37	1.24	231.6%	5.69	1.27
Free Cash Flow/Price	FundValue	0.37	1.22	224.6%	5.11	0.94
Trend Factor	FundMom	0.37	1.21	224.1%	3.11	1.44
Net Stock Issuance	Technical	0.37	1.12	198.8%	4.77	1.39

When it comes to price momentum (Table 8), **FundValue** signals such as **Gross Profit Margin/Price**, **R&D/Price** and **Price/Book** as well as several **Quality** signals such as **Growth in Net Operating Assets (ΔNOA)**, **Asset Usage Efficiency**, **Piotroski's F-Score** provide the most value added when combined with 6-month price momentum. For example, ΔNOA blended with momentum more than doubles the IR of the latter (0.75 to 1.53, t-value 6.73).

Table 8. Top 10 Most Additive Signals to 6-month past return (Momentum) strategy¹⁴

Signal Name	Theme	IR of Momentum		Momentum ΔIR, %	T-value of ΔIR	Signal IR
		without signal	with signal			
Trend Factor	FundMom	0.75	1.61	114.2%	3.93	1.44
Growth in Net Operating Assets	Quality	0.75	1.53	104.1%	6.73	1.58
Gross Profit Margin/Price	FundValue	0.75	1.51	101.0%	7.14	0.81
Price/Book	FundValue	0.75	1.49	98.5%	3.47	0.43
Modified Short-Term Reversal	FundMom	0.75	1.48	97.4%	5.29	1.55
Free Cash Flow to Assets	Quality	0.75	1.38	83.6%	8.10	2.00
R&D/Price	FundValue	0.75	1.37	82.3%	4.23	0.67
Net Operating Cash Flow/Assets	Quality	0.75	1.36	81.8%	7.28	1.88
Asset Turnover	Quality	0.75	1.35	80.4%	8.67	1.25
Piotroski's F-Score	Quality	0.75	1.35	80.1%	8.43	2.03

It is well known that unconditional momentum strategy suffered dramatic underperformance during the recent credit crisis of 2008-2009, particularly, during Q2/2008 and Q2/2009, with drawdowns from long-short portfolios of roughly -30-35%. Backtest results suggest that momentum blended with, say, ΔNOA (Growth in Net Operating Assets) would have produced a portfolio whose drawdown during that period would be reduced to around -10% instead of -35% for momentum alone due to the fact that ΔNOA did particularly well during the time when momentum suffered its worst performance due to the sharp rebound of losers in Q2/2009. It appears that ΔNOA could potentially serve as a buffer against momentum crashes (Daniel and Moskowitz, 2013). Drawdowns on the other momentum portfolios blended with signals from Table 7 would have ranged between -10% and -21%.

3.4 Additivity to Long-Only Quant strategies

Money managers who are not allowed to short stocks or who find shorting prohibitively expensive will be more interested in the additivity of signals on the long side of the trade. However, as can be seen in Table 8, adding value on the long side is a considerably more difficult task than it is for long-short portfolios, as many signals tend to derive most of their alpha from the short side.

Table 9 lists the top signals in terms of long-only additivity. The first four spots are taken by signals from the Fundamental Momentum theme, based mainly on price trends, with the exception of Earnings Surprises. The latter, which bets on continued positive drift in stocks of firms whose most recent earnings beat analyst estimates, has the highest individual long-only IR (0.72). Even though Table 9 shows some overlap of signals with those that are most additive for long-short portfolios (i.e. the “usual suspects” such as **Trend Factor**, **Modified Short-Term Reversal**, and **Seasonality**), there are also a number of new names, such as **Idiosyncratic Vol**, **Market Beta**, **Short Interest Ratio** and **Short Squeeze Probability**.

¹⁴ In all tables in this section, highlighted in red are the signals that were newly added to the WRDS Quant Alpha Library in Q3/2014 (with back-tested performance from Jan 1990). The IR numbers are rounded to two decimal points

Table 9. Top 10 Most additive Long-Only (LO) signals

Signal name	Theme	IR of WRDS Alpha LO Portfolio		WRDS Alpha Long-Only Δ IR %	T-Value of Δ IR	Signal LO IR
		without signal	with signal			
Trend Factor	FundMom	1.06	1.09	2.98%	2.89	0.43
Modified Short-Term Reversal	FundMom	1.06	1.09	2.50%	5.18	0.59
Seasonality	FundMom	1.06	1.09	2.45%	5.93	0.31
Earnings Surprises	FundMom	1.07	1.09	2.00%	4.54	0.72
Idiosyncratic Volatility	Technical	1.07	1.09	1.84%	5.53	0.51
Market Beta	Technical	1.07	1.09	1.72%	3.68	0.34
Piotroski's F-Score	Quality	1.07	1.09	1.60%	7.40	0.61
Short Squeeze Probability	Technical	1.08	1.09	1.22%	5.07	0.25
Short Interest Ratio	Technical	1.08	1.09	1.15%	4.30	0.31
R&D/Price	FundValue	1.08	1.09	1.14%	5.69	0.30

Idiosyncratic Volatility strategy is based on Ang et al.'s (2006) finding that stocks with high idiosyncratic volatility (ivol) have abysmally low returns. **Market Beta** signal is similar to Frazzini and Pedersen's (2013) "Betting against Beta". **Probability of Short Squeeze** is related to extreme high levels of **Short Interest Ratio** in the prior month, which are likely to reverse the following month in when the price moves against the short sellers who rush to cover their positions.

On the surface, the finding that betting on low beta, low ivol, and low short interest ratio stocks contributes significantly to the risk-adjusted performance of the LO quant portfolio may seem counterintuitive, as these strategies are usually perceived to derive most of their alpha from the short side. However, bets on low beta, low ivol and low short interest stocks tend to have much lower total and active risk, considerably lower tracking error, and lower drawdowns compared with the other signals offering higher active returns. In fact these three signals fall either in top 5/top 10 long-only strategies (out of 132) in terms of annualized volatility, tracking error and maximum drawdown. When added to the long-only mix, they help reduce active risk without hurting active return, thereby improving overall risk/reward profile of the LO portfolio.

Even though returns of a long-only portfolio of ten highest individual signal IR strategies exceed those of a "highest additivity" LO portfolio (i.e. top 10 signals in terms of LO additivity), by 0.47% per annum, the latter outperforms the former on a risk-adjusted basis. The "highest additivity" strategy features an information ratio of 1.33 (vs 1.12) and also achieves lower maximum drawdown (46.70% vs 53.08%), lower tracking error (7.60% vs 8.99%), lower annualized volatility (17.31% vs. 19.24%) and higher Sharpe Ratio (1.26 vs. 1.18) than those of the "highest IR" long-only portfolio.

If a money manager were to solely rely on Sharpe and Information Ratios of long-only quant signal portfolios, at least half of her picks (among 130+ signals) would have been different as they would include a number of cash-flow based strategies from **Quality** and **Fundvalue** themes mentioned above. This selection would overlook some powerful **Fundamental Momentum** and **Technical** theme signals such as **Seasonality**,

Short squeeze probability, and **Short interest ratio**, each of which turn out to be quite additive on the long-side, notwithstanding their modest individual IRs.

3.5 Additivity to Theme Portfolios

Many active investment managers may decide to simultaneously play quality, value and momentum in their portfolios. Given a relatively large number of documented return-predictive signals¹⁵ which can be used to construct robust theme portfolios that best capture factor premiums, the issue is how to decide which signals to pick within their respective theme. Table 10 presents results of a horse race among different alpha factors *within* their respective themes. Note that within-theme additivity tests were run among 38 **Quality**, 30 **Fundamental Momentum**, 15 **Fundamental Value** and 49 **Technical** signals.

One of the primary findings in Table 10 is that, while there is overlap of theme-specific results with the signals most additive to the overall WRDS Alpha composite (see table 6), they are still quite distinct. For example, **R&D/Price** and **Firm Tangibility** are not the most valuable signals when considered against the *entire* universe of signals (including those from **Technical** and **FundMom** themes), but they are highly additive within their respective themes of **FundValue** and **Quality**, indicating the importance of these signals to managers running value- or quality-oriented portfolios.

Accruals and **Growth in Net Operating Assets** come out as the most valuable quality signals by significantly adding value both in long-short as well as long-only **Quality** portfolios. **Free Cash Flow/Price** comes out as the strongest strategy within the FundValue theme in terms of improvement of risk-adjusted performance, though **R&D/Price** and Shiller's version of **Price/Average Cash Flow** also appear important in any value-oriented portfolio. Most additive signals within **Fundamental momentum** are dominated by price-trend signals, with **Trend Factor** being the undisputed winner, boosting the IR of this theme by 14.5% (LS) and ~20% (LO). **Extreme Returns** and **modified STR** are also some of the most additive signals for the momentum-oriented portfolio. Last, but not least, the **Technical** theme, which currently features a combination of nearly 50 signals (most of any other theme) benefits most from **Put-Call Parity Volatility spread** in the long-short market neutral portfolio and from **Idiosyncratic Vol** on the long leg of the trade.

¹⁵ Green, Hand and Zhang (2014) test at least 100 different factors, whereas Hou et al. (2014) consider 10 alpha factors.

Table 10. Most additive signals to market neutral and long-only portfolios by Theme

IR of MN Quality					IR of Long-Only Quality				
Signal Name	without signal	with signal	Quality MN Δ IR	T-value of Δ IR	Signal Name	without signal	with signal	Quality LO Δ IR	T-value of Δ IR
Accruals	2.49	2.61	4.65%	5.8	CHS Dsitress Score	0.60	0.62	3.80%	2.44
Net Operating Assets	2.5	2.61	4.43%	2.9	Accruals	0.60	0.62	3.73%	4.73
Growth in Net Operating Assets	2.55	2.61	2.29%	5.35	Free Cash Flow/Assets	0.61	0.62	2.75%	4.99
Growth in CapEx/Assets	2.58	2.61	1.18%	3.87	Net Operating Cash/Assets	0.61	0.62	2.33%	2.53
Corporate Investment	2.59	2.61	0.62%	2.74	Growth in Net Operating Assets	0.61	0.62	1.81%	3.4
IR of MN FundValue					IR of Long-Only FundValue				
Signal Name	without signal	with signal	FundValue MN Δ IR	T-value of Δ IR	Signal Name	without signal	with signal	FundValue LO Δ IR	T-value of Δ IR
Free Cash Flow/Price	0.87	0.96	10.90%	4.47	Free Cash Flow/Price	0.41	0.45	8.89%	5.86
R&D/Price	0.9	0.96	6.97%	3.78	R&D/Price	0.42	0.45	6.08%	2.02
Shiller's Price/Average Cash flow	0.91	0.96	5.19%	4.85	Dividend Yield	0.43	0.45	4.43%	2.43
Net Operating CF/Price	0.92	0.96	5.00%	3.14	Shiller's Price/Average Cash flow	0.43	0.45	3.80%	4.44
Shiller's Price/Average Income	0.93	0.96	2.84%	1.04	Net Operating CF/Price	0.43	0.45	3.57%	3.15
IR of MN FundMom					IR of Long-Only FundMom				
Signal Name	without signal	with signal	FundMom MN Δ IR	T-value of Δ IR	Signal Name	without signal	with signal	FundMom LO Δ IR	T-value of Δ IR
Trend Factor	1.59	1.82	14.49%	3.75	Trend Factor	0.43	0.51	19.33%	4.17
Modified Short-Term Reversal	1.65	1.82	10.29%	5.21	Earnings Surprise	0.45	0.51	13.11%	4.86
Momentum Acceleration	1.69	1.82	7.68%	3.31	Seasonality	0.46	0.51	11.24%	3.85
Long-term Growth in CapEx	1.74	1.82	4.80%	3.18	Modified Short-Term Reversal	0.46	0.51	10.93%	5.29
Extreme Returns	1.74	1.82	4.77%	6.61	Extreme Returns	0.46	0.51	10.12%	11.24
IR of MN Technical					IR of Long-Only Technical				
Signal Name	without signal	with signal	Technical MN Δ IR	T-value of Δ IR	Signal Name	without signal	with signal	Technical LO Δ IR	T-value of Δ IR
Put-Call Parity Volatility Spread	1.47	1.53	4.18%	3.84	Idiosyncratic volatility	0.62	0.66	6.38%	4.54
Short Squeeze Probability	1.49	1.53	2.78%	3.4	Short Squeeze Probability	0.64	0.66	3.80%	4.46
ATM Put Volatility Skewness	1.49	1.53	2.65%	3.15	Net Stock Issuance	0.64	0.66	3.73%	3.94
Probability of Dividend Increase	1.49	1.53	2.62%	4.99	Composite Equity Issuance	0.64	0.66	3.69%	7.82
Volatility of ROA	1.5	1.53	2.28%	3.25	Short Interest scaled by Supply	0.65	0.66	2.33%	3.64

3.6 Relationship between additivity and individual signal performance

One of the key inferences of the above is that the relationship between stand-alone IR of a particular strategy and its additivity to a composite or strategy designed to capture existing factor premia is not monotonic. In other words, a quant manager should not simply rely on individual signal performance metrics (such as Sharpe, IR, IC or even statistical significance) to make an informative decision as to which signals she should pick and combine.

To further explore this question, we use two of the aggregate signal-specific additivity scores described above and three signal-specific risk-adjusted performance measures (Information Ratio, Sharpe Ratio and t-statistic of Information Coefficient), covering Jan 1990-Sep 2014.

One of the first key findings is that the cross-signal correlations between aggregate additivity score and signal-level IR and Sharpe Ratio are relatively high at 87% and 81% respectively, when using a broad array of quant signals from all themes. The same is true of the relationship between overall additivity and Information Coefficient (IC) and t-value of IC: each sports a correlation of 83-84% with the weighted additivity score. This high correlation is primarily driven by the fact that WAS is significantly skewed by additivity to Price/Book and Price Momentum dimensions (both individual signals) despite each having only 5% in the overall WAS calculation. The reason is that the individual IR of a signal is much likelier to forecast additivity to these well-known strategies. However, if WAS were to exclude signal additivity values for P/B and momentum, the correlation between individual signal IR and its WAS would drop to 25%.

In other words, the relationship between individual signal IR and its additivity *weakens dramatically if it is evaluated in combination with multi-signal portfolios* such as WRDS Quant Alpha (130+ signals) or WRDS Traditional (8 signals). For example, when value added is assessed vis-à-vis these composites only, the correlation between individual signal IR and additivity (measured by % change in composite IR) drops to just 3.5% and 19%, respectively. Using individual Sharpe ratio instead of IR, the relationship is somewhat stronger, but still low, at 27% and 37%, respectively.

The following example provides a more concrete demonstration. **Piotroski's F-score** features one of the highest individual IRs of 2.03 between Jan 1990 through Sep 2014. However, combining it with the rest of the signals in **WRDS Traditional** composite increases its IR only by 3.19% (from 2.34 to 2.41 with t-stat of 2.44), whereas **Net Operating Assets (NOA)** boosts the IR of blended conventional quant strategies by 16% to 2.71 (with t = 5.51) despite having an IR of 1.06, only about half that of F-Score. Simple correlation analysis shows that firms with high F-score also tend to rank higher on other quant signals in Traditional composite such as momentum, P/E, and gross profitability, and have lower discretionary accruals. In other words, they tend to be more profitable, higher priced, more growth firms with higher past returns. Whereas NOA (which bets against firms with high balance sheet "bloat"¹⁶) tends to exhibit negative correlations with gross profitability, P/E and momentum and nearly no correlation with earnings surprises results in higher IR for **WRDS Traditional** after it is added to the mix.

¹⁶ Measured by cumulative deviation between accounting and cash value added. See Hirshleifer et al., 2004.

Table 11. Top Signals by individual IR vs. Top Signals by Additivity to Traditional strategies

By Additivity					
Signal Name	IR of WRDS Traditional				
	without signal	with signal	Traditional MN ΔIR	T-value of ΔIR	Signal IR
Net Operating Assets	2.34	2.71	16.01%	5.51	1.06
Trend Factor	2.34	2.68	14.93%	2.98	1.44
Firm Tangibility	2.34	2.65	13.68%	3.63	0.57
Accruals	2.07	2.34	12.77%	5.97	0.94
R&D/Price	2.34	2.58	10.39%	4.59	0.67
Modified Short-Term Reversal	2.34	2.58	10.29%	4.07	1.55
Put-Call Parity Volatility Spread	2.34	2.57	10.21%	3.82	1.22
ATM Put Volatility Skewness	2.13	2.34	9.39%	2.74	1.29
Probability of Dividend Increase	2.34	2.54	8.85%	3.80	0.08
Growth in Inventory Turnover	2.34	2.53	8.16%	3.51	0.25

By IR (Information Ratio)					
Signal Name	IR of WRDS Traditional				
	without signal	with signal	Traditional MN ΔIR	T-value of ΔIR	Signal IR
Piotroski's F-Score	2.34	2.41	3.19%	2.44	2.03
Free Cash Flow/Assets	2.34	2.42	3.69%	1.99	2.00
Net Operating CF/Assets	2.34	2.38	1.76%	0.50	1.88
Operating profitability	2.34	2.34	0.16%	-0.16	1.67
Growth in Net Operating Assets	2.34	2.39	2.25%	4.30	1.58
Modified Short-Term Reversal	2.34	2.58	10.29%	4.07	1.55
Extreme Returns	2.34	2.45	5.13%	5.50	1.49
Gross Profitability	2.36	2.34	-0.85%	-0.22	1.48
Trend Factor	2.34	2.68	14.93%	2.98	1.44
Net Stock Issuance	2.41	2.34	-3.29%	0.18	1.39

As table 11 shows, of the top 10 individual strategies with highest IRs, only 20% (modified STR and Trend Factor) are also among the top 10 most additive to traditional signals – the rest add no more than 5% to 8 widely-traded signals in Traditional composite.

We observe a similar result when we examine how reliably individual IRs forecast additivity at the theme level – in many cases they tell you little of whether any specific strategy would be a valuable addition to

the theme. Table 12 presents the relationship between theme-level additivity and signal-specific performance measures, showing the IR and Sharpe Ratio have the best ability to proxy for theme-level additivity within FundValue theme and the worst ability within Quality theme.

Table 12. Correlation between individual signal performance metrics and theme-level additivity

	Sharpe Ratio	Information Ratio (IR)	Information Coefficient (IC)	T-value of IC
Quality	-0.03	-0.18	-0.03	0.02
Fundamental Value	0.34	0.57	0.33	0.76
Fundamental Momentum	0.41	0.10	0.21	0.36
Technical	0.41	0.10	0.21	0.36

This suggests that Additivity Analysis is particularly valuable for Quality signals, where, somewhat surprisingly, the correlation between individual IRs and theme-level additivity is actually negative in some cases, again suggesting that relying solely on individual signal back-tested performance may lead to suboptimal and in some cases, value-destroying decisions when it comes to creating an optimal quant portfolio of quality signals.

In summary, the value of performing additivity analysis increases as the portfolio of signals grows. If, on the other hand, a manager is using just one or two signals in his portfolio, individual IRs of candidate strategies should be able to indicate whether a signal is worth adding to the overall strategy mix. It is also important to conduct additivity analysis at the theme level as well as the overall portfolio level, as evidence suggests that its value differs depending on whether the manager is tilting its portfolio towards quality, value, momentum or technical strategies.

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Appendix

Table 13. Top Signals that add value using IAS score

T-Value is the t-statistic of the mean difference in rolling 24-month IRs of the respective composite with and without a given signal

Signal Name	Theme	WRDS Alpha MN ΔIR	T value	Theme MN ΔIR	T value	WRDS Traditional ΔIR	T value	Price/Book ΔIR	T value	Momentum ΔIR	T value
Modified Short Term Reversal	FundMom	1.83%	5.34	10.29%	5.21	10.29%	4.07	179.70%	5.89	97.41%	5.29
Maximum Return	FundMom	0.71%	5.01	4.77%	6.61	5.13%	5.5	197.70%	9.99	72.11%	12.47
Seasonality	FundMom	1.11%	3.67	4.61%	3.72	6.12%	2.49	178.40%	4.62	52.42%	4.02
Accruals	Quality	1.45%	4.83	4.65%	5.8	12.77%	5.97	101.50%	4.03	73.90%	5.84
Trend Factor	FundMom	2.81%	3.38	14.49%	3.75	14.93%	2.98	224.10%	3.11	114.20%	3.93
Free Cash Flow/Price	FundValue	-0.68%	-0.41	10.90%	4.47	-2.84%	0.88	224.60%	5.11	43.20%	6.57
Change in Net Operating Assets	Quality	0.45%	2.86	2.29%	5.35	2.25%	4.3	182.70%	7.56	104.10%	6.73
R&D/Price	FundValue	2.06%	6.37	6.97%	3.78	10.39%	4.59	53.26%	1.54	82.25%	4.23
Piotroski's F-Score	Quality	0.58%	1.82	2.36%	2.67	3.19%	2.44	280.90%	6.58	80.08%	8.43
Earnings Surprise	FundMom	0.48%	1.06	0.35%	0.62	3.16%	0.93	231.60%	5.69	33.86%	4.41
Put-Call Parity Volatility Spread	Technical	1.58%	2.62	4.18%	3.84	10.21%	3.82	124.80%	4.35	76.26%	4.23
Net Operating CF/Price	FundValue	-0.75%	-0.38	5.00%	3.14	-4.59%	0.39	150.50%	4.84	64.72%	8.58
Short Interest scaled by Supply	Technical	-0.15%	0	1.60%	1.25	-2.20%	0.51	162.70%	3.91	45.66%	4.85
Change in Capex/Assets	Quality	0.06%	2.08	1.18%	3.87	1.13%	4.12	128.00%	4.4	56.07%	6.53
Volatility of liquidity	Technical	1.08%	2.4	2.81%	2.3	7.64%	3.7	116.80%	4.28	20.87%	3.4
Shiller's Price/Cash Flow	FundValue	-0.37%	0.18	5.19%	4.85	-1.08%	1.04	114.00%	4.81	21.61%	7.5
Volatility of cash flow margin	Technical	0.49%	1.08	1.81%	4.34	4.03%	4.75	94.61%	3.06	25.66%	4.76
Short Squeeze Probability	Technical	1.00%	3.62	2.78%	3.4	4.99%	2.66	78.08%	2.51	13.87%	1.64

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