Quantifying the Quant Crisis – 5 years later

A review of August 2007 and subsequent abnormal market events

Five years ago in August, the quantitative investment community was turned on its head in what is now referred to as the Quant Crisis of 2007. In what seemed to be normal market conditions, quantitative hedge funds suffered exceptional losses in just a few days. As the 5-year anniversary of this extraordinary event has come to pass, we step back in time to put context around the incident. We also review market movements in its aftermath and highlight several episodes of abnormal market phenomena of particular interest to the quantitative community.

Robert C. Merton was a pioneer in applying sophisticated mathematical methods in the investment world beginning with his early research on quantifying diversification. Quantitative investing is considered to date back to the early 1970s although at the time it was not trusted by conventional portfolio managers and quantitative models were dubbed as black boxes. Many years passed before quantitative investing became mainstream.

Quantitative investing has since taken on a broad definition and branched beyond equities and bonds into derivative products such as futures, options and credit default swaps. Particularly in the equity asset class, which is the focus of this report, quantitative methods have evolved from standard momentum- and valuation-based models to high frequency approaches in the statistical arbitrage and algorithmic trading space. Yet ultimately underneath all quantitative investment processes lie computerized models derived from numerical techniques to analyze patterns for predicting market trends.

The ten years leading up to 2007 were arguably the best time for quantitative strategies in general. They marked a period of strong performance for quant-driven funds, and significant growth in assets under management. In fact, the combined assets of quant-driven funds peaked at approximately $1.7 trillion in 2007, according to eVestment Alliance.

Yet, while quantitative analysts meticulously monitor risk and systematic exposure, something went seriously wrong during the summer of 2007 on the back of the subprime crisis. Perhaps exacerbated by a series of margin calls on crowded trades in a market of relatively low liquidity, the Quant Crisis of August 2007 ensued, marked by extreme underperformance in quantitative hedge fund returns. In fact, quantitative portfolio managers' fundamental brethren for the most part were unscathed during the period. The August 2007 turbulence in the quant world marked the beginning of a downtrend for quant funds in general. This was exacerbated by the financial crisis and the negative press surrounding quantitative strategies.

In this research note, we do what is expected of quantitative analysts: we study the time period of the Quant Crisis and analyze subsequent market movements in its aftermath. We first review factor returns during August 2007 and place them in historical context. Next we examine subsequent trends in market movements with further focus on additional episodes of outlying events.

DATA AND METHODOLOGY

We focus on factor-based strategies in the pre- and post-crisis periods to analyze how much this basic tenet of quant investment has been challenged in recent times. The factors reviewed span major investment styles including Value, Growth, Momentum, Risk and Quality (see Appendix for factor definitions). We select 15 indicators common to many quant strategies, from our extensive library of approximately 400 factors in the US. Note that Markit's Global Factor Analyst maintains historical data from the mid 1980's for the US market, and the majority of these factors have been running on a live basis since the early 2000's.

We utilize many performance statistics to quantify factor efficacy. In this report we focus on decile spread returns which align with the methodology of many hedge funds at the focal point of the Quant Crisis. The decile spread is calculated based on an investment strategy going long (short) the top (bottom) 10% of factor ranks. The spread is simply the difference between the average stock return in the top (D1) and bottom (D10) deciles.

We also put the events in the context of variation from past decile returns. For this we make use of our historical return data and report on a commonly-used measure of the magnitude of outlier occurrences known as 3-sigma events. A standard deviation, or sigma, is based on observations from a normal, or bell-shaped, distribution. Statistically, two-thirds of the returns lie within an interval encompassing one standard deviation around the average. In turn, a 3-sigma event is equivalent to three times the normal volatility and is expected to occur less than 1% of the time and thus considered an extreme movement from expectations.

Combining the two concepts, we also present the information ratio (IR) as the average decile spread returns to the volatility of those returns. Essentially, it is a measure of risk-adjusted signal return.

Our coverage will focus on US securities. Analysis of large capitalization stocks will center on the Russell 1000 (R1000) index constituents. Likewise, the Russell 2000 (R2000) will represent the small capitalization universe.

THE QUANT CRISIS

We begin by putting the Quant Crisis into historical context comparing August 2007 monthly decile return spreads to historical levels for R1000 (see Table A1 in Appendix for a summary of 10-year average factor returns). Figure 1 plots the August 2007 decile return spread (blue marker) within a one standard deviation range (gray bar) of the historical average. From the vantage point, we do not detect extreme factor behavior during August 2007. One may ask then, "What quant crisis?"

However, as we dig a little deeper into daily August returns (see Figure 2 on Page 3) computed on open-to-close prices, we reveal what the headlines were all about. Here we observe that while daily returns displayed increased volatility at the start of the month, wild swings were seen between August 8th and 10th. R2000 results (see Figure A1 in Appendix) portrayed similar trends but with higher volatility.
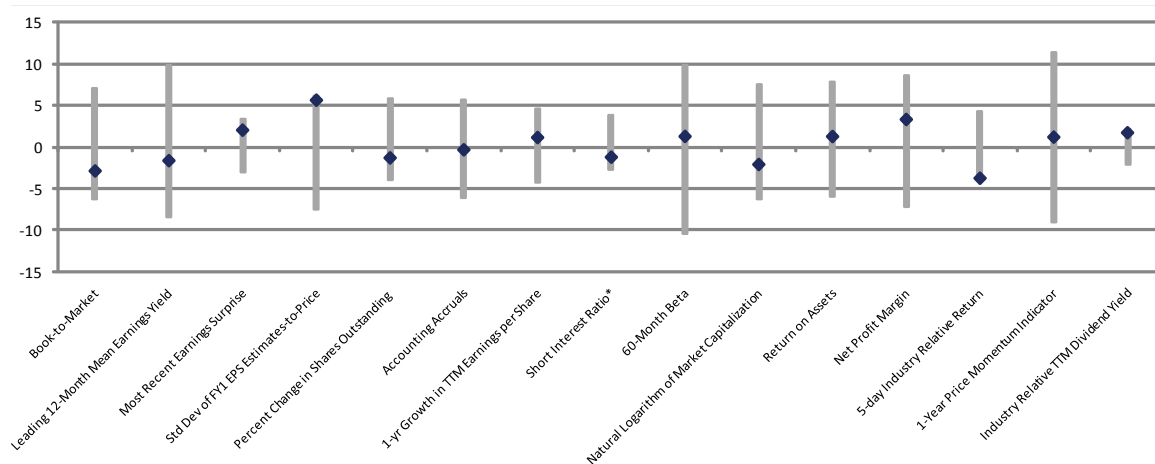

Figure 1: R1000 monthly decile return spread (%) versus 10-year historical standard deviation, Aug 2007

Scaling down to the 3-day period between August 8th and August 10th, Table 1 lists counts of the number of days that the factor returns qualified as 1- and 3-sigma events for R1000 and R2000. Standard deviations were calculated over the prior 5 years (August 2002 – July 2007) to capture the market environment of that period. The results confirm the high frequency of performance outliers. Further, the crowded trade suggested by many as an explanation for overwhelming the markets is consistent with the greater effects observed for the lower-volume small capitalization names. Yet, by August 17th, volatility for both universes settled down to historical range-bound levels. Indeed, any quantitative hedge fund manager who took a late-summer vacation in the first part of August would have been oblivious to whole event.
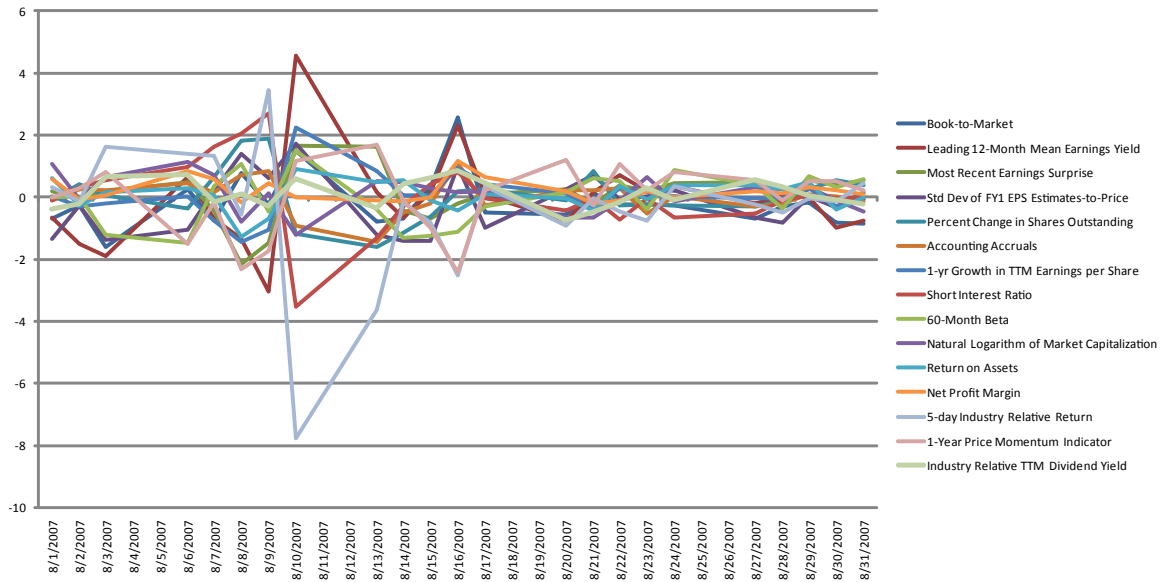

Figure 2: R1000 daily decile return spreads (%), Aug 1, 2007 – Aug 31, 2007

	R1000		R2000	
	1-sigma	3-sigma	1-sigma	3-sigma
Book-to-Market	1		2	
Leading 12-Month Mean Earnings Yield	3	1	3	1
Most Recent Earnings Surprise	3	3	3	3
Std Dev of FY1 EPS Estimates-to-Price	3		1	
Percent Change in Shares Outstanding	3	2	3	3
Accounting Accruals	1		3	1
1-yr Growth in TTM Earnings per Share	2		2	1
Short Interest Ratio	3	3	3	2
60-Month Beta	2		1	
Natural Logarithm of Market Capitalization	3		2	
Return on Assets	1		3	1
Net Profit Margin	1		3	
5-day Industry Relative Return	3	2	3	3
1-Year Price Momentum Indicator	3		3	1
Industry Relative TTM Dividend Yield	2		3	1

Table 1: Daily count of decile return spread outliers, Aug 8, 2007 – Aug 10, 2007, based on daily returns from Aug 2002 – Jul 2007

POST QUANT CRISIS

We turn now to analysis of the years following the Quant Crisis. First we investigate monthly decile return spreads in the subsequent five years versus those of the previous 10. Table 2 (see Page 4) summarizes R1000 and R2000 average and standard deviation (Std Dev) differences between the two periods.

	R1000		R2000	
	Average	Std Dev	Average	Std Dev
Book-to-Market	-0.40	1.9	-0.21	-0.6
Leading 12-Month Mean Earnings Yield	-1.21	-5.5	-0.76	-8.0
Most Recent Earnings Surprise	-0.54	-0.2	-0.44	0.4
Std Dev of FY1 EPS Estimates-to-Price	0.62	2.0	-0.04	-1.1
Percent Change in Shares Outstanding	-0.82	-1.8	-0.75	-3.2
Accounting Accruals	1.31	-2.8	0.11	-2.1
1-yr Growth in TTM Earnings per Share	-0.31	0.4	-0.47	-1.6
Short Interest Ratio*	-0.44	0.6	-0.68	1.9
60-Month Beta	-0.69	-0.1	-1.51	-1.3
Natural Logarithm of Market Capitalization	0.47	2.9	0.34	-3.6
Return on Assets	-0.59	-1.5	-1.10	-5.2
Net Profit Margin	-0.73	-2.4	-0.79	-6.2
5-day Industry Relative Return	-0.37	0.2	-1.63	-1.6
1-Year Price Momentum Indicator	-1.40	-1.7	-2.16	-3.2
Industry Relative TTM Dividend Yield	0.59	2.6	0.36	2.9

* Data begins August 2001

Table 2: Monthly decile return spread (%) statistics, Aug 2007 – Jul 2012 versus Aug 1997 – Jul 2007

We observe that decile return spread averages decreased in general in the past five years versus the prior ten. However, volatility was recently more stable for the most part versus the long-term history. This decrease in overall volatility level resulted from the relatively lower variability compared with the extremes of the tech bubble inflation and subsequent deflation period. For example, if we limit comparison of the 5-year post-Quant Crisis period to the prior 5-year period for R1000, we indeed find that most factors exhibit higher volatility recently, with the exception of *Leading 12-Month Mean Earnings Yield, Accounting Accruals* and *Return on Assets.* Similar results are posted for R2000 (results not shown here).

One notable exception between the past five years vs. previous ten relates to the higher recent returns for the *Industry Relative TTM Dividend Yield* factor, which was particularly rewarded in April 2009 (more on this time period below). The enhanced performance is likely due to an extreme flight to safety which characterized sentiment during the uncertain economic environment seen during recent years.

We also remark on the two Price Momentum indicators, *5-day Industry Relative Return* and *1-Year Price Momentum Indicator*, which underperformed in the last 5 years versus the prior 10. We have commented frequently over recent periods (see our monthly Key Drivers Reports) on the global emphasis towards Price Momentum, which would raise expectations for enhanced average performance. Yet, recent spread levels were no match to the robust numbers posted in the earlier analysis period, particularly through the strong momentum-driven markets up to December 2002.

Next we focus on other time periods of significance to quantitative analysts. In August 2008, volatility re-entered the market place as exemplified by VIX levels not seen since the October 1987 stock market crash. In turn, factor return volatility increased (see Table 4 on Page 5 for counts of the number of days that the factor returns were qualified as 1- and 3-sigma events versus the 5-year pre-Quant Crisis period) and culminated in tremendous decile return spreads in April 2009 off of the market trough of the previous month. Indeed, R1000 April 2009 performance (see Table 5 on Page 5) reached significant levels. Further, we highlight in gray those values which coincided with the maximum or minimum over the full pre- and post-Quant Crisis period for the respective factor.

However, for R2000 the effects of the internet bubble in January 2001 were more impactful and thus only *Industry Relative TTM Dividend Yield* realized a 15-year extreme return in April 2009. Yet, if we exclude January 2001 from the analysis then a handful of R2000 factors did in fact attain an extrema (gray-shaded numbers in R2000 column).

Even with this, April 2009 outlying events still seemed focused more on large capitalization stocks as indicated by larger magnitude in R1000 returns across all factors. We also remark that the high R1000 return spread for *Book-to-Market* (45.63%)

	R1000		R2000	
	1-sigma	3-sigma	1-sigma	3-sigma
Book-to-Market	133	74	125	47
Leading 12-Month Mean Earnings Yield	94	11	16	
Most Recent Earnings Surprise	132	63	103	31
Std Dev of FY1 EPS Estimates-to-Price	130	63	99	24
Percent Change in Shares Outstanding	139	87	118	43
Accounting Accruals	74	5	81	5
1-yr Growth in TTM Earnings per Share	95	19	91	7
Short Interest Ratio	123	55	145	85
60-Month Beta	116	37	92	16
Natural Logarithm of Market Capitalization	136	62	108	31
Return on Assets	101	17	53	1
Net Profit Margin	103	25	42	1
5-day Industry Relative Return	141	97	144	95
1-Year Price Momentum Indicator	83	14	95	12
Industry Relative TTM Dividend Yield	149	108	152	126

Table 4: Daily count of decile return spread outliers, Sep 1, 2008 – Apr 30, 2009 versus Aug 2002 – Jul 2007

	R1000	R2000
Book-to-Market	45.63	38.24
Leading 12-Month Mean Earnings Yield	-9.46	-8.66
Most Recent Earnings Surprise	-14.66	-7.55
Std Dev of FY1 EPS Estimates-to-Price	-48.38	-38.17
Percent Change in Shares Outstanding	-9.31	1.30
Accounting Accruals	17.13	13.42
1-yr Growth in TTM Earnings per Share	-26.70	-14.08
Short Interest Ratio	-14.58	9.58
60-Month Beta	-54.88	-40.56
Natural Logarithm of Market Capitalization	60.02	39.97
Return on Assets	-26.77	-6.55
Net Profit Margin	-26.65	-10.67
5-day Industry Relative Return	16.03	7.34
1-Year Price Momentum Indicator	-45.78	-44.10
Industry Relative TTM Dividend Yield	28.29	22.79

Table 5: Decile return spreads (%), Apr 2009

and the low R2000 return spread for *60-Month Beta* are consistent with the exceptional rally of value and high risk names during this inflection period.

The next mar that blighted investors' faith in market fundamentals was the Flash Crash on May 6, 2010. On this day, the Dow Jones Industrial Average plummeted to its largest intraday point loss, only to bounce back within minutes. Blame for this event centered on high-frequency trading and its reliance on computer-driven algorithms. After the advent of electronic exchanges in 1998, high-frequency trading has grown exponentially and trading execution times have decreased to microseconds now accounting for the majority of equity volume.

Not surprisingly, the implications of the Flash Crash were less impactful on decile return spreads as only about half of the factors experienced 1-sigma events in R1000 and R2000 that day, and no spreads were outside of three standard deviations. Yet quantitative managers were still affected by the Flash Crash in terms of the vital impact on transaction costs.
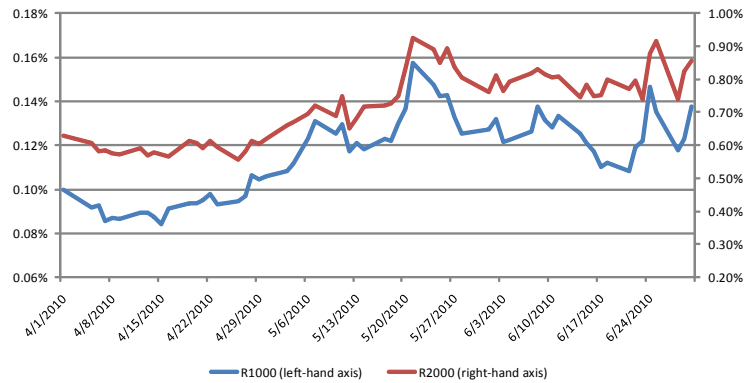
Figure 3: Markit TCost Model average daily transaction cost, Apr 1 2010 – Jun 30 2010

To represent this analysis we employ the Markit TCost model (for more about this model see *Markit's Equity Impact Cost Model: Unparalleled Accuracy* Apr 2011) on a stock by stock basis to produce estimated transaction costs, including both spreads and market impact. The portfolio size used to generate the transaction costs for R1000 (R2000) was roughly $1 million ($500,000) per position.

Figure 3 displays average daily transaction costs for R1000 and R2000 over days prior to and following the Flash Crash.

We observe that average transaction costs did indeed increase on May 6th and remained in a temporarily elevated channel throughout the subsequent month. We remark, however, that transaction costs during this period are not at the levels experienced over the aforementioned high-volatility episode from September 2008 through April 2009.

CONCLUSION

In this report we recognize the five-year anniversary of the Quant Crisis of August 2007. During this period quantitative hedge funds suffered exceptional losses in just a few days during what seemed to be normal market conditions. The evolution of computer-driven quantitative funds prior to the event ultimately extended from simple valuation- and momentum-based equity models to more sophisticated high frequency trading applications, and was an auspicious time of strong performance and asset growth for that segment of the asset management community.

We begin by stepping back in time to put context around the incident in question. Analysis of factors from major investment styles shows that, while monthly performance in August 2007 was well within historical volatility levels, daily variation, particularly between August 8th and 10th, was outlier-ridden. The impetus from the crowded-trade effect manifested itself especially for small capitalization stocks.

We next review market movements in the aftermath of the Quant Crisis. Our examination reveals in general that lower average monthly spreads were awarded to standard factors in the five years since the episode versus the prior 10-year history. However, volatility levels are also less extreme in part due to the exclusion of the tech bubble inflation and deflation period.

Finally, we highlight several other episodes of abnormal market phenomena of particular interest to the quantitative community. One such period includes September 2008 through April 2009, which was characterized by relatively higher daily volatility and culminated in exceptional spreads in April, particularly for large capitalization stocks.

Another event which cast notoriety once again on quantitative funds is the Flash Crash of May 6, 2010. The proliferation of high-frequency trading and its reliance on computer-driven algorithms were blamed for an abrupt, unprecedented drop in the Dow Jones Industrial Average that bounced back within minutes. While little impact was detected in the volatility of daily factor returns, transaction costs were affected adversely in a persistent manner throughout the subsequent month. Perhaps most importantly, though, is the lingering distrust of small investors in the overall market.

APPENDIX

	R1000			R2000		
	Average	Std Dev	IR	Average	Std Dev	IR
Book-to-Market	0.39	6.7	0.06	0.73	8.1	0.09
Leading 12-Month Mean Earnings Yield	0.68	9.2	0.07	1.52	11.9	0.13
Most Recent Earnings Surprise	0.17	3.2	0.05	0.53	3.0	0.17
Std Dev of FY1 EPS Estimates-to-Price	-0.63	6.9	-0.09	0.54	9.9	0.05
Percent Change in Shares Outstanding	0.99	4.9	0.20	1.62	6.3	0.26
Accounting Accruals	-0.22	5.9	-0.04	0.42	5.5	0.08
1-yr Growth in TTM Earnings per Share	0.18	4.5	0.04	0.33	5.4	0.06
Short Interest Ratio*	0.60	3.3	0.18	1.77	2.9	0.60
60-Month Beta	-0.23	10.2	-0.02	0.28	9.7	0.03
Natural Logarithm of Market Capitalization	0.63	6.9	0.09	-0.23	11.9	-0.02
Return on Assets	0.90	6.9	0.13	1.38	9.5	0.15
Net Profit Margin	0.74	7.9	0.09	1.36	10.7	0.13
5-day Industry Relative Return	0.96	3.4	0.28	2.98	5.1	0.59
1-Year Price Momentum Indicator	1.20	10.3	0.12	2.05	11.6	0.18
Industry Relative TTM Dividend Yield	0.00	2.1	0.00	0.48	1.6	0.31

* Data begins August 2001

Table A1: Monthly decile return spread (%) statistics, Aug 1997 – Jul 2007
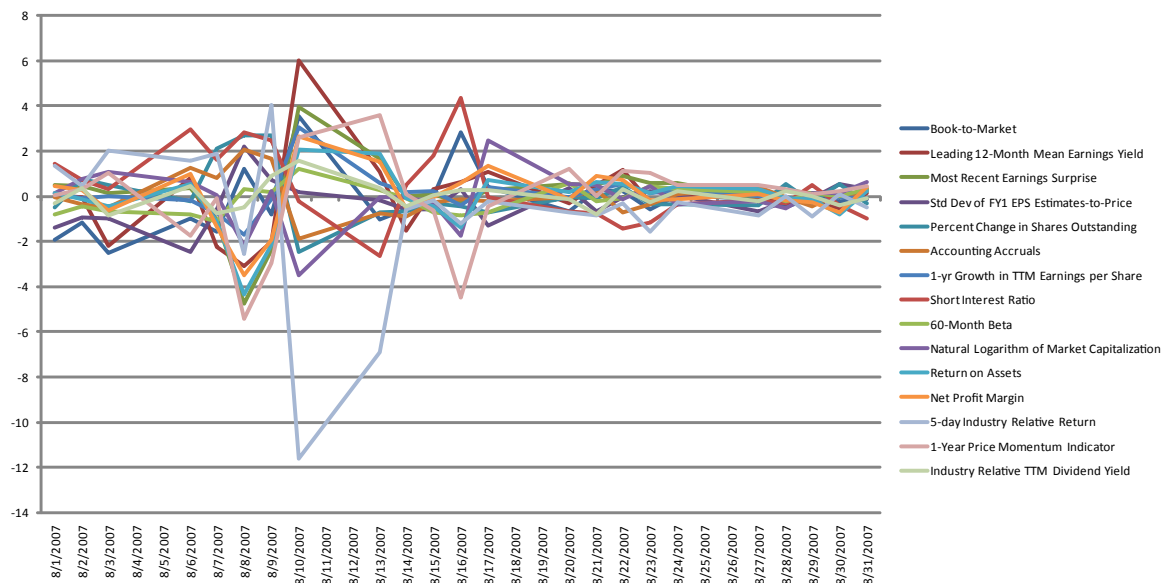
Figure A1: R2000 daily decile return spreads (%), Aug 1, 2007 – Aug 31, 2007

Deep Value

Book-to-Market It is defined as the most recently reported book value per share deflated by its trading price. Markit ranks this factor in descending order.

Leading 12-Month Mean Earnings It is defined as the next 4-quarter's mean consensus earnings estimate divided by the price. Markit ranks this factor in descending order.

Earnings Momentum

Most Recent Earnings Surprise It is defined as the most recent quarterly earnings surprise adjusted by the standard deviation of analyst forecasts. Markit ranks this factor in descending order.

Std Dev of FY1 EPS Estimates-to-Price It is defined as the standard deviation of analyst forecasts for fiscal year 1 earnings scaled by closing price. Markit ranks this factor in ascending order.

Earnings Quality

Percent Change in Shares Outstanding Percent change in a company's current number of outstanding shares as compared to the number of shares outstanding one year ago. Markit ranks this factor in ascending order.

Accounting Accruals Difference between the trailing 12-month net income and the trailing 12-month operating cash flow scaled by the beginning total assets. Markit ranks this factor in ascending order.

Historical Growth

1-yr Growth in TTM Earnings per Share Percent change in most recent trailing 12-month earnings per share before extra items (EPS) as compared to the EPS 4 quarters ago. Markit ranks this factor in descending order.

Liquidity, Risk & Size

Short Interest Ratio Number of shares sold short divided by the average daily trading volume of the stock over the last 30 trading days. Markit ranks this factor in ascending order.

60-Month Beta 0.67 times the 60-month beta plus 0.33. Beta is the covariance between a stock's monthly return and the monthly S&P 500 index return in the prior 60-month period divided by the variance of the monthly S&P 500 index return in the same period. Markit ranks this factor in ascending order.

Natural Logarithm of Market Capitalization Natural logarithm of the cubic of a stock's total market value. Markit ranks this factor in ascending order.

Management Quality

Return on Assets Trailing 12-month income before extra items divided by the average of total assets in the same period. Markit ranks this factor in descending order.

Net Profit Margin Most recently reported quarterly net income after tax divided by the corresponding quarterly sales. Markit ranks this factor in descending order.

Price Momentum

5-day Industry Relative Return A stock's return in the last 5 days minus the average of the comparable returns of all stocks in the same industry, then deflated by the standard deviation of these returns. Markit ranks this factor in ascending order.

1-Year Price Momentum Indicator is the correlation coefficient between the natural logarithm of stock daily closing price and the corresponding daily dates in last 260 days.   Markit ranks this factor in descending order.

Relative Value
Industry Relative TTM Dividend Yield A stock's trailing 12-month dividend yield (DivYield) less the average of the DivYields of all stocks in the same industry deflated by their standard deviation. Markit ranks this factor in descending order.

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Markit is a leading, global financial information services company with over 2,200+ employees.

The company provides independent data, valuations and trade processing across all asset classes in order to enhance transparency, reduce risk and improve operational efficiency.

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London	+ 44 20 7260 2000
New York	+ 1 212 931 4900
Naperville	+ 1 630 637 8088
Dallas	+ 1 972 560 4420
Sydney	+ 61 2 0 89 89 80
Tokyo	+ 81 3 6402 0130
Singapore	+ 65 6499 0088
Frankfurt	+ 49 69 299 868 140
Amsterdam	+ 31 20 502 5800