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Building a Better Beta:
Combining Fundamentals Weighting, Low Volatility, and Momentum Strategies

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Research Affiliates launched the RAFI® Fundamental Index® methodology in 2005. Since then, smart beta[1] or alternative index assets have grown to a total of nearly $300 billion.[2] The rising acceptance of smart beta strategies reflects two facts: (1) traditional passive investing offers no more than the market return,[3] and (2) most active managers underperform the market after fees (Malkiel, 2005). Simulated smart beta strategies have generally earned long-term returns that are approximately 2% per annum higher than the returns of traditional capitalization-weighted indices (Chow et al., 2011). In addition, smart beta investments have substantially lower costs than active management.

In this paper, we will discuss three distinct smart beta strategies: the fundamentals weighting approach, low volatility investing, and momentum. In each case, the index construction methodology employed will affect short-term performance patterns as well as portfolio characteristics, including turnover, liquidity, capacity, sector allocations, and exposures to return factors. Thanks to these differing characteristics, smart beta strategies can contribute meaningfully to a diversified investment program with a core-satellite structure.

A BRIEF DESCRIPTION OF THE STRATEGIES

This white paper presents U.S. equity strategies and analyzes their performance and characteristics over the period from 1967 through 2013. Readers who are not very familiar with smart beta investing, or want a refresher, may find the following descriptions of fundamentally weighted, low volatility, and momentum investing helpful. Others may wish to skip ahead to the next section.

Fundamentals Weighting

Fundamentals weighting is an index construction methodology that uses indicators of company size (such as sales, cash flow, dividends, and book value) to select index holdings and set their weights. The goal of fundamentals weighting is to break the link between stock prices and portfolio weights while maintaining reasonably low tracking error against cap-weighted benchmarks and retaining important benefits of traditional passive indexing: high capacity and low implementation costs relative to active management. Fundamentals weighting is a contrarian strategy that methodically increases weights in stocks which have fallen in price (thus buying low) and reduces weights in stocks that have gone up in price (selling high). Long-term simulations show that, on an annualized basis, fundamentally weighted strategies outperform cap-weighted indices by approximately 2%, and much of the excess return results from trading against market price movements by periodically rebalancing to fundamental weights. This paper will use a simulated fundamentals-weighted strategy similar to the Fundamental Index methodology pioneered by Research Affiliates. (Arnott, Hsu, and Moore, 2005). The strategy will select and weight the top 1,000 U.S. securities by sales, cash flow, dividends, and book value, and rebalance annually on January 1.

Low Volatility

As the name implies, low volatility investing is simply investing in a portfolio of securities that exhibit less price variability than the overall market. While there are many theories about the causes of the low volatility effect, its existence has been well documented.[4] Similar to fundamentally weighted indexing, low volatility strategies are contrarian and have been shown to outperform cap-weighted indices by about 2%. (Low volatility strategies have lower volatility of returns than fundamentally weighted indices, but they also have higher tracking error against cap-weighted benchmarks.) There are several ways to construct a low volatility index, but the different methodologies yield comparable

risk/return profiles (Chow et al., 2014). This paper will use a straightforward methodology of selecting the top 1,000 U.S. securities by market capitalization, choosing the 200 securities with the lowest volatility from that opportunity set,[5] and weighting each security by 1/volatility, giving the largest allocations to the stocks with the lowest volatilities. Like the fundamentally weighted portfolio, this simulated strategy is rebalanced annually on January 1.

Momentum

Unlike fundamentals weighting and low volatility investing, momentum strategies are not contrarian. They can be characterized by purchasing stocks that have recently risen in price, holding them for a period, and then rebalancing into more recent winners. The momentum effect has also been well documented, and several theories have been advanced to explain its cause (Larson, 2013). Although momentum strategies have been shown to provide excess returns in line with those of other smart beta strategies, they tend to exhibit higher volatility than the overall market.[6] This paper will use the returns of a Big [Size], High [Momentum] portfolio published by Kenneth French, a widely accepted source.[7]

PERFORMANCE AND CORRELATIONS

The three smart beta strategies under consideration produce results with very different characteristics. **Table 1** compares the performance, volatility, tracking error, Sharpe ratio, and information ratio of the simulated strategies over the 47-year period from 1967 through 2013.[8] All three outperformed a cap-weighted benchmark, the S&P 500 Index, by approximately 2% to 3% per annum over the measurement period. As one would expect, low volatility has the lowest standard deviation of returns, and momentum has the highest. Because the percentage reduction in volatility is much greater than the percentage decline in return, low volatility yields the highest Sharpe ratio; but it also has the lowest information ratio due to its high tracking error vis-à-vis the cap-weighted index. The fundamentally weighted strategy most resembles the cap-weighted index in that its volatility is closest to the overall market and it has the lowest tracking error. Relatedly, fundamentals weighting also yields the highest information ratio.

TABLE 1: SIMULATED SMART BETA STRATEGIES, 1967–2013

	ANNUALIZED RETURN	ANNUALIZED VOLATILITY	TRACKING ERROR	SHARPE RATIO	INFORMATION RATIO
Fundamentals Weight	12.4%	15.7%	4.5%	0.46	0.47
Low Volatility Strategy	12.0%	12.5%	8.5%	0.55	0.21
Momentum Strategy	13.3%	17.2%	7.3%	0.47	0.42
S&P 500 Index	10.3%	15.3%	–	0.33	–

Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

Comparing the strategies from another perspective also yields some noteworthy differences. **Table 2** uses a five-factor regression model to decompose the strategies' sources of return.[9] The fundamentally weighted portfolio loads heavily on value and has a negative momentum exposure. Intuitively, this makes sense; a portfolio that reverts to fundamental weights at each rebalance reduces the allocation to upward-trending stocks and increases the allocation to securities whose prices have fallen. This

TABLE 2: FACTOR EXPOSURES OF FUNDAMENTALS WEIGHTING, LOW VOLATILITY, AND MOMENTUM STRATEGIES, 1967–2013

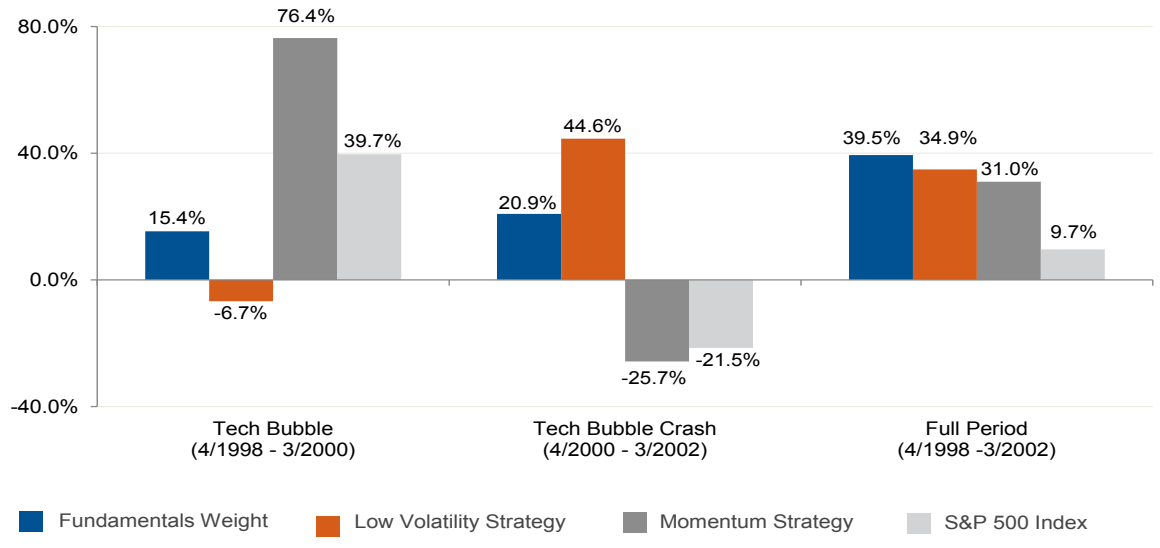
	MARKET BETA	SIZE (SMB)	VALUE (HML)	MOMENTUM (WML)	LOW VOLATILITY (BAB)
Fundamentals Weight	1.01	−0.05	0.34	−0.10	0.05
Low Volatility Strategy	0.74	−0.03	0.16	−0.08	0.41
Momentum Strategy	1.06	−0.01	0.05	0.39	−0.05
S&P 500 Index	0.99	−0.18	0.02	−0.02	0.00

Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

creates a strong value tilt that is entirely consistent with negative momentum. The low volatility strategy also has some exposure to value because it trades against market price movements, just as fundamentals weighting does, but it uses a volatility measure as the rebalancing anchor. The market beta of the low volatility strategy is significantly lower than that of the other strategies; this analysis indicates that low volatility investing redistributes factor exposures from market beta to value and, especially, low volatility. The momentum strategy, which is pro-cyclical in nature, has very little value and low volatility factor exposure and significant loading on momentum.

Given that these three smart beta strategies have different sources of return, one would expect strikingly different patterns of short-term performance. In an environment where stock prices have reversed direction and are heading back to their long-term average, a fundamentally weighted strategy would probably add the greatest value. In a strong growth-driven environment, where stock prices are trending higher, a momentum strategy would likely outperform. To illustrate these patterns, **Figure 1** and **Figure 2** display the time-varying performance of the smart beta strategies during two extreme market events: the technology bubble and global financial crisis.

FIGURE 1: SMART BETA PERFORMANCE IN THE TECHNOLOGY BUBBLE (CUMULATIVE RETURNS)



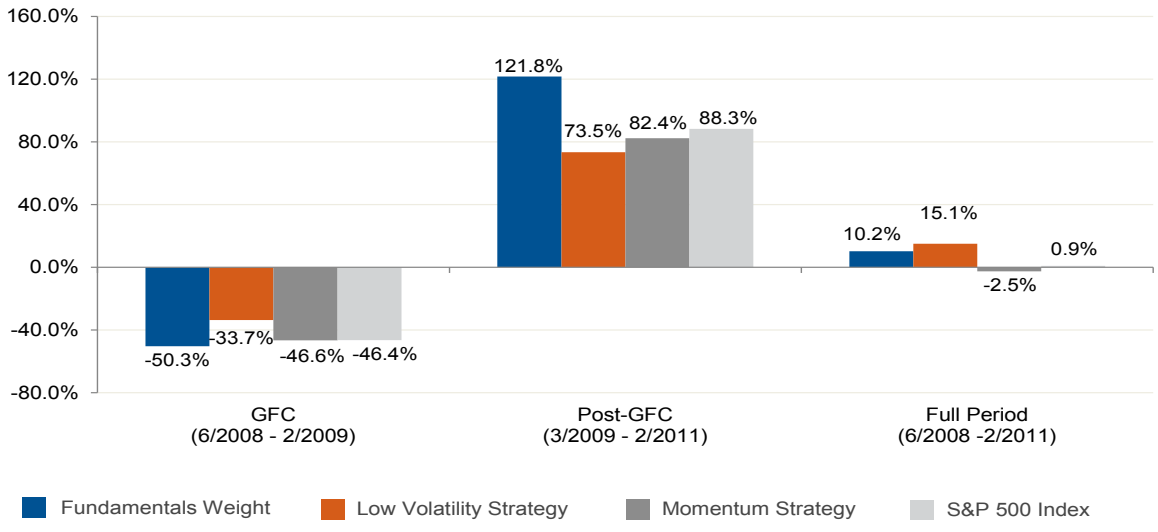
Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

Over the entire boom-and-bust period of the tech bubble, all three smart beta strategies produced cumulative excess returns in the range of 20% to 30% over cap-weighting. Breaking down the performance into two separate periods, however, reveals some interesting results. During the run-up to the tech bubble, the S&P 500 posted a cumulative return of 39.7%. This was an overheated period exemplified by rapid price appreciation in the stocks of several technology companies. Cisco rose 569%, Yahoo!, 770%, and Sun Microsystems, 784%.[10] With plenty of willing buyers to push the technology stock prices higher and higher, the momentum strategy outstripped the cumulative performance of the S&P 500 by almost 37%. The fundamentally weighted and low volatility strategies did not fare well in this heady environment. Their cumulative returns trailed the cap-weighted benchmark by 24.3% and 46.4%, respectively. Both strategies have a value tilt and rebalance against market price movements, resulting in significantly lower-than-benchmark allocations to technology stocks. In periods when stock prices are trending upward, rebalancing away from recent winners is not a successful strategy.

The two years after the bursting of the tech bubble yielded the opposite results. The fundamentally weighted strategy outperformed by 42.4%, cumulatively, and the low volatility strategy by 66.1%. And again, intuitively, this is understandable. Any strategy that rebalances against price movements will perform relatively well during market corrections. Both of these strategies had significantly underweight positions in the technology sector and were therefore well positioned to lose less than the benchmark when tech stock prices fell back toward their long-term mean. Conversely, the momentum strategy underperformed the market during this period when the prices of many recent winners reversed direction and headed down.

The smart beta strategies' results were sharply different in the global financial crisis. Figure 2 displays their performance during this period. All three strategies recorded negative returns in the midst of the crisis and positive returns in the aftermath. Despite its underperformance against the

FIGURE 2: SMART BETA PERFORMANCE IN THE GLOBAL FINANCIAL CRISIS (CUMULATIVE RETURNS)

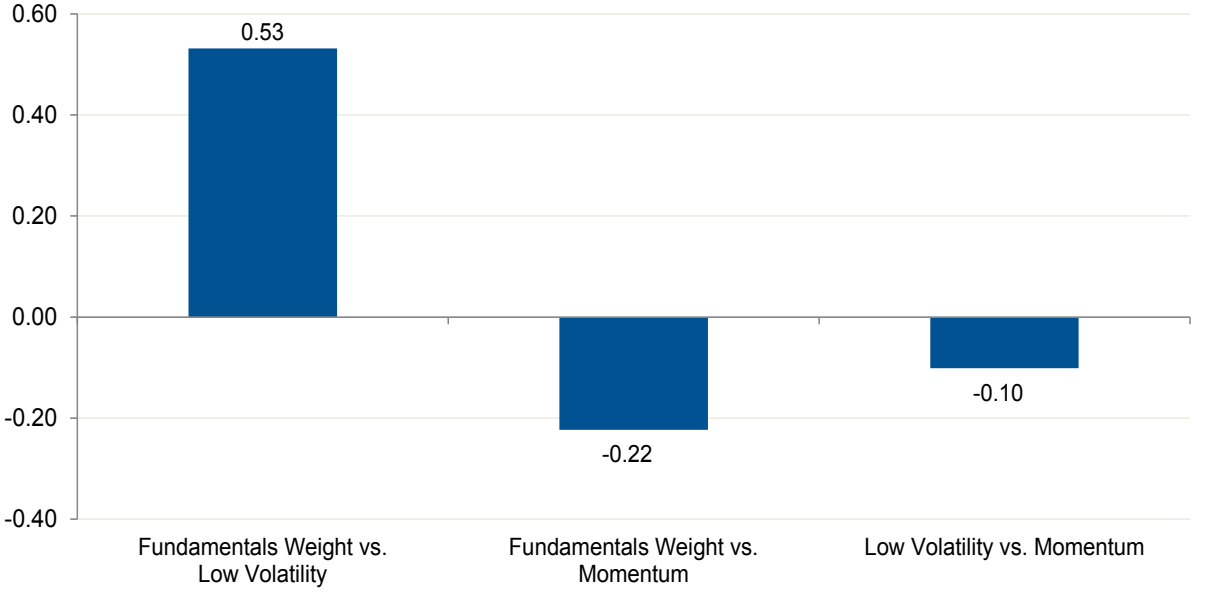


Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

broad market in the two years following the crisis, the low volatility strategy delivered the highest return for the full period because it had earlier provided substantial downside protection This pattern is not unusual; low volatility stocks tend to lose less in a bear market and gain less in a bull market. (We mentioned previously that the market beta of the simulated low volatility strategy was less than unity in the 1967–2013 period.) The fundamentally weighted strategy also outperformed the market during the full period surrounding the crisis. Its strong performance was driven by a large positive active position in deep value stocks, most notably including financial stocks, which were big losers prior to the crisis but rebounded smartly after the crash. It is interesting that the momentum strategy significantly underperformed the market over the full period. Its return in the run-up period nearly matched the overall market return, but the momentum strategy fell about 5.9% short of the benchmark return in the post-crisis period.

Our purpose in revisiting these extreme market events is not to discern which smart beta strategy is "the best" on the basis of short-term performance. It is to illustrate how unalike the strategies' short-term performance patterns can be in different market environments (even though they have all generated excess returns of roughly 2% to 3% per year in long-term simulations). The divergent return patterns imply that combining these smart beta strategies might provide a risk-dampening benefit in the form of factor diversification. **Figure 3** shows the correlation of benchmark-relative excess returns for all three smart beta strategies. The fundamentally weighted and low volatility strategies have the highest correlation with one another (0.53). As we have seen, they are both contrarian strategies that trade against market prices. A positive correlation of excess returns is, therefore, to be expected, even if it is far from perfect. By contrast, the excess returns of the momentum strategy versus both the fundamentally weighted and low volatility strategies is negative. In other words, momentum investing typically outperforms when the two contrarian strategies underperform, and vice versa.

FIGURE 3: CORRELATION OF RETURNS IN EXCESS OF S&P 500 INDEX RETURNS, 1967–2013



Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

CONSTRUCTING A PORTFOLIO OF SMART BETA STRATEGIES

Institutional investors such as pension plans, university endowment funds, and charitable foundations usually develop investment policy statements that set forth their financial objectives, risk tolerance, target asset mix, and investment guidelines. They typically engage consultants to recommend the target asset mix, or desired combination of asset classes and investment strategies, on the basis of an asset–liability study which produces a customized model portfolio with a mathematically optimized risk/return profile. The scope of this white paper is *much* more limited. Our objective is merely to illustrate a few ways of combining a small set of smart beta strategies which, taken together, have the potential to provide attractive excess returns with less volatility than the individual strategies exhibit in isolation from one another. In each example, we will designate one of them as the "core" strategy and the others as "satellite" strategies.

An important question to consider in developing an overall investment program is: "What is the appropriate measure of risk-adjusted return?" Many institutional and individual investors evaluate their investment results in comparison with a benchmark index. For example, the rate of return earned by a U.S. equity portfolio might be compared with the return of the S&P 500 in the same period. In consequence, the investors may be more or less "benchmark-constrained" (i.e., unable or unwilling to stray very far from the investment strategy or style that the index represents). Institutional investors often have specific tracking error budgets, relative to the benchmark, that they cannot exceed. Individual investors may not have formal investment policy statements in place, but they do tend to measure their investment performance against the overall market, and the likelihood that they will eventually terminate an underperforming advisor or portfolio manager might be seen as an implicit tracking error constraint.

Investors for whom tracking error is the preferred risk measure should seek to maximize the information ratio. We saw in Table 1 that the fundamentally weighted strategy had the highest information ratio and lowest tracking error; accordingly, fundamentals weighting would be a reasonable core strategy for a benchmark-constrained investor.[11]

In addition to deciding how to evaluate investment results, investors should take into account other considerations influencing the selection of a core strategy. Desirable characteristics in a core portfolio include high capacity, broad diversification across economic sectors, low turnover, and low fees. Arnott, Hsu, Kalesnik, and Tindall (2013) demonstrate that any alternative index strategy that severs the link between stock price and portfolio weight outperforms cap-weighting in long-term simulations; but fundamentals weighting results in the highest weighted average market capitalization, highest average daily trading volume, and lowest turnover. A fundamentally weighted strategy that reflects the macro-economy and operates efficiently resembles a cap-weighted index without the return drag that results from systematically overweighting high-price securities and underweighting low-price securities.

A smart beta portfolio that uses the fundamentally weighted strategy as the core holding can be enhanced with complementary positions in low volatility and/or momentum strategies. The combinations shown in **Table 3** are examples of core-satellite portfolios with multiple smart beta strategies.

TABLE 3: SIMULATED CORE-SATELLITE SMART BETA STRATEGIES, 1967–2013

	ANNUALIZED RETURN	ANNUALIZED VOLATILITY	TRACKING ERROR	SHARPE RATIO	INFORMATION RATIO
Fundamentals Weight	12.4%	15.7%	4.5%	0.46	0.47
Low Volatility Strategy	12.0%	12.5%	8.5%	0.55	0.21
Momentum Strategy	13.3%	17.2%	7.3%	0.47	0.42
S&P 500 Index	10.3%	15.3%	–	0.33	–
60% Fundamentals Weight 20% Low Volatility Strategy 20% Momentum Weight	12.6%	14.7%	3.9%	0.51	0.62
70% Fundamentals Weight 30% Momentum Strategy	12.8%	15.6%	3.4%	0.49	0.74
70% Fundamentals Weight 30% Low Volatility Strategy	12.3%	14.4%	5.0%	0.50	0.42

Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

All three core-satellite mixes preserve the individual smart beta strategies' long-term return advantage of 2% to 3% over cap-weighting. The portfolio with a 60% allocation to fundamentals weighting, 20% to low volatility, and 20% to momentum (the 60/20/20 portfolio) produces a tracking error that is lower than the lowest tracking error of the constituent strategies. This is a powerful result. It stems largely from the negative correlation of the pro-cyclical momentum strategy's excess returns with the excess returns of the contrarian fundamentally weighted and low volatility strategies.

In addition to reducing the tracking error, combining the three strategies creates a portfolio whose simulated volatility is lower than that of the overall market, as represented by the S&P 500. Thus the 60/20/20 portfolio has an attractive Sharpe ratio (reflecting total risk) as well as an appealing information ratio (reflecting benchmark risk).

The other two core-satellite portfolios illustrate the trade-offs investors face. Complementing a 70% commitment to the fundamentally weighted strategy with a 30% allocation to momentum generates the highest information ratio (0.74)—a key measure for benchmark-constrained investors. However, it results in higher-than-market volatility. Conversely, the portfolio with 70% of assets in the fundamentals-weighted strategy and 30% in the low volatility strategy has lower-than-market volatility but a higher tracking error.

All three core-satellite portfolios distribute factor exposures a little more evenly than any of the individual strategies. In comparison with the fundamentally weighted strategy, the 60/20/20 portfolio has somewhat less value exposure and modestly more low volatility exposure (**Table 4**). Additionally, the negative momentum that naturally results from trading against market price movements is offset by the portfolio's allocation to the momentum strategy.

It is also instructive to see how a core-satellite smart beta approach performed in the same extreme environments we examined earlier: the technology bubble and the global financial crisis. The

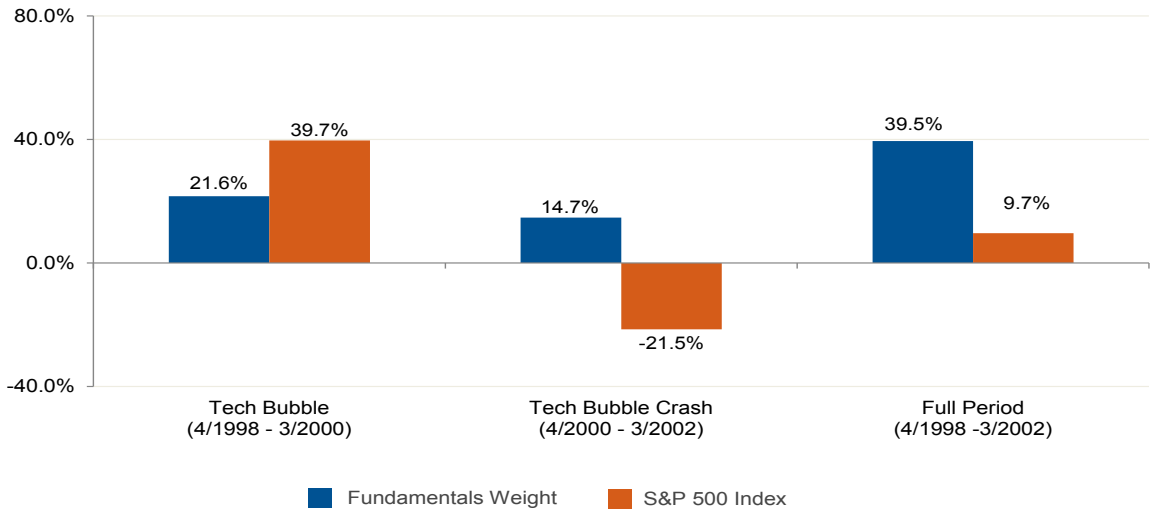
TABLE 4: FACTOR EXPOSURES OF CORE-SATELLITE SMART BETA STRATEGIES, 1967–2013

	MARKET BETA	SIZE (SMB)	VALUE (HML)	MOMENTUM (WML)	LOW VOLATILITY (BAB)
Fundamentals Weight	1.01	−0.05	0.34	−0.10	0.05
Low Volatility Strategy	0.74	−0.03	0.16	−0.08	0.41
Momentum Strategy	1.06	−0.01	0.05	0.39	−0.05
S&P 500 Index	0.99	−0.18	0.02	−0.02	0.00
60% Fundamentals Weight 20% Low Volatility Strategy 20% Momentum Weight	0.97	−0.04	0.24	0.00	0.10
70% Fundamentals Weight 30% Momentum Strategy	1.02	−0.04	0.25	0.05	0.02
70% Fundamentals Weight 30% Low Volatility Strategy	0.93	−0.04	0.28	−0.09	0.15

Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

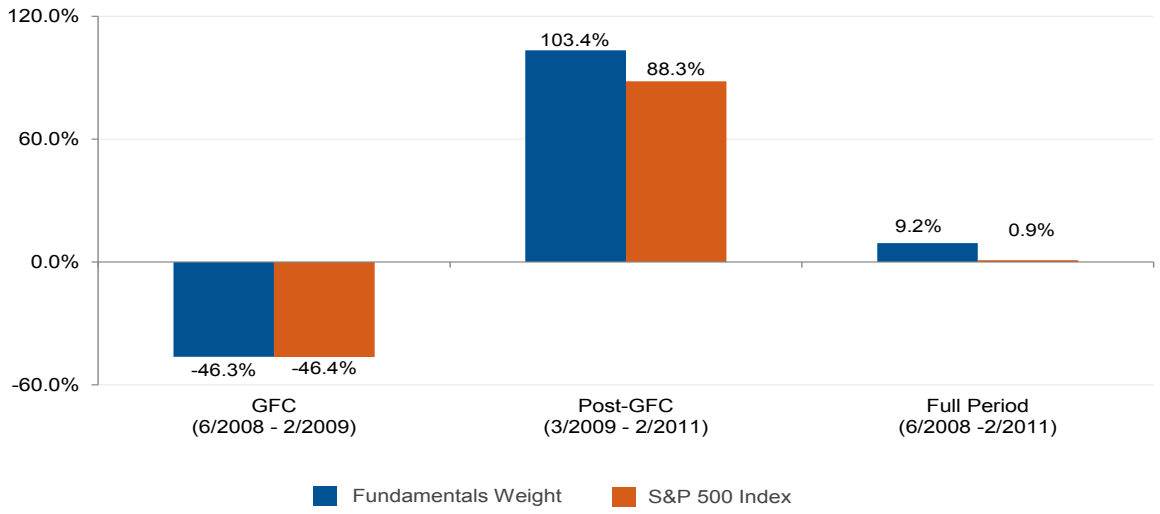
60/20/20 strategy posted a positive return both in the run-up to the tech bubble and in the two years following the crash, and cumulatively outperformed cap-weighting over the full period by approximately 30% (**Figure 4**). Allocating 80% of the portfolio to contrarian strategies led to underperformance during the run-up to the tech bubble, but the portfolio outperformed by 36.2% in the two-year period after the market correction.

FIGURE 4: 60/20/20 CORE-SATELLITE PERFORMANCE IN THE TECHNOLOGY BUBBLE (CUMULATIVE RETURNS)



Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

FIGURE 5: 60/20/20 CORE-SATELLITE PERFORMANCE IN THE GLOBAL FINANCIAL CRISIS (CUMULATIVE RETURNS)



Source: Research Affiliates, based on data from CRSP/Compustat, Factset, and Kenneth French Data Library.

During the global financial crisis, the 60/20/20 strategy exceeded the benchmark return by 8.3% cumulatively over the entire period (see **Figure 5**). The core-satellite smart beta strategy and the cap-weighted benchmark posted virtually identical returns while the crisis was in progress. Although the fundamentally weighted strategy and momentum both underperformed cap-weighting during this period, the downside protection provided by incorporating the low volatility strategy helped to keep overall returns in line with the market. In the two years following the crisis, the 60/20/20 strategy outperfomed by approximately 15%, largely driven by superior performance from fundamentals weighting.

CONCLUSION

Although research shows that smart beta investing can add long-term value over cap-weighted approaches, the methodology employed by any specific smart beta strategy has distinctive effects on the resulting portfolio's risk/return profile as well as its short-term performance in various market environments. Different smart beta strategies access different sources of excess return; consequently, they can be combined in ways that preserve the expected value-added return while reducing aggregate ex ante risk. However, the effect on total risk and benchmark risk depends on which strategies are selected and the proportions in which assets are allocated to each strategy in a core-satellite portfolio structure. In this paper, we examined three smart beta asset allocation policies using a fundamentally weighted strategy as the core, and low volatility and momentum strategies as satellites. These sample portfolios illustrate how a mix of smart beta strategies can potentially help investors achieve their long-term financial objectives.

REFERENCES

Arnott, Robert D., Jason C. Hsu, and Philip Moore. 2005. "Fundamental Indexation." *Financial Analysts Journal*, vol. 61, no. 2 (March/April):83–99.

Arnott, Robert D., Jason Hsu, Vitali Kalesnik, and Phil Tindall. 2013. "The Surprising Alpha From Malkiel's Monkey and Upside-Down Strategies." *Journal of Portfolio Management*, vol. 39, no. 4 (Summer):91–105.

Arnott, Robert D., and Engin Kose. 2014. "What 'Smart Beta' Means to Us." Research Affiliates (August).

Carhart, Mark M. 1997. "On Persistence in Mutual Fund Performance." *Journal of Finance*, vol. 52, no. 1 (March):57–82.

Chow, Tzee-Man, Jason Hsu, Vitali Kalesnik, and Bryce Little. 2011. "A Survey of Alternative Index Strategies." *Financial Analysts Journal*, vol. 67, no. 5 (September/October):37–57.

Chow, Tzee-Man, Jason Hsu, Li-Lan Kuo, and Feifei Li. 2014. "A Study of Low Volatility Portfolio Construction Methods." *Journal of Portfolio Management*, vol. 40, no. 4 (Summer):89–105.

Fama, Eugene F., and Kenneth R. French. 1992."The Cross-Section of Expected Stock Returns." *Journal of Finance*, vol. 47, no. 2 (June):427–465.

———. 1993. "Common Risk Factors in the Returns on Stocks and Bonds." *Journal of Financial Economics*, vol. 33, no. 1 (February):3–56.

Frazzini, Andrea, and Lasse H. Pedersen. 2014. "Betting Against Beta." *Journal of Financial Economics*, vol. 111, no. 1 (January):1–25.

Hsu, Jason, and Feifei Li. 2013. "Low-Volatility Investing." *Journal of Index Investing*, vol. 4, no. 2 (Fall):67–72.

Larson, Ryan. 2013. "Hot Potato: Momentum as an Investment Strategy." Research Affiliates (August).

Li, Feifei, and Philip Lawton. 2014. "True Grit: The Durable Low Volatility Effect." Research Affiliates (August).

Malkiel, Burton G. 2005. "Reflections on the Efficient Market Hypothesis: 30 Years Later." *Financial Review*, vol. 40, no. 1 (February):1–9.

ENDNOTES

1. Arnott and Kose (2014) define equity smart beta as a "category of valuation-indifferent strategies that consciously and deliberately break the link between the price of an asset and its weight in the portfolio, seeking to earn excess returns over the cap-weighted benchmark by no longer weighting assets proportional to their popularity, while retaining most of the positive attributes of passive indexing." They further expand on their definition of smart beta as index strategies with the following traits: they are transparent, rules-based, low cost relative to active management, high capacity and liquidity, and well-diversified.

2. http://www.etftrends.com/2014/04/flows-show-investors-favoring-smart-beta-em-etfs/

3. Market cap-weighted indices, while representative of the overall investment opportunity set, have an inherent flaw. The weights of individual securities are linked to their prices, and cap-weighted indices systematically overweight overvalued securities and underweight undervalued securities. As the price of a security increases, the cap-weighted index favors that security by assigning it an increasingly higher weight in the index. As the price of a security falls, and it becomes more attractive from a valuation perspective, its index weight declines. This results in a return drag of approximately 2% per annum in developed markets, (Arnott, Hsu, and Moore, 2005).

4. Several proposed explanations of the low volatility effect are summarized by Hsu and Li (2013) and Li and Lawton (2014).

5. Volatility is calculated by using daily volatility for the previous five years.

6. While momentum strategies take advantage of a well-known return factor, they do have some drawbacks as investment strategies delivered in a smart beta index construct. The large drawdowns and frequent rebalancing they entail lead to high turnover and transaction costs. Particular attention should be paid to these characteristics when evaluating a smart beta momentum strategy versus active management.

7. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

8. The Sharpe ratio is a measure of performance per unit of risk taken. It is defined as the portfolio return in excess of the risk-free rate divided by the portfolio's standard deviation. This paper uses the 1-month T-bill return from Ken French's data library as the risk-free rate. The information ratio is a measure of performance per unit of tracking error. The information ratio is calculated as the portfolio return in excess of the benchmark return, divided by the portfolio's tracking error against the benchmark.

9. The market beta, size, and value factors were defined by Fama and French (1992, 1993); momentum by Carhart (1997); and low volatility by Frazzini and Pedersen (2014).

10. Cumulative returns for the period April 1, 1998, to March 31, 2000. Source: FactSet.

11. For investors who seek to maximize their total return with the lowest possible volatility, the Sharpe ratio is an appropriate measure, and the low volatility strategy would serve well as the core strategy (see Table 1).

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