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Exotic Beta Revisited

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The authors propose portfolios comprising simple and intuitive risk premiums (exotic betas) that are transparent and cost effective, perform well in different market environments, and are uncorrelated with equities. They are an alternative to traditional portfolios that are defined by their asset class allocations. The authors show that exotic beta investing offers a better risk–return profile than risk parity and hedge fund replication and that adjusting exposures to capture variation in risk premiums further improves performance.

The recent financial crisis has imparted many lessons, a critical one being that the investment landscape is continually evolving and that finding appropriate and diversified sources of return is a constant challenge. Traditional equity market beta is a consistent source of return in the very long run, but it has disappointed over the last decade, particularly relative to its risk, which is as great as ever. For all its simplicity and transparency, the equity risk premium consistently exposes investors to sudden and intense drawdowns. Further, some investors expect the equity risk premium to be lower in the future than it has been historically.[1]

Finding alpha on a consistent basis is especially hard in today's competitive environment. Hedge funds, proprietary traders, and high-frequency algorithms continuously scour the markets in hopes of finding inefficiencies before others can. Successful alpha strategies also tend to attract additional entrants and lead to crowding that can lower returns and, at times, produce liquidity stresses. This trend has accelerated in recent years as technological and information barriers have receded. For institutional investors who rely heavily on skill-based returns to meet their investment objectives, sourcing consistent alpha has become ever more imperative and difficult.

How should investors respond to these challenges? One way is to focus more carefully on the drivers of risk and return in a portfolio, not simply in terms of stocks versus bonds or alpha versus beta but in terms of developing a better and more complete understanding of the underlying risk factors and other portfolio characteristics, including liquidity, leverage, return per unit of risk, expected correlation in stress scenarios, capacity, and sustainability.

Eight years ago, well before the global financial crisis, we began discussing *exotic beta*,[2] a concept that many investors refer to as "alternative risk premiums," "risk factor investing," or "smart beta."[3] We continue to believe this idea is useful to investors, but in this article, we reexamine and update it in the context of the events of the past few years.

Defining and Testing Exotic Beta

We define exotic betas as exposures to risk factors that are uncorrelated with global equity markets and have positive expected returns.[4] We describe them as existing on a continuum—a "spectrum"—between alpha and the ubiquitous equity factor. Like alpha, they are a source of uncorrelated returns to most portfolios, but unlike alpha, they are not opportunities created by very short-term inefficiencies or that require a unique skill to

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exploit. Exotic beta factors are compensated risk factors for which investors earn excess returns. They are transparent, relatively well known, and intuitive. What differentiates exotic beta factors from the equity premium is simply the source of the return.

There is little doubt that the principal risk in global financial markets is equity risk. This risk is pervasive and often embedded in strategies that purport to deliver uncorrelated returns. As we have seen over the past few years, when that dominant risk factor experiences a large negative shock, secondary risk factors can become highly correlated. For example, when liquidity evaporated during the 2007–08 financial crisis, risks that in normal times would be uncorrelated with the market suffered large negative shocks, if only because investors needed to reduce risk and find liquidity. Despite the damage it caused, the crisis demonstrated that this result is not true for all priced risks; for example, pure insurance against hurricanes and earthquakes was not materially affected.[5]

Nonequity risk premiums are not new to portfolio theory. Modern finance has long recognized that there may be many different priced risks in the investment landscape. Whether it is the capital asset pricing model (CAPM), the intertemporal CAPM (I-CAPM), or the arbitrage pricing theory,[6] most asset pricing models posit a specific set of systematic risk factors for which investors demand a risk premium. Unfortunately, except for the CAPM and one factor in the I-CAPM, the theory behind most models offers limited insight to identify those risk factors, and as a consequence, the specification of most exotic betas relies heavily on empirical analysis.

This issue raises the question of whether our exotic betas are decidedly priced risk factors in the equilibrium sense or manifestations of temporary disequilibrium relative to those theoretical models.[7] That question may be relevant because, in theory, return predictabilities that are not associated with systematic risk are arbitraged away and, therefore, should not exist in equilibrium. We prefer not to take a stand on that distinction because the answer relies on empirical evidence that must be collected over extensive periods of time. In this context, we believe our concept of a spectrum of risk premiums best describes the landscape.

Several dimensions distinguish exotic beta from true alpha, including time horizon, capacity, liquidity, transparency, and, perhaps most importantly, a judgment as to whether there is a real or perceived risk that justifies a premium. For all these reasons, the approach that institutional investors take to source returns from alternative risks should be different from that required to source alpha. In addition, because alternative risk premiums are more transparent and more liquid and have more capacity than sources of alpha, the fees associated with them should be lower.

The motivation for including these alternative betas in an investor's portfolio is that combining market beta with exposures to uncorrelated risk factors and alpha from active management results in a more efficient portfolio. This is a key element in what has come to be known as the endowment model of portfolio construction.

In a recent review of modern financial theory and its implications for the Norwegian sovereign wealth fund, Ang, Goetzmann, and Schaefer (2009) emphasized that "opportunities for the fund lie in the potential to seek return through both fixed and time-varying exposure to factor risk" (p. 119).[8] These are precisely the types of opportunities we refer to as exotic betas.

Value investing in equities is a good example of an alternative risk premium. However, most investors think of value investing as a style or as a skill sourced from individual managers—not as a risk factor. Indeed, we can and should separate the risk factor exposure created by a passive tilt toward cheap stocks from the skill that would outperform such a benchmark. Moreover, the risk of an equity portfolio with a value tilt is primarily exposure to equities, not value.

Using tradable equity securities, we can create a liquid pure "value" factor in equities that is hedged to the returns on an equity index. A value manager's skill can then be measured by adjusting his or her performance for exposure to market beta and the equity value factor. Decomposing returns in this way can result in a total portfolio view of exposures to equities, value, and alpha. In addition, because the value factor is directly investable, investors can easily, and at very low cost, adjust the size of the value exposure without adjusting individual manager allocations.

Analytically, this type of decomposition is straightforward. Using position data on their managers and the defined factors, investors can disaggregate their portfolio risks into equity beta, risks from each alternative factor, and a residual that we call "alpha." This analysis may also be performed using observed returns and linear regression techniques. The math is simple, but obtaining the data required and defining the alternative risk factor are far more involved. To our knowledge, there is no third-party risk provider that generates this type of analysis today.

Our Exotic Beta Factors. For the purposes of this article, we define nine liquid alternative risk premiums that we believe are associated with positive expected returns after adjusting for exposure to equity market beta. All the risk premium portfolios are strictly rule based. Most are constructed by ranking assets on the basis of a valuation indicator and mapping those rankings into a long–short (relative value) portfolio. In addition, the risk premiums are hedged to global equities and, therefore, are "exotic" relative to the CAPM.

The list we propose is not meant to be exhaustive, but we believe that these factors capture a broad spectrum of uncorrelated risk premiums available in global markets that may be readily implemented with liquid securities and derivatives.

- *Equity value:* A global market-neutral risk factor designed to gain exposure to scaled-price (book/price and dividend/price) and market-integration (GDP/market capitalization) factors at the country level—long exposure to countries with the most attractive fundamental value relative to price, hedged by short exposure to countries with the least attractive fundamental value relative to price. This premium is consistent with both a behavioral explanation—that it is psychologically difficult to buy markets that have dropped in value—and a liquidity provision (see Asness, Liew, and Stevens 1997).
- *Bond yields:* A GDP-weighted combination of long positions in 10-year global sovereign bonds and a market-neutral portfolio that is long 10-year sovereign bonds in countries with high yields and short 10-year sovereign bonds in countries with low yields. The first risk premium is compensation for shocks to inflation.[9] The market-neutral yield risk premium stems from structural and behavioral barriers to moving capital across borders.
- *Bond slope:* A GDP-weighted, duration-neutral, global carry portfolio and a market-neutral portfolio that is long sovereign term spreads in countries with high spreads and short sovereign term spreads in countries with low spreads. The carry portfolio focuses on 2-year and 10-year bonds globally and is long the asset with the higher yield per unit of duration and short a duration-equivalent position in the other asset. This is a form of carry applied to the term structure of interest rates. Risks to monetary policy shocks, preferred habitat, and institutional constraints motivate this premium. We define the term spread as the 10-year yield minus the 2-year yield. As in the case of the market-neutral yield premium, we believe the premium from the market-neutral term spread portfolio derives from structural and behavioral barriers to moving capital across borders.
- *Commodities:* A basket of long commodity futures and a market-neutral portfolio that is long commodities with the greatest backwardation in futures prices and short those that are the least backwardated. The long commodity basket is 70% weighted to the S&P GSCI and 30% weighted to an equal-risk portfolio of individual commodities. Both portfolios are motivated by the supply–demand imbalance we discuss in the next section (see, for example, Gorton and Rouwenhorst 2006).
- *Real assets:* A market-capitalization-weighted combination of REIT securities. Real assets, such as real estate or timberland, embed both structural and liquidity rationales for a risk-adjusted return over public equities.
- *Currency value:* A market-neutral portfolio that is long high-interest-rate and weak purchasing power parity (PPP) currencies and short low-interest-rate and strong PPP currencies. Structural and behavioral explanations have been proffered for the carry and PPP effects in currencies.[10]
- *Volatility:* A portfolio that is short US equity index volatility through variance swaps and CBOE Volatility Index (VIX) futures. The premium derives from investor fear of market crashes.[11]
- *Credit:* A basket of corporate indexed credit default swaps—20% US investment grade, 10% European investment grade, 55% US high yield, and 5% European high yield. Similar to the volatility exotic beta strategy, investors pay high insurance premiums for extreme and unpleasant events.
- *Catastrophe bonds:* A market-capitalization-weighted basket of bonds linked to catastrophic reinsurance risk. Structural barriers restrict the free flow of risk capital into and out of the insurance industry, and homeowners are willing to pay high premiums to insure what is in many cases their largest single risk.

Sources of Compensated Risk Premiums. In order to understand why—and to recognize when—the premium embedded in an alternative risk factor has disappeared, we must understand why it exists in the first place. We believe behavioral biases offer a reasonable explanation for most risk premiums. Most investors do not behave in the rational manner assumed by many theoretical models.

Most asset pricing models assume that rational investors care about the volatility of their total wealth. As a consequence, the volatility of individual assets does not matter, and in equilibrium, investors earn a risk premium for the covariance of their portfolio returns with a number of risk factors, not for volatility.

For example, Sharpe's (1964) capital asset pricing model implies that the only covariance that deserves a risk premium is the covariance with the market portfolio. The intuition behind this result is that assets that perform poorly when global markets perform poorly do not offer a hedge for those difficult periods. Therefore, investors demand a premium in good times to compensate for the expected losses in bad times, which is why a portfolio that is long equities deserves a risk premium, even in equilibrium. This covariance is the source of the equity risk premium. Interestingly, although a short equity index position is just as volatile as a long position, such a position does not earn a premium; instead, it imposes an expected cost on an investor's portfolio. Because a short position pays off in bad states of nature, it acts as a form of insurance, and as a consequence, its expected return is significantly negative. With commodities, there is no obvious covariance with good or bad times. Because this covariance is generally close to zero and sometimes negative, no significant risk premium is implied by most theoretical models that assume rational behavior, even though commodities are quite volatile.

Covariance matters in the simplest version of the theory. However, more complex models can be designed. For example, if global markets are at least mildly segmented, then investors may require compensation for exposure to country-specific volatility, in addition to covariance with a global market index. In this case, an alternative risk premium will exist.

Another source of return is demand for liquidity. For example, some have argued that much of the historical return from exposure to commodities—and commodity futures in particular—comes from providing liquidity to the hedging needs of commodity producers. We agree. But if liquidity supply is the source of return, then it is important to monitor relative supply and demand. In commodity markets, the slope of the futures price curve—whether a given commodity is backwardated (downward sloping) or in contango (upward sloping)—is a clear indicator of the relative supply and demand for hedging in that market. Futures markets that are backwardated tend to reflect excess demand for short futures contracts to hedge long positions. In recent years, as investors have moved in to supply liquidity, the expected returns—as indicated by the more recent contango in the futures curves—have been much less positive or, indeed, potentially negative.

A third reason for the existence of premiums on exotic beta factors is that their returns have fat tails on the downside and investors expect compensation to accept the risk of those unlikely but extreme events. Exposure to natural catastrophe risk is an example: The left-tailed distribution of returns is undesirable to many, even if it has a diversifying effect on their portfolios. Behavioral biases exaggerate those risk premiums as investors clamor for tail-risk protection immediately after extreme events.

Another behaviorally motivated explanation for some of the premiums is investor aversion to assets that have dropped in value and, conversely, the attraction to assets that have risen. It takes a strong conviction to become a contrarian—to sell assets that have gone up significantly and buy assets that have disappointed. In our opinion, this bias accounts for much of the persistence in value risk premiums in most asset classes.

Structural impediments may also drive these apparent dislocations. For example, many investors in bonds are limited by either regulations or preferences to invest in bonds of a specific term or rating. Such impediments may explain the large difference in spreads between bonds of similar risk that are on opposite sides of the investment-grade cutoff. Similarly, the strongly inverted long end of the UK government bond curve is understood to be driven by insurance company positions mandated by regulators. As mentioned earlier, the home bias in geographical diversification is yet another regularity that drives structural imbalances.

Some have suggested that leverage creates the value in alternative risk premiums. That argument is incorrect. Leverage is a useful tool, but it does not create value in and of itself: It can be used to increase the overall risk and return for a given level of capital, but it will not affect the expected return per unit of risk.[12] Leverage is helpful if it relaxes constraints that otherwise prevent a portfolio from achieving a desired set of risk allocations, but it does not create the opportunities. Modern portfolio theory certainly never assumed those constraints, so there is nothing "postmodern" about these concepts.[13] Those opportunities exist if markets work differently from the equilibrium implied by the simplest version of the CAPM.

In addition, even if leverage may sometimes help relax some portfolio constraints, it may also lead to liquidity needs at the worst possible time, and thus, it needs to be carefully managed.

Data and Backtest Simulations. We obtain data primarily from Bloomberg and Datastream. Our index data include the Datastream capitalization-weighted equity country indices, the MSCI All Country World Index (ACWI) and Emerging Markets Investable Market Index (IMI), the Citibank government bond indices for US and world sovereign bonds, the BofA Merrill Lynch indices of inflation-linked bonds, the Barclays indices of corporate bonds and the Global Aggregate index hedged to currencies, the J.P. Morgan Emerging Market Bond Index global composite, and the S&P GSCI. For our backtest simulations, we use tradable instruments, including the Bloomberg generic futures series for all futures contracts, Bloomberg generic forward returns on foreign currencies, the on-the-run CDX and iTraxx index swap prices from Markit, and REIT prices from the Vanguard REIT Index. For 2010 and beyond, S&P 500 Index variance swap prices are from Credit Suisse; pre-2010 prices are derived from historical one-month implied volatilities across generic strike levels.

All the returns on the underlying markets are calculated in excess of the risk-free rate, as proxied by the one-month US LIBOR, and all the portfolios are constructed using those excess returns. For derivative instruments, such as futures, forwards, and swaps, the returns are by definition net of return on collateral, so there is no need to subtract the risk-free return. We make no attempt to re-add the risk-free rate to estimate a total return and instead report only excess returns. When comparing our results with those of hedge funds, we use the monthly asset-weighted HFRI index from Hedge Fund Research. Most of our data are daily, and we use that frequency to estimate risk and in some cases to simulate hedging and rebalancing strategies. However, for ease and consistency of analysis, all the results reported in this article are based on monthly returns. We use data from as far back as they are available and in some cases splice several series together to create a more complete historical record. For ease of comparison across the various analyses in this article, we consistently use the 23-year period from January 1990 to December 2012. Appendix A provides a comprehensive listing of our data.

We begin by creating backtest simulations for each exotic beta factor. In the first step, we create a "theoretical" exotic beta factor portfolio with zero forecasted equity beta that holds indices and trades without costs or constraints. We require a three-year minimum history for risk estimates. In the second step, we construct "implementable" exotic beta return series that track the theoretical exotic beta factors using only tradable instruments, our best estimates of real-world transaction costs and position limits, and a moderate aversion to tracking error from the theoretical series.[14] For purposes of our backtest simulations throughout this article, we assume a portfolio size of $1 billion, although the evidence is not meaningfully different for simulations with a portfolio size of $10 billion owing to the high liquidity of markets used in the strategy.

Every theoretical exotic beta factor is rebalanced daily to have an *ex ante* annualized volatility of 10% and an *ex ante* ACWI beta of zero.[15] In addition, we use the forecasted correlation matrix of exotic beta returns to produce an "equal-risk portfolio" combination of these factors for which the targeted annualized volatility is again 10% and the standalone volatility of each exotic beta in the portfolio is the same for all exotic betas. Like the theoretical exotic beta factors, each individual implementable exotic beta strategy is rebalanced daily. The equal-risk portfolio of exotic beta factors is rebalanced monthly.

To illustrate our approach to the implementable exotic beta factors, we consider the equity value exotic beta portfolio as of 31 December 2011 and show the details of the building process in **Table 1**. We begin by ranking the equity indices on the basis of the average of their book/price, dividend/price, and GDP/market capitalization ranks. To make the analysis easily implementable, for each value measure, we use the most recent reported data up to one full day prior to portfolio construction. Next, we create a long–short portfolio of those countries for which the weights are linear in rank, the weights sum to zero, and the long (short) positions sum to 100% (–100%). Then, we add

Table 1. Exotic Beta Portfolio Construction for Equity Value

Country	Book/ Price	Dividend Yield	GDP/ Market Cap	Overall Rank	Linear Rank Weight	Equity Hedge	Linear Rank + Hedge	Rescaled to 10% Volatility	Tracking Portfolio
Australia	0.48	4.0%	1.3	8	6.6%	0.0%	6.6%	9.0%	14.4%
Austria	0.76	2.2	4.7	14	2.2	0.0	2.2	3.0	0.0
Belgium	0.78	2.0	2.4	15	1.5	0.0	1.5	2.0	0.0
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Taiwan	0.47	3.3	1.6	16	0.7	0.0	0.7	1.0	2.2
UK	0.59	2.9	0.9	13	2.9	–2.8	0.2	0.2	–2.5
US	0.44	1.8	1.1	31	–10.3	–13.8	–24.1	–32.9	–32.9
Total				33	0.0%	–27.6%	–27.6%	–37.7%	–26.5%
Volatility					8.2	3.8	7.4	10.0	4.0[a]

[a]For the tracking portfolio, we report the tracking error relative to its target.

an equity hedge portfolio of liquid markets to neutralize the strategy's *ex ante* ACWI beta and rescale to an *ex ante* volatility of 10%.[16] Finally, we create a tracking portfolio of equity index futures contracts that best tracks this resulting theoretical portfolio through an optimization that is averse to tracking error and that explicitly charges for transaction costs. In the example, the implementable portfolio results in a tracking error to the theoretical portfolio of 4.0%. This process is repeated daily and results in a fully implementable strategy that attempts to replicate the theoretically optimal exotic beta inclusive of real-world transaction costs.

Table 2 illustrates the degree to which our implementable exotic beta portfolios track their theoretical equivalents. Not surprisingly, the implementable strategies earn lower Sharpe ratios owing to transaction costs and real-world constraints that limit our ability to perfectly track the theoretical portfolios. This loss is generally small, however, and most of the individual exotic beta portfolios have low tracking error to the theoretically optimal risk premiums. The exception is the exotic beta portfolio for catastrophe bonds, which tracks its theoretical counterpart poorly owing to its high transaction costs and substantial changes in forecasted volatility over time.

We also report the statistics on an "equal-risk portfolio" for which the exotic beta strategies are all sized to have the same *ex ante* volatility level and the overall portfolio has an *ex ante* volatility of 10%. This portfolio is rebalanced monthly. The total annual transaction cost to implement the equal-risk exotic beta strategy is 2.5%, reflecting the relatively high liquidity and low transaction costs in the underlying markets traded. The implementable version of this portfolio also tracks the theoretical version quite closely, with a moderate information ratio (IR) reduction from 1.74 to 1.41 and a low tracking error of 1.8%.

As stated earlier, each exotic beta strategy targets zero correlation with equities and constant volatility. In practice, it is interesting to learn how big those equity hedges are. **Table 3** summarizes the distribution of estimated monthly equity betas for each exotic beta strategy before hedging as well as for an

Table 2. Comparison of Theoretical and Implementable Exotic Beta Strategies

	Sharpe Ratio			
	Theoretical	Implementable	Correlation	Tracking Error
Exotic beta strategy				
Equity value	0.65	0.57	0.93	4.1%
Bond yields	0.67	0.45	1.00	1.0
Bond slope	0.75	0.31	0.95	3.4
Commodities	0.55	0.49	0.99	1.5
Real assets	0.53	0.43	1.00	1.0
Currency value	1.27	1.16	1.00	0.3
Volatility	1.02	0.99	1.00	0.2
Credit	0.19	0.13	1.00	0.6
Catastrophe bonds	1.42	1.03	0.68	8.5
Equal-risk portfolio	1.74	1.41	0.99	1.8%

Table 3. Distribution of Equity Beta Estimates on Unhedged Exotic Beta Strategies

	ACWI Beta Estimate			
	Average	Standard Deviation	Minimum	Maximum
Exotic beta strategy				
Equity value	–0.05	0.27	–0.51	0.77
Bond yields	0.01	0.35	–0.53	1.00
Bond slope	–0.10	0.13	–0.43	0.37
Commodities	0.09	0.18	–0.32	0.57
Real assets	0.49	0.18	0.13	0.97
Currency value	0.25	0.26	–0.28	0.96
Volatility	0.61	0.25	0.15	1.35
Credit	0.51	0.21	0.19	1.16
Catastrophe bonds	0.07	0.07	–0.07	0.22
Equal-risk portfolio	0.24	0.12	0.02	0.52

equal-risk portfolio of the exotic beta strategies. We found that the magnitude and direction of the equity hedges vary across risk premiums and, in several instances, with time, which illustrates the importance of dynamic adjustments. Not surprisingly, the highest average betas are in real assets, volatility, and credit. On average, the estimated beta of the equal-risk portfolio before hedging is 0.24, with a range of 0.02–0.52.

Risk Premium Summary Statistics. In **Table 4**, we report the excess return statistics of our implementable exotic beta strategies targeting 10% volatility.[17] Except for volatility and catastrophe bonds, all the data begin in January 1990, and the sample ends in December 2012. We report realized volatility, equity correlation, average excess returns, Sharpe ratios, and maximum peak-to-trough drawdowns using monthly observations. Because our forecasts of volatility and equity beta are not perfect, the realized volatility and beta of these portfolios are not precisely 10% and 0, respectively. For comparison purposes, we report the excess return statistics of an equal-risk strategy targeting 10% volatility, the MSCI ACWI, and a strategy targeting 10% *ex ante* risk in the ACWI.

We evaluated the time series of three-year rolling volatility of our constant-target-risk exotic beta strategies (these results are not reported in this article). For most of our exotic beta strategies, the risk estimates over three-year windows are fairly stable, indicating that our risk forecasting models do a reasonable job of scaling positions to achieve a constant risk.[18] Forecasting volatility is more challenging for risk premiums in volatility, credit, and real assets. In the case of volatility and credit, this is due to the nonlinear payoff structure in the underlying securities; in essence, these markets have modest volatility and low correlations with equities under most market conditions but occasionally display large and sudden spikes during major market events.[19] For real assets, risk forecasts are hampered by the high and fairly unstable correlation of REITs with the global equity hedge.

The historical distributions of the exotic beta strategies are quite attractive when compared with a passive exposure to equities; most risk premiums exhibit higher Sharpe ratios with similar maximum drawdowns. Because the exotic beta strategies hedge out expected equity risk, even a low Sharpe ratio can be beneficial in terms of expected IR when combined with equities in a portfolio. The level of the Sharpe ratios in many cases is quite high—in our opinion, higher than one should expect in the future. Also note the different dates when each exotic beta strategy reaches its maximum drawdown, indicating significant diversification benefits in left-tail risk and limited correlation with equity drawdowns.

Table 4 also reports the statistics on the equal-risk combination of exotic betas already mentioned. This portfolio has a small correlation with equities and generates performance per unit of risk more than five times greater than that of a constant-risk global equity portfolio with similar volatility. Also noteworthy is the diminished maximum drawdown relative to global equities: 21% for the exotic beta portfolio versus 35% for the constant-risk ACWI. For comparison, we also report performance for the raw ACWI, which realized a maximum drawdown of 57% over our sample period. The much higher performance of the equal-risk exotic beta strategy can be attributed to equity beta hedging as well as the very low correlation between our alternative risk premiums, as documented in **Table 5**. Another benefit of these characteristics is a very stable risk

Table 4. Summary Statistics on Exotic Beta Strategies

	First Month	Volatility	Correlation with ACWI	Average Annual Excess Return	Sharpe Ratio	Maximum Drawdown	Date of Peak Drawdown
Exotic beta strategy							
Equity value	Jan/90	10.4%	0.07	6.0%	0.57	–38%	May/12
Bond yields	Jan/90	10.3	–0.01	4.7	0.45	–25	Jun/08
Bond slope	Jan/90	9.9	–0.03	3.1	0.31	–37	Nov/06
Commodities	Jan/90	10.3	0.10	5.0	0.49	–35	Jan/99
Real assets	Jan/90	11.5	0.06	4.9	0.43	–37	Feb/00
Currency value	Jan/90	11.3	0.03	13.1	1.16	–16	Nov/07
Volatility	Sep/95	14.2	0.27	14.0	0.99	–36	Nov/08
Credit	Nov/90	12.2	0.23	1.6	0.13	–55	Feb/08
Catastrophe bonds	Jan/03	10.7	0.17	11.0	1.03	–27	Nov/05
Equal-risk portfolio	Jan/90	10.4%	0.21	14.6%	1.41	–21%	Jan/99
ACWI	Jan/90	16.3	1.00	3.5	0.21	–57	Feb/09
Constant-risk ACWI	Jan/90	11.0	1.00	2.7	0.25	–35	Sep/02

Table 5. Exotic Beta Return Correlations

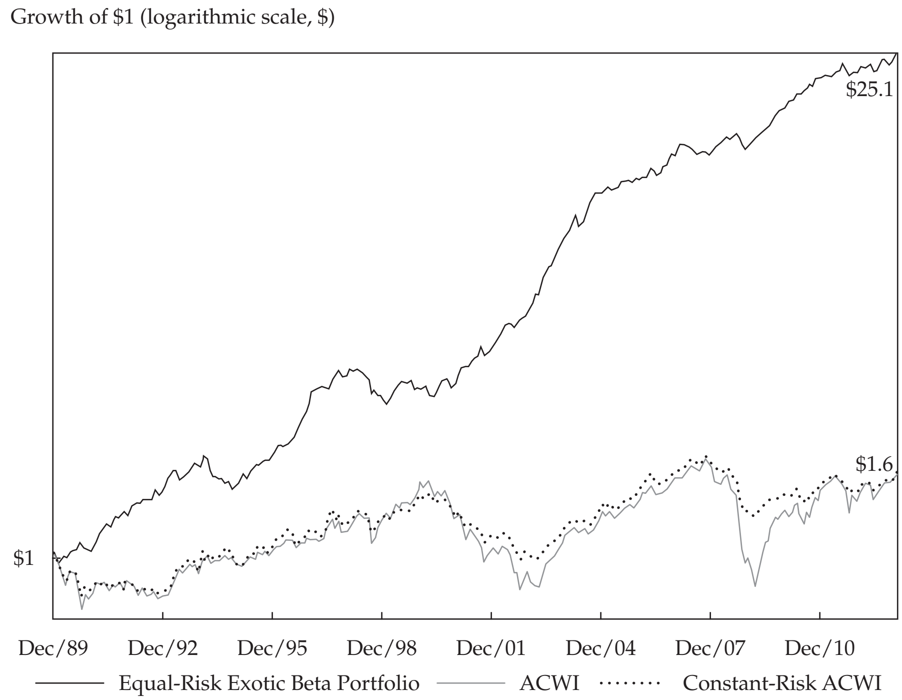
	Equity Value	Bond Yield	Bond Slope	Commodities	Real Assets	Currency Yield	Volatility	Credit	Catastrophe Bonds
Equity value	1.00								
Bond yields	0.10	1.00							
Bond slope	–0.02	–0.20	1.00						
Commodities	–0.01	–0.01	–0.03	1.00					
Real assets	0.04	0.12	0.00	0.00	1.00				
Currency value	0.13	0.01	–0.01	0.08	0.09	1.00			
Volatility	0.08	–0.02	–0.11	0.10	0.08	0.17	1.00		
Credit	0.06	0.01	0.03	0.00	0.21	0.14	0.18	1.00	
Catastrophe bonds	0.02	0.18	0.06	0.12	0.01	–0.14	0.17	–0.06	1.00

posture. The rolling three-year volatility of our equal-risk exotic beta strategy has a tight distribution, reaching a maximum of 12.4% in April 1995. Three-year correlations with the ACWI vary moderately, with a standard deviation of 0.16 and a maximum value of 0.51 in June 2004.

Although we have removed most of the correlation with equities in our exotic betas, there is no guarantee that the correlations between the exotic beta strategies themselves are low, at least in theory. In practice, our estimates indicate that there are differences in cross-correlations between risk premiums, but the average cross-correlation for the 10 exotic beta strategies is only 0.04. The complete set of correlations is shown in Table 5. For the full 23-year sample, the standard error of the correlation estimates is approximately 0.06, and only 10 of the 36 correlation estimates are more than two standard errors away from zero. The correlations change over the sample period, but the range is not particularly wide. Using three-year windows, the average cross-correlation reaches a minimum of –0.04 in October 1997 and a maximum of 0.10 in October 1994 and is 0.02 at the end of December 2008. The largest three-year cross-correlation pairs are also not extreme: Less than 7% of the 36-month pairwise correlations are greater (in absolute value) than 0.35, and only 0.5% are greater than 0.50.

Figure 1 displays the cumulative excess return for the equal-risk exotic beta portfolio compared with the ACWI and a 10% constant-risk exposure to the ACWI. The end-of-period wealth from the exotic beta portfolio is 15 times greater than that of either

Figure 1. Cumulative Excess Return on Global Equities and Equal-Risk Exotic Beta Portfolio



Note: The ending values are $25.1 for exotic beta, $1.64 for ACWI, and $1.62 for constant-risk ACWI.

equity portfolio. In addition, it is easy to visualize how unrelated the equal-risk exotic beta portfolio is to either method of attaining equity exposure. The two noticeable drawdowns in exotic beta occur in 1994, during the massive global run-up in sovereign bond yields, and in the late 1990s, when Long-Term Capital Management unwound its positions and the internet frenzy was near its peak.

It is important to note that to achieve the targeted risk level of 10% in the equal-risk exotic beta portfolio, the strategy requires an average leverage of 2.8 times for both the long and the short sides. The leverage is predominantly embedded in the derivatives themselves and does not come from outright borrowing to invest in underlying securities. Given the liquid nature of the assets considered in this simulation, this magnitude of leverage is easily supported and, on the basis of recent margin rates, results in an average unencumbered cash level for the portfolio of about 70% above collateral and margin requirements. In addition to the use of leverage, the exotic beta strategy turns over 100% of the portfolio every 2.5 months, so it requires a considerable amount of trading.[20]

Comparing Exotic Beta with Other Alternative Risk Premium Approaches

In the broader category of alternative risk premium strategies, the two most common approaches are "risk parity" and "hedge fund replication." In this section, we explain those approaches and compare them with our notion of exotic beta.

Risk Parity. The key idea behind risk parity is to normalize various asset classes to a constant risk and then equally weight them in a portfolio. For example, consider the 10 asset classes shown in **Table 6**, which are the typical components of most institutional benchmarks.[21] For each asset class, we report the results from a strategy that adjusts exposures on a monthly basis to target 10% annualized volatility, accounting for estimated transaction costs. We also report the native volatility for each series.

The Sharpe ratios vary around a level similar to that of global equities, 0.25, as shown in Table 4. Also note that the maximum drawdown in each asset class is related to the correlation between that asset class and equities: The more correlated asset classes have larger drawdowns.

Correlations between asset classes, shown in **Table 7**, are also fairly high, with an average of 0.23. Notable exceptions are the very small correlations between equities and bonds and the near-zero correlations between commodities and all other asset classes.

Unlike the exotic beta factors, the correlations of the constant-target-volatility assets vary considerably over the sample period. Using rolling three-year windows as before, the average pairwise correlation ranges from 0.12 for September 2005 to 0.36 for July 2011 and is 0.24 for December 2008. The maximum absolute three-year pairwise correlation is 0.97, and more than 25% of the estimated absolute correlations are greater than 0.5. These correlations compare poorly with those for the exotic betas, for which only 0.5% of the estimates are above 0.5. Of course, the much higher average pairwise correlation is due to the fact that the risk parity asset classes are highly correlated subsets of global equities and global bonds.

The risk parity portfolio (bottom row of Table 6) represents a monthly rebalanced strategy with equal volatility for each asset class and a targeted 10% overall volatility.[22] As before with the equal-risk exotic beta strategy, the monthly rebalance uses the estimated conditional correlations between asset classes

Table 6. Asset Class and Risk Parity Portfolio Summary Statistics

	Start Date	Native Annualized Volatility	Realized Volatility of Constant-Risk Strategy	Sharpe Ratio	Maximum Drawdown (10% Target Volatility)	Correlation with ACWI
Asset class						
Developed int'l. equities	Jan/90	18.4%	10.7%	0.09	–39%	0.96
Emerging market equities	Jul/94	24.5	11.9	0.16	–46	0.83
US equities	Jan/90	15.3	9.8	0.48	–32	0.83
Developed int'l. bonds	Feb/93	3.1	10.4	0.70	–22	–0.07
US bonds	Jan/90	3.7	10.1	0.79	–21	0.09
Emerging market bonds	Feb/94	13.4	13.4	0.47	–41	0.60
High-yield bonds	Sep/98	9.9	14.0	–0.03	–60	0.46
Inflation-linked bonds	Feb/98	6.4	10.0	0.42	–29	–0.26
Real estate	Jan/90	20.7	10.9	0.64	–30	0.48
Commodities	Jan/90	21.5	10.9	0.16	–36	0.21
Risk parity portfolio	Jan/90		12.6%	0.63	–38%	0.77

Table 7. Asset Class Correlations

	Developed Int'l. Equities	Emerging Market Equities	US Equities	Developed Int'l. Bonds	US Bonds	Emerging Market Bonds	High-Yield Bonds	Inflation-Linked Bonds	Real Estate	Commodities
Developed int'l. equities	1.00									
Emerging market equities	0.74	1.00								
US equities	0.74	0.85	1.00							
Developed int'l. bonds	–0.12	–0.10	–0.16	1.00						
US bonds	0.12	0.07	–0.05	0.59	1.00					
Emerging market bonds	0.54	0.53	0.65	0.12	0.33	1.00				
High-yield bonds	0.49	0.45	0.51	–0.23	0.00	0.46	1.00			
Inflation-linked bonds	–0.19	–0.33	–0.23	0.36	0.32	0.07	0.10	1.00		
Real estate	0.60	0.52	0.49	–0.06	0.17	0.39	0.42	–0.09	1.00	
Commodities	0.19	0.27	0.36	–0.12	–0.01	0.19	0.12	–0.23	0.10	1.00

in order to deliver an *ex ante* volatility of 10%. The realized volatility in the strategy is 12.6%, which indicates that our models underestimate risk by approximately 25% on average. The variability in realized three-year volatility is also quite high, reaching 17.1% in October 2008. Much of this variability is driven by the relatively high correlation with equities of 0.77. The three-year rolling correlation is also quite variable, ranging from 0.44 to 0.92 over our sample period.

Naturally, this strategy requires a modest amount of leverage, averaging about 1.80 times on the long side over the 23-year history. Owing to the regular rebalancing to equal risk, the strategy turns over 100% of the portfolio every 9.6 months, resulting in estimated average annual transaction costs of approximately 0.2%.[23] The strategy results in better historical risk and return characteristics than those of a prototypical traditional institutional allocation, in part because of the relatively higher allocations to bonds during a period when yields continuously declined.

The risk parity portfolio is often considered an "alternative beta" portfolio and has gained a significant amount of traction among institutional investors. Therefore, we will use it as a benchmark for comparison with our notion of exotic beta. Note, however, that exotic beta is built around risk premiums, not asset classes, and the constituent strategies in exotic beta are orthogonalized to market risk, whereas for risk parity, they are not. These two features are key differences between the two approaches. We emphasize that risk parity's constraint to hold only (levered) long positions is a significant limitation relative to exotic beta strategies, which generally comprise long–short portfolios.

One key concept in portfolio construction is the expected return on each component of the portfolio. We use "implied views" to back out expected returns.[24] The implied views of a portfolio are the expected excess returns for which the holdings represent a mean–variance-optimal portfolio relative to estimated correlations and volatilities. From a mathematical perspective, obtaining the implied views is a simple exercise that basically amounts to running the portfolio optimization in reverse.[25]

To illustrate this concept, consider the risk parity portfolio we have already described. Using the historical covariance of these asset classes, we can back out the implied expected returns for each asset class that would make that portfolio optimal. As shown in **Table 8**, the implied expected returns and Sharpe ratios across asset classes are not equal because pairwise correlations are different. For comparative purposes, we also report the risk premiums implied by the CAPM, using full-history estimates of equity betas and the equity risk premium.

Table 8. Implied Asset Class Risk Premiums from Risk Parity Portfolio

Asset Class	Implied Risk Premium	Implied Sharpe Ratio	CAPM Risk Premium
Developed int'l. equities	2.6%	0.14	2.6%
Emerging market equities	6.0	0.25	2.2
US equities	5.6	0.37	2.3
Developed int'l. bonds	0.3	0.09	–0.2
US bonds	0.9	0.25	0.2
Emerging market bonds	6.0	0.45	1.6
High-yield bonds	3.8	0.38	1.2
Inflation-linked bonds	1.0	0.16	–0.7
Real estate	10.1	0.49	1.3
Commodities	5.7	0.27	0.6

A common misconception is that the risk parity portfolio either implies nothing about expected returns or assumes expected returns are equal, but as the previous example illustrates, this is not true. In fact, an equal-risk combination of underlying asset classes is optimal only under very different expected returns. The low implied Sharpe ratios for developed international bonds, inflation-linked bonds, and commodities are driven primarily by the fact that these asset classes have low correlations with the other asset classes, so it is still optimal to hold them with an equal weight, even with a relatively low expected return per unit of risk. It is also interesting to contrast the asset class implied risk premiums to the CAPM risk premium estimates, which are even smaller. Real estate and commodities stand out on this dimension; both exhibit a low correlation with global equities, so their CAPM expected returns are far lower than a risk parity portfolio would imply.

As described previously, we can also define an equal-risk combination of our exotic beta strategies and evaluate its implied views.[26] The evidence, reported in **Table 9**, confirms how dispersed the expected returns can be across risk premiums. The implied risk premium on bond slope is considerably lower than any other risk premium because of its unusually low correlations with the other exotic beta factors. In contrast, credit, real assets, and volatility imply relatively higher Sharpe ratios owing to their higher correlations with the other premiums.

Table 9. Implied Risk Premiums from Equal-Risk Combination of Exotic Betas

Exotic Beta Strategy	Implied Risk Premium	Implied Sharpe Ratio
Equity value	5.7%	0.57
Bond yields	4.8	0.48
Bond slope	2.9	0.29
Commodities	5.0	0.50
Real assets	6.3	0.63
Currency value	6.0	0.60
Volatility	6.7	0.67
Credit	6.4	0.64
Catastrophe bonds	5.5	0.55

It is also interesting to contrast the dispersion in implied Sharpe ratios for the risk parity asset classes and the equal-risk exotic beta strategies. The cross-sectional standard deviation of the asset class implied Sharpe ratios is 47% of the average. For the exotic beta strategies, the comparative figure is just 20%. The relatively larger cross-sectional variation in asset class correlations—almost certainly due to the higher equity content in risk parity—results in equal-risk combinations of asset classes, which, in turn, imply greater differences in expected returns than do equal-risk combinations of exotic beta strategies.

Notwithstanding the difference in cross-sectional dispersion, the implied risk premiums from an equal-risk portfolio of exotic betas are probably no more sensible than the implied risk premiums from the risk parity portfolio of asset classes. In both analyses, we assume that correlations are constant over the entire sample period and, owing to different starting dates for some series, not all correlations are estimated over the same period. Although this approach has merit, we prefer to forecast the risk premiums explicitly and construct an optimal portfolio accordingly, an exercise we perform later in this article.

Hedge Fund Replication. The second common approach to alternative risk premiums is hedge fund replication. In this approach, one attempts to mimic the returns on a hedge fund strategy or index using a simple portfolio of tradable instruments. For example, a risk arbitrage hedge fund strategy can be approximated by buying the stocks of all the announced acquisition targets and shorting an equivalent amount of the proposed acquiring company's stock. As Mitchell and Pulvino (2001) showed, this simple replication strategy delivers most of the performance of the merger arbitrage hedge fund index, even with the survivorship bias in the index.

One method of tracking the broader hedge fund index returns is to measure the index's market risk exposures over time and then attempt to track them with a much cheaper package of derivatives that approximates the returns from those exposures. Although this method may be a relatively inexpensive way to approximate many of the risk factors embedded in actively managed portfolios, these exposures are imprecisely estimated on the basis of returns that are both lagged and infrequently observed, and therefore, this approach fails to capture the true dynamics of the factors. The Goldman Sachs Absolute Return Tracker (ART) is an example of this approach. It remains to be seen whether these strategies deliver returns similar to those of the hedge fund index.[27]

More generally, many have noted in recent years that much of the return from hedge funds can be attributed to time-varying exposures to well-known risk factors, many of which are the same risks that we refer to as exotic betas.[28] We assess whether our risk factors explain hedge funds by regressing the monthly excess returns of the HFRI hedge fund index on the contemporaneous monthly excess returns of the MSCI ACWI and our individual exotic beta factors. Given Asness, Krail, and Liew's (2001) findings of monthly autocorrelation in returns, we also include the ACWI lagged by one month as prescribed in Scholes and Williams (1977) to address potential nonsynchroneity in valuation. To account for changes in the composition of the index as well as time-varying factor exposure by managers, in our analysis, we run these estimates over rolling five-year windows.

The results of this analysis suggest that our exotic beta factors are not a large component of the hedge fund index's returns in excess of its equity exposure. In **Table 10**, we report the results for the 18 years from January 1995 to December 2012, a period chosen so as to eliminate much of the survivorship and look-ahead bias in the early hedge fund data.[29] Hedge funds returned 5.49% above cash over that period, but when taking into account their equity beta, the alpha is a much smaller 2.28%. When compared with the broader model portfolio that includes both global equities and exotic betas, the estimated alpha further declines to 0.61%. The exotic beta risk factors of commodities, currency value, and credit are all statistically significant in explaining hedge fund performance. Unfortunately, they account for only a 4.2% increase in R^2. Moreover, our exotic beta factors do not incorporate any management fees, so in practice, the actual alpha of hedge funds relative to equities and our exotic beta factors would be somewhat higher.

This analysis demonstrates that the index of hedge funds does incorporate some exposure to a few of our exotic betas, but it is probably suboptimal to source exotic betas in this way. As illustrated, the primary risk factor exposure in the hedge fund index is simply equity markets. Although this is well known and was confirmed in the 2007–08 financial

Table 10. Linear Regression of HFRI Hedge Fund Index on Global Equities and Exotic Beta Factors, January 1995–December 2012

		Equity Beta		Equity + Exotic Beta	
	HFRI	Regression Coefficient	t-Statistic	Regression Coefficient	t-Statistic
Explanatory variable					
Annualized return/alpha	5.49%	2.28%	2.36	0.61%	0.60
ACWI		0.36	20.90	0.33	19.80
ACWI lagged by one month		0.06	3.62	0.04	2.71
Commodities				0.09	3.61
Equity value				0.05	1.98
Bond slope				0.03	1.00
Bond yields				–0.04	–1.59
Currency value				0.06	2.47
Real assets				–0.01	–0.59
Credit				0.05	2.48
Volatility				0.03	1.38
Catastrophe bonds				0.02	0.63
Adjusted R^2		69.0%		73.2%	

crisis, it bears repeating. There is no good reason for investors to source a significant amount of equity market beta from hedge funds, especially given performance fees associated with such long-term equity exposure. In addition, many of the risk factors in hedge funds—especially equity market beta—are easily and more cheaply sourced directly in the markets or through the use of derivative instruments.

We think it is fair to characterize hedge funds as providing considerable exposure to equity market risk and to alternative risk premiums, along with exposure to alpha. Exposures to exotic beta within actively managed portfolios of managers do not pose a problem in and of themselves, but investors are advised to measure and monitor these factor exposures directly. The hurdles we have mentioned suggest that there are better ways to access exotic betas than through hedge funds or hedge fund replication strategies. Alternative risk premium products have lower fees and more transparency than hedge funds have, and we believe they make more sense than hedge fund replication strategies make when an investor is looking to source exotic betas.

Comparing Exotic Beta with Risk Parity, Hedge Funds, and Traditional Asset Classes. As previously noted, the exotic beta strategy offers a different perspective in the quest for alternative risk premiums compared with such popular approaches as risk parity and hedge fund replication. To quantify the marginal benefit of exotic beta over those two alternatives, we use a standard performance measurement technique. We regress the excess returns of exotic beta on the risk parity portfolio and hedge funds. The beta in each regression indicates how related exotic beta returns are to returns on the respective strategy, whereas the intercept reveals how much more alpha the exotic beta portfolio delivers relative to the alternative approach. The results are shown in **Table 11**.

The evidence shows that neither risk parity nor hedge funds explain very much of the return variation in exotic beta—only 27% and 12%, respectively.

Table 11. Summary Statistics on Major Asset Classes and Alternative Risk Premium Strategies

	Risk Parity		Hedge Funds	
	Regression Coefficient	t-Statistic	Regression Coefficient	t-Statistic
Explanatory variable				
Annualized alpha	11.18%	5.98	11.00%	5.24
Risk parity portfolio	0.43	10.23		
HFRI			0.53	6.33
Adjusted R^2	27.4%		12.4%	

Further, the estimated annualized alphas of exotic beta—11.2% for the risk parity portfolio and 11.0% for the HFRI index—are almost the same as the 14.6% average annual excess return reported in Table 4. In contrast, if the risk parity portfolio is regressed on the equal-risk exotic beta portfolio, the estimated alpha is –1.39% per year. As reported in Table 10, the alpha of hedge funds relative to global equities and the exotic betas is 0.61%. Taken together, these results suggest that the equal-risk exotic beta portfolio differs from and offers substantial performance benefits over risk parity and hedge funds.

Next, we produce a variety of measures to compare the equal-risk exotic beta strategy with the risk parity portfolio as well as global equities, global bonds, and hedge funds.[30] Note that the returns on risk parity, exotic beta, and hedge funds are all biased upward owing to survivorship and selection biases. The hedge fund index is biased because hedge fund returns are self-reported and generally backfilled after good performance and hedge funds that fail because of poor performance are often missing. Risk parity and exotic beta also suffer from selection bias in that these strategies were finalized after looking back at history, a bias that is slightly smaller for risk parity because of its simplicity. In the next section, we attempt to correct for some of these biases by conducting a forward-looking analysis.

Notwithstanding these biases, the five return streams are compared in **Table 12**. To put risk parity and exotic beta on a fair footing, we incorporate fixed annual management fees of 0.5% and 1.5%, respectively. Because they each realize different risk levels, the Sharpe ratio is the most relevant return statistic for comparison purposes. Moving across the table, the Sharpe ratio increases steadily from equities to bonds, to risk parity, to hedge funds, and, finally, to exotic beta. Also relevant is the level of maximum drawdown per unit of volatility, which is at least 3.0 for equities, bonds, risk parity, and hedge funds and only 2.0 for exotic beta. The correlation with equities is also the lowest for exotic beta. What may be surprising to many is the relatively high correlation of risk parity with global equities, very similar to hedge funds' correlation with global equities. In practice, although risk parity has delivered more attractive returns and some diversification benefits, the diversification is not as large as some may believe.

Where Do Exotic Beta Exposures Belong?

How should investors think about exotic betas in the context of asset allocation and strategic benchmarks? We support the use of strategic benchmarks as targets for long-term asset allocation; such benchmarks reflect an agreed-upon risk tolerance as well as a portfolio of agreed-upon asset classes with their associated long-term risks and expected returns. They also embed the particular structure of an investment objective, such as, for example, the interest rate exposures of long-lived pension liabilities. Benchmarks play a useful, and indeed critical, role as a stable, agreed-upon long-term reference against which to measure shorter-term portfolio risks.

Ang et al. (2009) argued that exotic betas (which they called "factor exposures") should be embedded in benchmarks. They support a value bias, for example, in the equity benchmarks. We certainly agree that it may make sense to engineer a value tilt into equity portfolios. The value tilt is a great example of a well-known, intuitive, long-term risk exposure that has paid off extremely well over time. However, it is a risk that needs to be sized appropriately alongside all other risks. In addition, its returns display substantial variation over time, as is the case for many alternative risk premiums. For this reason, we believe that investors need to understand, monitor, and manage their exposures over a shorter time frame than is practical in the context of a strategic benchmark.

Risk Budgeting. For many investors, the broad exposure to equity markets—the market beta—is the dominant source of portfolio risk. For this reason, the degree of market exposure in the strategic benchmark is almost always a decision made by a

Table 12. Summary Statistics on Major Asset Classes and Alternative Risk Premium Strategies

Statistic	ACWI	Barclays Global Aggregate	Risk Parity	HFRI	Equal-Risk Exotic Beta
Average excess return	3.5%	3.0%	8.0%	6.9%	14.6%
Projected management fees			0.5%		1.5%
Net average excess return	3.5%	3.0%	7.5%	6.9%	13.1%
Annualized volatility	16.3%	5.5%	12.6%	7.0%	10.4%
Sharpe ratio	0.21	0.54	0.63	0.98	1.41
Maximum drawdown	–57%	–17%	–38%	–24%	–21%
Maximum drawdown per unit of volatility	–3.5	–3.1	–3.0	–3.5	–2.0
Correlation with ACWI	1.00	0.31	0.75	0.78	0.22

governing board. Depending on how much detail is included, exposures to some of the exotic beta risk factors may also be incorporated in strategic benchmarks, at least in part, through the allocations to different asset classes. Many of the exposures to exotic betas, however, will typically not be determined by the benchmark. Most benchmarks today, for example, include substantial allocations to hedge funds but not to the many risk factors that are pervasive in that space. As most investors readily understand, looking at only the credit component of the fixed-income allocation in a portfolio that also includes a separate and significant allocation to hedge funds would be incomplete.

For this reason, we advocate building a risk budget that includes the capability to monitor the risk factor exposures across all the components of an investor's portfolio. We also recommend creating a risk budget for the exotic beta exposures. The risk budget allows investors to understand and manage the amount of portfolio risk that is the result of each risk factor exposure. It also allows investors to have a context for understanding the sources of active risk relative to the benchmark and for anticipating the level of excess returns from the exotic beta program. In some cases, investors may want a dedicated allocation to this category of return that is separate from their other strategic allocations.

Once investors have determined the expected returns and risk, they can derive the optimal risk budget for exotic beta alongside global equities, global bonds, hedge funds, and a risk parity portfolio. Long-term volatilities and correlations are fairly well estimated using our data sample of 23 years. Unfortunately, historical returns are noisy, upward-biased estimates for expected return. Therefore, we use a simplified version of the Black–Litterman (1992) model to "shrink" the realized average returns toward the CAPM equilibrium model. Specifically, we take a weighted average of the historical average excess return and the return implied by the CAPM, where the weight on equilibrium is determined subjectively.

For the risk-budgeting analysis, we consider two asset classes—global equities and global bonds—and three strategies: risk parity, equal-risk exotic beta, and hedge funds.[31] We take the realized performance of global equities as given, which is 3.5% annual excess return for our sample. We believe that the realized performance of global bonds and risk parity is modestly biased and, therefore, shrink them 25% toward their CAPM-implied expected returns. Global bond returns benefited from a substantial decline in interest rates over our sample period that cannot continue at the same pace in the future, which justifies a downward adjustment. Similarly, risk parity benefits from the unusual performance of bonds as well as the hindsight bias of including certain asset classes and not others. For example, in 1990, it was not obvious that inflation-linked bonds and emerging market debt were major asset classes and many would have argued that small-cap stocks were a unique asset class. Had the risk parity strategy included small-cap stocks and excluded inflation-linked and emerging market bonds, the performance would have been worse.

The potential for bias may be greater for exotic beta and hedge funds. The issue for exotic beta is the same as that for risk parity in that we have identified the exotic betas today and are backtesting their performance in history. Although the requirement that the risk premium be a well-understood phenomenon mitigates hindsight bias, it cannot be completely eliminated. As discussed earlier, the hedge fund index benefits from the exclusion of hedge funds that failed and from the backfilling of returns on hedge funds that succeeded. In order to handicap exotic beta and hedge funds, we shrink them 50% toward their CAPM-equivalent returns. We also assume that the annualized standard deviation for risk parity and exotic beta will be 10%. Finally, we subtract our previously discussed estimates of the management fees required to implement the risk parity and exotic beta strategies.

Table 13 lays out our forecasts for the risk premiums of each asset class and strategy. The global equity risk premium is unchanged, whereas the

Table 13. Black–Litterman Shrinkage Estimates for Risk Premiums

Asset Class/ Strategy	Average Excess Return	Standard Deviation	Sharpe Ratio	Realized Global Equity Beta	Shrinkage Ratio	Management Fees	Black–Litterman Excess Return	Black–Litterman Sharpe Ratio
Global equities	3.5%	16.3%	0.21	1.00	0%		3.5%	0.21
Global bonds	3.0	5.5	0.54	0.10	25		2.3	0.42
Risk parity	8.0	12.6	0.63	0.58	25	0.50%	4.7	0.37
Equal-risk exotic beta	14.6	10.4	1.41	0.14	50	1.50	5.8	0.56
Hedge funds	6.9	7.0	0.98	0.33	50		4.0	0.57

global bond premium drops from 3.0% to 2.3%. The risk parity premium also drops, from 8.0% to 4.7%. Exotic beta and hedge funds suffer the largest declines, from 14.6% to 5.8% in the case of exotic beta and from 6.9% to 4.0% in the case of hedge funds. Consistent with Black and Litterman (1992), we do not make any adjustments to estimated correlations but instead take them as given. The implied Sharpe ratios from our simplified Black–Litterman shrinkage procedure are shown in the final column of Table 13.

Correlations are reported in **Table 14**. As noted previously, global equities, risk parity, and hedge funds are highly correlated, whereas global bonds and exotic beta are not very correlated.

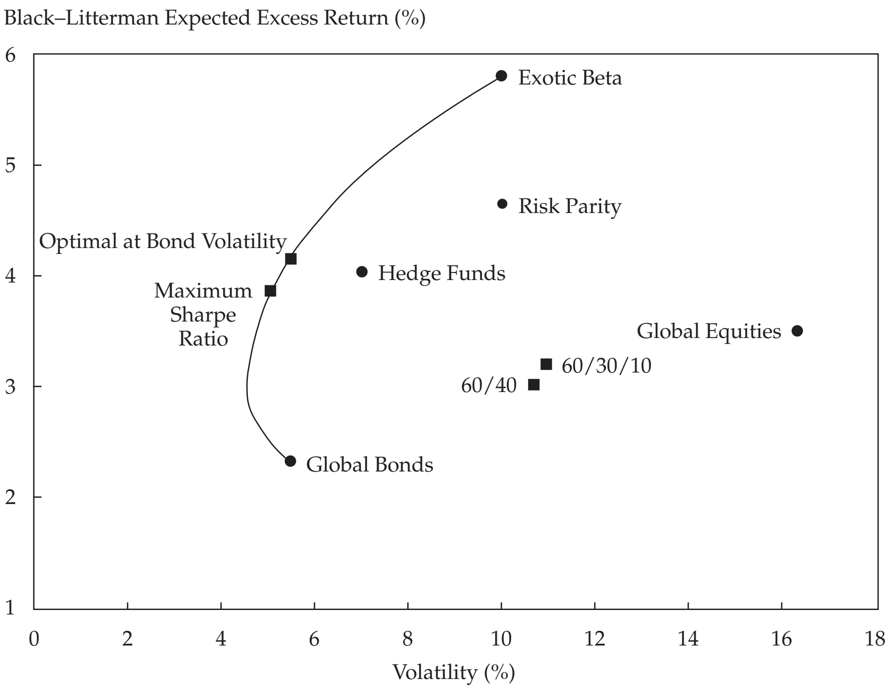
Using the expected returns, volatilities, and correlations from this procedure, we evaluate the risk and return properties of various portfolios of the five assets and display them in **Figure 2**. The dots represent the expected return and volatility for each individual asset class or strategy. The squares display specific portfolio combinations of the assets. The portfolios are constrained to hold only long positions and do not use leverage (except for the leverage embedded in each strategy). The line shows the efficient frontier under those assumptions, which is the lowest-risk portfolio possible for any given level of expected return.[32]

The 60/30/10 portfolio holds 60% in global equities, 30% in global bonds, and 10% in hedge funds. Although this is a modest improvement over a 60/40 portfolio, it is clear that holding the hedge fund index does not materially improve the efficiency of the portfolio, arguably owing to the very high equity beta of most hedge funds. Two interesting alternatives to this portfolio are the maximum Sharpe ratio portfolio and the optimal portfolio that delivers the same volatility as global bonds. The maximum Sharpe ratio portfolio has an important interpretation in the CAPM: It is the tangency portfolio that investors may lever or delever if they can borrow and lend at the risk-free rate without

Table 14. Asset Class and Alternative Risk Premium Strategy Correlations

	Global Equities	Global Bonds	Risk Parity	Exotic Beta	Hedge Funds
Global equities	1.00				
Global bonds	0.31	1.00			
Risk parity	0.75	0.44	1.00		
Exotic beta	0.22	0.16	0.53	1.00	
Hedge funds	0.78	0.14	0.69	0.36	1.00

Figure 2. The Efficient Frontier and Risk–Return Trade-Offs for Various Portfolios



frictions. In our case, the maximum Sharpe ratio portfolio holds 37% in global bonds, 26% in exotic beta, and 37% in hedge funds. Although it may be surprising that there is no holding in global equities, note that hedge funds deliver slightly lower correlations with the other assets and a higher expected return than global equities do. The Sharpe ratio on the maximum Sharpe ratio portfolio is 0.76. The portfolio on the efficient frontier with the same volatility as global bonds holds 28% in global bonds, 33% in exotic beta, and 39% in hedge funds, and it delivers a Sharpe ratio of 0.75.

It is also somewhat surprising that there is no allocation to risk parity in any of the portfolios on the efficient frontier. Empirically, the annualized expected return on the risk parity portfolio would have to be 1.75% higher (implying an expected Sharpe ratio of 0.51) before it is held in the maximum Sharpe ratio portfolio. Using similar logic, the expected return on exotic beta would need to be 3.5% lower (implying an expected Sharpe ratio of 0.25) before exotic beta drops out of the maximum Sharpe ratio portfolio. These results illustrate the importance of looking at asset allocation through the lens of a portfolio as opposed to an asset. Because exotic beta is designed to have very little equity risk, it takes only a small expected return for it to be held in an optimal portfolio.

Repeating this analysis for global equities is also interesting because this group of assets is not held in any optimal portfolio along the efficient frontier. Keeping all the other expected returns and volatilities unchanged, the global equity risk premium has to increase by 4.5% per year to 8% before it is held in the maximum Sharpe ratio portfolio, which implies a Sharpe ratio of 0.50—more than twice what Fama and French (2002) measured for the United States since 1872.

One critique of this analysis is that it is inherently backward looking because we use the full history of returns to determine what would have been the optimal allocations over that period. To address this issue, at least in part, we repeat the same analysis twice, using data first up to December 2005 and then up to December 2008. In each case, we produce an optimal risk budget and then evaluate the performance of the optimal Sharpe ratio using only out-of-sample observations. **Table 15** compares performance for 2006–2008 and 2009–2012.

The maximum Sharpe ratio portfolio established at the end of 2005 holds 21% in bonds, 38% in exotic beta, and 41% in hedge funds, which is a smaller allocation to exotic beta and a larger allocation to hedge funds than in the full-sample results discussed earlier. In the following three years, this maximum Sharpe ratio portfolio earns a Sharpe ratio of 0.32, far exceeding the Sharpe ratio of –0.40 on the traditional 60/30/10 portfolio, owing to its absence of equity exposure during the financial crisis. In the subsequent four years, 2009–2012, this portfolio also significantly outperforms the 60/30/10 portfolio. Repeating the same risk-budgeting process at the end of December 2008, the maximum Sharpe ratio portfolio comprises 23% bonds, 35% exotic beta, and 42% hedge funds, which implies a modest shift from exotic beta to hedge funds relative to the optimal portfolio in 2005. In the four subsequent years, the maximum Sharpe ratio portfolio generates a Sharpe ratio of 1.90, once again materially exceeding the performance of the 60/30/10 portfolio. Although these are just two specific observations, the robustness of the out-of-sample results suggests that the full-sample analysis is reasonably representative.

The significance of the optimal allocations to the exotic beta strategy suggests that these types of risk factors should play a meaningful role in a client's portfolio alongside other risk strategies. In most cases, investors managing their own exposures will have a different set of issues to deal with, but our discussion should offer some idea of how they might approach the problem if there are no constraints or existing positions to worry about. Investors may also raise concerns about our method for building expected returns for exotic beta because the risk

Table 15. Out-of-Sample Risk-Budgeting Comparisons

	2006–2008			2009–2012		
Asset Class/Strategy/Portfolio	Annual Return	Standard Deviation	Sharpe Ratio	Annual Return	Standard Deviation	Sharpe Ratio
Global equities	–10.6%	18.4%	–0.57	15.0%	19.4%	0.77
Global bonds	2.3	6.4	0.36	5.2	5.9	0.88
Risk parity	–10.7	16.8	–0.64	18.7	8.1	2.29
Dynamic exotic beta	8.2	9.8	0.84	14.9	8.0	1.86
Hedge funds	–3.9	7.9	–0.49	6.4	6.6	0.97
60/30/10 portfolio	–5.3	13.4	–0.40	12.8	14.6	0.87
2005 maximum Sharpe ratio portfolio	2.0	6.4	0.32	9.4	5.3	1.76
2008 maximum Sharpe ratio portfolio				10.9	5.7	1.90

premium is relatively large even after the haircutting process. However, meaningful allocations to exotic beta are optimal even under more conservative assumptions. For example, with everything else held constant, an exotic beta risk premium of just 3.3% results in a meaningful 10% allocation in the maximum Sharpe ratio portfolio. This level of return is one-fifth of our backtested performance and one-third of our hobbled forecast described earlier.

Implementation Issues and Tactical Management

During the recent financial crisis, we learned several important lessons about managing exposures to risk premiums. First, though often slow moving, the optimal exposures to risk factors should vary over time. This lesson was underscored by the size of the market moves: Even portfolios designed to weather all storms were forced to safe harbor. But more generally, the volatilities, the correlations, and, in particular, the risk premiums associated with different risk factors do change over time and so should the exposures to them. Second, investors should be very cautious about crowding, excessive leverage, and exposures to liquidity needs. Finally, many risk premiums have predictable reactions to market stress. And as we have seen both in recent years and in the more distant past, value tends to underperform during periods of market distress. Not all risks can be eliminated, but careful attention to managing those dynamics can improve the expected performance of a portfolio of exotic beta factors. As we argued earlier, we believe that it makes sense for most institutional investors to manage the portfolio of alternative risks dynamically and outside the context of their strategic benchmark.

Because financial markets and investor preferences are constantly evolving, some risk premiums may decline over time. If enough investors are willing to offer insurance against a particular risk factor, then the premium associated with that risk can become very low. A recent example of this is natural catastrophe risk: This premium jumped considerably after the major hurricane seasons of 1992 (Hurricane Andrew) and 2005 (Hurricanes Katrina, Rita, and Wilma) and then gradually declined to its current low level through accelerating institutional demand. For the same reason, one may expect new opportunities to arise over time. Thus, investors must continually monitor the premiums associated with each factor in order to decide when they are attractive and how to weight them in their portfolios. In this sense, investing in exotic betas may be viewed as a form of value investing in risk factors, rather than value investing in individual securities.

There are many methods for accessing alternative risk premiums. Certainly, many existing portfolios already include exposures to many of the risk premiums we have described through their long-only and absolute return strategies. Those exposures come naturally with many forms of active management, including investments in hedge funds as well as investments in such asset classes as commodities. They also arise from tilts of the strategic benchmark away from market-capitalization weights by, for example, overweighting emerging markets.

There is no right or wrong way to access exotic betas. We simply stress that investors should be aware of their exposures, understand them, and manage them purposefully. In addition, investors should not pay excessive fees for exotic betas. Some exotic beta exposures are available in liquid markets and are relatively easy to create through security purchases and sales, whereas others can be accessed and managed through the use of exchange-traded funds (ETFs) and derivatives. In other cases, the exposures are more difficult to obtain because either they exist in less liquid markets or they require active management of hedges, and in these cases, the exposures are probably best sourced through professional asset managers.

As we previously noted, exotic betas exist along a spectrum that runs from pure alpha to passive market beta. For this reason, the optimal sourcing of exotic betas also spans the spectrum from passive portfolios (such as ETFs and index funds) on one side to actively managed accounts and vehicles (e.g., hedge funds and commodity pools) on the other. The key issue for any portfolio is to understand what risks are being sourced and the size of the exposures. The next step is to proactively make judgments about the expected returns of the risk factors and, from these judgments, to make decisions about where opportunities may exist to increase or decrease allocations to these factors.

Managing a Portfolio of Exotic Betas. We believe there are two critical elements in the process of managing an exotic beta portfolio. The first is identifying the exotic betas as equity-neutral risk premiums for a real or perceived risk. The second is choosing a strategic allocation to each exotic beta and constructing an actual portfolio of tradable instruments that reflects that allocation. Although the choice of exotic betas will in most cases differentiate incarnations of alternative risk premium strategies, differences in the approach to portfolio construction can also be impactful.

Our approach to managing a portfolio of exotic betas is in many ways similar to a typical portfolio management problem. A targeted level of overall risk is agreed upon, and the allocations to individual exotic beta strategies are crafted to optimize return while being consistent with the overall risk target. Even abstracting from changes in expected returns, those allocations would need to be adjusted as volatilities and correlations change over time.

We believe the mean–variance paradigm is helpful in distilling approaches to exotic beta allocation. In the subsequent analysis, we consider two allocation alternatives: (1) equal risk and (2) dynamic. The equal-risk approach relies exclusively on a risk model, disregarding any information on the expected risk premiums in the allocations. The dynamic strategy—our preferred method—incorporates empirical forecasting models for risk and returns. We will compare the return and risk characteristics for these exotic beta allocation approaches later in the article.[33]

Equal-Risk Portfolio of Exotic Betas. The first portfolio approach is the equal-risk combination of underlying exotic beta strategies already introduced. To review, this portfolio is constructed using only the backward-looking estimates of volatility and correlations, and it targets 10% portfolio volatility through monthly rebalances that include estimates of transaction costs. As shown earlier, for our sample, the equal-risk portfolio of exotic betas realizes a Sharpe ratio of 1.41. The realized volatility of this portfolio is a little more than 10%, indicating that the expanding-window estimates of risk are biased slightly downward. Not surprisingly, given our earlier discussion of implied views, the marginal contribution to risk is not the same for all risk premiums.[34] In fact, the dispersion in risk is reasonably broad, with 15% coming from credit and more than 13% from both equity value and real assets. In contrast, only 7% can be attributed to bond slope. Although this portfolio might be motivated by parity in terms of standalone volatility from each risk premium, the risk decomposition is definitely not equal.[35]

Dynamic Exotic Beta Strategy. The equal-risk portfolio can be viewed generally as a near-static allocation to strategies because the underlying risk allocations to exotic betas change very modestly over time and do not incorporate information beyond volatility. A second approach to this problem is to augment the existing measures of risk and expected returns with forecasting models that estimate the magnitude of the risk premiums and their variation over time. These *conditional expectations* of the risk premiums are then blended to form a single set of expected returns, which become the input for a mean–variance optimization along with estimates of volatility and correlation to determine the optimal allocation.

We believe that risk premiums vary over time, and different risk premiums respond differently to changes in market conditions and investors' attitudes toward risk. For example, after a series of defaults, all credit spreads widen significantly. Some of this widening might reflect an increased probability of subsequent defaults, but much of it is driven by an increased demand for insurance against default. The same process occurs in catastrophic insurance risk after a season of storms or a large earthquake. In many cases, the change in the risk premium (or insurance premium if one views it from the perspective of the insurance buyer) can be a multiple of its value in a steady state. It is very hard to forecast such events, but with the benefit of prior history, one can assess the attractiveness of a given risk premium relative to its past, on both an expected return basis and a risk basis. As discussed, we believe this dynamic process should be thought of as value investing in risk premiums: When a given risk premium is relatively high (and its volatility is relatively low), it is sensible to increase exposure to that factor.

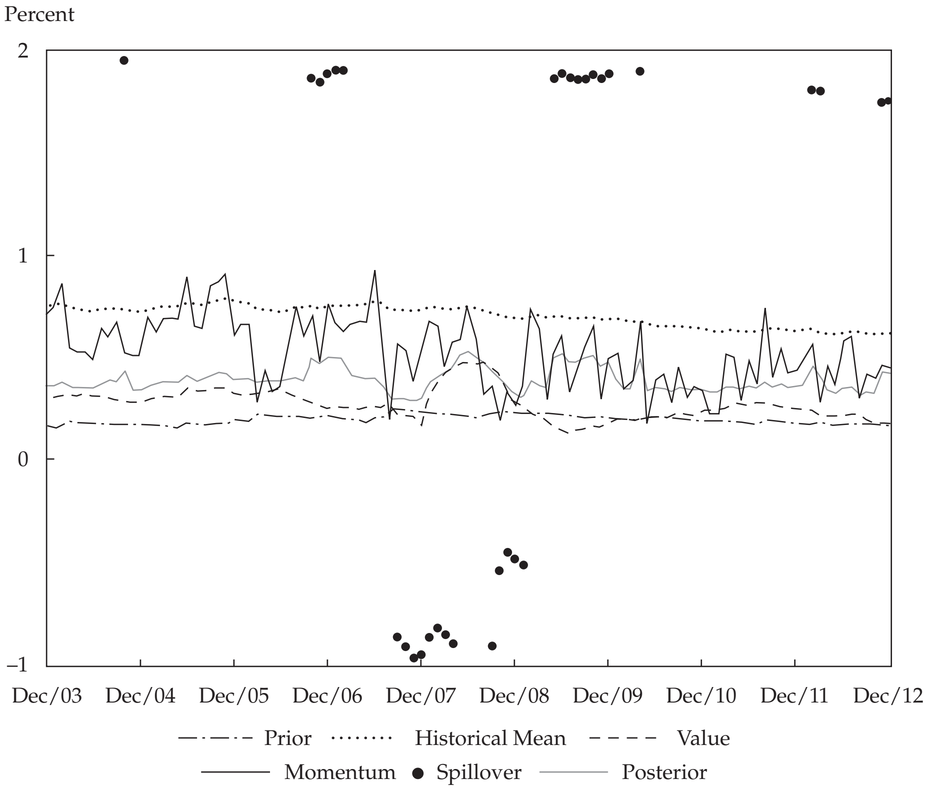
There are various measures for value in alternative risk premiums. Some metrics, such as deviations from long-term trend returns, can be applied to many types of risk factors. Other metrics—such as yield spreads in fixed income, backwardation in commodities, or the spreads in deviations from purchasing power parity in currencies—are specific to a particular asset class. In most cases, each alternative risk premium will have several unique measures of the relative expected risk premium at each point in time.

In building forecasts of risk premiums, we incorporate valuation-type metrics as their key inputs. These may include the level of spreads relative to their history in credit markets and the level of implied volatilities relative to their history in equity index volatility. Other forecasting models may consider the underlying components of supply and demand for hedging in each of those markets. There is a large universe of factors inspired by the concept of "value," and in all instances, they are motivated by the idea that risk premiums revert to their mean over the long term.[36]

To produce our dynamic risk premium forecasts, we combine four models: (1) historical mean, (2) value, (3) momentum, and (4) spillover. **Figure 3** illustrates how we build the monthly forecasted return on the carry exotic beta strategy in currencies.

Our example covers the nine years from December 2003 to December 2012. Each line or dot in the figure represents the forecast from a specific model. The "Prior" line portrays the forecast

Figure 3. Monthly Forecasts of Currency Carry Exotic Beta Strategy



from the prior, an IR of 0.25, which corresponds to approximately 0.20% per month. Although the IR remains the same every month, the implied expected return varies slightly owing to minor variation in the forecasted volatility of the exotic beta tracking portfolios.

The dotted line shows the historical mean estimate over time, as measured by the historical average excess return on the risk premium from the beginning of the sample period through the prior month. In the case of the currency carry exotic beta portfolio, the historical mean declines from 0.75% per month in December 2003 to 0.62% in December 2012. As the sample length increases, this forecast becomes more stable.

The "Value" line portrays the forecasts from our valuation model, which in this case is based on the *z*-score of the contemporaneous spread between short-term yields of the long and short sides of the exotic beta portfolio. Note that the value forecast for the currency risk premiums was 0.18% in December 2007 but climbed to 0.48% in August 2008 because of declining interest rates in the Organisation for Economic Co-Operation and Development markets relative to the developing markets.

The momentum model, represented by the solid black line, is considerably more variable because it focuses on the recent performance of the exotic beta strategy. The momentum model uses exponentially weighted averages of past returns with an average half-life of approximately two months. From June 2007 to August 2007, the momentum forecast drops from 0.92% to 0.20% owing to pronounced poor performance of this exotic beta strategy during the sell-off in investment-grade corporate credit and quantitative equity market–neutral strategies in July and August.

The dots represent monthly forecasted returns from a "spillover" model of broad market disruption, which is described in Appendix A. This forecasting model is active only when the spillover index is in the top or bottom 10% of its historical distribution. For example, starting in August 2007, the spillover index is in the top 10% of its history, which indicates a high degree of market disruption spilling over from one market to another. This situation lasts until April 2008 and occurs again from September 2008 to January 2009. The forecast from this model is the historical average return on the exotic beta strategy when the spillover index is in the top 10%. On the opposite side of the index distribution, the model forecasts relatively high expected returns starting in May 2009 on the basis of the unusual calmness of markets at that time. The monthly changes in the figure reflect the updates in conditional forecasts as new observations become available.

It is important to note that the estimated risk premiums are subject to significant noise. For example, the Sharpe ratio of the global equity risk premium is about 0.25, which means that its annual average is one-quarter of its annual standard deviation. If returns were normal, it would take 64 years of data for the risk premium estimate to be statistically significant at the commonly used levels.[37] Given the amount of noise in financial returns, the efficacy of any one of these forecasting models is not exceptionally high. As such, these forecasts should be treated with a healthy degree of skepticism.

Bayesian statistical methods lend themselves well to combining disparate forecasts with various levels of uncertainty and typically perform well in out-of-sample predictions. Such models are particularly well suited to forecasting situations where short-term forecasting is noisy and statistical validity can be attained only from large samples of data. The Black–Litterman (1992) asset allocation model is a widely used Bayesian model that is appropriate for this application. Although its origins are found in traditional asset allocation problems, it can easily be applied to the allocation of exotic betas.

The intuition behind the Black–Litterman model is that one can identify expected returns for the exotic betas that are consistent with a risk model as well as some notion of equilibrium and then average them with tactical views expressed through proprietary models. The so-called equilibrium expected returns are those implied by a given allocation, which in the global asset allocation application of Black–Litterman is typically the global capitalization-weighted portfolio motivated by the CAPM.

In the case of our exotic betas, we have already hedged out the equity beta, so in a CAPM equilibrium, the exotic beta portfolios should have risk premiums of zero. Because the basic notion of exotic beta is that there are excess returns above those of an equilibrium model, we need to choose a nonzero forecast for the risk premiums as a starting point. For simplicity, we assume that all the exotic betas have a Sharpe ratio of 0.25, which is our Black–Litterman "prior" expected return.

These empirical forecasts—the historical mean, value, momentum, and spillover models—are combined with the prior using the Black–Litterman model to produce a "posterior" return forecast. The weight of each component in the posterior reflects the confidence in each model. The confidence in the prior is judgmental and fixed through time, whereas the confidence in the timing models is based on the statistical significance of each model fit up to the date of the optimization. We require a three-year minimum history before including any exotic beta in a portfolio. Consistent with the Bayesian learning paradigm, the weight of the prior steadily decreases as evidence of the efficacy of the timing models accumulates over time. In the early part of the backtest, the prior accounts for approximately 80% of the weight in the model, whereas at the end of the sample period, the prior contributes between 30% and 60%, depending on the forecasting accuracy of each exotic beta timing strategy. In **Table 16**, we illustrate the forecasts from each model as well as the confidence-weighted contribution to return as of November 2007.

Table 16. Example of Black–Litterman Model for Currency Carry, November 2007

Input	Model Forecast	Contribution to Forecast
Prior mean	0.24%	0.17%
Historical mean	0.73	0.31
Value model	0.22	–0.13
Momentum model	0.38	–0.01
Spillover model	–0.96	–0.06
Posterior mean		0.28%

In the example of the currency carry exotic beta strategy in Figure 3, the posterior forecast ranges from 0.28% in November 2007 to 0.52% in June 2009. This posterior forecast becomes an input to a monthly mean–variance optimization that produces an optimal portfolio of exotic betas. As in the previous examples, we assume a constant risk aversion and rebalance monthly using conditional risk forecasts as well as our estimates of transaction costs. We refer to this approach as the *dynamic exotic beta strategy*.

The dynamic exotic beta simulation incorporates a number of additional constraints that the other approaches do not. First, we limit the position size in each market to five times the average daily trading volume. Second, we limit the daily trade size to 20% of the average daily trading volume. Third, the catastrophe bond position is limited to 10% of the portfolio's value. The catastrophe bond limit is motivated by challenges in borrowing against those securities, which result in unlevered holdings that use 10% of the value in the portfolio. We use recent margin levels to approximate how much capital is locked up in the noncatastrophe bond positions. Over our simulation history, the total collateral used is 30%, on average, leaving an average 70% cushion of free cash.

The results in **Table 17** show that the incorporation of simple forecasting models can materially improve performance. The realized Sharpe ratio of 2.03 for the Black–Litterman model with timing views is a 45% improvement over the Sharpe ratio of 1.41 for the equal-risk portfolio. The difference reflects the efficacy of the timing component in our forecasts. The timing views realize a tracking error of 5.1% relative to the equal-risk portfolio, which represents a 27% marginal contribution to risk under our assumptions. In practice, the risk allocated to timing is easily scaled to smaller or larger risk levels. The information ratio on those timing views is 0.81, much lower than the Sharpe ratio for the basic strategy without timing. However, because the timing views are uncorrelated with a static allocation and the weighting to timing is modest, the overall Sharpe ratio is improved.

Table 17. Comparison of Portfolio Construction Approaches Using Exotic Beta Strategies

Statistic	Equal Risk	Dynamic
Average excess return	14.6%	19.2%
Annualized volatility	10.4%	9.5%
Sharpe ratio	1.41	2.03
Maximum drawdown	–21%	–14%
Maximum drawdown per unit of volatility	–2.0	–1.4
Correlation with ACWI	0.21	0.13
Average marginal contributions to risk		
Equity value	13.1%	13.5%
Bond yields	9.6	10.3
Bond slope	7.2	5.5
Commodities	9.3	13.6
Real assets	13.0	9.7
Currency value	10.9	24.1
Volatility	11.6	18.4
Credit	15.3	3.1
Catastrophe bonds	10.1	1.8
Total	100.00%	100.00%

The risk allocation is, on average, more concentrated than it is in the equal-risk portfolio. Almost one-quarter of risk is allocated to currency value, 18% is allocated to volatility, and less than 6% is allocated to bond slope, credit, and catastrophe bonds. The large allocations to currency and volatility are not surprising, given their high Sharpe ratios throughout the sample period. Low Sharpe ratios in bond slope and credit explain their low allocations. Credit is particularly interesting in that it receives relatively higher allocations in the mid- to late 1990s but then has very little risk after 2000 owing to a much lower historical mean, as seen in the cumulative return to this exotic beta over our sample period.

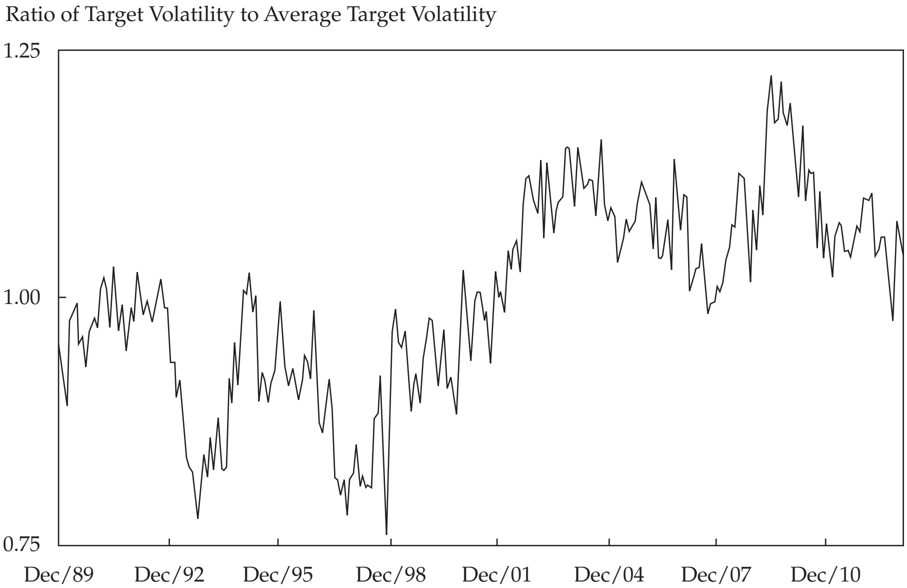
Although the overall improvement in performance from the Black–Litterman forecasts is measurable, the portfolio neither turns over very much nor relies on extreme weights. Ignoring the trading in the underlying securities to mimic and hedge the individual risk premiums, the reallocation across exotic beta strategies results in an average turnover of nine months. **Table 18** shows the minimum and maximum weights applied to each exotic beta strategy relative to its average weight. Over the 24-year period of our simulations, the weight range for most of the risk premiums is approximately one-half to twice the average weight, which is relatively narrow.

Table 18. Range of Risk Targets Relative to Average for Dynamic Exotic Beta Strategy

	Range of Tilts (× Average)	
	Maximum	Minimum
Exotic beta strategy		
Equity value	0.51	1.89
Bond yields	0.47	1.72
Bond slope	0.62	1.41
Commodities	0.40	1.53
Real assets	0.69	1.28
Currency value	0.61	1.20
Volatility	0.16	1.41
Credit	0.00	2.61
Catastrophe bonds	1.00	1.00
Full exotic beta strategy	0.76	1.22

The overall risk level in this simulation also varies modestly, from 0.76 to 1.22 times its average value. This variation occurs because our optimization does not target a specific total risk and instead assumes a constant risk aversion parameter. Conceptually, whenever the optimal-weighted portfolio of exotic betas has an above-average (below-average) forecasted Sharpe ratio, the dynamic strategy will optimally choose to take above-average (below-average) risk. **Figure 4** plots the full history of the risk target over our sample period. There is some variation from one month to the next, but the long-term cycles are more noteworthy. Risk drops considerably in late 1992 because of strong convergence in yields, term spreads, and calendar spreads in fixed-income and commodity markets. After returning to average levels in early 1995, the risk target declines again during the Asian currency crisis and the Long-Term Capital Management unwind, before gradually rising until

Figure 4. Targeted Risk Variation for Dynamic Exotic Beta Strategy



early 2004. From that point to September 2007, the risk target declines owing to poor momentum in the yield and currency risk premiums. After rising for the next year, the risk drops quickly in the last quarter of 2008, during the financial crisis, but then rebounds to even higher risk levels in 2009. From a longer-horizon perspective, risk increases over the sample because of increased confidence in the historical means, which elevates the posterior expected returns relative to our priors as more data are included.

The dynamic allocation process described above is built around simple and intuitive measures of valuation, momentum, and levels of financial distress. Although the timing component is slow moving, the benefits from tilts in the risk premiums more than compensate for their costs. Nonetheless, the dynamic reallocation process accounts for only one-quarter of total portfolio risk and about one-fifth of portfolio return. The bulk of the total return from the strategy comes from the long-term risk premiums embedded in the underlying exotic beta strategies.

Investability. Throughout this article, we have attempted to use reasonable real-world assumptions about costs, trading frictions, and liquidity. However, it behooves us to review those issues and consider other potential criticisms of the recommendations implied by our analysis.

First, we review transaction costs. For all the assets included in the analysis, we model frictions from our experience trading those instruments. In addition to estimates of commissions and bid–ask spreads, our models incorporate a quadratic market impact function, which means that transaction costs increase in the square of trade size. Over our simulation of the dynamic exotic beta strategy, estimated transaction costs are 1.7% per year.[38] To be clear, these costs are incorporated in the simulations throughout the article. The other important cost is management fees. From our cursory review of alternative risk premium products, the market rate of management fees for a portfolio of alternative risk premiums varies from 0.5% to 2%. We have attempted to adjust for this explicitly at the end of the section "Defining and Testing Exotic Beta" and throughout the section "Comparing Exotic Beta with Other Alternative Risk Premium Approaches" so that the comparison across return sources is fair.

It is also critical to consider the liquidity needs and ability to finance the positions and leverage implied by our analysis. **Table 19** reports the one-sided leverage in the dynamic exotic beta strategy.[39]

Table 19. Dynamic Exotic Beta Strategy Leverage Decomposition

	Leverage	
	Average	Maximum
Exotic beta strategy		
Equity value	0.21	0.41
Bond yields	0.36	0.84
Bond slope	0.63	1.31
Commodities	0.22	0.51
Real assets	0.11	0.26
Currency value	0.69	1.52
Volatility	0.13	0.28
Credit	0.20	0.69
Catastrophe bonds	0.04	0.05
Full exotic beta strategy	2.49	4.42

The average is 2.49, although it varies over the sample period, with a maximum of 4.42. Exotic betas in the lower-volatility asset classes, such as bonds and currencies, consume the largest leverage. Note that the leverage in this strategy derives from the leverage in the underlying instruments traded. For example, to enter into a long position in an S&P 500 futures contract on 25 October 2013, one needs to provide 5.1% in initial margin. This is not the same as outright borrowing from a broker/dealer, who can change terms or revoke the credit entirely on short notice. The leverage we refer to requires only that investors meet the requirements to transact in exchange-traded markets.

Taking into account the unique margin requirements on each security, including the assumption that catastrophe bonds are held without leverage, the total margin required to support the leverage in this simulation is 30.3%, on average, with a maximum of 60.7% and a minimum of 14.3%. This translates into unencumbered cash of 69.7%, on average, with a minimum of 39.3%. From most perspectives, this is a very healthy cash buffer.

The Benefit of Hindsight. Another real-world issue is the difference between a backtest and true out-of-sample performance. The importance of this issue is hard to overstate, and it applies to virtually all published empirical analyses. In this article, we postulated a trading strategy and simulated its performance over a 23-year history. We did not design the strategy in 1990 and then test it for the next 23 years. Our choice of alternative risk premiums, how they are constructed, and how they are timed all suffer from the bias of hindsight. This bias is mitigated by the intuitive nature of the premiums selected, our robust methods of risk premium construction, and straightforward models to forecast the risk premiums. In addition, none of our empirical analysis uses forward-looking data for portfolio construction purposes, whether for hedging or risk and return forecasting. In all cases, we forecasted these parameters using only the data up to the day before the portfolio is adjusted. All these factors significantly mitigate, albeit not completely eliminate, the backtesting bias in our simulations.

Conclusion

Many risk factors—which we call "exotic betas"—are neither equity exposure nor pure skilled active management. In this article, we updated our thoughts about including exotic beta strategies in investor portfolios in light of the global financial crisis. We continue to recommend that investors create a framework for understanding, appropriately sizing, and managing the multiple risk factors that provide sources of return in their portfolios.

One of the many investment themes that survived the global financial crisis is that the exposures to exotic beta are very attractive in a portfolio context. However, an important caveat is that such exposures should not be static over time. In addition, we believe it is optimal for investors to access these risk premiums in relatively lower-cost, more transparent, and customized implementations. On the basis of our perception of currently available products, it seems that the industry is already headed in this direction.

We benefited from constructive comments from Kent Clark, Marty Leibowitz, George Main, John Minahan, Peter Stein, and the participants in the Fall 2011 Q Group Seminar.

This article qualifies for 1 CE credit.

Appendix A.

Data

Exhibit A1 provides a comprehensive listing of our data.

Exotic Beta Tracking Portfolio Optimization

For a given theoretical exotic beta portfolio at time t with weight vector $\mathbf{h}_t$; tracking portfolio weight vector $\mathbf{w}_t$; covariance matrix $\mathbf{\Sigma}_t$; transaction cost function $T(\mathbf{w}_{t-1}, \mathbf{w}_t; \mathbf{c}, \mathbf{b}, \mathbf{i})$ with commission vector $\mathbf{c}$, bid–ask spread vector $\mathbf{b}$, and quadratic market impact coefficient $\mathbf{i}$; tracking error aversion coefficient λ; and transaction cost aversion coefficient θ, the representative tracking portfolio weight vector $\mathbf{w}_t$ is the solution to the following optimization problem:

$$\mathbf{w}_t = \underset{\mathbf{w}_t}{\text{argmin}} \begin{bmatrix} \lambda\left(\mathbf{w}_t - \mathbf{h}_t\right)' \mathbf{\Sigma}_t \left(\mathbf{w}_t - \mathbf{h}_t\right) \\ + \theta T\left(\mathbf{w}_{t-1}, \mathbf{w}_t; \mathbf{c}, \mathbf{b}, \mathbf{i}\right) \end{bmatrix},$$

where λ and θ are chosen subjectively to balance the costs of trading against the tracking error between the two portfolios and $T(\mathbf{w}_{t-1}, \mathbf{w}_t) = (\mathbf{c} + \mathbf{b}/2)'(\mathbf{w}_t - \mathbf{w}_{t-1}) + \mathbf{i}'(\mathbf{w}_t - \mathbf{w}_{t-1})^2$.

Spillover Index

This index is a weighted average of normalized measures of market disruption in global financial markets. The data include various credit spreads,

Exhibit A1. Risk Parity and Exotic Beta Data

Risk Parity Assets

Asset Class	Description
US equities	United States—Datastream market.
Developed int'l. equities	MSCI World ex USA in US dollars. Pre-1/Jan/01, we use Datastream World ex-USA in US dollars.
Emerging market equities	MSCI Emerging Markets Investable Market in US dollars.
Real estate	United States—Datastream real estate investment trusts (REITs).
US bonds	Barclays United States Aggregate Bond Index.
Developed int'l. bonds	Citibank World Government Bond Index 7–10-year ex-USA, hedged to USD. Pre-10/Nov/01, we use the unhedged index hedged with DXY (US Dollar Index).
Emerging market bonds	J.P. Morgan Emerging Market Bond Index (EMBI) global composite.
Inflation-linked bonds	Bank of America Merrill Lynch indices in EUR, GBP, and USD. EUR and GBP foreign exchange exposure is hedged, and the indices are blended with equal weights.
High-yield bonds	History starts with US high yield (HY) and then EUR hedged. EU HY is blended with equal weights.
Commodities	S&P Goldman Sachs Commodity Index Total Return.

Exotic Beta Generic Assets

Asset Class	Countries or markets included in the theoretical portfolios
Equity indices	Australia, Austria, Belgium, Brazil, Canada, China, Denmark, EURO STOXX, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Italy, Japan, Malaysia, Mexico, the Netherlands, Norway, Poland, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, the United Kingdom, and the United States.
Fixed-income markets	Australian 3 year and 10 year, Canadian 2 year and 10 year, Euro bund 10 year, Euro Schatz 2 year, Japanese 2 year and 10 year, UK gilt 2 year and 10 year, and US Treasury 2 year and 10 year.
Currency markets	Argentinean peso, Australian dollar, Brazilian real, British pound, Canadian dollar, Chilean peso, Colombian peso, Czech koruna, euro, Hungarian forint, Indian rupee, Indonesian rupiah, Israeli shekel, Japanese yen, Mexican peso, New Zealand dollar, Norwegian krone, Peruvian new sol, Philippine peso, Polish zloty, Russian ruble, Singapore dollar, South African rand, South Korean won, Swedish krona, Swiss franc, Taiwanese dollar, Thai baht, and Turkish lira. These currencies are freely tradable in both directions, albeit with varying degrees of liquidity over our sample.
Commodity markets	Aluminum, Brent crude, cocoa, coffee, copper, corn, cotton, feeder cattle, gas oil, gasoline, gold, heating oil, hogs, Kansas wheat, lead, live cattle, natural gas, nickel, orange juice, palladium, platinum, silver, soybeans, soybean meal, soybean oil, sugar, tin, West Texas Intermediate (WTI) crude, wheat, and zinc.
Other markets	Credit default swaps in investment-grade (IG) and HY corporate securities in the United States (CDX) and Europe (iTraxx), Swiss Re catastrophe bond index, Vanguard REIT index, VIX, and variance swaps on the S&P 500.

Exotic Beta Securities

Asset Group	Markets included in the implemented portfolios
Equity index futures	Australia: ASX 200, Canada: TSX, China: H-shares, EURO STOXX 50, France: CAC 40, Germany: DAX, Hong Kong: Hang Seng, India: CNX NIFTY, Italy: MIB, Japan: TOPIX, Malaysia: KLCI, Netherlands: AEX, Poland: WIG 20, Singapore: SGX MSCI, South Africa: JSE TOP 40, South Korea: KOSPI2, Spain: IBEX 35, Sweden: OMX 30, Switzerland: SMI, Taiwan: TAIEX, Thailand: SET 50, Turkey: BIST 30, United Kingdom: FTSE 100, and United States: S&P 500.
Equity index ETFs	Brazil, Chile, Indonesia, Mexico, and Russia.
Bond futures	Australian 3 year and 10 year, Canadian 10 year, Euro Schatz 2 year, Euro bund 10 year, Japanese 10 year, UK gilt 10 year, and US Treasury 2 year and 10 year.
Commodity futures	Aluminum, Brent crude, cocoa, coffee, copper, corn, cotton, feeder cattle, gas oil, gasoline, gold, heating oil, Kansas wheat, lead, lean hogs, live cattle, natural gas, nickel, orange juice, palladium, platinum, silver, soybeans, soybean meal, soybean oil, sugar, tin, wheat, WTI crude, and zinc.
Currency forwards	Argentinean peso, Australian dollar, Brazilian real, British pound, Canadian dollar, Chilean peso, Colombian peso, Czech koruna, euro, Hungarian forint, Indian rupee, Indonesian rupiah, Israeli shekel, Japanese yen, Mexican peso, New Zealand dollar, Norwegian krone, Peruvian new sol, Philippine peso, Polish zloty, Russian ruble, Singapore dollar, South African rand, South Korean won, Swedish krona, Swiss franc, Taiwanese dollar, Thai baht, and Turkish lira.
Credit instruments	iBoxx HY ETF, iBoxx IG ETF, and credit default swaps for CDX IG, CDX HY, iTraxx Europe, and iTraxx Europe high volatility.
Volatility instruments	VIX futures and variance swaps on the S&P 500.
Other instruments	Vanguard REIT ETF and Swiss Re catastrophe bond index.

default forecasts, implied volatilities, returns on modeled crowded trades, returns on hedge fund strategies, measures of financial institution liquidity, and multivariate measures of abnormal volatility and correlation across global markets and market indicators. The index attempts to capture the degree of stress and de-risking across global markets, and we have found that there is persistence in changes in the index over time. Therefore, the spillover index has been an effective early warning indicator for changes in investor risk appetites. See, for example, Kritzman and Li (2010) and Garzarelli, Vaknin, Verstyuk, Karoui, and Ahmed (2008).

Black–Litterman Forecasting Model

Mean–variance optimization techniques are susceptible to estimation error and often result in solutions that exhibit unusual sensitivity to even small changes in assumed parameters. To overcome this challenge, financial engineers often augment the standard mean–variance problem either with smooth estimators of mean and variance or by more directly (and bluntly) constraining the optimization itself. The Black–Litterman (BL) framework belongs to the former approach. By using Bayesian statistical techniques, the BL model offers a formalized approach to mitigate estimation error in expected return.

Consistent with its Bayesian genealogy, the BL framework allows the practitioner to update his or her initial beliefs of expected returns, or the *prior*, with evidence, or—in the more traditional vernacular—*views*.

Prior

In Bayesian econometrics, the prior is associated with the practitioner's initial beliefs about the random variable (or parameter) of interest. In our case, these parameters are the expected risk premiums. The prior describes a probability distribution $\underline{f}\left(r_\beta\right)$ of expected risk premiums.

In the BL framework, the prior distribution of expected returns is assumed to be normal. The critical features of the normal distribution—namely, the mean and variance—reflect the practitioner's beliefs.

Our prior distribution of exotic beta expected returns is given by

$$\underline{f}\left(r_\beta\right) \sim N(\pi, \tau\boldsymbol{\Sigma}),$$

where π is the prior mean (i.e., the central moment of the prior distribution of expected returns). Because it describes a belief, π can take on any value the practitioner desires. Also, because the prior need not be based on any information, it is often referred to as an unconditional distribution. In the original version of the BL framework, the prior distribution of expected returns is motivated by equilibrium theory. Some practitioners may use models that are more or less sophisticated.

To construct our prior, we assume that the different premiums have identical long-term Sharpe ratios of 0.25. Then, each prior mean is the product of the assumed Sharpe ratio and the estimated volatility of each premium. By anchoring the Sharpe ratio, we make the expected returns' volatility invariant.

Uncertainty in the prior is shown by $\tau\boldsymbol{\Sigma}$, which the practitioner can incorporate in the variance of the prior distribution. One approach is to proxy for $\boldsymbol{\Sigma}$ with the variance–covariance matrix of the premium returns; τ is a scaling parameter used to translate the uncertainty of premium returns into the uncertainty of premium *expected* returns.

Views

If desired, one can incorporate time-varying forecasts of the risk premiums. Typically, these relationships are encapsulated by a series of conditional expectation functions. For example, one forecast approach might use a linear regression of the credit premium on recent lagged credit spreads. The output of these functions—the conditional expected returns—are referred to as "views."

The BL framework allows us to update our beliefs on the expected returns with views. Similar to the prior, we usually describe these views in the form of a conditional normal distribution:

$$\hat{f}\left(q \mid r_\beta\right) \sim N\left(\mathbf{P}' r_\beta, \boldsymbol{\Omega}\right).$$

As stated previously, the view expected returns, q, are assumed to be linearly related to the expected returns, r_β. $\mathbf{P}$ is a matrix of coefficients that describes the linear relationship between the view expected returns and the premium expected returns. $\boldsymbol{\Omega}$ is the matrix of uncertainties of view expected returns.

One can use views to modulate the forecasted return to the various premiums. In our previous example, we posited that the expected credit premium is linearly related to past credit spreads. If the coefficient is positive, then we expect a larger-than-average return on credit during periods of high credit spreads. *Ceteris paribus*, the Black–Litterman expected return for the credit premium should be larger, resulting in a larger-than-normal allocation to the credit premium.

Black–Litterman Posterior

The prior and view distributions can be combined with Bayes's theorem to arrive at the posterior distribution of expected returns:

$$\bar{f}\left(r_\beta \mid q, \mathbf{P}, \mathbf{\Omega}, \tau\mathbf{\Sigma}, \Pi\right) \propto \hat{f}\left(q \mid r_\beta\right) \underline{f}\left(r_\beta\right).$$

Because we have assumed that both the prior and the view distributions are normal, the posterior distribution is also normal:

$$\bar{f}\left(r_\beta \mid q..\right) \sim N\left(\mu_{BL}, \mathbf{\Sigma}_{BL}\right),$$

where

$$\mu_{BL} = \left[\left(\tau\mathbf{\Sigma}\right)^{-1} + \mathbf{P}'\mathbf{\Omega}^{-1}\mathbf{P}\right]^{-1}\left[\left(\tau\mathbf{\Sigma}\right)^{-1}\mu + \mathbf{P}'\mathbf{\Omega}^{-1}q\right]$$

$$\mathbf{\Sigma}_{BL} = \left[\left(\tau\mathbf{\Sigma}\right)^{-1} + \mathbf{P}'\mathbf{\Omega}^{-1}\mathbf{P}\right]^{-1}$$

The posterior mean, μ_{BL}, commonly referred to as the "Black–Litterman expected return," can be used directly in a mean–variance optimization to construct a portfolio of alternative risk premiums.

Notes

1. Selection bias as well as a secular increase in price-to-earnings multiples over the last century suggest that past experience in the United States is better than one should expect in the future. See, for example, Carhart and Winkelmann (2003).
2. See www2.goldmansachs.com/gsam/pdfs/USI/education/aa_beyond_alpha.pdf. We credit the term "exotic beta" to George Main of DGAM.
3. We certainly are not the first to propose investing in factors. This topic is addressed in numerous papers, including Ennis (1991), Sharpe (1992), Fama and French (1993), and Fung and Hsieh (1997, 2002, 2004). For sake of clarity, when we refer to a risk factor portfolio, we use the terms "factor," "portfolio," or "strategy." When talking about the returns on a risk factor, we use the terms "risk premium" or "return." Finally, when we are referring to exposures to risk factors, we use the terms "betas" or "exposures."
4. See Litterman (2005).
5. Catastrophe bond prices did temporarily decline during the crisis owing to a demand for liquidity. In addition, a few catastrophe bonds were impaired because Lehman Brothers was an uncollateralized counterparty.
6. See, respectively, Sharpe (1964); Merton (1973); Ross (1976).
7. This concept was considered by Lo (2004).
8. See the section "Factor Risk Opportunities" in Ang et al. (2009, pp. 119–141).
9. Over the past three decades, bonds have generated an attractive risk premium as yields have declined significantly. However, fixed-income markets have arguably become much less attractive in recent years from a valuation perspective. This fact highlights the need to monitor forward-looking measures of expected risk premiums and to adjust exposures accordingly.
10. Although such portfolios have performed very well historically, there is a well-known danger in that they perform poorly when investors become more risk averse. This portfolio provides an example of a risk premium for which it is important to closely monitor market conditions and to adjust exposures accordingly.
11. This portfolio provides another example of a premium that varies considerably with market conditions.
12. In the CAPM, the set of optimal portfolios with borrowing and lending at the risk-free rate is known as the capital market line.
13. See Dalio (2005).
14. We used closing daily prices adjusted by the Kepos Capital transaction cost model, which incorporates unique estimates of commissions, bid–ask spreads, and a quadratic market impact cost for every security traded. The formal optimization problem is described in Appendix A. As an example of a position limit, in our final simulations, we restricted holdings in all markets to be less than five times the average daily trading volume.
15. Throughout this article, our risk forecasting models—whether for estimation or portfolio construction—use exponential decay with half-lives of three months for volatilities and six months for correlations, combined with a correction for autocorrelation. The model is described in De Santis, Litterman, Vesval, and Winkelmann (2003).
16. The markets included in the equity hedge are equity index futures in EURO STOXX, Hong Kong, Japan, the United Kingdom, and the United States.
17. Hereafter, we use the implementable backtests for the exotic beta strategies.
18. The standard deviation in three-year estimates of volatility is very low—approximately 1%.
19. Note that credit and catastrophe bonds have higher correlations with ACWI than one might expect because our simulated hedge never looks forward in the data and, thus, could not anticipate the degree of correlation between those exotic beta strategies and global equities during the 2007–08 financial crisis. Because the negative returns were so large in that period, they significantly influence the full-sample correlations.
20. For all leverage and turnover calculations in this article, the fixed-income asset classes are duration adjusted to the equivalent of a 10-year zero-coupon bond.
21. The 10 asset classes were discussed by Dalio (2005). The specific indices we used are reported in Appendix A.
22. By using *ex ante* estimates of risk and targeting a constant level of volatility at each point in our sample period, our method of constructing a risk parity portfolio is analogous to that of Asness, Frazzini, and Pedersen (2012).
23. Where possible, we assume asset class rebalancing is performed using liquid derivatives.
24. "Implied views" is a term originally coined by Black and Litterman (1992).
25. It is a simple matrix multiplication, but it does leave open one degree of freedom because if all expected excess returns are multiplied by a constant, the optimal portfolio remains unaltered. In Table 8, we normalize the scale of the expected returns to 0.63, which corresponds to the risk parity portfolio's Sharpe ratio over our full sample period.
26. Here, we normalize the scale of the expected returns to the Sharpe ratio on an equal-risk combination of exotic beta strategies over our full sample period (January 1990–December 2012), shown in Table 4 to be 1.41.
27. Kolm and Li (2013) evaluated 20 hedge fund replication products and found that they have underperformed the hedge fund indices by an average of 3.5% per year.
28. See, for example, Fung and Hsieh (2004).
29. See, for example, Liang (2000).

30. Note that unlike before, the MSCI ACWI global equity index series represents the underlying index return, not the return to a strategy that targets 10% volatility in the index every month.
31. We also considered the HFRI-replicating basket of exotic betas as an alternative strategy, but it was stochastically dominated by the other assets and, therefore, was never held in any of the optimal portfolios along the efficient frontier.
32. This analysis is meant to replicate a typical real-world investor's portfolio construction problem. In theory, if investors are willing to permit short positions and leverage within a given component of their portfolios, they should also allow them across all their investments. If we did allow short selling and additional leverage, the results would show that additional short positions would be held in equities to improve the Sharpe ratio of holdings in hedge funds and risk parity.
33. See Table 17.
34. Marginal contribution to risk is the decomposition of total variance into the components that are specific to each asset in a portfolio.
35. We also considered an optimized portfolio of exotic betas for which each risk premium is assumed to have the same expected return. We do not report the results, but they are not materially different from those of the equal-risk case.
36. Owing to the higher transaction costs and more opaque historical data, we do not include any timing forecasts for catastrophe bonds.
37. A t-statistic of 2 requires the standard error in the mean estimate to be one-half of the risk premiums. Under the assumption that returns are independent and identically distributed, the standard error is 1 divided by the square root of T times the standard deviation.
38. The transaction costs of the dynamic strategy are lower than those of the equal-risk version primarily because it imposes position limits on some of the less liquid markets, such as catastrophe bonds.
39. One-sided leverage is the average of the absolute value of long exposure and short exposure. For example, a portfolio with 100% of value held long and another 100% of value held short would have one-sided leverage of 1.

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