STATE STREET.

VISIONFOCUS

JUNE 2010

Rethinking Asset Allocation

Modern Portfolio Theory is being updated with new techniques that take advantage of the vast computational and information-aggregation capabilities available in contemporary financial markets. Increasingly, frequent non-normal returns and dramatic swings in valuations suggest that management of tail risk may emerge as a new frontier of asset allocation.

This is State Street

With $19.0 trillion in assets under custody and administration and $1.9 trillion in assets under management,* State Street is a leading financial services provider serving some of the world's most sophisticated institutions.

We offer a flexible suite of services that spans the investment spectrum, including investment management, research and trading, and investment servicing.

With operations in 25 countries serving clients in more than 100 geographic markets, our global reach, expertise, and unique combination of consistency and innovation help clients manage uncertainty, act on growth opportunities and enhance the value of their services.

*As of March 31, 2010

A VISION SERIES THOUGHT LEADERSHIP PUBLICATION

State Street's Vision Series distills our unique research, perspective and opinions into publications for our clients around the world.

Introduction

Portfolio construction and risk modeling were sorely tested over the course of the 2007–2009 financial crisis. But, while some portfolios were more exposed to risk than investors had thought, many quantitative asset allocation and optimization practices successfully mitigated the damage. What's more, new techniques that focus on measures of market turbulence and on convergent/divergent strategies that can outperform in both rising and falling markets effectively passed the "live test" presented by those volatile markets.

The Rise of Markets

When the young Harry Markowitz published his doctoral thesis, "Portfolio Selection",[1] in the *Journal of Finance* in 1952, he laid down a critical intellectual marker for two generations of economists, financial academics and market professionals. More than 50 years later, Markowitz's Modern Portfolio Theory (MPT) and its intellectual descendants still provide a critical framework for asset allocation theory and practice. Throughout the years, in response to various financial market reversals, critics have risen to declare MPT dead, or even to declaim the past 50 years of financial risk management as a pseudo-science.

In a sense, all financial management approaches are potentially flawed in that they are based on past experience and built upon presumptions of outcomes that may never come to pass. The best financial models are scientifically created and offer a best estimate of expectations based upon mean reversion and trending. But, they are based on average expectations, and reality always follows a unique path.

With MPT, Markowitz had not discovered an immutable law of nature; he was an economist, not a physicist. And his simple and elegant framework — one of the first to introduce mathematical rigor into financial markets — created baseline standards for the balancing of expected return and risk, and for incorporating measures of mean return and covariance into financial portfolios across the risk spectrum.

MPT belongs to a family of loosely related intellectual precepts and tools — the efficient markets hypothesis, the capital asset pricing model, Black Scholes concepts for option pricing, value at risk measures and mean variance optimization — that still are an important part of the toolkit of finance.

[1] Harry Markowitz, "Portfolio Selection," *Journal of Finance*, March 1952. Markowitz was awarded the Nobel Prize in Economics in 1990 for his development of Modern Portfolio Theory.

Are Markets Efficient?

The efficient markets hypothesis presumes that investor behavior is rational and constant, and that markets are liquid. But, amid the pendulum swing of fear and greed, market liquidity varies. And investor rationality hinges on the notion that all market participants have access to all relevant information, and that this information is accurate and timely. In the great asset boom of the first decade of the 21st century, this was not the case.

Securitization, inappropriate risk-rating and sale of much of this debt infused markets with several trillion dollars worth of securities for which only the most vague risk characteristics could be realistically estimated.

What we now call the financial crisis began as a credit crunch. When markets buckled, many traditionally liquid credit-related instruments froze. The inherent opacity of hundreds of billions of dollars worth of structured products was instantly translated into counterparty risk.

What's more, as credit seized up, investors discovered that not only did the market for securitized assets vaporize, but the liquidity of their hedge funds and private equity structures was unexpectedly impaired as well. This impairment was due to the opacity introduced by securitization and by virtue of the unique lock-ups to which investors had earlier agreed.

The result: Thousands of investors had to sell what they could in a financial stampede that left some investors, who had never employed outsized leverage or purchased structured products, exposed to a generalized collapse in equity and fixed-income markets. The fluid global networks that had effectively transmitted economic development and financial flows had, just as efficiently, transmitted market contagion.

It goes without saying that the recent financial crisis, which, by one measure, incinerated nearly $29 trillion worth of equities and real estate in only 15 months spanning 2008 and early 2009,[2] opened the floodgates on commentary and best-sellers dancing on the ashes of carefully constructed investment portfolios and quantitatively driven models. Asset allocators can be forgiven for wondering, if only for a moment, whether their entire professional toolkit had been made redundant.

However, it is always instructive to take the longer view. For example, this financial crisis did indeed constitute a record market correction, decreasing the value of global financial market assets by $16 trillion in 2008. Even with this record setback, the cumulative value of these assets still stood at $178 trillion.[3] And these asset valuations climbed back substantially as governments around the world collaborated on stimulus programs and market interventions, with the MSCI All Country World Index rising nearly 80 percent[4] in the 12 months following the lowest point of the market in March 2009.

The debate at the heart of the financial crisis — whether the models or human factors were to blame — will no doubt continue for another 50 years. In the meantime, asset allocators still have a job to do. Fortunately, they now have at their disposal a more nuanced and experienced view of portfolio risks centering on market volatility, portfolio construction and trading liquidity.

Perhaps even more intriguing are new, emerging quantitative approaches aimed specifically at the challenges of turbulent markets and the non-normal investment returns that they engender. The study of turbulence and unusual price movements, for example, helps investors to understand market sentiment and construct robust risk models.

---

[2] McKinsey Global Institute, "Global Capital Markets: Entering a New Era," 2009.

[3] Ibid.

[4] MSCI All Country World Index, March 2009–March 2010.

Asset Allocation Best Practices

Risk Management, Market Volatility and Strategic Asset Allocation

Investment portfolio components are often asymmetrically covariant — they diverge in rising markets and re-couple in times of crisis. This unfortunately concentrates risk and disperses gains, leaving investors with few places to find uncorrelated investments when they are needed most. The problem of unwanted correlation raises investor sensitivity toward portfolio construction methodologies, driving them to think much harder about traditional risk and return assumptions.

In the wake of a financial crisis that has raised equity market volatility and further impaired funding levels, asset owners are re-examining strategic asset allocation across the entire investment spectrum, including alternatives, currency, tactical allocation and asset liability models, with a view to determining whether high levels of equity risk are appropriate.[5]

In this post-crisis period, many investors have been going back to basics, shifting their focus from benchmarking outperformance to ensuring that their liabilities are met. Investors are protecting capital, allocating to more liquid investments, targeting asset/liability gaps and seeking to build "all-weather" portfolios that can withstand varied market environments. They are mitigating allocation risk and portfolio drift through periodic rebalancing to their target asset allocations, shifting more funds toward passive management and reducing their strategic equity exposures.

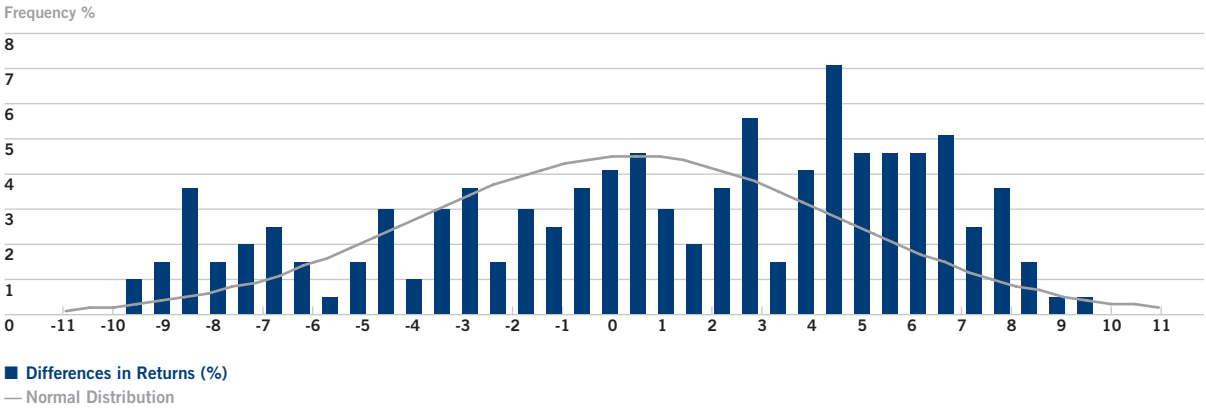
Strategic asset allocation has traditionally focused on long-term fixed asset weights typically measured in years. But, the accelerating speed and volatility of markets is driving investors to undertake more frequent portfolio risk analysis, as well as ongoing monitoring and maintenance of portfolios.

Asset allocators are paying increased attention to within-horizon risk (the risk of portfolio elements breaching a pre-determined threshold at any time during the investment horizon). As a consequence, strategic allocation (normally associated with beta and long-term risk premiums) and tactical allocation (normally associated with the pursuit of alpha) are blending into a more holistic process. To effectuate this, investors are increasingly turning to global macro hedge funds, effectively outsourcing their tactical asset allocation.

When financial dislocation hit world markets, investors were surprised at the high levels of correlation found in portfolios they thought were broadly diversified. Many absolute return and active alpha strategies were revealed to be merely long, leveraged forms of beta and, thus, dependent on equity and credit spreads. In response, many investors today are allocating risk budgets to alternatives that provide greater diversification and liquidity.

[5] Monica Fan, "The Benefits of Dynamic Strategic Hedging," State Street Global Advisors, 2009.

Distribution of Differences Between Hedged and Unhedged Five-Year Rolling Annualized Returns on the MSCI World ex USA Index



Source: State Street Global Advisors and MSCI estimates. The MSCI World ex USA Index℠ is a trademark of Morgan Stanley Capital International.

Some investors are also using active currency hedging strategies, increasing currency hedges when their home currencies depreciate and reducing them when their home currencies strengthen. This kind of disciplined currency strategy has the potential to add value over the cycle and reduce downside risk. After all, currency gains and losses are not normally distributed around an average of zero; currency losses can be more frequent and larger than currency gains.

Bolstering the argument in favor of active currency management is the foreign exchange market, one of the few remaining markets in which most participants are not profit-seeking. This offers active currency managers a rich set of opportunities to outperform.

Investors are using strategies based on minimum variance indices, as well as using long-short equity strategies, to avoid the volatility associated with long-only strategies, diversify their sources of active returns and preserve portfolio wealth.

Notwithstanding the general efficiency of normal markets over long timeframes, market prices overshoot in both directions during times of high volatility and non-normality. Disciplined tactical allocation strategies seek to take advantage of this tendency by overweighting and underweighting asset classes with a view to adding uncorrelated returns and reducing total portfolio volatility.

Considering that investors continually overshoot their balanced allocation targets is a reminder that investors should diversify over as many different sources of returns as possible — both in terms of active styles and asset classes. Market overshoot also suggests that there is no point to investors "chasing" active manager returns because by the time that a particular investment style is understood, the market regime supporting that style may well have moved on to a different paradigm.

We believe that no single strategy can solve the funding problems of all pension plans, endowments and other investors. However, careful examination of investor liabilities and the use of risk budgets — calibrating reductions and increases in allocations in accordance with different risk scenarios — can potentially improve total risk-adjusted returns.

Optimal Asset Allocation

Optimal asset allocation seeks to identify asset classes that improve portfolio efficiency by raising returns and/or lowering risk.[6] In building their portfolios, investors should choose asset classes large enough to absorb investment without causing market impact and liquid enough to allow for periodic reallocations and cash disbursements.

Having identified prospective asset classes, investors need to identify efficient allocations consistent with estimations of returns, standard deviations and correlations. Using a combination of quantitative tools and judgment, investors can develop expected returns for each asset class, adjusted in accordance with their views about departures from fair value.

Investors should think about whether two basic assumptions of MPT apply to their circumstances. Are their returns normally distributed, and is there a smooth trade-off between wealth and satisfaction (i.e., quadratic utility)? If these assumptions do not apply, they should consider an alternative optimization methodology called full-scale optimization.

Risk estimation centers on the standard deviation of asset classes and on correlations between them. These measures are not stable through time, as investors who experienced the financial crisis can attest. So, it is important that investors disaggregate historical returns derived from normal periods and those associated with periods of market turbulence[7] and stress-test their exposure to loss and risk for each period.

Typically, investors use value-at-risk (VAR), which is a widely used risk measure of the magnitude of a potential loss, to determine exposure to loss at the end of their investment horizon. But, to better calculate the likelihood that a given investment will depreciate to a pre-determined level at any time from inception to the conclusion of the investment horizon, they may consider using continuous VAR that identifies the worst probable outcome throughout the horizon.[8]

Most investors substantially underestimate within-horizon exposure to loss, as evidenced by the considerable market reversals associated with the financial crisis. For example, an investor may face a 1 percent chance of losing 10 percent or more over the course of five years. But, that investor may also face a much higher chance that the portfolio will depreciate by at least that amount at some point along the way. In turbulent periods, the likelihood of this loss may rise even more.[9]

The duration of investment horizons — whether one year or five years — is important to the end-of-horizon estimates. And tolerance to within-horizon risk varies in accordance with investors' liability profiles and their ability to tolerate interim volatility across the time horizon. So, it is important that investors understand their liquidity requirements and liability schedules, taking on as much risk as is appropriate to maximize wealth and income opportunities that grow over time.

Traditional asset allocation methodologies measure dispersion around an average to identify portfolios along an efficient frontier. This approach can be augmented with monitoring of tracking error against selected benchmarks to identify an efficient surface in three dimensions: expected return, standard deviation and tracking error.

---

[6] State Street Global Markets, "Optimal Asset Allocation," *Managing Institutional Portfolios*, 2010.

[7] G. Chow, E. Jacquier, M. Kritzman, and K. Lowry, "Optimal Portfolios in Good Times and Bad," *Financial Analysts Journal*, May/June 1999.

[8] Mark Kritzman and Don Rich, "The Mis-measurement of Risk," *Financial Analysts Journal*. May/June 2002.

[9] State Street Global Markets Research and State Street Associates, "Exposure to Loss," *Managing Institutional Portfolios*, 2010.

Full-Scale Optimization and Non-Normal Return Distributions

Many investors today are deploying larger allocations to hedge funds, private equity and other alternative investments in pursuit of non-correlated returns. As they do, an increasing proportion of their strategies generates non-normal return distributions with significant skewness and kurtosis, which measure the degree of distortion relative to a "bell curve" distribution, and are typically associated with the risk of larger and more frequent losses.

Conventional mean-variance optimization that calculates expected returns, standard deviations and correlations among portfolio components presumes that investors have quadratic utility (equal aversion to deviations both above and below the mean) and that returns are distributed normally. But, this does not hold true for investors with different utility preferences that are invested in portfolios delivering non-normal returns. Strategies that involve derivatives and certain hedge funds may exhibit highly non-normal returns, with losses occurring far more frequently than a normal distribution would suggest.

Advances in computer processing power today allow investors to use an alternative optimization methodology called full-scale optimization to calculate portfolio utility for every period in a sample, considering as many asset mixes as necessary to identify allocations that yield the highest expected utility. Full-scale optimization is particularly appropriate for investors with an aversion to losses below a specified threshold — for example, those facing reserve requirements, loan covenants, or the risk of insolvency or termination.

Asset Class Diversification

The need for portfolio diversification is perhaps the most universally accepted precept in investing. Unfortunately, most portfolios demonstrate asymmetrical correlation, with returns more diversified on the upside and considerably less on the downside — precisely the opposite of what most investors are seeking.[10]

In the financial market tug-of-war between greed and fear, risk aversion is a powerful driver of herding. The tendency toward reduced diversification in down markets has been observed amid country equity allocations, global industry returns, individual stock performance, international bond market returns and even with hedge fund investment.

Given that correlation parameters estimated from periods of sharply positive or negative returns differ markedly from those estimated from full samples, investors may want to consider more nuanced asset allocation approaches, for example, using full-scale optimization to mitigate correlation breakdowns.

The only conditional portfolio correlations that seem to improve diversification amid turbulence — when it is needed most — are correlations across asset classes. And even this tendency can fall apart under stress. In the worst months of the financial crisis, for instance, traditionally uncorrelated asset classes such as mortgage-backed securities and high-yield debt succumbed to risk aversion and demonstrated notable correlation.

It stands to reason that investors may want to increase allocations to risky assets when investor confidence is high, while reallocating to fixed-income instruments and cash when market sentiment swings the opposite way. But, this kind of dynamic allocation is difficult to achieve with conventional approaches, especially in the context of portfolio construction founded on full-sample analysis and end-of-horizon risk estimation.

A good starting point may be to consider alternative asset allocation methodologies, including full-scale optimization, which seek to maximize expected utility over samples of varied returns, thereby creating the potential for greater upside unification and downside diversification.

[10] David B. Chua, Mark Kritzman and Sebastien Page, "The Myth of Diversification," *Journal of Portfolio Management*, Fall 2009.

Portfolio Rebalancing

Managing Asset Allocation and Exposure in Illiquid Markets

Once investors have designed their portfolio architecture, taking into account their unique liquidity requirements and risk tolerances, and taking steps to mitigate the pitfalls of traditional approaches to portfolio construction, they must undertake the periodic rebalancing of their portfolios back to their target weights.

Just as sophisticated modeling can be used in portfolio allocation, investors can introduce quantitative rigor into the rebalancing process with a view to maximizing desired investment exposures and saving on trading costs, minimizing market impact, maintaining critical liquidity and reducing cash drag.

A good example of this includes exposure management strategies that deploy derivative instruments to equitize cash positions and facilitate rebalancing across asset classes. With this technique, investors can seek to enhance the liquidity of their positions while maintaining exposures that allow opportunities for growth.

Another way for investors to keep their investments liquid is to find relatively liquid assets within their nominally less-liquid alternative allocations. As an example, hedge fund replication strategies use derivatives to ensure liquidity, while delivering returns similar to those of broad-based hedge fund-of-fund indices. Similarly, real estate investment trusts (REITS) can be used as a more liquid proxy for direct real estate investment.[11]

When financial markets seized up in the worst weeks of the financial crisis, fixed-income investors saw interest rate spreads between government and corporate bonds widen to all-time highs. Because of this, many fixed-income managers found it difficult to sell their bonds, thus making it difficult for plan sponsors to rebalance their portfolios without incurring substantial costs.[12]

This kind of liquidity risk highlighted the urgency for institutional investors to maintain positions liquid enough to accommodate pension benefit payments, fees and expenses, and opportunistic cash calls from private equity managers. These cash positions can also serve to rebalance portfolios in the face of severe dislocation between asset classes represented in their portfolios.

In times of high volatility and problematic liquidity, investors may consider turning to overlay strategies using highly liquid index futures contracts to maintain their strategic asset allocations, efficiently access liquidity, facilitate implementation and equitize their cash balances to avoid cash drag.[13] For markets in which no liquid, synthetic vehicle is available, investors can use passive cash funds.

Strategic overlay programs can be used to periodically rebalance portfolios against benchmarks when markets turn volatile. And while it may seem counter-intuitive to allocate assets toward asset classes that are underperforming, those investors not using momentum strategies may find that disciplined rebalancing creates

[11] Alistair Lowe, "Back to Growth: Where to Take Risk to Earn Real Returns," *SSgA Capital Insights*, September 2009.

[12] Tony Beaulac, "Challenges of Managing Asset Allocation in Illiquid Markets," *SSgA Capital Insights*, February 2009.

[13] iBid.

the potential for them to benefit from markets' mean-reverting properties. This is particularly the case when market dislocation is driven more by emotion and liquidity issues than by fundamental factors.

Overlay strategies seek to facilitate liquidity by exposing a designated cash pool to global markets, allowing for periodic cash flows and maintaining asset mix targets. To achieve this, many such strategies use a combination of index-based futures and total return swaps overlay. As part of an overall cash management plan, exposure management can help investors maintain allocation targets and keep cash on hand with minimal capital commitments.

Optimal Rebalancing

Institutional investors usually employ mean-variance analysis to determine optimal portfolio weights. But, as soon as they construct a portfolio, it begins to drift from optimality as the various portfolio elements gain or lose value. What's more, these gains and losses occur at different rates of speed.[14]

In a perfect world without transaction costs, investors would simply set up a trading algorithm to continually drive rebalancing, returning the portfolio to optimal weights in near real-time. But, trading costs can be substantial and vary according to the type of security being traded, the size of the position, and the time and place of the trade execution. Investors must therefore trade off the performance impacts of sub-optimality with the transaction cost of restoring optimal weights.[15]

Two sub-optimal approaches to portfolio rebalancing are used by many investors. Calendar-based strategies periodically rebalance to target allocations in accordance with a pre-determined schedule, such as monthly or quarterly. These strategies are often used by those seeking to manage benchmark risks, as benchmarks are themselves calendar-based. Tolerance-band approaches, usually used by those seeking absolute returns, trigger rebalancing whenever portfolios drift from a pre-determined band, for example, 3 percent or 5 percent above or below target.

The problem with calendar-based rebalancing is that markets might shift substantially between periodic rebalancing or, conversely, that rebalancing on a given date might be unnecessary as assets have not drifted enough to merit the rebalancing. Tolerance-band rebalancing is generally thought to be an improvement, but with the caveat that different portfolio components have different levels of elasticity. For example, a 5 percent spike in the price of one asset may be normal, while for another asset it represents an extreme price move.

Optimal rebalancing programs use multi-period optimization technology to generate trading rules for a specified time horizon.[16] Using massively parallel processing to drive dynamic programming, the algorithm seeks to create a roadmap that can be utilized until the assumptions used to build the optimal portfolio change. To mitigate costs, asset allocators typically use futures to rebalance assets to avoid unwanted costs associated with the trading of physical securities.

Deciding to Reallocate

As we emerge from the financial crisis, we are only beginning to see the outlines of a market environment that has been characterized as the "new normal." In a period of recuperation and recovery, markets expect slower economic growth, increased regulatory restrictions, a gradual re-ordering of capital imbalances, and a massive rise in official indebtedness and of sovereign and currency risk in developed markets. Perhaps most chilling to asset allocators is the threat of official restrictions on cross-border investing.

How should asset allocators respond to this brave new world? There is a case to be made for doing nothing. Over short-time horizons, markets can certainly deviate from normality, lose efficiency and misprice financial

[14] Mark Kritzman, Simon Myrgen and Sebastien Page, "Optimal Rebalancing: A Scalable Solution," *Journal of Investment Management, Vol. 7, No. 1*, 2009.

[15] Mark Kritzman, Simon Myrgren and Sebastien Page, "Portfolio Rebalancing: A Test of the Markowitz-Van Dijk Heuristic," *MIT Sloan Research Paper No. 4641-07*, March 2007.

[16] Sebastien Page, "The Right Mix: How and When to Rebalance," *Canadian Investment Review*, May 15, 2009.

assets. But, over the long run, even the market collapse of 2007–2009 may come to be seen as a simple exercise in mean reversion.

The increased levels of official debt incurred by governments and central banks to finance market recovery and economic stimulus, over a long enough timeframe, may diminish in significance. These new burdens may seem onerous at face value, but they may seem less so when compared to the vastly larger structural debt of these governments' unfunded pension liabilities.

Meanwhile, asset allocators have no choice but to continue their work, tending to their fiduciary obligations and continuing to evolve their financial practice. Market complexities, imbalances and the non-normal returns that come with them may continue to be a fact of life. Fortunately, new fields of financial research offer intriguing potential solutions.

Asset Allocation 2.0

Convergent and Divergent Strategies

The financial crisis, while noteworthy for its size and scope, is not unique. After all, most crises of recent decades have triggered sharp increases in major asset class correlation. Given that markets may continue moving through cycles of serial correlation, asset allocators may want to consider strategies that can take advantage of both quiet and turbulent markets.

This process begins by dividing portfolio strategies into two categories: convergent and divergent.[17] Convergent strategies are based on the notion that the intrinsic value of asset classes and securities can be expressed in fundamental data, and that investors can develop opinions as to whether investment targets are overvalued or undervalued in the expectation that market prices will converge to this intrinsic value over time. Our research shows that convergent strategies tend to perform best during periods of relative calm in which markets process all available information to identify assets that are overvalued or undervalued.

Divergent strategies, by contrast, aim to profit when fundamental valuations are ignored by the market. They seek to exploit serial price movements, such as trend and momentum, which reflect changing market themes and sentiments. Divergent strategies tend to perform best during periods of rising volatility and uncertainty.

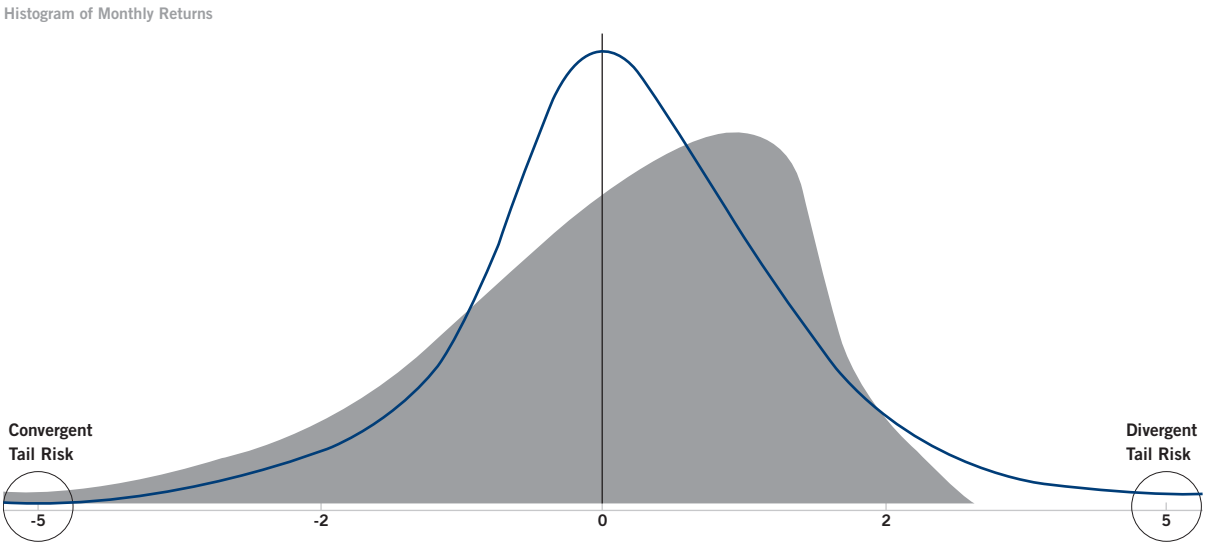
Most mainstream investment strategies are convergent, including hedge fund strategies such as equity market neutral, convertible arbitrage and many credit strategies. In calm or normal markets, convergent strategies reliably deliver risk/return characteristics in line with investor expectations. But, as markets became volatile in 2008, volatility and correlations typically observed in quiet periods broke down and convergent strategies fared poorly.

Conversely, the divergent strategist seeks to identify and exploit serial price movements (including trends and momentum) driven by investor sentiment (particularly extreme risk aversion) that moves prices away from fundamental value. When markets turn irrational and prices become disconnected from fundamental characteristics, divergent strategies can be successfully applied to a variety of equity, fixed income, currency and commodity investment programs. Divergent strategies, such as global macro and managed futures, did particularly well during the market dislocation in the worst months of the financial crisis as valuations collapsed and cross-asset class covariance spiked.

During the heart of the financial crisis, many investors with various proportional mixes of stocks and bonds in their portfolios endured painful negative returns. While varying stock/bond mixes may increase or decrease equity risk, this tactic does not affect issues of correlation. For these portfolios, capital may have been diversified, but risk was not, leaving investors with only minimal downside protection.

[17] Sam Chung, Mark Rosenberg and James Tomeo, "Hedge Fund of Fund Allocations Using a Convergent and Divergent Strategy Approach," *The Journal of Alternative Investments*, Summer 2004.

Investment Overview



Convergent Hedge Fund Strategies: Strategies that tend to perform best during periods of relative calm in which the market processes all available information in an effort to determine assets that are overvalued and undervalued

Divergent Hedge Fund Stategies: Strategies that tend to perform best during periods of rising volatility and uncertainty, capitalizing on serial price movement across many markets in a marketplace that temporarily ignores fundamental information

Source: State Street Global Advisors

Markets may forever be buffeted by powerful behavioral forces as investors overreact and underreact to macro events. Portfolios that combine convergent and divergent investment approaches, within tactical asset allocation strategies that manage for various factor risks, can enjoy improved diversification and risk management benefits that have the potential to reduce portfolio volatility and negative outliers, while increasing opportunities for capturing upside.

Turbulence

History may prove that the single greatest failure of risk management in recent years was using average risk numbers rather than regime-specific risk analysis to gauge risk. The study of financial turbulence seeks to help asset allocators to develop more reliable inputs into portfolio construction and risk management during volatile markets.

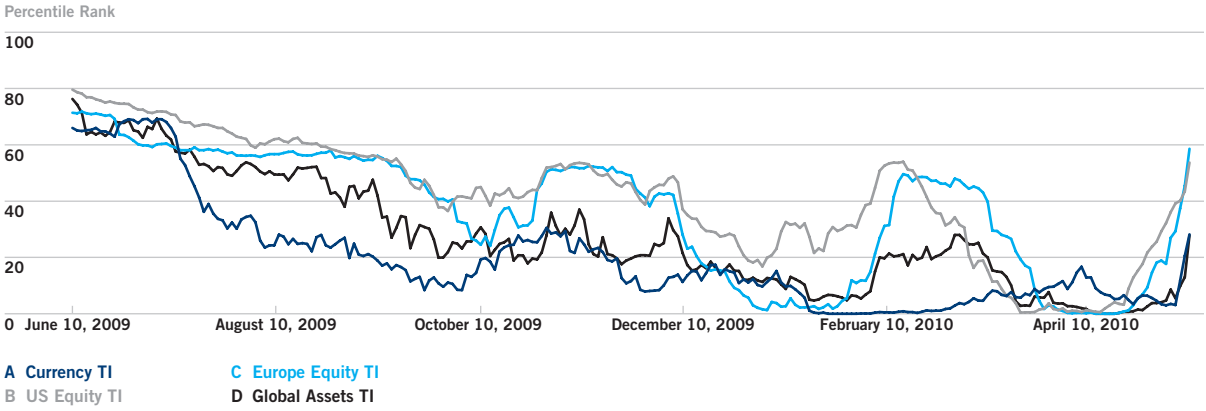
Turbulence is a statistical measure designed to identify periods of unusual financial returns — either in terms of volatility or correlation, or both. In most cases, periods of statistical turbulence map very well onto well-known episodes. Extreme political and financial scenarios are distinct examples: the 1987 stock market crash, the first Gulf War, the Russian default, the bursting of the technology, media and telecommunications bubble, or the recent mortgage- and credit-driven crisis.

Over the course of the financial crisis, turbulence measures aimed at currencies, United States and European equities, and global assets spiked in unison. They declined steadily as markets regained their equilibrium through 2009 and into the first half of 2010.

Traditional risk models that measure the diversification benefits of various assets using only average correlations can be misleading.[18] For example, when US and non-US equities produce returns greater than one standard

[18] Mark Kritzman and Yuanzhen Li, "Skulls, Financial Turbulence and Risk Management," *Revere Street Working Paper Series, Financial Economics* 272-25, 2010.

State Street Turbulence Index



Source: State Street Global Markets, period ending June 11, 2010

deviation *above* their mean, their correlation is 17 percent. But, when both markets produce returns more than one standard deviation *below* their means, correlation shoots up to 76 percent.[19] This explains why investors who believed their portfolios to be well diversified suffered catastrophic losses during the financial crisis when turbulence and correlation soared.

Turbulence is not the manifestation of investor opinion or behavior. Rather, it is a statistical expression of unusual price changes. Periods of extraordinarily high returns could be considered just as turbulent as those of market collapse; the dot-com bubble and the collapse of housing prices were both highly turbulent events. Sharp departures from normal pricing — on the upside and the downside — define turbulence, as do breakdowns of statistical correlations. And turbulence measures can be applied objectively across any market or asset class.

In terms of asset allocation strategy, the study of turbulence reveals that traditional quantitative expressions of risk, which place equal significance on normal and non-normal markets, significantly underestimate the impact of turbulent events. By contrast, covariance estimated from market outliers provides a model of portfolio risk superior to estimates derived from full-sample analysis.

Turbulence is Persistent

To take maximum advantage of turbulence, investors would benefit from knowing when turbulence is likely. Armed with this information, they could decide whether to avoid the turbulent days, or indeed, use this knowledge to engage risk. This predictive strategy is feasible because turbulence is persistent. Investors may not know when turbulence will hit, but once it does, they may still have time to take action.

Market turbulence is analogous to turbulence encountered by aircraft. Turbulence may arrive randomly, but once it begins, it takes time to get through such systems. As markets encounter one of their 10 percent most turbulent days, the likelihood of that turbulence continuing over the next 5, 10 or 20 days is substantially larger than during normal times.

Understanding how specific market segments react during turbulent and non-turbulent regimes, investors can stress-test portfolios and estimate probability of loss, use turbulence-related risk parameters to build more resilient portfolios and scale the risk exposures of various strategies in anticipation of regime shifts.

[19] Ibid. These correlations are based on monthly returns of the S&P 500 and MSCI World ex USA indexes from the period starting in January 1970 and ending in February 2008.

Liquidity and Liability

The emerging field of liquidity risk analysis[20] (LRA) turns on the concept of liquidity at risk, which can be defined as the most cash that investors would need to raise in a given period with a specified confidence. For example, if a one-month 95 percent liquidity value at risk were $100 million, then the monthly cash requirement would exceed $100 million only once every 20 months (5 percent of the time).

Liabilities drive investor cash requirements. When markets become turbulent, the degree to which investors can tolerate market declines is defined by how much and how soon they need to raise liquidity. Investors that develop a comprehensive understanding of their cash requirements can better understand how vulnerable their portfolios are to sudden restrictions in market liquidity. Precisely this type of liquidity risk caused the most damaging effects of the financial crisis.

LRA begins with a list of commitments for which investors might have to raise capital in a given month. Armed with this knowledge, investors can use futures positions and cash to cover margin calls, and capital calls that might arise from real estate and private equity positions. Regular cash commitments, such as benefit payments, may also be factored in with a benefits payment optimizer.

The LRA process simulates the cash needed for futures positions across a wide range of potential market environments. Capital calls are estimated from the historical monthly capital calls for real estate and private equity. The distribution of cash needed across all simulations allows investors to plan their cash needs for a given month at a confidence level of 95 percent.

Given that risk parameters are unstable through time, liquidity value at risk can be calculated separately for quiet and turbulent periods. Turbulence has a quantifiable impact on liquidity risk probability; investors would do well to take this into account when building models they hope will withstand the next round of systemic risk.

Liability-driven investing (LDI) is a framework for managing funding-status volatility by evaluating asset class risk and return relative to fund liabilities. LDI programs help investors to better identify, measure and manage risk. As pension plans build new strategies for recovering from funding shortfalls and for accommodating the possible adoption of mark-to-market reporting of assets and liabilities, they can use LDI strategies to manage against asset allocation targets while protecting against various types of risk — volatility, downside, funding and liquidity risk.[21]

LDI solutions range from fixed-income beta strategies to alternatives and managed-volatility equity strategies. The objective is to improve the risk profile of funds' bond exposures by moving to a more closely matched solution relative to the duration of plan liabilities.[22]

By modeling the liquidity demands of their particular liability profile, investors can maintain liquidity sufficient to comply with cash requirements without forgoing return possibilities by holding too little risk. Part of this solution turns on balancing holdings of more liquid securities such as government debt or index investments with less-liquid positions in private equity, hedge funds or real estate.

Investors may also consider allocating more of their risk budget to alternative investments that provide greater levels of liquidity, such as hedge fund replication strategies that invest in underlying returns (or betas) behind well-understood hedge fund strategies.[23]

[20] State Street Global Markets Portfolio Solutions, "Liquidity Risk Analysis" (ongoing research).

[21] State Street Global Advisors, "LDI: Narrowing the Funding Gap," *SSgA Market Overview*, January 2009.

[22] Stacey L. Marino, "Innovative Solutions for Managing Risk in Volatile Times," State Street Global Advisors.

[23] Andrew Soper, "Re-examining Strategic Asset Allocation," *SSgA Capital Insights*.

Investor Behavior and Regime Analysis

Portfolio risk management demands that investors take into account the significance of specific time periods. But, the significance of these time periods varies according to the characteristics of individual portfolios. The emerging field of investor behavior examines the activities of investors in aggregate with a view to understanding their sentiment, particularly their tolerance for risk. Clustering this behavior into regimes[24] makes clear that regimes dictate behavior, and that this behavior has a quantifiable impact on asset-return characteristics.

Understanding investment regimes allows investors to anticipate the performance of different market elements, and then to allocate their own portfolios in response. For example, in times of eager risk engagement, investors seek out commodity-based investments and emerging markets, and they reallocate to equities with an accent on growth. Conversely, when investors are risk averse, they might adhere to positions in consumer staples, health care and utilities. In terms of geography and style, risk-averse investors engage investments in the US and demonstrate a broad-based retrenchment away from equity markets.

As is the case with turbulence, investment regimes are persistent. Once investors enter a particular regime, the duration of their positions and the likelihood of their next regime destination (for example, from risk engagement toward risk aversion or the opposite) can be interpreted with a simple probability matrix. The study of investment regimes complements the study of turbulence. Market turbulence engenders risk aversion. Quiescent markets stimulate risk appetite. A key strategic point for investors is to apply their judgment, informed by an understanding of their own risk tolerances, on regimes or turbulence measures with a view to timing their migration from one investing style to the next.

[24] State Street Global Markets, "Mapping Investment Regimes," December 12, 2006.

Conclusion

Over the course of the financial crisis, investors encountered many varied pitfalls borne of their dependence on portfolio construction and risk models centered on average market behavior and normal return distributions. As a result, some traditional asset allocation practices are up for reconsideration.

Modern Portfolio Theory (MPT), while called into question during the crisis, remains deeply relevant. But, it should be updated with new techniques that take advantage of the vast computational and information aggregation capabilities available in contemporary financial markets.

The central concept of MPT — the balancing of risk and return assumptions — is arguably more relevant than ever. Risk management has moved to center stage, and managing tail risk (the risk of non-normal returns) may emerge as a new frontier of asset allocation best practice.

Many strategists believe that non-normal investment returns and dramatic swings in valuation may occur more frequently in the coming years than traditional standard deviation and bell-curve models suggest. Investors have various methods of optimization at their disposal, including classic mean-variance. But, with increased incidence of outlier events, they may want to consider full-scale optimization. That said, managing for tail risk with sophisticated overlays and hedges can be expensive, so investors, in a sense, may be forced to optimize their use of optimization.

Because unusual events may surface in markets with more frequency in the future, investors should give new consideration to within-horizon risk, investment regimes and turbulence. And to make the best of this volatile investment climate, they may want to consider convergent and divergent strategies to help develop all-weather portfolios with the potential to take advantage of markets with both normal and non-normal return characteristics.

Given the unique credit-driven nature of the financial crisis and the manner in which counterparty risk seized markets, liquidity management has emerged as a critical new challenge. Investors need to better measure their liquidity risk and more fundamentally integrate liquidity considerations into their asset allocation decisions.

To facilitate this, investors would do well to enhance their reallocation processes with optimal rebalancing that could mitigate trading risk while maximizing desired exposures. Moreover, investors could further enhance their liquidity through the use of derivatives and futures overlay, equitizing cash to gain market exposure while retaining the ability to draw out cash to meet either scheduled or unforeseen contingencies.

A burgeoning area in asset allocation will likely concentrate on the creation of new kinds of investment products — be they exchange traded instruments, replication strategies or simply liability-focused fixed-income programs — that seek to maximize exposure to alpha opportunities while protecting investors' ability to liquidate the instruments.

Passive and Active

Investors appear to be reappraising their balance of passive and active strategies now. The performance of many hedge fund strategies across the 2007–2009 market correction suggests far greater correlation between alternative investment programs and broader markets than investors had anticipated. This, in turn, has led investors to question the high cost of alternative strategies with undesired beta exposure.

Some observers have noted a "barbell" structure emerging, whereby investors will allocate larger portfolio proportions to liquid and passive investments, while allocating their risk budgets to more exotic strategies such as long-short equity allocations and opportunistic fixed-income programs. In this regard, interest in hedge funds with concentrated risk exposures and low beta remains very strong.

There is already evidence that investors are undertaking a fundamental shift in the content of their asset allocations.[25] In response to the financial dislocation of the crisis, investors have reduced their exposures to domestic equities in favor of increased domestic fixed income and alternatives, and have increased allocations to emerging market equities and to passive versus active equity strategies.[26]

This reappraisal of portfolio architecture may prove to be an initial phase of an ongoing process of dynamic asset allocation, rather than a permanent change. In the future, investors may be more eager to lock in returns through regular rounds of de-risking instead of riding dynamic alpha returns for protracted periods. The traditional practice of reviewing allocations on a biannual or even triennial basis amid fast-changing markets may be abandoned in favor of something that looks very much like constant risk assessment and rebalancing.

Investors learned a great deal over the course of this financial crisis. Regulators, central banks and industry bodies are actively reorganizing market norms and practices with a view to reducing systemic risk and increasing sustainable market growth. We believe that asset allocators are doing their part by addressing markets with an improved sense of their liabilities and risks, and by increasing the productivity of their investment management processes with beneficial effects for both their clients and for markets as a whole.

[25] State Street Associates, "Plan Sponsor Asset Allocation Trends," *Investment Strategy Analysis*, February 2010.

[26] "P&I 1000 Statistics at a Glance," *Pensions and Investments*, February 2010.

Contact Information

If you have questions regarding State Street's services and capabilities for portfolio construction and asset allocation, please contact:

Jeremy Armitage
+44 20 3395 7880
jarmitage@statestreet.com

Will Kinlaw
+1 617 234 9496
wbkinlaw@statestreet.com

Daniel Farley
+1 617 664 3319
daniel_farley@ssga.com

For questions or comments about our Vision series, e-mail us at **vision@statestreet.com**.

STATE STREET.

State Street Corporation
State Street Financial Center
One Lincoln Street
Boston, Massachusetts 02111–2900
+1 617 786 3000
www.statestreet.com
NYSE ticker symbol: STT

Design and production by State Street Global Marketing

10-STT01210610