portfolio construction CONFERENCE
24/25/26 August 2010 | Australian Technology Park , Eveleigh, Sydney

Critical Issues Forum Research Paper

How to Kill a Black Swan? Risk and Asset Allocation in Crises

Remy Briand & David Owyong, MSCI Barra
May 2009

Introduction

We have all been shocked by the events of 2008, and are left wondering how they happened and what led us there. Some have argued that this is an unprecedented situation, which may be true if you consider the speed and magnitude of the shock, and possibly the long-term impact on the real economy. But this may not be true with regard to the elements that triggered the crisis and the way it has been unfolding.

Rogoff and Reinhart [2008] have pointed to eighteen major banking crises after World War II, and a casual count of recent crises shows a pattern of a major market event at least every 10 years. Most of the time, these crises have been linked to excess liquidity in the economy combined with a general misjudgment on the benefits of a certain type of innovation. This time is not different, with excess savings from emerging markets re-invested in developed financial and housing markets, combined with a false sense of systemic risk reduction through the widespread use of sophisticated securitized instruments.

The experience of this last market shock highlights several shortcomings in the risk management and asset allocation practices that have been commonly adopted by industry practitioners. It is now clear that the underestimation of the frequency and magnitude of extreme events left many unprepared. In particular, the consequences of contagion on portfolios have been overlooked. By increasing correlation across asset classes, contagion significantly reduces the benefits of diversification in otherwise well- diversified portfolios. In addition, the flight to quality associated with contagion did significantly reduce liquidity in many parts of the capital markets, leading to cash-flow issues for most investors, including many long-term investors such as endowments and pension funds. Finally, the intensity of this particular crisis has highlighted the negative consequences of all the relatively neglected non market risks, such as counterparty risk, operational risk, and concentration risk. This is vividly captured by Warren Buffet's now famous quote: "Only when the tide goes out do you discover who's been swimming naked".

In our view, the events of last year will force a number of changes in investment practices in the following areas:

- Management of extreme events: Business Continuity Planning (BCP) is a standard operational risk control practice for organizations, enabling critical processes to function in all conditions. Asset managers and plan sponsors need BCP plans for their portfolios. Achieving this will require methods to measure and model tail risk, rules to trigger BCP plans on predefined market conditions, and a consistent framework for stress testing portfolios and planning for extreme event scenarios.

- Strategic Asset Allocation: Investors are rethinking asset allocation practices with a view to manage downside risk better and avoid investment horizon mismatches, in particular for individual retirement products. They may more formally take into consideration cash-flow requirements and eventually move towards more risk-based allocations.
- Integrated Risk Management: There is wider recognition now that investors need an all-encompassing view of portfolio risk. They need tools to understand not only the level of risk but also the sources of risks. Breaking asset class silos will allow investors to view the sources of risk across all assets in the portfolio. New tools will be needed to look beyond market risk into other types of portfolio risks, such as counterparty risk, concentration and liquidity risk.

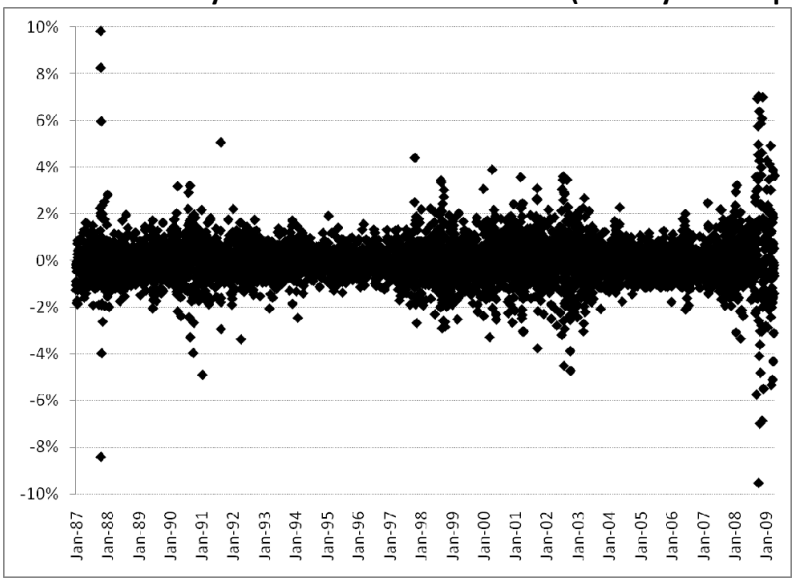
The rest of the paper addresses these three areas in more detail by looking at the main issues of last year's crisis and possible solutions to mitigate their impact.

I. Managing extreme events

Extreme events can be characterized by volatility jumps, increased risk aversion, negative returns for risky assets, and increased correlation across asset classes. Such events actually happen more often than is commonly perceived. The following are examples of major market events that happened over a span of 21 years: Black Monday (1987), Gulf War (1990), European ERM Crisis (1992), Mexican Crisis (1994), Asian Crisis (1997), LTCM (1998), Tech Bubble Crisis (2000), September 11 (2001), Quant Crisis (2007), Credit Crisis (2008).

Aside from the frequency of occurrence, it is also interesting to look at how volatility spikes and clusters through time. Exhibit 1shows the one-day losses in the MSCI World Index over a 20+ year period and reveals how market volatility can change drastically and unexpectedly in extreme events.

Exhibit 1: One-day Losses in MSCI World Index (January 1987- April 2009)



Source: MSCI Barra.
Note: This graph plots losses, and hence negative values denote gains.

Understanding risk regime shifts and flight to quality

A high volatility regime usually develops with a shock in one asset class, extends to other asset classes as investors worry about the consequences of the shock and, in a herding movement, snowballs into panic. At that point, returns from assets are inversely proportional to their riskiness, which is the opposite of expected behavior in normal times. This is illustrated in Exhibit 2, which compares the returns of various asset groups in the worst month of five major crises.

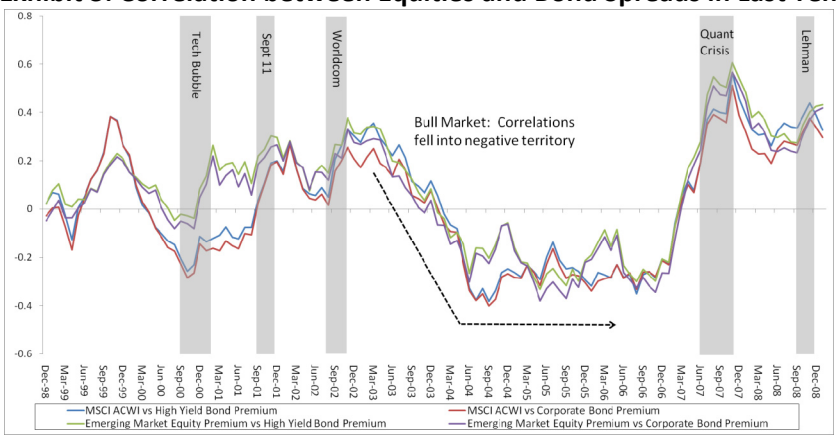
Exhibit 2: Comparison of Asset Returns During Major Crises

	Month	Global Equities			US T-Bills	Global Bonds			MSCI EM Currency Index
		MSCI ACWI	MSCI World(DM)	MSCI EM		Sovereign	High-Yield Premium	Corporate Premium	
LTCM	Aug-1998	-14.2%	-13.5%	-29.3%	0.9%	2.5%	-2.2%	-1.5%	-2.0%
Tech Bubble	Nov-2000	-6.2%	-6.1%	-8.8%	0.7%	2.0%	-1.3%	-0.7%	-0.2%
Sept 11	Sep-2001	-9.1%	-8.8%	-15.5%	1.0%	0.8%	-1.4%	-0.7%	-2.0%
Quant Crisis	Aug-2007	-0.2%	0.0%	-2.1%	0.7%	1.6%	-0.8%	-0.9%	-0.8%
Lehman	Oct-2008	-19.8%	-18.9%	-27.4%	0.7%	-1.9%	-7.4%	-6.3%	-6.3%

Note: The bond indices are sourced from Merrill Lynch, the T-bill data from Federal Reserve and the rest are from MSCI Barra. All returns are based in US dollars. The MSCI EM Currency Index measures the strength of emerging market currencies relative to the US dollar. The high-yield and corporate bond premia are based on the differential in returns between the high-yield or corporate bond index and the sovereign bond index.

While equities were the worst performers in all these crises, bonds were also affected through the widening of credit spreads. The other aspect of this contagion phenomenon is that assets that were previously negatively correlated may no longer remain so in a crisis, which significantly alters the diversification picture of a portfolio. Exhibit 3 illustrates this effect by displaying the correlations between equities and bond premia in the last ten years. For equities, we display the returns of global equities and the relative returns of global emerging to developed market stocks. For bonds, we use the returns of global corporate and high-yield bonds relative to global sovereigns. In general, correlations are unstable and tend to change over time. However, during the periods of crisis as highlighted in grey, correlations generally rose substantially, which caused equities to become more correlated with bonds and hence reduced diversification benefits.

Exhibit 3: Correlation between Equities and Bond Spreads in Last Ten Years



Source: MSCI Barra, Merrill Lynch.

Note: Correlations are monthly, computed using all daily returns within each month, and smoothed by using a six-month moving average.

Since correlations can change quickly over time, particularly in crises, a well-diversified portfolio in normal times may still be subject to unexpected volatility in extreme circumstances. It is therefore also important for us to understand tail risk, particularly how to estimate and manage it appropriately.

Modeling Extreme Events

A common statistic currently used to measure downside risk is Value at Risk (VaR). This statistic is defined as the maximum loss a portfolio is expected to incur over a specified time period, with a specified probability or confidence level. For example, if the one-week 99% VaR of a portfolio is 20%, then there is a 99% chance that the loss of this portfolio over a week is not more than 20%. In other words, there is only a 1% chance that the weekly loss would exceed 20%.

Traditional VaR methods, however, tend to underestimate the likelihood of extreme events because they usually assume that returns are normally or lognormally distributed. In reality, the empirical distribution of asset returns displays what is called “fat tails”, which simply means that extreme events are more likely to occur than is implied by the normal distribution. Assuming a normal distribution may underestimate the likelihood and magnitude of extreme losses. Risk estimates that may be acceptable during normal periods are prone to fail just when extreme events actually happen, resulting in unexpectedly large losses.

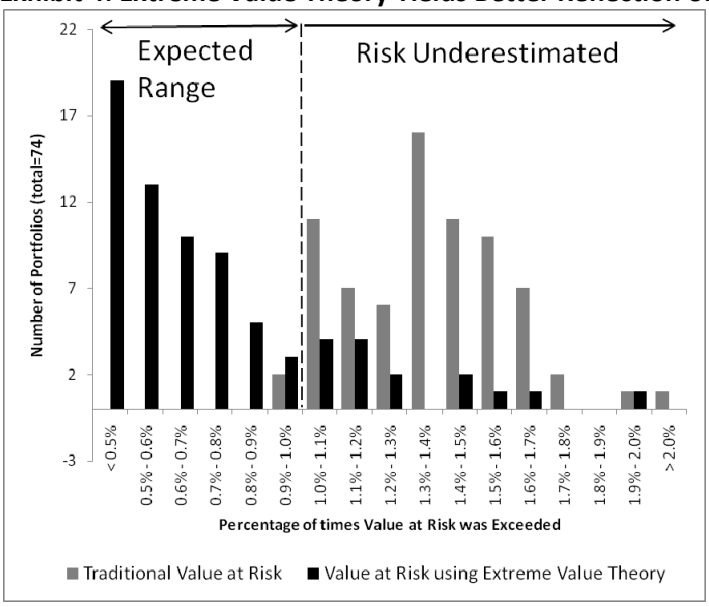
This problem of fat tails is not unique to financial markets and has received much attention in other disciplines, such as hydrology and structural engineering. Researchers in these disciplines approach this problem using extreme value theory, which focuses on the distribution of returns at the tails. This is precisely what is required for analyzing market crises, since these are extreme or tail events. The normal distribution is only adequate as a reflection of average returns but not extreme ones. In extreme value theory, the distribution of the tail values instead follows the Generalized Extreme Value (GEV) distribution. Once the tail distribution is determined, the VaR can then be computed as in the normal distribution.

Exhibit 4 provides an example, extended from Goldberg et al [2008], of how extreme value theory can provide a better reflection of the downside risk. We compare the relative robustness of the traditional VaR and the extreme-value VaR for a variety of portfolios composed of US equities. Daily returns are taken from December 1996 to October 2007, a period that covers major crises that include the Asian crisis, LTCM, Tech Bubble, September 11, and the Quant Meltdown in August 2007. Value at risk figures are generated using two methods: the traditional way in which returns are assumed to be normally distributed and exponentially weighted across time, as well as through extreme value theory. We choose a confidence level of 99% and a time horizon of one day, so that the resultant VaR figures should represent the maximum daily loss that would be incurred with 99% probability.

To compare the two measures over a variety of different portfolios, we evaluated 74 factor-tilted portfolios. It is important to note that the VaR numbers generated here are forecast values. In Exhibit 4, the horizontal axis is divided into interval ranges that denote the percentage of days in which

actual losses are greater than the VaR, while the vertical axis displays the number of portfolios (out of the possible 74 in our sample) within each interval. Ideally, all portfolios should be to the left of the broken line. This is true for the majority of the portfolios when using the extreme value VaR, but not in the case of the traditional VaR. While about 80% of the portfolios meet this criterion under the extreme value measure, only 3% do so in the case of the traditional measure. There is therefore a stark contrast between estimates of a risk measure – value at risk – that is generated based on normal and non-normal distributional assumptions.

Exhibit 4: Extreme Value Theory Yields Better Reflection of Downside Risk



Source: Barra Extreme Risk (BXR) model.

In addition to better modeling of fat tails, extreme value theory also introduces a tail risk measure that provides a more complete reflection of the expected loss in a worst case scenario. While value at risk tells an investor his worst expected loss in 99% of the trading days, it does not indicate how severe the loss would be in the remaining 1%. *Expected Shortfall* measures the expected loss within that worst 1%. Goldberg, Hayes, Menchero and Mitra [2009] have demonstrated how this new concept can be integrated in the standard toolkit used to measure portfolio risk and to show how different portfolios have different downside characteristics.

Options to Manage Tail Risk

Business Continuity Planning (BCP) is a standard risk control practice for organizations, enabling critical processes to stay in operation even if a disaster strikes. This practice is well established in all industries including finance, as well as in non-business organizations such as the military. We suggest that an analogous concept, which will be referred to as Portfolio BCP, would be relevant for portfolio management.

Generally, Portfolio BCP would require the following steps to be implemented. Firstly, the definition of an extreme event has to be determined. This could be based on returns, volatility, tracking error, value at risk, drawdown, or a combination of these measures as captured in a scenario. In addition, risk factors like the Barra style and industry factors may also be used as measures. The probability and severity of the extreme events can then be quantified, as was carried out in Bhansali [2008]. Secondly, thresholds have to be decided upon, so that the conditions for triggering the BCP are clear to everyone involved. Thirdly, scenarios should be elaborated to cover the most likely current threats. In order to rehearse these potential extreme events, stress tests should be performed to simulate the performance of portfolios under such situations. Finally, portfolio trades reflecting the mitigating decisions should be prepared and pre-approved by the various investment committees for fast and consistent execution, should those extreme events happen.

In this context, the importance of stress testing under extreme conditions should be emphasized, since this would help determine how much tail risk should be hedged away. In recent years, stress testing has attracted the attention of both regulators and practitioners as an important measure that complements traditional risk measures such as volatility, tracking error and VaR. Increasingly, regulators such as the Basel committee and EU Commission (UCITS III Directive) require that practitioners incorporate stress testing into their regular risk management practice. Stress testing is particularly important because it helps to mitigate the over-dependence on recent historical data. Multi-asset class risk systems often include dozens of predefined stress testing scenarios.

II. Rethinking strategic asset allocation

The issues of last year also highlighted the mismatch between the investment horizon, the level of risk investors can bear and the characteristics of their portfolio. The most problematic cases were seen in the defined contribution space, but this issue also affects mature pension plans.

A retiring worker who expects to exit the work force in one year should take on much less risk in his investments than a young worker in his twenties who is looking at another forty years of employment. Sounds obvious? Yet, individuals retiring in 2009 that put their savings in a 2010 target date fund would typically have seen them shrink by 20 to 30%. For someone purchasing an annuity at retirement under these circumstances, it means a permanent loss of revenues in the same proportion.

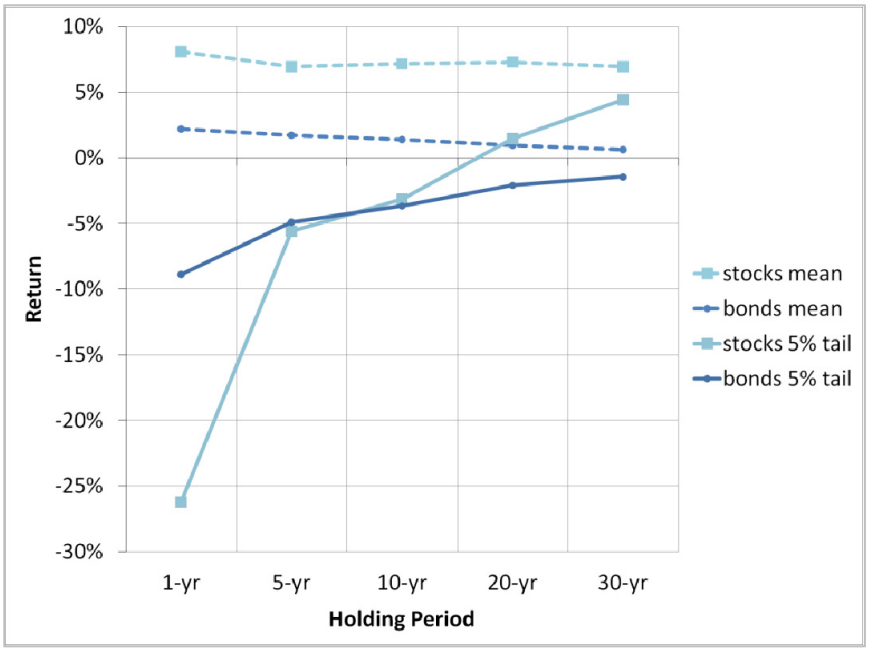
Understanding Investment Horizon and Downside Risk

Asset allocation decisions have to be made in the context of the risk-return characteristics of various asset classes and the tolerable downside risk, which is determined by the length of the investment horizon. The investment problem is therefore to maximize long-term real returns, subject to having protection against inflation or deflation, as well as having downside risk bounded within an acceptable level.

The investment horizon is an important element to this problem because it is related to the appetite for downside risk. While the returns of an asset may be positive in the long run, in the short run the possibility of losses cannot be ruled out. Long horizon investors have greater capacity to withstand

short-term losses because they see beyond these short-run fluctuations to the long-term trend that will in time reassert itself. Exhibit 5 illustrates the various dimensions of the problem.

Exhibit 5: Historical Real Returns for US Stocks and Bonds (1926-2008)



Source: MSCI Barra, US Census Bureau, Federal Reserve and Global Financial Data.

This chart compares the historical returns of US stocks and bonds, net of inflation (real returns), over different holding periods or investment horizons from 1 year to 30 years. The dotted lines represent the average returns for stock and bonds for all periods and the solid ones show the bad outcomes (divider between the best 95% and the worst 5%). When you look at the simple average, stocks offered systematically higher real returns, even after the two major down markets of 2002 and 2008. These results for the US markets are largely consistent with findings in other markets around the world over similarly long periods, even if the US equity market has one of the highest returns, as highlighted by Dimson, Marsh and Staunton [2009].

However, when looking at downside risk, as measured by the worst 5% of returns, the picture is completely different. Equities were very volatile over a one-year horizon, while bonds were less so. Only cash provided more protection in extreme events. More generally, the downside risk was higher in the case of stocks for relatively short holding periods of up to five years. For longer investment horizons, the drawdown risk was not as significant, and in fact for horizons of more than 10 years stocks even enjoyed a slight advantage.

Why is this particularly important for individual investors? Most retirement solutions offered to individuals today are trying to find optimal solutions for average investors, which is different than solving for the constraint of an individual retiring at a unique point in time. This is not surprising given that most research has been conducted in the context of vehicles pooling assets and liabilities such as defined benefit plans. Unfortunately, an individual in a defined contribution world does not benefit from pooling liabilities with others. An individual planning for retirement needs to have

sufficient funds until his or her maximum life expectancy and not the average one. On the contrary, an insurance company providing an annuity service would be pooling the liabilities, allowing it to focus on the average life expectancy since individual differences are cancelled out at the aggregate level. Similarly, while the average investor will not retire on a catastrophic year since that is not a regular event, the prudent individual investor cannot rule out the possibility that he or she will retire in a year like 2008.

Segregation of assets and liabilities forces individual investors to put more emphasis on tail risk than pension funds with very long horizons. The optimal solution for an individual is therefore found in the context of the worst case scenarios and not the average ones. The logical consequence of this statement should lead to a dramatic change of the asset allocation of individual retirement products, such as target date funds, towards less risky assets close to retirement.

Towards Risk-Based Asset Allocations

Another reason why diversified portfolios did not offer as much downside protection as anticipated during the events of 2008 is that diversification strategies were often mis-applied. In particular, it has become clear that the categorization of asset classes in a portfolio has an influence on the approaches chosen for diversification. Many pension plans are still using a categorization of assets classes that groups assets into three buckets: equities, fixed income and alternatives. The category of alternatives includes private equity, private real estate, hedge funds, commodities and other real assets.

This segmentation reflects more the structure of the asset management practices than the role that the assets are supposed to play in the portfolio, and that has lead to some undesirable effects. Firstly, the fixed income category has evolved to include a mix of low risk government bonds with higher yielding assets like corporate high yield bonds and emerging markets bonds. The rationale for including these higher risk fixed income instruments in the fixed income segment was that these assets were providing higher returns and diversification to the rest of the bond portfolio, which is true if you look only at the bond portfolio in isolation. However, as we have seen in the first section, high risk assets tend to be highly correlated in times of crisis. At the portfolio level, those risky fixed income assets are in fact reducing the downside diversification that you expect from your allocation to bonds. Peters [2008] offers a particularly clear and elegant explanation of this phenomenon.

Secondly, the alternative asset class has often been viewed as in a world of its own where its risk-return profile has no relation with the two other segments, which is obviously not true. One of the characteristics of these alternative asset classes is illiquidity. Illiquidity can create the illusion that assets are not correlated in naïve comparisons with publicly listed equivalents. In reality, there are many fundamental reasons to link alternatives to equities and bonds. Many studies have shown that hedge funds strategies have a high component of traditional beta. Private equity returns are closely linked to public equity returns. Private real estate assets are subject to the same real estate cycles as public real estate assets.

This general loss of purpose about why an asset is in a portfolio in the first place has lead several leading asset owners around the world to move away from the traditional asset class categorization

towards one that explicitly accounts for the role of the asset in the portfolio. We will refer to this approach as risk-based asset allocation.

Exhibit 6: Risk-Based Asset Allocation

Category	Equities	Real Assets	Liability Hedging	Absolute Returns Strategies
Role	To provide the highest long-term real returns	To provide protection against inflation	To match duration of assets with liabilities	To enhance returns with uncorrelated risk premia
Includes	Developed Markets Emerging Markets Small Cap Equities Private Equity Equity Hedge Funds	Real Estate Timberland Farmland	Low-Risk Sovereign Bonds Inflation-protected Bonds	Value/Growth Momentum Credit Spread High Yield Spread Merger Arbitrage Convertible Arbitrage Currency strategies

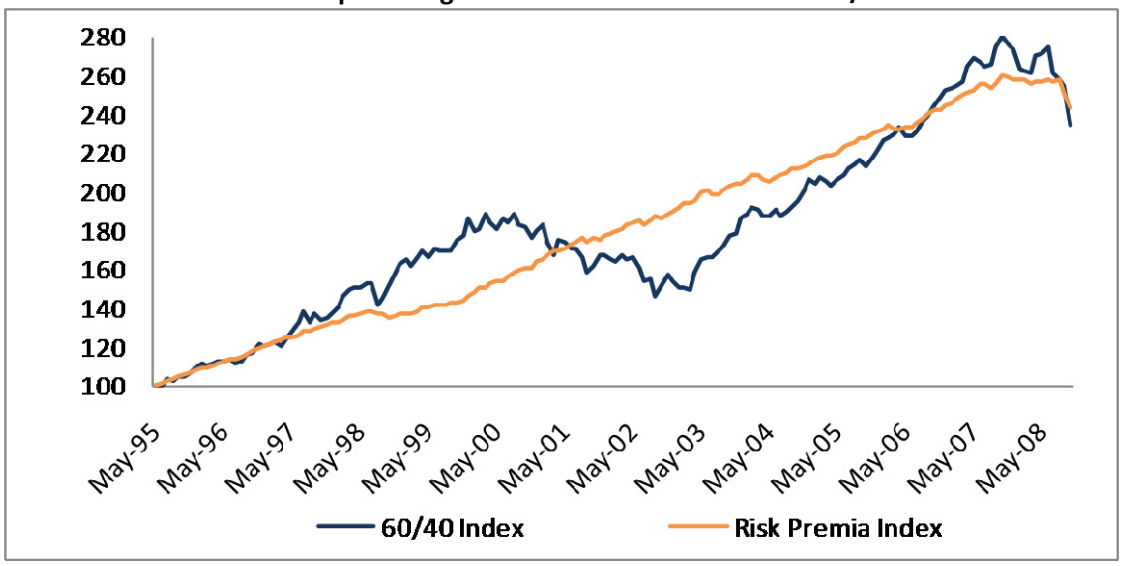
Under this approach, as illustrated in Exhibit 6, a risk-based asset allocation could be structured along four broad segments: equities, real assets, liability hedging bonds, and absolute return strategies. For investors adopting this approach, the equity segment opportunity set could be represented by global public equities covering the broadest investable universe, such as the one captured by the MSCI All Country World Investable Market Index (ACWI IMI). Allocations to private equity and long / short equity hedge funds could complement this core equity allocation to provide a diversified return stream with a strong alpha component. The primary purpose of the equity allocation is to provide the highest long term real returns possible, matching long term economic growth. This core equity allocation could be complemented by real assets. The real assets category could cover real estate, timber and farmland, as well as commodities. Infrastructure investments could also be put in this category, although some may argue it belongs to the equity segment. Real assets would principally be included to provide additional and more effective protection against inflation risk. The third component of this asset allocation framework is liability-hedging. Given the high level of downside risk of risky assets, the closer a retirement plan is to the pay-out phase, the better the liabilities need to be matched with assets of similar nature and duration. This constraint calls for a mix of low risk government bonds, including some allocation to TIPS.

A framework that included only these assets would still leave a high number of sources of risky returns unexploited. These sources could be found in the various risk premia associated with the fundamental factors driving traditional asset classes, such as the small cap or value premium in equities or the credit premium for corporate bonds. For example, an investor investing in small caps receives a market return for investing in equities plus a risk premium for holding small-cap securities. This risk premium arises because small caps are riskier than the average stock, and hence the risk premium is compensation for the added risk that an investor has to bear. Similarly, high-yield bonds yield a return or beta that equals the corresponding yield on a government bond of a comparable maturity, plus a risk premium or spread for assuming the higher risk of holding such a bond. Strategies that aim to capture a specific risk premium through the execution of systematic trading rules also qualify for the risk premium approach. For example, arbitrage strategies such as merger arbitrage or convertible arbitrage qualify under that scheme.

These additional sources of return could be captured in the absolute returns strategies segment of this strategic allocation framework. Briand, Nielsen and Stefek [2009] analyze the risk return characteristics of these risk premia and show that it is possible to create portfolios of risk premia that

offers similar returns to a traditional portfolio composed of 60% in equities and 40% in bonds with significantly lower volatility. The returns of an equal weighted one are displayed in Exhibit 7.

Exhibit 7: Performance of Equal-Weighted Risk Premia Portfolio vs. 60/40 Portfolio



Source: MSCI Barra, Merrill Lynch.

III. Developing an integrated view of risk

Finally, the recent crisis in financial markets has raised the importance of some types of risk that often receive little attention under normal market conditions. These risks include counterparty risk, operational risk, liquidity risk, and concentration risk.

Counterparty risk captures the potential loss from derivative contracts (including swaps, CDS, etc.) should a counterparty default. The bankruptcy of Lehman Brothers has left many pension plans and asset managers scrambling to measure their counterparty exposure to Lehman, which is not a good sign of preparedness. Operational risk refers to the risks attached to people, processes, technology or external events such as fraud. Brown, Goetzmann, Liang and Schwarz [2009] provide a detailed description of how to build a scoring model to detect operational risk in hedge funds.

Concentration risk is the risk arising from all investments in securities of a particular issuer, sector, country, or other common factor. Concentration risk emerged in this recent crisis when securitized subprime assets were found to be present in many parts of investors' portfolios without proper management of the aggregate exposure. Many cash management products, money market funds, and other commonly used investment vehicles were found to be exposed to subprime assets.

The recent credit crisis has also reminded us of the importance of liquidity risk. Market liquidity may fall very quickly as risk aversion suddenly rises in a crisis situation, effectively shutting down certain segments of the market and increasing the cost of selling in most others. For investors, this raises the danger of being unable to meet cash-flow obligations. In 2008, the endowments that were

heavily invested in illiquid asset classes, such as private equity and real estate, found themselves with a sharp liquidity mismatch and had to liquidate part of their holdings at distressed values.

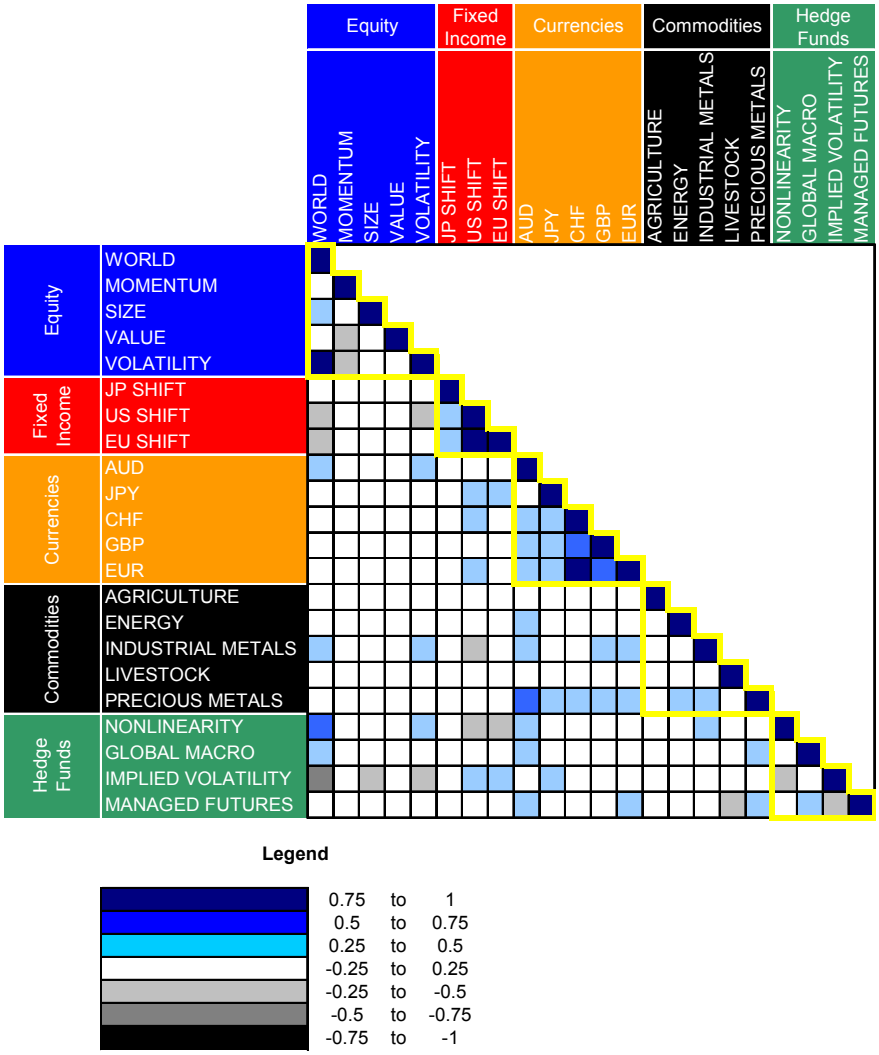
Given the variety of problems, the dynamic nature of portfolios, and the links between assets and asset classes, it is hard to imagine efficiently managing risk at the portfolio or enterprise level without a proper framework to measure, monitor, and aggregate risk. Multi-asset class risk systems can help address this problem.

Fundamental Factors Driving Portfolio Risk and Return

While value at risk and volatility act as barometers to provide an advance warning signal against heightened volatility, these measures are not useful in understanding the sources of risk. Looking at the fundamental factors driving each asset will reveal where the rising risk is coming from. The individual impact of such factors can be derived using multiple-factor models, which not only measure and forecast risk for a portfolio, but also break down that risk according to the contribution from the various factors used in the model. In the Barra risk models, for example, each stock receives an exposure to various factors such as country, sector or style (value, growth, leverage, liquidity, size, nonlinear size, and momentum) that drive risk. These country and industry factors help to determine how much of a portfolio's risk is specific to a particular country or industry after netting out other effects. For instance, a portfolio of Korean stocks is clearly subject to the country risk of Korea, but also reflects the risk of the tech sector that has a disproportionately high weight in that market. Using country and industry factors helps to disentangle these effects and identify "pure" exposures of a portfolio to country and industry risk. Similarly, a portfolio of bonds has different exposures to different changes in the term structure, whether it is a shift of the whole curve, a steepening or flattening of the curve, or a change in its convexity.

At the portfolio level, these fundamental factors will be linked across different asset classes. For example, the value and size factors in equities will be linked to yield curve factors in fixed income, as well as other factors from commodities and other asset groups. Exhibit 8 illustrates how factors can be integrated into a multi-asset class correlation matrix.

Exhibit 8: Subset of a Multi Asset Classes Risk Correlation Matrix



Source: Barra Integrated Model.

With an integrated factor model, factors from the country level are in fact combined together to arrive at the global factors that apply to all markets. This greater granularity allows for different factors in different markets, thereby facilitating a finer analysis of exposures of various assets worldwide. By combining all factors from different asset groups, a portfolio manager can then analyze the exposure of his portfolio to multiple dimensions from a cross-asset class perspective.

In the recent crisis, many investors did not have sufficiently strong modeling capabilities to comprehensively cover the many derivatives in their portfolio, thus causing them to miscalculate the true risk of these instruments. It is now clear that there was an over-reliance on credit ratings, which in some cases were based upon wrong or flawed models. Given the importance of models in risk measurement, modeling risk cannot be put aside. The integrity of the models used, including that of the modelers, should be assessed. Complex and untested instruments should be subject to additional prudential constraints.

Conclusion

This review revealed the complexity of dealing with the many facets of portfolio risk. Hopefully, it also introduced a high-level roadmap for better handling extreme market events.

This crisis has been an acid test to determine which institutions have put risk management front and center and which have neglected it. While risk management did not fully prevent downside in portfolios, it is clear now that the organizations that invested in the intelligent dissection of risks and acted on their findings fared significantly better than those that did not.

At the end of the day, risk management is a state of mind, not a technique. To be successful at managing risk, one needs a desire to be prudent, the means to understand risk, and the discipline to make difficult decisions.

REFERENCES

Bhansali, Vineer [2008]. "Tail Risk Management", Journal of Portfolio Management (Summer 2008), pp 68-75.

Briand, Remy, Frank Nielsen and Dan Stefek [2009]. "Portfolio of Risk Premia: A New Approach to Diversification", MSCI Barra Research Insights (January).

Brown, Stephen, William Goetzmann, Bing Liang and Christopher Schwarz [2009]. Estimating Operational Risk for Hedge Funds, Financial Analysts Journal (January/February), Vol. 65, No.1, pp. 43-53.

Dimson, Elroy, Paul Marsh and Mike Staunton [2009]. "Looking to the Long Term", Credit Suisse Investment Returns Yearbook 2009, pp.11-18.

Goldberg, Lisa, Michael Hayes, Jose Menchero and Indrajit Mitra [2009]. "Extreme Risk Management", MSCI Barra Research Insights (February).

Goldberg, Lisa, Guy Miller and Jared Weinstein [2008]. "Beyond Value at Risk: Forecasting Portfolio Loss at Multiple Horizons", Journal of Investment Management, Vol. 6, No. 2, pp.73–98.

Peters, Ed [2008]. "Does Your Portfolio Have Bad Breadth?" First Quadrant Perspective, Vol. 5, No. 04.

Rogoff, Kenneth and Carmen Reinhart [2008]. "Is the 2007 US Sub-Prime Financial Crisis So Different? An International Historical Comparison", American Economic Review, Vol. 98, pp 339-344.