The role and modernisation of risk management in discretionary multi-asset investing

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Introduction

The importance of risk management has become ever more pronounced in the aftermath of the Global Financial Crisis (GFC). In an effort to spur their economies out of recession and raise risk assets out of a lost decade of returns, developed central banks pulled interest rates to historical lows and, thereby, extended the secular bull market in bonds.

In this post-GFC world, investors have broadened their investment universe to find alternative sources of both return and risk mitigation. This has led to a modernisation of risk management that is more suitable to an investment approach that goes beyond a traditional stock and bond portfolio.

The focus of this paper is to explore the role of quantitative analysis within the realm of discretionary portfolio management, where humans – rather than models – ultimately make capital allocation decisions, specifically within a multi-asset investment framework. In this type of qualitative approach, risk management is necessary for robust portfolio construction. The opportunity set for multi-asset portfolios crosses asset classes, geographies, sectors and currencies. Hence, there are many relationships that should be considered by portfolio managers to take risks efficiently.

Furthermore, aiming to deliver a positive, absolute return in all market conditions shifts the role of risk management from a policing and ex-post analysis function versus a benchmark to one of active involvement in the portfolio construction process. In our view, the analysis and dialogue regarding investment risk is optimal when a risk management expert sits within the investment team and among the portfolio managers to ensure constant and iterative interaction. In this paper, we explore the tools and considerations that comprise our on-desk risk management process, which we believe is essential for enabling a portfolio management team to thoughtfully take risk to garner returns.

Systematic? Discretionary? Or both.

Multi-asset investing broadly encompasses strategies whose investable universe spans more than one asset class. However, these strategies can be sub-categorised on a number of descriptors, including whether they use an approach that is either systematic or discretionary.

The distinction between the two is the main driver of identifying investment opportunities: theoretically, the former makes use of a quantitative model, whilst the latter utilises fundamental analysis. In practice, however, there tends to be some overlap, as human input may play a role in systematic strategies, just as models and systems can play a role in discretionary multi-asset strategies.

The common view is that discretionary, or qualitative, multi-asset strategies may not apply the same rigor as their systematic peers because decision-making is left to humans. However, we believe strategies that have elements of both qualitative and quantitative disciplines may be well suited to avoiding the biases of each – quantitative modelling can mitigate the portfolio managers' behavioural biases just as qualitative input can provide judgement that may mitigate model error.

Ultimately, the role of risk management and a risk manager is to help multi-asset portfolio managers take compensated risk and avoid uncompensated risk to achieve return goals. Risk management is not about limiting risk-taking, as all successful portfolios are inherently risky and return cannot be achieved without accepting some level of risk. Even with the combination of quantitative analytics and experienced, qualitative analysis, investors must remember the distinction between risk and uncertainty outlined in Frank Knight's book, 'Risk, Uncertainty and Profit'[1]. *Risk* applies to situations where the outcome of a given situation is unknown, but the odds can be accurately measured. *Uncertainty* applies to situations, where the odds cannot be accurately measured as not all the information needed is known.

Risk management can explore events and situations, in which outcomes and probabilities can be modelled. However, uncertainty is not measurable; therefore, it is something that investors must accept as a potential disruptor. In our view, the presence of risk and uncertainty in the macroeconomy supports a balance of both quantitative and qualitative inputs into a multi-asset portfolio construction process.

The magnitude and impact of the GFC at the end of the last decade challenged many beliefs on risk and risk management, which sparked a modernisation of industry regulation, as well as the role of quantitative analytics for both systematic and discretionary investment processes. Relying on a single metric alone, such as Value at Risk (VaR), to calculate the potential for losses over a specified time frame for a specified level of certainty, was challenged more meaningfully than in prior market events. The years following the crisis have also coincided with such anemic bond yields that many investors felt the need to reach further out of the risk spectrum for returns and rethink the role of fixed income in terms of diversification and risk mitigation.

Through the "lost decade" in stocks, which started with the tech-media-telecom (TMT) bubble run-up and ended with the thud of the GFC in March 2009, multi-asset portfolios began to evolve by relaxing constraints and finding additional sources of return beyond traditional markets. They introduced a broader scope of investable asset classes and instruments with the aim of achieving the dual needs of investors: return generation and risk mitigation. However, moving beyond the '60/40' style of balanced investing required a deeper analysis of the underlying risk exposures in a portfolio and greater scrutiny of expected diversification, particularly in stressed market environments like the ones experienced during the first decade of the 2000s.

Regardless of the investment style, or analytic tools used, it is important to remember that risk management is not primarily about limiting risk, but improving the profile of risk that a portfolio manager can accept. In that sense, risk management is a bit of a misnomer because it should always take into consideration return management as well. Ultimately, the purpose of risk management is to ensure that risk is being taking thoughtfully, in order to reach a return expectation. However, many risk metrics may be insufficient to effectively reflect both risk and return properly.

Standard deviation, for example, is calculated based on asset price moves. However, we believe that it is essential to consider the composition of total return when thinking about the risk of an investment: what portion of it is price, or capital, moves and what may be the expected carry?

A steady cash flow, or 'carry', may be a component of a total return expectation in an investment, such as income from a bond or dividends from equities. Two markets may appear to have a similar standard deviation, but all things equal, the one that boasts returns with a higher cash-flow component would usually be the preferable option, as this can be a steadier source of return. Likewise, if we look at markets deemed to be more 'risky', such as emerging markets, risk may seem higher than it does for its developed counterparts, and yet, you may be compensated for this through a higher carry.

From a risk-modelling perspective, a manager may be willing to accept more volatility in their day-to-day price moves because the capital moves are being complemented by attractive carry. Another instance where a discrepancy between risk and return can be found is at the point of buying at-the-money call options. They generally look less risky than an outright position in the underlying security or index. However, they will typically have an inherent cost to owning them, which most risk models will not consider, but should be considered in return expectations.

In our view, it is important to have the ability to make that qualitative judgement between risk and return. To do so, it is vital to understand the components of actual return that may not be factored into standard risk analytics. This not only impacts risk management, but return management as well.

Independent risk vs. Portfolio risk

There are often two types of risk that a manager should consider when evaluating their portfolio – standalone, or independent risk, and diversified, or portfolio risk.

In a single asset class portfolio, such as a global equity portfolio, analysing the portfolio's standalone risk means viewing the risk specific to each company's stock held in the portfolio. Independent risk analysis may include an interrogation of the assumptions on each holding – its expected VaR or standard deviation based on how it has behaved in the past - as well as an assessment of how it may behave in left and right tail scenarios. Additionally, a manager may also take a qualitative approach to considering a stock's idiosyncratic risk in their assessment.

Portfolio risk would then take into consideration the interaction of the holdings that comprise the portfolio. Do they diversify one another? Does this combination cause a high exposure to specific risk factors? Making the leap from independent risk to portfolio risk does require some level of acceptance that there is some stability in the assumptions that underlie measures, such as correlations across the portfolio's holdings. For this reason, a sensible approach could be to bucket the holdings into groups that are likely to have a high degree of similarity or stability over time.

In the equity portfolio example above, that might be sectors. So, while company X and company Y might not have a stable correlation due to company specific, idiosyncratic risks, broader sector buckets may have characteristics that tend to persist over time – like the sensitivity of interest rates to consumer staples. Applying risk analytics at this level of grouping rather than at the whole portfolio level effectively helps you to create mini-portfolios that you can interrogate independently, and you can also look at the interaction between them.

This concept can also be applied to a multi-asset framework. Independent risk may be applied at the holding level, but managers may also prefer to apply several different grouping methodologies to allow them to disaggregate risk into manageable partitions. Regardless of the asset class or investment discipline, it is often beneficial to group holdings that have strong, persistent correlations. This can provide more meaningful risk analysis outputs. The diversification benefits implicit in any portfolio, and particularly multi-asset portfolios, are heavily dependent on the interactions, or correlations, between the holdings or risks. Breaking the portfolio down into smaller and more manageable groups within which the correlations assumptions can be better trusted, allows us to analyse these partitions independent of the less stable correlations that may exist at the portfolio level.

Another potential benefit is that these groupings can be purely subjective to allow risk analysis to be done at any granularity required and using any sensible grouping method. For the Invesco Global Targeted Returns strategy (read the investment risks that relate to this strategy on page 11) managed by our team, we use a multi-asset investment approach that we call 'Investing in Ideas'. Here, we group holdings by each macro theme or 'idea' expressed in our strategy to understand risk.

One example of a macro theme is 'Asian Competitiveness', which is expressed by being long the Japanese yen and short the Korean won. This idea looks at the relationship between the central bank weakened yen and the stronger, and potentially overvalued won and their impact on their exports. We can also group by macro factors to understand how an overarching macroeconomic risk, or geopolitical risk may be represented in the portfolio. It is important to use more than one grouping methodology when viewing risk, as many macro themes or ideas can cross asset classes or markets, which may build in diversification within a grouping and 'hide' risk. Slicing and dicing the portfolio into different groupings can help alleviate this. Ultimately, it helps managers understand what portion of their portfolio risk is related to a particular factor – whether it be to a country (e.g. the United States), to a region (e.g. emerging markets), or more generally, to a broad market, like equities. One can even look at subjectively grouping holdings that are exposed to a political event such as the exit of the United Kingdom from the European Union, also known as 'BREXIT'.

This method of disaggregating risk does not diminish the importance of top-down portfolio level risk, since each way of viewing risk (independent, grouped, portfolio) can provide different perspectives and each will have varying elements and degrees of assumptions made that need to be considered. Risk analytics at the portfolio level still help in determining overall levels of expected portfolio risk in conjunction with broad stress-testing and other metrics that are essential parts of many risk models.

Risk Modelling – A Multi-Pronged Approach

"The most that can be expected from any model is that it can supply a useful approximation to reality: All models are wrong; some models are useful."

George Box[2]

Ex-ante risk analytics (parametric risk models)

Initially, research is done to determine which positions a manager may find advantageous to hold in a portfolio to achieve their return objectives. Once a proposed mix of investments is determined, the first necessary step from a risk management perspective is to assess the forward-looking, or ex-ante, risk of those holdings in a single portfolio.

Typically, this involves loading the portfolio's positions into a risk model to provide an estimate of expected risk metrics, such as standard deviation and VaR. There are many different types of risk models that can be used, but one that tends to provide easily digestible information is a parametric, or statistical, risk model. Parametric risk models are often built by taking time series of historically-observed returns for each holding and from them, extrapolating covariance matrixes that provide information on how those positions may interact with each other. This information is then used to make assumptions about how the positions in the portfolio may be expected to act in the future, which allows the manager to assess the risk of each holding on its own (independent risk), as well as taking diversification into consideration, as with grouped or portfolio risk, by using the ex-ante correlations of the holdings.

Ex-ante risk analysis is, therefore, an essential part in informing final portfolio decision making. Fundamental research may not be sufficient support for capital allocation decisions for the portfolio. Using a statistical risk model can provide additional context and confidence that a portfolio's investments, or ideas, are not all representing the same risk exposures and that by combining them into a single portfolio, one can reduce the overall expected risk. Additionally, using a risk model can provide some context around risk budgeting, as shown in Figure 1 – how much risk is being attributed to each investment or grouping and what is the implied diversification benefit of a given combination of them?

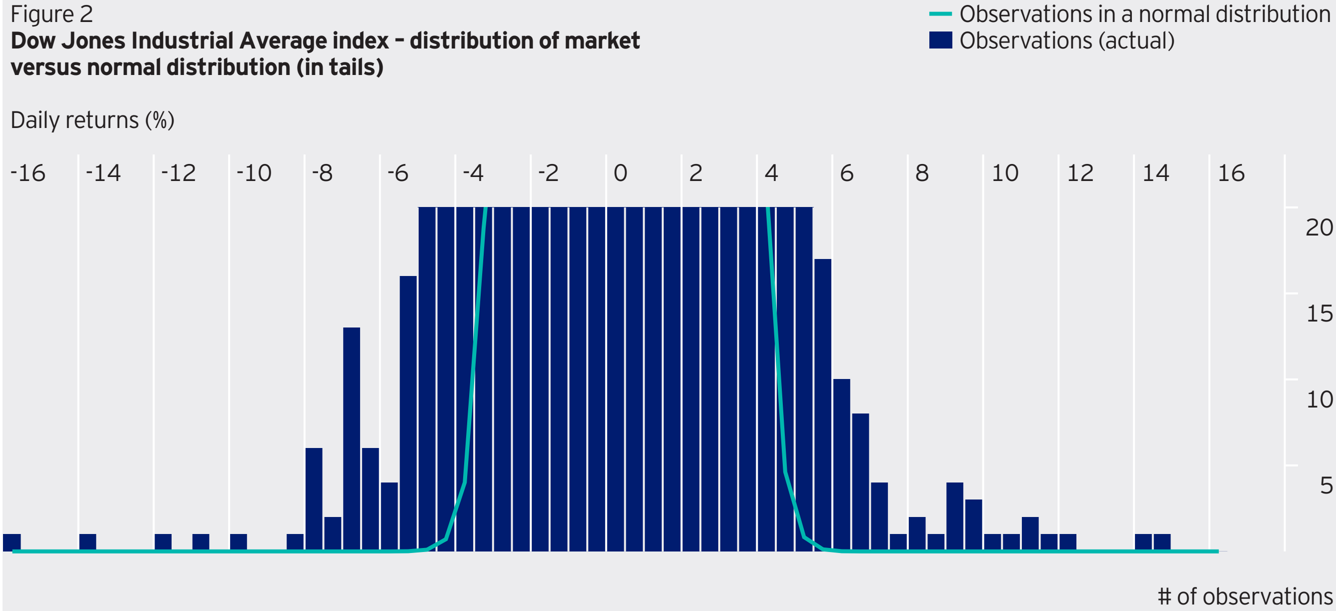
Figure 1
Diversification benefit

For illustrative purposes only.

This 'new' information can be fed back into the qualitative portfolio management discussions to aid in the decision-making process. Are the risks in the portfolio well-diversified? Is the portfolio dependent on any one assumption or single risk factor or exposure? What is the total portfolio risk? Portfolio managers can then consider this information and compare it to the expected returns they may achieve from each investment, investment idea or at the total portfolio level.

As with any models, there are limitations to the ex-ante calculations being evaluated. Therefore, a qualitative assessment of the risk output should include a discussion on model risk. Quantitative models are dependent on the data fed into them, so scrutiny needs to be applied. Statistical models make assumptions on the distribution and independence characteristics of the inputted variables (or in this case, historical return streams of portfolio holdings). Many models, for instance, require acceptance of a normal distribution of returns (or a bell curve), in which the observations are symmetrical around the mean and virtually no observations should exist approximately three standard deviations away from the mean. You can see this illustrated in Figure 2 where the normal distribution of the last 100 years of returns for the Dow Jones would suggest no observations of returns roughly +/-4%, however in reality you can see from the bars that there have been a number of daily returns that exist in the "tails" some well into the teens.

Figure 2
Dow Jones Industrial Average index – distribution of market versus normal distribution (in tails)



Source: Invesco and Bloomberg, L.P. as at 30 June 2017. Data period used: January 1917 to June 2017.

Therefore, when looking at market data, a normal distribution may not be a realistic assumption as many markets can have extreme tails, or even a non-normal skew, so the output from a model may be incorrectly biased. The improper accounting for tail risk can also be an issue when it comes to VaR calculations, which may give investors a false sense of security as the extreme tail (1%) that is not captured in a 99% confidence interval may be well beyond the 99% VaR number.

Another important model assumption that may be challenged in practice is the independence and identical distribution (IID) of the variables being assessed. This assumes that the price move in each portfolio holding is independent and identically distributed, like a coin toss, or rolling dice. However, we can observe that many systems such as financial markets can be subject to persistence or trends. Hence, what a statistical risk model is actually saying is that if returns are both IID and normally distributed, and the past repeats itself exactly with respect to asset relationships and volatilities, then you can expect the outcomes the model extrapolates – but these assumptions are often violated in practice. In fact, financial markets data can exhibit persistence in trends or relationships that are not typically stable over time and, as previously shown, asset returns are not always normally distributed.

The above should be taken into consideration when using ex-ante estimates of correlations and therefore diversification, which are by no means assured ex-post. For example, it is often observed and assumed that when equities fall, bond prices will rise and vice-versa. While typically equities and bonds are reasonably diversifying, it can be an unstable relationship showing periods of both positive and negative correlation. Therefore, one must consider scenarios where historical correlations or assumptions can break down. This is addressed later in the paper when we discuss scenario analysis.

Another noteworthy limitation of risk models is the treatment of instruments with a non-linear payoff profile. Multi-asset managers may take advantage of derivative structures that allow for an asymmetric, or non-linear, return stream. Ex-ante risk models often do not capture non-linear assets or strategies particularly well as they extrapolate risk from short return time frames.

An option or option-strategy's behaviour over a week, for example, can be very different to its behaviour over a month or year and statistical risk models often use extrapolated weekly (or even daily) returns to approximate the risk of the asset. Using these shorter time frames as indicated can be approximately accurate for linear assets, like futures, but can either over- or underestimate the risk of non-linear derivatives substantially. If disregarded this would clearly impact investment decisions, as the benefit of holding the non-linear structure would not come through in the risk analysis.

The ability to have greater upside capture than downside capture for an equal, but opposite move in a market can be a great benefit to investors and one that must be properly accounted for to make appropriate risk budget and capital allocation decisions.

While you cannot completely avoid any of these model risks or biases, there are measures that managers can take to try to complement risk model outputs to provide additional perspectives on risk exposures. In fact, it is essential to take further steps in order to overcome statistical model risk and shortcomings.

Sample bias
Within risk models, one can vary the data set being used to try and avoid any sample biases. Using a rolling window look-back period will allow you to view risk through different regimes, which we believe to be important. This is because ex-post, or realised, risk is not always the same as ex-ante, or expected, risk.

This can be evidenced by the information in Figure 3, where you can see the rolling annualised risk of a portfolio consisting of 60% equities and 40% bonds[3], otherwise known as a 60/40 portfolio, going back to the lead up to the GFC. At start of 2008, the expected 12-month risk for the portfolio would appear to have been roughly 8%. However, as we know, volatility increased dramatically through the peak of the GFC. The realised 12-month risk of this portfolio in 2008 was not known until 2009, but at its peak, this was actually 23%.

Thus, someone investing in 2008 would not necessarily factor into their evaluations that a risk level of 23% was possible by looking at just the single data point of ex-ante risk provided by a risk model. Looking at a range of ex-post risk for a holding, portfolio or grouping may allow you to see a more realistic range of outcomes.

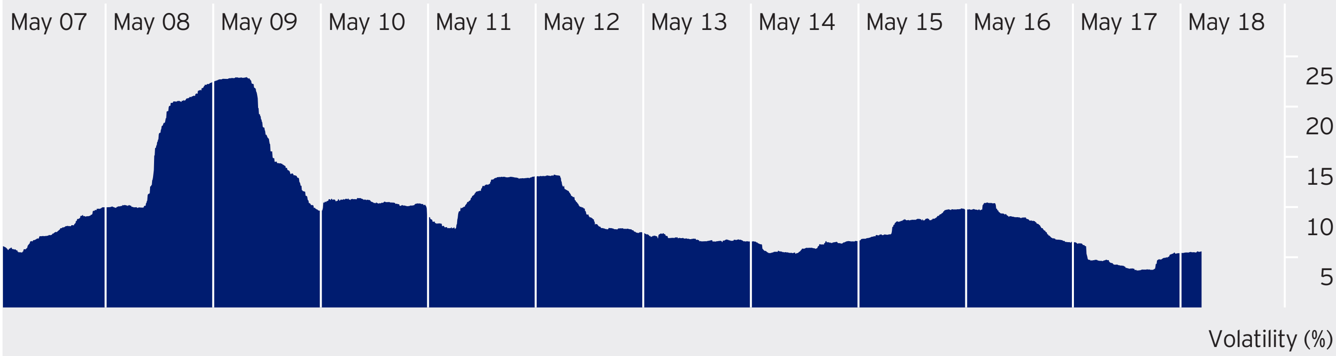
Similarly, Figure 3 shows that investors today may be comfortable considering a risk of 5.5% (measured by standard deviation), as recent experience has been one of a low volatility regime. However, a rolling time window analysis that incorporates events like the GFC shows the consideration of risk should range from at least 4%-23%.

Adding rolling windows and considering a more realistic range for ex-ante analysis represents one step in overcoming a limitation of ex-ante risk models. However, we believe that it is important to extend risk work to additionally consider the non-linearity of certain instruments, the general instability of relationships between assets and the range of outcomes, especially in extreme market events ('tails'), to gain a fuller risk perspective.

Incorporating non-linearity and fat tails
Often, risk models assume that risk can be scaled over different periods, even when rolling periods are considered.Risk metrics like standard deviation can simply be converted from daily to monthly to annually and can be used to calculate VaR over a 95% or 99% confidence interval – take your pick. This is because risk models and many risk metrics assume linearity and IID. Whilst this may not impact some generic uses of risk analytics, it can become problematic the greater the exposure is to non-linear instruments, such as options, or in cases where the output must be extremely precise. Thus, we must extract more empirical information than what a model can offer.

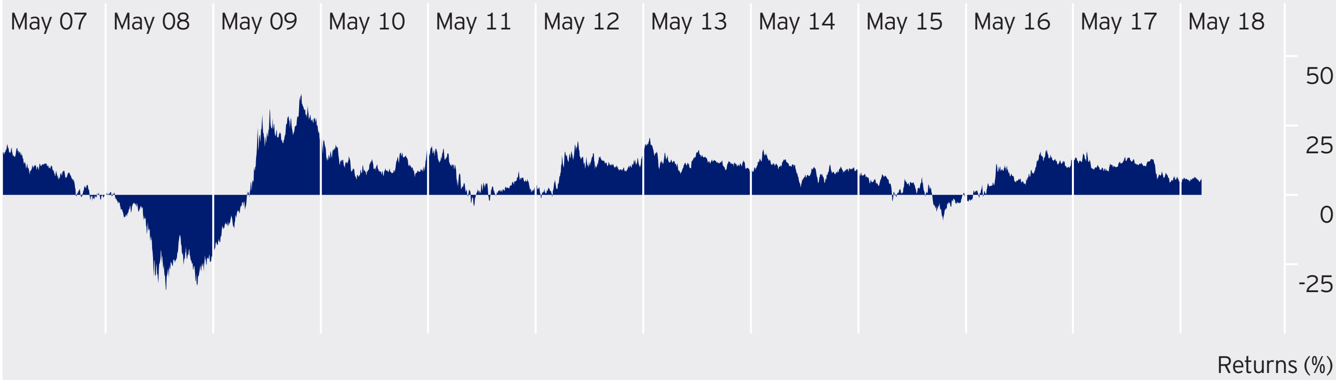
Historical backtesting can provide a more precise range of outcomes or expectations for the portfolio or grouping without having to rely on any correlation assumptions as empirical (observed) asset price moves are used in the simulations. Figure 4 shows a historical backtest of a 60/40 portfolio using rolling 252-day windows. It depicts an expected return range of −37% to +34%, inclusive of any expected carry. We would consider this to be a realistic, empirical collar for volatility and, hence, return expectations as well.

Figure 3
Portfolio risk of a hypothetical 60/40 portfolio using a rolling window of 252 days



Source: Invesco and Bloomberg, L.P. as at 11 July 2018. Period covered: 18 May 2007 to 11 July 2018.
Volatility is measured by standard deviation.

Figure 4
Historical backtest of a hypothetical 60/40 portfolio using a rolling window of 252 days



Source: Invesco and Bloomberg, L.P. as at 11 July 2018. Period covered: 18 May 2007 to 11 July 2018.

With respect to non-linearity, historical back testing allows you to accommodate changes in the behaviour of option structures through time. Inherent in many option structures is a benefit of convexity, whereby the holder is less exposed to the downside than the upside of an equal-sized negative or positive move in the underlying market, typically at some cost. For example, if your exposure to the FTSE 100 Index has a convex, non-linear payoff profile, you would generally experience a higher upside capture of a positive move in the UK equity market than downside capture in a negative move.

One can also appropriately factor in the cost of implementing the strategy to both approximate a realistic return target for the amount of risk assumed, and gain insight into how the strategy has performed previously. Using empirical data can help provide solutions for risk output limitations of non-linear instruments, and it can also take into consideration the shape of the distribution curve, which – as previously discussed – is often non-normal. In the examples provided, the convexity in the payoff profile would lead to a positive skew in the portfolio's distribution shape.

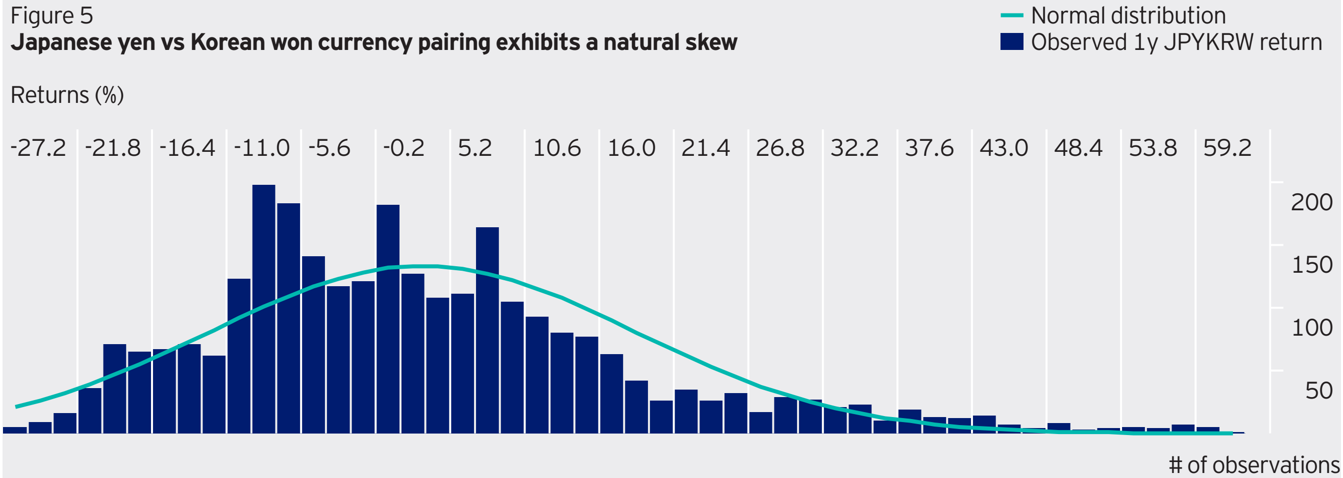
Non-linear instruments are not the only ones that can exhibit skew; some investment relationships, or pairs, can display a natural skew. To illustrate this, let us look at a currency pairing that is long the Japanese yen and short the Korean won. Figure 5 shows that there is a natural skew to this pairing. The bars represent the actual rolling 252-day returns of the currency pair, which are characterised by a much more extreme right tail and a more shallow left tail. This implies a natural skew, whereby the yen has tended to outperform the won in extreme moves.

Figure 6 shows a simulation, which suggests that holding ideas with a natural positive skew, such as the Japanese yen vs Korean won pairing, could have benefitted a 60/40 portfolio during periods of large drawdowns, as the more shallow left tail allows the impact of the drawdown to be lessened. Historical backtesting can allow portfolio managers to contemplate a distribution of returns that exhibit a shape that is more realistic than the 'bell curve' shape that many risk models imply. This may lead to better decision-making, as it could uncover a range of potential outcomes that may be deemed too narrow or too large for the investor base.

When using instruments, like options, to access or protect market exposures, it is important to assess the path dependency of the option strategies to better understand what the payoff profile could look like through time. Many option structures and strategies can appear to have the intended payoff profile at initiation. However, there are many moving parts in determining the price of an option, which can change and affect the true outcome. One way to evaluate this risk is to run simulations which can illustrate many of the potential outcomes for these structures. For more information on this type of modelling please refer to our white paper, Coping with Chaos (Jubb and Singer, 2017).

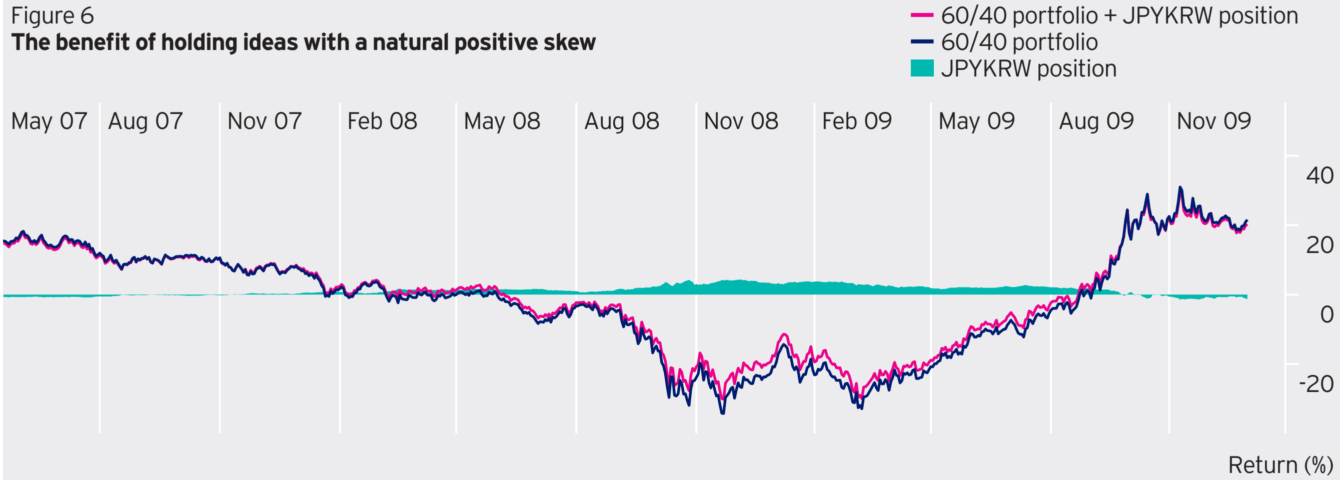
While all models can have their limitations and 'be wrong', they can still be useful and provide meaningful information. It is our view that to address model risk, one must look at risk through many lenses by supplementing model outputs with additional risk measures and qualitative decision making. It is especially important to do this in a way that limits the dependency on easily challenged assumptions, particularly when a portfolio's construct is complex. We do not believe that this should be done by increasing the fit of the model through more complex modelling, as it can then be harder to discern if assumptions are reasonable, and there can be an increased chance of more extreme model risk. Instead, we believe models can be kept robust by limiting dependence on complex model assumptions, and done through experienced, qualitative discussion and judgement.

Figure 5
Japanese yen vs Korean won currency pairing exhibits a natural skew



Source: Invesco as at 31 July 2018.

Figure 6
The benefit of holding ideas with a natural positive skew



Source: Invesco. Period covered: 1 May 2007 to 31 December 2009. For illustrative purposes only.

A tool that is often used to complement ex-ante risk models is stress-testing. This typically involves taking the current holdings of a portfolio and putting them through historical scenarios (e.g. 1987 Market Crash, 1997 Asian Tigers Crash or the 2008 Global Financial Crisis). This would imply using a single correlation matrix or an empirical set of asset returns to determine how those shocked markets would impact the rest of the portfolio.

The result would be a single output of what the expected return would be under those conditions, if the market shock were to happen again today. Whilst this can provide some meaningful information, the correlation matrix that reflects a historical period is not likely to be the same correlation experience that markets will reflect during the next crisis. Many historical shock periods see bond prices rise as equity markets fall, making bonds appear to be a good diversifier to equities. Might the relationship between stocks and bonds behave differently in a period of market stress, if those markets were impacted by central bank policy more than they had been in other historically volatile equity environments?

Many major market events have taken place over weeks, months or even years, but stress-testing generally implies an instantaneous shock. This can provide some context around an extreme outcome for a portfolio. However, it is likely that in a period of market stress, managers would not hold the exact same positions throughout its entirety. Lastly, instantaneous shocks do not often accurately reflect how non-linear structures would perform. In fact, it is extremely important that the path dependency of non-linear structures is well understood in periods of market stress and outcomes may vary based on the speed of the market move.

A more robust application of scenario analysis can help overcome many of the limitations of historical stress-testing by using specified hypothetical events that may be more likely to challenge portfolios given an expected macroeconomic backdrop rather than what had been observed in the past. For example, over most historical periods, it appears that the Japanese currency (the yen), and Japanese equities (represented by the Nikkei 225 index) have moved in opposite directions, or are negatively correlated. This would appear to make sense as a weaker currency can help Japanese exporters, which should in turn be reflected in their share price. Additionally, the yen is considered a safe-haven currency, and would typically do well in risk-off periods which may also see the Nikkei decline.

Investing in both of these Japanese markets (given adequate return expectations) can be a potential source of diversification for a portfolio and one that would be seen favourably by a risk model, in our view. However, since 2017, we have started to see more evidence of positive correlation between the pair, which a risk model with an intermediate term or longer time horizon may not have picked up.

The acknowledgement that correlations can be unstable – even if only temporarily – is important for risk analysis. Historical stress-testing and ex-ante risk models may not consider a temporary change in correlation between two assets, but hypothetical scenario analysis can provide the freedom to challenge historical assumptions and define a portfolio's sensitivity to them.

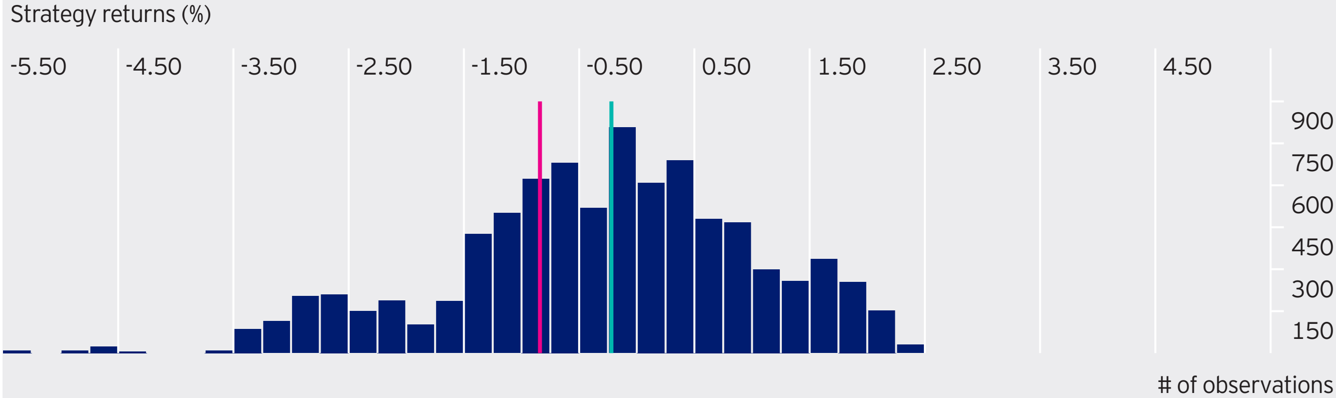
In the scenario analysis work completed by our team, we test a hypothetical scenario of the breakdown of Abenomics, whereby the Nikkei 225 index may fall dramatically, whilst at the same time, the US dollar strengthens against the Japanese yen. This type of risk work is important for two reasons: it allows managers to understand the sensitivity of their portfolio to a market shock by providing a distribution of potential returns, and to test their dependence on the correlation structure by seeing what happens when it breaks.

Here, it is important to note that multiple correlation matrixes are being used to understand the potential return outcomes for a portfolio for this given scenario. As mentioned previously, stress-testing often limits managers to seeing the outcome using a single assumption of correlations, which can be too narrow of a scope to understand what actually may happen. A single point in time risk assessment may thus be overly biased. In our scenario analysis, we use one-year daily rolling windows, whereby actual correlation matrixes are shocked to derive the impact to the portfolio holdings given a specified hypothetical shock scenario. This produces thousands of potential outcomes that can be analysed.

In Figure 7, we show a distribution of potential outcomes in a hypothetical recession market shock, which is specified as US equities falling by 50%, whilst US 10-year Treasury yields fall 100bps. Each window gives a manager insight to a potential outcome based on how markets may interact for a given scenario and can provide insight for more informed decision-making. Investment managers can dig into specific windows to see when the portfolio was positively or negatively impacted by a scenario and delve deeper into what investments or ideas were most and least affected and make some judgements around why it occurred.

Assessing the potential for a similar regime to occur again is then essential in deciding how much weight to give to a particular outcome or window. Investment managers can then make proposed changes to the portfolio and re-run the scenario analysis to understand if adding, removing or changing a holding or investment idea changes the profile of the distributions.

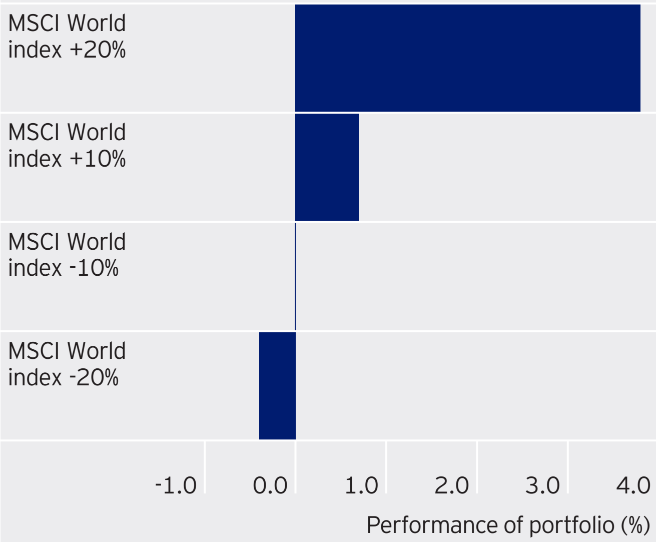
Figure 7
Hypothetical scenario testing – US recession
Distribution of potential strategy returns for a given scenario[1]



Source: Invesco as at 30 September 2018. The data shown relates to a representative account of the Invesco Global Targeted Returns strategy. Portfolios managed in accordance with the strategy may differ due to specific investment restrictions and guidelines.
[1] Green line indicates probability-weighted best estimate, pink line indicates worst case using lower quartile outcomes.
For illustrative purposes only.

Hypothetical scenario analysis should not be limited to macroeconomic-related shocks, but can also encompass single market or single instrument shocks to test a portfolio's sensitivity. Unilateral shocks as part of hypothetical scenario analysis can enhance discussions around convexity and improving VaR assessments. To better understand convexity in a portfolio, a set of symmetrical asset shocks, such as testing a portfolio when the MSCI World index moves up and down 10% or 20% (Figure 8) will show the difference in upside versus downside capture, if any.

Figure 8
Hypothetical testing of a portfolio against the MSCI World index



The data shown relates to a representative account of the Invesco Global Targeted Returns strategy. Portfolios managed in accordance with the strategy may differ due to specific investment restrictions and guidelines.

On a related note, the tail risk of a non-linear portfolio can be vastly understated by calculations like VaR. For example, selling far out-of-the-money options that have very little chance of being exercised, particularly as it moves closer to expiry, is unlikely to be registered in a VaR calculation, and yet could cause a meaningful hit to a portfolio's performance should a crash occur. Scenario analysis can identify and mitigate these exposures.

The information from scenario analysis can be an additional input into the decision-making process, as it informs the decision-makers of how they may be compensated for holding a particular investment, given the possibility of a plausible, but improbable event. As with other risk models and metrics discussed, whilst scenario analysis helps alleviate the prevalence of a regime or time period bias in modelling, it is not without shortcomings.

Whilst multiple time windows and correlation matrixes are used to understand impact, one limitation of the discussed approach to hypothetical scenario analysis is that it still applies an instantaneous shock to each window, disregarding the reality of market events, which typically play over time. Additionally, just because the correlation assumptions used can be varied, this does not mean that every possible iteration has been captured.

Moreover, it is still necessary to make assumptions about the weightings of the outcomes to derive some sense of what the best estimate of the scenario's impact to a portfolio is. Our team uses a weighted average of thousands of possible outcomes, which overweighs correlation environments that are more consistent with the prescribed shock. In our 'Failure of Abenomics' scenario example, outcomes from windows where the Nikkei 225 index and Japanese yen both fell together would be overweighed in the calculation relative to a period where they exhibited negative correlation, in order to get a 'best guess' estimate of the portfolio's hypothetical return in that scenario.

Lastly, while scenario analysis does incorporate the change in exposure to things such as Greeks in option strategies, it downplays the fact that the broader holdings of a portfolio may not remain static, as managers typically have the ability to trade during a market event.

We believe that having the final decision for a portfolio be driven by a qualitative decision-making process can help improve upon model risk. The human element of portfolio construction can allow for sound judgement, based on experience and qualitative analysis, to overcome biases in risk model outputs. This can be especially helpful near an inflection point or around a market shock. Quantitative models may not have the ability to assess the escalation of a geopolitical event or the increase in potential for policy error. Whilst human timing is by no means perfect, the overlay of qualitative judgement on quantitative inputs may better digest information that would otherwise not be found in data until after the event occurs. While it is also the case that there are behavioural biases that can lead to poor decision-making, the introduction of fundamental assessments provide additional information that can be essential to a macro-driven investment process.

Measuring diversification through factor work

At the start of this paper, we defined independent risk and the notion of grouping to aggregate risks into related and digestible partitions. That grouping exercise was defined as being largely subjective, whereby managers can take related macro ideas, asset classes, or market exposures and turn them into a group for risk and return analytics.

An additional approach to grouping a portfolio can be similar to factor work, which quantitative managers apply to understand the types of risk factors that comprise their portfolios. Looking at a multi-asset portfolio through a factor lens requires different work than decomposing the portfolio into the style factors used by many equity managers (momentum, size, quality, etc.). Here, we will explore additional methodologies of quantitative analysis akin to factor risk work that can complement subjective macro grouping to understand risk and expected diversification of a portfolio.

Traditional factor analysis allows you to directly test the explainability of a portfolio's returns on a set of defined market or style factors. Often, investors allocate to multi-asset portfolios to provide a return stream that is independent of easily observable, replicable factors. To prove that a portfolio's returns could not have been easily replicated through a set of factors, single and multiple regression analysis can be done on the portfolio's returns. This can also be useful to a portfolio manager to see, if there has been a single exposure or factor that has been driving returns as it may be unlikely that this will persist indefinitely.

Ideally, the outcome of the regression analysis shows that there is little explanation of a portfolio's returns from a single index or a set of indexes. This would be observed by analysing the R-squared and F-statistics in the output of a regression analysis from a statistical software package. For example, if you are testing the returns of a multi-asset portfolio (dependent variable) against common market indexes (independent variables), you would be testing how close to the same return stream you could have gotten by holding one or more of those markets instead.

The F-statistic would tell you if the independent variables are jointly significant in explaining the multi-asset portfolio's returns. Here, significance is a minimum threshold for believing the validity of the analysis. If deemed not significant, then your model has no explainable power. The R-squared would express how well the independent variables have explained the portfolio's return stream. A low R-squared indicates a low level of strength of the model. However, macro-driven investing may require a more specific strategy or discretionary set of macro factors to truly extract the clustering of hidden risks in a portfolio. Market-adopted style factors (value, momentum, size, etc) typically work best in an equity context, but will fail to pick up certain exposures when incorporating other asset classes.

Principal component analysis (PCA) can be one approach to discerning the level of genuine diversification in a multi-asset portfolio. This mathematical tool explains the drivers of the variance of a portfolio by decomposing it into a set of uncorrelated (orthogonal) variables called principal components (PC), which are ranked based on how much of the portfolio's variance each represents. While the principal components themselves are just statistical variables, you can do further sensitivity testing to understand their relationships to various markets.

For example, in many equity long-biased portfolios, you will find that the first and most significant principal component (PC1) may be highly correlated to equities and negatively correlated to volatility. PC2 will then be represented by the next highest grouping that explains the residual variance. If this was a traditional 60/40 balanced portfolio, PC2 would probably look a lot like interest rate risk and these two principal components would explain a fair amount of the total portfolio variance.

In a more diversified, multi-asset portfolio, you may still find that at times PC1 is highly correlated with a single asset class, such as equities. However, you likely have several other large principal components that explain a significant proportion of the portfolio's variance. For this reason, PCA can help determine if a portfolio is truly diversified and independent as expected.

PCA provides a distribution rather than a simple statistic, which makes it difficult to interpret. We use a method introduced by Attilio Meucci[4] to summarise the distribution into a single number. With this simple statistic we can then, for example, look at how the level of diversification has varied through time. Simplistically, what this single number shows is how many equally-weighted, uncorrelated risk factors explain the variance of the portfolio's returns.

Even if a portfolio is believed to be comprised of many idiosyncratic risks, one must be aware of the possibility of spurious correlation. This term explains when a variable, in this case portfolio holdings or groups like ideas, appear to be correlated and lose their diversification benefit, but not for a fundamental or explainable reason. Spurious correlation between truly independent investments should not persist over longer periods of time, but can occur on a day to day or week to week basis. This means that even a portfolio that is highly comprised of idiosyncratic risks can appear to have components that are interdependent on another, the broader markets or factors. Because of this, investors should be wary of judging a portfolio's factor dependency or diversification on a short-term basis.

Also, during periods of higher volatility, diversification amongst markets which previously appeared less correlated can evaporate and can cause investments to correlate positively. If a portfolio is constructed robustly, it should still have a high number of independent variables explaining its risk, and therefore also driving its returns – a "truly diversified portfolio". We can use this analysis to sense check the expected diversification of a portfolio through time. This compliments the output that the ex-ante risk analysis provides on the diversification benefit of holding our investment ideas in a single, risk-managed portfolio.

Conclusion

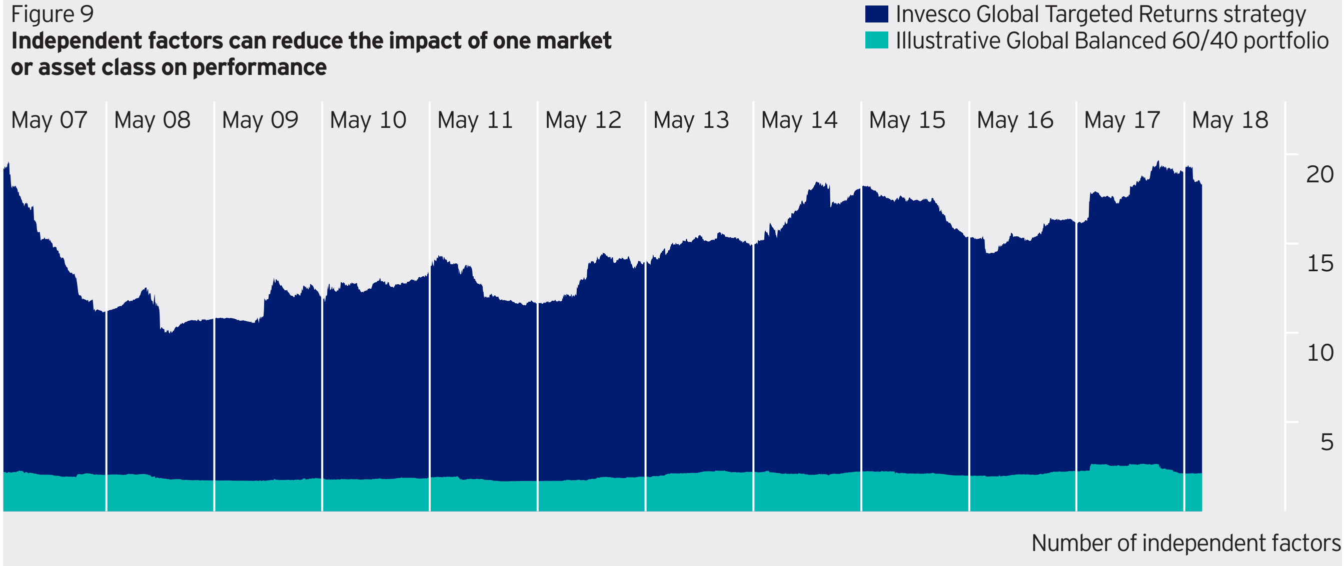
The role of risk management and a risk manager is to provide portfolio managers with the ability to take risk in a manner that helps them achieve their mandate. In the case of a multi-asset portfolio, this mandate is typically centred on steady capital appreciation through a diverse set of sources, leading to a lower volatility profile.

By taking a multi-pronged approach to risk modelling, risk managers can help mitigate model risk. For example: How does a multi-asset portfolio perform in different regimes? Does the portfolio have good asymmetry and skew (more positive months or quarters than negative ones)? Does the portfolio have a narrow distribution of returns that avoids extreme tails?

To achieve results consistent with investors' expectations for multi-asset mandates, we believe that risk management needs to be an inherent and iterative part of a portfolio construction process. Furthermore, if a manager is purporting to have the ability to provide a return stream with greater consistency through diversification, then it should be apparent in their return attribution that there is significant breadth across the sources of performance contributors over a cycle (as defined by the manager's time horizon).

As discussed, risk managers should approach risk from many different lenses using the modern tools that are available, but be cognizant of the potential for model risk and, of course, that uncertainty will always exist. Complementing strong quantitative input with experience and time-tested qualitative judgement may yield the best results when investing across many markets and asset types, where assessing historical and expected relationships is essential.

Figure 9
Independent factors can reduce the impact of one market or asset class on performance



Source: Invesco as at 30 June 2018. For illustrative purposes only. Subject to change. *Illustrative Global Balanced 60/40 portfolio comprises of 60% global equities (15% FTSE 100, 15% Eurostoxx 50, 30% S&P 500) and 40% global bonds (20% US Treasuries, 5% Global high yield, 15% Global corporate bond indices). To determine independent factors, Principal component analysis was used to explain the variance of portfolio holding returns as statically uncorrelated factors and the distribution of these factors was summarised as a single numerical statistic. This statistic is equivalent to the number of equally-weighted uncorrelated factors that comprise the portfolio.

About risks

The value of investments and any income will fluctuate (this may partly be the result of exchange rate fluctuations) and investors may not get back the full amount invested.

The Invesco Global Targeted Returns Strategy uses derivatives (complex instruments) for investment purposes, which may result in a portfolio being significantly leveraged and may result in large fluctuations in value. The strategy may hold debt instruments which are of lower credit quality which may result in large fluctuations in value. Changes in interest rates will result in fluctuations in value.

Derivatives may be more volatile and less liquid than traditional investments and are subject to market, interest rate, credit, leverage, counterparty and management risks. An investment in a derivative could lose more than the cash amount invested. A decision as to whether, when and how to use options involves the exercise of skill and judgment, and even a well-conceived option transaction may be unsuccessful because of market behaviour or unexpected events. The prices of options can be highly volatile and the use of options can lower total returns.

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Commodities, currencies and futures generally are volatile and are not suitable for all investors.

Important information

[1] Knight, F.H. (1921) Risk, Uncertainty and Profit. Hart, Schaffner & Marx; Houghton Mifflin, Boston and New York.

[2] Box, George E. P., Hunter, J. Stuart & Hunter, William G. (May 2005) Statistics for Experimenters: Design, Innovation, and Discovery – 2nd Edition. Wiley-Interscience

[3] Equities are represented by a 30% holding in the S&P 500 Total Return index, a 15% holding in the FTSE 100 Total Return index and a 15% holding in the Euro Stoxx 50 Net Return index. Bonds are represented by a 20% holding in the Bloomberg Barclays US Treasury Total Return Unhedged USD index, a 15% holding in the Bloomberg Barclays Global Agg corporate Total Return Value Unhedged index and a 5% holding in the Bloomberg Barclays Global High Yield Total Return Value Unhedged index.

[4] Meucci, Attilio (2009) Managing Diversification, Bloomberg Education & Quantitative Research and Education Paper.

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