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Managing investment uncertainty with asymmetric strategies

Key messages

- As investors, we want to convert our risk tolerance into a source of opportunity. In doing that, we will always face uncertainty around market events and their timing. Adherence to strong convictions as events unfold can lead us to deviate from our investment objectives, potentially triggering undesirable market timing mistakes.
- Consciously separating uncertainty (which we accept as a source of potential opportunity and loss) from risk (which we want to avoid taking on excessively) helps investors to take more efficient risk management decisions.
- Systematic downside protection can be used to allow us to remain within risk tolerance levels, while extending upside exposure as far as possible.

01 Introduction: why systematic downside protection?

As investors, we expose ourselves to **uncertainty**. We do this with the ultimate goal of achieving financial gains that make it worthwhile to subject ourselves to this uncertainty. However, along with this return goal, we also – consciously or implicitly – pursue a **risk objective**. We want to remain within our own risk tolerance: the amount of loss we think we can endure without being driven to change our market exposure.

This fundamental investment objective translates into a behavioural one: we are able to lose some money, but not so much that we are panicked into responding in an impulsive and irrational way, deviating suddenly and drastically from our existing investment strategy, which was designed to pursue our long-term goals. Most investors have at some point experienced situations of extreme uncertainty and doubt, which have led them to change their investments significantly. The opportunity cost of such changes often leads to underperformance over the long term, compared to remaining invested continuously.

When we talk to prospective clients about introducing **systematic downside protection** into their portfolios, in order to fully benefit from their risk-taking ability, while avoiding unwanted losses and the behavioural impact that comes with them, we usually face two kinds of responses:

- One type of investor – **the market timer** – fundamentally views portfolio protection as a drag on performance. While they would welcome having less risk, they are not willing to continuously invest to achieve this goal, because they are confident about their opinion on the market risks in the immediate future. When they view these risks as acceptable, they don't see a need for protection. When on the other hand they worry about declining markets, they purchase protective instruments or change their asset allocation. Typically, market timers proceed to take action by either investing or disinvesting, when they have a strong opinion on future market developments; in between those market timing actions, they maintain exposure, or a lack of exposure, with lower conviction.

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- The second type of investor – the **strategic asset allocator** – would like to keep their portfolio stable and avoid taking significant allocation decisions in the context of market moves – because they consider these market moves as unpredictable. However, they are confident about their long-term assessment of the relative attractiveness of different market segments; in particular, they would show a preference for shifting their risk exposure into asset classes with superior real long-term returns (such as equities). Strategic asset allocators view portfolio protection as a complementary tool to the diversification of risk factors, supporting them to maintain their exposure to attractive market segments at as high levels as possible, in a continuous way. Similar to any economic decision as to whether or not to purchase an insurance policy, their willingness to invest into ongoing downside protection depends on their long-term market expectations, and on the cost of the protection.

In summary, investors' inclination towards systematic downside protection depends essentially on what they are confident about – which could either be their ability to predict markets and act accordingly in the short term, or their ability to assess market segments' attractiveness in the long term, and to stick to a consistent investment approach continuously. It is commonly understood that **market timing** is not only very difficult, but investors would have to be taking successful market timing decisions far more than half of the time, in order to overperform a continuous investor[1]. Nevertheless, investors' acceptance of long-term, systematic investment and risk management approaches still depends on their varying perceptions around their ability to explain and forecast market moves.

In this publication, we set out the challenges of investing in uncertain markets, how these challenges impact our perceptions and decisions as investors, and how systematic risk management can best be used to support our long-term goals – by protecting our portfolios from excessive losses, and from the undesirable investor actions that often come with them.

What are systematic downside protection strategies?

When we use the term "systematic downside protection" in the context of this publication, we understand such an investment strategy to be rule-based with the ultimate objective of achieving a defined risk exposure. The benefits and costs of increased robustness (i.e., being able to limit risk as reliably as possible) are consistently weighed against those of higher efficiency (i.e., being able to reduce risk as cheaply as possible); a systematic economic advantage is pursued. In this understanding, such approaches consistently use market pricing models based on real statistical data. They are independent from short-term market opinions. In summary, these types of approaches use historic data in a consistent way to gain a future economic advantage, and they have the tools to measure their success in retrospective.

However, the term "systematic downside protection" is sometimes also used for approaches which are only rule-based, without incorporating the future relative attractiveness of the different investments, or Risk Premia. Typically, they make use of certain market signals (which are then taken as input triggers to change the allocation), or they pursue a parametric purchasing programme[2] of certain derivatives. These latter types of strategies may well be systematic in terms of applying a specific rule set, but they do not have the means to evaluate the economic rationale for the investor of sticking to those rules over time.

In the present publication, we focus on the first of the above-mentioned strategies which, at their core, have the purpose and the means to provide a quantifiable economic long-term benefit to the investor.

02 Uncertainty and recent market crises

The uncertainties of investing are twofold: It is uncertain what will happen, and when it will happen – both in terms of real events, and of the markets' response to them. In terms of portfolio construction, the "classical" approach to dealing with these uncertainties has been to **diversify investments** across asset classes that (it is hoped) will respond in different ways to future events.

However, recent market crises – 2007-2008, 2020 and 2022 (see box overleaf) – show that this portfolio diversification approach to managing uncertainty may not be reliable enough. The relationship between asset classes' returns has been different in each of these crises: simultaneous falls in different asset classes have led to overall portfolio losses.

Recent market crises nevertheless have one important common factor. Each one appears predictable, logical, unavoidable and even obvious in hindsight. Still, all of them took the financial community by surprise. Why? The problem is that we are good at finding explanations in retrospect – but, when evaluating the future, a rational choice between the many plausible market scenarios is very difficult. As a result, investors tend to put too much weight on short-term perceptions and convictions. Such perceptions and convictions can make us rationalize a given situation – they help us to take any decisions amidst uncertainty. However, when they turn out to be wrong, they can lead investors into very difficult situations which can trigger drastic actions on their portfolios.

Recent market crises: all different

One lesson that we take from the last three market crises – the Global Financial Crisis (GFC) which started in 2007-2008, the 2020 stock market crash prompted by the Covid-19 crisis, and the 2022 bond market sell-off – is that history does not repeat itself. These crises were interconnected, but each had a different impact on financial markets.

***The 2007-08 start to the GFC** caused the largest global decline in equities and real estate assets since the Great Depression in 1929. But, since government bond markets became a safe haven for investors, diversification effects in multi-asset portfolios mitigated part of the heavy equity losses.*

***The 2020 Covid-19 crisis** led to an even faster stock market crash. Investors worried about the global economy's resilience to global lockdowns. But, unlike in the GFC, European and U.S. government bonds also sharply lost value in parallel with equities' severe declines. During much of March-April 2020, trading in most fixed income securities became difficult due to market liquidity issues.*

***The 2022 bond market crash** was also coupled with a global decline in equities – albeit a far more moderate one than in the GFC and Covid-19 crises – , but for rather different reasons. Rapid central bank interest rate rises due to inflation worries led to an unprecedented decline in government and corporate bond pricing. But at the same time equities were also affected by concerns around global trade, broad geopolitical turmoil, and the Russia-Ukraine war. Both asset classes declined largely in unison, meaning that diversification had little effect (aside from commodities price increases).*

As a result, losses in 2022 for most fully-invested multi-asset portfolios were in a relatively narrow range: it didn't make a significant difference whether an investor had been positioned at the outset of 2022 as 'conservative' (with a low equity allocation and a focus on government bonds) or 'aggressive' (with significant equity and credit exposure).

03 Current challenges to investor perceptions

Current contradictory perceptions around inflation and the "transition" to higher rates illustrate this problem. The start of central bank rate hikes in 2022 has kicked off **a period of transition which deeply challenges our perceptions, inclinations and metrics on the returns we pursue and the investor risks we are prepared to take.**

During one and a half decades of ultra-low to negative interest rates up until 2020-21, and inflation persistently below central bank targets, investors learned to look to (higher yielding) equity exposure to help them achieve their investment objectives. Thinking about returns in nominal terms also became the norm, because inflation seemed non-existent (at least according to traditional measures – not so in terms of some asset prices).

Fed rate increases in 2022 started to upset these ingrained perceptions which had been prevalent since the GFC. They destroyed one old conviction: that it should be almost impossible to lose significant amounts of capital invested in high-quality debt, whether governmental or corporate. But they also created a new conviction: that, with the end of the era of low yields, risk-averse investors would be able to get fairly compensated again with regular, predictable cash flows, which they had yearned for all these years. This, in turn, fostered a belief that investors could reach their return objectives with fixed income investments – despite continuing high inflation, which will likely diminish gains from higher yields.

There are multiple reasons for this **propensity of investors to revert to a fixed income and cash focus**. One reason is a belief that inflation should be transitory, while higher yields are perceived as more durable. Another reason is a view that 2022's fixed income losses should be treated as a one-off, with its effects mitigated by the higher yields now on offer. Also, some fixed income investors tend to pursue a "pull-to-par" approach (i.e. they rely on the expected tendency, barring a default, of a bond's price to approach face value as its maturity date nears), which effectively results in treating the fixed income portfolio as an illiquid buy-and-hold investment, with full exposure to roll risk at its maturity – while accepting the much lower return expectations for a liquid bond portfolio, compared to the profitability demands on private debt.

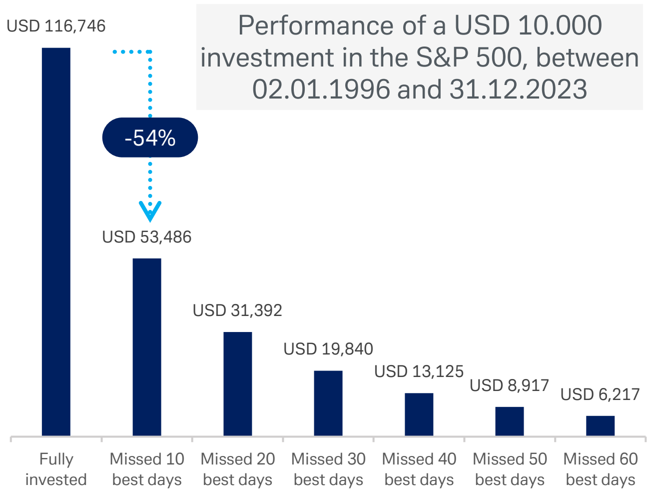
These perceptions don't just rely on a belief that we can predict the future. They also remind us that **supposedly rational investment calculations are often based on shaky metrics**. Investors, for example, can find it difficult to translate strategic return objectives from nominal into real terms because it is hard to determine which real-time inflation rate should be applied. These problems are hard to resolve and worth detailed analysis. Focusing on falling purchasing power over long-term time horizons (rather than current inflation rates) can be one way to help us navigate our mindset around the question how to achieve resilience in the financial markets. But it should always be remembered that such an approach is based on inflation-related price changes of consumer goods, services and rents. Investors need also to consider the value development of asset prices. We may return to this subject in a future study.

04 Building better portfolios: distinguishing uncertainty from risk

Successful investing depends on challenging our own perceptions and interpretations of what is happening. We may be reluctant to do this. We tend to avoid change as long as possible, until the circumstances trigger a sudden strong response. But changes made when we reach the limits of our risk tolerance (e.g. during market crises) can be very expensive, as assets may have to be sold off cheaply, limiting our scope for future gains when the market eventually picks up.

Figure 1 illustrates how costly such sell-offs can become over a long investment time horizon. Not being in the market during the few days with very strong performance can have a high impact on the ultimate performance outcome. It is also interesting to consider that the majority of days with the best and worst market performance have typically occurred within very short timeframes, when market turbulence has been at its peak. In summary, this indicative analysis not only underlines the importance of remaining invested, but also points out the challenges of trying to time the market.

Figure 1: The cost of not staying invested



Source: Deutsche Bank AG. Data as of September 2023.

We can consciously invest into precautions to minimize the chances of reaching these risk tolerance limits. But this involves answering two basic questions:

First, how do I measure my investment success/performance?

Second, how do I define my risk tolerance – and what will I do when it is reached?

Answering these questions prepares the ground for the way we ultimately construct our portfolios, and how we act as investors over time.

Some of the consequences of our answers to these questions are relatively straightforward. On the **performance** question, for instance, if we want to prioritize steady cash flow expectations over total return objectives, then this will shift the asset allocation's tendency towards fixed income securities – meaning we accept that inflation's impact on the portfolio might be stronger, in the long run, than for an allocation with higher equity exposure. Conversely, the more we align our chosen return comparison to real market returns, as opposed to nominal ones, the more the portfolio design needs to aim towards higher inflation resilience – but the more unpredictable and volatile its short- to medium-term performance is likely to turn out.

Our **risk tolerance** answer could in fact be even more decisive for our fate as investors, because it will heavily impact our short-term behaviour in response to immediate market developments. The word "behaviour" is used here with care: it does not just imply an active, conscious choice (e.g. direct asset allocation changes in response to changing market conditions). It can also refer to the passive acceptance of certain types of opportunity costs as a result of our selected risk management strategy.

Measures of risk tolerance can exist over multiple dimensions. For instance, we may want to accept only a certain level of **volatility** in a portfolio. Or we may want to set a hard limit to the **maximum drawdown** of a portfolio, after which we accept being unable to invest. If we do this, we have to decide over what timeframe this drawdown should be measured; the timeframe has an influence on how likely specific drawdowns may occur. We also have to decide whether to define risk tolerance in absolute terms, or to link it to a benchmark allocation (which ideally has similar expected risk as our portfolio).

All these decisions have important implications. Putting a limit on volatility, for example, either implies that we limit our exposure to volatile asset classes or have risk management measures in place which mitigate volatility. The timeframe for drawdowns will have implications for how reliably a loss is limited and how frequently we may end up in a cash lock. Defining risk tolerance relative to the behaviour of a benchmark allocation means that we will have less direct control over our maximum loss, but we will more likely be able to remain invested. Our decision-making process can be supported by transparency on what the outcome of an alternative, acceptable strategy would have been.

Successful portfolio investing also requires a **distinction between the concepts of uncertainty and risk. Uncertainty** means that we have expectations about the future based on prior observations – but accept that the outcome may deviate from them: We can't anticipate the future. This uncertainty can materialize at multiple levels: what, how frequently and when things will happen, and their likely impact on financial markets (all of which are difficult to predict). By contrast, taking on too much **risk** means that we decide to subject ourselves to the risk of negative outcomes that we don't want to experience. This distinction supports us in being able to embrace uncertainty and control risk.

But the key point is to accept uncertainty about future returns as a fundamental feature of financial decision-making, not an unwelcome problem. Then we can see uncertainty as a source of opportunity as well as challenge. To do this, we could start thinking (in some ways) as an entrepreneur. We have to be convinced we have long-term opportunities worth pursuing and that to do this we have to stay in the game at all times – through both unexpected setbacks and successes. To stay in the game, we need to do what we can to avoid risks that might cut our participation short.

05 How asymmetric strategies work

Asymmetric[3] investing can help us avoid the risks inherent to investments exceeding our risk tolerance limits. Once investors recognize that the boundaries of their risk tolerance may impact their behaviour in an undesirable way (e.g. by making them withdraw fully or partially from the market), they consciously invest into precautions to minimize the chances of reaching those limits. Uncertainty is accepted as a fact of life; the aim is to manage risk in a systematic, consistent way throughout time.

How can asymmetry be introduced to portfolios? One way is via **rapid, rule-based, continuous allocation changes** as a result of actual performance developments. A second approach is to use systematic purchases of asymmetric protective derivatives, such as Put options[4], to effectively **invest in a hedging layer** which partially compensates for negative portfolio performance in market downturns, and adapts its value in real time.

For both approaches, risk management quality depends – albeit to a varying degree – on both how realistic the underlying market models are, and how efficiently the strategies are implemented. Investors should be able to compare the systematic advantages and disadvantages of both approaches – in particular, the balance between their robustness and their efficiency. Do I prefer a strategy that requires virtually no investment in most market phases (like CPPI, i.e. Constant Proportion Portfolio Insurance[5]), but can have high and unpredictable costs in very volatile markets? Or do I prefer an approach (systematic purchase of non-linear derivatives – usually options) that requires a predictable, moderate investment in most market phases, and can provide a reliable reward in very negative markets?

The perspective an investor takes to assess the economic benefits and costs of protection in a given market phase will also be important. A **risk-adjusted perspective** compares the chosen asymmetric portfolio to a symmetric one with similar likelihood for losses beyond our risk tolerance; a **return-adjusted perspective,** by contrast, will compare the asymmetric portfolio to a similar asset allocation, but without the protective measures – which therefore is more risky.

All in all, we consider that the second alternative, an **option-based hedging programme,** with the purpose of a long-term risk-adjusted advantage at a portfolio level, should best reflect the interests of an investor seeking to remain invested throughout unexpected market phases. Maintaining as much predictability as possible in your hedging strategy's comparative performance behaviour makes it easier to hang on to it over the long run, and not get frustrated by unexpected setbacks (with accompanying temptations to disinvest) – which is really the key objective of this type of investor.

Asymmetry, portfolio returns and the importance of perspective

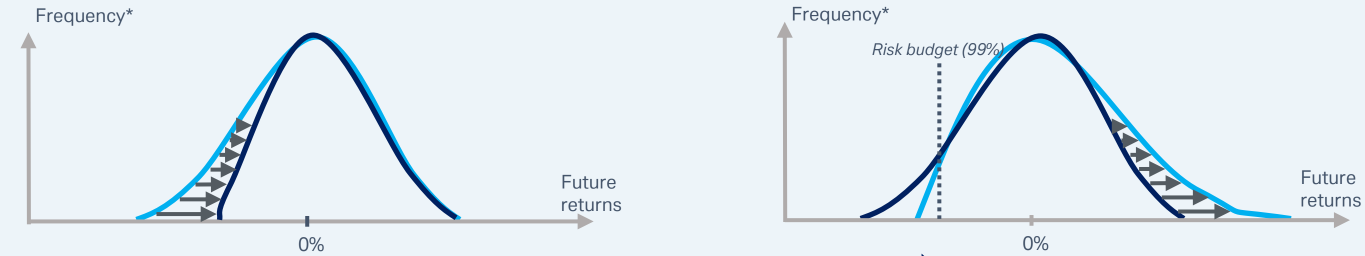
The two schematic charts in Figure 2 illustrate how the return distribution of a portfolio can be transformed through the introduction of an asymmetric investment strategy, where the left-hand side of returns (which are undesired) is compressed into a smaller range than the right-hand, attractive return scope.

*Starting from the same basic allocation, the chart on the left shows the resulting return distribution when the investor has a focus on maintaining similar returns but achieving lower downside risk than in the past; this investor keeps **a return-adjusted perspective** when comparing the performances of the old and new portfolios. It will take a major market downturn for investors with a return-adjusted perspective to see the advantage of asymmetry in a portfolio.*

*Conversely, the chart on the right shows the result of taking a **risk-adjusted** perspective: here, the investor is focused on maintaining a similar downside risk as before, whilst expanding the portfolio's upside potential. As most investors tend to change their allocation choices due to changing risk perceptions (and usually not due to the perception of their returns' adequacy), taking a risk-adjusted perspective is key to evaluate the attractiveness of investment strategies in general, but especially of an asymmetric investment strategy. This perspective helps to see how asymmetry can turn exposure to the positive side of uncertainty into a long-term advantage; it highlights the strong impact of rare and unpredictable very high returns on the long-term compounded return.*

Figure 2: Return- and risk-adjusted comparisons of long-only and asymmetric strategies

Return-adjusted perspective | Risk-adjusted perspective



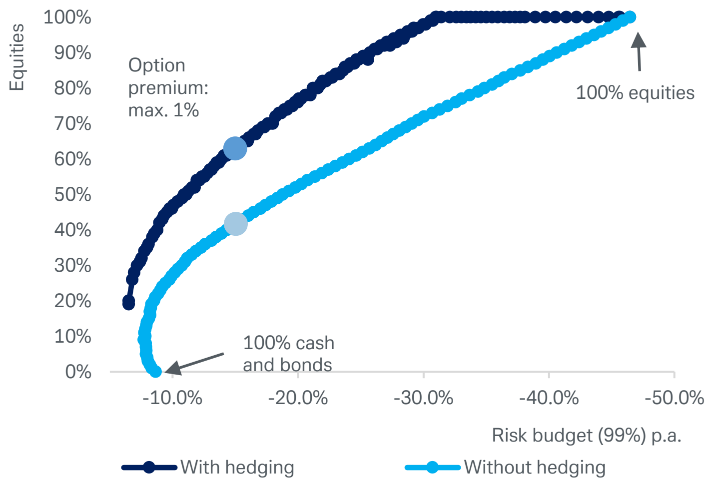
Return-adjusted perspective:
- Idea: Decrease the risk budget while maintaining upside participation
- Approach: Comparing investment strategies with same expected return

Risk-adjusted perspective:
- Idea: Increase upside participation while maintaining the risk budget
- Approach: Comparing investment strategies with same risk budget

*Logarithmic scaling. No assurance can be given that any forecast or target will be achieved. Source: Deutsche Bank AG. Indicative charts only.

What such option-based hedging can do is allow an investor to increase their allocation to equities, for a similar level of risk. The indicative chart below shows the impact on risk-adjusted market exposure. We consider a simple portfolio consisting of two assets, the MSCI World index and the JPM Government Bond index (1-10 year maturities). The simulations show what happens to the tradeoff between equity exposure and risk, when the equity allocation is gradually changed from 0% to 100%. The light blue curve shows the risk resulting from a given equity allocation for a symmetric portfolio. The dark blue curve represents a portfolio which can have up to 1% investment in options, selected by an optimization procedure which aims for the highest upside exposure at a given risk.

Figure 3: Hedging strategy supports more equity for similar risk: Risk budget vs. Equity exposure for unhedged and hedged portfolios



The risk budget of a portfolio is the maximum loss the portfolio is expected to have, over a specific time horizon, with a specific probability. For example, a portfolio with an annual risk budget of -15% at a confidence level[6] of 99% is expected not to exceed a -15% loss in 99 out of 100 one-year timeframes. Source: Deutsche Bank AG. Data as of December 2023. Indicative chart only.

The above chart is only indicative, as it is based on a range of assumptions. But the underlying message is clear: asymmetry can enable more upside for the same risk, over the long term.

Many factors will impact the extent of this upside. More expensive options, for example, will limit the possible increase in equity allocation. The composition of the fixed income part will also strongly affect the achievable equity increase; portfolios with riskier fixed income allocations may benefit to a lesser degree from option-based hedging.

Such an approach can only make economic sense if there is no “hedging at any cost”; protection should only be purchased if this is expected to increase our long-term chances for higher returns – i.e., the balance between hedging costs and expected upside from higher exposure should always be used to validate a hedging decision economically. By pursuing the most efficient strategy in a consistent, continuous and efficient manner, we can support our key long-term investment goals in a rational way: Maintaining as much upside exposure as possible, in view of our risk tolerance, and staying invested in irrational markets.

06 Conclusion: use your risk tolerance to pursue long-term investment goals

We always take decisions under uncertainty; as investors, we must fundamentally accept this. The key to success is to remain conscious of this uncertainty: we will never be able to predict the future, and our short-term convictions can turn out to be utterly wrong. Instead, we need to see uncertainty as a key feature of the investment landscape that can be managed to our advantage. We want to benefit from our risk tolerance as a source of opportunity; at the same time, we need to avoid facing a situation where our risk tolerance is exceeded, leading us to withdraw (expensively) from the market.

Asymmetric strategies can support this goal, if investors are able to define their market exposure and risk tolerance objectives – which can be mirrored in a reference long-only allocation. By mitigating extreme risks, asymmetric investing can enable higher exposure to attractive, more volatile asset classes. There are several different asymmetric portfolio approaches. Our conviction is that an option-based hedging strategy best reflects the interests and requirements of an investor seeking to remain invested through unexpected market phases. If it can be implemented in an economically efficient way, option-based systematic hedging can support the achievement of investors’ long-term objectives.

For most investors, the main objective is to maximize their upside exposure, given the downside risk they can accept. To achieve this goal as well as possible, two actions are key: Taking the investor’s risk tolerance as a starting point to build the investment strategy; and maintaining a consistent risk-adjusted comparison perspective throughout time, to evaluate past results and to decide on the way forward.

In summary: asymmetric strategies’ pros and cons

What are the benefits?

- More potential upside to attractive and hence risky assets, for a given portfolio risk;
- Enhanced reliability of portfolio returns in addition to diversification, leading to higher robustness;
- More transparency and measurable impact in harsh market conditions;
- Allows consistency over time in goal-setting.

What are the disadvantages?

- Any form of risk reduction decreases upside potential, for a given allocation;
- Possible economic cost in specific market situations;
- Requires a long-term strategy and comprehensive portfolio view.

Notes

1. See our report "SAA key topics: market timing" for a fuller explanation.

2. I.e., derivatives with specific properties are continuously rolled over (for instance, a constant proportion of a portfolio's notional could be covered on a monthly rolling basis with S&P Put options which are, at purchase, at 90% moneyness and 3 months maturity)

3. Asymmetric, in a broad sense, refers to a situation where the two sides of an object or distribution are of different size or shape. An asymmetrical investment strategy will show different types of performance behaviour in positive and negative markets; its goal is to expand the scope of potential positive returns, while aligning the range of potential negative returns with the risk tolerance of the investor. The distribution of financial returns in an asymmetric investment strategy (as outlined in Figure 2) therefore shows positive outcomes to be more broadly distributed than negative ones.

4. A Put option is a contract giving the option buyer the right, but not the obligation, to sell a specified amount of an underlying asset at a defined price, at or prior to the option's expiration.

5. Constant Proportion Portfolio Insurance or CPPI products are based on a dynamic asset allocation strategy, which actively allocates between a riskless asset class and a risky asset class. In rising markets, the strategy allocates more towards the risky asset class, while in falling markets, the strategy allocates more towards the safe asset class.

6. A 99% confidence level for an annual risk budget implies that according to model-based estimations, the portfolio loss could exceed the risk budget in 1 out of a 100 annual time periods.

Previous Deutsche Bank publications on related topics:

SAA: Robustness amidst uncertainty (September 2019)
SAA key topics: market timing (February 2020)
SAA robustness: what it means (May 2020)
Diversification: managing eggs and baskets (November 2020)
High nominal yields, high inflation: the case for systematic hedging (May 2023)

Glossary (1/2)

The term asset allocation refers to the distribution of the investor's capital across multiple asset classes, such as equity, fixed income, debt, cash, and others. The primary purpose of asset allocation is to reduce the risk associated with the overall investment, while maintaining the upside potential as high as possible.

An asymmetrical investment strategy aims to change an evenly-balanced distribution of returns/losses into an asymmetric distribution where the positive outcomes are more broadly distributed than the negative ones.

A cash lock describes the event that the exposure to risky assets in a portfolio drops to zero and remains there, unless the investor takes an active decision to increase risk exposure again.

Constant proportion portfolio insurance or CPPI products are based on a dynamic asset allocation strategy, which actively allocates between a riskless asset class and a risky asset class. In rising markets, the strategy allocates more towards the risky asset class, while in falling markets, the strategy allocates more towards the safe asset class.

The Consumer Price Index is a widely-used inflation measure. It tracks the price change over time for a basket of goods and services, which is representative of current consumer spending patterns. The change in the basket's price represents the rate of overall inflation faced by consumers.

The diversification of a financial portfolio is the allocation of capital in such a way that exposure to any one particular asset or source of risk is reduced.

Downside protection is the approach chosen by an investor to prevent an unwanted loss in their investment value.

The Global Financial Crisis in 2007-2008 was the most severe global economic and financial crisis since the Great Depression (1929-1939).

The JPM Government Bond Index tracks the performance of government securities issued by the most liquid developed markets.

Market timing means the purchase and sale of financial assets due to the anticipation of pricing changes.

The maximum drawdown is an asset's largest price drop from a peak to a trough.

The MSCI World Index includes large and mid-cap stocks across 23 developed markets, with around 1,500 constituents.

Nominal interest rates are the rates quoted in loan and deposit agreements. Real interest rates, on the other hand, are obtained by adjusting nominal rates for the decrease in the real value (i.e. purchasing power) of the borrowed or deposited funds. The decrease in the real value of the funds over a given period is equal to the rate of inflation for that period.

The normal distribution or Gaussian distribution is a continuous probability distribution with certain mathematical properties which make it very practical for analytical calculations. In natural, social and financial sciences, it is often used to model the behavior of real random variables with unknown probability distributions. However, many actual variables can show extreme behaviours that deviate significantly from those resulting from a normal distribution.

The opportunity cost of an investor is the potential lost profit resulting from making a specific investment choice amongst the spectrum of different potential alternatives.

Option-based hedging is a risk mitigation strategy which uses options to reduce a potential loss in an asset's value.

By parametric purchasing programme, we understand a hedging strategy where derivatives with specific properties are continuously rolled over (for instance, a constant proportion of a portfolio's notional could be covered on a monthly rolling basis with S&P Put options which are, at purchase, at 90% moneyness and 3 months maturity).

Protective non-linear derivatives are generally options (as opposed to linear derivatives such as futures, forwards or swaps). Options have a non-linear pay-off, which changes with the value of the underlying asset.

Glossary (2/2)

In this text, the concept of risk is understood to be a characteristic of undesired events, which can be quantitively measured. For investors, taking on excessive risk means that their investment strategy is not in line with their risk tolerance (defined below), as the potential returns of their investment may show an unacceptably high likelihood to turn out so low that the investor would change their asset allocation as a consequence. Conversely, taking on too little risk implies that the investor foregoes upside opportunities which they would be able to benefit from, given their risk tolerance.

The Risk Budget of a portfolio is the maximum loss the portfolio is expected to have, over a specific time horizon, with a specific probability. For example, a portfolio with an annual risk budget of -15% at a confidence level of 99% is expected not to exceed a -15% loss in 99 out of 100 one-year timeframes.

Risk Premia are the expected returns of risky assets which exceed the risk-free rate of return, thereby compensating the investor for the incurred risk.

Risk tolerance is the level of risk an investor is willing to assume in order to achieve a potential desired return.

An investment approach is characterized as robust when its pursued risk-return profile depends as little as possible from uncertain assumptions (like e.g. the reliability of underlying data). The investment strategies' robustness increases if adverse errors affect its risk-return-profile to a lower degree. In this regard, the balance between efficiency (how can I improve my return expectations most strongly, assuming my assumptions/data is valid?) and robustness (how strongly do I rely on the validity of my assumptions/data?) constitutes an important dimension for the design of investment strategies.

Rule-based investment approaches continuously apply specific, pre-defined rules in order to implement changes to an asset allocation.

The S&P 500 is a market capitalization-weighted index of the leading publicly-traded companies in the U.S.

In this text, we use the word uncertainty to describe the fundamental circumstance that real events may potentially deviate from expectations. For investors, the acceptance of being subject to the uncertainty of financial returns, whilst trying to understand and quantify this uncertainty as well as possible, can be useful to help shape their investment strategy.

The volatility of a financial asset is the degree of variation of its trading price series over time. It is usually measured by the standard deviation of logarithmic returns from the asset's average value.

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