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VOLATILITY – AN INVESTABLE ASSET CLASS

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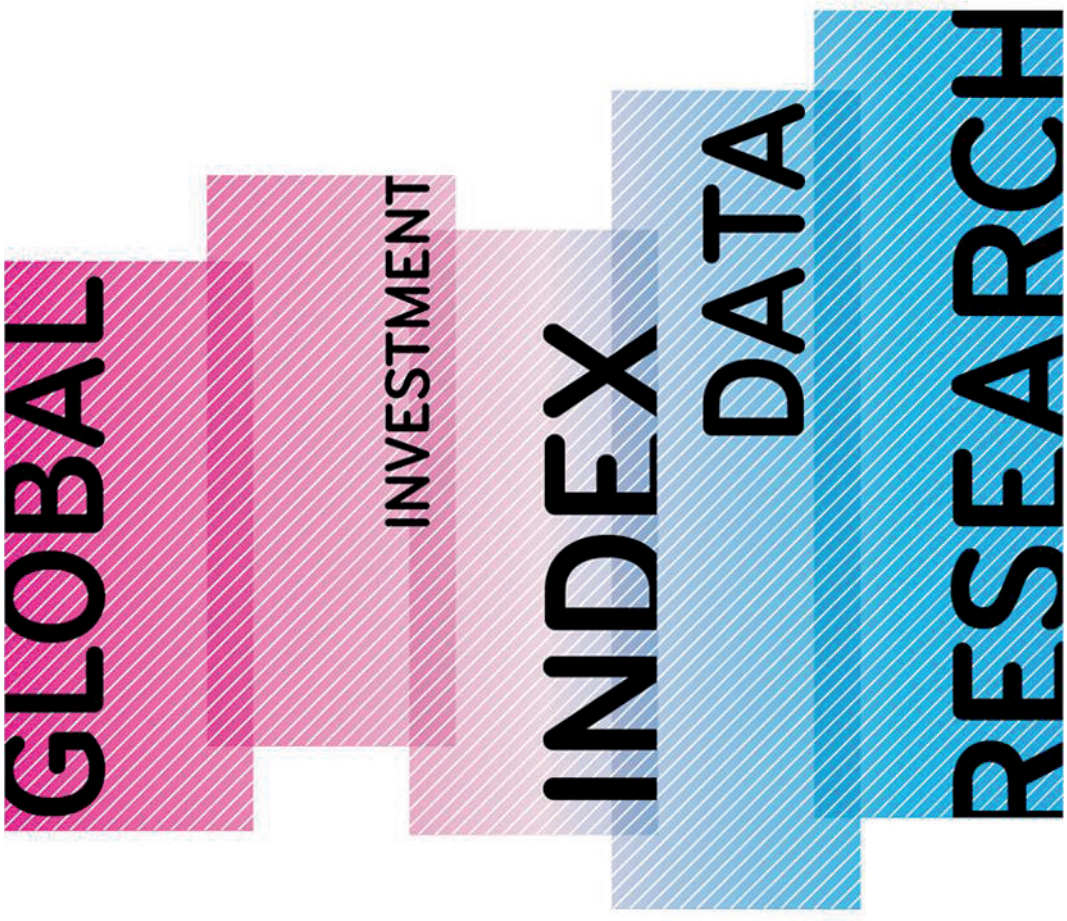

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INTRODUCTION

Ever since the onset of the financial crisis in 2008, volatility has become a critical aspect for investors to consider, measure and position in their portfolios. During the peak of the financial crisis, realized volatilities of asset prices soared as well as volatilities implied by option prices and measured by volatility indices such as the EURO STOXX 50® Volatility (VSTOXX®) Index and VDAX® reached unprecedented levels, reflecting the increasing cost of buying downside protection in the form of options during the market turmoil. Volatilities, both implied and realized, have subsided since the height of the financial crisis and in fact reached historical lows due to the mostly unidirectional move in the stock markets over the decade – with intermittent spikes owing to the taper tantrum, the US Federal Reserve raising the interest rate for the first time in almost a decade, or the more recent tiff between the US and China over trade tariffs.

Volatility has long ceased to be a mere measure for the level of uncertainty prevailing in financial markets. In fact, some experts argue that it has become an asset class for investors looking to diversify their portfolio strategy. Exposure to volatility is available in the form of a wide range of investment opportunities for institutional investors as listed and OTC derivatives, in particular on the EURO STOXX 50®, DAX®, S&P500, FTSE 100 and Nikkei. Over the years, volatility as an investable asset class has evolved from being a niche strategy for institutional investors and is now accessible to retail investors in the form of certificates and structured products, though the complexity of investing in the asset class restricts its widespread availability to and use by retail investors.

Participants in the volatility markets typically intend to obtain exposure to volatility for the purposes of reducing risk (downside protection or regular income generation), with some participants aiming to also enhance returns (speculation, arbitrage/relative value). Downside protection is achieved typically either by buying options – typically put options – as an insurance for existing investor portfolios, selling call options to earn premiums that partially cushion the downside, or by employing a strategy such as a collar that combines call and put options. Participants looking to enhance returns typically speculate about the direction of volatility by taking an appropriate directional position in volatility (using volatility futures, for example), or employ relative value strategies – such as volatility arbitrage – to benefit from mispricing between forecast future volatility and implied volatility.

In this paper, we introduce the topic of volatility as an investable asset class, focusing mainly on equity volatility. We attempt to familiarize readers with the various indices offered by STOXX, describe in brief the objective and construction methodology of each index, and even discuss a sample of other strategies that may be constructed using some of the existing indices. We analyze the performance of each index and attempt to explain each index's performance as well as any potential risks to be aware of.

The source for all data and charts in this paper is STOXX Ltd.

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CHARACTERISTICS OF VOLATILITY

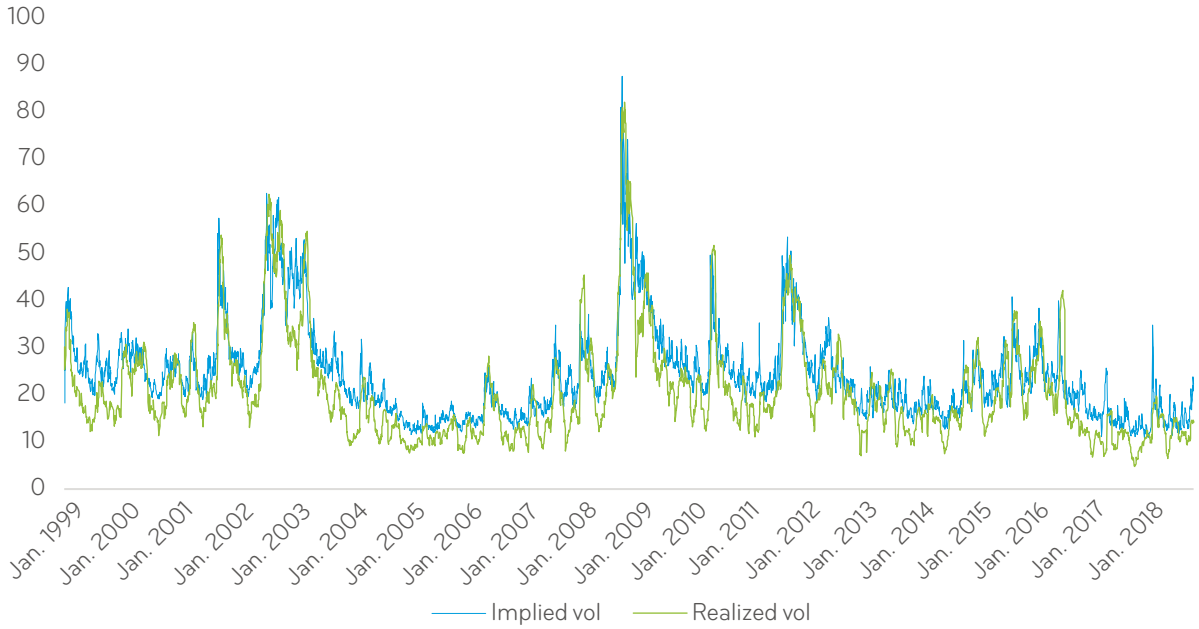
To give a better understanding to readers, we first discuss some characteristics of volatility that make it different from traditional asset classes such as equities and therefore have a bearing on index construction and rebalancing/review methodology:

1. Volatility is a measure of the level of uncertainty prevailing in certain markets. There are two different measures of volatility:
   a. Historical or realized volatility: involves measuring the standard deviation of historical closing prices for any particular security over a given period of time;
   b. Implied volatility: is derived from option prices and represents volatility estimates and assumptions by market participants.

   Neither measure of volatility, therefore, produces any direct return for investors such as dividends or interest.

2. On average, implied volatility tends to be higher than realized volatility. This can be explained by the fact that during market turbulence, many investors tend to buy protection for their portfolios, thereby pushing option prices and hence implied volatilities upwards. In addition, investors buying such protection typically pay a risk premium to the protection seller, causing the implied volatility to be generally higher than realized volatility.

FIGURE 1: THE (LAGGED) IMPLIED VOLATILITY AS MEASURED BY THE EURO STOXX 50 VOLATILITY (VSTOXX) INDEX VERSUS THE REALIZED VOLATILITY OF THE EURO STOXX 50 INDEX



Two aspects are worth mentioning: Firstly, volatility tends to jump occasionally to high levels and then shows a mean reversion over a period of time. Secondly, on average implied volatility exceeds realized volatility.

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3. Volatility is typically high when equity markets are falling and vice versa, i.e. there exists a negative correlation between volatility and the underlying equity market. This negative correlation between volatility and the equity markets may be explained by the fact that during market turbulence, investors typically buy protection for their portfolios. This pushes option prices and hence implied volatilities upwards.

FIGURE 2: NEGATIVE CORRELATION BETWEEN THE EQUITY MARKET AND VOLATILITY

There is also an alternative fundamental explanation for the negative correlation between equity markets and volatility based on the leverage effect: a decline in share price of a company equity (and thus its overall equity value) results in an increase in the company's balance sheet leverage. This makes its equity riskier and consequently increases the volatility in its share price.

4. Volatility typically displays jumps or upward spikes within short periods of time and then follows a downward trend to return to the medium- to long-term level (see Figure 1) over a relatively longer period.

5. Volatility, theoretically speaking, exhibits a mean-reverting property in the medium to long run (see Figure 1). It therefore has the tendency to always swing back to an average value over the medium to long term.

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VOLATILITY INDICES

EURO STOXX 50 VOLATILITY (VSTOXX) INDICES

The EURO STOXX 50 Volatility (VSTOXX) Index is designed to reflect the market expectations of near- to long-term volatility by measuring the square root of the implied variance. VSTOXX does not only measure implied volatilities of at-the-money EURO STOXX 50 options but considers the implied variance across all options with a given time to expiration. The option contracts on the EURO STOXX 50 are among the products with the highest trading volume on the Eurex derivatives exchange.

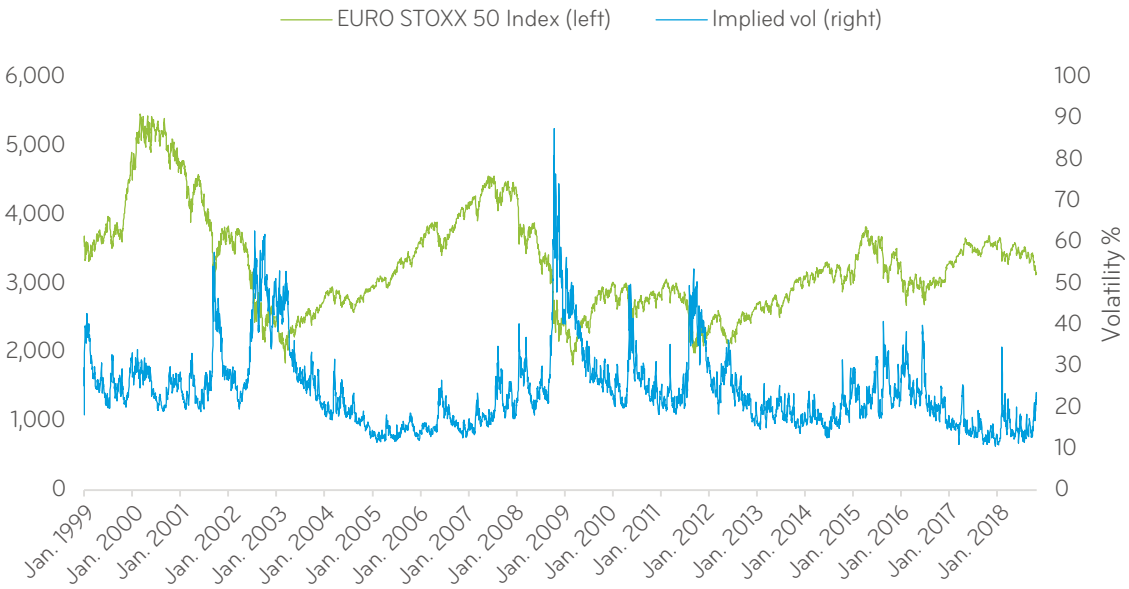
A total of twelve main VSTOXX indices are calculated for rolling 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 days to expiry via linear interpolation of suitable sub-indices. The VSTOXX main indices therefore effectively have constant times to expiry and in effect do not expire. This helps eliminate effects of volatility fluctuations close to expiry of options contracts.

The VSTOXX main indices are calculated using eight sub-indices covering the EURO STOXX 50 option expiries ranging from one month to two years. For options with longer time to expiry, no such sub-indices are currently available. The VSTOXX sub-indices are calculated on the basis of all options available and traded on Eurex.

The model for VSTOXX aims at making pure volatility tradable – i.e. to enable the replication of indices using an options portfolio that does not react to price fluctuations but only to changes in volatility. This is achieved through direct replication of variance (square of volatility) rather than volatility itself. A portfolio of EURO STOXX 50 options with different exercise prices and weighting meets this goal, as it considers the implied volatilities of all eligible options with a given time to expiry.

As evident from Figure 2, which charts the VSTOXX Index and the EURO STOXX 50 Index, there exists a negative correlation between volatility and equity markets as observed empirically. As discussed earlier, this may be explained by the fact that during market turbulence investors typically buy protection for their portfolios pushing options prices, and hence implied volatility, upwards.

FIGURE 3: EURO STOXX 50 AND IMPLIED VOLATILITY AS MEASURED BY THE EURO STOXX 50 VOLATILITY (VSTOXX) INDEX, MEASURED IN EUR PR



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The long-term correlation between the two time series Table 1 – is around -0.35 measured over the time period between Jan. 4, 1999 and Oct. 31, 2018.

TABLE 1: CORRELATIONS OF VSTOXX INDEX LEVELS WITH THE EURO STOXX 50 INDEX

Period	Correlation
1 month	-0.62
3 month	-0.89
YTD	-0.64
1 Y	-0.67
3 Y	-0.81
5 Y	-0.51
Since inception	-0.34

All figures are based on EUR PR. Index data as of Nov. 29, 2018.

Using the power of perfect hindsight, we look at a sample of date ranges in the past where equity markets may likely be considered to have been distressed. The negative relationship between volatility and equity markets becomes even more pronounced during times of market distress with the correlation becoming more negative, exceeding -0.80.

TABLE 2: CORRELATION OF VSTOXX INDEX LEVELS WITH THE EURO STOXX 50 INDEX DURING PERIODS OF MARKET DISTRESS

Period		Possible reasons/concerns	Correlation
Start date	**End date**		
Sep. 5, 2014	Oct. 16, 2014	Market correction, Fed stimulus withdrawal speed	-0.97
Dec. 5, 2014	Jan. 07, 2015	U.S. dollar strength, weak oil prices owing to weak demand from Europe and Asia	-0.90
Aug. 5, 2015	Oct. 02, 2015	Emerging markets financial crisis, devaluation of the Yuan	-0.90
Nov. 26, 2015	Feb. 12, 2016	China, oil prices, Fed rate increase	-0.90
Jan. 23, 2018	Feb. 09, 2018	Inflation concerns, speed of Fed stimulus removal	-0.97
Aug. 27, 2018	Oct. 30, 2018	Trade tariff war between the US and China	-0.95

All figures are based on EUR PR.

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VDAX INDICES

The VDAX-NEW® Index measures the volatility of the German equity market based on DAX options traded on the Eurex derivatives exchange. Just like for VSTOXX, the model for VDAX-NEW aims at making pure volatility tradable – i.e. the index should be trackable by a portfolio that does not react to price fluctuations but only to changes in volatility. VDAX-NEW computes the square root of implied variance across all the at-the-money and out-of-the-money DAX options for a given time to expiration.

Apart from the main index VDAX-NEW (which is irrespective of a specific time to expiration), sub-indices for each maturity of DAX options ranging from one month up to two years are calculated and distributed. No such sub-indices are currently available for options with a longer maturity. The VDAX-NEW is determined as the main index with a constant remaining time to expiration of 30 days by interpolation of the relevant nearest sub-indices.

FIGURE 4: VDAX-NEW INDEX AND DAX INDEX, MEASURED IN EUR PR

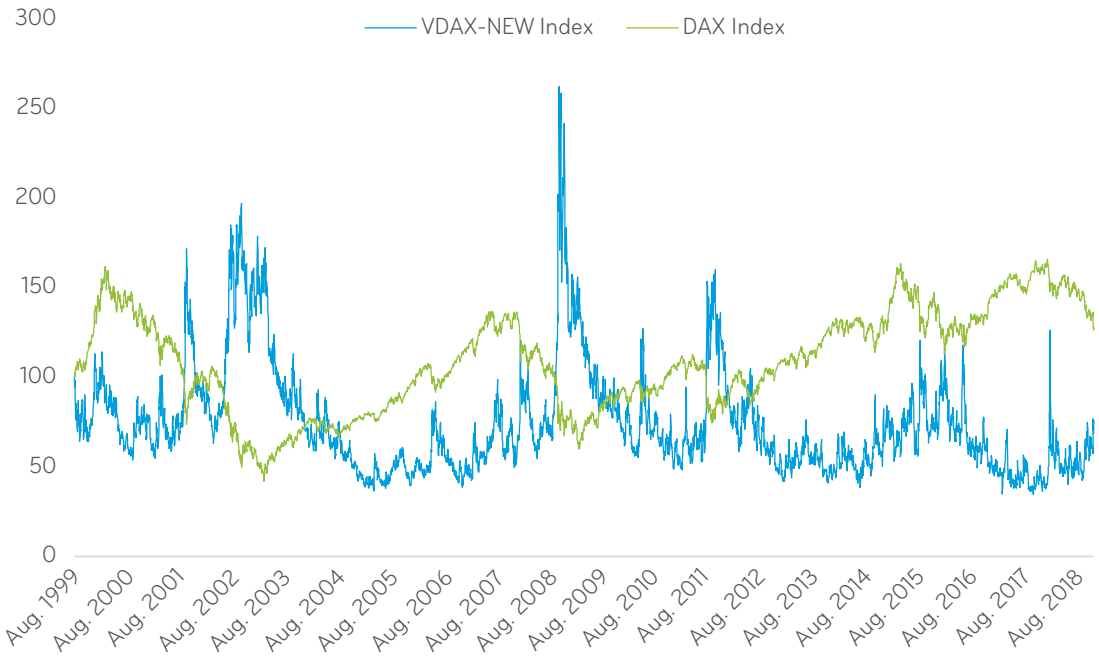

TABLE 3: CORRELATIONS OF INDEX LEVELS WITH THE DAX INDEX

Period	Correlation
1 month	-0.90
3 month	-0.92
YTD	-0.56
1 Y	-0.60
3 Y	-0.83
5 Y	-0.51
Since inception	-0.51

All figures are based on EUR PR. Index data as of Dec. 11, 2018.

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As evident from Figure 4, there exists a negative correlation between volatility and equity markets as observed empirically, which only becomes more pronounced during times of market distress, as can be seen from Table 4.

TABLE 4: CORRELATIONS OF INDEX LEVELS TO THE DAX INDEX DURING PERIODS OF MARKET DISTRESS

Period		Correlation
Start date	End date	
Sep. 5, 2014	Oct. 16, 2014	-0.94
Dec. 5, 2014	Jan. 7, 2015	-0.90
Aug. 5, 2015	Oct. 2, 2015	-0.88
Nov. 26, 2015	Feb. 12, 2016	-0.91
Jan. 23, 2018	Feb. 09, 2018	-0.90
Aug. 27, 2018	Oct. 30, 2018	-0.93

All figures are based on EUR PR.

EURO STOXX 50 VOLATILITY OF VOLATILITY INDEX (V-VSTOXX)

The EURO STOXX 50® Volatility of Volatility Index (V-VSTOXX) measures the implied volatility of option contracts on the VSTOXX futures, traded on the Eurex derivatives exchange. The V-VSTOXX Indices are based on VSTOXX real-time options prices and are designed to reflect market expectations of near- to long-term volatility-of-volatility by measuring the square root of the implied variance across all options of a given time to expiration.

A total of seven V-VSTOXX main indices are calculated for rolling 30, 60, 90, 120, 150, 180, 210 days to expiry via linear interpolation of the suitable sub-indices. The V-VSTOXX main indices, like the VSTOXX indices, therefore effectively have constant times to expiry and in effect do not expire. This helps eliminate effects of volatility fluctuations close to the expiry of options contracts.

The V-VSTOXX main indices are calculated using eight sub-indices covering the VSTOXX option expiries ranging from one month to eight months. Just like the VSTOXX sub-indices, the V-VSTOXX sub-indices are calculated on the basis of all options available on Eurex.

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FIGURE 5: EURO STOXX 50 VOLATILITY OF VOLATILITY (V-VSTOXX) INDEX, EURO STOXX 50 VOLATILITY (VSTOXX) INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR PR

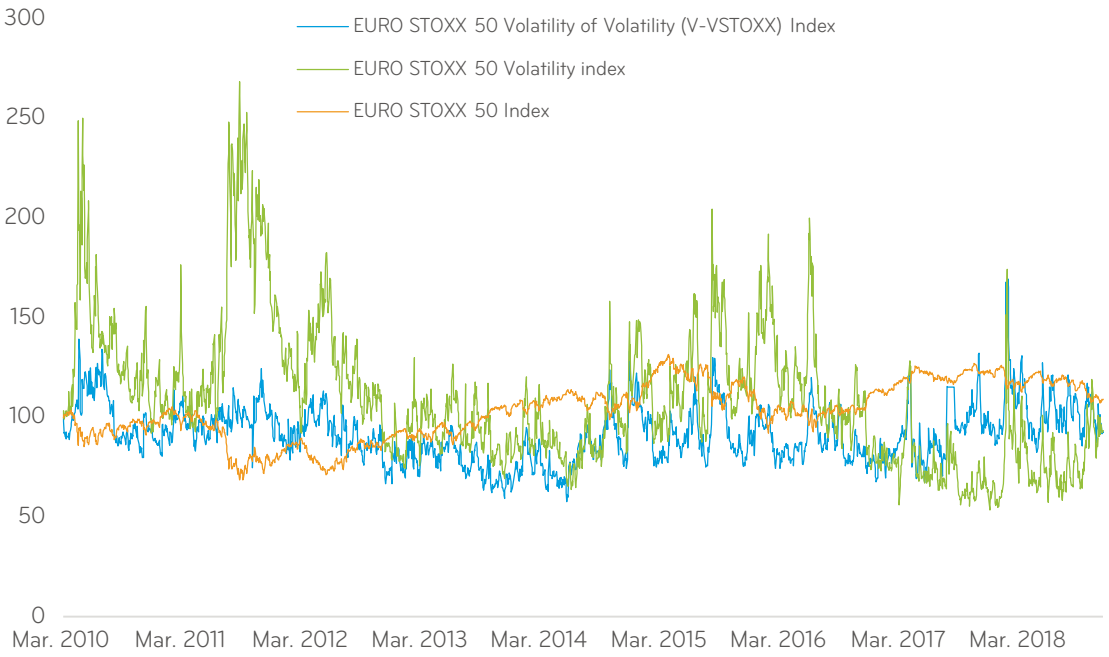

TABLE 5: CORRELATIONS OF INDEX LEVELS RELATIVE TO THE EURO STOXX 50 VOLATILITY OF VOLATILITY INDEX

Period	Correlation Wrt EURO STOXX 50 Volatility Index	Correlation Wrt EURO STOXX 50 Index
1 month	0.77	-0.34
3 month	0.55	-0.31
YTD	0.80	-0.29
1 Y	0.80	-0.32
3 Y	0.14	0.13
5 Y	0.32	0.07
Since inception	0.45	-0.08

All figures are based on EUR PR. Index data as of Nov. 29, 2018.

TABLE 6: CORRELATION OF INDEX LEVELS RELATIVE TO THE EURO STOXX 50 VOLATILITY OF VOLATILITY INDEX DURING PERIODS OF MARKET DISTRESS

Period		Correlation	Correlation
Start date	**End date**	**Wrt EURO STOXX 50 Volatility Index**	**Wrt EURO STOXX 50 Index**
Sep. 5, 2014	Oct. 16, 2014	0.97	-0.94
Dec. 5, 2014	Jan. 7, 2015	0.90	-0.85
Aug. 5, 2015	Oct. 2, 2015	0.89	-0.80
Nov. 26, 2015	Feb. 12, 2016	0.83	-0.85
Jan. 23, 2018	Feb. 9, 2018	0.97	-0.97
Aug. 27, 2018	Oct. 30, 2018	0.73	-0.72

All figures are based on EUR PR. Correlation figures are calculated on index level.

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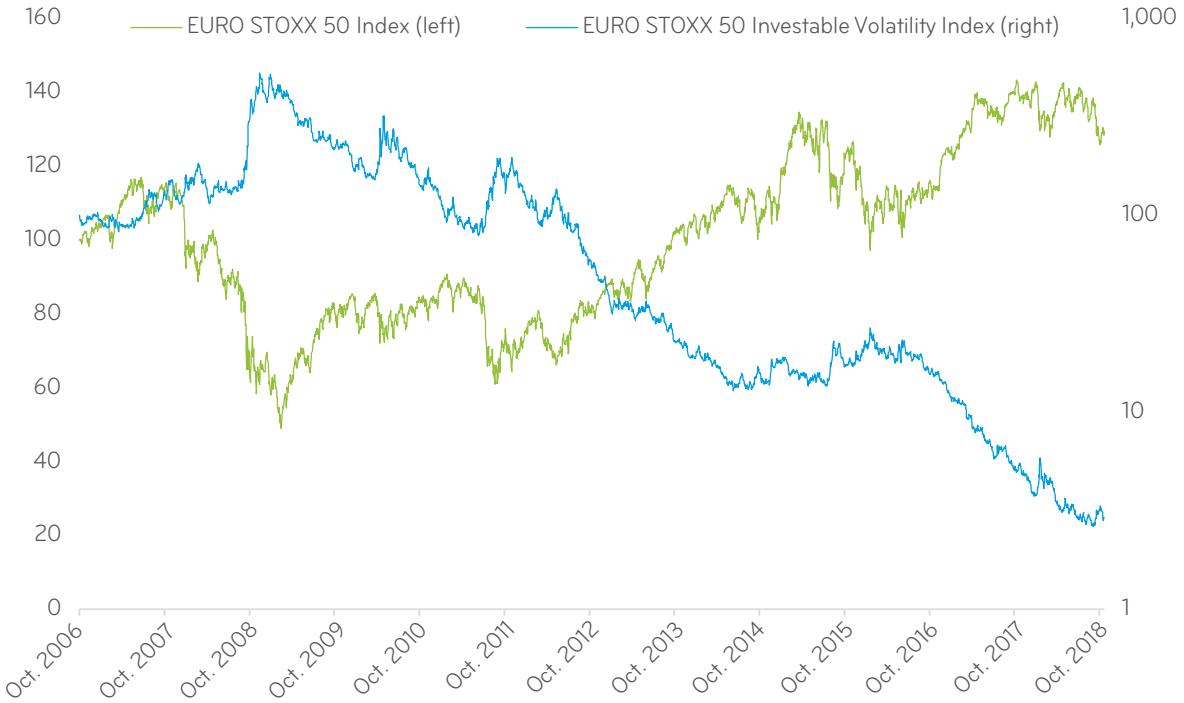
VOLATILITY STRATEGY INDICES

EURO STOXX 50 INVESTABLE VOLATILITY INDEX

The EURO STOXX 50® Investable Volatility Index measures forward implied volatility in the Eurozone equity market in a form that can be directly replicated by holding a portfolio of liquid derivative instruments that replicates the daily returns of the index. This sets it apart from the VSTOXX Index, which is calculated using spot implied volatility levels and whose returns are thus not directly replicable. Rather than linking the index level to current spot implied variance levels, the returns of the EURO STOXX 50 Investable Volatility Index are linked to the movement in forward volatility levels. The forward implied volatility is determined using the spot implied variance level between EURO STOXX 50 option expiries as implied by the VSTOXX sub-index level for each expiry.

The EURO STOXX 50 Investable Volatility Index is designed as a rolling index that targets a constant 3-month (90-day) forward, 3-month maturity volatility exposure. The index is calculated entirely using VSTOXX 6M and VSTOXX 9M sub-indices that are based on the implied volatility of EURO STOXX 50 Index options available on the Eurex exchange.

FIGURE 6: EURO STOXX 50 AND EURO STOXX 50 INVESTABLE VOLATILITY, MEASURED IN EUR GR



As evident from Figure 6 above, the performance of the investable volatility index is inversely correlated to the performance of the EURO STOXX 50 Index (GR). During times of market distress this negative correlation becomes even more pronounced with the investable volatility index significantly outperforming the EURO STOXX 50 Index. However, during benign times and over the long term during which the equities markets have witnessed a unidirectional upward trend, the investable volatility index drifts downward significantly underperforming the EURO STOXX 50 Index.

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TABLE 7: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF EURO STOXX 50 INVESTABLE VOLATILITY INDEX

Period	Returns		Volatility		Correlation
	EURO STOXX 50 Investable Volatility Index	EURO STOXX 50 Index	EURO STOXX 50 Investable Volatility Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
1 month	-9.06%	0.94%	44.3%	12.8%	-0.64
3 month	2.73%	-6.18%	39.6%	12.8%	-0.90
YTD	-31.7%	-6.3%	48.7%	13.0%	-0.19
1 Y	-38.5%	-8.6%	48.1%	12.9%	-0.08
3 Y	-44.6%	0.4%	43.8%	16.4%	-0.94
5 Y	-32.9%	4.2%	41.8%	18.0%	-0.86
Since inception	-25.4%	2.1%	48.6%	23.0%	-0.76

All figures are based on EUR GR. Return figures calculated for a duration of more than one year are annualized. Volatility figures are based on daily returns and correlation figures are based on index level. Index data as of Nov. 29, 2018.

TABLE 8: CORRELATIONS OF INDEX LEVELS TO BENCHMARK DURING PERIODS OF MARKET DISTRESS

Period		Returns		Correlation
Start date	End date	EURO STOXX 50 Investable Volatility Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
Sep. 5, 2014	Oct. 16, 2014	31.42%	-12.05%	-0.96
Dec. 5, 2014	Jan. 7, 2015	35.90%	-7.53%	-0.87
Aug. 5, 2015	Oct. 2, 2015	65.12%	-15.85%	-0.86
Nov. 26, 2015	Feb. 12, 2016	53.93%	-20.93%	-0.96
Jan. 23, 2018	Feb. 9, 2018	54.47%	-9.28%	-0.95
Aug. 27, 2018	Oct. 30, 2018	22.59%	-8.75%	-0.96

All figures are based on EUR GR. Correlation figures are calculated on index level.

A constant directional view on volatility using the investable volatility index is unlikely to be a profitable strategy in the long run, mainly due to the mean-reversion property of volatility. However, the investable volatility index may be used during times of market distress to generate additional returns and/or to reduce the volatility of an investment portfolio, in particular when used in combination with existing equity positions, exploiting the negative correlation between the two 'asset classes'. Identifying or predicting the start of a period of equity market distress is critical for exploiting this relationship, though doing so accurately is not only extremely difficult but quite involved, something that is outside of the scope of this paper.

VSTOXX SHORT-TERM AND MID-TERM FUTURES INDICES

The VSTOXX® Short-Term Futures and the VSTOXX® Mid-Term Futures Indices replicate hypothetical portfolios that measure the returns of a long position in constant-maturity one-month implied volatility on the basis of a one- or a five-month forward respectively, on the underlying EURO STOXX 50 Index. Both indices constantly roll over on a daily basis. While the EURO STOXX 50 Volatility Short-Term Futures Index rolls out of the front-month Eurex VSTOXX Futures contract into the second-month contract, the EURO STOXX 50 Volatility Mid-Term Futures Index rolls daily out of the fourth-month contract into the seventh-month contract to maintain a constant weighted expiration.

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On the business day preceding the VSTOXX Futures settlement date all of the weight is allocated to the new front-month futures contract for the VSTOXX Short-Term Futures Index. From the following day on, a fraction of the front-month contract is sold on a daily basis and an equal notional amount of the second-month contract is bought until the next settlement date, at which the index roll is complete and the front-month VSTOXX Futures contract is settled. At this point, the remaining maturity of the second-month contract is one month. Therefore, it becomes the front-month contract, and the index is gradually rolled into a new futures contract with a two-month maturity.

In a similar manner, on each business day preceding the Eurex VSTOXX futures settlement date, the VSTOXX Mid-Term Futures Index is invested equally (one-third weights to each) in the fourth-, fifth- and sixth-month contracts. From the following day, a fraction of the fourth-month contract is sold on a daily basis and an equal notional amount of the seventh-month contract is bought until the next settlement date, at which the index roll is complete. The index at this time would again be equally invested in the fourth-, fifth- and sixth-month contracts.

The VSTOXX Short-Term Futures Index and VSTOXX Mid-Term Futures Index are both available in excess and total return versions. In the total return version of the index, the investment into the futures contracts is fully collateralized by a daily investment into the EONIA market (euro overnight index average). The interest earned from this collateralization is re-invested in the portfolio on a daily basis.

FIGURE 7: EURO STOXX 50, EURO STOXX 50 VOLATILITY (VSTOXX) SHORT-TERM FUTURES AND EURO STOXX 50 VOLATILITY (VSTOXX) MID-TERM FUTURES, MEASURED IN EUR GR

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TABLE 9: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF VSTOXX SHORT-TERM AND MID-TERM FUTURES INDICES

Period	Returns			Volatility			Correlation	
	VSTOXX Short-Term Futures Index	VSTOXX Mid-Term Futures Index	EURO STOXX 50 Index	VSTOXX Short-Term Futures Index	VSTOXX Mid-Term Futures Index	EURO STOXX 50 Index	VSTOXX Short-Term Futures Index	VSTOXX Mid-Term Futures Index
1 month	-12.05%	-3.78%	0.94%	53.3%	20.6%	12.8%	-0.74	-0.78
3 month	6.87%	8.66%	-6.18%	49.9%	19.5%	12.8%	-0.84	-0.84
YTD	-11.8%	-4.6%	-6.3%	76.3%	23.3%	13.0%	-0.83	-0.80
1 Y	-18.5%	-10.2%	-8.6%	74.9%	23.0%	12.9%	-0.83	-0.80
3 Y	-51.4%	-19.2%	0.4%	60.7%	21.0%	16.4%	-0.79	-0.77
5 Y	-33.3%	-13.1%	4.2%	58.4%	22.2%	18.0%	-0.80	-0.78
Since inception	-41.6%	-19.0%	5.8%	57.1%	24.4%	19.9%	-0.81	-0.79

All figures are based on EUR GR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures to benchmark (EURO STOXX 50 Index) are based on daily returns. Index data as of Nov. 29, 2018.

As with the Investable Volatility Index, the Short-Term and Mid-Term Futures Indices are inversely correlated to the EURO STOXX 50 Index (GR) with long-term correlations upward of -0.80 each. And as with the Investable Volatility Index, these Short-Term and Mid-Term Futures Index correlations against the EURO STOXX 50 Index (GR) become even more negative during times of market distress, increasing to upwards of -0.90. However, during times of market distress these indices generate additional returns and/or reduce the volatility of an investment portfolio, in particular when used in combination with existing equity positions, exploiting the negative correlation between the two 'asset classes'.

TABLE 10: CORRELATIONS OF INDEX TO BENCHMARK (EURO STOXX 50 INDEX) DURING PERIODS OF MARKET DISTRESS

Period		Returns			Correlation	
Start date	End date	VSTOXX Short-Term Futures Index	VSTOXX Mid-Term Futures Index	EURO STOXX 50 Index	VSTOXX Short-Term Futures Index	VSTOXX Mid-Term Futures Index
Sep. 5, 2014	Oct. 16, 2014	42.99%	14.58%	-12.05%	-0.78	-0.67
Dec. 5, 2014	Jan. 7, 2015	46.75%	13.98%	-7.53%	-0.84	-0.81
Aug. 5, 2015	Oct. 2, 2015	63.85%	28.15%	-15.85%	-0.86	-0.80
Nov. 26, 2015	Feb. 12, 2016	51.84%	27.22%	-20.93%	-0.87	-0.82
Jan. 23, 2018	Feb. 9, 2018	69.86%	20.35%	-9.28%	-0.87	-0.86
Aug. 27, 2018	Oct. 30, 2018	32.72%	17.85%	-8.75%	-0.90	-0.86

All figures are based on EUR GR. Correlation figures are based on daily returns.

Two additional indices, the VSTOXX® Short-Term Futures Investable Index and VSTOXX® Short-Term Futures Inverse Investable Index, are also available. They work the same way, with the VSTOXX Short-Term Futures Inverse Investable Index taking a short position in the corresponding futures instead of a long position. Moreover, both these indices take into account the bid-ask spread during the roll procedure to more accurately capture the returns.

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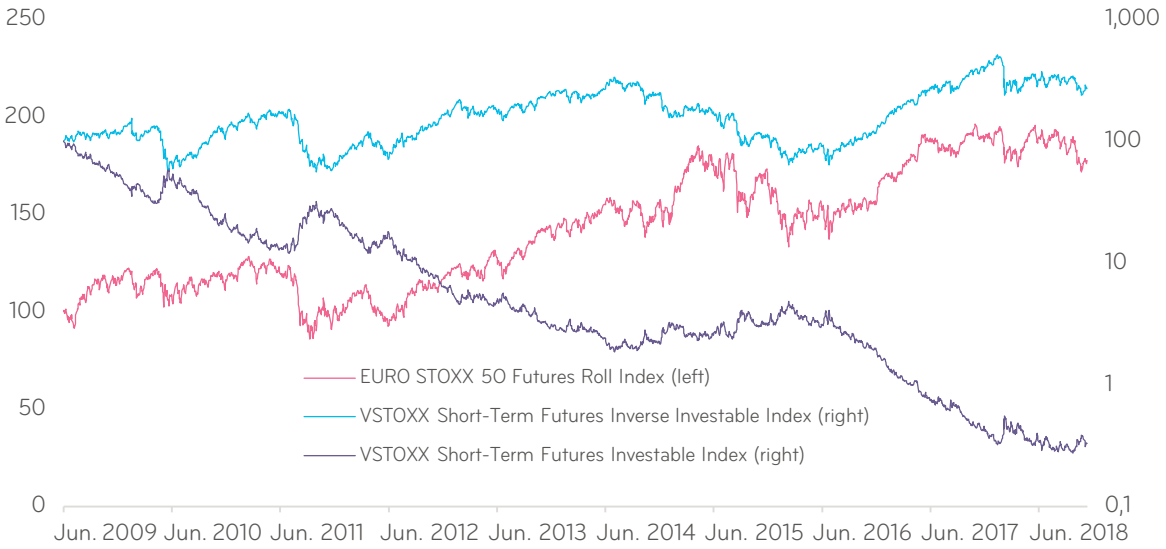
FIGURE 8: VSTOXX SHORT-TERM FUTURES INVESTABLE INDEX, VSTOXX SHORT-TERM FUTURES INVERSE INVESTABLE INDEX AND EURO STOXX 50® FUTURES ROLL INDEX, MEASURED IN EUR ER



The performance of the Short-Term Futures Investable Index mirrors that of the Short-Term Futures Index. However, the Short-Term Futures Inverse Investable Index seems to perform very well over the long term given its inverse exposure to volatility. As volatility drops from elevated levels to its medium- to long-term levels because of the mean-reverting nature of volatility, the Inverse Investable Index performs well due to its inverse exposure to volatility. This index, as a result, has a strong positive correlation with the EURO STOXX 50 Index upwards of 0.70 since inception.

TABLE 11: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF VSTOXX SHORT-TERM FUTURES INVESTABLE INDEX AND VSTOXX SHORT-TERM FUTURES INVERSE INVESTABLE INDEX

Period	Returns			Volatility			Correlation	
	VSTOXX Short-Term Futures Investable Index	VSTOXX Short-Term Futures Inverse Investable Index	EURO STOXX 50 Futures Roll Index	VSTOXX Short-Term Futures Investable Index	VSTOXX Short-Term Futures Inverse Investable Index	EURO STOXX 50 Futures Roll Index	VSTOXX Short-Term Futures Investable Index	VSTOXX Short-Term Futures Inverse Investable Index
1 month	-12.32%	10.61%	0.92%	53.3%	53.2%	13.3%	-0.69	0.69
3 month	5.88%	-12.99%	-5.89%	49.9%	49.9%	13.6%	-0.83	0.83
YTD	-14.8%	-36.9%	-6.0%	76.4%	76.5%	14.0%	-0.83	0.83
1 Y	-21.7%	-34.4%	-8.3%	75.1%	75.1%	13.8%	-0.83	0.83
3 Y	-53.2%	35.5%	0.5%	60.8%	60.9%	16.7%	-0.81	0.81
5 Y	-35.9%	1.5%	4.1%	58.7%	58.7%	18.3%	-0.80	0.80
Since inception	-45.9%	11.0%	6.2%	57.7%	58.0%	20.5%	-0.81	0.80

All figures are based on EUR ER. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Nov. 29, 2018.

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Given the inverse exposure to volatility, the Inverse Investable Index underperforms the EURO STOXX 50 index during market turbulence, and the correlation with the EURO STOXX 50 Index increases to upwards of 0.85.

TABLE 12: CORRELATIONS OF INDEX TO BENCHMARK (EURO STOXX 50 FUTURES ROLL INDEX) DURING PERIODS OF MARKET DISTRESS

Period		Returns			Correlation	
Start date	End date	VSTOXX Short-Term Futures Investable Index	VSTOXX Short-Term Futures Inverse Investable Index	EURO STOXX 50 Futures Roll Index	VSTOXX Short-Term Futures Investable Index	VSTOXX Short-Term Futures Inverse Investable Index
Sep. 5, 2014	Oct. 16, 2014	42.37%	-33.09%	-11.94%	-0.80	0.80
Dec. 5, 2014	Jan. 7, 2015	46.20%	-35.87%	-7.86%	-0.83	0.83
Aug. 5, 2015	Oct. 2, 2015	63.06%	-45.62%	-16.09%	-0.85	0.85
Nov. 26, 2015	Feb. 12, 2016	50.98%	-40.89%	-21.19%	-0.88	0.88
Jan. 23, 2018	Feb. 9, 2018	69.49%	-51.69%	-9.62%	-0.88	0.88
Aug. 27, 2018	Oct. 30, 2018	31.80%	-28.28%	-8.58%	-0.91	0.91

All figures are based on EUR ER. Correlation figures are based on daily returns.

DYNAMIC VSTOXX INDICES

The Dynamic VSTOXX® Index is an 'index of indices', i.e. its value is calculated based on the value of other underlying indices. The indices constituting the Dynamic VSTOXX Index are the EURO STOXX 50 Volatility Short-Term Futures Index and EURO STOXX 50 Volatility Mid-Term Futures Index.

The goal of the index is to allocate dynamically between the two components, based on the surmise that short-term futures typically offer a better returns profile during stressed markets than longer-term futures. The hypothesis is that stressed markets are typically associated with backwardation, and thus an indicator of the current backwardation/contango status may be used to trigger the allocation between the two index components.

The portion allocated to each component index is adjusted on every index rebalancing day. Such an event can occur as frequently as daily, depending on certain conditions being met which is triggered by the level reached by a trading signal. The trading signal is calculated as the ratio of the closing values of the VSTOXX Index and the VSTOXX® 120 Days Index. A higher ratio level corresponds to a higher relative allocation to the EURO STOXX 50 Volatility Short-Term Futures Index.

The index is available in standard, long-only and alpha versions, according to the different allocation split triggered between the VSTOXX Short-Term Futures Index and VSTOXX Mid-Term Futures Index. While the alpha version allows a short exposure to the VSTOXX Short-Term Futures of up to -50%, the standard version limits this to -30%. In the long-only version, any short exposure to the underlying index is prohibited.

Table 13 details how a trading signal is computed into allocation weights for the three different index variants.

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TABLE 13: WEIGHT ALLOCATION TO THE THREE STRATEGIES FOR THE DYNAMIC VSTOXX INDEX BASED ON THE TRADING SIGNAL

Trading signal (TSd-1)	Short-term target exposure (STEd)	Mid-term target exposure (MTEd)
Standard version	**Standard version**	**Standard version**
TSd-1 < 100%	-30%	70%
100% ≤ TSd-1 < 103%	0%	100%
103% ≤ TSd-1 < 110%	25%	75%
TSd-1 ≥ 110%	50%	50%
Long-only version	**Long-only version**	**Long-only version**
TSd-1 < 100%	0%	0%
100% ≤ TSd-1 < 103%	0%	50%
103% ≤ TSd-1 < 110%	25%	75%
TSd-1 ≥ 110%	50%	50%
Alpha version	**Alpha version**	**Alpha version**
TSd-1 < 100%	-50%	50%
100% ≤ TSd-1 < 103%	-25%	75%
103% ≤ TSd-1 < 110%	25%	75%
TSd-1 ≥ 110%	50%	50%

As can be observed in Figure 9, the Dynamic VSTOXX® Long-Only Index follows a relatively flat trend over long periods of time earning only the returns on the collateral, which may be attributed to the fact that a trading signal of less than 1 results in no exposure to either short-term or mid-term volatility futures.

FIGURE 9: DYNAMIC VSTOXX STANDARD INDEX, DYNAMIC VSTOXX LONG-ONLY INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR GR

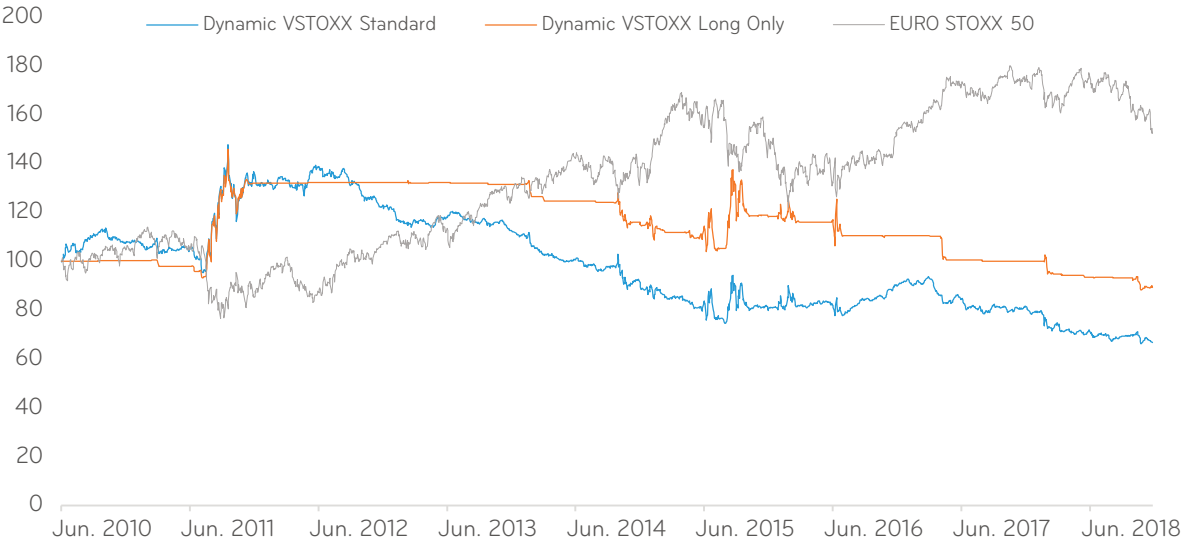

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TABLE 14: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF DYNAMIC VSTOXX STANDARD INDEX AND DYNAMIC VSTOXX LONG-ONLY INDEX

Period	Returns			Volatility			Correlation	
	Dynamic VSTOXX Standard Index	Dynamic VSTOXX Long-Only Index	EURO STOXX 50 Index	Dynamic VSTOXX Standard Index	Dynamic VSTOXX Long-Only Index	EURO STOXX 50 Index	Dynamic VSTOXX Standard Index	Dynamic VSTOXX Long-Only Index
1 month	0.84%	1.12%	-5.32%	8.0%	5.3%	17.9%	-0.42	-0.76
3 month	-3.12%	-4.32%	-7.85%	9.7%	7.3%	15.0%	-0.40	-0.57
YTD	-15.2%	-10.7%	-9.8%	11.9%	6.8%	13.6%	0.23	-0.38
1 Y	-18.0%	-10.9%	-11.9%	11.7%	6.7%	13.5%	0.23	-0.37
3 Y	-6.6%	-9.3%	2.1%	12.2%	12.0%	16.4%	-0.26	-0.57
5 Y	-10.2%	-7.6%	4.4%	16.5%	16.2%	18.1%	-0.42	-0.56
Since inception	-4.7%	-1.4%	5.4%	16.3%	15.0%	20.0%	-0.45	-0.52

All figures are based on EUR GR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Dec. 11, 2018.

The alpha index version is quite interesting in the way it is envisaged to work, and at first glance seems to have had a reasonably good long-term performance compared with the EURO STOXX 50 Index. The signal seems to have captured the directional trend relatively effectively between 2010 and mid-2014. However, between late 2014 until around mid-2016, the index gave up most of the gains from the previous years. One of the reasons for this was likely due to the fluctuation of the trading signal around 1.0, which is also indicated in the increased realized volatility (1 month) of the VSTOXX Index. This resulted in less efficient allocation to the short-term and mid-term indices than in prior years. Subsequently when the VSTOXX Index became less volatile, the alpha index performance recovered again albeit retreating temporarily during late January 2018.

FIGURE 10: PERFORMANCE OF EURO STOXX 50 INDEX VERSUS DYNAMIC VSTOXX® ALPHA INDEX, MEASURED AS EUR GR

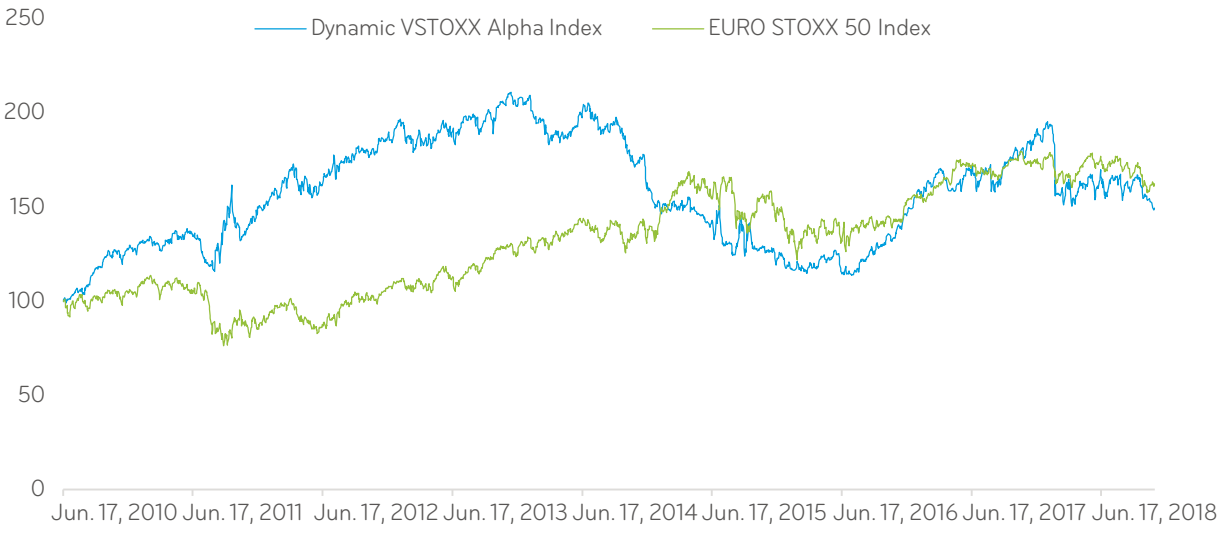

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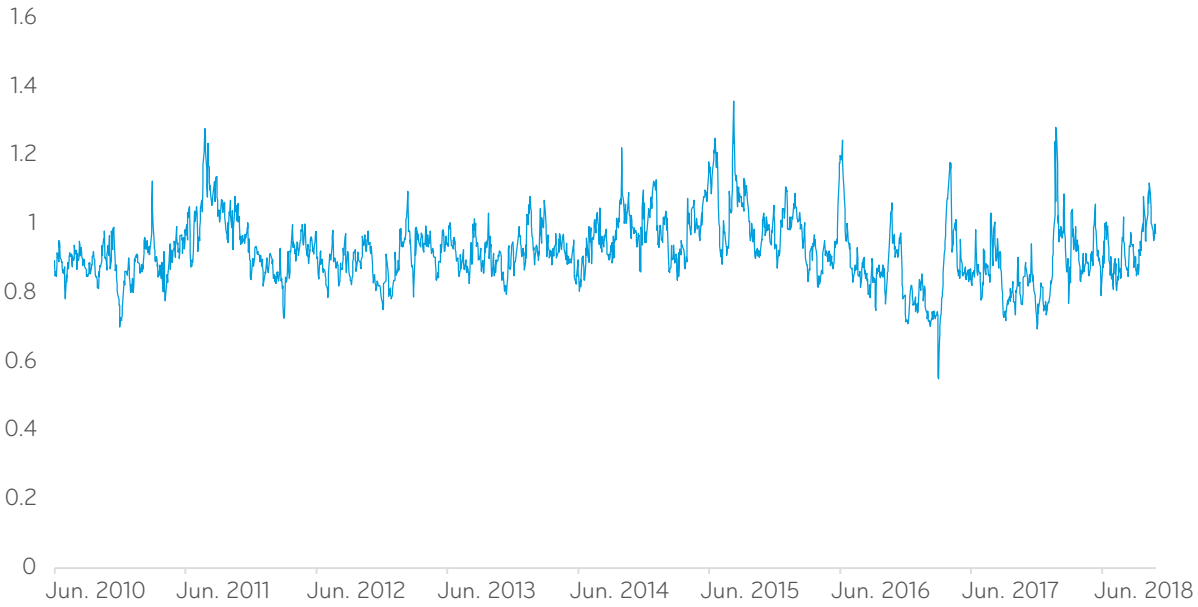
TABLE 15: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF DYNAMIC VSTOXX ALPHA INDEX

Period	Returns		Volatility		Correlation
	Dynamic VSTOXX Alpha Index	EURO STOXX 50 Index	Dynamic VSTOXX Alpha Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
1 month	-4.54%	-5.32%	19.4%	17.9%	0.82
3 month	-12.36%	-7.85%	15.0%	15.0%	0.72
YTD	-23.0%	-9.8%	26.1%	13.6%	0.72
1 Y	-24.2%	-11.9%	25.7%	13.5%	0.72
3 Y	5.1%	2.1%	19.4%	16.4%	0.46
5 Y	-7.1%	4.4%	20.0%	18.1%	0.20
Since inception	4.4%	5.4%	19.3%	20.0%	0.19

All figures are based on EUR GR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Dec. 11, 2018.

FIGURE 11: TRADING SIGNAL (TSD) FOR THE DYNAMIC VOLATILITY STRATEGY



VOLATILITY-BALANCED INDICES

The EURO STOXX 50® Volatility-Balanced Index aims to provide improved risk-adjusted returns relative to the EURO STOXX 50 Index by replicating a hypothetical portfolio that combines a base investment in the EURO STOXX 50 with an investment in equity volatility, using the VSTOXX Short-Term Futures Index (see page 13).

The rationale for the strategy is that equity volatility typically displays negative correlation to the underlying equity market, and therefore serves as a hedge during volatile periods in the market. The EURO STOXX 50 Volatility-Balanced Index dynamically changes allocation to equity and its exposure to volatility based on the prevailing market environment by increasing the exposure to volatility during unstable periods,

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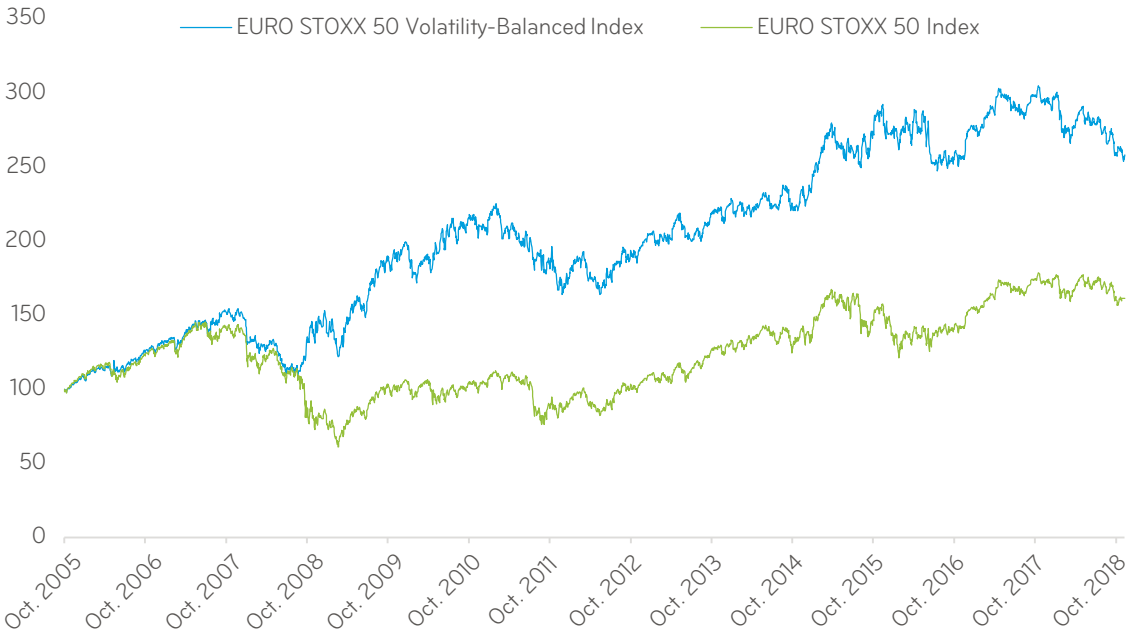
and conversely keeping a lower exposure during more stable or up-trending markets. The prevailing volatility environment is determined by comparing the market expectation of short-term volatility to the actual realized volatility during that period.

FIGURE 12: EURO STOXX 50 VOLATILITY-BALANCED INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR GR



The index attempts to diversify the risk of the portfolio across the business cycle. During bear market or market correction phases where equities are sluggish or retreating, the index performance is improved by higher exposure to rising volatility levels often seen in such market conditions. Since inception the performance of the index has been superior on an absolute and a risk-adjusted basis.

TABLE 16: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF VOLATILITY-BALANCED INDEX

Period	Returns		Volatility		Correlation
	EURO STOXX 50 Volatility-Balanced Index	EURO STOXX 50 Index	EURO STOXX 50 Volatility-Balanced Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
1 month	-1.85%	0.94%	10.3%	12.8%	0.88
3 month	-5.31%	-6.18%	10.5%	12.8%	0.77
YTD	-10.7%	-6.3%	10.9%	13.0%	0.67
1 Y	-13.0%	-8.6%	10.8%	12.9%	0.69
3 Y	-3.9%	0.4%	12.6%	16.4%	0.83
5 Y	3.0%	4.2%	13.3%	18.0%	0.78
Since inception	7.6%	3.6%	16.8%	22.4%	0.78

All figures are based on EUR GR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Nov. 29, 2018.

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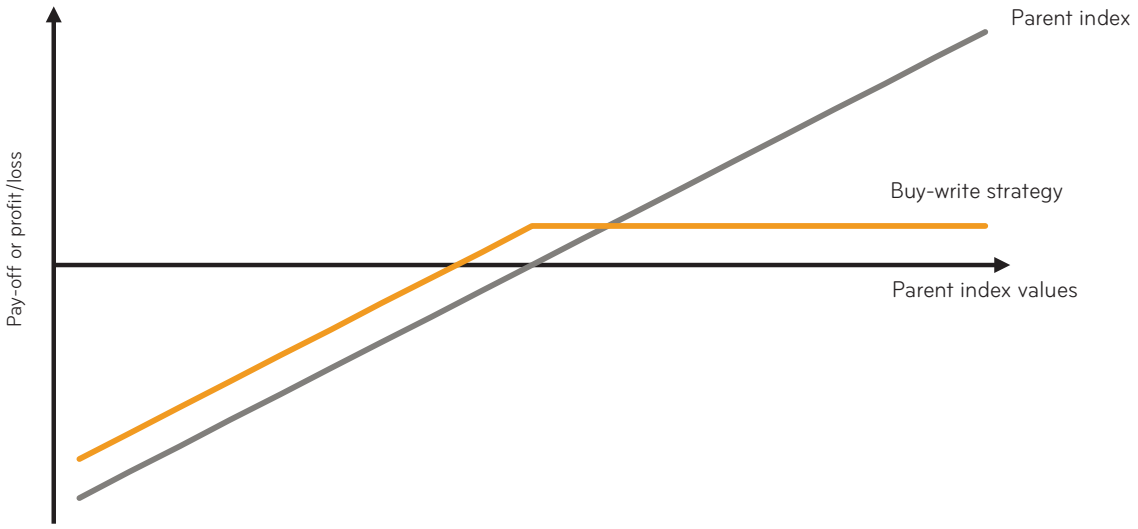
OPTION-WRITING STRATEGIES

Buy-write strategy

Buy-write strategy, also referred to as 'covered call', represents a long position (buy) in an equity and a short in a call (write) on the same underlying. By rolling the strategy at or around the option expiry, an investor would continuously be able to earn the call premium as long as implied volatilities are higher than realized volatilities. In the past years, buy-write strategies have typically produced extra returns compared to 'simple' equity long-only strategies and implied a lower volatility, as indicated in Table 17. However, the performance of such a strategy is influenced both by market volatility and the performance of the underlying asset and hence is not a plain investment strategy for volatility.

FIGURE 13: PAY-OFF MODEL FOR A BUY-WRITE INDEX



EURO STOXX 50 BuyWrite Index

The EURO STOXX 50® BuyWrite Indices are designed to measure the performance of hypothetical portfolios that combine the EURO STOXX 50 Index and a sold – or written – EURO STOXX 50 call option. These two components are held in equal amounts and are adjusted on a monthly basis, when a new one-month EURO STOXX 50 call option replaces the expiring EURO STOXX 50 call option.

Two variants of the index are made available: the EURO STOXX 50 BuyWrite Index, with option struck at 105%, and the EURO STOXX 50® BuyWrite (100%) Index, with option struck at 100%. The difference between the index with call option struck at 105% compared to the one with strike of 100% is that the call option is 5% out-of-the-money rather than being at-the-money.

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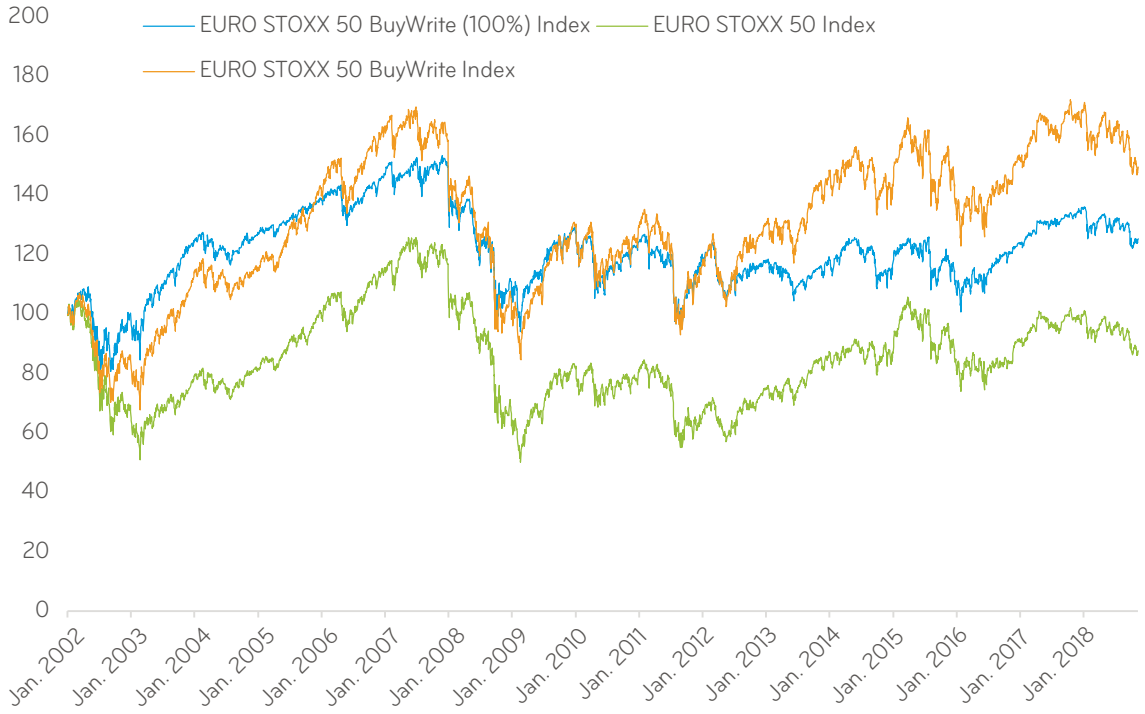
FIGURE 14: EURO STOXX 50 BUYWRITE INDEX, EURO STOXX 50 BUYWRITE (100%) INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR GR



As seen in the chart above, the EURO STOXX 50 BuyWrite Indices have delivered positive outperformance over the long term, with the regular EURO STOXX 50 BuyWrite Index delivering higher returns than the EURO STOXX 50 BuyWrite (100%) Index. The reason for this is that the index with the call option struck at 100% reduces the upside potential but increases the downside protection as the option premium (a function of volatility, time and strike price, besides other factors) is typically greater than that for the option struck at 105%. As a consequence, the EURO STOXX 50 BuyWrite (100%) Index has a lower annualized volatility than the EURO STOXX 50 BuyWrite Index. On a risk-adjusted basis however, the EURO STOXX 50 BuyWrite Index has performed the best.

TABLE 17: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF EURO STOXX 50 BUYWRITE INDICES

Period	Returns			Volatility			Correlation	
	EURO STOXX 50 BuyWrite Index	EURO STOXX 50 BuyWrite (100%) Index	EURO STOXX 50 Index	EURO STOXX 50 BuyWrite Index	EURO STOXX 50 BuyWrite (100%) Index	EURO STOXX 50 Index	EURO STOXX 50 BuyWrite Index	EURO STOXX 50 BuyWrite (100%) Index
1 month	1.15%	2.35%	0.86%	12.3%	9.6%	12.8%	1.00	0.77
3 month	-5.84%	-3.11%	-6.45%	12.6%	10.0%	12.9%	0.98	0.86
YTD	-8.4%	-6.4%	-9.4%	13.0%	10.4%	13.1%	0.98	0.91
1 Y	-10.7%	-6.4%	-11.8%	12.9%	10.2%	12.9%	0.99	0.91
3 Y	-1.4%	1.7%	-3.1%	14.8%	11.7%	16.4%	0.97	0.89
5 Y	0.7%	1.5%	0.6%	16.2%	13.3%	18.0%	0.95	0.86
Since inception	2.5%	1.4%	-0.8%	19.9%	17.4%	23.1%	0.95	0.85

All figures are based on EUR PR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Nov. 29, 2018.

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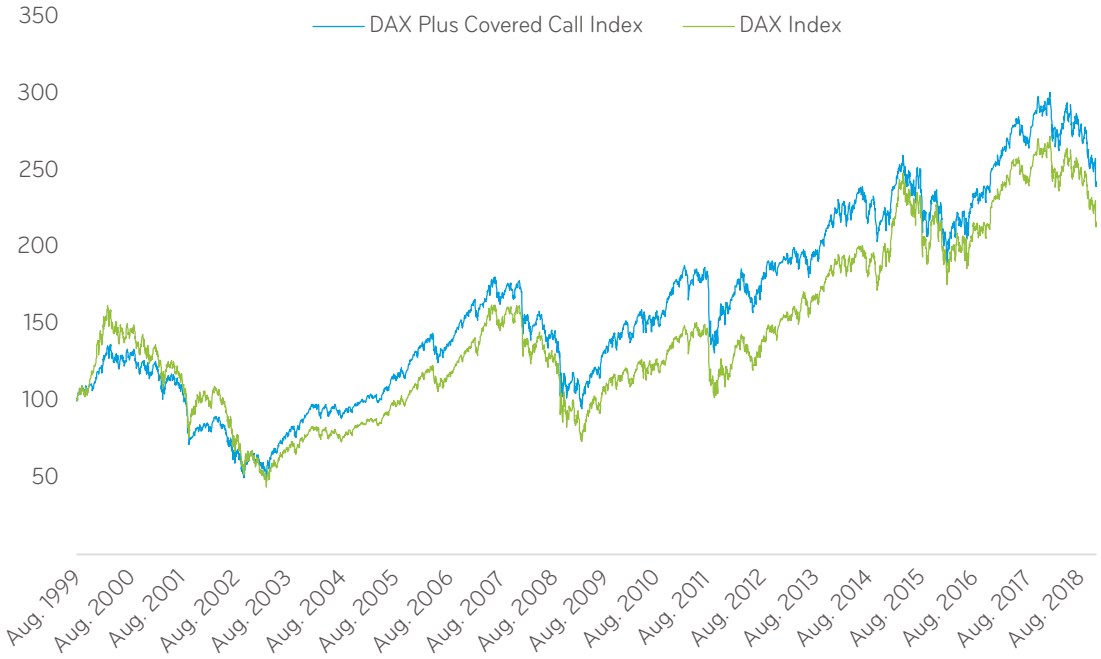
Buy-write strategies may be applied to any equity index with tradable options and typically tend to outperform a conventional long-only position in the corresponding index during market downturns, with the option premia serving as a downside buffer. However, the strategy typically underperforms in bull markets, with the written call option capping the upside potential, essentially acting as a cap on performance. The strategy also has lower volatility compared to the corresponding plain-vanilla index, owing to the option premia offsetting market falls, while at the same time stunting market rallies.

Other variations of the buy-write strategy (not available as STOXX indices) include writing deep-in-the-money options to exploit the decay-of-time premium.

DAXplus Covered Call Index

The DAXplus® Covered Call Index also reflects the so-called 'covered call' option strategy, on the DAX Index. This strategy, which is also referred to as 'buy-write', involves the purchase of an underlying instrument and the simultaneous sale of a call option on that instrument. The index is based on the DAX Index and a (short) DAX call option traded at Eurex.

FIGURE 15: DAXPLUS COVERED CALL INDEX AND DAX INDEX, MEASURED IN EUR TR



As with the EURO STOXX 50 BuyWrite Index, the DAXplus Covered Call Index has delivered better returns since inception than the DAX Index and with a lower realized volatility at that.

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TABLE 18: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF DAXPLUS COVERED CALL INDEX

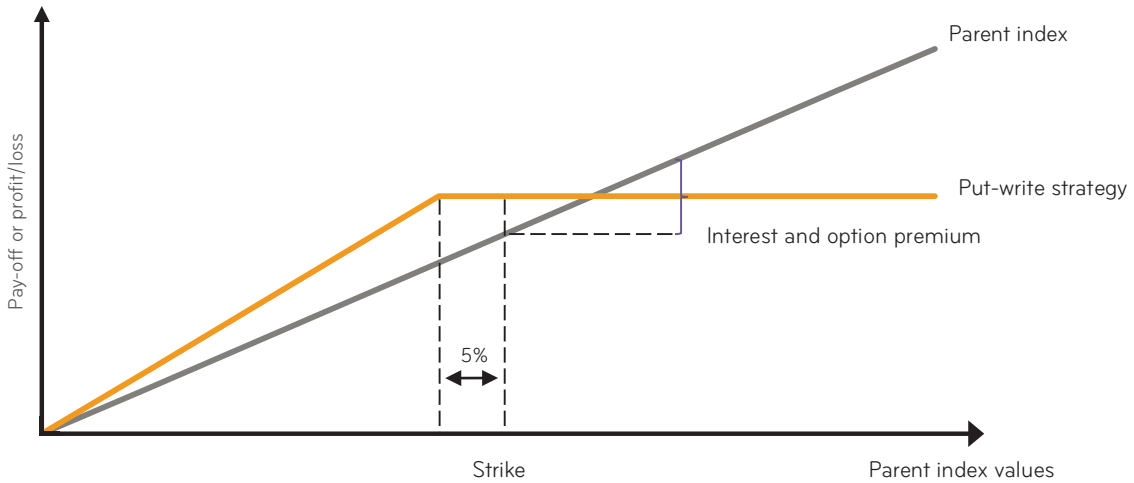
Period	Returns		Volatility		Correlation
	DAXplus Covered Call Index	DAX Index	DAXplus Covered Call Index	DAX Index	Wrt DAX Index
1 month	-6.14%	-6.43%	20.4%	21.1%	1.00
3 month	-9.78%	-10.34%	16.5%	17.0%	1.00
YTD	-15.2%	-16.5%	15.3%	15.6%	1.00
1 Y	-16.9%	-18.2%	15.2%	15.4%	0.99
3 Y	3.8%	1.5%	15.0%	16.7%	0.98
5 Y	2.6%	3.6%	16.4%	18.3%	0.96
Since inception	4.8%	4.2%	20.4%	23.8%	0.95

All figures are based on EUR TR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Dec. 11, 2018.

Put-write strategy

A put-write strategy involves systematically selling – or 'writing' – put options on an underlying equity or equity index. A 'naked' or 'uncovered' put-write strategy involves writing put options without holding a short position in the underlying security, whereas a 'covered' put-write strategy involves writing put options to offset an existing short position in the underlying security. While writing a covered put option holds a huge potential of upside risk with limited profits, writing an uncovered put option contains huge downside risk with limited profits as premium. A collateralized or 'cash-secured' put-write strategy writes put options and at the same time deposits or sets aside the full cash amount for a possible purchase of the underlying security.

FIGURE 16: PAY-OFF PROFILE FOR PUT-WRITE INDEX



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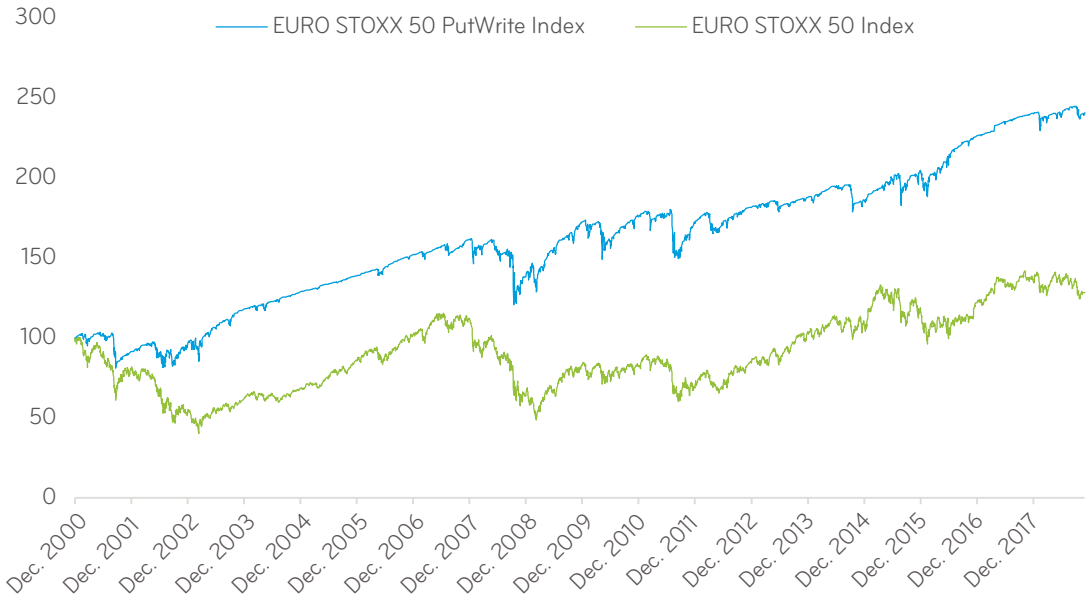
EURO STOXX 50 PutWrite Index

Notwithstanding, the risk-reward profile of a collateralized put-write strategy – as well as that of a 'naked' put-write strategy – mirrors that of a buy-write strategy (see charts below). The EURO STOXX 50® PutWrite Index replicates the collateralized put-write strategy of writing put options on the EURO STOXX 50 Index on a monthly basis, fully collateralized by an investment into the three-month Euribor market.

The amount of such investment is equal to the index close on the day before the options are written plus the premium from selling the put options. Each month the EURO STOXX 50 PutWrite Index rolls from the previously expiring put options contracts into the new one-month put options contracts, with the number of put options each month determined by the total amount of the collateralization. The money market investment, the option premium and the interest earned must cover the potential worst-case loss on the underlying put options contracts.

FIGURE 17: EURO STOXX 50 PUTWRITE INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR GR



Since the inception of the index, the PutWrite Index has had an annualized return of 5.85%, higher than that of the EURO STOXX 50 Index. The annualized standard deviation of the PutWrite Index has been 12.4%, significantly lower than that of the EURO STOXX 50 Index and that of the BuyWrite Indices. Depending on market conditions, the PutWrite Index performs slightly differently. When the equity markets are trending downward or tend to remain flat, the PutWrite Index is generally expected to out-perform the EURO STOXX 50 index as the premia received for the sale of put options in addition to the return on the collateral act as a buffer to the downside. However, when the equity markets rally sharply, the PutWrite Index tends to underperform as the participation in the market upside is capped to the extent of the premium and collateral. In effect, put-write offers market participation while simultaneously dampening the volatility by reducing downside risk.

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TABLE 19: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF EURO STOXX 50 PUTWRITE INDEX

Period	Returns		Volatility		Correlation
	EURO STOXX 50 PutWrite Index	EURO STOXX 50 Index	EURO STOXX 50 PutWrite Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
1 month	1.09%	0.86%	3.3%	12.8%	0.82
3 month	-1.35%	-6.45%	5.5%	12.9%	0.70
YTD	0.3%	-9.4%	6.1%	13.1%	0.73
1 Y	0.5%	-11.8%	5.9%	12.9%	0.72
3 Y	6.0%	-3.1%	6.3%	16.4%	0.76
5 Y	5.2%	0.6%	7.1%	18.0%	0.75
Since inception	5.9%	-2.3%	12.4%	23.4%	0.78

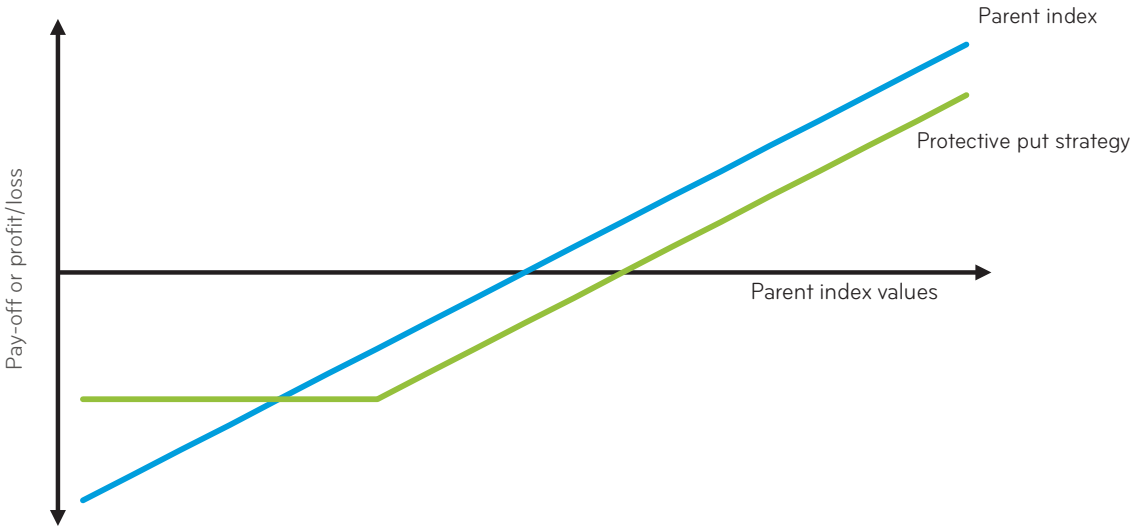
All figures are based on EUR PR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Nov. 29, 2018.

OPTION-BUYING STRATEGIES

Protective put strategy

A protective put strategy involves going long on the underlying and long a put option on the underlying. This is essentially a defensive strategy that acts as an insurance against adverse market movements. The maximum loss that may be incurred on this strategy is limited to the premium paid for the option, and thus dampens the volatility of the strategy compared to the underlying index.

FIGURE 18: PAY-OFF PROFILE FOR A PROTECTIVE PUT STRATEGY



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EURO STOXX 50 Protective Put 80% 18m 6/3 Index

The EURO STOXX 50® Protective Put 80% 18m 6/3 Index aims to replicate a combined investment in the EURO STOXX 50 Index and a long position in a put option on the same index. The investment objective of the replicated strategy is to profit from the appreciation of the EURO STOXX 50, while simultaneously limiting the losses in falling markets by means of the put option. The put option is rolled quarterly in March, June, September and December. On each roll date, the existing option is sold and replaced by a new one with 80% strike. The options purchased in June and December will mature in 18 months, while those purchased in March and September will mature in 15 months (i.e. they keep the same maturity of the existing option).

FIGURE 19: EURO STOXX 50 PROTECTIVE PUT 80% 18M 6/3 INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR PR

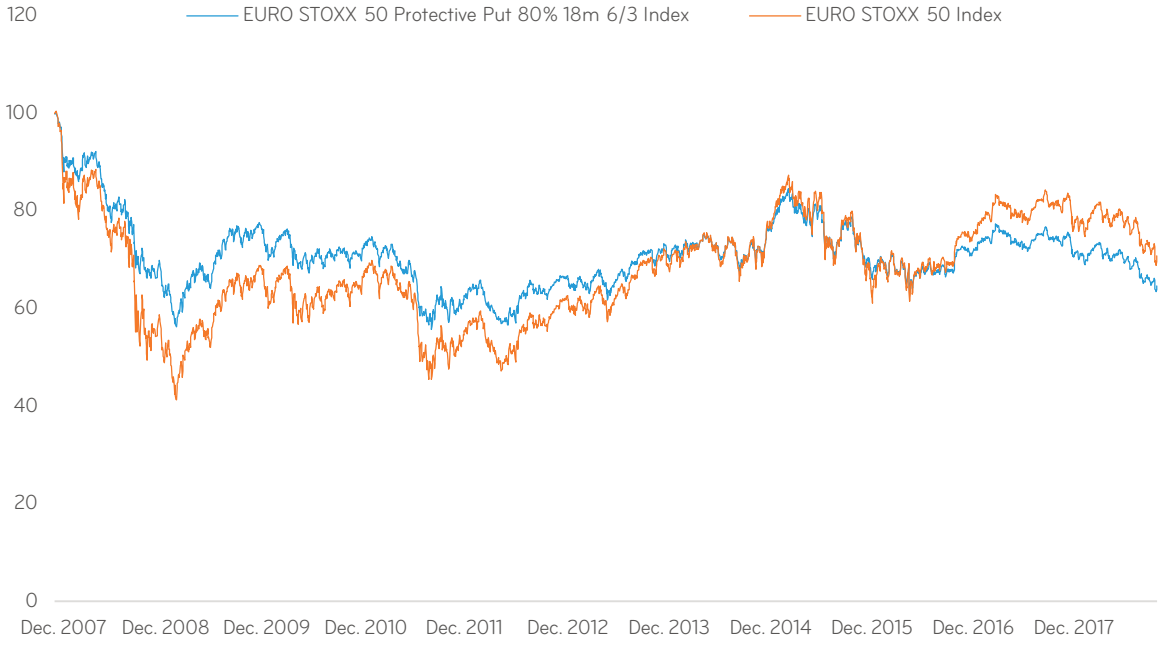

TABLE 20: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF EURO STOXX 50 PROTECTIVE PUT 80% 18M 6/3 INDEX

Period	Returns		Volatility		Correlation
	EURO STOXX 50 Protective Put 80% 18m 6/3 Index	EURO STOXX 50 Index	EURO STOXX 50 Protective Put 80% 18m 6/3 Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
1 month	-0.86%	-0.76%	8.2%	11.5%	0.99
3 month	-5.85%	-6.48%	9.3%	12.8%	0.99
YTD	-10.1%	-9.4%	9.6%	13.1%	0.98
1 Y	-12.0%	-11.3%	9.5%	12.9%	0.98
3 Y	-6.0%	-3.3%	11.6%	16.4%	0.98
5 Y	-1.9%	0.6%	12.9%	18.1%	0.98
Since inception	-3.9%	-3.0%	15.1%	23.7%	0.96

All figures are based on EUR PR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Nov. 29, 2018.

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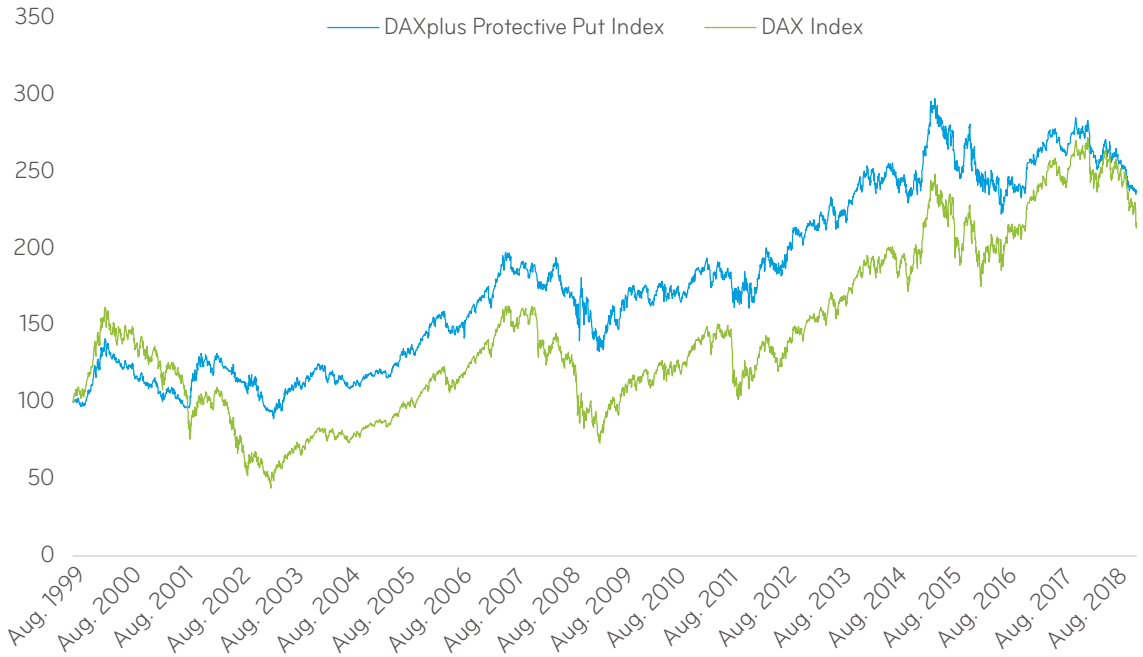
DAXplus Protective Put Index

The DAXplus® Protective Put Index reflects the protective put investment strategy, which intends to provide protection from losses. This strategy combines an index investment with a long position in a put option on the underlying index. The index is based on the DAX Index and a (long) DAX put option traded on the Eurex exchange.

FIGURE 20: DAXPLUS PROTECTIVE PUT INDEX AND DAX INDEX, MEASURED IN EUR TR



Compared with the DAX Index, the DAXplus Protective Put Index has much lower volatility due to the downside protection offered by the long put options position. In terms of returns, the Protective Put Index has performed slightly better though the recent 3-year and 5-year performance have been lower due to the drag caused by premia paid for being long the put options.

TABLE 21: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF DAXPLUS PROTECTIVE PUT INDEX

Period	Returns		Volatility		Correlation
	DAXplus Protective Put Index	DAX Index	DAXplus Protective Put Index	DAX Index	Wrt DAX Index
1 month	-1.49%	-6.43%	9.5%	21.1%	0.40
3 month	-6.50%	-10.34%	9.1%	17.0%	0.50
YTD	-12.8%	-16.5%	10.3%	15.6%	0.78
1 Y	-14.6%	-18.2%	10.3%	15.4%	0.78
3 Y	-2.4%	1.5%	14.0%	16.7%	0.84
5 Y	0.0%	3.6%	15.1%	18.3%	0.86
Since inception	4.7%	4.2%	17.5%	23.8%	0.83

All figures are based on EUR TR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Index data as of Dec. 11, 2018.

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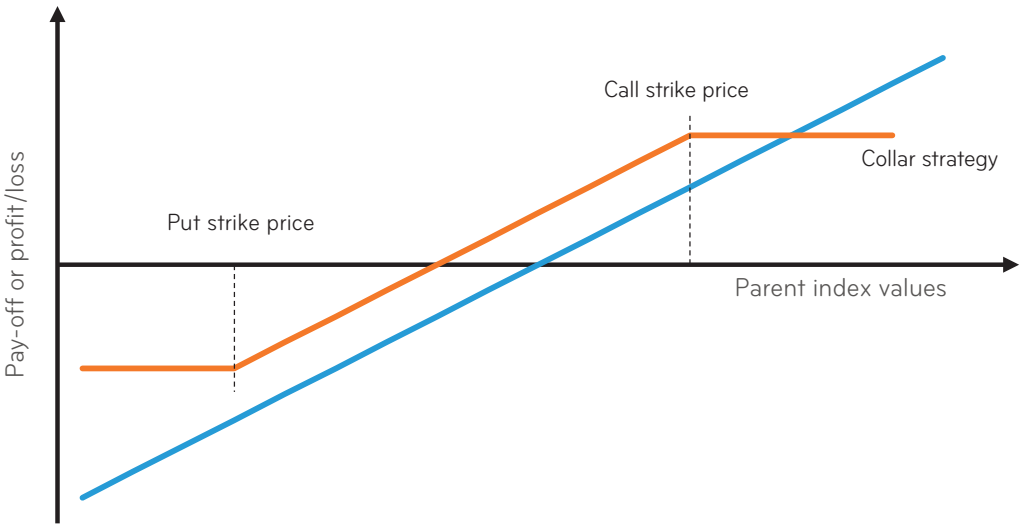
OPTION COMBINATION STRATEGIES

Collar strategy

A collar is an options trading strategy constructed by buying or owning shares of a stock while simultaneously buying protective puts and selling call options on the underlying security. The options, both call and put, are typically out-of-the-money options with the same expiration and an equal number of contracts. If the underlying security price increases beyond the strike price of the call, the call option limits the upside potential of the strategy. If the underlying security price increases beyond the strike price of the put, the put option limits the downside of the strategy. The collar strategy therefore attempts to limit the risk or volatility by limiting both the upside and downside of the position. The typical pay-off profile for this strategy is depicted in Figure 21.

FIGURE 21: PAY-OFF PROFILE OF A COLLAR STRATEGY



EURO iSTOXX 50 Collar Index

The EURO iSTOXX® 50 Collar Index aims to replicate a hedging strategy on the EURO STOXX 50 Index using an option collar. The strategy consists of purchasing daily a fraction of two quarterly put options, one with expiry in the next twelve months and one with the next expiry date afterwards, and selling daily a fraction of two to six monthly call options, with expiry in the next one and two months, while holding a long position in the underlying EURO STOXX 50 Index.

Each option remains in the option portfolio until its expiry. The quantity of options to be bought and sold daily is balanced in order to be on average long one put and short one call. All options are out-of-the-money with the strike level for put options set to 90% of the EURO STOXX 50 level. The call options position is split between options with strike at 102.5% and 104.5% of the EURO STOXX 50 level.

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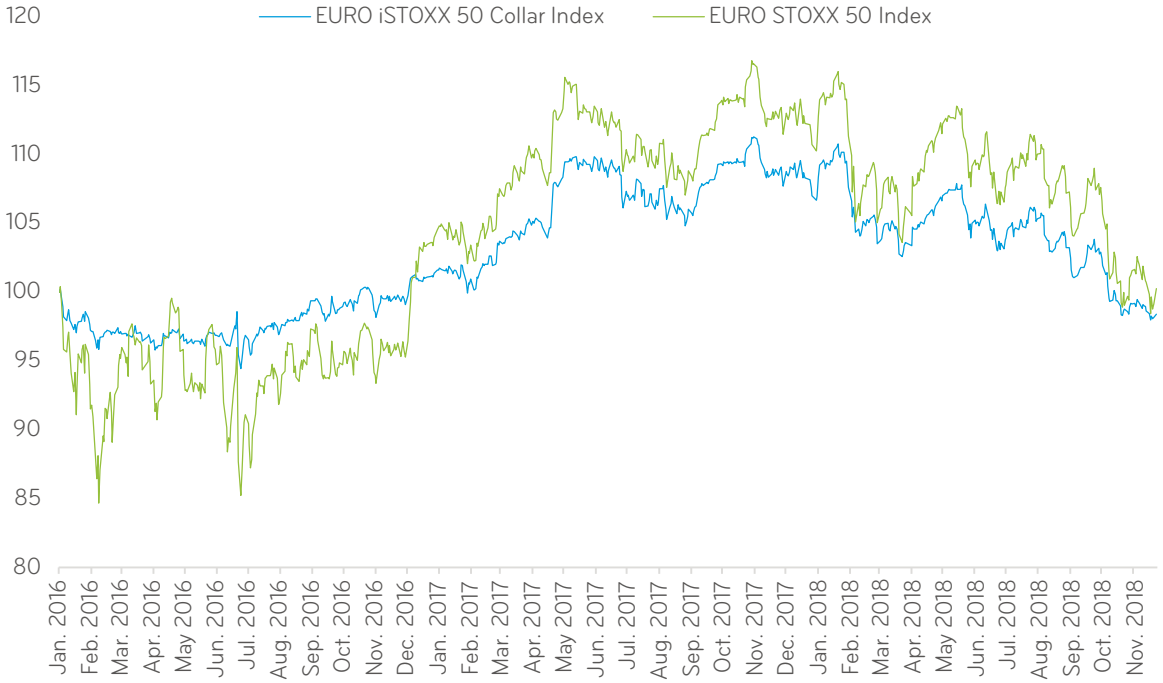
FIGURE 22: EURO ISTOXX 50 COLLAR INDEX AND EURO STOXX 50 INDEX, MEASURED IN EUR PR



This option collar therefore aims to implement a defensive strategy to smooth down returns and reduce volatility, as evident from the table below. The strategy attempts to provide long-term downside protection using long put options positions while forgoing large gains by holding short call options positions.

TABLE 22: RETURNS, STANDARD DEVIATIONS AND CORRELATIONS OF EURO ISTOXX 50 COLLAR INDEX

Period	Returns		Volatility		Correlation
	EURO iSTOXX 50 Collar Index	EURO STOXX 50 Index	EURO iSTOXX 50 Collar Index	EURO STOXX 50 Index	Wrt EURO STOXX 50 Index
1 month	-0.04%	0.86%	4.3%	12.8%	0.92
3 month	-4.71%	-6.45%	6.1%	12.9%	0.92
YTD	-8.1%	-9.4%	7.3%	13.1%	0.95
1 Y	-10.0%	-11.8%	7.4%	12.9%	0.95
Since inception	-0.6%	0.1%	7.1%	15.9%	0.83

All figures are based on EUR PR. Return figures calculated for a duration of more than one year are annualized. Volatility and correlation figures are based on daily returns. Time period: Jan. 2016 – Nov. 2018.

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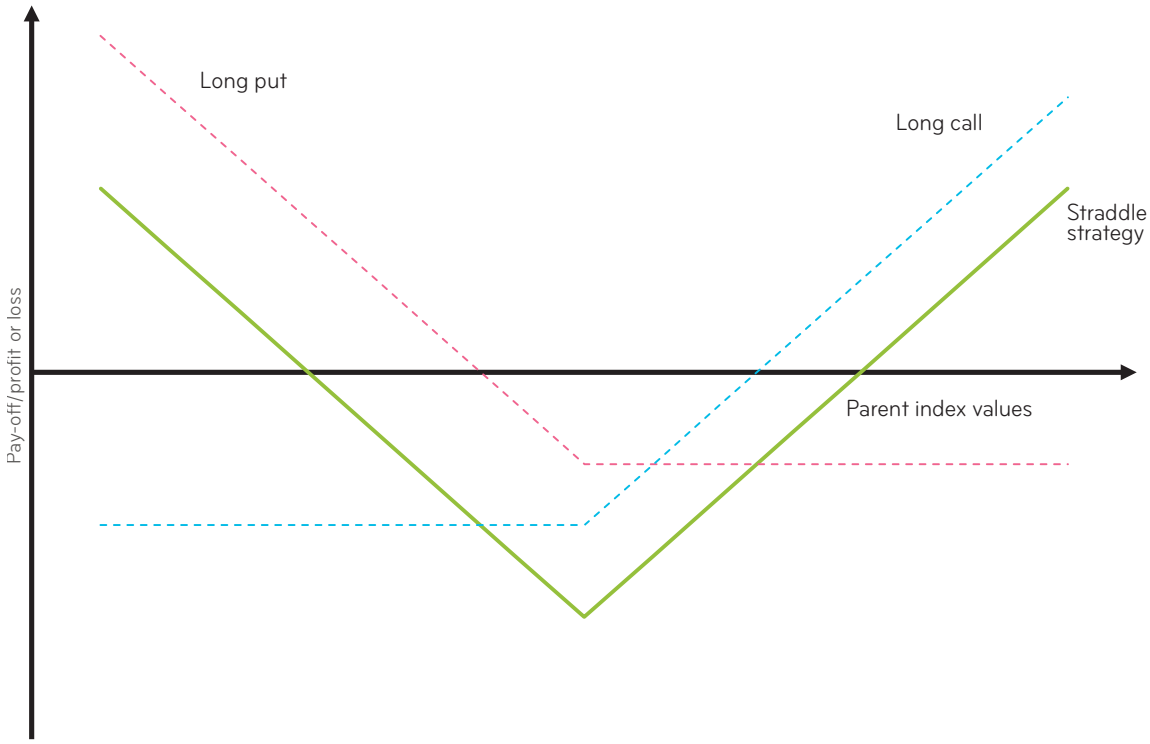
OTHER STRATEGIES

Apart from the volatility index strategies listed above, there are other strategies that may be considered when seeking exposure to volatility for enhancing returns or hedging the downside. A sample of such strategies is described below, and although these are currently not available as STOXX indices, they may be constructed either by combining other strategies discussed in this paper or by employing underlying listed options and futures used in the existing indices.

OPTIONS STRADDLE

The most commonly used strategy for speculating on a rise of volatility is a straddle, i.e. a long call option and a long put option on the same underlying, typically with the same strike and expiration. In this strategy, the investor would profit from rising volatility since he or she is long the Greek 'vega', i.e. the sensitivity of a derivative strategy to volatility, reflecting the likelihood of the underlying moving upwards or downwards.

FIGURE 23: THE PAY-OFF PROFILE OF A STRADDLE STRATEGY



The disadvantage of such options-based strategies compared with volatility futures or tracker certificates is the fact that their performance does not only depend on volatility but also on the price of the underlying asset.

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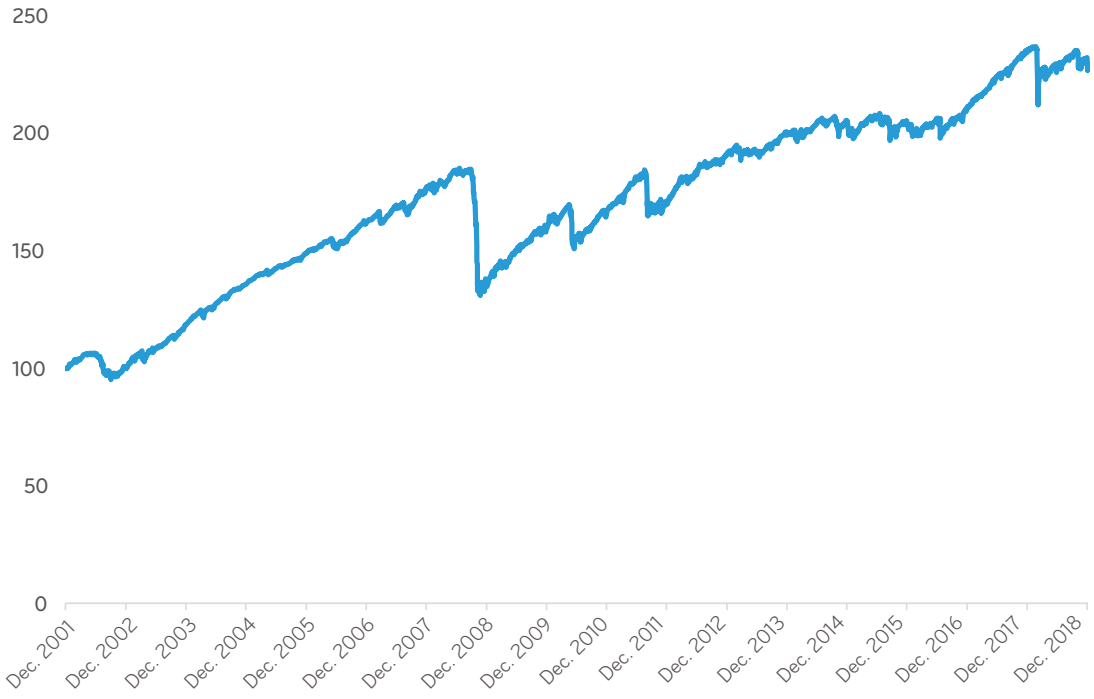
VOLATILITY ARBITRAGE

Volatility arbitrage attempts to perfectly segregate the performance of volatility from that of the underlying asset. A variance swap, which involves receiving implied variance (i.e. square of volatility) and paying realized variance on a rolling basis, attempts to achieve this objective. The main advantage of using variance swaps over volatility-based swaps is that they can be replicated more easily using a portfolio of plain-vanilla options. The return generated is based on the 'pure' difference between implied and realized variance unlike in a buy-write strategy that is typically 'diluted' by movements in the underlying. The performance is indicated in Figure 24.

FIGURE 24: HYPOTHETICAL PERFORMANCE SIMULATION OF A ROLLING INVESTMENT RECEIVING ONE MONTH IMPLIED VARIANCE AND PAYING THE REALIZED VARIANCE ON THE BENCHMARK INDEX



Apparently, the performance of the volatility arbitrage strategy is closely linked to the difference between implied and realized volatility as indicated in Figure 1, i.e. the index performance is mostly positive except for phases where realized volatility jumps upwards, typically due to market turbulences, and hence exceeds implied volatility.

However, these periods tend to be relatively short since protection sellers typically react quickly by increasing the cost of selling protection, bringing implied volatility back above realized volatility and hence ensuring positive returns for the volatility arbitrage strategy.

The volatility arbitrage strategy is well-known in the derivatives market and is even available for retail investors in the form of volatility arbitrage certificates.

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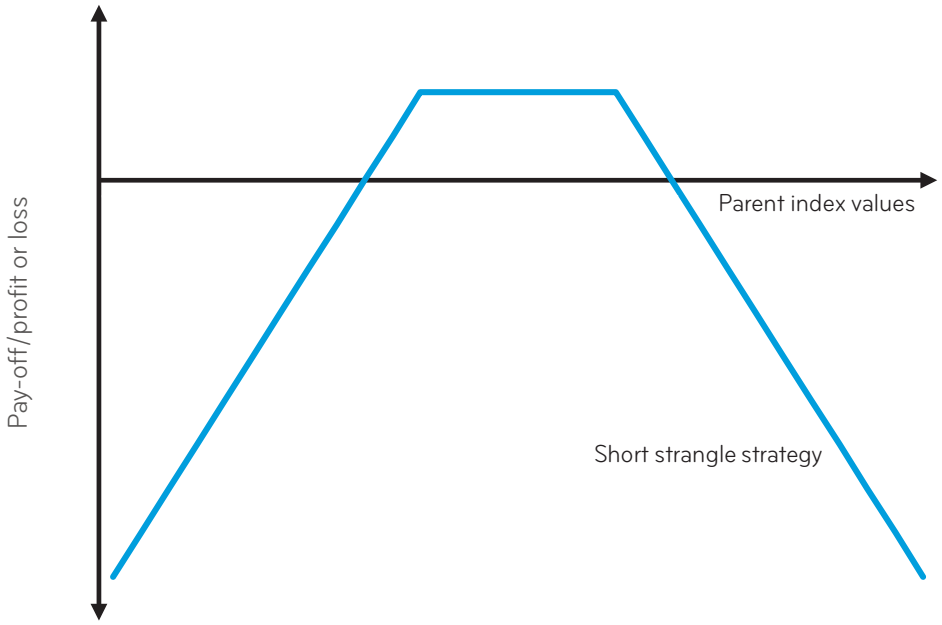
The reason why implied volatilities usually exceed realized volatilities and hence why investors can expect continuously good performance from volatility arbitrage lies in the fact that options are largely used as hedging instruments to insure portfolios against adverse movements of financial markets. Consequently, as in the insurance business, protection providers (i.e. options writers) expect a risk premium on top of their expected payouts to compensate for the risks they are assuming, which drives the performance of the volatility arbitrage strategy.

SHORT STRANGLE

The short strangle is a position created by selling a higher-strike call option and selling a lower-strike put option with the same expiration date. It is a non-directional short volatility strategy, where the price of the underlying is not expected to move much during the time until expiration. This strategy is a limited-profit but unlimited-loss strategy and is suitable for investors who expect the underlying to exhibit low volatility in the near term.

FIGURE 25: PAY-OFF PROFILE OF A SHORT STRANGLE STRATEGY



IRON CONDOR

The iron condor is a limited-risk, non-directional option-trading strategy that is designed to have a large probability of earning a small limited profit when the underlying security is perceived to have low volatility. The iron condor strategy can also be visualized as a combination of a bull put spread and a bear call spread. In this strategy, a trader buys an out-of-the-money call option and a put option, having the same absolute value of delta.

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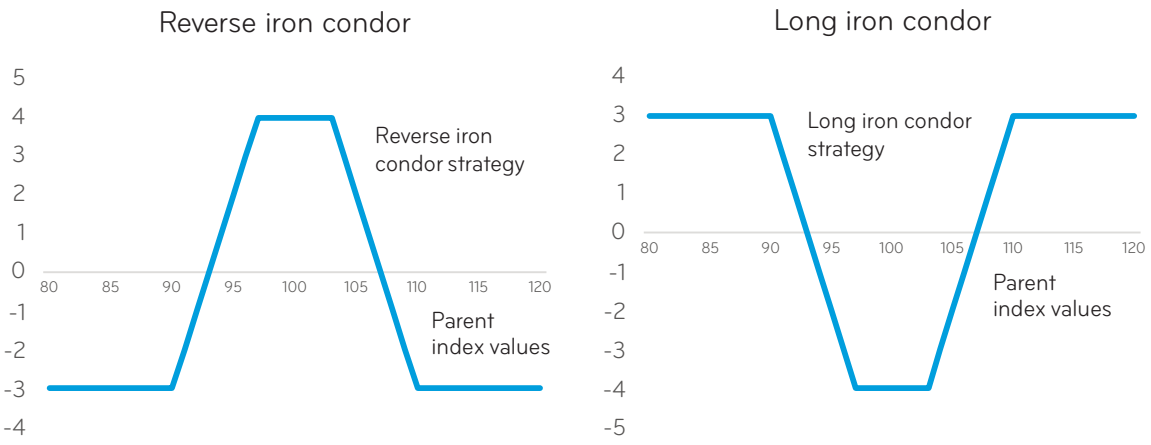
FIGURE 26: REVERSE AND LONG IRON CONDOR



PORTFOLIO-BASED STRATEGIES

Other volatility-related concepts that have been employed by investors are risk-controlled or risk-budget investment schemes, which typically combine a risky asset with a riskless asset based on volatility signals. Such portfolios tend to be employed by institutional investors operating under strict risk management rules, e.g. pension funds. Similarly, investors have employed portfolios that invest into a combination of equities (usually between 75% and 95%) and fixed income (between 5% and 25%) with the objective of harvesting the (typically) negative correlation or extremely low correlation between equity and fixed-income markets, thereby improving the risk-return profile. We shall discuss some of these risk-based and risk-controlled strategies in a separate research note.

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CONCLUSION

STOXX offers various indices providing direct exposure to volatility as well as other strategy indices that employ derivatives to offer volatility exposure. These volatility indices and volatility strategy indices allow investors to either speculate or express a directional view on volatility, or even allow users to construct additional indices with a favorable risk-return performance. However, investors need to be aware of the main characteristics of volatility whilst considering exposure to it as an investable asset class.

The most important property of volatility that investors need to be aware of is its mean-reverting property. Investors also need to be cognizant of the asymmetry between up and down movements in volatility, as seen in the empirical evidence in the paper. Upward movements in volatility are typically short, intense, and usually not foreseeable, making it extremely difficult, nearly impossible rather, to employ a strategy that tracks a 'trend' of rising volatility. In contrast, jumps in volatility are typically followed by a period of falling volatility towards its medium- to long-term average levels. Therefore, strategies that go short volatility after sudden spikes may prove to be rewarding. In either case, a constant directional view may not be deemed a profitable strategy in the long run due to the lack of direct returns from volatility and its mean-reversion property.

Some of the other options-based strategies or a dynamic combination of some of the direct futures-based exposures to volatility may be used to generate returns and/or to reduce the volatility of an investment portfolio. When used in combination with long equity positions, these strategies assist in exploiting the negative correlation between the two 'asset classes'. However, the performance of such a strategy is typically influenced by both market volatility and the performance of the underlying asset, and hence is not a plain investment strategy for volatility.

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About STOXX Ltd.

STOXX Ltd. is a global index provider, currently calculating a global, comprehensive index family of over 10,000 strictly rules-based and transparent indices. Best known for the leading European equity indices EURO STOXX 50, STOXX Europe 50 and STOXX Europe 600, STOXX Ltd. maintains and calculates the STOXX Global index family which consists of total market, broad and blue-chip indices for the regions Americas, Europe, Asia/Pacific and sub-regions Latin America and BRIC (Brazil, Russia, India and China) as well as global markets.

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