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STRATEGY INSIGHT

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LOW-RISK-BASED INVESTING

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MARKET INSIGHT

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OVERVIEW

LOW-RISK-BASED INVESTING HAS REWARDED INVESTORS OVER LONGER PORTFOLIO HOLDING PERIODS. THE FACT THAT LOW-RISK STOCKS HAVE HIGHER EXPECTED RETURNS CONTRADICTS ONE OF THE FOUNDATIONS OF FINANCE THEORY: RISK -BEARING ASSETS ARE EXPECTED TO GENERATE A RETURN PREMIUM.

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The findings of Haugen and Heins, who in an original analysis dating back to the mid-1970s started to challenge the generally accepted paradigm of the efficient market hypothesis of Fama, have been confirmed in numerous studies across various markets.

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Although there is supporting evidence of low-risk portfolios outperforming market-cap portfolios with lower risk in the long run, over the short term relative performance is somewhat dependent on market conditions. The asymmetric response of low-volatility portfolios to market movements points to their ability to provide a certain level of downside protection in uncertain market conditions.

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In today's market environment, where volatility patterns are triggered by information flows and geopolitical tensions, lower-volatility features embodied by low-risk-weighted and minimum-volatility strategies are particularly appealing to investors.

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The EURO STOXX® Low Risk Weighted 100 Index—a fixed-component index with 100 constituents that represents the least volatile companies from the EURO STOXX® index—outperformed by far the "plain-vanilla" European benchmark for the period Mar. 19, 2001-Apr. 30, 2015. The stellar 221.75% indexed performance in euro gross-return terms (with an annualized log-return volatility of 14.53%) of the EURO STOXX Low Risk Weighted 100 Index compared to the 72.76% return of the EURO STOXX Index (with an annualized log-return volatility of 22.08%).

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Based on daily gross returns for the period Mar. 20, 2001-Apr. 30, 2015 (3,622 daily observations), the EURO STOXX Low Risk Weighted 100 Index outperformed the EURO STOXX Index 78.49% of the time during down markets, while it outperformed the "plain-vanilla" European benchmark 20.57% of the time during up markets.

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For the period Feb. 29, 2012-Mar. 31, 2015, the active return generated by the EURO STOXX Low Risk Weighted 100 Gross Return Index stood at 10.50%, with a positive 22.05% factor contribution—statistically significant at the 95% confidence level. In terms of style factors, with a 17.09% overall positive contribution, the low-risk-weighted portfolio had a statistically significant exposure to growth (+0.90%) and medium-term momentum (+3.95%) and a negative bias to high-volatility stocks (+16.05%). Conversely, value (-3.32%) detracted from the style contribution.

"CONSTANT EXPOSURE TO DANGERS WILL BREED CONTEMPT FOR THEM."

– Marcus Annaeus Seneca (54 BC–39 AD)

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1 LOW-RISK-BASED INVESTING

1.1 INTRODUCTION AND LITERATURE REVIEW

Low-volatility strategies have gained increased popularity in the aftermath of the global financial crisis, capturing the attention of risk-conscious investors. In particular, minimum-variance portfolio strategies, which have been widely promoted in recent years, derive their legitimacy from Harry Markowitz's seminal work published in 1952[1].

The practical importance of low volatility in portfolio construction has been championed by Haugen and Heins[2] since the mid-1970s. In an original analysis, they started to challenge the generally accepted paradigm of the efficient market hypothesis of Fama[3]. The two authors gave evidence of a negative relationship between risk and return in the US stock and bond markets for the period from 1962 to 1971. They also addressed a number of limitations of previous studies about the relationship between risk and realized return.

The low-volatility anomaly has been investigated thoroughly by Haugen and Baker since their seminal paper[4] on minimum-variance portfolios. The fact that low-risk stocks have higher expected returns contradicts one of the foundations of finance theory: risk-bearing assets are expected to generate a return premium.

The original findings from Haugen and Heins have been confirmed in numerous studies across various markets. Particularly, in a research paper dating back to 2008[5], Haugen and Baker performed a cross-sectional analysis on US companies using a 56-factor model, with a database of 677 stocks at the start of the period in 1963 that rose to 6,382 in 2007. The evidence was compelling. In every one of the 45 years analyzed except one (2003), the stocks with the highest risk—defined in terms of most expensive, highest price momentum and fastest growing—generated the lowest returns. The authors found that "the statistical significance of risk in determining the structure of the cross-section of stock returns is high, but the payoff to risk has the wrong sign period after period. The riskiest stocks over measures including market beta, total return variance, and residual volatility tend to have the lowest returns." And, the expected return factor model is "very powerful in predicting the future relative returns on stocks. High-return stock decile composites tend to be relatively large companies with low risk and they have positive market price momentum. The profitability of high-return stocks is good and getting better. The low-return counterparts to these stocks have the opposite profile."

In a more recent study[6], Haugen and Baker extend their early findings over the period from 1990 to 2011, relying on a survivorship bias-free database of stocks, representing 99.5% of the capitalization for each country in 21 developed nations and 12 emerging markets. In their study, the authors provided additional empirical evidence that "bearing relative risk in the equity markets of the world yields an expected negative reward."
More recently, Jurczenko, Michel and Teiletche[7], based on a large sample of international developed-market equities over the 2002-2012 period, found that "the portfolio construction behind risk-based investing implicitly picks up asset pricing anomalies, especially the size and the low-beta pricing anomalies."

[1] Markowitz, H. (1952), "Portfolio Selection," The Journal of Finance, V ol. 7, No. 1, pp. 77-91.
[2] Haugen, R. A. and A. J. Heins (1972), "On the Evidence Supporting the Existence of Risk Premiums in the Capital Market," Wisconsin Working Paper, December.
[3] Fama, E. F. (1970), "Efficient Capital Markets: A Review of Theory and Empirical Work," Journal of Finance, Vol. 25, Issue 2, pp. 383-417.
[4] Haugen, R. and N. L. Baker (1991), "The Efficient Market Inefficiency of Capitalization-Weighted Stock Portfolios," Journal of Portfolio Management 17, pp. 35-40.
[5] Haugen, R. and N. L. Baker (2008), "Case Closed," The Handbook of Portfolio Construction: Contemporary Applications of Markowitz Techniques, edited by John B. Guerard Jr.
[6] Baker, N. L. and R. A. Haugen (2012), "Low Risk Stocks Outperform Within All Observable Markets of the World," SSRN, April.
[7] Jurczenko, E., T. Michel and J. Teiletche (2013), "Generalized Risk-Based Investing," SSRN, March.

Baker, Bradley and Wurgler[8] showed for the period January, 1968–December, 2008, how low-volatility and low-beta portfolios provide a desirable combination of high average returns and small drawdowns. "This outcome runs counter to the fundamental principle that risk is compensated with higher expected return." In their study, the authors applied principles of behavioral finance to shed light on the drivers of this anomalous performance and to assess the probability of persistence of the phenomenon. According to the authors, "this anomaly may be partly explained by the fact that the typical institutional investor's mandate to beat a fixed benchmark discourages arbitrage activity in both high-alpha, low-beta stocks and low-alpha, high-beta stocks." And, "regardless of whether we define risk as volatility or beta or whether we consider all stocks or only large caps, low risk consistently outperformed high risk over the period."

Although there is supporting evidence of low-risk portfolios outperforming in the long run market-cap portfolios with lower risk, over the short term relative performance is somewhat dependent on market conditions. The asymmetric response of low-volatility portfolios to market movements points to their ability to provide a certain level of downside protection in uncertain market conditions.

Historically, data evidence has shown an inverse relationship between stock market volatility and market cycles. Volatility typically rises during recessionary periods and market uncertainty.

In particular, implied volatility typically rises when markets are falling and vice versa. The negative correlation of implied volatility with stock market trend can be explained easily by the fact that during market disturbances investors buy protection for their portfolios, pushing upward options prices and hence implied volatilities.

In his analysis of stock market volatility patterns, Schwert[9] found weak evidence that macroeconomic volatility can help to predict stock and bond market return volatility. Rather, data evidence appeared to support the statement that stock market volatility helps to explain future macroeconomic volatility as policymakers respond to large moves in the stock market.

At the same time, according to Schwert's findings, a relationship between trading activity and stock market volatility seems to exist. Both the number of trading days in a given month and trading volume growth are positively related to stock market volatility.

A significant relationship between volatility and the volume in the market is supported by data evidence in financial literature. Usually, the last variable (Lamoureux and Lastrapes[10]; Karpoff[11]) is considered a proxy for new information flow/arrival and is linked to major events in the stock market. In addition, in financial data, volatility fuels its intrinsic process (volatility clustering), since it can be observed generally in the market that days of high volatility are followed by subsequent days of high volatility, and vice versa—days of low volatility follow each other. Furthermore, the autoregressive conditional heteroskedasticity (ARCH) process present in daily returns disappears when the volume is included as a regressor in the variance equation used to estimate ARCH-class models.

In today's market environment, where volatility patterns are triggered by information flows and geopolitical tensions, lower-volatility features embodied by low-risk-weighted and minimum-volatility strategies are particularly appealing to investors.

1.2 LOW-VOLATILITY PERSISTENCE – THE INVESTMENT RATIONALE

The EURO STOXX® Low Risk Weighted 100 Index in particular is a fixed-component index with 100 constituents that represents the least volatile

[8] Baker, M., B. Bradley and J. Wurgler (2011), "Benchmarks as Limits to Arbitrage: Understanding the Low Volatility Anomaly," Financial Analyst Journal, Vol. 67, No. 1, pp. 1-15.
[9] Schwert, G. W. (1989), "Why Does Stock Market Volatility change over time?," Journal of Finance, Vol. 44, December, 1989, pp. 1115-1153.
[10] Lamoureux, C. G. and W. D. Lastrapes (1990), "Heteroskedasticity in Stock Return Data: Volume Versus GARCH Effects," Journal of Finance, Vol. XLV, No. 1, pp. 221-229.
[11] Karpoff, J. M. (1987), "The Relation Between Price Changes and Trading Volumes: A Survey," Journal of Financial and Quantitative Analysis, Vol. 22, No. 1, pp. 109-126.

companies from the EURO STOXX® index. The methodology underlying the EURO STOXX Low Risk Weighted 100 Index is fairly simple. It assumes the stocks that have been the least volatile for the past 12 months will continue to record below-average volatility for at least the next quarter.

Constituents are selected on the basis of their 12-month historical volatility and are weighted by the inverse of their 12-month historical volatility, with 10% component capping. The formulation is as follows:

$$w_i = \frac{\frac{1}{\sigma_i}}{\sum_{i=1}^{n}\frac{1}{\sigma_i}},$$

where:

$w_i = i_{th}\ constituent\ weight,$

$\sigma_i = historical\ 12\ month\ volatility\ of\ i_{th}\ component,$

$n = index's\ constituents\ number.$

The weighting factor is given by:

weighting factor = weight * (1,000,000,000 / closing price of the stock in EUR), rounded to integers.

The weighting mechanism enables the index to benefit from an additional layer of diversification, leading to enhanced risk-return characteristics. At the same time, it avoids concentrating investment in the largest companies.

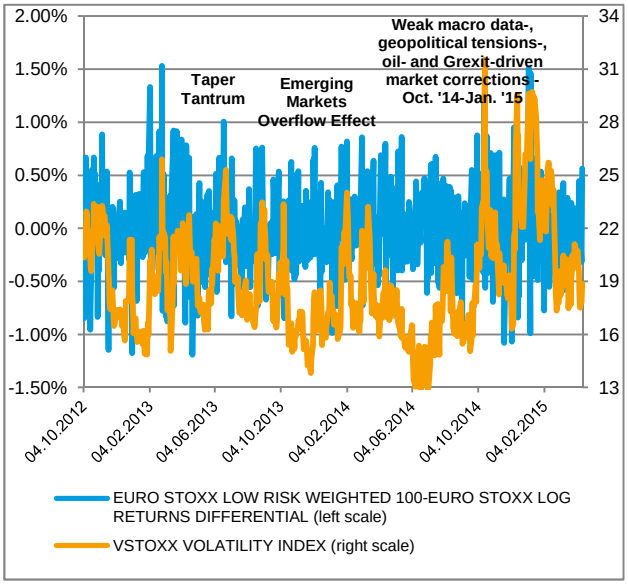
The introduction of the 12-month volatility weighting decreases the risk of high weightings for single and more volatile components. The risk-based approach in the index construction aims to reduce the index's risk on average, since the risk contributions of the index's constituents are scaled according to the historical volatility. In risk budgeting terms, the marginal risk contributions[12] of the index are volatility scaled.

In January, 2015, which will be remembered as the month of the central banks' longest drag race as the currency war intensified, geopolitical tensions escalated and economic growth faltered. The EURO STOXX Index experienced a daily change of over 1% in absolute terms in 11 of the 21 trading sessions, corresponding to 52% of the time.
The same percentage calculations for October, 2014; December, 2014 and March, 2015 were 35%, 39% and 36%, respectively.

For January, 2015, the EURO STOXX Low Risk Weighted 100 Price Index outperformed the EURO STOXX Price Index by 200 basis points (bps), with the low-risk-weighted index returning 9.06% for the month.

Historically, low-risk-weighted strategies have performed relatively better in volatile periods. The chart below plots the daily log-return difference between the EURO STOXX Low Risk Weighted 100 Index and the EURO STOXX. Also, the EURO STOXX 50® Volatility (VSTOXX)—a gauge of market fear, since it reflects the assessment of market expectations on future levels of realized volatility—is included in the chart.

FIGURE 1 EURO STOXX LOW RISK WEIGHTED 100, EURO STOXX LOG-RETURN DIFFERENTIAL AND VSTOXX VOLATILITY INDEX (OCT. 4, 2012-APR. 14, 2015)

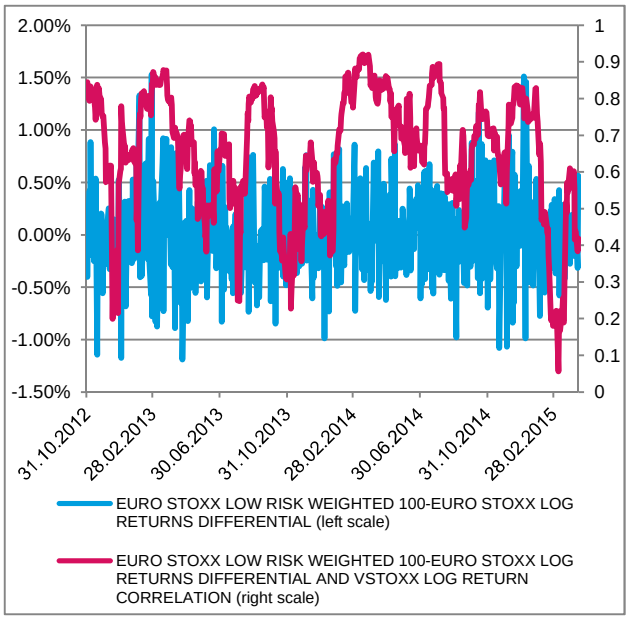


Source: STOXX

[12] Generally speaking, marginal risk contributions indicate the sensitivity of the portfolio's risk to a change in the weightings of the assets.

The low-risk-weighted index has outperformed the EURO STOXX Index in days when volatility was rising. At the same time, despite some differences in the underlying between the EURO STOXX Index and the VSTOXX[13], the chart below shows a significant correlation pattern between the positive log-return difference between the EURO STOXX Low Risk Weighted 100 Index and the EURO STOXX Index and higher implied volatility levels.

FIGURE 2 EURO STOXX LOW RISK WEIGHTED 100, EURO STOXX LOG-RETURN DIFFERENTIAL AND 20-DAY ROLLING-WINDOW CORRELATION WITH VSTOXX VOLATILITY INDEX LOG RETURNS (OCT. 4, 2012-APR. 14, 2015)



Source: STOXX

The charts below plot indexed performance, 20-day annualized rolling-window volatility, correlation and maximum drawdown of the EURO STOXX Low Risk Weighted 100 Index and the EURO STOXX Index for the period Mar. 19, 2001-Apr. 30, 2015[14].

The stellar 221.75% indexed performance in euro gross-return terms (with an annualized log-return volatility of 14.53%) of the EURO STOXX Low Risk Weighted 100 Index compared to the 72.76% return of the EURO STOXX Index (with an annualized log-return volatility of 22.08%).

The EURO STOXX Low Risk Weighted 100 Index underperformed in price-return terms year to date at the Apr. 30, 2015, close against the EURO STOXX Index (-100 bps), posting a 15.25% performance. Conversely, it outperformed the "plain-vanilla" European benchmark for the one- (+658 bps) and three-year (+274 bps) periods as the low-risk-weighted benchmark posted remarkable 20.93% and 62.22% returns, respectively.

In gross-return terms, despite posting a negative return for the month, the EURO STOXX Low Risk Weighted 100 Index outperformed the EURO STOXX Index for April (+0.42%). Conversely, it underperformed the plain-vanilla European benchmark year to date at the Apr. 30, 2015, close by 77 bps, posting a 16.42% performance. It outperformed the EURO STOXX Index for the one-year (+726 bps) and three-year (+287 bps) periods, returning 25.23% and 79.90%, respectively.

As expected, throughout the overall measurement period, log-return volatility—as measured by a 20-day annualized rolling window—was lower for the EURO STOXX Low Risk Weighted 100 Index compared to the plain-vanilla European benchmark. For the same period, the EURO STOXX Low Risk Weighted 100 Index recorded a maximum drawdown of 53.16%, while the EURO STOXX Index posted a drawdown of 61.75%.

The EURO STOXX Low Risk Weighted 100 Index showed a mixed correlation pattern with the EURO STOXX Index for the overall period. Generally speaking, except for periods of volatility clustering, lower-volatility levels were observed in periods of decreased correlation patterns.

[13] The VSTOXX index provides a key measure of market expectations of near-term, medium-term and long-term volatility based on the EURO STOXX 50 options prices.

[14] The EURO STOXX Low Risk Weighted 100 Index was launched on Oct. 9, 2012 (hereinafter, the launch date). Index values calculated for any date or period prior to the index's launch date are considered backtested.

FIGURE 3 EURO STOXX LOW RISK WEIGHTED 100 INDEX AND EURO STOXX INDEX, INDEXED PERFORMANCE (MAR. 19, 2001-APR. 30, 2015, PRICE RETURN)

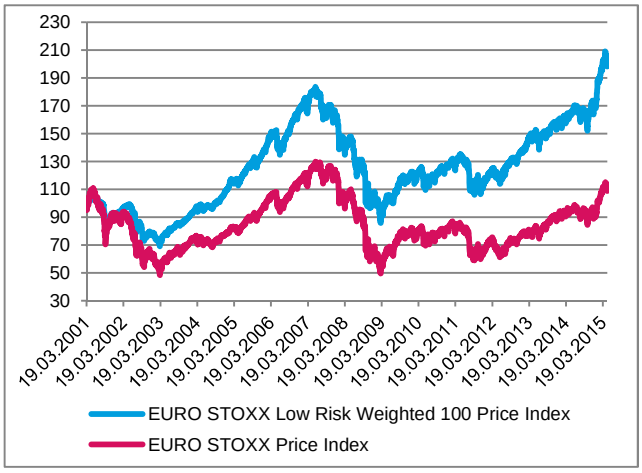
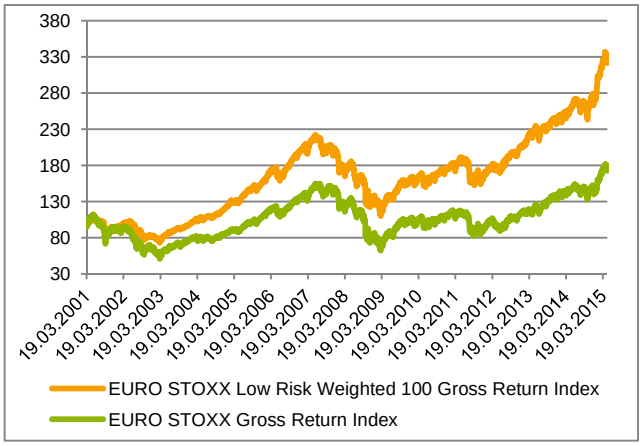
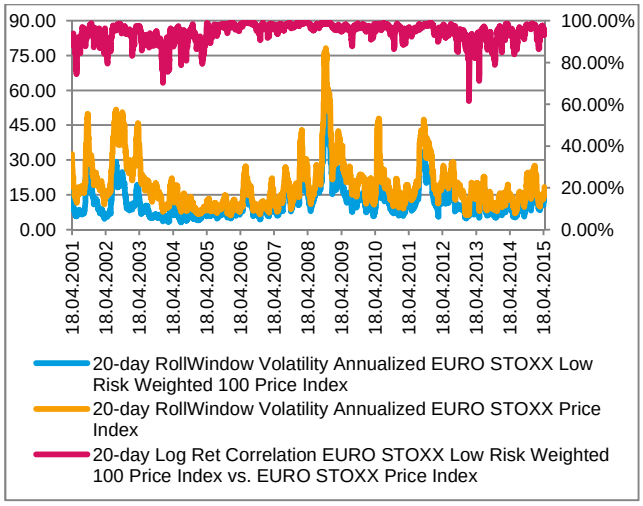


FIGURE 4 EURO STOXX LOW RISK WEIGHTED 100 INDEX AND EURO STOXX INDEX, INDEXED PERFORMANCE (MAR. 19, 2001-APR. 30, 2015, GROSS RETURN)



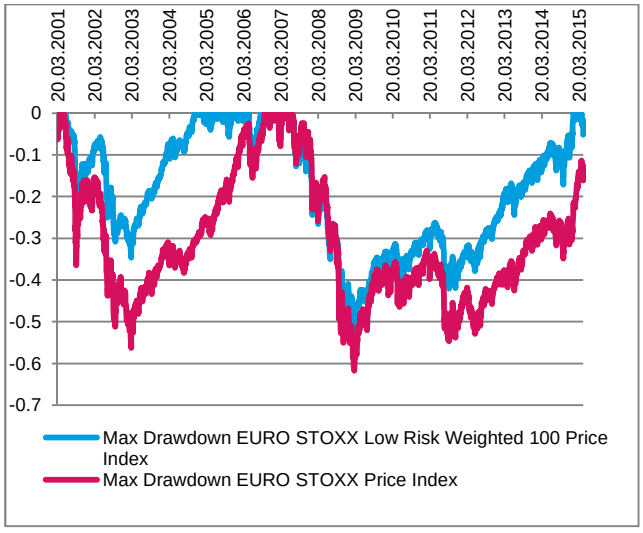
Source: STOXX

FIGURE 5 EURO STOXX LOW RISK WEIGHTED 100 INDEX AND EURO STOXX INDEX, LOG-RETURN CORRELATION VERSUS ROLLING-WINDOW VOLATILITY (MAR. 19, 2001-APR. 30, 2015, PRICE RETURN)



Source: STOXX

FIGURE 6 EURO STOXX LOW RISK WEIGHTED 100 INDEX AND EURO STOXX INDEX, MAXIMUM DRAWDOWN (MAR. 19, 2001-APR. 30, 2015, PRICE RETURN)



Source: STOXX

1.3 RISK/RETURN AND PORTFOLIO CHARACTERISTICS OF THE EURO STOXX LOW RISK WEIGHTED 100 INDEX

Figures 7 and 8 below show that both the price-return and the gross-return versions of the EURO STOXX Low Risk Weighted 100 Index have generated superior returns—in both absolute and risk-adjusted terms—for various measurement periods, with substantial reduction in volatility relative to the EURO STOXX Index.

FIGURE 7 EURO STOXX LOW RISK WEIGHTED 100 INDEX AND EURO STOXX INDEX, SUMMARY OF RISK/RETURN MEASURES (MAR. 19, 2001-APR. 30, 2015, PRICE-RETURN INDICES)

	EURO STOXX Low Risk Weighted 100 Price Index			EURO STOXX Price Index		
	Annualized Return (%)	Annualized Volatility (%)	Return/Risk Annualized	Annualized Return (%)	Annualized Volatility (%)	Return/Risk Annualized
3-Year	17.50	11.20	1.41	16.83	16.14	0.98
5-Year	10.37	13.72	0.71	6.65	20.00	0.34
10-Year	5.77	15.37	0.36	3.32	21.58	0.16
14-Year	4.71	14.49	0.31	-0.04	22.03	0.01
Max Drawdown (%)						
Since Mar. 19, 2001	-53.16			61.75		

Source: STOXX

FIGURE 8 EURO STOXX LOW RISK WEIGHTED 100 INDEX AND EURO STOXX INDEX, SUMMARY OF RISK/RETURN MEASURES (MAR. 19, 2001-APR. 30, 2015, GROSS-RETURN INDICES)

	EURO STOXX Low Risk Weighted 100 Gross Return Index			EURO STOXX Gross Return Index		
	Annualized Return (%)	Annualized Volatility (%)	Return/Risk Annualized	Annualized Return (%)	Annualized Volatility (%)	Return/Risk Annualized
3-Year	21.62	11.13	1.79	20.97	16.11	1.20
5-Year	14.51	13.69	1.01	10.69	19.96	0.52
10-Year	9.69	15.37	0.61	7.05	21.57	0.32
14-Year	8.35	14.49	0.56	3.27	22.02	0.16
Max Drawdown (%)						
Since Mar. 19, 2001	-50.64			-59.71		

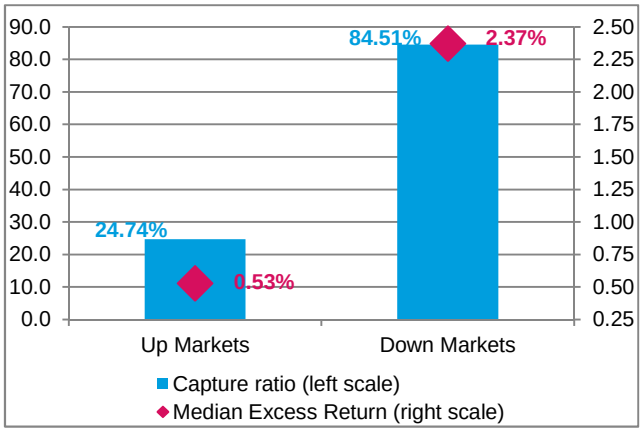
Source: STOXX

The asymmetric response of low-volatility portfolios to market movements points to their expected underperformance in bull markets and their ability to provide a certain level of downside risk protection in uncertain market conditions and bear markets in general.

Based on monthly gross returns for the period April, 2001-April, 2015 (169 monthly observations), the EURO STOXX Low Risk Weighted 100 Index outperformed the EURO STOXX Index 84.51%[15] of the time during down markets, while it outperformed the plain-vanilla European benchmark only 24.74% of the time during up markets. The median level of monthly outperformance of the EURO STOXX Low Risk Weighted 100 Index was 0.53% during up-market periods and 2.37% during down markets.

Based on daily gross returns for the period Mar. 20, 2001-Apr. 30, 2015 (3,622 daily observations), the capture ratio of the EURO STOXX Low Risk Weighted 100 Index was 78.49% during down markets, while it was a lower 20.57% during up markets. The median level of daily outperformance of the EURO STOXX Low Risk Weighted 100 Index was 0.10% during up-market periods and 0.36% during down markets.

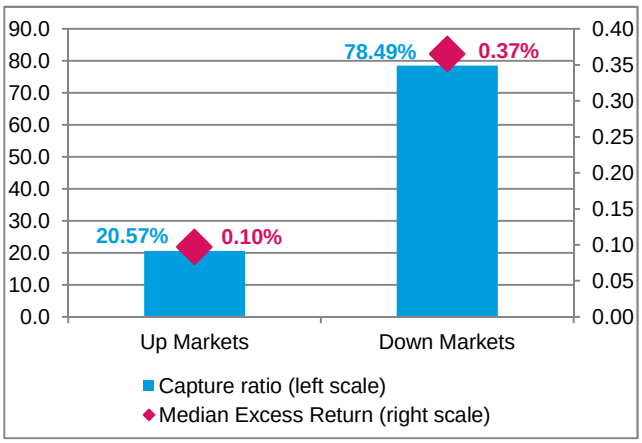
FIGURE 9 EURO STOXX LOW RISK WEIGHTED 100 INDEX VERSUS EURO STOXX INDEX, CAPTURE RATIO AND MEDIAN EXCESS RETURN (APRIL, 2001-APRIL, 2015, GROSS-RETURN INDICES, MONTHLY DATA)



Source: STOXX

[15] That percentage is generally referred to as the capture ratio.

FIGURE 10 EURO STOXX LOW RISK WEIGHTED 100 INDEX VERSUS EURO STOXX INDEX, CAPTURE RATIO AND MEDIAN EXCESS RETURN (APR. 20, 2001-APR. 30, 2015, GROSS-RETURN INDICES, DAILY DATA)



Source: STOXX

Cross-sectional dispersion, also referred to as either dispersion or stock-pairwise volatility, measures the degree of variation of a portfolio's constituents and represents the opportunity for active portfolio management. In periods of high cross-sectional dispersion, the performance range between the top performers and the worst performers is relatively wide. Conversely, when cross-sectional dispersion is low, the performance range tightens.

Cross-sectional dispersion is an intuitive measure of the benefits of diversification, since it accounts for the effect of both correlation and volatility patterns. An increased dispersion of returns generally determines a lower intracorrelation, i.e., a lower correlation among constituents and—to a certain extent—sectors. Generally speaking, lower intracorrelation among portfolio constituents and sectors leads to higher levels of diversification for both managers and investors (a desirable feature) as well as higher expected risk-adjusted returns.

Cross-sectional dispersion is generally computed for equally weighted portfolios as the cross-sectional standard deviation of the portfolio constituents' performances for the measurement period. For non-equally weighted portfolios, cross-sectional dispersion is computed by weighting portfolio constituents by their respective weightings in the standard deviation calculation. Computation of cross-sectional dispersion requires specification of the period for which returns are measured as well as the breakdown level at which the calculation is performed (for an equity index, the cross-sectional volatility could be measured alternatively at the country or sector level).

$$\textit{Cross-sectional dispersion} = \sqrt{\sum_{i=1}^{n} w_i \left(r_i - r_p\right)^2},$$

where:

$r_p = portfolio\ return,$

$r_i = i_{th}\ constituent\ return,$

$w_i = i_{th}\ constituent\ weight,$

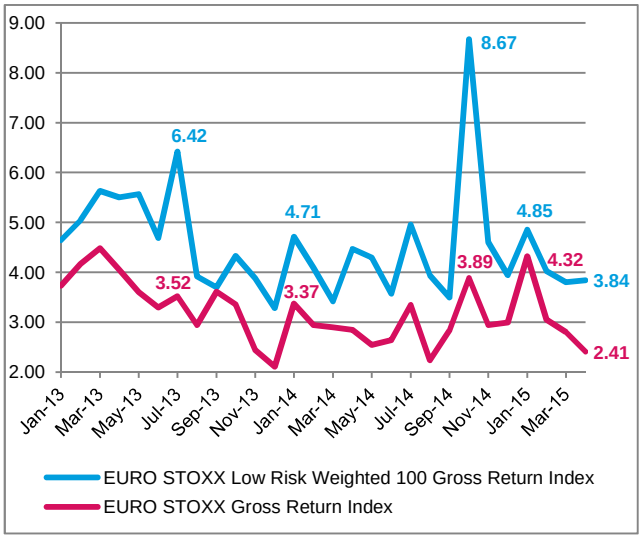
$n = index's\ constituents\ number.$

Differently from time-series volatility, cross-sectional dispersion is computed taking into account only the most recent information and measures the cross-sectional variation over a single time period. Under a list of simplifying assumptions, Solnik and Roulet[16] show that cross-sectional dispersion of stock market returns is an alternative to the time-series approach to estimate the global correlation level of equity markets. In other words, cross-sectional volatility provides an "instantaneous" measure of realized correlation.

Intuitively, the cross-sectional dispersion accounts for a diversification benefit. It is a cost-opportunity measure, since it computes the cross-sectional variation that is not reflected in the overall market movement and, therefore, is not captured when the market portfolio as a single investable asset is taken into account.

[16] Solnik, B. and J. Roulet (2000), "Dispersion as Cross-Sectional Correlation," Financial Analysts Journal, Vol. 56, No. 1 (January/February), pp. 54-61.

FIGURE 11 EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX VERSUS EURO STOXX GROSS RETURN INDEX, MONTHLY CROSS-SECTIONAL DISPERSION (JANUARY, 2013-APRIL, 2015)

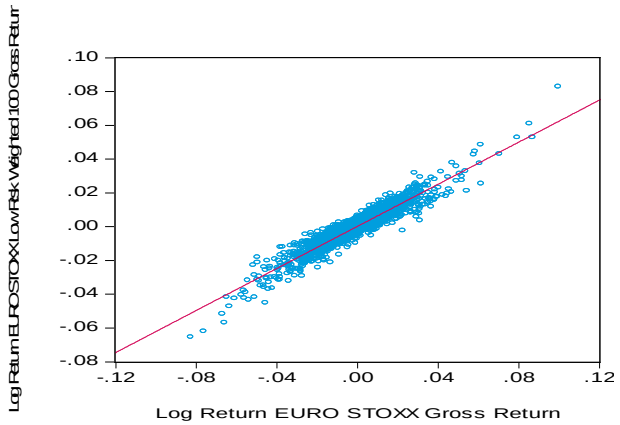


Source: STOXX

The chart above plots the cross-sectional dispersion for the EURO STOXX Low Risk Weighted 100 Index and the EURO STOXX Index. The superior diversification benefits of the low-risk-weighted index are reflected in the higher values of the cross-sectional dispersion, compared to the plain-vanilla benchmark.

Those benefits were particularly evident in the sharp market correction episodes (May, 2013 through June, 2013; January, 2014; and October, 2014 through January, 2015) when cross-sectional dispersion for the low-risk-weighted index spiked. It is noteworthy that the cross-sectional dispersion of the EURO STOXX Low Risk Weighted 100 Gross Return Index jumped to 6.42 for July, 2013, and to 8.67 for October, 2014. For the same dates, those readings compared to 3.52 and 3.89, respectively, for the EURO STOXX Index. A more detailed sector-allocation analysis for those market-correction episodes will be performed later in the report.

FIGURE 12 EURO STOXX GROSS RETURN INDEX VERSUS EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX, SCATTERPLOT (MAR. 20, 2001-APR. 30, 2015)



Source: STOXX

The scatterplot for the EURO STOXX Low Risk Weighted 100 Gross Return Index and the corresponding plain-vanilla European benchmark confirms a positive correlation between the stock indices' log returns. Also, the traditional calculation of the correlation coefficient between the two indices for different sample periods (full sample, January, 2009-April, 2015 and since the launch date) confirms the strength of the linear relationship between the log-return distribution of the two time series of the indices. The correlation coefficient calculated for each of the three periods above was in excess of 0.93.

At a more accurate level, given the leptokurtic and negatively skewed distribution of log returns of the two indices, a nonparametric statistic (Kendall's tau) has been computed. Kendall's tau is a nonparametric statistic that is based on the ranked data and uses and makes reference to the relative orderings of rankings. Despite lowering the strength of the linear relationship between the two indices to 0.76 for the period since the launch of the EURO STOXX Low Risk Weighted 100 Index, the Kendall's tau statistic measures of association confirmed the existence of a significant positive relationship between the two log-return time series. The number of concordances in the rankings of the two time series of returns outnumbered the number of discordances.

In addition, we tested whether the relationship between the low risk weighted index and the "plain-vanilla" benchmark differed between up-market periods and down-market periods. In order to do that, we compared two different pairs of log-return time series, one computed for up markets and the other calculated for down markets. Also, we included in the analysis the VSTOXX Index, computing log-returns in both up-market and down-market periods to test the existence of any relationship between the two European benchmarks and the implied volatility index.

For both up-market and down-market periods the Kendall's tau statistic measures of association showed a lower positive relationship between the two log-return time series, with negligible differences between the two market cycles. Interestingly, the negative relationship between the VSTOXX and either the EURO STOXX Low Risk Weighted 100 Index or the EURO STOXX appeared to be asymmetric in the two market periods. The negative association of the VSTOXX with the two indices was, as expected, of a relatively larger magnitude in down-markets and more pronounced with the "plain-vanilla" benchmark (-0.44), compared to the low-risk-weighted index (-0.38). These findings point to the ability of the EURO STOXX Low Risk Weighted 100 Index to provide a certain level of downside risk protection in bear markets.

FIGURE 13 EURO STOXX GROSS RETURN INDEX, EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX, AND VSTOXX, KENDALL'S TAU, DOWN MARKETS (MAR. 20, 2001-APR. 30, 2015, DAILY LOG-RETURNS)

Covariance Analysis: Kendall's tau

Sample: 1 1730
Included observations: 1730

tau-b			
tau-a			
Concordances (C)			
Discordances (D)			
Probability	EURO STOX...	EUROSTX L...	VSTOXX
EURO STOXX	1.000000		
	0.999919		
	1495464		
	0		

EUROSTX LOWRIS...	0.654944	1.000000	
	0.654909	0.999974	
	1237449	1495546	
	257977	0	
	0.0000	-----	
VSTOXX	-0.437775	-0.380366	1.000000
	-0.437757	-0.380360	0.999998
	420379	463341	1495582
	1075082	1032202	0
	0.0000	0.0000	-----

Source: STOXX

FIGURE 14 EURO STOXX GROSS RETURN INDEX, EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX, AND VSTOXX, KENDALL'S TAU, UP MARKETS (MAR. 20, 2001-APR. 30, 2015, DAILY LOG-RETURNS)

Covariance Analysis: Kendall's tau

Sample: 1 1882
Included observations: 1882

tau-b			
tau-a			
Concordances (C)			
Discordances (D)			
Probability	EURO STOX...	EUROSTX L...	VSTOXX
EURO STOXX	1.000000		
	0.999992		
	1770007		
	0		

EUROSTX LOWRIS...	0.656015	1.000000	
	0.655994	0.999946	
	1465518	1769926	
	304394	0	
	0.0000	-----	
VSTOXX	-0.332102	-0.279561	1.000000
	-0.332100	-0.279553	0.999998
	591090	637554	1770018
	1178914	1132369	0
	0.0000	0.0000	-----

Source: STOXX

In light of the results above, and given the existence of correlation does not necessarily imply causation in a significant sense of the word[17], we run a five-day lag length Granger[18] causality test among the three indices, the EURO STOXX Gross Return Index, the EURO STOXX Low Risk Weighted 100 Gross Return Index, and the VSTOXX for both the up-market and down-market periods.

The Granger approach helps to identify the direction of causality between two variables and see how much of the current value of the variable can be explained by past values of a given factor and then to see whether adding lagged values of the same variable can improve the explanation. Granger causality does not necessarily indicate causation in the broader meaning of the term. Rather it measures information content and to what extent one variable could help predict the other. A two-way causation between two variables is frequently the case, although there are plenty of cases where causality runs one-way only and not the other way.

In up-market periods the Granger causality test did not generate results statistically significant. In other terms, we could not reject the null hypothesis of the absence of either a one-way or two-way causation among the three indices.

Conversely, in down-market periods a statistically significant one-way causation (and not the other way) from the VSTOXX to the EURO STOXX was supported by strong data evidence, with the F-statistic significant at the 99% confidence interval. At the same time, the existence of either a one-way or a two-way Granger causality between the VSTOXX and the EURO STOXX Low Risk Weighted 100 Index were not supported by data evidence. This result appeared to confirm once again the ability of low-risk-weighted indices of insulating from implied volatility patterns and market disturbances in bear markets.

[17] The econometric analysis is full of significant correlations, which are simply spurious or meaningless. Among others, it is worth noting a positive correlation between the death rate in the UK and the proportion of marriages solemnized in the Church of England.
[18] Granger, C. W. J. (1969), "Investigating Causal Relations by Econometric Models and Cross-spectral Methods," Econometrica, Vol. 37, No. 3 (August), pp. 424-438.

Furthermore, the results of the Granger causality test showed a one-way causation, statistically significant at the 95% confidence interval, from the EURO STOXX Low Risk Weighted 100 Index to the EURO STOXX in down-market periods.

FIGURE 15 EURO STOXX GROSS RETURN INDEX, EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX, AND VSTOXX, GRANGER CAUSALITY, DOWN MARKETS (MAR. 20, 2001-APR. 30, 2015, DAILY LOG-RETURNS)

Pairwise Granger Causality Tests

Sample: 1 1730
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGRETEUROSTXLOWRISKGROS does not Granger Cause LOGRETEUROSTXGROSS	1725	2.85458	0.0142
LOGRETEUROSTXGROSS does not Granger Cause LOGRETEUROSTXLOWRISKGROS		1.45720	0.2008
LOGRETVSTOXX does not Granger Cause LOGRETEUROSTXGROSS	1725	3.09386	0.0087
LOGRETEUROSTXGROSS does not Granger Cause LOGRETVSTOXX		0.54414	0.7429
LOGRETVSTOXX does not Granger Cause LOGRETEUROSTXLOWRISKGROS	1725	1.81941	0.1059
LOGRETEUROSTXLOWRISKGROS does not Granger Cause LOGRETVSTOXX		1.02001	0.4042

Source: STOXX

FIGURE 16 EURO STOXX GROSS RETURN INDEX, EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX, AND VSTOXX, GRANGER CAUSALITY, UP MARKETS (MAR. 20, 2001-APR. 30, 2015, DAILY LOG-RETURNS)

Pairwise Granger Causality Tests

Sample: 1 1882
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGRETEUROSTXLOWRISKGROS does not Granger Cause LOGRETEUROSTXGROSS	1877	1.78276	0.1131
LOGRETEUROSTXGROSS does not Granger Cause LOGRETEUROSTXLOWRISKGROS		0.41877	0.8359
LOGRETURNVSTOXX does not Granger Cause LOGRETEUROSTXGROSS	1877	0.51017	0.7688
LOGRETEUROSTXGROSS does not Granger Cause LOGRETURNVSTOXX		1.94928	0.0833
LOGRETURNVSTOXX does not Granger Cause LOGRETEUROSTXLOWRISKGROS	1877	0.78043	0.5637
LOGRETEUROSTXLOWRISKGROS does not Granger Cause LOGRETURNVSTOXX		1.44661	0.2044

Source: STOXX

In order to assess the degree of relationship among the index constituents and the extent to which underlying market movements are shared among

them, we have computed the stock pair-wise correlation for the indices. For an index of n constituents, that requires calculating n*(n-1)/2 pair-wise correlations and then computing the weighted average of those correlations.

Under a number of assumptions (among others, the correlation of all the different constituents of the index is assumed to be identical[19]), the correlation implied by index and single-stock implied volatility can be estimated as the variance of the index divided by the weighted average single-component variances. A rule of thumb says that such computation returns a correlation level that is a point or two higher than the actual pair-wise correlation. Nonetheless, that is a reasonable approximation of the true value.

$$\textit{Pair-wise correlation} \approx \frac{\sigma_I^2}{\sum_{i=1}^{n} w_i \sigma_i^2},$$

where:

$\sigma_I^2 = index\ variance,$

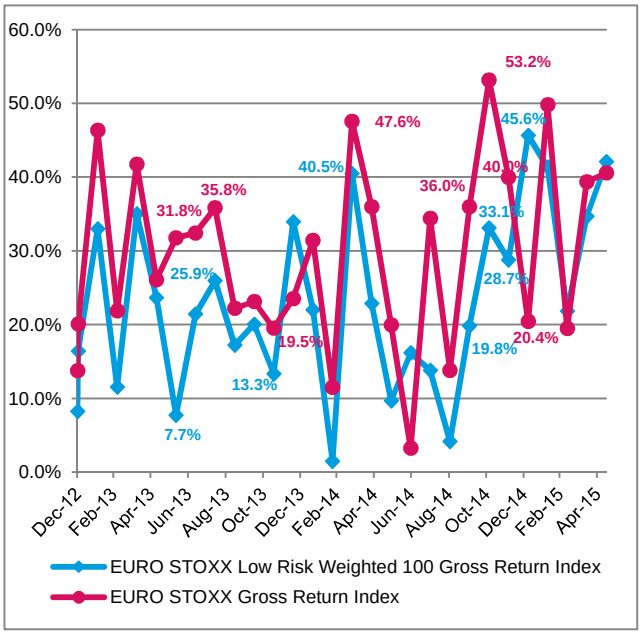
$\sigma_I^2 = i_{th}\ constituent\ variance,$

$w_i = i_{th}\ constituent\ weight,$

$n = index's\ constituents\ number.$

The chart below plots the stock pair-wise correlation for both the EURO STOXX Low Risk Weighted 100 Gross Return Index and the EURO STOXX Gross Return Index for the period December, 2012-April, 2015. Despite a few noticeable exceptions, the lower intracorrelation and the lower level of market variance that is shared among constituents of the low-risk-weighted index are reflected in the lower values of the stock pair-wise correlation of the EURO STOXX Low Risk Weighted 100 Gross Return Index compared to the plain-vanilla benchmark. That was particularly evident in the sharp market correction episodes referred to in the analysis of the cross-sectional dispersion.

FIGURE 17 EURO STOXX LOW RISK WEIGHTED 100 GROSS RETURN INDEX VERSUS EURO STOXX GROSS RETURN INDEX, STOCK PAIR-WISE CORRELATION (DECEMBER, 2012-APRIL, 2015)



Source: STOXX

The table in figure 18 details the characteristics of a factor-exposure analysis on the EURO STOXX Low Risk Weighted 100 Gross Return Index compared to the EURO STOXX Gross Return Index for the period Feb. 29, 2012-Mar. 31, 2015.

[19] Please refer to Bennett, C. (2014), "Trading Volatility: Trading Volatility, Correlation, Term Structure and Skew."

FIGURE 18 EURO STOXX LOW RISK WEIGHTED 100 INDEX VERSUS EURO STOXX INDEX, SUMMARY OF FACTOR-EXPOSURE ANALYSIS (FEB. 29, 2012-MAR. 31, 2015, GROSS-RETURN INDICES)

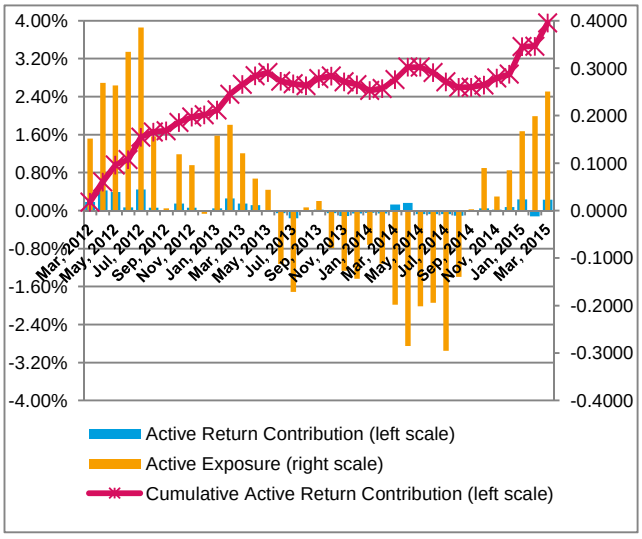
Source of Return	Contribution	Avg Exposure	Hit Rate	Risk	IR	T-Stat
Portfolio	80.98%			8.76%		
Benchmark	70.47%			12.05%		
Active	10.50%			6.81%	0.34	0.60
Specific Return	-11.55%			3.98%	-0.64	-1.13
Factor Contribution	22.05%			3.84%	1.27	2.24
Style	17.09%			2.89%	1.31	2.30
Exchange Rate Sensitivity	-0.20%	-0.0618	62.16%	0.16%	-0.28	-0.50
Growth	0.90%	0.2030	67.57%	0.16%	1.24	2.18
Leverage	-0.13%	0.1906	54.05%	0.18%	-0.16	-0.29
Liquidity	-1.10%	-0.2769	37.84%	0.40%	-0.61	-1.07
Medium-Term Momentum	3.95%	0.0287	62.16%	0.52%	1.67	2.94
Short-Term Momentum	-0.28%	0.0093	56.76%	0.47%	-0.13	-0.23
Size	1.23%	-0.2845	51.35%	0.94%	0.29	0.51
Value	-3.32%	-0.2916	35.14%	0.53%	-1.38	-2.42
Volatility	16.05%	-0.3625	64.86%	1.53%	2.32	4.08
Country	-1.85%			0.92%	-0.45	-0.78
Austria	0.14%	0.09%	59.46%	0.05%	0.62	1.08
Belgium	1.55%	4.92%	67.57%	0.41%	0.84	1.47
Finland	0.05%	0.31%	51.35%	0.04%	0.23	0.40
France	-0.92%	-2.76%	29.73%	0.33%	-0.62	-1.09
Germany	-0.93%	-3.83%	37.84%	0.38%	-0.54	-0.94
Greece	0.08%	-0.27%	51.35%	0.09%	0.20	0.34
Ireland	1.03%	1.63%	54.05%	0.30%	0.76	1.34
Italy	-1.72%	-3.63%	48.65%	0.54%	-0.71	-1.25
Netherlands	0.55%	4.45%	51.35%	0.31%	0.39	0.68
Portugal	-0.02%	0.64%	43.24%	0.15%	-0.03	-0.05
Spain	-1.67%	-1.61%	45.95%	0.57%	-0.65	-1.14
Industry	6.82%			1.34%	1.13	1.99
Currency	0.00%			0.00%	-1.06	-1.87
USD	0.00%	0.00%	10.81%	0.00%	-1.06	-1.87
Market	-0.01%			0.01%	-0.22	-0.39
Global Market	-0.01%	-0.05%	45.95%	0.01%	-0.22	-0.39
Sectors	6.82%	-0.05%		1.34%	1.13	1.99
Consumer Discretionary	0.27%			0.42%	0.14	0.25
Consumer Staples	1.44%			0.30%	1.06	1.87
Energy	2.93%			0.32%	2.00	3.51
Financials	-0.77%			0.86%	-0.20	-0.35
Health Care	-0.40%			0.33%	-0.27	-0.48
Industrials	1.40%			0.19%	1.66	2.92
Information Technology	-0.38%			0.14%	-0.59	-1.04
Materials	0.85%			0.14%	1.33	2.34
Telecommunication Services	0.31%			0.15%	0.46	0.81
Utilities	1.16%			0.16%	1.58	2.78

Source: AXIOMA based on STOXX data

The active return generated by the EURO STOXX Low Risk Weighted 100 Gross Return Index was 10.50%, with a positive 22.05% factor contribution—statistically significant at the 95% confidence level. Conversely, the stock-specific source of return came in at a negative 11.55% contribution.

In terms of style factors, with a 17.09% overall positive contribution, the low-risk-weighted portfolio had a statistically significant exposure to growth (+0.90%), a medium-term momentum (+3.95%) and a negative bias to high-volatility stocks (+16.05%). Conversely, value (-3.32%) detracted from the style contribution. As expected, the EURO STOXX Low Risk Weighted 100 had lower market beta[20] (0.66) than the plain vanilla EURO STOXX Index.

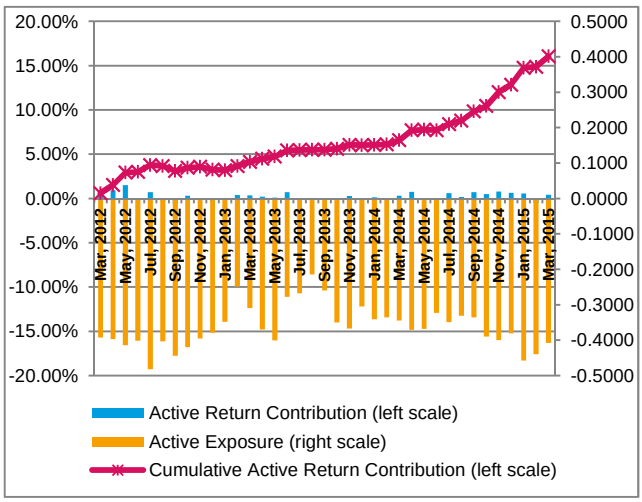
FIGURE 19 EURO STOXX LOW RISK WEIGHTED 100 TOTAL RETURN INDEX VERSUS EURO STOXX TOTAL RETURN INDEX, MEDIUM-TERM MOMENTUM, ACTIVE RETURN CONTRIBUTION VERSUS ACTIVE EXPOSURE (MARCH, 2012-MARCH, 2015)



Source: AXIOMA based on STOXX data

[20] Beta calculations are for the period Oct. 4, 2012-Apr. 30, 2015 and are based on excess log returns against a risk-free asset, given by the 12-month Eurozone government bill.

FIGURE 20 EURO STOXX LOW RISK WEIGHTED 100 TOTAL RETURN INDEX VERSUS EURO STOXX TOTAL RETURN INDEX, VOLATILITY, ACTIVE RETURN CONTRIBUTION VERSUS ACTIVE EXPOSURE (MARCH, 2012-MARCH, 2015)



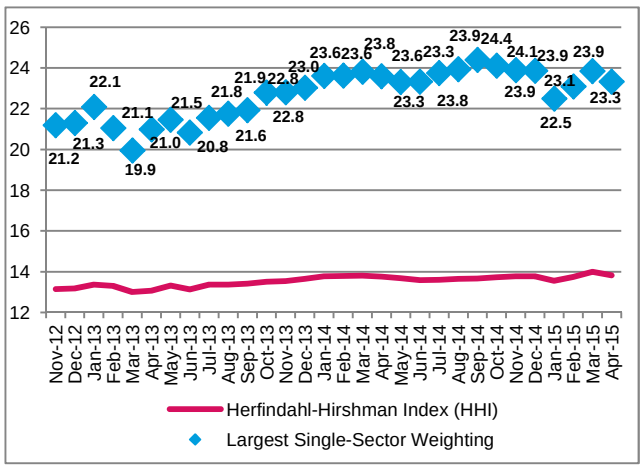
Source: AXIOMA based on STOXX data

Among industry sectors—which overall posted a positive 6.82% factor-return contribution—a negative exposure to energy (+2.93% contribution) and materials (+2.34% contribution), a positive exposure to industrials (+1.40% contribution) and a mixed exposure to utilities (+1.16% contribution) counted the most for the active return recorded for the period. The last sector, which is a more defensive one, appeared to show a counter-cyclical exposure. Nonetheless, anticipated changes in the economy and interest rates were expected to have a muted impact on the revenue and earnings of companies within the sectors.

Interest rate-sensitive sectors of the index such as financials (-0.77% contribution) and consumer discretionary (+0.27% contribution) had a mixed exposure throughout the period. The former sector flipped the exposure sign in the index to positive at the beginning of the year 2015 as the ECB's massive asset-purchase program fueled a rosier macro outlook and inflationary expectations.

The relatively lower sector-concentration risk of the EURO STOXX Index, as computed according to the Herfindahl-Hirschman Index (HHI)[21], compared to the EURO STOXX Low Risk Weighted 100 Index did not pay off in performance terms throughout the December, 2012-April, 2015 period. Financials remained the industry sector with the largest weighting throughout the entire measurement period for the plain-vanilla European benchmark. Conversely, the low-risk-weighted index showed higher industry sector dynamics in the largest weighting representation. In fact, financials accounted for the maximum sector weighting for the period June, 2013-November, 2013 and from June, 2014-April, 2015; consumer goods for the period December, 2012-May 2013 and for December, 2013 and industrials for the period from January, 2014-May, 2014.

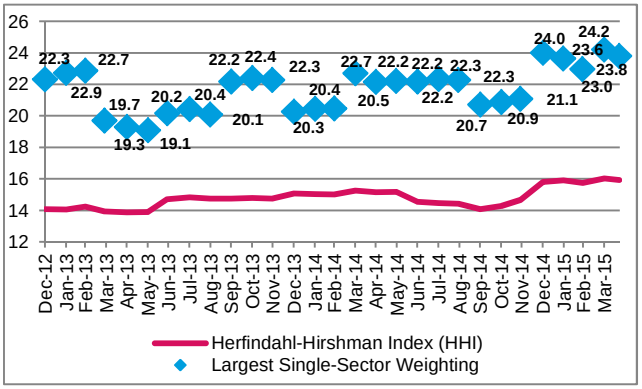
FIGURE 21 EURO STOXX INDEX, HERFINDAHL-HIRSHMAN INDEX (HHI) VERSUS LARGEST SINGLE-SECTOR WEIGHTING, PERCENTAGES (NOVEMBER, 2012-APRIL, 2015)



Source: STOXX

[21] The Herfindahl-Hirshman Index (HHI) is calculated as the sum of the square of ten ICB sectors' weighting at the end of each calendar month. A higher number of the Herfindahl-Hirshman Index implies higher sector concentration and vice versa.

FIGURE 22 EURO STOXX LOW RISK WEIGHTED 100 INDEX, HERFINDAHL-HIRSHMAN INDEX (HHI) VERSUS LARGEST SINGLE-SECTOR WEIGHTING PERCENTAGES (DECEMBER, 2012-APRIL, 2015)



Source: STOXX

Figures 23 and 24 show historical sector weightings of the EURO STOXX Index and the EURO STOXX Low Risk Weighted 100 Index for the period from November, 2012-April, 2015.

The sector allocation of the EURO STOXX Low Risk Weighted 100 Index changed more dynamically than that of the plain-vanilla European benchmark because of its low-volatility screening.

It is worth highlighting the sector-allocation changes around three major market events, i.e., the "taper tantrum" of May, 2013-June, 2013; the emerging markets overflow effect that ensued in the following months until January, 2014 and the sharp market corrections that between October, 2014 and January, 2015 were primarily driven by geopolitical tensions, macro information arrival, the crude oil slump and Grexit fears.

In May and June, 2013, markets perceived the preannouncement made by the Federal Reserve about the tapering of asset purchases as an early signal of the start of a tightening cycle, amid rosier US recovery expectations. At the June, 2013 rebalancing of the EURO STOXX Low Risk Weighted 100 Index, the weighting of financial stocks, which belong to an interest rate-sensitive sector and had experienced a period of low volatility in stock prices, saw an increase of 17.01%. Financial stocks' rebalancing in June, 2013 followed a 63.34% rise in March of the same year. Also in June, 2013, for the EURO STOXX Low Risk Weighted 100 Index the weighting of utilities—more defensive and noncyclical stocks—was reduced 35.37%. Telecommunications' and consumer services' weightings in the low-risk-weighted index were reduced 22.44% and 17.97%, respectively.

Conversely, financial stocks' weighting in the EURO STOXX Index was reduced 2.91% at the June, 2013 rebalancing. On the same date, utilities, telecommunications and consumer services recorded increases to the tune of 1.55%, 2.58% and 2.53%, respectively, within the same index.

Market corrections that followed the "taper talks" were observed mainly in emerging markets and were accompanied by currency depreciations, overflow effects and increases in external financing premiums. European markets recorded negative performance for June, 2013 and January, 2014 as the EURO STOXX Index posted returns for the same months to the tune of minus 5.66% and minus 2.22%, respectively. At the same time, the VSTOXX, a gauge of market fears, recorded increases in implied volatility levels in June, 2013 (+11.29%); August, 2013 (+23.15%); December, 2013 (+23.49%) and January, 2014 (+20.60%).

In light of the above, at the December, 2013 rebalancing, utility stocks' weighting in the EURO STOXX Low Risk Weighted 100 Index rose 33.68%. The rise in utility sector stocks followed a 65.65% increase in September, 2013. Significant changes in sector weightings in December, 2013 were also observed for technology (-22.72%), healthcare (-34.42%), financials (-10.84%), consumer services (-15.71%), consumer goods (+19.90%) and basic materials (+14.95%). Sector-weighting changes in December, 2013 for the low-risk-weighted index compared to those for the EURO STOXX Index were utilities (-3.36%), technology (-0.87%), healthcare (-5.11%), financials (+0.99%), consumer services (+2.16%), consumer goods (+0.06%) and basic materials (+0.18%).

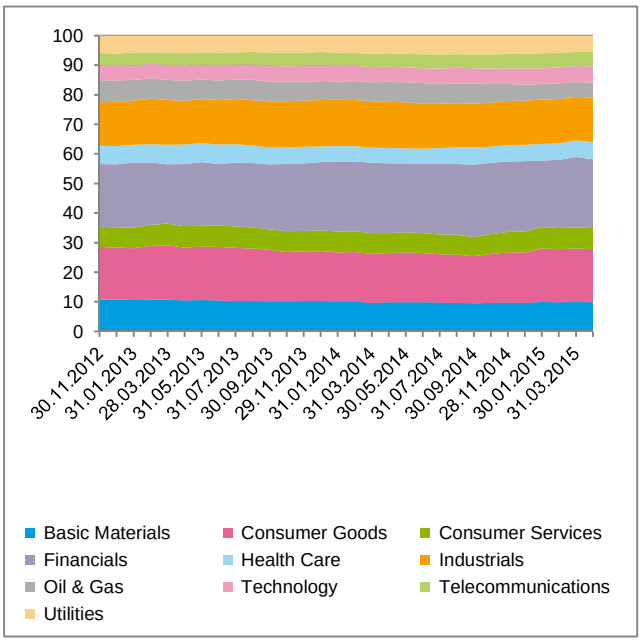
In last quarter 2014, deflationary concerns and the creeping resurgence of the sovereign debt-induced crisis took their toll, and global markets plunged to

record lows around mid-October. The VSTOXX climbed 76.59% on Oct. 16 from September's month-end close, paring down thereafter and closing 42.82% below its mid-October peak. Doom and gloom were at play in the second week of December, 2014 when global stock markets resumed their selloffs. Concerns about ECB balance sheet expansion, the oil price nosedive, implications arising from the announced political elections in Greece and the Grexit argument, the expected results of the further round of ECB stress tests on European banks and—last but not least—the Bank of Russia's failed defense of the ruble weighed on market sentiment. On Dec. 15 the VSTOXX spiked to 29.53 from November's close at 18.02, hitting a reading above its historical 25.27 average. Implied volatility edged downward thereafter, closing on Dec. 19 below the historical average.

January, 2015 saw an exacerbation of the currency war. A higher-volatility scenario materialized in global markets amid the "Francogeddon" move by the Swiss National Bank and expectations of aggressive ECB bond buying. The VSTOXX, after rising about 12.0% in the first half of the month, pared down thereafter and closed January 5.57% below the end-of-December, 2014 reading.

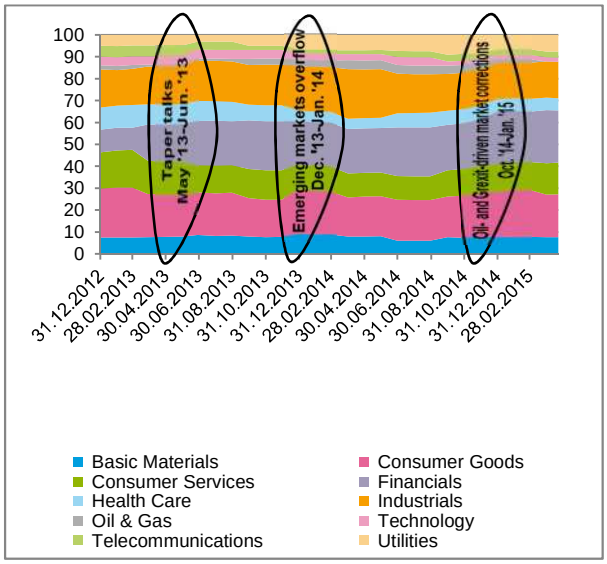
In the scenario above, the stock price pattern (and volatility thereof) of financials was primarily driven by the ultra-loosening monetary policy of the central banks on one side and expectations about the start of a tightening cycle by the Fed on the other. As a result, financial stocks' weighting in the EURO STOXX Low Risk Weighted 100 Index recorded two successive increases, 13.90% and 5.43%, respectively, at the December, 2014 and March, 2015 rebalancings. It was noteworthy that utility stocks recorded a 21.32% underweighting at the December, 2014 rebalancing, while a 15.76% overweighting was observed in the defensive sector at the March, 2015 rebalancing. The weighting of stocks belonging to the oil and gas sector in the low-risk-weighted index was progressively reduced to zero at the March, 2015 rebalancing, with a significant 47.96% decrease that occurred as early as December, 2014.

FIGURE 23 HISTORICAL SECTOR WEIGHTINGS OF THE EURO STOXX INDEX (NOVEMBER, 2012-APRIL, 2015)



Source: STOXX

FIGURE 24 HISTORICAL SECTOR WEIGHTINGS OF THE EURO STOXX LOW RISK WEIGHTED 100 TOTAL RETURN INDEX (NOVEMBER, 2012-APRIL, 2015)



Source: STOXX

The report was closed with information available as of the market close on Apr. 30, 2015.

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