HISTORICAL, IMPLIED AND REVERSE SECTOR RISKS IN THE EUROZONE

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ABSTRACT

In this paper we intend to provide a comprehensive survey of the sector risks in the Eurozone. Besides volatilities, correlations and covariances, the focus lies on the betas of the 18 sectors according to the Industry Classification Benchmark (ICB). The calculations of the betas are enforced with three different approaches: one historical, one reverse and one implicit. It turns out that the distinct methods can lead to substantially different estimates of betas of the considered Eurozone sectors. The question to be raised is which concept of beta estimation delivers correct as well as reliable estimates of systematic sector risks. The empirical evidence shows that the sector betas are far from stable in time and it is conclusive that there are not simply estimation errors but that there are economic reasons for time-varying betas.

Key words: Volatility, Beta, Implied volatility, Sector risk

JEL Codes: G14, G15

I. INTRODUCTION

The valuation of a company based on discounted cash flow approaches and the related concept of shareholder value are essential for a multiplicity of reasons: the ability to determine the inner value (fair value) of a stock, to use in a business purchase or in the case of an initial public offering, management buy-out or merger and to exploit by way of example in the case of a squeeze out. Within the framework of due diligence as well as of asset management and investment management, besides the expected returns, the risks involved are of substantial significance.

The most commonly used risk measures are the beta and the volatility. The risk measures of the risky return can be identified by either historical or current monitoring of stock prices, riskless interest rates and market capitalizations. The main problem with historical approaches, even if substantially modified, is that they

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focus on the past. If the intention is to form an estimate of an up-to-date risk premium it is quite hazardous to trust fully in a mean-reverting process and data from the past.

In this paper, we intend to provide a comprehensive survey of the sector risks in the Eurozone. Besides volatilities, correlations and covariances, the focus lies on the betas of the 18 sectors according to the Industry Classification Benchmark (ICB). The calculations of the betas are enforced with three different approaches: one historical, one reverse and one implicit. Additionally, the implied and reverse approaches are combined to obtain a reverse implicit beta. The beta is closely connected to the risk premium. In the framework of the Capital Asset Pricing Model following Sharpe (Sharpe, 1964) and Lintner (Lintner, 1965), the expected return of a specific investment is a combination of the riskless interest rate plus a specific risk premium connected alternatively to a company, a country or an index. The specific risk premium is the product of the beta and market risk premium factors as is described in detail in Damodaran (Damodaran, 2009) as well as in Dimson/Marsh/Staunton (Dimson, Marsh & Staunton, 2003). For a detailed discussion on the relevance of beta see Grinold (Grinold, 1993).

As the name reveals, the calculation of historical betas is solely oriented to the past. However, within the historical estimation there are countless possibilities of variation, for example in the choice of the time horizon, the time interval, the approach used to calculate the mean returns, the exponential smoothing of past returns and last but not least the very choice of the index representing the market.

That beta, which is closely connected to the present time due to current market capitalizations, we will refer to as a reverse beta. The calculation of this beta is based on the Bayesian prior that the current market portfolio represents an efficient and optimal set as shown by Idzorek (Idzorek, 2004) as well as Walters (Walters, 2009). Instead of estimating the mean returns, volatilities and correlations in order to evaluate the optimal portfolio weights, the optimization process can be reversed. The calculation of all cross correlations and covariances remains an historical approach.

The third variant of the method for calculating the beta uses exchange traded options on sector indices to derive implied volatilities. Using an option-pricing model like that of Black and Scholes (Black & Scholes, 1973) it is necessary to search iteratively for the exact volatility that leads to the price observed on the market. By means of these implied volatilities it is easy to obtain the covariances that are needed to calculate the sector betas. These betas and the corresponding risk premia are linked to the future as the implied volatilities reflect the expectation of the market from the time of observation until the maturity of the options.

The remainder of the paper is organized as follows. In section 2 we outline the three approaches used to calculate the beta. In section 3 we explain the data and the time horizon, as well as the use of indices and selected aspects concerning the calculation of the implied volatilities. In section 4 we present the empirical results and section 5 concludes the paper.

II. ALTERNATIVE ESTIMATION APPROACHES

A. Historical volatility and betas

The main concern of market participants naturally relates to the expected returns or future risk premiums and not to the returns realized in the past. However, the indications for estimations lie in the past. Therefore, most investors and portfolio managers have to look into the past in order to estimate risk premiums. The most commonly used approach is called the historical method. The realized returns of stocks or indices are estimated based on observable prices over a long time horizon and compared with the riskless return at the given time. The difference between these two returns on an annual basis is the historical risk premium.

The risk premium of any security is easy to calculate according to the CAPM. The expected risk premium, i.e. the proportion of the return above the risk-free rate, is directly proportional to its beta.[i] Therefore, the knowledge of specific sector betas is of substantial importance for the purpose of estimating sector risks and sector risk premiums.

There is no "the" historical risk premium or "the" historical beta. We are able to mention three reasons that oppose this "the": first, the dissimilar time horizons from which the data stem; second, the dissimilar riskless interest rates and indices surrogating the market; and third, the different methods to calculate the average return of a specific time horizon.

- *Time horizon*

If one uses data that lie increasingly in the past, the sample size continues to grow. From a theoretical point of view, it is true that the larger the sample, the smaller the sampling errors and the better the resulting estimators. However, the problem with long time horizons is that the times may have changed. Data from the nineteenth century are less reliable. Furthermore, developed markets nowadays are much more similar to emerging markets then. One can deal with this problem with two distinct approaches: first, one concentrates on the recent past but uses shorter time intervals, e.g. days, weeks or months, but not years; second, one uses all the observable data but puts less weight on the earlier observations due to any form of exponential smoothing. Whatever the choices are, there are so many variants that one can hardly overview them all. In order to keep the variations as small as is considered sensible, in our standard calculations we will always use the equally weighted weekly returns of a history of ten years.

- *Risk-free interest rate and market index*

The well-known beta estimator according to the CAPM is given by:

$$\beta_i = \frac{\mathrm{Cov}\ r_{it} - r_t, r_{Mt} - r_t}{\sigma^2(r_{Mt} - r_t)}$$

The time-dependent surrogate for the riskless interest rate in the eurozone can be found either in one of the Euribor interest rates (e.g. one month, three months or a year) or in the near-term governmental bond with the lowest possible default risk. However, estimations omitting riskless interest rates deliver almost identical results.[ii] Miller and Scholes (Miller & Scholes, 1972) confirm that ignoring the effect of riskless interest rates does not cause any major problems.[iii] Concerning the appropriate surrogate for the eurozone market, there are several benchmarks to choose from: Stoxx Limited calculates indices for Europe, for the eurozone, for Europe excluding the United Kingdom as well as for Europe without the eurozone. In addition, Stoxx Limited constructs so-called blue-chip indices, for example the Euro Stoxx 50, which serves as underlying for options. In our empirical part, we will use the Euro Stoxx index that contains some 300 single assets, thereby representing large, medium and small capped firms.

- *Arithmetic versus geometric average*

Throughout the paper, we will use arithmetic means due to the important aspect of obtaining unbiased estimators for the expected risk premiums. The geometric mean would be appropriate if either the historical performance or the median of the expected terminal wealth were of special interest. Throughout we will use simple returns and not continuously compounded returns. One advantage of simple, discrete returns is that they represent realized, empirically observable returns, which the continuously compounded ones do not. The choice of which alternative to use to calculate the average returns is still controversial. This is confirmed by Damodaran's current report on risk premiums, which considers weighting schemes between the two alternatives.[iv]

From a mathematical point of view, the beta represents the slope of the regression line. In our empirical part, the specific sector excess returns are regressed toward the Dow Jones Euro Stoxx. Formally, the calculation of the historical betas is as follows:

$$\beta_i = \frac{Cov(r_i, r_M)}{\sigma_M^2} = \rho(r_i, r_M)\frac{\sigma_i}{\sigma_M}$$

This is identical to the beta estimator of the index model:

$$r_i = \alpha_i + \beta_i \cdot r_M.$$

In the formula of the historical beta, the Greek letter ρ corresponds to the correlation between the returns. The calculation of the beta additionally requires the historical volatilities of the respective sector as well as of the market. The historical volatility can be calculated from the past data as follows:

$$\sigma_i = \sqrt{\frac{1}{n-1} \cdot \sum_{t=1}^{n} (r_t - \bar{r})^2}$$

with r representing the arithmetic mean of all the returns to be considered within the calculation. The value of the annualized volatility depends on the time frequency underlying the observation. Daily data require the multiplier of sqrt(250), weekly data require the multiplier of sqrt(52) and monthly data require the multiplier of sqrt(12).

B. Implied volatility and betas

The covariance is the product of the three factors correlation coefficient, standard deviation of the respective sector and standard deviation of the market. In order to calculate an implied beta, we use the implied volatilities of exchange traded options in the respective sectors instead of the historical volatilities. In order to obtain the best possible unbiased estimator, we use the three nearest at the money options. A more detailed description of the specific options used is presented in section 3. Formally, the calculation of the implied betas is as follows:

$$\beta_i = \frac{\rho\ r_i, r_M\ (\sigma_i^{impl})}{\sigma_M^{impl}}$$

C. Reverse betas through inverse optimization with historical and implied volatilities

Reverse betas are the result of a reverse optimization process according to the idea of the Black–Litterman model from 1992 (Black & Litterman, 1992). In a first step, we consider the sector-specific returns according to the CAPM, namely

$$\mu_i = E(r_i) - r = \beta_i\ E(r_M) - r\ = \beta_i \cdot \mu_M$$

Secondly, the vector μ serves as input representing the vector of expected returns for the general optimization programme:

$$\text{maximize } w^T\mu - \frac{1}{2}\lambda \cdot w^T C w$$

Herein w represents the column vector of individual portfolio weights. Calculating the partial derivate with respect to w leads to the optimal portfolio weights for arbitrarily chosen return vectors and the corresponding covariance matrices. The λ is the parameter of risk aversion. Before we solve explicitly for w, we obtain the equation:

$$\mu - \lambda \cdot Cw = 0.$$

This, after the appropriate substitution and rearrangement of terms, leads to:

$$\beta_i \cdot \mu_M = \lambda \cdot Cw.$$

As can easily be seen, it is possible to reverse the optimization by taking the current market capitalizations of the individual sectors for optimal and obtaining the relation:

$$\beta_i = \frac{\lambda}{\mu_M} \cdot Cw.$$

At a first glance the parameters λ and μ_M appear substantial for the beta as the precise shape of the beta could be the result of an arbitrary choice of λ or μ_M. In fact, the risk aversion parameter matches the quotient of market risk premium μ_M and squared market risk σ_M^2. In the market equilibrium, the reward for one marginal unit of risk in terms of variance of returns exactly matches the market risk premium:

$$\lambda = \frac{\mu_M}{\sigma_M^2}.$$

Consequently, the market risk premium cancels out the relation and the risk aversion parameter vanishes. The market variance can be estimated from the past data. According to these rules, the calculation formula for the reverse historical beta is as follows:

$$\beta_i = \frac{1}{\sigma_M^2} \cdot Cw.$$

In the less compact notation using sums, the beta can be calculated as:

$$\beta_i = \frac{\sum_{j=1}^{n} \rho(r_i, r_j) \cdot \sigma_i \cdot \sigma_j \cdot w_j}{\sigma_M^2}$$

with

$$r_M = \sum_{i=1}^{n} r_i \cdot w_i$$

and

$$\sigma_M^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \rho(r_i, r_j) \cdot \sigma_i \cdot \sigma_j \cdot w_i \cdot w_j = w^T Cw.$$

Herein the specific sector weights w can be determined empirically. The historical sector risk as well as the historical market risk can be calculated on the basis of past daily, weekly or monthly returns. The most characteristic difference from the implied betas consists of the direct significance of the current sector capitalizations that determine the specific optimal sector weights. The optimal weights are not the resulting outputs of an explicit optimization programme using returns and volatilities as inputs. Additionally, as an alternative, instead of the historical volatilities the option implied volatilities can be used to calculate the reverse implicit beta as follows:

$$\beta_i = \frac{\sum_{j=1}^{n} \rho(r_i, r_j) \cdot \sigma_i^{impl} \cdot \sigma_j^{impl} \cdot w_j}{\left(\sigma_M^{impl}\right)^2}$$

with

$$\left(\sigma_M^{impl}\right)^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \rho(r_i, r_j) \cdot \sigma_i^{impl} \cdot \sigma_j^{impl} \cdot w_i \cdot w_j = w^T Cw.$$

III. DATA

The primary source of data is constituted by the Dow Jones Euro Stoxx sector indices as well as the Dow Jones Euro Stoxx price index, which stem from DataStream. We preferred to use price indices instead of performance indices because the traded options on sector indices refer to the price indices as underlying. The data used for the empirical investigation begin with 14 January 2000 and end with 15 January 2010. We obtained daily, weekly and monthly end of day index values. The standard calculations all refer to weekly returns.

As the primary source of data concerning implied volatilities we used Bloomberg. Due to the illiquidity of exchange traded options there is only restricted reliability with respect to deriving implied volatilities from option prices. This problem does not become striking since Bloomberg calculates implied volatilities based on prices that stem from market makers. The time to maturity of the considered options is five months. The exact period of time is the third Friday and option expiry date in January, 15 January 2010, until the third Friday in February, the option expiry date on 19 February 2010.

IV. EMPIRICAL RESULTS

A. Volatilities

First, we focus on the total risk, which is measured by calculating the square root of the variance of returns and as such comprises systematic, market-induced risk as well as unsystematic, sector-specific risk.

i. Historical volatilities of each single year as well as of the whole decade

To calculate the historical volatilities of the single years from 2000 to 2009, we apply the formula from subsection 2.1 to the 52 weekly returns of each year. The historical volatilities calculated with the above-mentioned approach exhibit enormous variation over this specific period of time. To put it another way, volatility itself is very volatile. Whilst in the year 2000 the media, technology and telecom sectors exhibited the largest volatilities, this picture changed in the years 2008 and 2009. In the latter two years, the automobile and banking sectors displayed the highest volatilities. Table 1 presents the respective volatilities of all the sectors for each single year from 2000 to 2009 as well as the volatilities of the individual sectors based on the whole sample. The figures are denominated in per cent per anno.

Table 1

Historical volatilities

Sector\ Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	all
AUTO & PARTS	20,7	39,2	29,2	30,9	18,4	14,6	18,1	24,5	78,2	44,4	36,3
BANKS	16,3	33,5	29,6	15,9	11,2	10,9	14,5	18,4	47,3	52,7	29,5
BASIC RESOURCE	30,6	34,9	34,3	30,4	19,2	16,9	23,6	26,4	60,3	49,6	35,1
CHEMICALS	23,1	36,3	26,6	22,9	13,7	14,2	16,2	17,5	36,3	29,6	25,6
CON & MAT	20,2	24,2	25,6	19,8	11,2	12,0	16,8	22,0	44,4	35,5	25,2
FINANCIAL SVS	18,3	36,9	27,3	18,4	10,3	9,4	14,9	21,6	39,8	32,6	25,3
FOOD & BEV	24,6	19,7	18,1	25,6	10,6	9,7	11,9	13,7	31,7	19,9	19,0
HEALTH CARE	21,6	27,7	23,5	23,5	12,8	11,7	15,3	13,7	40,3	21,3	22,9
INDS GDS & SVS	24,2	30,7	24,4	24,1	15,1	11,3	18,1	20,7	40,5	33,2	25,2
INSURANCE	17,4	37,3	40,1	18,1	17,6	13,9	17,1	19,5	47,0	46,4	31,8
MEDIA	44,2	38,9	35,9	40,2	15,7	10,6	11,2	13,2	33,8	19,7	27,3
OIL & GAS	22,0	33,8	25,3	21,9	13,8	17,4	17,0	16,9	45,8	27,9	25,5
PERS & H/H GDS	23,5	37,7	27,9	22,7	15,1	12,4	15,9	13,1	31,1	27,2	24,1
RETAIL	19,7	23,9	23,3	19,4	14,5	12,2	12,0	15,8	36,5	22,5	22,0
TECHNOLOGY	50,2	53,3	47,7	49,3	27,1	18,2	20,5	15,7	38,1	30,6	35,9
TELECOM	45,5	38,5	33,7	42,8	13,5	10,3	16,1	16,5	34,7	18,4	27,0
TRAVEL & LEIS	18,6	39,1	30,9	17,2	16,2	12,2	12,9	23,2	35,2	29,5	26,2
UTILITIES	17,1	17,0	18,3	16,3	11,0	12,7	17,1	16,2	41,0	23,8	20,8

ii. Implied volatilities as of January 2010

To calculate the implied volatilities we are looking for the options nearest at the money. The level of the respective index is in all but three cases within 1 per cent above or below the closest offered strike price. This is best described in technical terms as "moneyness". The corresponding values can be found in columns 1–3 of table 2. The calculated implied volatilities in column four are to be compared with the short-term and long-term historical volatilities in columns 5 and 6.

Table 2

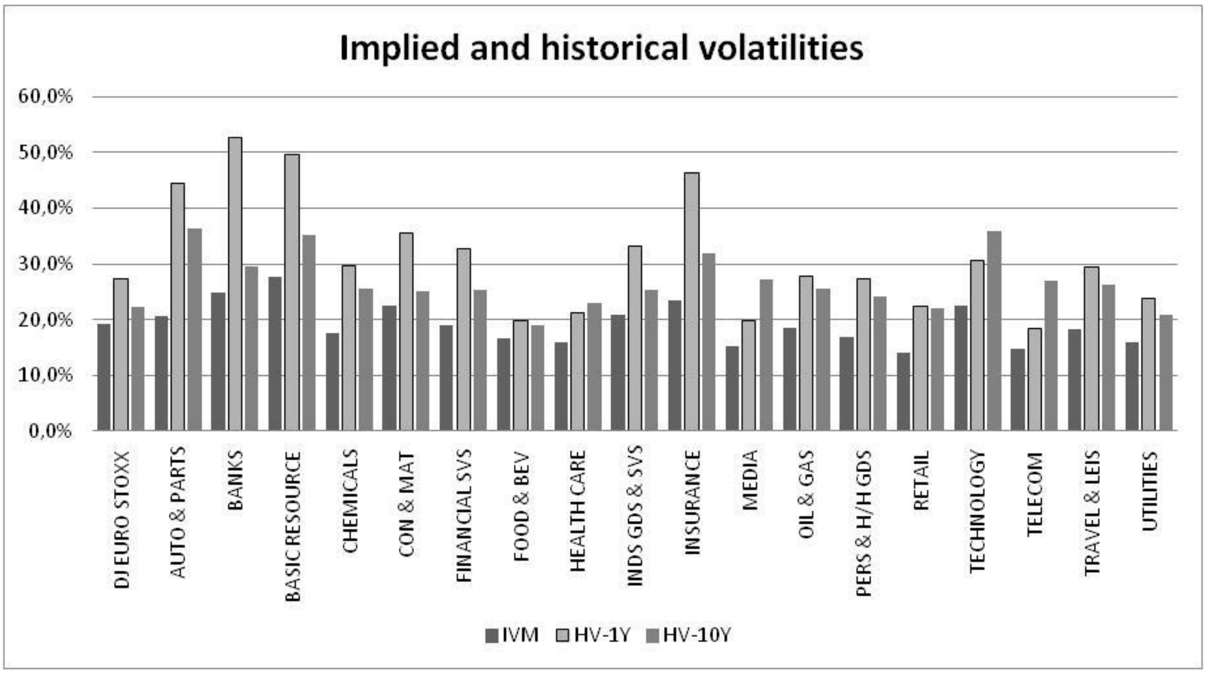
Implied and historical volatilities

	Index	Strike	ATM in %	IVM	HV-1Y	HV-10Y
DJ EURO STOXX	2973,05	2950	100,8	19,3%	27,4%	22,3%
AUTO & PARTS	239,28	240	99,7	20,6%	44,4%	36,3%
BANKS	220,74	220	100,3	24,9%	52,7%	29,5%
BASIC RESOURCE	283,55	285	99,5	27,6%	49,6%	35,1%
CHEMICALS	537,03	540	99,5	17,7%	29,6%	25,6%
CON & MAT	295,13	295	100,0	22,5%	35,5%	25,2%
FINANCIAL SVS	237,24	235	101,0	19,1%	32,6%	25,3%
FOOD & BEV	294,35	295	99,8	16,7%	19,9%	19,0%
HEALTH CARE	438,15	440	99,6	16,0%	21,3%	22,9%
INDS GDS & SVS	395,23	395	100,1	20,9%	33,2%	25,2%
INSURANCE	162,96	165	98,8	23,4%	46,4%	31,8%
MEDIA	157,26	155	101,5	15,3%	19,7%	27,3%
OIL & GAS	335,09	335	100,0	18,6%	27,9%	25,5%
PERS & H/H GDS	318,98	320	99,7	16,9%	27,2%	24,1%
RETAIL	282,47	280	100,9	14,1%	22,5%	22,0%
TECHNOLOGY	225,88	225	100,4	22,5%	30,6%	35,9%
TELECOM	406,15	405	100,3	14,8%	18,4%	27,0%
TRAVEL & LEIS	101,12	100	101,1	18,3%	29,5%	26,2%
UTILITIES	387,33	385	100,6	16,0%	23,8%	20,8%

Exhibit 1 shows the values of the implied volatilities (IVM), the values of the historical volatilities using one year of data (HV-1Y) and the values of the historical volatilities using the whole sample of ten years of data (HV-10Y). All the results are annualized to attain a better method of comparison.

Exhibit 1

Implied and historical volatilities



What we realize from figure 1 is that the actually dealt volatilities (as of January 2010), that is, the offered implied volatilities from the market makers, are far lower than the realized risks of the year before. Secondly, the implied volatilities are without any exception lower than the average risks that are calculated via the annualized empirical standard deviations of the past ten years. All in all, the implied volatilities are at an historical low level. There is a strikingly high ten-year standard deviation in the telecom and technology sectors. This is in contrast to the medium one-year standard deviation and implied volatility of technology and especially to the second-lowest implied volatility of the sector telecom. The reason for this is simply that the dot-com bubble is still contained in the data.

We need not overlook the fact that implied volatilities are subject to high spreading over time. Stoxx Limited calculates an index called VSTOXX, which is computed as a volatility index based on the prices of options on the Dow Jones Euro Stoxx 50 price index. Volatility indices are commonly labelled the "Fear Index". The VSTOXX originates from a rolling calculation of the mean of the 2 next to maturity options with an artificial time to maturity of 45 days. Therefore, it represents the market's expectation of volatility in the near future. Exhibit 2 shows the historical path of the VSTOXX in the past 10 years in contrast to the 200-day volatility of the Dow Jones Euro Stoxx 50 on the primary scale (left side). The secondary scale shows the historical path of the Dow Jones Euro Stoxx 50 (right side).

Exhibit 2

Fear indicator VSTOXX

B. Correlations and covariances

i. Historical correlations of the last decade and the year 2009

To obtain a complete picture of the historical covariance matrix requires the explicit calculation of 171 pairwise correlations, which is simply subject to the data constellation of 18 sectors and 1 sector index. In all these correlations the food and beverage sector reveals the three lowest values of all the coefficients, namely with media at 0.30, with technology at 0.25 and with telecom at 0.22. These are very low values given the fact that they are sector correlations. The highest correlation coefficients are to be found between the bank and the insurance sector with a value of 0.87 and with the construction and industry sectors with 0.84.

If one compares the values of the 1-year and the 10-year historical correlation matrixes one will find the largest difference at minus 0.23 in the correlation coefficient between telecom and media. Almost all the differences amount to less than 0.1 in absolute terms. This allows the statement that the correlations are quite constant over time.

Table 3 is to be read as follows: the upper triangular matrix shows the ten-year correlations and the lower triangular matrix the one-year correlations of the year 2009.

Table 3

One- and ten-year correlations

Correlations 1 year\ 10 years	DJ EURO STOXX	AUTO & PARTS	BANKS	BASIC RESOURCE	CHEMICALS	CON & MAT	FINANCIAL SVS	FOOD & BEV	HEALTH CARE	INDS GDS & SVS	INSURANCE	MEDIA	OIL & GAS	PERS & H/H GDS	RETAIL	TECHNOLOGY	TELECOM	TRAVEL & LEIS	UTILITIES
DJ EURO STOXX	1,00	0,69	0,89	0,73	0,81	0,86	0,85	0,58	0,63	0,89	0,87	0,77	0,74	0,88	0,79	0,78	0,69	0,78	0,76
AUTO & PARTS	0,79	1,00	0,61	0,58	0,62	0,68	0,62	0,46	0,45	0,65	0,57	0,44	0,54	0,63	0,57	0,47	0,37	0,59	0,44
BANKS	0,90	0,63	1,00	0,66	0,75	0,79	0,84	0,57	0,53	0,78	0,87	0,58	0,64	0,76	0,70	0,61	0,48	0,71	0,62
BASIC RESOURCE	0,85	0,80	0,64	1,00	0,71	0,75	0,69	0,49	0,42	0,77	0,67	0,50	0,60	0,65	0,58	0,50	0,36	0,61	0,52
CHEMICALS	0,88	0,79	0,68	0,83	1,00	0,76	0,75	0,56	0,57	0,75	0,75	0,51	0,68	0,74	0,66	0,54	0,42	0,69	0,66
CON & MAT	0,90	0,79	0,73	0,81	0,86	1,00	0,79	0,52	0,51	0,84	0,75	0,63	0,63	0,76	0,71	0,62	0,50	0,72	0,62
FINANCIAL SVS	0,87	0,70	0,82	0,71	0,76	0,80	1,00	0,62	0,57	0,75	0,82	0,56	0,69	0,75	0,73	0,56	0,46	0,71	0,63
FOOD & BEV	0,63	0,38	0,54	0,51	0,50	0,48	0,59	1,00	0,61	0,50	0,55	0,30	0,55	0,53	0,58	0,25	0,22	0,53	0,57
HEALTH CARE	0,56	0,42	0,36	0,44	0,54	0,50	0,49	0,51	1,00	0,48	0,56	0,41	0,58	0,52	0,55	0,36	0,35	0,51	0,59
INDS GDS & SVS	0,94	0,84	0,76	0,90	0,87	0,92	0,81	0,58	0,52	1,00	0,75	0,71	0,63	0,81	0,68	0,71	0,56	0,73	0,63
INSURANCE	0,95	0,73	0,92	0,74	0,76	0,84	0,84	0,54	0,48	0,85	1,00	0,58	0,65	0,76	0,70	0,62	0,48	0,74	0,63
MEDIA	0,80	0,54	0,64	0,69	0,70	0,80	0,64	0,53	0,44	0,77	0,73	1,00	0,44	0,68	0,61	0,72	0,73	0,60	0,54
OIL & GAS	0,85	0,63	0,73	0,76	0,75	0,74	0,79	0,56	0,49	0,81	0,77	0,67	1,00	0,60	0,58	0,40	0,34	0,54	0,69
PERS & H/H GDS	0,89	0,79	0,71	0,82	0,86	0,86	0,76	0,59	0,48	0,93	0,79	0,77	0,81	1,00	0,77	0,76	0,55	0,77	0,58
RETAIL	0,78	0,54	0,72	0,62	0,68	0,65	0,74	0,69	0,39	0,72	0,70	0,65	0,74	0,76	1,00	0,59	0,48	0,71	0,60
TECHNOLOGY	0,83	0,70	0,76	0,73	0,73	0,80	0,77	0,35	0,42	0,81	0,81	0,61	0,61	0,76	0,60	1,00	0,67	0,60	0,45
TELECOM	0,59	0,42	0,39	0,50	0,58	0,54	0,43	0,50	0,41	0,52	0,47	0,50	0,43	0,56	0,50	0,47	1,00	0,46	0,50
TRAVEL & LEIS	0,79	0,58	0,63	0,76	0,76	0,78	0,66	0,39	0,37	0,79	0,73	0,75	0,68	0,78	0,65	0,72	0,43	1,00	0,53
UTILITIES	0,70	0,42	0,55	0,55	0,63	0,60	0,51	0,39	0,46	0,60	0,65	0,61	0,57	0,54	0,42	0,51	0,46	0,56	1,00

ii. Historical and Implied Covariances

Having calculated the historical covariances one cannot say if the values are high, low or moderate. The values in table 4 are annualized using the factor square root of 52, which should be sufficiently exact, since there are no significant auto correlations within the data. The coefficients are multiplied by 10,000 and therefore display squares of per cents. This is to support a better readability of the data. Besides the values in the diagonal, the highest values can be found in the covariance between the bank and the insurance sector. Table 4 displays the 10-year covariances in the greyed-out triangle. The 1-year covariances of the year 2009 are in the lower triangular matrix.

Table 4

One- and ten-year covariances

Co-variances 1 year\ 10 years	AUTO & PARTS	BANKS	BASIC RESOURCE	CHEMICALS	CON & MAT	FINANCIAL SVS	FOOD & BEV	HEALTH CARE	INDS GDS & SVS	INSURANCE	MEDIA	OIL & GAS	PERS & H/H GDS	RETAIL	TECHNOLOGY	TELECOM	TRAVEL & LEIS	UTILITIES
AUTO & PARTS	1314	652	742	578	617	565	318	375	591	652	432	496	545	455	605	364	558	334
BANKS	1316	866	682	565	585	625	317	354	579	815	461	483	537	454	640	377	546	377
BASIC RESOURCE	1579	1550	1228	641	660	614	325	335	683	745	476	536	545	450	626	342	564	379
CHEMICALS	904	953	1095	656	491	488	273	337	485	612	358	446	454	373	492	288	463	351
CON & MAT	1068	1205	1259	614	633	501	246	294	535	603	435	406	461	390	556	337	471	324
FINANCIAL SVS	886	1277	1036	325	810	640	296	332	479	655	385	442	457	405	505	311	473	331
FOOD & BEV	299	516	455	335	299	343	361	268	241	333	155	266	242	244	171	114	263	227
HEALTH CARE	355	378	425	683	339	311	198	525	279	408	255	338	289	275	294	217	305	279
INDS GDS & SVS	1031	1142	1277	745	897	740	324	320	636	602	489	403	491	377	642	384	483	332
INSURANCE	1354	2089	1579	476	1242	1156	455	442	1141	1009	506	527	583	489	701	407	614	417
MEDIA	383	554	568	536	455	341	174	157	396	564	742	304	447	364	702	537	431	308
OIL & GAS	673	950	935	545	627	629	275	260	627	897	300	650	367	326	366	233	361	367
PERS & H/H GDS	794	874	951	450	690	571	273	239	671	860	322	511	578	405	656	360	482	290
RETAIL	452	731	592	626	430	457	260	161	430	630	223	383	371	483	462	283	410	277
TECHNOLOGY	862	1148	1032	342	780	702	196	258	720	1087	311	471	551	358	1285	647	562	339
TELECOM	301	338	411	564	303	226	162	145	265	358	149	190	233	174	240	728	322	278
TRAVEL & LEIS	696	917	1038	379	738	580	215	217	673	948	375	505	544	374	619	212	685	288
UTILITIES	366	588	558	370	420	335	155	202	381	622	224	313	277	177	320	167	345	434

The implied covariance matrix is the result of using implied volatilities instead of the historical standard deviations. The implied covariances can be used to calculate the implied sector betas. The values in table 5 are multiplied by the factor 10,000. In the greyed-out upper triangular matrix are the results using the 10-year correlations. The lower triangular matrix shows the implied covariances on the basis of the correlations of 2009.

Table 5

One- and ten-year implied covariances

Implied co-variances 1 year\ 10 years	AUTO & PARTS	BANKS	BASIC RESOURCE	CHEMICALS	CON & MAT	FINANCIAL SVS	FOOD & BEV	HEALTH CARE	INDS GDS & SVS	INSURANCE	MEDIA	OIL & GAS	PERS & H/H GDS	RETAIL	TECHNOLOGY	TELECOM	TRAVEL & LEIS	UTILITIES
AUTO & PARTS	422	313	331	226	313	241	158	148	277	273	138	205	218	166	215	113	221	145
BANKS	322	620	454	330	443	398	235	209	405	508	220	297	320	247	340	175	323	245
BASIC RESOURCE	455	443	762	348	465	364	225	184	445	432	211	308	302	228	310	148	310	230
CHEMICALS	286	298	403	313	303	254	165	162	277	311	139	224	221	166	213	109	224	186
CON & MAT	364	407	500	341	507	338	194	183	396	398	219	264	290	224	312	165	295	223
FINANCIAL SVS	273	390	372	256	344	363	196	174	299	364	163	242	242	196	239	129	249	192
FOOD & BEV	131	224	233	148	181	188	278	164	175	215	77	170	150	138	94	55	161	153
HEALTH CARE	137	145	192	153	181	150	136	255	161	210	100	171	141	123	129	83	148	150
INDS GDS & SVS	359	394	519	323	431	322	200	175	436	367	228	243	286	201	333	174	279	211
INSURANCE	351	537	477	316	444	374	209	179	417	548	210	283	302	232	324	165	317	236
MEDIA	169	243	293	189	277	188	136	108	247	262	235	125	177	132	248	166	170	133
OIL & GAS	240	336	389	245	308	280	174	145	316	336	192	344	188	153	167	93	184	205
PERS & H/H GDS	274	299	383	257	329	246	167	129	327	312	199	255	286	183	289	139	237	157
RETAIL	158	253	242	169	208	200	162	88	212	231	140	194	181	199	186	100	184	137
TECHNOLOGY	324	427	452	291	404	329	131	152	382	429	209	256	289	191	507	223	247	164
TELECOM	129	144	206	151	179	121	124	97	160	161	115	118	139	105	156	219	124	117
TRAVEL & LEIS	220	287	383	247	322	229	121	107	300	315	212	230	240	167	298	117	335	155
UTILITIES	137	218	244	178	217	157	103	119	202	245	150	169	145	94	183	109	166	256

C. Historical betas of each single year and the whole decade

Table 6 displays the historical betas for every sector for the years 2000 to 2009, each value calculated using 52 weekly returns. What is most striking is the remarkable difference in the betas in the year 2000 relative to the comparably stable sector betas in the following years. Actually, there is even one beta negative: the food and beverage sector reveals a negative beta at -0.53.

Table 6

Historical betas of single years and total average

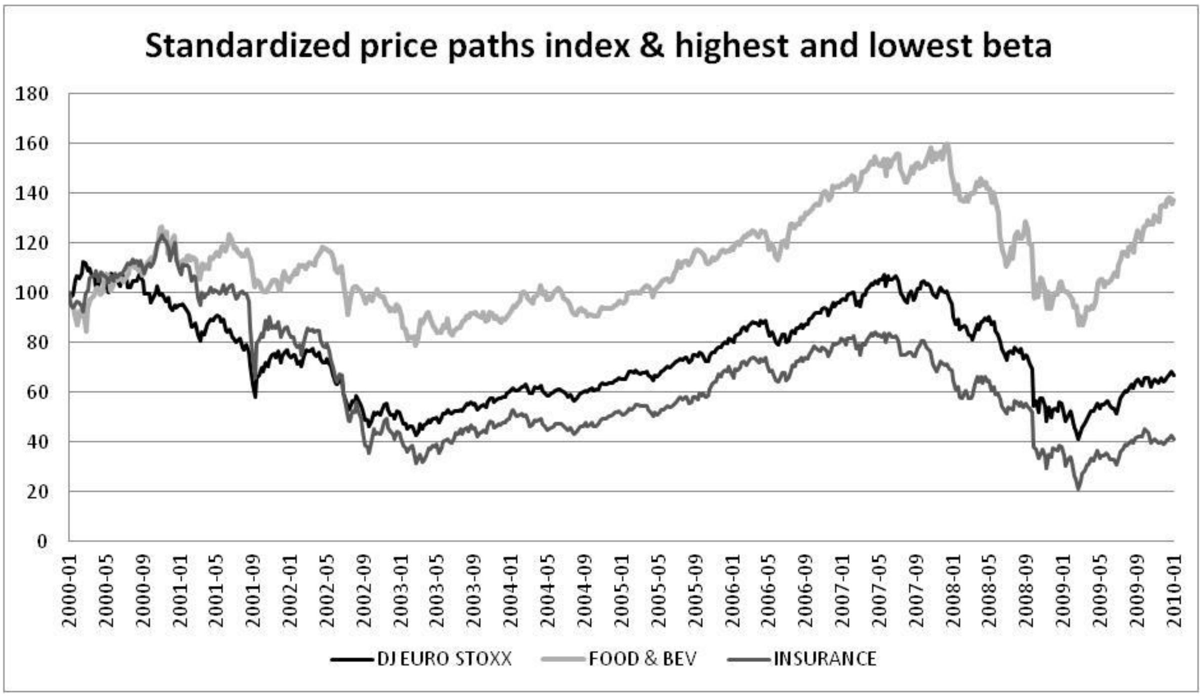
Sector\ Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	all
AUTO & PARTS	0,26	1,15	0,98	1,28	1,23	1,10	1,17	1,39	1,23	1,31	1,19
BANKS	0,45	1,13	1,13	1,01	0,91	1,05	1,01	1,08	1,19	1,73	1,22
BASIC RESOURCE	0,33	0,94	0,92	0,96	1,26	1,18	1,21	1,37	1,36	1,55	1,21
CHEMICALS	0,09	1,09	0,93	1,28	0,96	1,28	1,05	0,95	0,90	0,97	1,00
CON & MAT	0,81	0,74	0,81	0,90	0,85	0,98	1,12	1,30	1,08	1,18	0,99
FINANCIAL SVS	0,18	1,16	0,99	0,78	0,65	0,68	0,89	1,29	1,04	1,05	1,02
FOOD & BEV	-0,53	0,35	0,37	0,66	0,70	0,63	0,75	0,66	0,76	0,50	0,58
HEALTH CARE	0,02	0,61	0,64	0,94	0,54	0,57	0,70	0,62	0,86	0,44	0,69
INDS GDS & SVS	0,97	0,95	0,86	0,77	1,17	1,03	1,22	1,25	1,02	1,15	1,01
INSURANCE	0,20	1,18	1,49	1,56	1,42	1,22	1,17	1,15	1,16	1,59	1,32
MEDIA	1,92	1,10	1,02	1,01	1,20	0,89	0,67	0,75	0,81	0,60	0,88
OIL & GAS	0,00	0,91	0,79	0,72	0,64	1,11	0,92	0,85	1,10	0,88	0,91
PERS & H/H GDS	0,76	1,26	1,03	1,04	1,22	1,05	1,11	0,75	0,76	0,90	0,96
RETAIL	0,49	0,78	0,82	1,02	1,02	0,84	0,69	0,72	0,85	0,64	0,81
TECHNOLOGY	2,35	1,35	1,75	1,51	1,68	1,18	1,28	0,81	0,88	0,93	1,19
TELECOM	2,09	0,99	0,88	0,68	1,00	0,75	0,73	0,73	0,72	0,43	0,75
TRAVEL & LEIS	0,25	1,22	0,98	1,25	1,00	0,89	0,64	1,29	0,80	0,85	0,97
UTILITIES	0,56	0,40	0,55	0,67	0,68	0,96	1,01	0,83	0,97	0,65	0,72

Table 6 reveals that the technology and telecom sectors, which both exhibited betas above two at the beginning of the century, fall back to the midfield of betas considering technology and find themselves among the sectors with the lowest betas considering telecom. On the other side, there were conservative sectors at the beginning of the last decade, such as banks and basic resources, with very low betas, but these two sectors exhibited the highest betas at the end of the decade for very subtle and distinct reasons. Banks were hit hard by the financial crisis of the years 2007 and 2008. Basic resources were troubled by exploding commodity prices triggered by the demand created by the emerging markets of Brazil, Russia, India and China.

Taking the data from the whole decade, the insurance sector is to be considered the most risky historically, with a beta of 1.32, and food and beverage was the sector with the lowest systematic risk, with a beta of 0.58. Exhibit 4 shows the historical price path of these most distinct sectors as well as of the Euro Stoxx 50. All the values are normalized to a starting value of 100. One can hardly imagine that the betas are that different: from 2002 to 2008 the paths develop in parallel but the insurance sector recovered at a greater speed from the ramifications of the financial crisis.

Exhibit 3

Standardized price paths of high and low beta indices

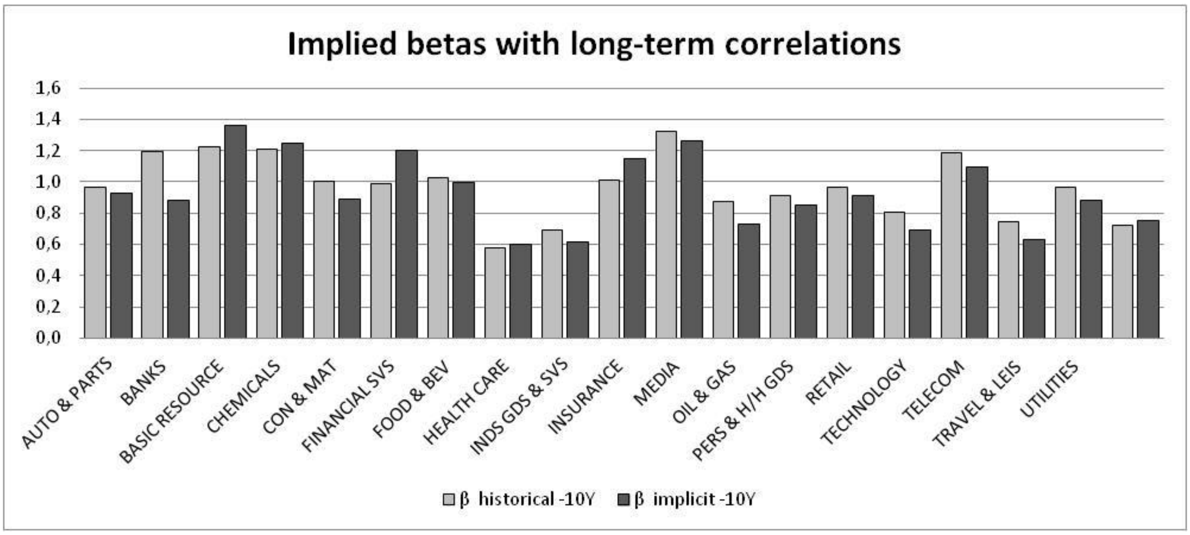


D. Implied betas

The most important factor that amounts to the value of implied betas is the implied volatility of the options. Concerning the covariance, the correlation is an important factor, which is why we calculate implied betas with 1-year correlations as well as 10-year correlations. Exhibit 5 illustrates the sizes as well as the differences of the implied sector betas using 10-year correlations and the historical betas using 10 years of weekly data: the differences partly amount to more than 0.2 in absolute terms but there is no clear tendency of one methodologically different beta being higher than the other one.

Exhibit 4

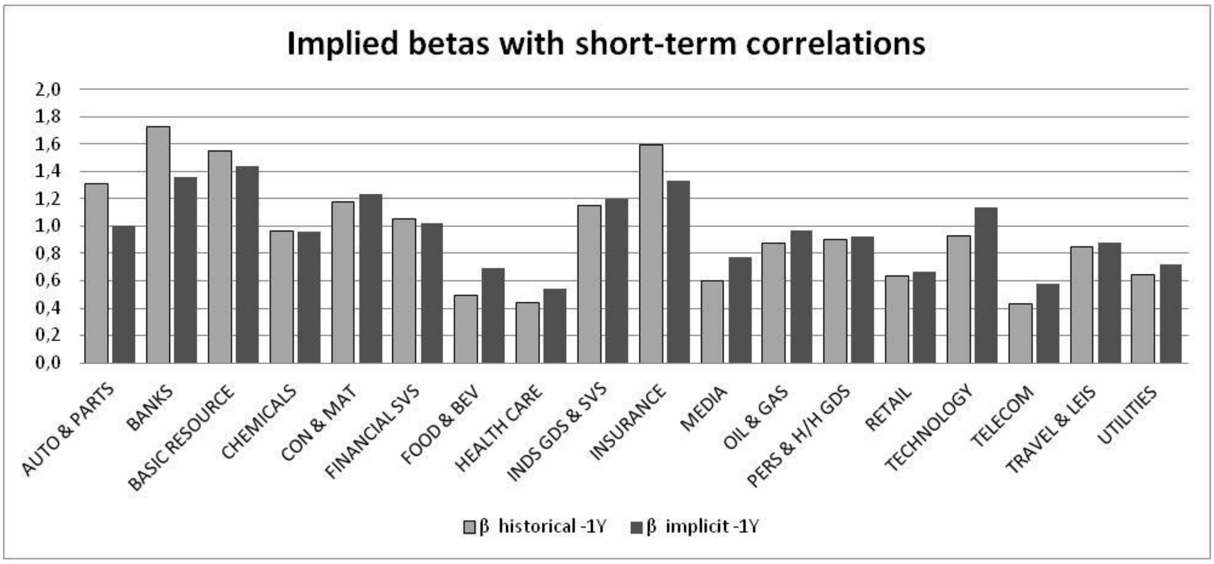
Implied betas with long-term correlations



The implied betas using 1-year correlations (here called short-term correlations) are displayed in exhibit 6. The light bars represent the sizes of the historical betas using 1 year of data. What is most striking is that the short-term betas exhibit a wider range from 0.4 for the health-care sector up to 1.7 for the banking sector. The exact values of all the betas are tabulated in the next section.

Exhibit 5

Implied betas with short-term correlations



E. Reverse betas

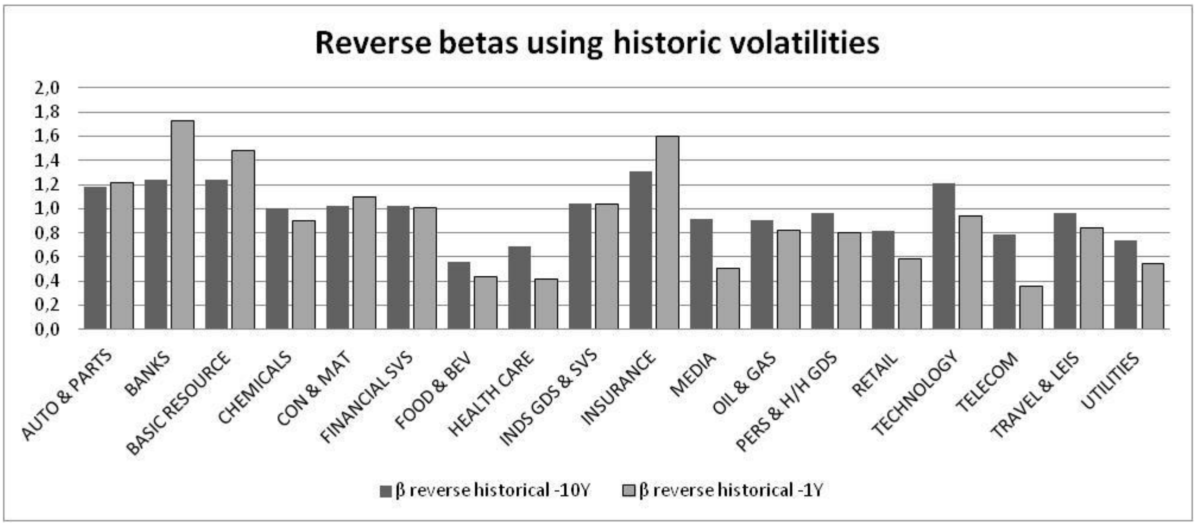
The calculation of reverse betas can be performed *reverse historically* using historical volatilities as well as *reverse implicitly* using implied volatilities. Correlations can again – as demonstrated with implied betas – be calculated as short-term correlations or as long-term correlations using one or respectively ten years of data. The illustration of the results begins with exhibits 7 and 8 and then finishes with table 7, which provides an overall survey of all the betas calculated.

i. Reverse betas based on historical volatilities

In order to calculate the so-called reverse betas as described in subsection 2.3, one needs the relative market capitalizations of the sectors. These data are provided by Stoxx Limited day by day. The respective values can be found in table 7 (see next page) together with the two different reverse historical betas using short-term as well as long-term correlations. The observable differences in exhibit 6 are solely due to the differences between long-term and short-term correlations as all the other factors are the same. The media sector is almost decimated as it halves from 0.91 to 0.50 with the switch from long-term correlations to short-term correlations. The telecom sector even decreases to less than half, to a value of 0.36 from 0.79. Concerning the banking as well as the insurance sector, we can observe a significant increase in correlations, leading to respective increases in betas. See table 7 on the next page for all the details.

Exhibit 6

Reverse betas using historical volatilities

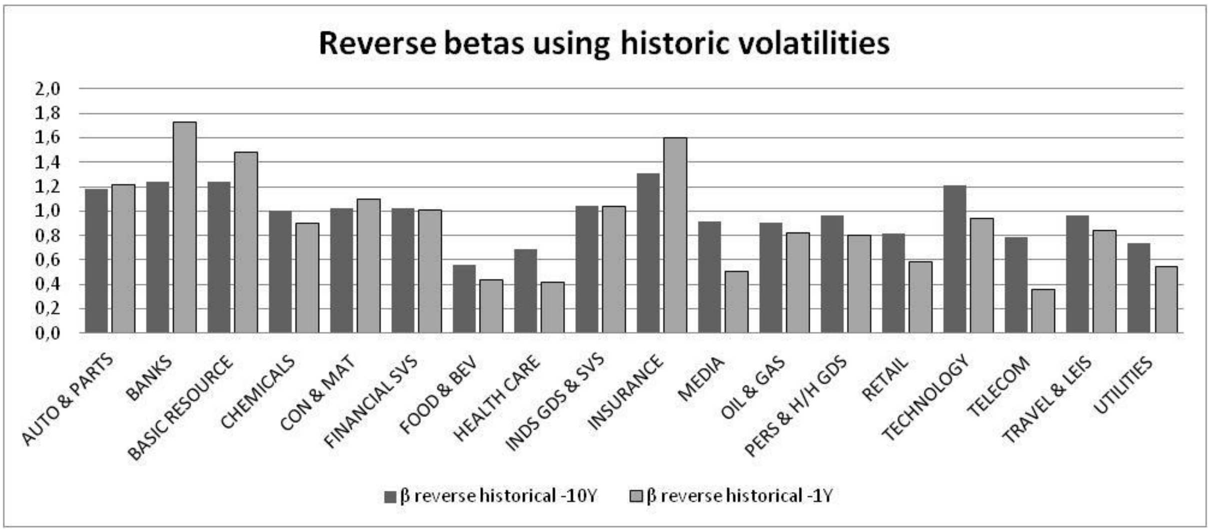


ii. Reverse betas based on implied volatilities

Exhibit 7 reveals the so-called reverse implied betas. In sharp contrast to the results of the implied historical betas, we cannot observe a significant influence of long-term versus short-term correlations. The usage of implied instead of historical volatilities leads to betas (or more rigorously speaking, beta estimates) that reflect the current market capitalizations of the sectors as well as the current market expectation with respect to volatilities. The banking, basic resources and insurance sectors reveal the highest betas at the time.

Exhibit 7

Reverse betas using implied volatilities



The many different betas from subsections 4.4 and 4.5 are now shown collectively in table 7.

Table 7

Survey of the methodologically different betas calculated

Sector\ Betas	Relative Market-Cap 15.01.2010	β implied -10Y	β implied -1Y	β reverse historic - 10Y	β reverse historic - 1Y	β reverse implied -10Y	β reverse implied -1Y
AUTO & PARTS	3,44%	0,88	1,01	1,18	1,21	0,89	0,98
BANKS	17,97%	1,36	1,36	1,24	1,73	1,42	1,35
BASIC RESOURCE	2,36%	1,25	1,44	1,24	1,49	1,31	1,41
CHEMICALS	6,25%	0,89	0,96	1,01	0,90	0,93	0,94
CON & MAT	4,42%	1,20	1,24	1,02	1,10	1,22	1,23
FINANCIAL SVS	1,19%	1,00	1,02	1,02	1,01	1,03	1,02
FOOD & BEV	4,96%	0,60	0,69	0,56	0,44	0,67	0,65
HEALTH CARE	4,19%	0,62	0,54	0,69	0,41	0,64	0,54
INDS GDS & SVS	8,40%	1,15	1,20	1,04	1,04	1,15	1,19
INSURANCE	7,23%	1,26	1,34	1,31	1,60	1,30	1,34
MEDIA	2,50%	0,73	0,77	0,91	0,50	0,67	0,74
OIL & GAS	7,73%	0,85	0,97	0,90	0,82	0,88	0,96
PERS & H/H GDS	3,82%	0,92	0,93	0,97	0,81	0,90	0,92
RETAIL	2,81%	0,69	0,66	0,81	0,59	0,70	0,67

TECHNOLOGY	4,44%	1,09	1,13	1,21	0,94	0,99	1,14
TELECOM	7,55%	0,63	0,58	0,79	0,36	0,56	0,53
TRAVEL & LEIS	0,99%	0,88	0,88	0,96	0,84	0,90	0,87
UTILITIES	9,75%	0,75	0,72	0,74	0,54	0,76	0,68

V. CONCLUSION

The inherent risk in risky securities can be estimated in many different manners. Volatility is a so-called total risk measure that can either be estimated historically or be implied by observing option prices. Within the historical approach it is possible to come up with quite different estimates, which are mainly due to different samples. The samples can vary in frequency as well as time period. On the other hand, the different values of implied volatilities are due to distinct options with distinct times to maturity or strike prices. The beta, in contrast to volatility, is not a total risk measure but it measures the systematic risk of the considered assets. From a methodological point of view, the beta can be estimated historically, implied or reverse. It turns out that the distinct methods can lead to substantially different estimates of betas of the considered Eurozone sectors. The question to be raised is which concept of beta estimation delivers correct as well as reliable estimates of systematic sector risks. The empirical evidence shows that the sector betas are far from stable in time and it is conclusive that there are not simply estimation errors but that there are economic reasons for time-varying betas. It is no use calculating an average of all the methodologically different betas in order to obtain a sound estimate of "the" right beta. It is more important to find the economic rationale behind which method to use in combination with the purpose for which the beta is to be used.

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[i] Black, F. /Jensen, M. /Scholes, M., The Capital Asset Pricing Model, p. 2.
[ii] Black, F./Jensen, M./Scholes, M., The Capital Asset Pricing Model, p. 8.
[iii] Miller, M./Scholes, M., Rates on Return in Relation to Risk, pp. 47–78.
[iv] See Damodaran, A., Risk Premiums, pp. 1–86. Damodaran cites Indro and Lee, who find both arithmetic as well as geometric means as convincing and consequently they propose a weighted average of both variants. The weight to the geometric mean thereby should be increased as the time horizon is enlarged.