

Guide to the Index Indicators of Deutsche Börse

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General Information

In order to ensure the highest quality of each of its indices, Deutsche Börse AG exercises the greatest care when compiling and calculating equity indices on the basis of the rules set out in this Guideline.

However, Deutsche Börse AG cannot guarantee that the various indices, or the various ratios that are required for index compilation and computation purposes, as set out in this Guideline, are always calculated free of errors. Deutsche Börse AG accepts no liability for any direct or indirect losses arising from any incorrect calculation of such indices or ratios.

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The equity indices of Deutsche Börse AG do not represent a recommendation for investment of whatever nature. In particular, the compilation and calculation of the various indices shall not be construed as a recommendation of Deutsche Börse AG to buy or sell individual securities, or the basket of securities underlying a given index.

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1 Introduction

Deutsche Börse calculates and publishes daily volatility data related to the DAX[®], MDAX[®], SDAX[®] and TecDAX[®] equity indices, as well as correlation data and beta factors for these indices.¹ While volatility and correlation data is calculated for periods of 30 and 250 exchange trading days, beta factors are only available for a 250-day period.

The calculation of these indicators (volatility, correlation, beta factor) is subsequently described in greater detail, illustrated by a comprehensive example at the end of each explanation.

The prices used for calculation have been adjusted where necessary, for instance, in the event of dividend distributions and changes in nominal values. For example, if the nominal value of a share changes from € 50 to € 5, the corresponding share prices will have to be multiplied by a factor of 10 (c_i factor) as from the day of such change.

The various indicators are calculated on the basis of daily changes in the relevant time series, with such changes being determined as the logarithm of the quotient of the value and the previous day's value, using adjusted prices.

Index closing prices are based on the respective Xetra[®] prices, whereby the last determined prices are used.

Apart from the volatility of a specific share, the corresponding index volatility as well as the covariance between share and index are required for the calculation of both beta factor and correlation coefficient (annualised). The following formulas apply accordingly:

$$\sigma_{\text{Share}} = \sqrt{250 \cdot \frac{1}{n-1} \sum_{i=1}^n (\text{Share}_i - \overline{\text{Share}})^2}$$

$$\sigma_{\text{Index}} = \sqrt{250 \cdot \frac{1}{n-1} \sum_{i=1}^n (\text{Index}_i - \overline{\text{Index}})^2}$$

$$\text{Cov}_{\text{Index,Share}} = 250 \cdot \frac{1}{n-1} \sum_{i=1}^n (\text{Index}_i - \overline{\text{Index}}) \cdot (\text{Share}_i - \overline{\text{Share}})$$

whereby:

m	= Period (30 or 250 days)
n	= Number of day's yields (based on $n+1$ prices)
l	= Time of calculation
$\text{Index}_1, \dots, \text{Index}_n$	= Index returns (e.g. $\text{Index}_i = \ln(\text{DAX}_i / \text{DAX}_{i-1})$)
$\text{Share}_1, \dots, \text{Share}_n$	= Price returns (e.g. $\text{Share}_i = \ln(\text{Share}_i / \text{Share}_{i-1})$)
$\overline{\text{Index}}$	= Mean value of n logarithmic index returns $\text{Index}_1, \dots, \text{Index}_n$
$\overline{\text{Share}}$	= Mean value of n logarithmic price returns $\text{Share}_1, \dots, \text{Share}_n$.

¹ DAX[®], MDAX[®], SDAX[®], TecDAX[®] and Xetra[®] are registered trademarks of Deutsche Börse AG.

2 Volatility

The term volatility is used to describe the fluctuation intensity of a certain share price around its mean value within a fixed period of time. Based on the assumption that historical values can be used as an indicator for future developments, this indicator can thus be used to evaluate the profit or loss potential of a share.

A share's volatility is calculated using the following formula:

$$\sigma_{\text{Share}} = \sqrt{250 \cdot \frac{1}{n-1} \sum_{i=1}^n (\text{Share}_i - \overline{\text{Share}})^2}$$

Volatility is particularly important for the pricing of options. As a measure of price fluctuations it reflects the extent to which a certain value will be subject to substantial changes in the future.

3 Correlation Coefficient

The correlation coefficient is a measure for the strength and direction of the linear correlation between the developments of two time series. For securities trading, this refers to calculating the correlation between the price movement of a share and that of a reference series (generally a benchmark equity index). Deutsche Börse calculates the correlation coefficient for each of the DAX[®], MDAX[®], SDAX[®] and TecDAX[®] component equities in relation to the respective index.

The formula for the correlation coefficient r of an individual share in relation to the corresponding index within a period of n days is shown below:

$$r_{\text{Index, Share}} = \frac{\text{Cov}_{\text{Index, Share}}}{s_{\text{Index}} \cdot s_{\text{Share}}} = \frac{\frac{1}{n-1} \sum_{i=1}^n (\text{Index}_i - \overline{\text{Index}}) \cdot (\text{Share}_i - \overline{\text{Share}})}{\sqrt{\frac{1}{n-1} \sum_{i=1}^n (\text{Index}_i - \overline{\text{Index}})^2} \cdot \frac{1}{n-1} \sum_{i=1}^n (\text{Share}_i - \overline{\text{Share}})^2}$$

The values assumed by the correlation coefficient $r_{\text{DAX, Share}}$ may range between -1 and $+1$.

A correlation coefficient of $+1$ of a share in terms of the corresponding index indicates a positive linear correlation of the time series involved. In other words, percentage changes in the share price involved are always exactly identical to those of the index.

The smaller the coefficient the weaker such correlation. In the event of a correlation coefficient of 0 , movements in the share price do not have any relation to the index. In rare cases of a negative correlation coefficient, the share price moves in the opposite direction to the index. An investment in such a share would thus represent an opportunity for diversification.

4 Beta Factor

The beta factor is a measure of a share's sensitivity to index fluctuations. The factor describes the extent to which the price of the share reflects the performance of that index.

The beta factor of an individual share in relation to the index is calculated using the following formula:

$$b_{\text{Index, Share}} = \frac{\text{Cov}_{\text{Index, Share}}}{s_{\text{Index}}^2} = \frac{\frac{1}{n-1} \sum_{i=1}^n (\text{Index}_i - \overline{\text{Index}}) \cdot (\text{Share}_i - \overline{\text{Share}})}{\frac{1}{n-1} \sum_{i=1}^n (\text{Index}_i - \overline{\text{Index}})^2}$$

If the beta factor is higher (lower) than 1, changes in the respective share during the period under review were disproportionately higher (disproportionately lower) than the changes in the index. For example, in the event of an increase in the DAX[®] by 10 percent, a beta factor of 1.2 indicates that the value of the corresponding share has risen by 12 percent in the same period. With a beta factor of 0.8, the share's rise would have been reduced to a mere 8 percent.

High beta factors thus reveal which shares are offering disproportionately stronger profit potential in a bullish market. At the same time, however, these very shares also bear greater risks with a falling index. The beta factor should always be taken into account in conjunction with the correlation coefficient.

Example: Comparison of Siemens in relation to the DAX® index within the period from 03/01/05 to 11/02/05 (30 exchange trading days):

Date	Price Siemens (not adjusted)	c _r -Factor	Price Siemens (adjusted)		y _{Siemens}	y _{DAX}	$d_{\text{Siemens}} = \frac{y_{\text{Siemens}} - y_{\text{Siemens}}}{y_{\text{Siemens}}}$		$d_{\text{DAX}} = \frac{y_{\text{DAX}} - y_{\text{DAX}}}{y_{\text{DAX}}}$		$d_{\text{Siemens}} \cdot d_{\text{DAX}}$	d_{Siemens}^2	d_{DAX}^2
	1		3	4			5	6	7	8			
03.01.2005	62,95	1	62,95	4291,53	-0,00558	-0,00024	-0,00540	-0,00101	0,00001	0,00003	0,00000	0,00000	0,00000
04.01.2005	62,60	1	62,60	4290,50	-0,01464	-0,00755	-0,01447	-0,00831	0,00012	0,00021	0,00007	0,00007	0,00007
05.01.2005	61,69	1	61,69	4258,24	0,00936	0,00998	0,00953	0,00921	0,00009	0,00009	0,00008	0,00008	0,00008
06.01.2005	62,27	1	62,27	4300,94	0,00513	0,00359	0,00530	0,00282	0,00001	0,00003	0,00001	0,00001	0,00001
07.01.2005	62,59	1	62,59	4316,40	-0,00096	-0,00209	-0,00078	-0,00286	0,00000	0,00000	0,00001	0,00001	0,00001
10.01.2005	62,53	1	62,53	4307,37	-0,01045	-0,01153	-0,01027	-0,01229	0,00013	0,00011	0,00015	0,00015	0,00015
11.01.2005	61,88	1	61,88	4258,01	-0,00779	-0,01162	-0,00761	-0,01238	0,00009	0,00006	0,00015	0,00015	0,00015
12.01.2005	61,40	1	61,40	4208,82	-0,00523	0,00079	-0,00505	0,00002	0,00000	0,00003	0,00000	0,00000	0,00000
13.01.2005	61,08	1	61,08	4212,14	-0,00131	0,00479	-0,00114	0,00402	0,00000	0,00000	0,00002	0,00002	0,00002
14.01.2005	61,00	1	61,00	4232,36	0,00946	0,00310	0,00964	0,00234	0,00002	0,00009	0,00001	0,00001	0,00001
17.01.2005	61,58	1	61,58	4245,51	0,00647	0,00122	0,00665	0,00046	0,00000	0,00004	0,00000	0,00000	0,00000
18.01.2005	61,98	1	61,98	4250,71	-0,00048	-0,00121	-0,00031	-0,00198	0,00000	0,00000	0,00000	0,00000	0,00000
19.01.2005	61,95	1	61,95	4245,55	-0,00599	-0,00593	-0,00582	-0,00670	0,00004	0,00003	0,00004	0,00004	0,00004
20.01.2005	61,58	1	61,58	4220,43	-0,00914	-0,00160	-0,00896	-0,00236	0,00002	0,00008	0,00001	0,00001	0,00001
21.01.2005	61,02	1	61,02	4213,70	0,00164	-0,00281	0,00181	-0,00357	-0,00001	0,00000	0,00001	0,00001	0,00001
24.01.2005	61,12	1	61,12	4201,89	0,01187	0,00760	0,01205	0,00684	0,00008	0,00015	0,00005	0,00005	0,00005
25.01.2005	61,85	1	61,85	4233,95	-0,00081	-0,00469	-0,00063	-0,00546	0,00000	0,00000	0,00003	0,00003	0,00003
26.01.2005	61,80	1	61,80	4214,12	0,02871	0,00054	0,02889	-0,00022	-0,00001	0,00083	0,00000	0,00000	0,00000
27.01.2005	63,60	1	63,60	4216,41	-0,01535	-0,00347	-0,01518	-0,00423	0,00006	0,00023	0,00002	0,00002	0,00002
28.01.2005	61,40	1,0200481	62,63	4201,81	-0,00916	0,01254	-0,00899	0,01178	-0,00011	0,00008	0,00014	0,00014	0,00014
31.01.2005	60,84	1,0200481	62,06	4254,85	0,00835	0,00589	0,00852	0,00512	0,00004	0,00007	0,00003	0,00003	0,00003
01.02.2005	61,35	1,0200481	62,58	4279,97	-0,00868	0,00381	-0,00850	0,00305	-0,00003	0,00007	0,00001	0,00001	0,00001
02.02.2005	60,82	1,0200481	62,04	4296,31	-0,02010	-0,00342	-0,01992	-0,00419	0,00008	0,00040	0,00002	0,00002	0,00002
03.02.2005	59,61	1,0200481	60,81	4281,64	0,00952	0,01337	0,00969	0,01261	0,00012	0,00009	0,00016	0,00016	0,00016
04.02.2005	60,18	1,0200481	61,39	4339,28	0,00860	0,00622	0,00878	0,00545	0,00005	0,00008	0,00003	0,00003	0,00003
07.02.2005	60,70	1,0200481	61,92	4366,35	-0,00495	0,00115	-0,00478	0,00039	0,00000	0,00002	0,00000	0,00000	0,00000
08.02.2005	60,40	1,0200481	61,61	4371,39	0,00232	-0,00418	0,00249	-0,00495	-0,00001	0,00001	0,00002	0,00002	0,00002
09.02.2005	60,54	1,0200481	61,75	4353,15	-0,00017	-0,00256	0,00001	-0,00333	0,00000	0,00000	0,00001	0,00001	0,00001
10.02.2005	60,53	1,0200481	61,74	4342,01	0,01427	0,01049	0,01445	0,00973	0,00014	0,00021	0,00009	0,00009	0,00009
11.02.2005	61,40	1,0200481	62,63	4387,80	-0,00508	0,02218	-0,00508	0,02218	0,00096	0,00304	0,00117	0,00117	0,00117
Total					-0,00508	0,02218	-0,00508	0,02218	0,00096	0,00304	0,00117	0,00117	0,00117
Mean value					-0,00018	0,00076	-0,00018	0,00076	0,00096	0,00304	0,00117	0,00117	0,00117

How to calculate the indicators:

Columns 1 and 4 contain the respective time series of the Siemens share and the DAX® index. A dividend payment for Siemens took place on 28/01/05. The resulting c_1 -factor is used for the determination of the adjusted price (column 3).

The next step is to determine the daily changes within the time series involved. The formula used in this context is shown below, using 28/01/05 as an example:

$$y_{\text{Siemens}} = \ln\left(\frac{61.40 \cdot 1.0200481}{63.60 \cdot 1.0000000}\right) = -0.01535$$

The daily changes for Siemens and the DAX® are recorded in columns 5 and 6, respectively. In addition the mean value of the changes can be taken from these columns. In the next step the mean value is deducted from the returns (columns 7 and 8).

Columns 9 to 11 are used to multiply the values from columns 7 and 8, deriving the indicators from the respective sums of these columns:

Volatility:

$$s_{\text{Siemens}} = \sqrt{\frac{250}{28} \cdot 0.00304} = 0.16487$$

$$s_{\text{DAX}} = \sqrt{\frac{250}{28} \cdot 0.00117} = 0.10220$$

The following value is also required for the calculation of the beta factor and correlation coefficient:

$$\text{Cov}_{\text{DAX, Siemens}} = \frac{250}{28} \cdot 0.00096 = 0.00859$$

Correlation:

$$r_{\text{DAX, Siemens}} = \frac{0.00859}{0.16487 \cdot 0.10220} = 0.50960$$

In this example the beta-factor is calculated over a period of 30 days.

Beta factor:

$$\beta_{\text{DAX, Siemens}} = \frac{0.00859}{0.10220^2} = 0.82212$$

Deutsche Börse calculates the beta-factors over a period of 250 days.

5 Your Direct Line to Deutsche Börse

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