Swiss Exchange

SIX Swiss Exchange Indices

Guide Governing Volatility Index VSMI

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Swiss Exchange

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1 Index Structure

1.1 Concept

Volatility is a measure of the level of uncertainty prevailing in certain markets, or with respect to individual underlying instruments. In principle, there are two different approaches for the estimation of volatility: on the one hand, it is possible to determine historical volatility by measuring the standard deviation of prices for any particular security over a given period of time. On the other hand, volatility can be derived implicitly from option prices ('implied volatility'); this kind of volatility represents the estimates and assumptions of market participants involved in a trade, on the basis of a given option price.

The VSMI® does not measure implied volatilities of at-the-money SMI® options but the implied variance across all options of a given time to expiration. This model offers great advantages in terms of trading, hedging and introducing derivative products on this index. The main index (which is not linked to a specific time to expiration) has a fixed remaining time to expiration of 30 days. The VSMI® and its various sub-indices are also updated every minute.

1.2 General principles

In order to achieve the stated index objective SIX Swiss Exchange defines the general principles that govern the index methodology. SIX Swiss Exchange publishes the index objective and rules for all indices.

– **Representative:**
  The development of the market is represented by the index.

– **Tradable:**
  The index components are tradable in terms of company size and market.

– **Replicable:**
  The development of the index can be replicated in practise with a portfolio.

– **Stable:**
  High index continuity.

– **Rules-based:**
  Index changes and calculations are rule-based.

– **Projectable:**
  Changes in rules are with appropriate lead time (usually at least 2 trading days) – no retrospective rule changes.

– **Transparent:**
  Decisions are based on public information.

1.3 Basis

The SMI (Swiss Market Index) is the main blue chip index for the Swiss equity market. It tracks the 20 most liquid and largest components of the SPI. It is equivalent to the SPI Large. The SMI is primarily available as a not dividend adjusted index (price index), however a total return index is published under the name SMIC (SMI Cum Dividend).

The index is published every 5 seconds.

The options contract on this index is one of the products of Eurex with the highest trading volume, the international derivatives exchange, and ranks among the top index options contracts worldwide. The VSMI is calculated on the basis of eight expiry months with a maximum time to expiration of two years.

Volatility represents the key risk factor for the price determination in options trading. The higher the estimated or expected volatility, the higher the price of an option.

1.4 Volatility Sub-Indices

Apart from the main index VSMI (which is irrespective of a specific time to expiration), sub-indices for each time to expiration of the SMI options ranging from one month up to two years are calculated and distributed for both models. For options with longer time to expirations, no such sub-indices are currently available.

The various VSMI sub-indices are calculated on the basis of all options available. The calculations are based on the best bid and best ask available for these options in the Eurex system.

Each main index is determined by way of linear interpolation using the two sub-indices which include to the remaining time to expiration of 30 days for VSMI. The main index is therefore irrespective of a specific time to expiration, i.e. it does not expire. This helps to eliminate effects that typically result in strong volatility fluctuations close to expiration.

1.5 Selection of Input Data

During the calculation hours of the VSMI and the respective sub-indices (8.50am to 5.30pm CET) a snapshot of the following data is taken every minute:

SMI	the SMI Index
OSMI	Best bid and best ask of all SMI-Options
LIBOR	London Interbank Offered Rates - money market reference rates for 1, 2, … 12 months (calculated once a day, 1.00 p.m. CET, by the british bankers association)

Index Name	**Period**
LIBOR 1 day (CHF)	1 day
LIBOR 1 week (CHF)	1 week
LIBOR 1 month (CHF)	1 month
LIBOR 2 months (CHF)	2 months
LIBOR 3 months (CHF)	3 months
LIBOR 6 months (CHF)	6 months
LIBOR 12 months (CHF)	12 months

1.6 Publication

The VSMI and its sub-indices are calculated on every Eurex exchange trading day, in the period from 8:50 a.m. to 5:30 p.m. CET.

The continuous calculation of a sub-index does, however, only commence as soon as all required input data is available.

The dissemination of the main index commences as soon as two sub-indices become available, the maturities of which include the 30-day time to expiration, and thus allow for an interpolation.

In line with the expiration structure of SMI options, each of the VSMI sub-indices is assigned to a specific expiration, which can be directly identified from the respective code. There is a system of 120 codes and ISINs, only eight of each of which are in simultaneous use at any time.

1.7 Historical Data

Index	ISIN	Daily Closing Prices since
VSMI	CH0019900841	02.01.99
VSMI-Subindex 1 (1 M.)	Section 5	02.01.99
VSMI-Subindex 2 (2 M.)	Section 5	02.01.99
VSMI-Subindex 3 (3 M.)	Section 5	02.01.99
VSMI-Subindex 4 (6 M.)	Section 5	02.01.99
VSMI-Subindex 5 (9 M.)	Section 5	02.01.99
VSMI-Subindex 6 (12 M.)	Section 5	18.03.96
VSMI-Subindex 7 (18 M.)	Section 5	18.03.96
VSMI-Subindex 8 (24 M.)	Section 5	18.03.96

m represents the respective expiry month (A = Jan, ... , L = Dec)
j represents the respective year (0, ... ,9)

The continuous calculation of the VSMI is conducted since 18 April 2005. The historical index series of the main index and the first five subindices reach back to 2 January 1999 based on daily settlement prices. SMI Options with longer terms (12, 18 or 24 months) and the corresponding VSMI subindices exist since 18 March 1996.

1.8 Review of index concept

The validity of the index concepts and rules is reviewed on a regular basis. In exceptional cases a broad market consultation can be conducted. The changes to the index rules are publicly announced with appropriate lead time (usually 3 months).

1.9 Termination of the index calculation

A decision to discontinue will be publicly announced by SIX Swiss Exchange with appropriate lead time.

In case of existing financial products linked to the index, of which SIX Swiss Exchange is aware, a market consultation is conducted in advance and a transition period is introduced before the definitive termination.

2 Index Calculation

2.1 Calculation Method

The model for VSMI aims at making pure volatility tradable – i.e. the index should be trackable by a portfolio which does not react to price fluctuations, but only to changes in volatility. This is not directly achieved through volatility, but rather through variance or squared volatility. A portfolio of SMI options with different exercise prices with a given weighting, as described below, meets this requirement. So the implied volatilities of all options of a given time to expiration are considered.

The sub-indices are calculated according to the formula shown below:

(1) $$VSMI_i = 100 \cdot \sqrt{\sigma_i^2}$$

wherby

(2) $$\sigma_i^2 = \frac{2}{T_i} \sum_j \frac{\Delta K_{i,j}}{K_{i,j}^2} \cdot R_i \cdot M(K_{i,j}) - \frac{1}{T_i}\left(\frac{F_i}{K_{i,0}} - 1\right)^2 \quad , i=1,2,..8$$

and

T_i Time to expiration of the **i**th OSMI

F_i Forward price derived from the prices of the **i**th OSMI, for which the absolute difference between call and put prices (**C** and **P**) is smallest.

Therefore:

(3) $$F_i = K_{\min|C-P|} + R_i * (C - P)$$

(**Note:** If a clear minimum does not exist, the average value of the relevant forward prices will be used instead.)

$K_{i,j}$ Exercise price of the **j**th out-of-the-money option of the **i**th OSMI expiry month in ascending order

$\Delta K_{i,j}$ Interval between the relevant exercise prices or half the interval between the one higher and one lower exercise price. On the boundaries, the simple interval between the highest and second highest exercise price (or lowest and second lowest exercise price) is used:

(4) $$\Delta K_{i,j} = \frac{K_{i,j+1} - K_{i,j-1}}{2}$$

$K_{i,0}$ Highest exercise price below forward price F_i

R_i Refinancing factor of the **i**th OSMI

(5) $$R_i = e^{ri*Ti}$$

r_i Risk-free interest rate to expiration of the **i**th OSMI

$M(K_{i,j})$ Price of the option $K_{i,j}$, whereby $K_{i,j} \neq K_{i,0}$

$M(K_{i,0})$ Average of the put and call prices at exercise price $K_{i,0}$

The sub-indices are calculated **up until two days** prior to expiration. Each new sub-index is disseminated for the first time on the second trading day of the relevant SMI options.

The individual steps with regard to data extraction are explained in the following chapters, sometimes with examples, as is the calculation process for the various factors used.

2.2 Extracting Data

During the calculation hours from 8:50 a.m. to 5:30 p.m. CET, the respective best bid and best ask of all SMI options contracts listed on Eurex are extracted from the stream of data generated by the Eurex system. To this end, a snapshot is taken at one minute intervals.

The various interest rates mentioned under 1.5 are recorded simultaneously.

2.3 Filtering of Data

a. Option price data is subject to filtering. All option prices that are one-sided – i.e. with either a bid or an ask price only – are disregarded. Naturally, the same applies to options without any price data.

b. Another filter verifies whether these remaining options are quoted within the established maximum spreads for Eurex market-makers. The maximum spread is derived from bid prices as shown in the table below:

Bid (Index Points)	Maximum Spread
0 – 35.0	3.5
35.0 – 350.0	10%
350.0 –	35

Example:

Bid = 45.32 und Ask = 54.3

Max. Spread: 45.32 * 0.10 = 4.532

=> both prices (bid and ask) are rejected

If Eurex activates Fast Market status, permitting market-makers to increase their quotation spreads under very turbulent trading conditions, maximum spreads are set higher accordingly. This is also taken into account for the calculation of the VSMI, with the applicable filter criteria being adjusted accordingly.

2.4 Preparing Data

a. Determining the prices used

The mid price is calculated for filtered option prices, using the respective best bid and best ask.

The most recent of each of the following pieces of information is used subsequently:Settlement-Preis (Vortag)

– Settlement price (previous day)

– Mid price

– Last traded price

Example:

Underlying	Settlement	Bid (time)	Ask (time)	Mid (time)	Last-traded (time)	Price	Underlying
4050	75.80	76.70	--	--	--		76.70
4100	56.03	53.71	--	--	--	54.01 (09:05)	54.01
4150	38.40	37.51	33.70 (09:04)	34.40 (09:05)	34.05 (09:05)		34.05
4200	21.04	22.54	17.29 (09:03)	19.53 (09:05)	18.41 (09:05)	20.21 (09:01)	18.41
4250	17.65						17.65

b. Cutting the wings

Yet another filter ensures that the various prices used (settlement, mid and last traded price) do not fall short of a minimum value of 0.5 index points. If there are two or more options with different exercise prices and mid prices exactly equal the minimum value of 0.5 just the one nearest to the at-the-money point is taken into consideration. With this, options that are far out-of-the money and that do not have much influence on the result of the calculation are filtered out and do not need to be considered.

c. Determining the time to expiration T_i

(6) $T_i = T_{Settlement\text{-}Calculation} / T_{Jahr}$

$T_{Settlement\text{-}Calculation}$ Seconds between index calculation and settlement

T_{Year} Seconds per annum

Beispiel:

Index calculation: 07.07.2010 um 12:00:00 midnight CET

Expiration(i=1): 20.08.2010 um 08:30:00 noon CET

T1 = 3.715.200 / (365 *60*60*24) = 0.1201484018

d. Determining risk-free interest rates

Linear interpolation is used to determine interest rates, the terms of which match the time to expiration of the OSMI.

(7) $$r_i \equiv r(T_i) = \frac{T_{k+1} - T_i}{T_{k+1} - T_k} r(T_k) + \frac{T_i - T_k}{T_{k+1} - T_k} r(T_{k+1}); \qquad T_k \le T_i < T_{k+1}$$

e. The refinancing factor Ri is determined according to equation (5)

2.5 Calculation Example

2.5.1 Determining the Forward Price F_i and the Excercise Price $K_{i,0}$

The forward price of the i^{th} expiry month is derived from OSMI prices, for which the difference (in absolute terms) between call and put prices is smallest. Accordingly, the forward price F_1 of the 1^{st} expiry month and the exercise price $K_{i,0}$, which is the closest exercise price below the forward price F_i, are subject to the following:

$$F_i = K_{i,0} + R_i * (\text{Call}_i - \text{Put}_i)$$

Example:

R_1 = 1.0000931282
$K_{1,0}$ = 6000
F_1 = 6001.0500977846

Where there are several pairs of calls and puts with identical differences, a forward price will be calculated for each of the corresponding exercise prices. $K_{i,0}$ is accordingly defined as the closest exercise price below the simple average of these forward prices.

2.5.2 Determining the Option Price $M(K_{i,j})$

The price $M(K_{i,j})$, which is used for the j^{th} out-of-the-money option of the i^{th} expiry month, is determined as follows:

$$M(K_{i,j}) = \begin{cases} \text{Put} & : K_{i,j} < K_{i,0} \\ \frac{\text{Put} + \text{Call}}{2} & : K_{i,j} = K_{i,0} \\ \text{Call} & : K_{i,j} > K_{i,0} \end{cases}$$

2.5.3 Determining the Sub-Indices

$$\text{VSMI}_i = 100 \cdot \sqrt{\sigma_i^2}$$

$$\sigma_i^2 = \frac{2}{T_i} \sum_j \frac{\Delta K_{i,j}}{K_{i,j}^2} * R_i * M(K_{i,j}) - \frac{1}{T_i} \left(\frac{F_i}{K_{i,0}} - 1 \right)^2$$

Under-lying $K_{i,j}$	$\Delta K_{i,j}$	Call	Put	|Call – Put|	$M(K_{i,j})$	$\frac{\Delta K_{i,j}}{K_{i,j}^2} R_i M(K_{i,j})$
4550	50	1510.5	3.2	1507.3	3.2	0.0000077293
4600	50	1461.4	4.1	1457.3	4.1	0.0000096890
4650	50	1411.9	4.7	1407.2	4.7	0.0000108693
4700	50	1362.5	5.3	1357.2	5.3	0.0000119975
4750	50	1313.2	5.9	1307.3	5.9	0.0000130760
4800	50	1263.9	6.7	1257.2	6.7	0.0000145413
4850	50	1214.8	7.5	1207.3	7.5	0.0000159437
4900	50	1165.8	8.5	1157.3	8.5	0.0000177026
4950	50	1061.5	9.6	1051.9	9.6	0.0000195917
5000	50	1013	12	1001	12	0.0000240022

Under-lying $K_{i,j}$	$\Delta K_{i,j}$	Call	Put	|Call – Put|	$M(K_{i,j})$	$\frac{\Delta K_{i,j}}{K_{i,j}^2} R_i M(K_{i,j})$
5050	50	964.6	12.2	952.4	12.2	0.0000239215
5100	50	916.4	13.8	902.6	13.8	0.0000265307
5150	50	868.5	15.6	852.9	15.6	0.0000294117
5200	50	822.3	17.6	804.7	17.6	0.0000325474
5250	50	775.05	23.85	751.2	23.85	0.0000432693
5300	50	728.2	26.95	701.25	26.95	0.0000479753
5350	50	681.85	30.55	651.3	30.55	0.0000533721
5400	50	636	34.7	601.3	34.7	0.0000595049
5450	50	590.8	39.45	551.35	39.45	0.0000664147
5500	50	546.25	45	501.25	45	0.0000743871
5550	50	502.6	51.2	451.4	51.2	0.0000831179
5600	50	458.5	58.3	400.2	58.3	0.0000929615
5650	50	416.6	66.55	350.05	66.55	0.0001042465
5700	50	376.1	75.75	300.35	75.75	0.0001165852
5750	50	336.8	86.15	250.65	86.15	0.0001302957
5800	50	299.05	98.35	200.7	98.35	0.0001461938
5850	50	262.95	112.3	150.65	112.3	0.0001640886
5900	50	228.85	128.25	100.6	128.25	0.0001842315
5950	50	196.9	146.55	50.35	146.55	0.0002069962
6000	50	168	166.95	1.05	167.47	0.0002326258
6050	50	140.3	189.5	49.2	140.3	0.0001916714
6100	50	115.95	215.6	99.65	115.95	0.0001558194
6150	50	94.3	243.6	149.3	94.3	0.0001246729
6200	50	75.1	274.25	199.15	75.1	0.0000976938
6250	50	59	308.15	249.15	59	0.0000755270
6300	50	45.6	344.9	299.3	45.6	0.0000574506
6350	50	34.6	383.95	349.35	34.6	0.0000429081
6400	50	25.7	425.15	399.45	25.7	0.0000313750
6450	50	18.95	468.35	449.4	18.95	0.0000227772
6500	50	13.75	513.1	499.35	13.75	0.0000162737
6550	50	9.95	559.25	549.3	9.95	0.0000115971
6600	50	7.15	605.9	598.75	7.15	0.0000082078
6650	50	5.05	653.85	648.8	5.05	0.0000057103

Under-lying $K_{i,j}$	$\Delta K_{i,j}$	Call	Put	|Call – Put|	$M(K_{i,j})$	$\frac{\Delta K_{i,j}}{K_{i,j}^2} R_i M(K_{i,j})$
6700	50	3.8	702.35	698.55	3.8	0.0000042330
6750	50	3	751.25	748.25	3	0.0000032925
6800	175	2.35	800.45	798.1	2.35	0.0000088946
7100	175	0.9	1100.2	1099.3	0.9	0.0000031247
7150	50	0.8	1150.2	1149.4	0.8	0.0000007825
7200	50	0.7	1200.1	1199.4	0.7	0.0000006752
7250	50	0.7	1250.1	1249.4	0.7	0.0000006659
7300	50	0.6	1300.1	1299.5	0.6	0.0000005630
7350	50	0.6	1350	1349.4	0.6	0.0000005554
7400	50	0.5	1400	1399.5	0.5	0.0000004566
					Σ	**0.002928748**

$$\sigma_i^2 = 0.04875217 - 0.00000026 = 0.048751913$$

$$\mathrm{VSMI}_1 = 100 \cdot \sqrt{0.048751913} = 22.07983532$$

2.6 Constructing the Volatility Index

Apart from the sub-indices for the various individual time to expiration, the VSMI is determined as the main index with a constant remaining time to expiration of 30 days (this index is not linked to a specific time to expiration). The VSMI is determined by linear interpolation of the sub-indices which are nearest to a remaining time to expiration of 30 days. If there are no such surrounding sub-indices, the VSMI is calculated using extrapolation. In this case, the two nearest available indices are used, which are as close to the time to expiration of 30 calendar days as possible.

$$\mathrm{VSMI} = 100 \cdot \sqrt{\left[T_i \cdot \sigma_i^2 \cdot \left[\frac{N_{T_{i+1}} - N_T}{N_{T_{i+1}} - N_{T_i}} \right] + T_{i+1} \cdot \sigma_{i+1}^2 \cdot \left[\frac{N_T - N_{T_i}}{N_{T_{i+1}} - N_{T_i}} \right] \right] * \frac{N_{365}}{N_T}}$$

$$= \sqrt{\left[T_i \cdot \mathrm{VSMI}_i^{\,2} \cdot \left[\frac{N_{T_{i+1}} - N_T}{N_{T_{i+1}} - N_{T_i}} \right] + T_{i+1} \cdot \mathrm{VSMI}_{i+1}^{\,2} \cdot \left[\frac{N_T - N_{T_i}}{N_{T_{i+1}} - N_{T_i}} \right] \right] * \frac{N_{365}}{N_T}}$$

N_{Ti} Time to expiration of the i^{th} OSMI

N_{Ti+1} Time to expiration of the $i+1^{th}$ OSMI

N_T Time for next x days

N_{365} Time for a standard year

2.7 Information on index events

Any relevant forthcoming extraordinary corporate events that result in an adjustment to the indices are published by e-mail via Investor Service.

The registration form is available on the SIX Swiss Exchange Website. SIX Swiss Exchange accepts no liability for Investor Service Equity.

2.8 Trade suspensions and market distorsions

Should a data source (for example a price source) not be available as result of challenging economic conditions or other market distortions the last available data will normally be used.

In extreme cases a deviation from the rules defined in this rulebook can occur, for example, shifting the schedule of a regular index review.

All changes will be publicly announced at least two trading days in advance.

2.9 Index corrections

Index corrections distinguish between calculation errors and incorrect input data.

Calculation errors detected within a trading day are corrected immediately. Intraday tick data are not corrected retrospectively.

Calculation errors that are older or based on erroneous input data are corrected if technically possible and economically viable. If significant differences exist, index values can also be corrected retrospectively.

Interested parties may subscribe to an e-mail notifications service on the website. SIX Swiss Exchange distributes notifications over this channel on

- Changes in corporate actions and dividends
- Updates to the periodic index reviews
- Problems and error in the index calculation
- The launch of new indices
- General information on SMI indices

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4 Contact

Information concerning the indices of SIX Swiss Exchange (index adjustments, announcements etc.) is available at the following Internet address:

http://www.six-swiss-exchange.com/indices_en.html

Any requests with respect to the indices may be directed to the following address:

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5 Static Data

A current list of all indices calculated by SIX Swiss Exchange is accessible at the SIX Swiss Exchange Website:

https://www.six-swiss-exchange.com/.../calculated_indices.xls

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