# Swiss Index

## Methodology Rulebook Governing Volatility Index VSMI

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SMI
INDICES®

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# 1 Index Structure

## 1.1 Concept

Price volatility is a measure of the level of uncertainty prevailing in markets, or with respect to individual underlying instruments. In principle, there are two different approaches to estimate 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'). Implied volatility therefore measures the estimates and assumptions of market participants towards the future, on the basis of a given option price.

The VSMI® does measure implied volatility across the options of a given time to expiration. This model offers advantages in terms of trading, hedging and introducing derivative products on this index. The VSMI as the main index has a fixed remaining time to expiration of 30 days. The VSMI® and its various sub-indices are calculated every five seconds.

## 1.2 General Principles

In order to achieve the stated index objective SIX defines the general principles that govern the index methodology. SIX 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 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 Swiss Market Index (SMI) is the main blue chip index of the Swiss equity market. It tracks the 20 most liquid and largest components of the Swiss Performance Index (SPI). The Price Return version of the index is used as the underlying of the option contracts which are traded at Eurex.

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

SIX calculates indices of variable time to expiration and fixed time to expiration. The variable indices consider all options which expire at a defined point in the future. They are ranging from one month up to two years. The fixed indices calculate a time weighted average of two variable indices in order to keep a constant time to expiration. For example the VSMI is the constant 30 day average of the sub-indices expiring within the next one month and the next two months.

## 1.5 Input Data and Publication

All prices for instruments to calculate the index values are unfiltered and received from EUREX trading platform. The indices are calculated from 9:02 to 17:20 CET on SIX Swiss Exchange trading days. For OSMI options prices bid quotes, ask quotes and traded prices are used in the calculation of the index. The latest available SARON fixing is used as the risk free rate.

The VSMI indices are published as calculated. In case a calculation is not possible the latest available index value stays valid. Historically the continuous calculation of the VSMI is conducted since 18 April 2005. A historical backcast of the main index and the first five sub-indices are available back to 2 January 1999 based on daily settlement prices. SMI Options with the terms 12, 18 and 24 months and the corresponding VSMI sub-indices are available since 18 March 1996.

## 1.6 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. Changes to index rules are publicly announced with appropriate lead time (usually 3 months).

## 1.7 Termination of the Index Calculation

A decision to discontinue the calculation of an index will be publicly announced by SIX with appropriate lead time.

If SIX is aware of existing financial products linked to the index, 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 VSMI model 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)** $$VSMI_i = 100\sqrt{\sigma_i^2}$$

**whereby**

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

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

(**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)** $$R_i = e^{r_i * T_i}$$

| | |
|---|---|
| $r_i$ | 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 Priority of prices used in the calculation

### 2.2.1 Trade Prices

During calculation hours every five seconds a snapshot is taken from the option price stream. The latest traded price per option within that snapshot is used in the calculation of the index.

### 2.2.2 Mid Prices

If there is no traded price in the snapshot, the following two step filter procedure is applied in order to determine a mid price:

1. Only options that have a bid and an ask quote are considered for a mid price calculation
2. Only Options within the maximum spreads for Eurex market-makers are considered for the mid price calculation. The maximum spread is derived from bid prices as shown in the table below:

| Bid (Index Points) | Maximum Spread | Maximum "Fast Market" Spread[1)] |
|---|---|---|
| 0.1 – 35.0 | 3.5 | 14 |
| 35.0 – 350.0 | 10% | 40% |
| 350.0 – | 35 | 140 |

**Example:**

Bid = 45.32 and Ask = 54.3

Max. Spread: 45.32 * 0.10 = 4.532

=> Both prices (bid and ask) are rejected

### 2.2.3 Settlement Price of the previous day

If no trade was executed and no Mid Price could be calculated, the latest of trade or mid price is used in the calculation. If there was no such price within the calculation day, the previous day's settlement price is used.

### 2.2.4 Cutting the wings

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.

### 2.2.5 Determining the time to expiration $T_i$

**(6)** $$T_i = {}^{T_{Settlement-Calculation}}/_{T_{Year}}$$

| | |
|---|---|
| $T_{Settlement-Calculation}$ | Seconds between index calculation and settlement |
| $T_{Year}$ | Seconds per annum |

**Example:**

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

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

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

[1] 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 consideration for the calculation of the VSMI by adjusting the filter criteria to the maximum Fast Market spread.

### 2.2.6 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)** $$r_i \equiv r(T_i) = \frac{T_{k+1} - T_i}{T_{k+1} - T_k} * r(T_k) + \frac{T_i - T_k}{T_{k+1} - T_k} * r(T_{k+1});\ \ T_k \leq T_i < T_{k+1}$$

The refinancing factor $\mathbf{R_i}$ is determined according to equation (5)

## 2.3 Calculation Example

### 2.3.1 Determining the Forward Price $F_i$ and the Exercise 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:

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

**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.

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

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

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

### 2.3.3 Determining the Sub-Indices

$$VSMI_i = 100\sqrt{\sigma_i^2}$$

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

| Underlying $K_{i,j}$ | $\Delta K_{i,j}$ | 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 |

| Underlying $K_{i,j}$ | $\Delta K_{i,j}$ | Call | Put | \|Call – Put\| | $M(K_{i,j})$ | $\frac{\Delta K_{i,j}}{K_{i,j}^2} R_i M(K_{i,j})$ |
|---|---|---|---|---|---|---|
| 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 |
| 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 |

| Underlying $K_{i,j}$ | $\Delta K_{i,j}$ | Call | Put | \|Call – Put\| | $M(K_{i,j})$ | $\frac{\Delta K_{i,j}}{K_{i,j}^2} R_i M(K_{i,j})$ |
|---|---|---|---|---|---|---|
| 6600 | 50 | 7.15 | 605.9 | 598.75 | 7.15 | 0.0000082078 |
| 6650 | 50 | 5.05 | 653.85 | 648.8 | 5.05 | 0.0000057103 |
| 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 |
| | | | | | $\Sigma$ | **0.002928748** |

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

$$VSMI_1 = 100\sqrt{0.048751913} = 22.07983532$$

## 2.4 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.

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

$$= \sqrt{\left(T_i\cdot VSMI_i^2\left(\frac{N_{T_{i+1}} - N_T}{N_{T_{i+1}} - N_{T_i}}\right) + T_{i+1}\cdot VSMI_{i+1}^2\left(\frac{N_T - N_{T_i}}{N_{T_{i+1}} - N_{T_i}}\right)\right) * \frac{N_{365}}{N_T}}$$

| | |
|---|---|
| $N_{Ti}$ | 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 |

## 2.5 Information on Index Adjustments

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

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

# 3 Correction Policy

An index-related correction is made if necessary data is or has not been available or it has been wrong.

## 3.1 Unavailable Data

If data to determine the price or weight of an index component is not available to SIX due to trade suspensions or market distortions, the latest available data is used. These changes may be related to review schedules, ordinary reviews and component and weighting changes outside of ordinary index reviews and are publicly announced with a notification period of at least 2 trading days.

## 3.2 Wrong Data

Data errors caused by calculation errors or by incorrect inbound data.

Calculation errors which are detected within a trading day are immediately corrected. Intraday tick data is not corrected retrospectively. Calculation errors that are older than a trading day and incorrect inbound data are only corrected if technically possible and economically viable. If the correction leads to a significant difference in the index levels, those can be corrected retrospectively.

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