GUIDE GOVERNING VOLATILITY INDEX VSMI®

CONTENTS

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.

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 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.

1.1.2
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.

1.1.3
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	Code	ISIN
LIBOR 1 day (CHF)	1 day	EU1D	EU000A0C3UG0
LIBOR 1 month (CHF)	1 month	EU1M	EU001A0C3UH8
LIBOR 2 months (CHF)	2 months	EU2M	EU002A0C3UJ4
LIBOR 3 months (CHF)	3 months	EU3M	EU003A0C3UK2
LIBOR 4 months (CHF)	4 months	EU4M	EU004A0C3UL0
LIBOR 5 months (CHF)	5 months	EU5M	EU005A0C3UM8
LIBOR 6 months (CHF)	6 months	EU6M	EU006A0AEZV7
LIBOR 7 months (CHF)	7 months	EU7M	EU007A0C3UN6
LIBOR 8 months (CHF)	8 months	EU8M	EU008A0C3UP1
LIBOR 9 months (CHF)	9 months	EU9M	EU009A0C3UQ9
LIBOR 10 months (CHF)	10 months	EU10	EU010A0C3UR7
LIBOR 11 months (CHF)	11 months	EU11	EU011A0C3US5
LIBOR 12 months (CHF)	12 months	EU12	EU012A0C3UT3
2 year SWAP Rate (CHF)	2 years	n/a	XC000A0C3UV8

1.2
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.

1.3
Historical Data

Index	ISIN	Tägliche Schlusskurse seit
VSMI	CH0019900841	02.01.99
VSMI-Sub-index 1 (1 M.)	Section 5	02.01.99
VSMI-Sub-index 2 (2 M.)	Section 5	02.01.99
VSMI-Sub-index 3 (3 M.)	Section 5	02.01.99
VSMI-Sub-index 4 (6 M.)	Section 5	02.01.99
VSMI-Sub-index 5 (9 M.)	Section 5	02.01.99
VSMI-Sub-index 6 (12 M.)	Section 5	18.03.96
VSMI-Sub-index 7 (18 M.)	Section 5	18.03.96
VSMI-Sub-index 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).

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:

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

whereby:

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

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 1.1.3 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 price (previous day)
- Mid price
- Last traded price

Example:

Underlying	Settlement	Bid (time)	Ask (time)	Mid (time)	Last-traded (time)	Price	Under-lying
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_{Jahr} = Seconds per annum

Example:

Index calculation: 07.07.2010 at 12:00 a.m. CET
Expiration (i = 1): 20.08.2010 at 8:30 a.m. CET
T_1 = 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) $$r_i \equiv r(T_i) = \frac{T_{k+1} - T_i}{T_{k+1} - T_k} r(T_k) + \frac{T_i - T_k}{T_{k+1} - T_k} r(T_{k+1}),$$
$$T_k \leq T_i < T_{k+1}$$

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:

$$F_i = K_{i,0} + R_i * (Call_i - Put_i)$$

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:

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

2.5.3
Determining the Sub-Indices

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

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

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
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

Underlying $K_{i,j}$	$\Delta K_{i,j}$	Call	Put	|Call – Put|	$M(K_{i,j})$	$\frac{\Delta K_{i,j}}{K_{i,j}^2} R_i M(K_{i,j})$
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
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
					$\sum$	0.002928748

$$\sigma_i^2 = 0.04875217 - 0.00000026 = 0.0487519\text{B}$$

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

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.

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

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

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

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3.2
Licensing

3.2.1
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4. CONTACT

Information concerning SIX Swiss Exchange indices (index adjustments, announcements etc.) is available at the following Internet address:
www.six-swiss-exchange.com/indices_en.html

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