「Nikkei Stock Average Volatility Index」

Index Guidebook

November 8, 2010

Nikkei Inc.

- With the commencement of the calculation and publication of the Nikkei Stock Average Volatility Index in November 2010, Nikkei Inc (Nikkei) drew up this index guidebook of the Nikkei Stock Average Volatility Index. It would be changed or modified corresponding to the revision of the index calculation rule etc in the future.
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1 : Concept

Prices traded on option markets are usually determined, among others, by the volatility of its underlying asset. From this price formation, in the calculation of the Nikkei Stock Average Volatility index, the volatility expected by investors is inferred from the option prices (premiums) in the markets.

A method widely used to estimate the fair variance rate in trading a variance swap etc on the OTC market is used in the index calculation.

2 : Formula

The Nikkei Stock Average Volatility Index is calculated in accordance with the following procedure.

①Calculate the volatility $\sigma_{1,t}$ based on the near-term (the first-term) option at a time of t, and the volatility $\sigma_{2,t}$ based on the next-term (the second-term) option at a time of t.

$$\sigma_{i,t} = \sqrt{\frac{1}{(T_i - t)/365}\left(1 + \frac{L_{i,t}(T_i - t)}{360}\right)\sum_{j=0}^{n_i}\left(\frac{V(K_{i,j,t}, T_i, t)}{K_{i,j,t}^2} + \frac{V(K_{i,j+1,t}, T_i, t)}{K_{i,j+1,t}^2}\right)\Delta K_{i,j,t}}$$

$K_{i,j,t}$: jth lowest Strike price (i.e. ascending order) of i th-term option at a time of t(*1)

$V(K_{i,1,t}, T_i, t) \sim V(K_{i,p-1,t}, T_i, t)$: Closing price of put option with the expiration date of T_i at a time of t (*2)

$V(K_{i,p,t}, T_i, t) \sim V(K_{i,n_i,t}, T_i, t)$: Closing price of call option with the expiration date of T_i at a time of t (*2)

(However $V(K_{i,0,t}, T_i, t)$=0, $V(K_{i,n_i+1,t}, T_i, t)$=0)

$\Delta K_{i,j,t} = K_{i,j+1,t} - K_{i,j,t}$ (However $\Delta K_{i,0,t} = \Delta K_{i,1,t}$, $\Delta K_{i,n_i,t} = \Delta K_{i,n_i-1,t}$)

p : minimum j satisfying $F < K_{i,j}$: F means prices of the near-term future

$L_{i,t}$: Euroyen LIBOR (360 days basis) on the previous business day

(1-month rate for the near-term and 2-month rate for the next-term)(*3)

*1 : In case of option contract which was not traded, the option with the strike price is ignored.

*2 : In the calculation, out-of-the-money (OTM) traded options (which have some volume) on the day are used. If there is no such option contract (i.e. not any OTM options traded on the day) or if there is just one traded OTM option on the day, use settlement prices of all of OTM options to calculate σ . The procedure of the above *1 is ignored in such case (using settlement prices). The OTM options are defined as put options where the strike prices are equal to or less than the near-term future prices and call options where the strike prices are greater than the future prices.

*3 : In case that the previous day for the calculation was not a business day in the London market or that the Euroyen LIBOR was not published for any reason, use the LIBOR rate previously available on the nearest day. Even if the previous day for the calculation was not a business day in Japanese markets and was a business day in the London market, the LIBOR rate on the day is used.

②Obtain the index value by linear interpolation or linear extrapolation of $\sigma_{1,t}$ and $\sigma_{2,t}$ to make the time to expiration one month (30 days),

$$\text{Index value} = \sqrt{\frac{1}{30}\left(\frac{\{30-(T_1-t)\}(T_2-t)}{T_2-T_1}\sigma_{2,t}{}^2 + \frac{\{(T_2-t)-30\}(T_1-t)}{T_2-T_1}\sigma_{1,t}{}^2\right)} \times 100$$

- Index value is expressed as the figures rounded to two decimal places.
- Unit of the index value is "points".
- Use closing prices or settlement prices of the Nikkei 225 futures and Nikkei 225 options on the Osaka Securities Exchange (OSE) as the future and option prices respectively. The prices published by the OSE on the morning session (including the evening session on the previous business day) and the afternoon session are used for the calculation.
- Cover the near-term (the first-term) option and the next-term (the second-term) option. The options to calculate the index are rolled to the next delivery month on three business days before the last trading date of the near-term.
- Cover the near-term (the first-term) future, and the future is rolled to the next-term future on three business days before the last trading date of the near-term.

3 : Calculation and publication of the index

（1）Calculation and publication of the index value

As a general rule, the index is calculated and published as the value on the end of day basis by 8pm on every business date (on the days when the OSE opens).

（2）Modification of the index value

If any event which affects the index value occurs (e.g. correction of the option or futures prices published by the OSE), as a general rule, retroactive calculation for the modification will not be conducted.

4 : Calculation example(in case of November 1, 2010)

①Conditions for the calculation is described below:

Closing price of the near-term Nikkei 225 future (expiration month: December 2010)=9160

Euroyen LIBOR 1-month rate=0.12625%, 2-month rate=0.15438%

②Decide options used for the calculation for the near-term; expiration month: Nov 2010 (see grayed cells)

Call Option		Put Option	
Strike Price	Closing Price	Strike Price	Closing Price
5000	4240	5000	—

5500	—	5500	—
6000	—	6000	—
6500	—	6500	—
6750	—	6750	—
7000	—	7000	1
7250	—	7250	—
7500	1740	7500	1
7750	—	7750	1
8000	—	8000	2
8250	—	8250	4
8500	—	8500	11
8750	430	8750	30
9000	235	9000	85
9250	100	9250	200
9500	30	9500	380
9750	9	9750	610
10000	3	10000	860
10250	1	10250	1050
10500	1	10500	—
10750	1	10750	—
11000	1	11000	—
11250	—	11250	—
11500	—	11500	—
11750	—	11750	—
12000	—	12000	2760
12500	—	12500	—
13000	—	13000	3760
13500	—	13500	—
14000	—	14000	—

Note) Use the out-of-the-money options

Note) — indicates there was no traded option price at the Strike price

③Calculation of the variance of the underlying asset price derived from the prices of the selected near-term options (11 business days to expiration date)

Strike Price	Number(j)	ΔK	Closing Price	α
-	0	500	-	0.00001020
7000	1	500	1	0.00001909
7500	2	250	1	0.00000861

7750	3	250	1	0.00001197
8000	4	250	2	0.00002250
8250	5	250	4	0.00005275
8500	6	250	11	0.00013602
8750	7	250	30	0.00036030
9000	8	250	85	0.00055453
9250	9	250	100	0.00037529
9500	10	250	30	0.00010677
9750	11	250	9	0.00003117
10000	12	250	3	0.00000988
10250	13	250	1	0.00000465
10500	14	250	1	0.00000443
10750	15	250	1	0.00000423
11000	16	250	1	0.00000207

Summation of α ($\Sigma\alpha$)=0.00171447

Note) α indicates the value used with the Σ (i.e. summation) in 2 Formula-①

$$\sigma_1^{\,2} = \frac{1}{11/365} \times \left(1 + \frac{0.12625\% \times 11}{360}\right) \times \sum \alpha = 33.18309822 \times 0.00171447 = 0.05689155$$

④Decide options used for the calculation for the next-term; expiration month: December 2010 (see grayed cells)

Call Option		Put Option	
Strike Price	Closing Price	Strike Price	Closing Price
3000	—	3000	—
3500	—	3500	—
4000	—	4000	—
4500	—	4500	—
5000	—	5000	1
5500	—	5500	—
6000	—	6000	1
6500	—	6500	1
7000	—	7000	3
7250	1990	7250	5
7500	1740	7500	10
7750	—	7750	15
8000	—	8000	25
8250	1020	8250	40

8500	—	8500	70
8750	515	8750	115
9000	355	9000	190
9250	210	9250	300
9500	115	9500	465
9750	55	9750	655
10000	25	10000	840
10250	14	10250	—
10500	7	10500	—
10750	4	10750	—
11000	2	11000	—
11250	1	11250	1990
11500	1	11500	—
11750	—	11750	2510
12000	—	12000	2760
12500	—	12500	—
13000	—	13000	—
13500	—	13500	—
14000	—	14000	—
14500	—	14500	—
15000	—	15000	—
15500	—	15500	—
16000	—	16000	—

Note) Use the out-of-the-money options

Note) — indicates there was no traded option price at the Strike price

⑤Calculation of the variance of the underlying asset price derived from the prices of the selected next-term options (39 business days to expiration date)

Strike Price	Number(j)	ΔK	Closing Price	α
–	0	1000	–	0.00004000
5000	1	1000	1	0.00006778
6000	2	500	1	0.00002572
6500	3	500	1	0.00004245
7000	4	250	3	0.00003909
7250	5	250	5	0.00006823
7500	6	250	10	0.00010688
7750	7	250	15	0.00016009
8000	8	250	25	0.00024458

8250	9	250	40	0. 00038914
8500	10	250	70	0. 00061772
8750	11	250	115	0. 00096193
9000	12	250	190	0. 00120001
9250	13	250	210	0. 00093215
9500	14	250	115	0. 00046320
9750	15	250	55	0. 00020714
10000	16	250	25	0. 00009581
10250	17	250	14	0. 00004919
10500	18	250	7	0. 00002453
10750	19	250	4	0. 00001279
11000	20	250	2	0. 00000611
11250	21	250	1	0. 00000387
11500	22	250	1	0. 00000189

Summation of α ($\Sigma\ \alpha$)=0. 00576028

Note) α indicates the value used with the Σ (i.e. summation) in 2 Formula-①

$$\sigma_2{}^2 = \frac{1}{39/365} \times \left(1 + \frac{0.15438\% \times 39}{360}\right) \times \sum \alpha = 9.36053960 \times 0.00576028 = 0.05391928$$

⑥Obtain the index value by linear interpolation of $\sigma_{1,t}$ and $\sigma_{2,t}$ to make the time to expiration 30 days

$$\sqrt{\frac{1}{30}\left(\frac{(30-11)\times 39}{39-11} \times 0.05391928 + \frac{(39-30)\times 11}{39-11} \times 0.05689155\right) \times 100} = \underline{23.30} \text{... Index Value}$$

5 : Others

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In developing the Nikkei Stock Average Volatility Index, Nikkei has gained the cooperation of Quantitative Research Center of Nomura Securities CO., LTD. The disclaimers in the above ② are also applied to Quantitative Research Center of Nomura Securities.

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