Nikkei Stock Average Volatility Index Real-time Version Index Guidebook
(to be effective from January 27, 2025)

Nikkei Inc.

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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: Index Calculation

(1)Basic Points

・The index value is expressed as the figures rounded to two decimal places. Unit of the index value is "points".
・Use the prices of the Nikkei 225 futures and Nikkei 225 options (excepting mini options) on the Osaka Exchange (OSE), which the OSE publishes as the future and option prices respectively.
・The index is calculated every 15 seconds during the day session of the Nikkei 225 options on the OSE (excluding the pre-closing) from Monday through Friday except Japanese national holiday. The index starts to be calculated from 15 seconds after the end of the opening auction usually 15 seconds past 9 A.M., and it is also calculated at the end of the closing auction.
・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 one business day before the last trading date of the near-term option. Also cover the near-term (the first-term) future (excepting mini futures and micro futures), and the future is rolled to the next-term future on one business day before the last trading date of the near-term future.

(2)Selection of the prices

The prices of the futures and options used for the calculation are selected in the following order of the priority.

①Latest traded price in for the past 15 seconds (however, at the end of the closing auction, a traded price obtained when the orders are matched by so called "Itayose" method)
②Middle price of best bid and best ask at the time of the calculation (every 15 seconds) while the orders are matched by the so called "Zaraba" method (however, at the end of the closing auction, the middle price of best bid and best ask after the orders are matched by the "Itayose" method (*1)
③Last traded price of today's session at the time before the past 15 seconds (including the night session on the previous business day)

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*1: Best bid and best ask prices to compute a middle price are invalid in cases that 1)best bid price is lower than or equal to 10yen and the difference between the best bid and best ask is greater than or equal to 4yen, 2)best bid price is greater than 10yen and best ask is greater than best bid by 30% or more, 3) best ask is lower than or equal to best bid.

(3)Formula

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

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

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

T_i : the expiration date of i th-term option (9:00:00am on SQ date) (*2)

Y_{365} : the number of seconds in a year on 365 day-basis (31,536,000 seconds)

$L_{i,t}$: Tokyo Term Risk Free Rate 1 month (TORF) on the previous business day (*3)

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

$V(K_{i,1,t}, T_i, t) ... V(K_{i,p_t-1,t}, T_i, t)$: Closing price of put option with the expiration date of T_i at a time of t

$V(K_{i,p_t,t}, T_i, t) ... V(K_{i,n_i,t}, T_i, t)$: Closing price of call option with the expiration date of T_i at a time of t

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

$$V(K_{i,q_t,t}, T_i, t) = \frac{Put(K_{i,q_t,t}, T_i, t) + Call(K_{i,q_t,t}, T_i, t)}{2} - \frac{|F_t - K_{i,q_t,t}|}{2(1 + L_{i,t}(T_i - t)/Y_{365})} (*4))$$

F_t : the price of the near-term future at a time of t

p_t : minimum j satisfying $F_t < K_{i,j,t}$

q_t : j minimizing the absolute difference between F_t and $K_{i,j,t}$ at a time of t (*5)

$n_{i,t}$: the number of strike prices of i th-term options using for the calculation at a time of t (*6,*7)

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

*2: the term to the expiration date is measured on the second time scale.

*3: In case that the TORF was not published for any reason, use the TORF rate previously available on the nearest day.

*4: For the option price whose strike price is nearest from the future price at a time of t, use the adjusted value calculated from the put option price and call option price at the strike price. In addition, $Put(K_{i,q_t,t}, T_i, t)$ and $Call(K_{i,q_t,t}, T_i, t)$ are put option price and call option price at strike price of $K_{i,q_t,t}$ and the expiration date of T_i at a time of t.

*5: If $F_t < K_{i,q_t,t}$, then $q_t = p_t$ and if $F_t \geq K_{i,q_t,t}$, then $q_t = p_t$-1

*6: Use out-of-the-money (OTM) traded options (which have some volume) where the future price at the time of the calculation is defined as at-the-money (ATM). However, the options whose prices are invalid at the time of the

calculation are treated as if these strike prices are not set (including cases by the Trading Suspension and the Immediately Executable Price Range Rule).

*7 : In case that at the 17th or more strike prices from the ATM, the option prices at five consecutive strike prices (hereinafter called "Target Strike Prices") are invalid or are less than or equal 1 yen, the prices of put options at lower strike prices than Target Strike Prices and the prices of call options at higher strike prices than Target Strike Prices are not used for the calculation even if these options are traded with some volume. Please note that the option prices at Target Strike Prices are used for the calculation even if the prices are less than or equal 1 yen.

② Obtain the index value by linear interpolation of $\sigma_{1,t}$ and $\sigma_{2,t}$ to make the time to expiration 30 days (*8,*9,*10)

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

M : the number of seconds in 30 days (2,592,000 seconds)

*8: If the term to expiration date is longer than 30 days, the index is calculated by liner extrapolation.

*9: As a result of the liner extrapolation, in case that the index value becomes imaginary number (meaning that the result for the square root becomes negative), the index value is calculated at a time of t by using $\sigma_{1,t-1}$ and $\sigma_{2,t-1}$ used for the calculation at a time of t -1 (just before the calculation of this time), instead of $\sigma_{1,t}$ and $\sigma_{2,t}$ (however, at the first calculation of the day, use closing price on the previous day)

*10: In the calculation of i th-term option at a time of t , 1)in case that the number of the strike prices whose option prices are valid is 0 or 1, or 2)in case that the price of near-term future is invalid, $\sigma_{i,t}$ at a time of t is not calculated, and the index value at a time of t is calculated by using $\sigma_{i,t-1}$ which is used just before the calculation of this time, instead of using $\sigma_{i,t}$ (however excluding in case of "3:Miscellaneous (3)In case the Circuit Breaker Rule is applied linked to Nikkei 225 Futures").

3: Miscellaneous

(1)Previous and Retroactively Calculation in the past

From the commencement date of the calculation (November 19, 2010) to January 27, 2012, the index was calculated on the end-of-day basis. And the index was calculated retroactively dating back from June 12, 1989 to November 18, 2010 by the same end-of-day basis method.

Also from the commencement date of the calculation to December 10, 2021, the index was calculated by using Euroyen LIBOR.

(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.

(3) In case the Circuit Breaker Rule is applied linked to Nikkei 225 Futures

In case that all trades of the Nikkei 225 futures and Nikkei 225 options are halted by the Circuit Breaker Rule linked to Nikkei 225 futures, Nikkei shall halt the updating of the Nikkei Stock Average Volatility Index. The complete trading suspensions of the OSE caused by its system failure etc., is treated as the same above.

4: Others

(1)Licensing

Nikkei Stock Average Volatility Index is an intellectual property that belongs to Nikkei. All of the rights to the indices such as right to calculate, publicize, disseminate, and use these indices are reserved by Nikkei.
Licensing agreement with Nikkei is necessary if companies intend to create Index - linked funds and passive funds etc. It is also required to use this index for disseminating, providing, showing and etc. to the third party in the way as Nikkei decides.

(2)Risk

Nikkei calculates and publishes the Nikkei Stock Average Volatility Index in accordance with the methods described in this document.   In the event of circumstance not described in this document, or if Nikkei determines it is impossible to use the methods described in this document, Nikkei may use an alternative method of the index calculation as it deems valid.
In case of a breakdown of computer system, natural disasters or any other unavoidable situations, Nikkei may postpone or cancel the calculation of the indices. Nikkei, under any circumstance, does not guarantee the accuracy of these indices. Should any error in the calculation of the index take place, Nikkei shall not be liable for any damages sustained by any person or organization.
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(3)Corporation for the development of the index

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.

(4)Contact

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Appendix : Change history of Index Guidebook

January 30, 2012 version	Initial version
February 9, 2012 version	(deleted)
March 5, 2012 version	in "4: Calculation Example (in case of the closing (3:15:00pm) on November 1, 2011)" - modified the α values at the strike prices of 8500 and 8750 in the table of "(4) Calculation of the variance of the underlying asset price derived from the prices of the selected near-term options (expiration month: Nov 2011)" - modified the number of decimal places of the Adjusted Value and a part of formula in the "(6) Calculate the adjusted value from option prices at the strike price nearest from the future price for the next-term; expiration month: Dec 2011" - modified the number of decimal places of the "Prices" at the strike price of 8750 in the table of "(7) Calculation of the variance of the underlying asset price derived from the prices of the selected next-term options (expiration month: Dec 2011)"
September 30, 2013 version	In "2:Index Calculation (3)Formula note(*7)" - modified the number of consecutive strike prices from 3 to 6.
March 24, 2014 version	In "2:Index Calculation (1)Basic Points - modified the exchange name to "Osaka Exchange" due to the trade name change.
December 13, 2021 version	In "2:Index Calculation (1)Basic Points" - Add the treatment for weekly options and on-demand strike prices In "2:Index Calculation (3)Formula" - Change the interest rate from LIBOR to TORF In "3:Miscellaneous (1)Previous and Retroactively Calculation in the past" - Add the change in interest rate Delete "4:Calculation Example"
May 29, 2023 version	In "2:Index Calculation (1)Basic Points"

	- Amend the description due to change in timing to roll to the next delivery month etc. In "2:Index Calculation (3)Formula Note *7" - Amend the description due to the change of definition of the target strike prices in the calculation
January 27, 2025 version (tentative)	In "2:Index Calculation (3)Formula Note *7" - Amend the range of target strike prices that defines the boundary for non-adoption prices in the index calculation.