Nasdaq OMX OMS II

Margin methodology guide for Equity and Index derivatives

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Document History

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1.6	2025-01-07	Karl Klasén	Annual review

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1 Model Purpose and Scope

The purpose of this document is to describe how the NASDAQ OMX's OMS II margin methodology is applied for standardized equity and index derivatives and to give examples of how margin calculations are performed.

The first part of the document describes the basic margin principles and the second part presents examples on margin calculations. The margin examples will be performed on both single positions and on hedged positions.

1.1 Purpose and objectives

In case of a clearing participant's default, it is the defaulting participant's margin requirement together with the financial resources of the CCP that ensures that all contracts registered for clearing will be honoured. This makes collecting margins from clearing participants a fundamental part of a CCP.

NASDAQ Clearing requires margins from all clearing participants and the margin requirement is calculated with the same risk parameters regardless of the clearing participant's credit rating. The margin requirement shall cover the market risk of the positions in the clearing participant's account. NASDAQ Clearing applies a 99.2% confidence level and assumes a liquidation period of two to five days (depending on the instrument) when determining the risk parameter.

1.2 Scope

This document aims to describe the OMS II methodology, which is used by NASDAQ Clearing to calculate margin requirements for equity and index derivatives.

2 OMS II MARGIN METHODOLOGY

2.1 Summary

The NASDAQ Clearing OMS II margin methodology is a scenario based risk model that aims to produce a cost of closeout, given a worst case scenario. For OMS II, the scenarios are defined by the model's input. The model inputs, such as individual valuation intervals and volatility shifts, are calculated with a minimum confidence level. OMS II is validated by back testing individual risk parameters and portfolio output. The confidence risk intervals are applied on each product using one year of historical price data.

To enable a trustworthy clearing service, reasonably conservative margins are required to avoid the risk of the clearing organization incurring a loss in a default. In theory, the margin requirement should equal the market value at the time of the default. However, under normal conditions an account cannot be closed at the instant a participant defaults at the prevailing market prices. It typically takes time to neutralize the account and the value of the portfolio can change during this period, which must be catered for in the margining calculation.

2.2 Definitions

In the following subsections, several concepts and parameters used in the OMS II methodology will be explained, in order to facilitate the understanding of the margin calculations in subsequent chapter.

2.2.1 Parameters

This section covers the configurable parameters utilized in the margin calculations for equity and index forwards, futures and options. Current up-to-date parameters are found in Appendix 13 of Nasdaq Clearing's rules and regulations (select APPENDICES – CLEARING RULES and scroll to the appendix 13 – Parameter Value List download link).

Parameter	Description
Risk parameter	Risk interval parameter. Determines how much the underlying price is stressed up and down from the unaltered price. The parameter is a percentage of the underlying price.
Risk free interest rate (%)	Risk-free interest rate used when evaluating options. The simple interest rate is translated into a continuous rate.
Dividend yield (%)	Dividend yield used when evaluating options. To properly evaluate American options on futures, the dividend yield is set equal to the risk free interest rate.

Adjustment for erosion of time value	The number by which the number of days to maturity will be reduced when evaluating held options.
Adjustment of futures (%)	Adjustment factor (spread parameter) for futures.
Highest volatility for bought options	Applies only to bought options.
Lowest volatility for sold options	Applies only to sold options.
Volatility shift parameter	Fixed parameter that determines the size of the volatility interval.
Volatility spread	Defines the spread for options. The spread parameter is a fixed value.
Highest value held in relation to written options (%)	Min. spread between the values for bought and sold options. If spread is too small the value of the bought option is decreased to this parameter value times the value of the written option.
Minimum value sold option	For a sold option with a theoretical value less than the minimum value, NASDAQ clearing uses the minimum value as the option's value in margin calculations.
Adjustment for negative time value	If the theoretical option value is lower than the intrinsic value, the price is adjusted to equal the latter.
Underlying price	The price of the underlying (stock or index etc.) in the used valuation point.
Strike price	The strike price of an option.
Volatility	The volatility used in margin calculations for options and which is stressed up and down by the volatility shift parameter.
Time to expiration of the option	Calculated as number of actual days / risk parameter. Days Per Year For Interest Rate Calculations.
Dividends	Known or expected dividends of the underlying affects the value of the option. This can be modeled as a continuous dividend yield or with discrete dividends (time and amounts).

Table 1: Description of pricing parameters.

2.2.2 Liquidation Period

It can take time to neutralize a position and as a result a lead time exists from the moment collateral has been provided until the clearing organization is able to close the participant's portfolio. The length of the lead time depends on the time it takes to discover that the participant has not provided enough collateral and the time required to neutralize the portfolio.

2.2.3 Volatility

When calculating implied volatility for exchange traded options, there are two opposing forces to consider: flexibility and stability. Using the individually implied volatility for each series theoretically allows the clearing organization to cover smile effects in volatility. However, the problem with obtaining accurate pricing for less liquid instruments makes this method unstable in such cases.

To be able to have stability in the volatilities for the most liquid instruments, NASDAQ Clearing has chosen to outsource the computation of the volatilities for those instruments to Markit. For other liquid instruments, an arithmetic average is calculated for the three closest at-the-money series for each underlying instrument and expiration. This is done separately for call options and put options. The mean value is then used as market volatility for all options with the same option type, expiration and underlying. For the most illiquid instruments NASDAQ Clearing applies a fixed volatility. The two latter methods do not consider smile effects, but have proven to be very stable.

A table showing the distinct methods of obtaining volatilities for margin calculation purposes can be found in Margin Price Handling.

2.2.4 Volatility Shifts

The price of an option can be strongly affected by changes in volatility. The risk of fluctuations in volatility is taken into account by calculating the value of the account, based not only on the current volatility, but also on a higher and a lower volatility. The amount by which the volatility is increased or decreased is determined and configured by NASDAQ Clearing. The neutralizing cost is calculated at each of the valuation points for three different volatility levels. Hence, for options a valuation interval consists of 3*31 valuation points.

2.2.5 Valuation Interval

OMS II varies the price for the underlying security for each series to calculate the neutralization cost. In this way, OMS II creates a valuation interval for each underlying security. The size of the valuation interval is given by the risk parameters for the instrument in question.

2.2.6 Valuation Points

The upper and lower limits of the valuation interval represent the extreme movements allowed for the underlying security. However, the worst-case scenario for a portfolio with different options and forwards/futures based on the same underlying instrument can occur anywhere in the valuation interval.

In order to reflect this, the valuation interval is divided into 31 valuation points. In each valuation point the underlying price is different; either stressed up/down or unaltered. Furthermore, for each of the 31 different price scenarios, options are valued with three different volatilities; the current volatility, one lower and one higher than the current.

The neutralization cost for each series with the same underlying security is calculated in each of these valuation points. The margin requirement is then based on the valuation point which resulted in the highest neutralization cost, i.e. the worst-case scenario.

2.2.7 Vector File/ Risk Matrix

By adding position data to a risk matrix, we obtain the neutralization cost in each valuation point for that position. The risk matrix is a vector file, in which each cell is a valuation point. In one dimension the underlying price is altered up and down and in the other dimension the volatility is altered up and down. If the instrument is not affected by volatility, i.e. futures and forwards, the values for the different volatilities will be the same. Different vector files are created for bought and sold positions. Below figure demonstrates a vector file.

Underlying price scenario	Low volatility	Unaltered volatility	High volatility
1 (upper limit) 2 … 16 (unaltered) … 30 31 (lower limit)	…	…	…

Table 2: Demonstration of a vector file

2.2.8 Fine Tuning

In order to obtain more appropriate margin requirements the following fine tuning features are used by OMS II. These features are illustrated in the following subsections.

2.2.8.1 Adjustment for Erosion of Time

In the case of bought options, the clearing house will have to sell the position in a default situation. This means that the clearing house will probably have to sell an option with a shorter time to delivery because of the lead time. This motivates that the time to expiration used when valuating bought positions is reduced by the number of lead days. Currently the adjusted time to expiration used for held options is determined by:

$$\max\left(T - \frac{ER}{250}; 0\right)$$

where T is the time to expiration and ER is the number of days by which the time to expiration is decreased with. Currently $ER = 1$.

2.2.8.2 Min/max volatility

In order not to value bought options too high, the volatility used for bought options has a maximum value and is currently set to 100%. The value is defined in the risk parameter Highest Volatility for bought Options. A similar approach is used for sold positions where the volatility is not allowed to go below a minimum value currently set to 10%.

2.2.8.3 Minimum value sold options

For a sold option with a theoretical value less than the minimum value, NASDAQ Clearing uses the minimum value as the option's value in margin calculations. Currently the minimum value for sold options is set to 0.01 SEK, or corresponding value in other currencies.

2.2.8.4 Highest value held in relation to written option

The spread between bought and sold options is not allowed to become too narrow. This is prevented by comparing vector file values for bought and sold options in the same valuation point and adjusting the value of the bought option if needed. Currently the parameter is set to 95% for a bought option in relation to a sold option. Thus if the price of a held option is 98% of a written option, the value of the held option would be decreased to 95% of the price of the written option.

2.2.8.5 Rounding

As a last step, the vector file values are multiplied by the contract size and then rounded to two decimal places. In the following, equations like"$[\ldots]_2$" means rounding to two decimals.

2.2.9 Margin Offset

In case price dependencies are observed, NASDAQ Clearing can provide offsets in margins between instruments within the same instrument group as well as offsets between instruments from different instrument groups. Margin offset is only provided in case correlation between products has been high historically and proven stable.

In the OMS II model the margin offsets are calculated by portfolio. Offsets are provided when the shift (stress) of the underlying prices of the products demonstrate a stable dependency. For options, the deviation in the shift of the implied volatilities is also assessed to decide the offset level.

Currently OMS II only apply offset for contracts with the same underlying instrument, which is a special case of the “Window Method” where the window size is 0%. The window method is described in Appendix A.6.

2.2.10 Margin Types

In this section, different types of margin will be explained.

2.2.10.1 Margin Requirement

The Margin Requirement is the collateral that an account holder has to deposit to cover the credit risk of his counterparty, taking into account any netting effects allowed in the margin model. It is the expected cost of closing out the account holder's positions in a worst case scenario. The Margin Requirement is calculated using vector files.

$$Margin\ Requirement = Required\ Initial\ Margin + Market\ Value + Payment\ Margin + Delivery\ Margin$$

2.2.10.2 Naked Margin

The Margin Requirement when the position is held in isolation. Hence, no netting effects are taken into account.

2.2.10.3 Initial Margin

The Initial Margin of a position reflects the market risk of the position during a close-out period in a worst case scenario.

2.2.10.4 Required Initial Margin

The Required Initial Margin of an instrument series is the Initial Margin, taking into account netting effects allowed in the margin model.

2.2.10.5 Naked Initial Margin

The Initial Margin when the position is held in isolation. Hence, no netting effects are taken into account.

2.2.10.6 Variation Margin

The Variation Margin is the mark-to-market value (unrealized profit/loss) of the portfolio's deferred settlement futures. The profit/loss of the future contracts is settled every day. For deferred settlement futures the profit/loss is calculated during the trading period and settled during the contract's delivery period.

2.2.10.7 Payment Margin

Payment Margin is only required for cash settled instruments in cases where the settlement occurs two or more business days after the expiration. The payment margin in those cases should cover the risk of a participant failing to fulfill the settlement payment and equals the amount to be cash settled.

2.2.10.8 Delivery Margin

Delivery Margin should cover the risk of a participant failing to deliver the contracted instruments. Delivery Margin is applied to instruments with physical delivery and consists of the position's profit and loss plus the market risk of the position between expiration and the final settlement.

3 Margin Calculations

In the subsequent sections margin calculations for futures, forwards and options are illustrated. Below table states the definitions of the various variables used in the margin calculations.

Variable	Definition
MA	Total Margin requirement
IM	Required Initial margin
VM	Variation margin
PnL	Profits and losses
PM	Payment margin
DM	Delivery margin
P_t	Spot price of underlying stock/Index value on day t
F_t	Fixing price (Margin settlement price) of future/forward on day t
CP	Contract price
Q	Number of contracts
T	Time to expiration day, from the day of entering the contract, expressed in years (days/365)
VOL	Volatility used for options
Instrument data	
CS	Contract size. The number of instruments that defines one contract for an instrument
K	Strike price of the option
DIV_I	Discrete dividend number that is included in the valuation of the option. Offset days for dividends If the value equals 0, this is dividends with ex-date in the time range (current date + 1 : expiration date). If the value equals 1, this is dividends with ex-date in the time range (current date + 1 : expiration date + 1)
Risk parameters	
Par	Risk interval parameter. Determines how much the underlying price is stressed up and down from the unaltered price.
$V_{u/d}$	Volatility shift parameter i.e. the maximum increase/ decrease in volatility
AD	Adjustment factor (spread)
r	Risk free interest rate (the simple rate is converted to continuous)
q	Dividend yield
ER	Adjustment for erosion of time value
HV	Highest value held option in relation to written option
ε	Minimum value sold option

Table 3: Definitions of variables used in margin calculations.

3.1 Futures Contracts

In this section, formulas for calculating margins for futures contracts will be presented, as well as an example.

3.1.1 Total Margin Requirement

The total margin requirement of futures contracts is the sum of two components:

- The variation margin of the position
- The initial margin of the position

$$MA = VM + IM \quad (1)$$

3.1.1.1 Variation Margin

The variation margin for futures positions is settled every day and is calculated as follows.

Bought position:

$$VM = Q \cdot CS \cdot [F_t - F_{t-1}]_2 \quad (2)$$

Sold position:

$$VM = Q \cdot CS \cdot [F_{t-1} - F_t]_2 \quad (3)$$

3.1.1.2 Initial Margin

The initial margins of a futures position is obtained by stressing the spot price with the risk parameter and the adjustment factor, then rounding the result and multiply with the contract size and quantity.

Bought/sold position:

$$IM = -Q \cdot CS \cdot [P_t \cdot (Par + AD)]_2 \quad (4)$$

3.1.2 Example 1: - Index Futures

Consider a position of 50 bought OMXS30 futures contract, expiring in April 2022. The closing futures price on day t, which is an arbitrary day prior to the expiration day, is 2051.42. All relevant parameters of the position, as well as margin calculation of the position, are found below.

F_t	2051.42
F_{t-1}	2052
P_t	2053.60
Par	6.0%
AD	0.5%
Q	50
CS	100

Table 4: Index Futures Example - Parameters.

3.1.2.1 Margin Requirement

On the following day, day t+1, the variation margin is to be settled. Using (2) :

$$VM = Q \cdot CS \cdot [F_t - F_{t-1}]_2$$
$$= 50 \cdot 100 \cdot [2051.42 - 2052]_2$$
$$= -2\,900$$

Furthermore, the initial margin of the position has to be covered. Using equation (4):

$$IM = -Q \cdot CS \cdot [P_t \cdot (Par + AD)]_2$$
$$= -50 \cdot 100 \cdot [2053.6 \cdot (0.06 + 0.005)]_2$$
$$= -667\,400$$

The worst case value of this position is found at the bottom of the vector file, i.e. the scenario where the price of the futures contract decreases maximally.

3.2 Forward Contracts

In this section, formulas for calculating margins for forwards contracts will be presented, as well as an example.

3.2.1 Total Margin Requirement

The total margin requirement of forward contracts is the sum of two components:

- The profits and losses of the position
- The initial margin of the position

$$MA = PnL + IM \quad (5)$$

The total margin requirement for bought and sold positions respectively is calculated in the following manner.

Bought position:

$$MA = Q \cdot CS \cdot ([F_t \cdot (1 - AD) - P_t \cdot Par]_2 - CP) \quad (6)$$

Sold position:

$$MA = Q \cdot CS \cdot (CP - [F_t \cdot (1 + AD) + P_t \cdot Par]_2) \quad (7)$$

3.2.1.1 Profit and Losses

The part of the total margin requirement which consists of the profits and losses of the position is calculated as follows.

Bought position:

$$PnL = Q \cdot CS \cdot [F_t - CP]_2 \quad (8)$$

Sold position:

$$PnL = Q \cdot CS \cdot [CP - F_t]_2 \quad (9)$$

3.2.1.2 Initial Margin

The initial margin of the position can now be extracted from equation (5):

$$\begin{gathered} MA = PnL + IM \;\; \Rightarrow \\ IM = MA - PnL \end{gathered} \quad (10)$$

3.2.2 Delivery Margin

The delivery margin for a forwards position consist of the same two components as the margin requirement before expiration day does. Hence, the delivery margin can be expressed in the following manner:

$$DM = PnL + IM \quad (11)$$

The delivery margin for bought and sold positions respectively is calculated as shown below.

Bought position:

$$DM = Q \cdot CS \cdot ([P_t \cdot (1 - AD) - P_t \cdot Par]_2 - CP) \quad (12)$$

Sold position:

$$DM = Q \cdot CS \cdot (CP - [P_t \cdot (1 + AD) + P_t \cdot Par_2]) \quad (13)$$

3.2.2.1 Profit and Losses

The part of the delivery margin which consists of the profits and losses of the position is calculated as follows.

Bought position:

$$PnL = Q \cdot CS \cdot [P_t - CP]_2 \quad (14)$$

Sold position:

$$PnL = Q \cdot CS \cdot [CP - P_t]_2 \quad (15)$$

3.2.2.2 Initial Margin

The initial margin part of the delivery margin is the market risk of the position between expiration and the final settlement. The initial margin component can be extracted from equation (11):

$$\begin{gathered} DM = PnL + IM \;\; \Rightarrow \\ IM = DM - PnL \end{gathered} \quad (16)$$

3.2.3 Example 2 – Single Stock Forwards

Consider a position of 100 bought Hennes & Mauritz (HMB) forward contracts. The underlying spot price on day t, an arbitrary day which is prior to the expiration day, is 122.30. Furthermore, the underlying spot price on the expiration day is 123.20. All relevant parameters of the position are listed below. In this example the margin requirement will be calculated both on day t and on expiration day, T.

F_t	121.83
P_t	122.30
P_T	123.20
CP	123
Par	8%
AD	2%
Q	100
CS	100

Table 5: Single Stock Forwards Example - Parameters

3.2.3.1 Margin Requirement on day *t*

The total margin requirement on day t is calculated using equation (6):

$$\begin{aligned} MA &= Q \cdot CS \cdot ([F_t \cdot (1 - AD) - P_t \cdot Par]_2 - CP) \\ &= 100 \cdot 100 \\ &\quad \cdot ([121.83 \cdot (1 - 0.02) - 122.30 \\ &\quad \cdot 0.08]_2 \;\; - 123) \\ &= -133\,900 \end{aligned}$$

The worst case value of this position is found at the bottom of the vector file, i.e. the price of the forward decreases.

The profit and loss of the position can be calculated through equation (14)

$$\begin{aligned} PnL &= Q \cdot CS \cdot [F_t - CP]_2 \\ &= 100 \cdot 100 \cdot [121.83 - 123]_2 \\ &= -11\,700 \end{aligned}$$

Now, the initial margin is easily obtained through equation (10):

$$\begin{aligned} IM &= MA - PnL \\ &= -133\,900 - (-11\,700) \\ &= -122\,200 \end{aligned}$$

3.2.3.2 Delivery Margin on Expiration Day

At expiration day T, the delivery margin is calculated using equation (12):

$$\begin{aligned} DM &= Q \cdot CS \cdot ([P_T \cdot (1 - AD) - P_T \cdot Par]_2 - CP) \\ &= 100 \cdot 100 \cdot ([123.20 \cdot (1 - 0.02) - 123.20 \cdot 0.08]_2 - \\ &\quad 123) \\ &= -121\,200 \end{aligned}$$

The worst case value of this position is found at the bottom of the vector file, i.e. the underlying price of the stock decreases.

The profit and loss of the position can be calculated through equation (14):

$$\begin{aligned} PnL &= Q \cdot CS \cdot [P_T - CP]_2 \\ &= 100 \cdot 100 \cdot [123.20 - 123]_2 \\ &= 2\,000 \end{aligned}$$

Now, the initial margin is easily obtained through equation (16)

$$\begin{aligned} IM &= DM - PnL \\ &= -121\,200 - 2000 \\ &= -123\,200 \end{aligned}$$

3.3 Options

The option price as a function of the underlying price is non-linear. Genium Risk assumes that two major factors affect option prices:

- Underlying price
- Implied volatility

As described in the section "Vector file/Risk matrix", the neutralization cost of the option position is calculated in each of the valuation points. This is done using a suitable valuation method. NASDAQ Clearing uses a number of valuation methods to calculate margins for different types of options. The option types and the respective valuation methods are stated in Table 16 in Appendix A. The worst possible outcome of the neutralization cost is then used as margin requirement for the position.

To simplify the calculations for a naked option position, it is enough to know which scenario in the vector file that will result in the highest neutralization cost. For a naked option position, we know that the largest and smallest option value will be at the end points of the interval. E.g. a bought (sold) call option will have the smallest value when underlying stock price and volatility are as low (high) as possible. However, for a portfolio consisting of different contracts with the same underlying, the margin calculation cannot be simplified in this way. Example 6 will illustrate how margin for a portfolio is calculated.

3.3.1 Equity Options

This section covers margin calculations for equity options.

3.3.1.1 Total Margin Requirement

Equity options are defined as premium paid options with American style expiry. As for forwards, margins for equity options consist of profits and losses and the initial margin. Thus, equation (5) holds for equity options as well:

$$MA = PnL + IM$$

The total margin requirement of equity options can be expressed like:

$$MA = Q \cdot CS \cdot \left[min\left\{ \left(P_t + (16 - i) \cdot \frac{P_t \cdot Par}{15}, VOL + (j - 2) \cdot Vu/_d, K, r, T, ER, DIV, HV, \varepsilon \right)_\psi \right\} \right]_2, \quad (17)$$

where $i = 1,2, \ldots ,31$ and $j = 1,2,3$.

The expressions inside the brackets $(\ldots, K, r, T, \ldots)_\psi$ are evaluated with an option valuation formula like Black and Scholes or the binomial method. The option valuation formulas used for the different option types are listed in Table 16, which is found in Appendix A. To further illustrate this, a few examples are given below:

- Inserting $i = 1$ yields the scenario where the underlying spot price is stressed to its maximum level, $P_t \cdot (1 + Par)$.
- Inserting $i = 16$ yields the scenario where the underlying spot price is unaltered.
- Inserting $j = 2$ yields the scenario where the volatility is unaltered.
- Inserting $j = 3$ yields the scenario where the volatility is stressed up with the volatility shift parameter.

After all the 3*31 valuation points have been evaluated with the applicable valuation formula, the minimum value of these is determined in order to obtain the neutralization cost in the worst-case scenario, i.e. the margin requirement.

3.3.1.2 Profit and Losses

The profits and losses of equity option positions are evaluated with the applicable valuation formula, without stressing the underlying spot price or the option volatility. This is done to get the current value of the position and not the worst-case value as in the margin requirement calculations.

Also, no adjustments for erosion of time value or “highest value held options in relation to written option” are made for bought options when calculating the profits and losses. For sold options on the other hand, the minimum value for sold options is still used in the calculation of PnL, as in the margin calculations.

Bought position:

$$PnL = Q \cdot CS \cdot \left[(P_t, VOL, K, r, T, DIV)_\psi \right]_2 \quad (18)$$

Sold position:

$$PnL = Q \cdot CS \cdot \left[(P_t, VOL, K, r, T, DIV, \varepsilon)_\psi \right]_2 \quad (19)$$

3.3.1.3 Initial Margin

The initial margin is obtained in the following way:

$$MA = PnL + IM \Rightarrow$$
$$IM = MA - PnL$$

3.3.1.4 Delivery Margin

If deliverable options are to be exercised, Delivery Margin is required. The delivery margin for equity options is calculated in the same manner as for a short dated forward, where the contract price equals the strike price of the option. Thus, the delivery margin at exercise is calculated in the following manner:

Bought call option or sold put option:

$$DM = Q \cdot CS \cdot [P_t \cdot (1 - Par - AD) - K]_2 \tag{20}$$

Sold call option or bought put option:

$$DM = Q \cdot CS \cdot [K - P_t \cdot (1 + Par + AD)]_2 \tag{21}$$

3.3.1.5 Profit and Losses

During the time period that delivery margin is required for equity options, the profits and losses are calculated in the following manner.

Bought call option or sold put option:

$$PnL = Q \cdot CS \cdot [P_t - K]_2 \tag{22}$$

Sold call option or bought put option:

$$PnL = Q \cdot CS \cdot [K - P_t]_2 \tag{23}$$

3.3.1.6 Initial Margin

The initial margin is obtained in the following way:

$$\begin{aligned} DM &= PnL + IM \;\; \Rightarrow \\ IM &= DM - PnL \end{aligned}$$

3.3.2 Example 3 – Equity Call Option

Consider a position of 10 sold equity call options. The underlying spot price on day t, an arbitrary day which is prior to the expiration day, is 237.20. Furthermore, the underlying spot price on the expiration day is 225. All relevant parameters of the position are listed below. In this example the margin requirement will be calculated both on day t and on expiration day, T.

K	220
P_t	237.20
P_T	225
DIV	none
r	0,5%
Par	8%
$V_{u/d}$	10%
CS	100
Q	10
T	30/365 years
VOL	20%
ε	0.01 SEK

Table 6: Equity Call Option Example - Parameters

3.3.2.1 Margin Requirement on day *t*

The margin requirement on day t is calculated in each scenario point, using equation (17). Each of the scenario points of the position are presented by the below vector file:

Underlying price Scenario	Vol Down	Vol Mid	Vol Up
1	-36 270	-36 280	-36 580
2	-35 000	-35 020	-35 360
3	-33 740	-33 760	-34 150
4	-32 470	-32 510	-32 940
5	-31 210	-31 250	-31 740
6	-29 940	-30 000	-30 550
7	-28 680	-28 750	-29 370
8	-27 410	-27 510	-28 200
9	-26 150	-26 270	-27 040
10	-24 880	-25 040	-25 900
11	-23 620	-23 820	-24 760
12	-22 350	-22 600	-23 640
13	-21 090	-21 390	-22 540
14	-19 820	-20 200	-21 450
15	-18 560	-19 020	-20 390
16	-17 300	-17 860	-19 340
17	-16 040	-16 720	-18 310
18	-14 790	-15 600	-17 300
19	-13 540	-14 500	-16 310
20	-12 300	-13 430	-15 350
21	-11 080	-12 390	-14 420
22	-9 890	-11 380	-13 510
23	-8 720	-10 410	-12 630
24	-7 590	-9 480	-11 780
25	-6 520	-8 580	-10 960
26	-5 510	-7 740	-10 170
27	-4 570	-6 930	-9 410
28	-3 720	-6 180	-8 680
29	-2 960	-5 470	-7 990
30	-2 310	-4 820	-7 330
31	-1 750	-4 210	-6 700

Table 7: Vector file for margin requirement.

The worst case scenario for a sold call option position is to stress the price up and the volatility up. Hence the margin requirement for this position on day t is $MA = -36\,580$.

Furthermore, equation (19) tells us that the profits and losses of the position is the unstressed valuation point in the vector file above. Thus the underlying price scenario 16, in combination with the mid volatility results in $PnL = -17\,860$.

3.3.2.2 Delivery Margin on Expiration Day

At expiration day T, the delivery margin is calculated using equation (21):

$$\begin{aligned} DM &= Q \cdot CS \cdot [K - P_T \cdot (1 + Par + AD)]_2 \\ &= 10 \cdot 100 \cdot [220.00 - 225.00 \cdot (1 + 0.08 + 0.02)]_2 \\ &= -27\,500 \end{aligned}$$

The profit and loss of the position on day T can be calculated through equation (23):

$$\begin{aligned} PnL &= Q \cdot CS \cdot [K - P_T]_2 \\ &= 10 \cdot 100 \cdot [220 - 225]_2 \\ &= -5\,000 \end{aligned}$$

3.3.3 Example 4 – Equity Put Option

Consider a sold equity put option position with 30 days to expiry, where the position has the below specified parameters.

K	230.00
P_t	237.20
DIV	None
r	0.5%
Par	8%
$V_{u/d}$	10%
CS	100
Q	1
T	30/365 years
VOL	17.79%
ε	0.01 SEK

Table 8: Equity Put Option Example – Parameters

3.3.3.1 Margin Requirement

The margin requirement is calculated in each scenario point, using equation (17). The vector file is created:

Underlying price Scenario	Vol Down	Vol Mid	Vol Up
1	-1	-7	-78
2	-1	-10	-90
3	-1	-12	-102

4	-1	-15	-113
5	-1	-21	-125
6	-1	-26	-145
7	-1	-32	-167
8	-1	-40	-188
9	-1	-52	-210
10	-1	-64	-231
11	-1	-76	-255
12	-2	-96	-290
13	-3	-117	-325
14	-6	-139	-360
15	-11	-164	-395
16	-19	-199	-430
17	-31	-235	-477
18	-51	-271	-529
19	-77	-319	-581
20	-113	-371	-633
21	-163	-423	-685
22	-221	-482	-742
23	-292	-553	-812
24	-378	-623	-883
25	-472	-694	-953
26	-575	-782	-1 023
27	-688	-870	-1 095
28	-805	-958	-1 183
29	-927	-1 056	-1 270
30	-1 051	-1 158	-1 358
31	-1 178	-1 261	**-1 445**

Table 9: Margin Requirements steps.

The worst-case value for a sold put option is to stress the price down and the volatility up. Thus, we will find the margin requirement in the bottom right corner of the vector file and the margin requirement for this position is $MA = -1\ 445$.

3.3.4 Example 5 – Equity Option at Expiry (Delivery Margin)

Consider a position with 50 sold equity put options with expiration today. The relevant parameters of the position, as well as calculation of the delivery margin, are presented below.

K	36
P_T	18
DIV	None

r	0.5%
Par	25%
AD	2%
$V_{u/d}$	10%
CM	100
T	0 years
CS	100
Q	50
VOL	17.79%
ε	0.01 SEK

Table 10: Equity Option at Expiry Example – Parameters.

3.3.4.1 Delivery Margin

The delivery margin on the expiration day is given by equation (20):

$$\begin{aligned} DM &= Q \cdot CS \cdot [P_t \cdot (1 - Par - AD) - K]_2 \\ &= 50 \cdot 100 \cdot [(18 \cdot (1 - 0.25 - 0.02) - 36]_2 \\ &= -114\,300 \end{aligned}$$

3.3.5 Index Options

This section covers margin calculations for index options.

3.3.5.1 Total Margin Requirement

Standardized index options are European future style options where the margin requirement is calculated similarly to premium paid options.

The total margin requirement of equity options can be expressed like:

$$MA = Q \cdot CS \cdot \left[min\left\{ \left(F_t + (16 - i) \cdot \frac{P_t \cdot Par}{15}, VOL + (j-2) \cdot Vu_{/d}, K, r, T, ER, DIV, HV, \varepsilon \right)_{\psi} \right\} \right]_2 \quad (24)$$

where $i = 1,2, \ldots, 31$ and $j = 1,2,3$.

The expressions inside the brackets $(\ldots, K, r, T, \ldots)_{\psi}$ are evaluated with an option valuation formula like Black and Scholes or the binomial method. The option valuation formulas used for the different option types are listed in Table 16, which is found in Appendix A. To further illustrate this, a few examples are given below:

Inserting $i = 1$ yields the scenario where the futures price is stressed to its maximum level, $F_t + P_t \cdot PAR$.

Inserting $i = 31$ yields the scenario where the futures price is stressed to its minimum level, $F_t - P_t \cdot PAR$.

Inserting $j = 2$ yields the scenario where the volatility is unaltered.

Inserting $j = 3$ yields the scenario where the volatility is stressed up with the volatility shift parameter.

After all the 3*31 valuation points have been evaluated with the applicable valuation formula, the minimum value of these is determined in order to obtain the neutralization cost in the worst-case scenario, i.e. the margin requirement.

3.3.5.2 Profit and Losses

The profits and losses of index option positions are evaluated with the applicable valuation formula, without stressing the futures price or the option volatility. This is done to get the current value of the position and not the worst-case value as in the margin requirement calculations.

Also, no adjustments for erosion of time value or "highest value held options in relation to written option" are made for bought options when calculating the profits and losses. For sold options on the other hand, the minimum value for sold options is still used in the calculation of PnL, as in the margin calculations.

Bought position:

$$PnL = Q \cdot CS \cdot \left[(F_t, VOL, K, r, T, DIV)_\psi \right]_2 \tag{25}$$

Sold position:

$$PnL = Q \cdot CS \cdot \left[(F_t, VOL, K, r, T, DIV, \varepsilon)_\psi \right]_2 \tag{26}$$

3.3.5.3 Initial Margin

The initial margin is obtained in the following way:

$$MA = PnL + IM \quad \Rightarrow$$
$$IM = MA - PnL$$

3.3.6 Example 6 – Index Option Portfolio

Consider a portfolio consisting of 15 bought OMXS30 call options with strike 1640 and 20 sold OMXS30 call options with strike 1660. Both the put option and the call option expire in March 2016. Assume that today there is 249 days left to expiration.

To calculate the margin requirement of this portfolio the window method is used. The window size in this example is 0%, since both options have the same underlying index. The window size of 0% corresponds to 100% correlation.

Bought OMXS30 call option		**Sold OMXS30 call option**	
K	1640	*K*	1660
P_t	1614.42	P_t	1614.42
F_t	1611.03	F_t	1611.03
DIV	None	*DIV*	None
r	0.5%	*r*	0.5%
Par	7%	*Par*	7%
AD	0.5%	*AD*	0.5%

$V_{u/d}$	10%	$V_{u/d}$	10%
CS	100	*CS*	100
Q	15	*Q*	20
T	249/365 years	*T*	249/365 years
VOL	16.61%	*VOL*	16.32%
ER	1 day	ε	0.01 SEK
HV	0.95%		

Table 11: Index Option Portfolio Example – Parameters.

3.3.6.1 Margin Requirement

First, the individual margin requirements of the two option positions are calculated:

		15 bought OMXS30 call options			20 sold OMXS30 call options		
Point	F_t	**Vol= 6.61%**	**Vol=16.61%**	**Vol=26.61%**	**Vol= 6.32%**	**Vol=16.32%**	**Vol=26.32%**
1	1724.04	132 075	198 870	274 065	-151 740	-252 140	**-360 120**
2	1716.51	123 345	191 790	267 330	-140 300	-242 660	-351 000
3	1708.97	114 840	184 830	260 700	-129 280	-233 400	-342 000
4	1701.44	106 590	178 005	254 130	-118 680	-224 300	-333 120
5	1693.90	98 610	171 315	247 665	-108 540	-215 420	-324 340
6	1686.37	90 930	164 745	241 260	-98 860	-206 700	-315 700
...	...	...	...	...	...	...	...
16	1611.03	32 355	106 740	182 100	-29 940	-130 660	-236 020
...	...	...	...	...	...	...	...
27	1528.16	5 655	59 535	127 470	-3 980	-70 460	-163 220
28	1520.62	4 650	56 100	123 060	-3 180	-66 180	-157 380
29	1513.09	3 780	52 800	118 755	-2 500	-62 060	-151 680
30	1505.55	3 060	49 635	114 525	-1 960	-58 140	-146 100
31	1498.02	**2 460**	46 605	110 400	-1 520	-54 380	-140 660

Table 12: Calculated Margin Requirements.

As seen in the vector files above, the two individual worst case values are located on opposite sides in the valuation interval (2 460 and -360 120 respectively). These values are referred to as each position's naked margin requirement.

If there was no correlation between the instruments, the portfolio's total margin requirement would equal the sum of these values. But since the options are correlated, a window is applied to determine the maximum allowable difference in price variation. In this case, the window size is 0%, which corresponds to a 100% correlation between the price movements of the two options (as they have the same underlying). This means that we cannot just add the naked margin requirements to get the total margin, because then we would assume that the underlying futures price would drop to its assumed minimum level in the same time as it moves to its assumed maximum level, which is impossible. Thus, when determining the total margin of this portfolio, the margin contributions of the options has to origin from the same underlying price movement. Consequently, 100% correlation gives a window size of 1 row. An example of how the window size is converted into rows/points is given in Table 21.

Next step is to calculate the sum matrix, which evaluates the combined position in each valuation point. The sum matrix is obtained by summarizing the individual margin requirements in each valuation point:

		Sum matrix		
Point	F_t	**Vol down**	**Vol mid**	**Vol up**
1	1724.04	-19 665	-53 270	-86 055
2	1716.51	-16 955	-50 870	-83 670
3	1708.97	-14 440	-48 570	-81 300
4	1701.44	-12 090	-46 295	-78 990
5	1693.90	-9 930	-44 105	-76 675
6	1686.37	-7 930	-41 955	-74 440
...	...	...	...	...
27	1528.16	1 675	-10 925	-35 750
28	1520.62	1 470	-10 080	-34 320
29	1513.09	1 280	-9 260	-32 925
30	1505.55	1 100	-8 505	-31 575
31	1498.02	940	-7 775	-30 260

Table 13: Sum matrix

The overall worst case value of the portfolio, and the total margin requirement, equals – 86 055. The total margin requirement is obtained by summarizing the values 274 065 and -360 120, which origin from the scenario where the volatility of the options goes up and the futures price moves to its assumed maximum level.

The naked margin of the options, as well as the total margin of the portfolio is shown in Table 14.

Series	Bought	Sold	Naked Margin	Required Margin	PnL	IM
OMXS306C1640	15	0	2 460	274 065	112 350	161 715
OMXS306C1660	0	20	-360 120	-360 120	-130 660	-229 460
Total			-357 660	-86 055	-18 310	-67 745

Table 14: Margin Requirement of the portfolio.

The profit and loss of a sold option is obtained by taking the scenario point in the middle of the vector file; -130 660. For bought options one cannot use the point in the middle of the vector file as PnL, since several adjustment parameters are added to calculate the margin requirement. We need to disregard those adjusting parameters (ER and HV) when calculating the PnL for bought options. Doing this gives the vector file:

Point	F_t	Vol= 6.61%	Vol=16.61%	Vol=26.61%
1	1724.04	139 027	209 333	288 483
2	1716.51	129 830	201 881	281 406
...	...	...	...	...
16	1611.03	34 060	112 355	191 679
...	...	...	...	...
30	1505.55	3 222	52 244	120 560
31	1498.02	2 585	49 053	116 216

Table 15: Vector file.

From this vector file, valuated without the parameter *ER* and *HV*, the scenario point in the middle can be used to obtain the *PnL* for the bought option; 112 355.

Appendix A - OPTION VALUATION FORMULAS

A.1 Valuation Methods

The table below shows the various valuation methods NASDAQ Clearing uses for options, with and without dividends. The risk free interest rate is denoted r and the dividend yield is denoted as q.

Product	Method without dividends	Method with discrete dividends
American call based on spot	Black -Scholes	Binomial with dividends
American put based on spot	Binomial if interest rate is non-zero, Black -Scholes if interest rate equals zero.	Binomial with dividends
European option based on spot	Black -Scholes	Discount spot with dividends, then use Black -Scholes
European option based on future	Black -76	Black -76
Binary Cash-or-Nothing based on spot	Standard formula	Discount spot with dividends, then use Black -Scholes
Binary Cash-or-Nothing based on future	Standard formula with $q = r$	Standard formula with $q = r$

Table 16: Table of valuation methods for options

Below sections illustrate the option valuation formulas used by NASDAQ Clearing. These are well known, widely used industry-standard formulas which can be found in the financial literature e.g. Hull 2021 and Haug 2007.

A.2 Binomial Valuation Model

The binomial pricing model traces the evolution of the option's underlying variables in time. This is done by means of a binomial tree, for a number of time steps between the valuation and expiration dates. NASDAQ Clearing utilize a tree structure with 30 steps. The following values for the parameters in the method are used:

Variable	Definition
C	Call price
P	Put price
S_0	Stock price at time zero

K	Strike price
r	Continuously compounded risk-free rate
q	Dividend yield
σ	Stock price volatility
T	Time to maturity
u	Up movement
d	Down movement
p	Probability up movement
$1-p$	Probability down movement

Table 17: Definitions

Up movement:

$$u = \frac{(a^2 + b^2 + 1) + \sqrt{(a^2 + b^2 + 1)^2 - 4a^2}}{2a}$$

Down movement:

$$d = \frac{1}{u}$$

Probability:

$$p = \frac{a - d}{u - d}$$

where

$$a = e^{(r-q)\Delta T}$$

and

$$b^2 = a^2(e^{\sigma^2 \Delta T} - 1).$$

Note: The discounting when walking backwards in the tree is done with r (not r-q).

A.3 Black-Scholes

The Black-Scholes model is used for pricing European options based on spot.

Variable	Definition
C	Call price
P	Put price
S_t	Stock price at time t
K	Strike price
r	Continuously compounded risk-free rate
q	Dividend yield
σ	Futures price volatility

T	Option's time to maturity

Table 18: Black Scholes definitions.

The option prices on a non-dividend-paying stock are calculated in the following manner:

$$C = S_t N(d_1) - Ke^{-rT} N(d_2)$$

and

$$P = Ke^{-rT} N(-d_2) - S_t N(-d_1)$$

where

$$d_1 = \frac{\ln\left(\frac{S_t}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

and

$$d_2 = \frac{\ln\left(\frac{S_t}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} .$$

The function $N(x)$ is the cumulative probability distribution function for a standardized normal distribution.

Note: For dividend-paying stock options, the stock price S_t is discounted with the dividend, i.e. with the term e^{-qT}. Also, the r in the expressions d_1 and d_2 is replaced with $r - q$.

A.4 Black-76

The Black-76 formula is used for options on futures contracts.

Variable	Definition
C	Call price
P	Put price
F_t	Futures price at time t
K	Strike price
r	Continuously compounded risk-free rate
σ	Stock price volatility
T	Option's time to maturity

Table 19: Black-76 definitions

The option prices options based on futures contracts are calculated in the following manner:

$$C = e^{-rT}\left(F_t N(d_1) - KN(d_2)\right)$$

and

$$P = e^{-rT}\left(KN(-d_2) - F_t N(-d_1)\right)$$

where

$$d_1 = \frac{\ln\left(\frac{F_t}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{\mathrm{T}}}$$

and

$$d_2 = \frac{\ln\left(\frac{F_t}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{\mathrm{T}}} = d_1 - \sigma\sqrt{\mathrm{T}}\,.$$

A.5 Binary Options Valuation

For binary Cash-or-Nothing options the definitions follow the Black-Scholes notation.

Variable	Definition
C	Call price
P	Put price
S_t	Stock price at time t
K	Strike price
Q	Fixed payout amount
r	Continuously compounded risk-free rate
q	Dividend yield
σ	Stock price volatility
T	Option's time to maturity

Table 20: Binary Option definitions.

Binary Cash-or-Nothing options based on spot are calculated in the following manner:

$$C = Qe^{-rT}N(d_2)$$

and

$$P = Qe^{-rT}N(-d_2)$$

where

$$d_2 = \frac{\ln\left(\frac{S_t}{K}\right) + \left(r - q + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{\mathrm{T}}}\,.$$

Note: For Binary Cash-or-Nothing options based on a dividend-paying stock, the stock price is discounted with dividends and then the Black & Scholes model is applied.

A.6 Window Method

In this method, the scanning range limits the individual movement of each series, but there is a maximum allowed difference between the scanning points of the two series.

Instruments are sorted into a number of groups called "window classes". Each window class has a window size in percent. The size of this window is estimated roughly by the same method that is used to estimate scanning ranges. Daily differences between the movements of the series are calculated using one year of data. These values are then used to build a numerical cumulative distribution from which 99.2 % confidence interval is applied. More details of how the window size is obtained are found in following subsection.

A sum matrix is created, which evaluates the combined position in each valuation point. The total margin requirement will equal the sum of the worst case from each individual position within the sliding window. The window in Figure 1 displays a spread, demonstrating the maximum allowable difference in price variation between two different products belonging to the same window class.

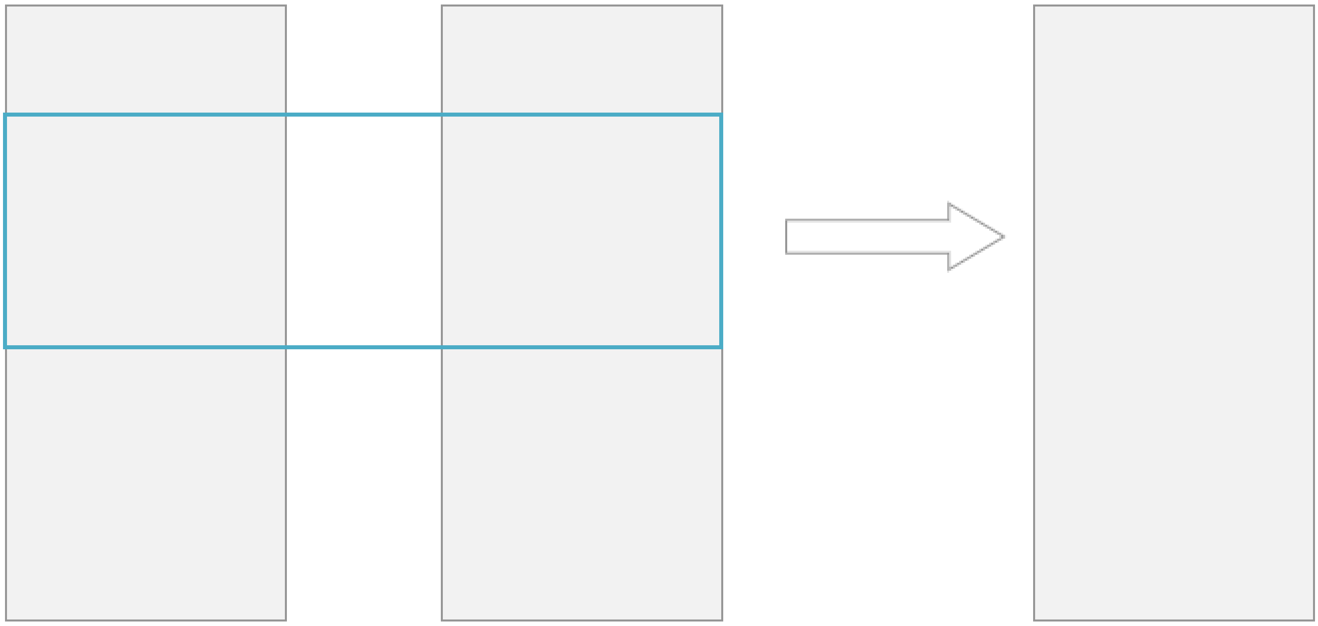

Figure 1: Illustration of the window method.

Window Size

The window size (WS) roughly corresponds to the inverse of the correlation of two or more instruments. To determine the correlation between instruments, the window size is calculated by using the instruments' normalized daily price changes in percentage. Based on one year of historical data the second largest difference is chosen.

1. Price changes in percentage per underlying instrument ($i = 1\ to\ n$) over a time period ($t = 1\ to\ T$).

$$\sum_{i=\mathrm{t}}^{T}\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)_i$$

2. Price changes are normalized by each underlying instrument's risk parameter (Par).

$$\sum_{i=\mathrm{t}}^{T}\frac{\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)_i}{Par_i}$$

3. A vector containing the largest price differences between instruments for each t is calculated.

$$\sum_{t}^{T}[\max(i:n)-\min(i:n)]$$

4. The second largest value from the vector is obtained.

$$large\left(\sum_{t}^{T}[\max(i:n)-\min(i:n)];2\right)$$

The obtained parameter, which is the maximum allowable price difference, is the risk interval parameter. Since the size of the risk interval is twice as big as the margin parameter (both up and down price stress is implied), the risk interval parameter needs to be divided by 2[*].

5. The parameter is then multiplied by the liquidation period. Hence, the Window Size equals:

$$large\left(\sum_{t}^{T}[\max(i:n)-\min(i:n)];2\right)\cdot\frac{1}{2}\cdot\sqrt{2}$$

Number of Nodes in Window

A window size given in percent can be converted into points and the algorithm for doing this is shown below. Also, an example of the algorithm is given to the right in the table, where the window size=50%.

1. Let x = (1.0 – window size/100) · (# points – 1)	x = (1 – 0.5) · (31 – 1) =15
2. Round x to nearest integer	x = 15
3. Let x = # points – x	x = 31 – 15 = 16
4. If x is even, increment x by 1	x = 16 + 1 = 17

***Table 21**: Algorithm for converting a window size in percent into points.*

[*] E.g. During a trading day the price move of stock A is +15% while the price moves of stock B is -15%. Both stocks have a parameter of 30%. The normalized values for A and B are 0.5 respectively -0.5. Hence, $\sum_{t}^{T}[\max(i:n)-\min(i:n)]=1$, i.e. the full length of the valuation interval. It is only possible for the price to move half that distance, up and down from the spot price. The value has to be divided in half to obtain the true interval.