Nasdaq Clearing AB

CCaR Model Instructions

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Revision history

Rev #	Date	Author	Description
1	2013-11-05	Karl Klasén	First version
2	2014-03-27	Karl Klasén	Added methodology for stress testing based on historical extreme events (historical simulation approach)
3	2014-10-20	Karl Klasén	Added historical extreme events currently included in historical simulation
4	2015-08-26	David Sjöblom	Revised scope of model stress testing
5	2016-04-19	Kjersti Ulset	Added historical extreme events defined but not implemented
6	2016-08-11	David Sjöblom	Annual revision
7	2017-11-10	David Sjöblom	Changes in reference to CPMI-IOSCO self assessment

Introduction

Nasdaq Clearing AB (Nasdaq Clearing) provides clearing and central counterparty (CCP) services. In order to prudently manage these services Nasdaq Clearing uses a proprietary stress test model, CCaR (Clearing Capital at Risk), as basis for deciding Nasdaq Clearing's regulatory capital level and the size of the default funds.

This document provides technical and quantitative guidelines that shall be adhered to by Nasdaq Clearing's Risk Management Department when running, maintaining and validating the CCaR model, specifically including estimation of CCaR model parameters and review of historical extreme scenarios.

Document outline

The CCaR Model Instructions document contains the following sections:

- Purpose of model
- Model framework
- Process description
- Model validation

Governance

The instructions in this document are governed by the following policies:

- Stress Testing Policy
- Parameter Policy

Changes to this document are prepared by the Chief Risk Officer (CRO) and reviewed and approved by the Clearing Risk Committee (CRC) and if material changes the Member Risk Committee (MRC).

Limitations

Due to the purpose of the model, back-testing is not relevant and is for this reason not covered in these instructions.

Purpose of model

The CCaR model was developed by Nasdaq Clearing in 2001-2003 with the purpose of providing estimates of clearing capital at risk under various assumptions on extreme market stress, such as counterparty defaults at the same time as extreme market movements occur. The CCaR model ensures that a sufficient level of clearing capital is held to cover a possible shortfall of margin collateral in case of counterparty defaults. Besides fulfilling regulatory requirements, stress tests provided by the CCaR model are useful when communicating the risk profile of the CCP to external parties, such as members and credit rating agencies.

While the margin models estimate risk in periods of market stress and high volatility, CCaR estimates risk in extreme or exaggerated worst case levels of market stress. The CCaR model was designed as a parametric model based on the margin models for the different markets cleared by Nasdaq Clearing:

Market	Margin models
Commodities	SPAN®[1]
Equities	OMSII
Fixed Income	CFM

The main requirement when developing CCaR was to appropriately model the above mentioned extreme scenarios and in the process capture all material financial risks that Nasdaq Clearing is exposed to. Other highly important requirements were that the CCaR model was possible to incorporate in the clearing system, that it could be run daily and that it covered all portfolios and all cleared instruments regardless of the margin method applied. These latter requirements essentially meant that the model chosen had to be possible to implement in a CCP framework, with requirements on instrument coverage, robustness and computational feasibility.

The most recent development of the CCaR model is the introduction of historical scenarios, in response to regulatory requirements. The aim of such stress testing is to replicate a set of historical events and measure the impact of those on current portfolios.

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[1] SPAN is a registered trademark of Chicago Mercantile Exchange Inc., used herein under license. Chicago Mercantile Exchange Inc. assumes no liability in connection with the use of SPAN by any person or entity.

Model summary

Two types of stress tests are performed by CCaR:

1. Data driven stress testing with hypothetical scenarios:
    a. Model parameters (extreme prices and changes in implied volatility) are determined based on statistical estimation of extreme price changes distribution (EVT).
    b. Scenarios are built from the extreme individual instrument price changes across history and assuming they will all occur on the same day (stress scenarios).
    c. All instruments within the same market (product group) are considered as totally correlated in case of extreme events.
    d. Hypothetical scenarios cover all possible combinations of up and down movements for all different product groups.
2. Historical simulation:
    a. Historical extreme events are replicated on current portfolios.
    b. A method for defining historical extreme events is developed and applied, based on the historical volatility in the most important risk factors and the current exposure.
    c. Historical quantitative data for each risk factor with a minimum look back period of 30 years, or as long as reliable data have been available, shall be considered when defining "historical events" for each risk factor. The events should be defined both on the size of the movement of the individual risk factor as well as the impact of the risk factor on the overall risk of Nasdaq Clearing.
    d. The historical events per risk factor shall be used as basis for the historical scenarios used by Nasdaq Clearing for historical simulation. Where applicable the selected historical scenarios shall concur with the Swedish Central Bank's (or other relevant authority) definition of a highly stressed market (Riksbankens Stressindex).
    e. Currently cleared products not existing in a historical scenario, or when the actual price movement of the product is deemed non representative, shall be approximated with the movement of the relevant risk factors of the product.

In both types of stress tests estimated losses per individual clearing counterparty are computed for current portfolios.

Model framework

CCaR methodology

The below sections give an overview of the key aspects of the CCaR methodology.

Overview

The CCaR model estimates losses per clearing counterparty under a wide range of extreme but plausible market scenarios. The market scenarios are divided into two categories:

1. Data driven hypothetical scenarios
2. Historical events

For a clearing counterparty's current portfolio the estimated loss in each market scenario is equal to the scenario-induced market value change less the available collateral after haircuts.. Estimated losses due to decreases in collateral value are not computed by CCaR, and are instead managed by collateral haircuts calculated to withstand extreme but plausible market conditions.

Further, the CCaR model estimates aggregated losses on CCP and Default Fund level through various credit scenarios, based on assumptions on the default of one clearing counterparty or the simultaneous defaults of more than one clearing counterparties.

On high level, the two major factors that affect the output from the CCaR model are therefore

1. Type of market scenario and level of market stress
2. Number of simultaneously defaulting counterparties

Hypothetical market scenarios

The purpose of hypothetical market scenarios is to simulate extreme but plausible market conditions, where applied price changes are statistically derived from historical data but where the constructed market-wide scenarios are entirely hypothetical.

Hypothetical market scenarios in CCaR are constructed with consideration to the properties of cleared instruments, the current risk exposure profile of the CCP and computational feasibility.

With respect to properties of cleared instruments, risk factors with a significant impact on the market value are identified;

- Prices/yields of underlying instruments or future/forward prices
- option implied volatilities
- currency rates

Stress of risk factors

For each risk factor the extreme but plausible market scenario is defined as the 99.9% percentile market movement estimated using EVT, see section *CCaR Stress Parameter Methodology* below for a description of the estimation. An example of risk factors with corresponding stress parameters is illustrated in the table below.

Risk factor	Stress parameter
ERICB underlying price	24%
SEK Swap curve PC1	30 bp
SEK Swap curve PC2	25 bp
Nordic power delivery period 22-29 days	15%
Option implied volatility	10%

Illustrative example of risk factors with corresponding stress parameters

It should be noted that the stress parameters are estimated independently from each other. This means that the stress parameter for a stock S1 can be based mainly on tail events in year Y1, while the stress parameter for another stock S2 can be based largely on tail events in another year Y2.

CCaR Product Areas and basic scenarios

Once the individual stress parameters are decided then the individual instruments are divided into product groups, or so called product areas (PA). The method for determining the CCaR Product Areas, detailed in section 1 of *Appendix 1 – Technical Descriptions*, is primarily risk based, i.e. based on instruments expected behavior in extreme market conditions.

For each CCaR Product Area a number of basic scenarios are defined. A basic scenario is a definition of risk factor stresses applied simultaneously for all instruments within a CCaR Product Area.

CCaR PA	Basic scenario 1	Basic scenario 2	Basic scenario 3	Basic scenario 4
Nordic stocks	UL up, iv up	UL up, iv down	UL down, iv up	UL down, iv down
Nordic bonds	PC1 up, PC2 up	PC1 up, PC2 down	PC1 down, PC2 up	PC1 down, PC2 down

Illustrative example of basic scenario configurations (UL = Underlying price, iv = implied volatility, PC = principal component for a yield curve)

Note that currency stress is always done in the worst possible way per portfolio under the CCaR methodology. It is not possible to specify a basic scenario with currency stress up or down.

The methodology further allows risk factors to be stressed independently from each other in a basic scenario. This is useful in order to keep the number of final (total) market scenarios down to a manageable number, but also means that stress scenarios are not applied consistently across portfolios. A possible configuration is exemplified in the table below.

Risk group	Basic scenario 1		Basic scenario 2	
Nordic stocks	UL up, worst of	iv up iv unchanged iv down	UL down, worst of	iv up iv unchanged iv down
Nordic bonds	PC1 up, worst of	PC2 up PC2 unchanged PC2 down	PC1 down, worst of	PC2 up PC2 unchanged PC2 down

Possible configuration of basic scenarios where worst of… is applied on portfolio and risk factor level

Final scenarios

Final scenarios are created by taking all possible combinations of basic scenarios for all CCaR Product Areas. For example if there would be only two CCaR Product Areas and only two basic scenarios per CCaR Product Area, then $2^2 = 4$ final scenarios would be created.

Final scenario #	PA 1	PA 2
1	Stress up	Stress up
2	Stress up	Stress down
3	Stress down	Stress up
4	Stress down	Stress down

Example with 4 final scenarios created as result of 2 PA's and 2 basic scenarios per PA

A configuration with ten PA's and two basic scenarios per PA would lead to $2^{10} = 1024$ final scenarios. A configuration with ten PA's with four basic scenarios per PA would lead to $4^{10} = 1048576$ final scenarios.

New instruments

New instruments are placed in existing or new CCaR Product Areas.

Historical market scenarios

The purpose of historical market scenarios is to replicate historical stressful market events on current portfolios. There are certain difficulties connected with historical simulation. For example, it might not be possible to replicate a historical event because instruments existing today did not exist in the time of the historical event. Another major issue is that the longer back in time an event took place, the higher the probability that the event is not representative for today's markets due to changes in regulation or market environment. Regulatory authorities have decided that historical events as long back as possible, and at minimum 30 years or as long as a market has existed, shall be considered when selecting historical events for stress testing. Exceptions may only be done with the consent of the regulatory authorities.

Risk factors

Risk factors are defined for all instruments cleared. The choice of risk factors is primarily risk based, i.e. based on market variables that are significant to the inherent risk in cleared instruments and given the overall risk exposure profile of the CCP. The risk factors are used for selecting historical events and for estimating losses in current portfolios.

Risk factor #	Fixed income	Equity	Commodity
1	PC's	Underlying price	Futures price
2	Currency	Implied volatility	Time to delivery
3	Credit	Market	Implied volatility
4	Implied volatility		Market
5			Risk group

Risk factors per asset class

The bond market can serve as an example of the use of risk factors. Instead of analyzing the behavior of individual instrument prices, the process looks at the volatility in the underlying yield curve. Assume that there are only SEK instruments cleared, of which no options. The day-to-day changes in bond prices would then be converted to yield curve changes expressed in the yield curve's (first three) principal components (parallel shift, slope change and curvature change). The graph below shows a hypothetical time series of those risk factors.

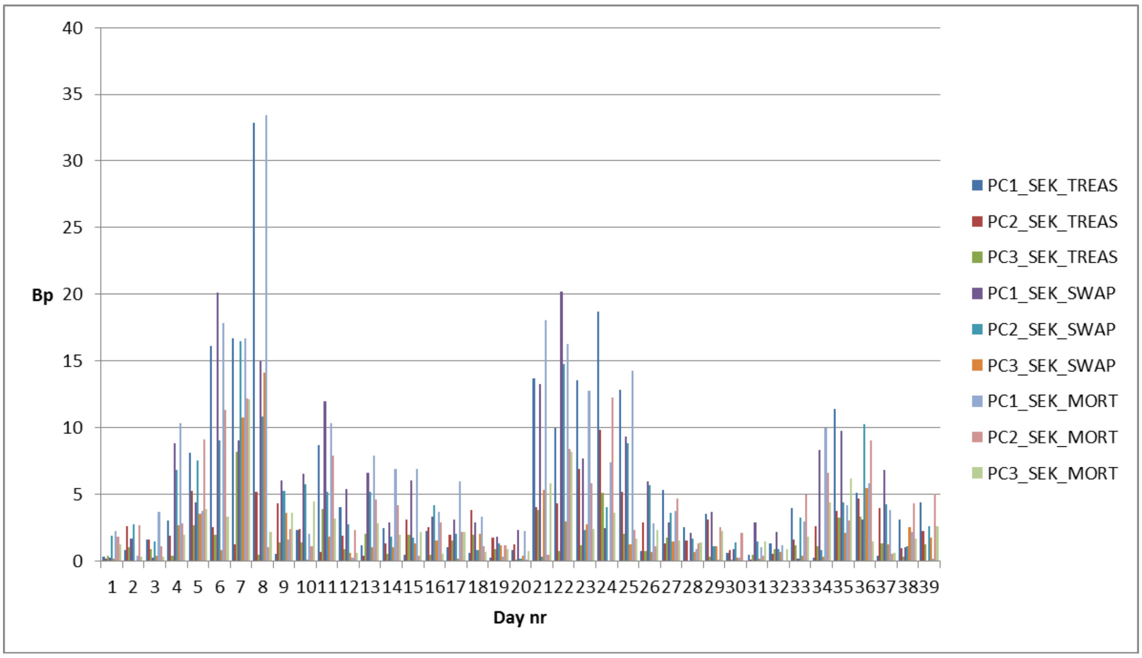


Illustration of volatility in fixed income risk factors over time, with PC's, currency and credit as risk factors

Note that proxies for risk factors are used when historical data is not available or is unreliable. For example if mortgage interest rate curves are not present before a certain date then those risk factors shall be proxied with the most appropriate existing risk factors, e.g. swap interest rate curves. Or if new markets such as emission allowances did not exist in a historical event where other related commodity markets, e.g. power, experienced stress, proxies must be constructed based on the products existed at that time.

Selecting historical events

Time series with the selected risk factors, or appropriate proxies, are created, per asset class. Events where several or all risk factors show simultaneous and significant changes are defined as historical stress events. The risk exposure profile of the CCP must be considered which means that the more significant a risk factor is the more weight it should be given when selecting stress events. Note that from maintenance perspective the selected historical events should be kept to a limited number.

The approach can be described by drawing on the above example of the bond market. Take the volatility over time per risk factor, as illustrated above, and construct an index where each risk factor is given equal weight:

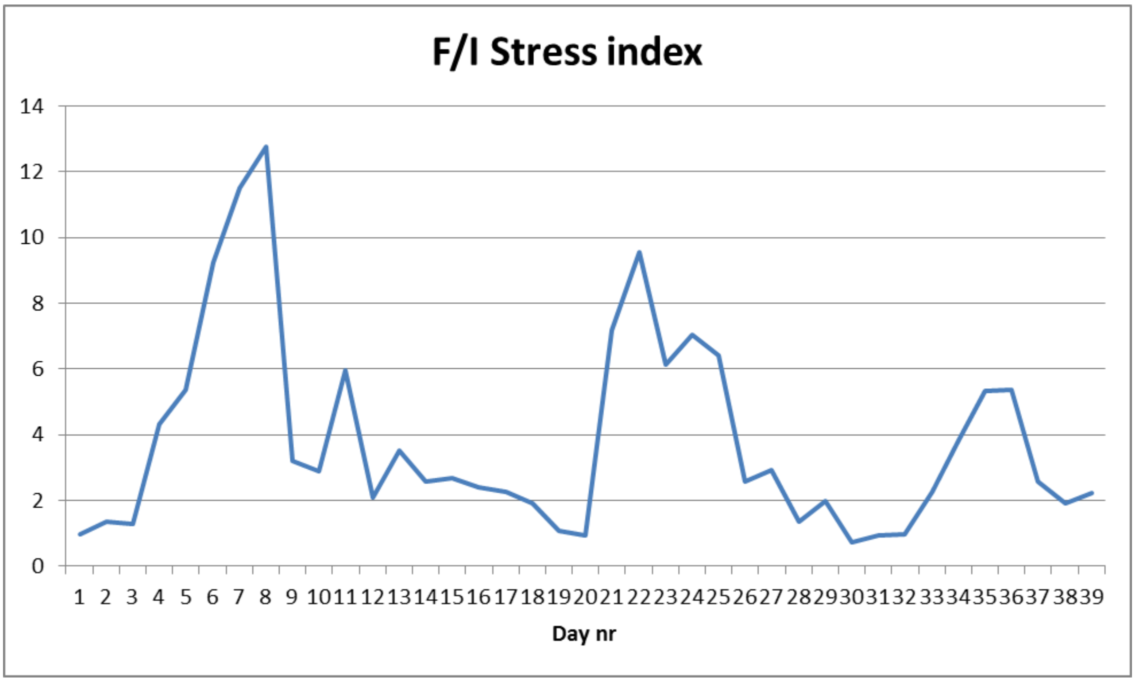


Illustration of fixed income (F/I) stress index with equal weights on all risk factors

However, when taking the risk exposure profile of the CCP into account, the risk factors should probably be weighted differently. With the below risk based weights applied, the stress index changes slightly.

Risk factor	Weight	Risk factor	Weight	Risk factor	Weight
PC1_SEK_TREAS	0,25	PC1_SEK_SWAP	0,25	PC1_SEK_MORT	0,15
PC2_SEK_TREAS	0,15	PC2_SEK_SWAP	0,15	PC2_SEK_MORT	0,05
PC3_SEK_TREAS	0	PC3_SEK_SWAP	0	PC3_SEK_MORT	0

Hypothetical risk based weights applied to risk factors in F/I Stress index II

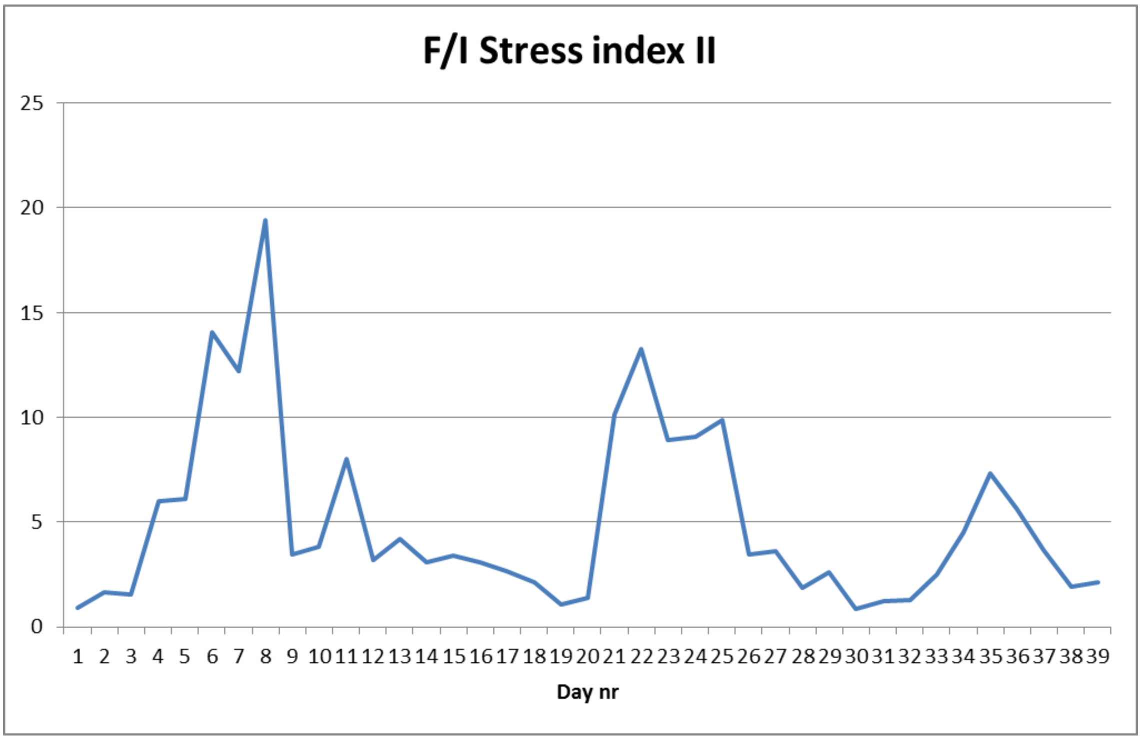


Illustration of F/I stress index with risk-based weights to risk factors

The weights applied to risk factors are thus an important part of the methodology for historical simulation. The weights for the risk factors are determined by their respective impact on the overall risk for the CCP. How this is done per asset class is described in the sections below. Note that according to the methodology, when a historical event once has been selected, that event is replayed to the extent possible including with movements in instruments/risk factors that were not used when selecting the event.

Equity

The weights of the risk factors are set to 1 for the SEK main market index and to 0 for other risk factors. The equity derivatives market is overwhelmingly dominated by SEK index and SEK single stock derivatives in terms of equity risk exposure for the CCP. Of the single stock exposure the main exposure stems from large cap stocks, i.e. index constituents. The risk exposure is fairly evenly distributed between futures and options, but the strong relation between stock price volatility and option implied volatility means that there is no added value in investigating historical volatility in option implied volatilities (e.g. volatility indices).

Fixed income

The weights of the risk factors are quantitatively established through sensitivity analysis per risk factor, by adding 1 basis point (bp) to each risk factor and analyzing the respective risk factor's risk impact. The exposure to F/I options is negligible and therefore option volatilities can be disregarded in the analysis.

Commodity

The commodity market is dominated by Nordic Power in term of risk exposure to the CCP. The weights of the risk factors for all scenarios not driven by Nordic Power are set to zero.

Seafood

With only one product on seafood, all weights for historical scenarios for seafood are 1.

Replicating historical events

Once the historical stress events to be replicated have been decided, there are some key decisions to make, in particular for derivatives. First of all it has to be made clear that the majority of instruments existing today did not exist at all in historical events. For example, the longest-dated equity options currently cleared by the CCP have five years to expiration. This means that out of all currently cleared equity options not a single one was present in one of the worst financial shocks of all times, the Lehman Brothers crisis in 2008. This means that some kind of mapping has to be done, e.g. a one-year at-the-money option of today could be mapped to a one-year at-the-money option of 2008. For all cleared instruments it has to be decided how this mapping should be done, including the degree of granularity.

Secondly, the underlying instruments change over time and it can be questioned what value there is in replaying the market movements of instruments if they have changed fundamentally since the historical event. For example a stock that existed in the stock market crash of -87 could at the time have been a small cap company with a local presence, while it at present date could be a large cap company with a global market presence, perhaps even active in an entirely different industry. Another example is government bonds with current rating of below investment grade while the rating in a historical event could have been triple A. Yet another example is the power market where several factors such as changes over time in production (e.g. a move from nuclear to wind power) and in transmission (e.g. new or ceased connections between areas or countries) have a major impact on the market prices. So a decision has to be made if instruments should get their observed past movement in the historical simulation or not. If the fundamentals behind a historical event do not longer apply, the relevance of the scenario should be questioned. A decision needs to be made if the historical event is to be considered representative to today’s market or not.

A feasible solution to the two above mentioned challenges would be to take full advantage of the use of risk factors. All current instruments are mapped to risk factors, and it is the volatility in risk factors that is used instead of directly observed price movements. An example from the stock market will be used to explain the approach. Assume a company A is mapped to the following risk factors:

Risk factor	Value
Currency	SEK
Industry sector	Telecom
Size	Mid cap
Introduction date	1991-01-01

Mapping of risk factors for a hypothetical company

Risk factor	1987 event	2008 event
All SEK stocks	-12%	+11%
All telecom stocks	-15%	+5%
All mid cap stocks	-10%	+15%
All stocks floated in -91	-	+8%
Stock A	-	+17%

Hypothetical risk factor values for two historical stress events

This hypothetical company existed in the Lehman crisis of 2008 but not in the stock market crash of 1987. When simulating the 1987 event for stock A there is thus no choice but to use a hypothetical price movement. And there are several alternatives for how to calculate this hypothetical price movement, for example just taking the movement of a broad stock index. But when simulating the 2008 event there is actually the choice of using the observed movement for stock A or using a hypothetical price movement. For example, the average of risk factors could be used:

	1987 event	2008 event
Average of all risk factors	-12%	+11%

Average of hypothetical risk factors for stress events

This approach entails that all instruments are re-classified against defined risk factors on regular basis. New instruments would obviously have to be classified against the risk factors when they are introduced for clearing. One advantage with this approach is that a lot of the historical information is used. However, if historical data is still considered representative to today's markets, actual observed price movements should be used to the largest extent possible and feasible, in line with requirements from the regulatory authorities. How this is applied per asset class is described in the sections below.

Equity

The price movements of single stocks that did exist in a historical event are replicated with the exact market movement in that historical event. For index instruments the main market index movement of the historical event is used. Option implied volatility movements are proxied with the largest observed volatility shift (average of all listed options) for main market index options.

Stocks not existing in a historical event are proxied with the main market index movement of the historical event.

Fixed income

Fixed income instrument price movements are replicated with yield curve changes (PC1-3) for the currency and credit in question. There is no consideration given to any credit changes over time (e.g. even if a government has deteriorated from AAA to C since a historical event it is still the historical curve change of that specific government that is applied). Option implied volatility movements are proxied with the largest observed volatility shift (average of all listed options) for interest rate options.

New products (e.g. if mortgage did not exist in a historical event) are in first hand proxied with the swap curve and in second hand the treasury curve.

Commodities

The price movements for the instruments existed at the moment of historical event are replicated by the price movements of the same instrument based on its time to delivery and time to delivery of corresponding underlying instrument (for options), which is formalized as Stressed volatility curve and implied volatility stress parameter.

The instruments, which were not present at the moment of historical event, are approximated in the same way with use of highest observed price movement of similar products at the moment of event. In case an instrument class has no correspondent class at the moment of historical event, the price movements are replicated based on the observed changes in the instrument class with highest volatility at the moment of historical event.

Credit risk scenarios

A credit risk scenario is an assumption of credit events that have impact on the clearing activity of participants. Examples are simultaneous default of one or more counterparties, with none or partial recovery of losses.

Types of credit risk scenarios

The CCaR model allows for great flexibility in different types of credit risk scenarios. Some of the alternatives are summarized in the table below.

Scenario alternative	Description
# global defaults	Regardless of type, credit etc., assume *x* of simultaneous defaults
# defaults by type	Assume *x* simultaneous defaults by account type
Fix include by credit	Always assume members with credit (Risk Rank) *y* to default
Fix exclude by credit	Never assume members with credit (Risk Rank) *y* to default
Recovery by credit	Assume *z*% recovery for credit (Risk Rank) *y*

Some possible credit risk scenario alternatives

Applied credit risk scenarios

The credit risk scenario applied is determined by the board of Nasdaq Clearing with consideration to regulatory requirements.

CCaR Runs

CCaR can be configured with several runs per day, with different combinations of included markets and credit risk scenarios. A few examples of possible configurations are provided in the table below.

Run #	Product Areas	Credit risk scenario	Currency
1	SEB, SES	Two largest regardless of category	SEK
2	SEB, SES	Two largest regardless of category + all DP clients	SEK
3	SEB, SES	Two largest regardless of category + all Risk Rank 1	SEK
4	SEB, SES	All Risk Rank 1 * 90% + all Risk Rank 2 * 50%	SEK
5	ENO, EUA	All * 10%	EUR

Possible configurations of CCaR Runs

The worst hypothetical loss calculated per run, given the product-defined market stress scenarios and the credit risk scenario.

CCaR stress parameter methodology

The CCaR stress parameter analysis uses Extreme Value Theory (EVT) to set a family of parametric functions that can be fitted to the tail distribution of historical returns for each particular product class. EVT can be as powerful as the Central Limit Theorem (CLT), albeit they are applicable in opposing circumstances. While the CLT is focused on predicting the distribution of measured average quantities in the limit of a large number of observations, EVT focuses on the distribution of stochastic value experiences in the limit that they are far from the mean. Generally, EVT can be applied in two ways:

- By producing a time series of block maxima, such as the largest experience in a particular period of time (say the time series of the largest yearly experiences).
- By analysing extreme events that cross over a particular threshold. This is the POT (points over threshold) procedure that is utilized to calculate CCaR stress parameters.

The distributions produced by EVT in the POT method are known as Generalized Pareto Distributions. During the fit procedure, two parameters are fit: a scale parameter and a shape parameter. The shape parameter is approximately a power-law type exponent that determines how far the tail extends into extreme values. Thus, the shape parameter determines crucially the level of tail risk for a particular product. The shape parameter allows the distributions to include Gumbel (shape parameter = 0), Frechet (shape parameter >0), and Weibull (shape parameter < 0) type distributions. Fitting of financial data across equity index, stock, fixed income, and electricity markets yields very different results on the types of distributions that fit on the data (which in this case consists of empirically observed end-of-day returns). As the risk profile varies across assets, it is fully expected that different products and asset classes exhibit different shape parameters. The exponent measurement can be affected by the lack of extensive data in some instances, introducing sample bias. In order to mitigate this sample bias, all available historical data within the past 10 years is utilized. Given that a family of distributions is fit as part of the procedure, a certain level of model risk is incorporated in the EVT fit, in particular due to the fact that confidence levels are obtained around the measured percentiles.

A variety of statistical techniques may be chosen to obtain the confidence levels around the percentile fit. Nasdaq Clearing has chosen to utilize the maximum likelihood method, which is one of the most conservative and widely utilized approaches, and it can produce, if necessary, asymmetric confidence boundaries around a percentile fit.

Given that the POT method is used to analyze the market data, the model risk introduced by choosing a particular threshold needs to be considered. Plots of both the shape and scale parameters as a function of threshold are produced, which can test the convergence and model risk involved in the results. Good convergence across data sets is generally observed, but it must be recognized that the confidence levels do in practice have some sensitivity to the threshold chosen. Due to this fact, it is reasonable to expect that most CCaR stress parameters results will not be known to better than 5% or 10% error, depending on how much data is available. The threshold needs to consider the amount of available data, while at the same time ensure that the selected data set is sufficiently far from the mean. The more data that is available, the further in the tail the sample is obtained without losing good statistical sampling. Generally, between 50 and 200 daily return observations are used directly as extreme value sample points for any given product.

Process description

Regularity

CCaR is calculated and monitored on a daily basis in accordance with the Stress Testing Policy. The CCaR stress scenarios are reviewed quarterly in accordance with the Stress Testing Policy

CCaR model parameters

The tables below show the parameters that are used in the CCaR methodology to stress test the main assumptions made in the margining methodologies. These parameters and the overall methodology are further described in detail in Appendix I – Technical Descriptions.

Hypothetical market scenario parameters

Parameter	Description
Basic stress scenarios	Explains all material changes in the price of a derivative contract, includes change in prices, yield curves and option volatilities. • SPAN® and OMSII: Price • CFM: Two main principal components of yield curve Basic stress scenarios also include stressed option volatilities.
CCaR stress parameters	Individual CCaR stress parameters for all products to which Nasdaq Clearing has a material risk exposure are calculated using the EVT methodology according to the CCaR stress parameter methodology. The individual stress parameters for all products to which Nasdaq Clearing has a non-material risk exposure are set to a percentage of the margin stress parameters applicable from time to time. These percentages are the following: • All products other than index products: 150% • Index products: 200% The percentages are reviewed on a quarterly basis and reflect the average ratios between CCaR stress parameters and margin stress parameters for which individual CCaR stress parameters are calculated.
Market segmentation	The construction of CCaR Product Areas is made using a risk based approach where factors of materiality are balanced against computational feasibility due to system limitations. The segmentation is reviewed annually or whenever there is reason to believe that the current segmentation is inadequate. If a temporary exception from the market segmentation is made, this should be reviewed every month until the exception is either made permanent or reversed.

Historical simulation parameters

Parameter	Description
Market stress parameters	Market stress parameters per historical event and product • Equity: Underlying price and implied volatility • Fixed income: PC1-3 and implied volatility • Commodity: Contract price term structure and implied volatility

The selection of historical events shall be reviewed on a quarterly basis. This includes reviewing the weights used when calculating stress index per asset class.

Other CCaR parameters

Parameter	Description
Number of simultaneous defaults (credit risk scenarios)	The various tranches of the clearing capital are designed to withstand a certain amount of simultaneous defaults as described in the Regulatory Capital Policy and the Stress Testing Policy. The CCaR methodology groups all branches and affiliated companies of a participant within the same legal entity into one “super member” used for the CCaR calculations.
Collateral value	CCaR takes into account the amount of collateral posted after haircuts. This value is however capped to the current margin requirement at the time the stress test is performed, assuming that that collateral exceeding the margin requirement is voluntary, excess collateral posted to the CCP that the clearing participant may withdraw during times of stress. This excess collateral is assumed to be non-available to the CCP.

CCaR stress parameters

The CCaR stress parameter methodology establishes the 99.9% percentile fit with EVT as the basis for the CCaR stress parameter.

To obtain the CCaR stress parameters for Financial Markets, the 99.9% percentile numbers are scaled by the square root of the liquidation period measured in the amount of days. It is assumed that the market returns are independent although they are not Gaussian, meaning that the 99.9% percentile multiplied by the square root of *n* days is not equal to the 99.9% percentile for *n*-day returns. The square root of *n* assumption is however applied due to the specially performed tests which have shown that the 99.9% percentile multiplied by the square root of *n* is higher than the 99.9% percentile of *n*-day returns, where *n* varies from 2 to 5 days. The tests provide strong evidence that the assumption is on the conservative side.

To obtain the CCaR stress parameters for Commodities, the 99.9% percentile numbers are estimated over the correspondent liquidation period, meaning that no scaling is used. The percentile numbers are dependent on time to delivery and compose a so called CCaR curve for each risk group. For each specified historical date stressed parameters are presented by a corresponding set of CCaR curves.

To guarantee that the CCaR parameter is greater than the margin parameter, however, it will be necessary to set a floor for the CCaR value based on each margin parameter. The methodology described in this document implies a CCaR stress parameter calculation that is fully independent of the margin parameter level, and therefore, there may be some instances where the CCaR stress parameters are smaller than the margin parameter. To handle this, floor parameters are applied as shown in the table below.

Product	Floor parameters
Fixed income	10 basis points above margin parameter (or equivalent in PC1 change)
Equity	5% above margin parameter
Equity index	2% above margin parameter, or minimum level of 12.5%
Commodities	2% above margin parameter

Setting floors by means of spreads, rather than by multiples of margin levels, assures that even for a product that already has the floor parameter applied, an increase in margin levels will not produce an increase in CCaR exposures, therefore maintaining the right-way incentive for the clearing house to maintain appropriately conservative margining practices.

If there is less than 10 years of historical data available for a product's stress parameter calculation, a 25% buffer is added to the calculated stress parameter.

CCaR as basis for capital requirements

The Regulatory Capital Policy describes the processes and routines associated with the default funds and the clearing capital held by Nasdaq Clearing. The CRC reviews the CCaR values on a regular basis and determines the sizes of the default funds and the clearing capital based on recent CCaR history. The default funds and the clearing capital are in this document referred to as the capital tranches. The sizes of the capital tranches are reviewed by the CRC on monthly basis, along with the results from other stress tests. Maximum CCaR values for a selected number of simultaneous defaults over a predefined time period sets the minimum levels for the various capital tranches. The number of simultaneous defaults in the CCaR value for each capital tranche is in line with EMIR requirements:

Capital tranche	CCaR value
Total clearing capital	Sum of 2 largest exposures
Default funds	Largest exposure or sum of second and third largest exposures

The different capital tranches have trigger levels that have been decided by CRC. The CRO notifies the CRC when a trigger level is breached. The CRC then determines the actions required, which could include recalculation of margin stress parameters and/or raising the size of relevant capital tranches. If the CCaR values breach the size of the total capital, or a certain predefined level above the default funds, immediate actions are required where the CRC decides on a new level for the clearing capital or relevant default funds. The CRO is responsible for reporting the results and remediation plan to the Nasdaq Clearing Board of Directors and the relevant regulatory authorities. The trigger levels, along with other detailed information on processes and routines, are found in the Regulatory Capital Policy.

Model validation

CCaR

The CCaR model is primarily validated by analyzing the adequacy of the model's main parameter: the level of market stress. The levels of market stress should be sufficient enough to cover the most volatile periods experienced by Nasdaq Clearing as well as the event of sudden sales and illiquid periods. The validation includes analysis of the scenario composition. The validation consists of the following tests:

Test	Description
Scenario composition	Compare actual returns for the applicable liquidation period for different instruments (with CCaR stress parameters. Review actual price behavior in extreme events to validate the adequacy of the correlation assumption within risk classes.
Cover most volatile period	Verify that CCaR scenarios are not less conservative than actual historical events. This is done by applying historical returns from "volatile days" to actual or hypothetical portfolios. Volatile days are identified as outliers for the main products in each product group, such as OMXS30 for Swedish equities.
Cover sudden sales	Identify sudden sales periods and calculate returns. Apply these returns to various portfolios like in the test above. Sudden sales periods are identified as the most severe price falls as they typically signify a significant excess of sellers in the market. The dates are identified the largest actual price movements for the applicable liquidation period for each instrument.
Cover illiquid periods	Identify periods with low liquidity and calculate returns. Apply these returns to various portfolios like in the test above. For illiquid periods, dates with zero or very low trading volumes relative to normal volumes are selected. The selection is based on top 3 products in each market.

Model stress tests

A series of hypothetical stress tests are performed in order to stress test the assumptions made in CCaR and the margining models that are used as basis in the CCaR calculations. The assumptions that are stressed are described in the table below. The stress tests are performed in accordance with the Stress Testing Policy.

Assumption	Description
Market segmentation	CCaR assumes that products are fully correlated within product segments, or the so called CCaR Product Areas. The market segmentation stress test is similar to CCaR only that these correlations are broken down. The test is designed to capture idiosyncratic risks, where correlations in each basic scenario are varied between 0% and 100% within each CCaR Product Area, meaning that only adverse price movements are taken into account for each product and counterparty. The market segmentation stress test helps to identify the potential exposure in case of extreme illiquidity and ensures that the market segmentation is granular enough.
Stress parameters	The EVT stress parameters are designed to cover extreme but plausible price movements. To validate the appropriateness of these stress parameters, CCaR calculations are run using two additional sets of stressed parameters. In the first set of parameters, the liquidation period of each product has been increased by one day. In the second set of parameters a confidence boundary is applied around the 99.9% percentile which is used as basis for the EVT stress parameters. For each instrument, the maximum parameter from the two sets above is chosen as stress parameter for this test.
Simultaneous defaults	CCaR assumes a number of simultaneous defaults. The amount that is used for determining the requirement on total financial resources is stressed by increasing the number of defaults by one.

These additional stress tests are performed on at least a monthly basis and reported to the CRC on a monthly basis, or when breaches are experienced. The trigger values for breaches are described in the Stress Testing Policy. If a trigger level is breached, the same procedures follow as when trigger levels for CCaR are breached, as described in the Regulatory Capital Policy. The summary report of the stress tests should identify any potential weaknesses in the models and possible enhancements to either the models or the stress tests.

Reverse stress tests

The parameters listed below are scaled to a point where the levels of financial resources are proven insufficient. The levels of financial resources correspond to the prevailing amount of financial resources with and without the assessment powers included.

1. CCaR stress parameters.
2. Number of simultaneous defaults.

The reverse stressed are performed and reported to the CRC on a quarterly basis.

Appendix I – Technical Descriptions

This appendix provides technical information on how the different stress tests are performed and how the stress test values are calculated. The following tests are covered in this appendix:

Test #	Test type	Test
1	Financial resources stress test	CCaR
2	Model stress test	Market segmentation
3	Model stress test	Increased stress parameters
4	Model stress test	Number of simultaneous defaults
5	Reverse stress test	Stress parameters
6	Reverse stress test	Number of simultaneous defaults

1. Financial resources stress test: CCaR

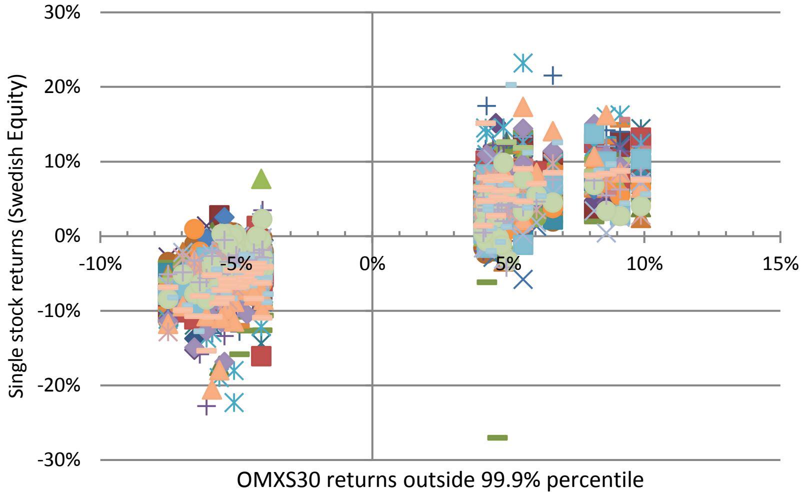
Hypothetical market scenarios

Market segmentation

All cleared products are categorized into different CCaR Product Areas. Underlying price correlation is assumed to be 100% within these groups. Examples on CCaR Product Areas are Swedish Equity, Danish Equity and Swedish Fixed Income. Correlation between CCaR Product Areas is considered being either -100% or 100%, thus capturing the absolute worst case scenarios for portfolios with products from different CCaR Product Areas. This however assumes that the worst case scenario lies in the extremes, where each market is stressed either 100% up or down. This is however typically the case.

The segmentation is verified by analyzing how the products in each CCaR Product Area behave under stressed market circumstances. Stressed market circumstances are determined by identifying occasions where each market's main product (in terms of open interest or volume) has a one day price move that exceeds a boundary level determined by a chosen percentile of returns.

For the CCaR Product Area "Swedish Equity", the OMXS30 index is considered being the main product in terms of volume and open interest. Using a look back period of almost 30 years and a liquidation period of 1 day, the boundary for the "Swedish Equity" look back period ends up being 7.9%. The remaining largest products of the CCaR Product Area are identified and their returns are calculated over the same look-back period. The days where the main product, OMXS30, exceeded the boundary are identified and the returns for all selected products are isolated for these days. The plot below shows how products in the CCaR Product Area behave when returns of the main product exceeds a boundary determined by the lower 99.9% percentile.



As seen in the plot, products pertaining to the CCaR Product Area “Swedish Equity” generally move in the same direction under stressed market circumstances. This statement was true for 95.3% of the observations in this example, and for 98.7% of the observations when the higher percentile of 99.9% was used. The significance of the correlation assumption is difficult to show, albeit data shows that correlation does exist. For computational reasons it is assumed that the correlation is 100% within each risk group. This correlation assumption is validated on an annual basis and is stress tested as part of the model stress testing framework where idiosyncratic risks are evaluated. Information on these model stress tests are found under model stress tests later in this document.

Basic and final stress scenarios

This section explains the Basic and Final stress scenarios which are important concepts in CCaR.

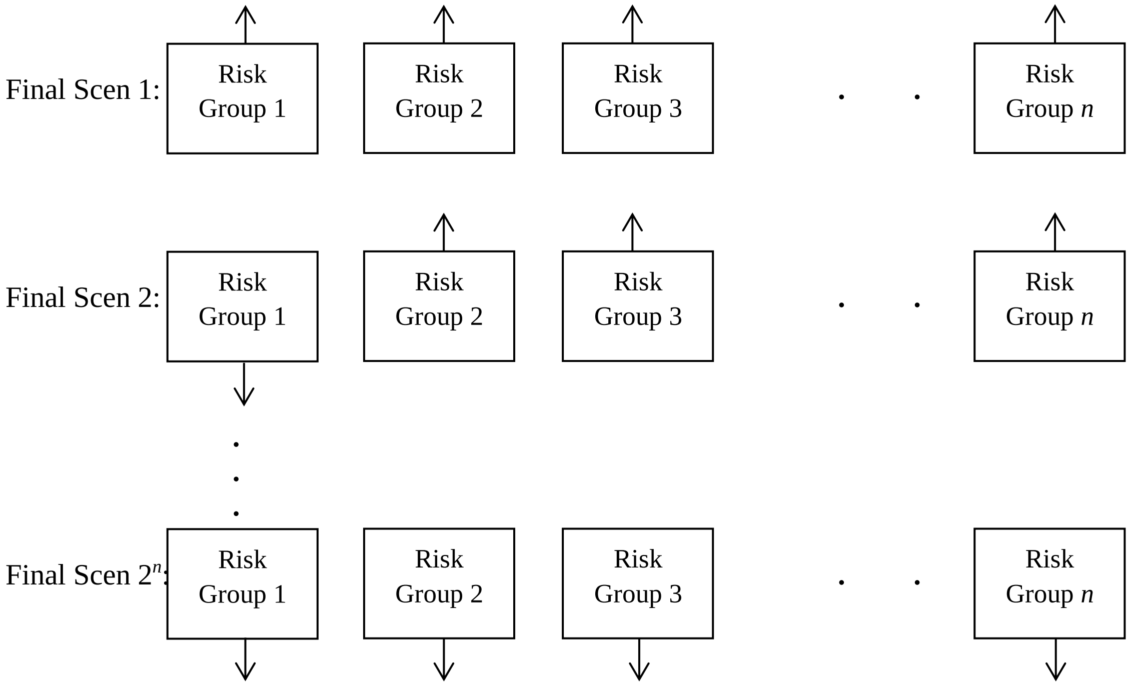
Basic scenarios are the stress scenarios that can take place within a single CCaR Product Area. For example, a basic scenario can be that the underlying price is stressed up for all products within the CCaR Product Area. Note that the magnitude of stress for individual instruments in the CCaR Product Area and basic scenario can be, and typically is, different. What is common for all instruments in a CCaR Product Area and a basic scenario is that underlying prices are stressed in the same direction (in this example up).

A CCaR Product Area can be assigned many basic scenarios, but the more basic scenarios per CCaR Product Area the more final scenarios will be created (see below how final scenarios are constructed). And due to computational feasibility (many final scenarios means heavy system load) and the fact that CCaR is used to model extreme events the typical setup is to have a few basic scenarios per CCaR Product Area. For equities a CCaR Product Area is typically assigned two basic scenarios (1 = full stress up and 2 = full stress down). For fixed income, where risk is calculated through stress of the yield curve, a typical setup is four basic scenarios (1 = parallel shift (PC1) up and slope change (PC2) up, 2 = PC1 up and PC2 down, 3 = PC1 down and PC2 up and 4 = PC1 down and PC2 down).

Final scenarios are the hypothetical scenarios that include all CCaR Product Areas, i.e. all cleared products. Since it is assumed under the stress test methodology that there is no correlation between products in different CCaR Product Areas, final scenarios are created by trying all combinations of basic scenarios for all CCaR Product Areas. For example, as the picture below clearly illustrates, if there are n CCaR Product Areas and each CCaR Product Area have 2 basic scenarios then 2^n final scenarios are evaluated.

Basic scenario 1: ↑ (stress up)

Basic scenario 2: ↓ (stress down)



Schematic description of CCaR hypothetical scenarios with two basic scenarios per CCaR Product Area

A feature with regards to CCaR final scenario construction is the ability to stress risk factors separately from account to account. This actually contradicts the purpose of the methodology, i.e. that all portfolios should be evaluated in consistent market (final) scenarios, but it is done so that the stress test loss per portfolio is maximized (i.e. the risk is over-estimated). This feature can be used to keep the number of final scenarios down to a feasible amount. A typical setup is to stress implied option volatility in such way, for example by setting three scenarios for implied volatility (1 = up, 2 = unchanged, 3 = down). In this example CCaR would produce three stress test loss sums per basic scenario and portfolio, but only the worst (highest) stress test loss per basic scenario and portfolio would be used in the final scenario calculations. Such setup means that one product can have its implied volatility stressed up and down at the same time, thus over-estimating the risk, but the number of final scenarios is greatly reduced.

Risk factors to stress

The risk factors to stress depend on the products and their expected behavior under assumptions of extreme level of market stress. As follows from the description above of how final stress scenarios are created, the more risk factors that are stressed the more final scenarios will be created. Only the most significant risk factors for each product type are subject to stress. There is no reason to waste computational power on stressing risk factors with no or little significance on the risk. For a derivatives CCP it is typically underlying prices for equity derivatives, commodity prices for commodity derivatives and yield curves for fixed income derivatives that are the significant risk factors. If options are cleared it is relevant to capture stress to implied option volatilities as well. If products in different currencies are handled then it is relevant to handle stress to FX rates.

Nasdaq Clearing has with regards to its product mix chosen to stress underlying prices and yield curves (PC1 and PC2) in the basic scenarios. Implied option volatilities and FX rates are also stressed, but separately from account to account.

Market	**Main risk factors**	Other **risk factors**	# basic scenarios per PA
Equities	Underlying prices	Implied vol, FX rates	2
Commodities	Commodity prices	Implied vol, FX rates	2
Fixed income	PC1 and PC2	Implied vol, FX rates	4

Historical simulation

A number of historical events are configured in CCaR. The methodology for defining the historical events as well as the methodology for the simulation is described above in section *Historical Market Scenarios*.

Currency stress

In CCaR the stress tests are pre-defined to be run in specific currencies. When converting derivatives exposures in a currency different from the CCaR run currency to the CCaR run currency, a currency risk stress is applied to each individual member's exposure. The conversion is done with a FX haircut to withstand extreme but plausible market conditions. It should be noted that the stress is done so that each individual member's hypothetical loss per stress scenario is maximized, i.e. it is not a stress that is consistent across all members and stress scenarios. This means that the total stress test loss measured in CCaR can be based upon a scenario where an exchange rate is stressed up for one member while the same exchange rate is stressed down for another. While such scenario is not likely to occur in reality it provides higher stress test losses (and thus higher clearing capital) than if FX risk would be modelled consistently across members.

Portfolio calculations

CCaR calculates the stressed market value for every stress scenario and portfolio. An account's stressed market value, *SMV*, for scenario i is the following, assuming that there is an amount of n CCaR Product Areas and calculated using prices p, positions PO and the set of stress parameters *Strpar*.

$$SMV_i = \sum_{j=1}^{n} MV(p_j, PO_j, Strpar_{j,i})$$

The set of stress parameters, $Strpar_i$, contains both EVT stress parameters, Par_k, and option volatility stress parameters, Vol_k, for every product k. For every product the stress parameter can assume either

Par_k or $-Par_k$, i.e. the product is either stressed up or down with a value corresponding to the stress parameter. The option volatility parameter can assume either Vol_k, 0 or $-Vol_k$. Once again, there is no correlation between option volatilities which means that for the same scenario *i* the option volatility for the same product can be stressed in different directions for different accounts. The matrix below shows the range of scenarios that are applied to each position.

Par, Vol	*Par, 0*	*Par, -Vol*
-Par, Vol	*-Par, 0*	*-Par, -Vol*

Individual CCaR values

CCaR is calculated for every stress scenario and counterparty. CCaR corresponds to the hypothetical collateral shortfall that arises when the stressed negative market value exceeds the available collateral after haircuts, *Collateral*. The collateral is capped to the margin requirement, *Margin*. The CCaR value for an account, *acc*, and scenario *i* is the following:

$$CCaR_{acc,i} = SMV_{acc,i} - \min[Collateral_{acc}, Margin_{acc}]$$

Once CCaR is calculated for every account, the CCaR values are aggregated by counterparty. Accounts are either client or house accounts, and the accounts are treated differently when aggregated as seen here below for scenario *i*.

$$CCaR_{Counterparty,i} = \min\left[0, \sum \min[0, CCaR_{Client,i}] + \sum CCaR_{House,i}\right]$$

As seen in the equation above, "positive" CCaR from client accounts cannot be used to offset CCaR from house accounts. Technically CCaR cannot be a positive value, and therefore an aggregated CCaR value over all CCaR Product Areas is set to 0 if positive. When CCaR is calculated for every stress scenario, the CCaR value that generated the greatest CCaR value represents the counterparty's individual CCaR.

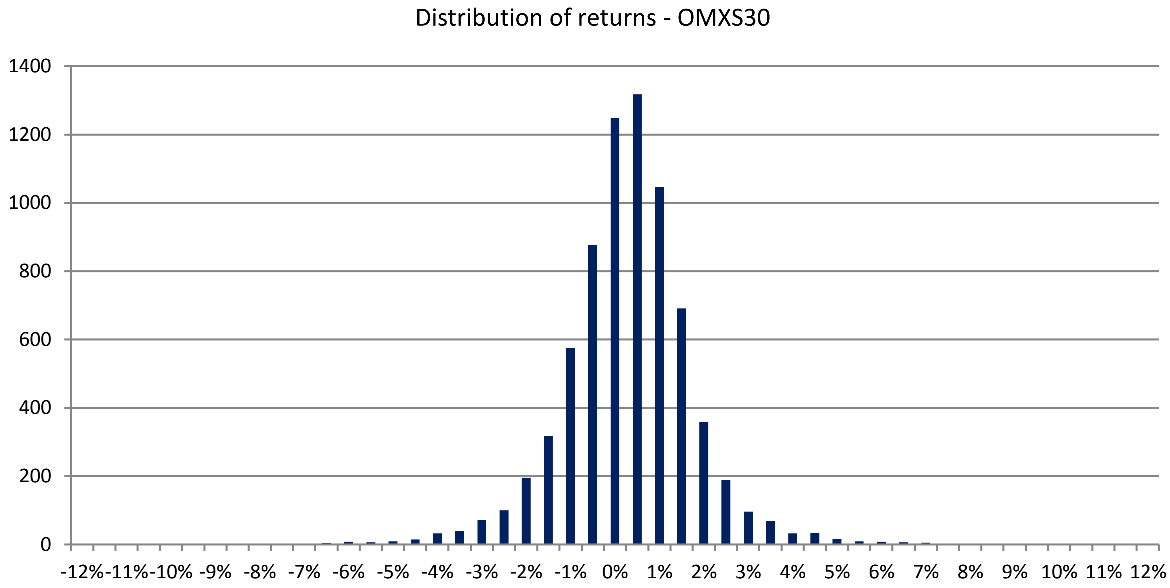
$$CCaR_{Counterparty} = \min_i\left[CCaR_{Counterparty,i}\right]$$

CCaR values

The size of Nasdaq Clearing's capital and its default funds are decided by the number of simultaneous defaults assumed. The CCaR value corresponds to the aggregated CCaR value for the counterparties that are assumed in default. When aggregating CCaR value from different counterparties, the values have to be selected from the same scenario. For example, if the top two counterparties are selected as basis for the CCaR calculations, the calculations are done by adding the top two counterparties in terms of CCaR for every scenario, and then choosing the scenario that generated the largest sum. The greatest aggregated loss determines the overall worst case scenario for that test and day.

Stress parameters

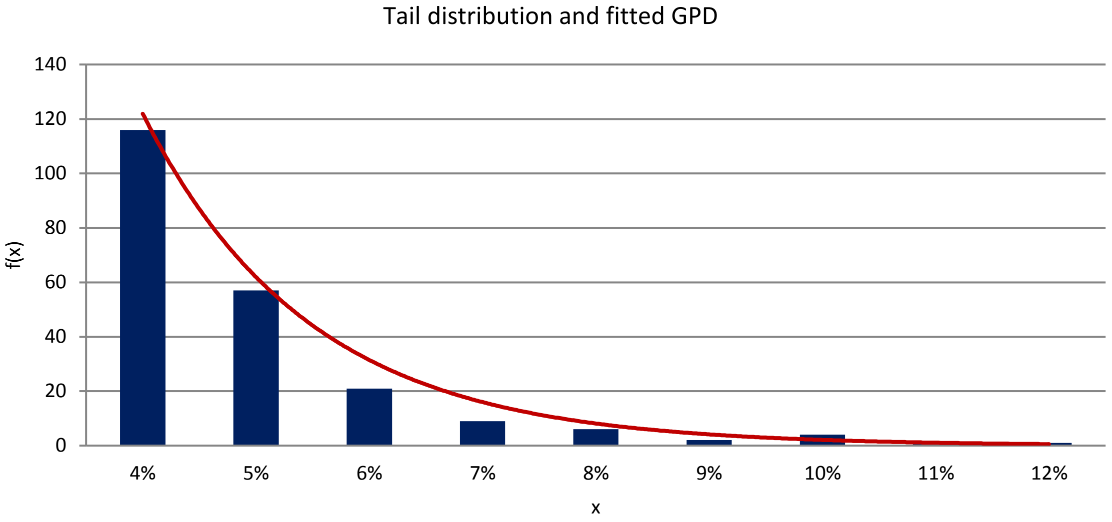
The stress parameters decide the stress intervals used in the basic stress scenarios. Individual stress parameters for all products to which Nasdaq Clearing has a material risk exposure are calculated using Extreme Value Theory (EVT). The parameters are based on the long-term historical tail risk of each product, where parametric functions are fitted to the tail distribution of historical returns. The POT (points over threshold) procedure analyzes all observations above a particular threshold, μ. Generalized Pareto Distributions are fitted to the distribution of these extreme events.



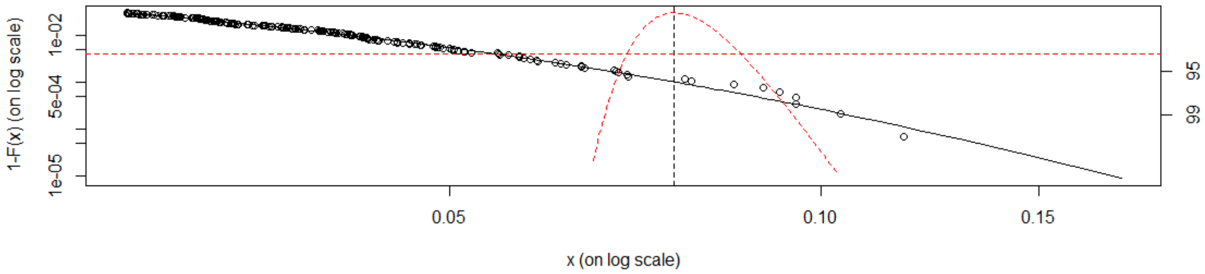
Two parameters decide the shape of the fit: the scale parameter, β, and shape parameter, ξ. The shape parameter is approximately a power-law type exponent that determines how far the tail extends into extreme values. Thus, the shape parameter determines crucially the level of tail risk for a particular product. The shape parameter allows the distributions to include Gumbel (shape parameter = 0), Frechet (shape parameter >0), and Weibull (shape parameter < 0) type distributions. The distribution function, *f(x)*, is the following:

$$f(x) = \beta^{-1} * \left(1 + \frac{(\xi * (x-\mu))}{\beta}\right)^{\frac{-1}{\xi}-1}$$

Fitting of financial data across equity index, stock, fixed income, and electricity markets yields very different results on the types of distributions that fit on the data (which in this case consists of empirically observed end-of-day returns). As the risk profile varies across assets, we should fully expect different products and asset classes to exhibit different shape parameters. The exponent measurement can be affected by the lack of extensive data in some instances, introducing sample bias. In order to mitigate this sample bias, all available historical data within the past 10 years is utilized. The distribution of OMXS30 returns in the plot above involves 29 years of data. The plot below shows the fitted distribution on the tail.



Given that a family of distributions is fit as part of the procedure, a good deal of model risk is incorporated in the EVT fit, in particular due to the fact that confidence levels are obtained around the measured percentiles. A variety of statistical techniques may be chosen to obtain the confidence levels around the percentile fit. Nasdaq Clearing has chosen to utilize the maximum likelihood method, which is one of the most conservative and widely utilized approaches, and it can produce, if necessary, asymmetric confidence boundaries around a percentile fit. The plot below shows the tail observations of OMXS30 on a logarithmic scale, with confidence boundaries around the 99.9% percentile. The confidence level is set at 94% and the EVT buffers are determined by where the boundaries cross the 94% line.



The EVT stress parameters used in the enterprise stress test, CCaR, does not use the EVT buffers. These buffers are instead used in the model stress testing as described under model stress tests in this document. The EVT percentiles are calculated for both the left and right tails of the distribution and the maximum percentile, *EVTP*, is chosen to be used as basis for the stress parameter. The liquidation period is also factored in:

$$Stress\ parameter = \max[EVTP_{left}, EVTP_{right}] \times \sqrt{t}$$

Given that the POT method is used to analyze the market data, the model risk introduced by choosing a particular threshold needs to be considered. Plots of both the shape and scale parameters as a function of threshold are produced, which can test the convergence and model risk involved in the results. Good convergence across data sets is generally observed, but it must be recognized that the confidence levels do in practice have some sensitivity to the threshold chosen. Due to this fact, it is reasonable to expect that most CCaR stress parameters results will not be known to better than 5% or 10% error, depending on how much data is available. To provide consistency, a special algorithm which automatically chooses the threshold is utilized by the EVT analysis. The aim is to obtain a sufficient amount of observations while staying far enough from the mean. The more data that is available, the further in the tail the sample is obtained without losing good statistical sampling. Generally, between 50 and 200 daily return observations are used directly as extreme value sample points for any given product. The model is designed to never use more than a 95% confidence level.

As mentioned earlier, not all stress parameters are based on the EVT methodology. For products to which Nasdaq Clearing does not have a material risk exposure, the stress parameters are set to a percentage of the margin individual margin parameters. The percentage or scale factor, *SF*, is determined by looking at the average ratio between calculated EVT parameters, *Par*, and margin parameters, *Mpar*, for the relevant CCaR Product Area *n*. This is shown in the equation below where the amount of products in CCaR Product Area *n* is *k*.

$$SF_n = \frac{\sum_{p=1}^{k} \frac{Par_p}{Mpar_p}}{k}$$

The stress parameters are calculated as seen in the equation below. All products *q* belong to the CCaR Product Area *n*.

$$Par_q = SF_n \times MPar_q$$

All stress parameters are subject to floor parameters. These floor parameters are either fixed at a certain level or fixed relative to margin parameters.

2. Model stress test: Market segmentation

The difference between this stress test and the financial resources stress test is the correlation assumption within CCaR Product Areas. As mentioned earlier, it is difficult to show the significance of this assumption, although products belonging to the same CCaR Product Area generally move in the same direction under stressed market circumstances. By not stressing all products simultaneously, this test helps identifying the idiosyncratic risks involved in the portfolios, i.e. the risk of extreme movements in one or a few products.

Basic stress scenarios

In this stress test the correlation in a CCaR Product Area's basic stress scenario can vary between 0% and 100%, where only adverse price movements for every underlying instrument, and counterparty, are taken into account. There is no correlation between individual underlying instruments in different accounts, other than the correlation ruled by the basic stress scenario. The equation for stressed market value is similar to that of CCaR. An account's stressed market value, *SMV*, for scenario *i* and CCaR Product Area *j* is the following, assuming that there is an amount of *K* products in CCaR Product Area *j* and that the market value is calculated using prices *p*, positions *PO* and stress parameters *Par*.

$$SMV_{i,j} = \sum_{k=1}^{K} \max\left[MV\left(p_k, PO_k, Par_{k,i}\right), MV\left(p_k, PO_k, 0\right)\right]$$

If there are *n* CCaR Product Areas, the stressed market value in scenario *i* for a specific account and is:

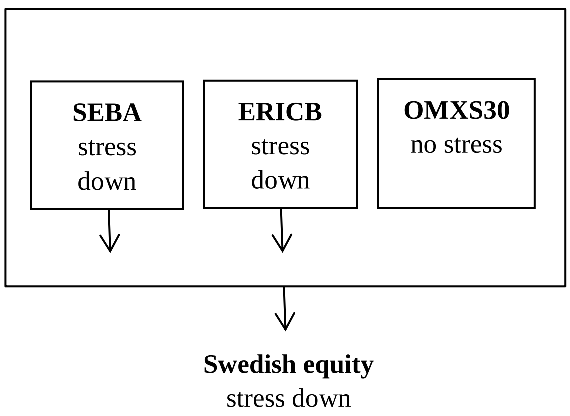
$$SMV_i = \sum_{j=1}^{n} SMV_{i,j}$$

As seen above, the only difference is that $Strpar_{j,i}$, the set of stressed parameters differs from customer to customer depending on the portfolio. If scenario *i* means that all products in CCaR Product Area *j* are stressed up, the parameters can be either 0 or *Par*, where *Par* is the stress parameter.

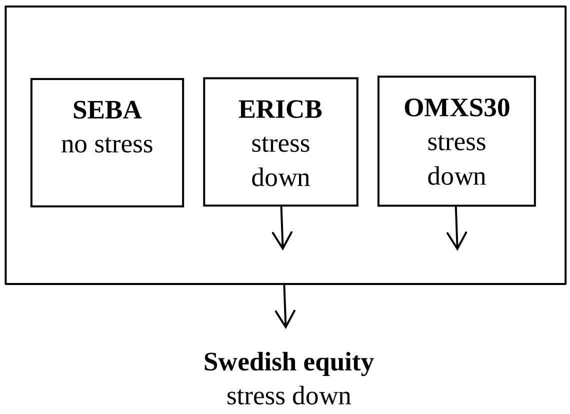
Example of basic stress scenario: Swedish equity stressed down

The example below shows the same basic stress scenario for two different counterparties.

<u>Counterparty A: Long SEBA, Long ERICB, Short OMXS30</u>



Counterparty B: Short SEBA, Long ERICB, Long OMXS30



3. Model stress test: Increased stress parameters

In this stress test CCaR is calculated using “stressed stress parameters. These parameters are calculated using either of the following approaches:

1. The liquidation period is increased by 1 day.
2. A confidence level is applied around the 99.9% percentile which is used as basis for the EVT stress parameter.

In the first set of parameters the liquidation period is increased to *t*+1 which makes the following change to the parameter equation:

$$Stress\ parameter = \max\left[EVTP_{left}, EVTP_{right}\right] \times \sqrt{t+1}$$

The second set of parameters uses the EVT buffers, *Buff*, derived from the confidence boundaries around the desired percentile, as described earlier in this appendix. The equation below reflects the change to the EVT stress parameters.

$$Stress\ parameter = \max\left[EVTP_{left} + Buff_{left}, EVTP_{right} + Buff_{right}\right] \times \sqrt{t}$$

The maximum of the two above parameters is chosen for each underlying instrument. CCaR is then calculated as usual using these increased stress parameters.

4. Model stress test: Number of simultaneous defaults

CCaR is calculated as usual. The only difference is that the number of simultaneous defaults assumed is increased by 1.

5. Reverse stress test: Stress parameters

CCaR is calculated using different sets of stress parameters. Each set corresponds to multiplier that is applied to all of the individual stress parameters. The table below is an example of a set of multipliers.

Set	Multiplier
1	120%
2	140%
3	160%
4	180%
5	200%
6	250%

CCaR for the various capital tranches is calculated. If the CCaR value for a set of stress parameters breaches the trigger level for a specific tranche, a final multiplier is determined using interpolation between CCaR results from the different sets. The table below shows an example of reverse stress test results.

Capital tranche	# defaults	Size	Multiplier
Default fund	Top 1 or 2+3	700 MSEK	122%
Clearing capital	Top 2	1 200 MSEK	134%
Clearing capital including assessment power	Top 2	1 500 MSEK	150%

The multiplier shows how much the stress parameters would have to increase in order to generate a breach.

6. Reverse stress test: Number of simultaneous defaults

CCaR is calculated as usual. For every scenario the top exposures in CCaR are aggregated until a capital tranche is breached. The scenario that breaches at the lowest amount of assumed defaults is chosen as the worst case scenario. The number of defaults for the various capital tranches corresponds to the amount of defaults the relevant tranche would withstand. Below is an example of the reverse stress test results.

Capital tranche	# defaults	Size	# of defaults
Default fund	Top 1 or 2+3	700 MSEK	2
Clearing capital	Top 2	1 200 MSEK	11
Clearing capital including assessment power	Top 2	1 500 MSEK	23

Appendix II – Historical extreme events

The historical extreme events, selected in accordance with the methodology described in section *Historical market scenarios* above, that are currently included in daily stress testing:

Date	Historical event	Affected markets	Market movement
1987-10-29	Stock market crash	Equity and fixed income	Equities down, rates down
2006-04-26	Allowances and power market crash	Power, allowances	Power, allowances down
2008-04-04	Bullish fuel prices	Power, allowances, fuel oil, freight	Power, allowances, fuel oil, freight up
2008-12-09	Post Lehman unrest	Equity and Fixed Income	Equities up, rates up
2012-06-07	Euro crises aftermath	Fixed income	Rates up
2011-06-05	Sharp decline in salmon prices	Seafood	Seafood down
2014-08-07	Import ban on Norwegian seafood to Russia	Seafood	Seafood down
2008-10-03	Financial crisis	Freight and fuel oil	Freight and fuel oil prices down
2011-03-15	Fukushima accident	European and UK power and gas	Power, wind index and gas prices down
2011-01-11	Low steel inventories	Steel	Steel prices up