

Margin Calculation Methodology

Securities Market

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Introduction

According to EMIR Art. 41 CCPA calculates initial margins to cover its credit exposure arising from market movements, mainly contributing to market risk and more general counterparty credit risk of the clearing of CCPA towards its members.

This document describes the methodology, process, parameters of the margin calculation for all cleared instruments ("ccp-eligible instruments") traded on Vienna Stock Exchange markets.

For all cash market instruments (equities, bonds, structured products) CCPA applies the same "risk-based margining" algorithm, but with different parameters.

Section 1 of this document describes the margin methodology as well as the determination of the main model parameters: The risk factor and the credit risk factor.

The risk factor is determined by using the following parameters according to the Commission Delegated Regulation (EU) 153/2013:

- Confidence interval (Reg. (EU) 153/2013, Art. 24)
- Time horizon for the calculation of historical volatility (Reg. (EU) 153/2013, Art. 25)
- Time horizon for the liquidation period (Reg. (EU) 153/2013, Art. 26)

Furthermore, CCPA's margin model uses an additional credit risk factor, which is based on the creditworthiness of the clearing members.

The document also explains how CCPA approaches portfolio margining (Reg. (EU) 153/2013, Art. 27) and how CCPA limits procyclicality effects (Reg. (EU) 153/2013, Art. 28).

Section 2 describes the process timing, frequency and monitoring of the margin calculation as well as the procedures for margin calls.

Section 3 summarizes all model parameters, which are subject to review by the Risk Committee on a regular basis.

The collateral management of CCPA (eligible collateral, determination of haircuts, collateral limits, etc.) is described in the <u>Collateral Policy Securities Market</u>.

1 Margin methodology

1.1 Risk-based margining

CCPA calculates the margin requirement of a clearing member on margin account level for net positions held therein, distinguishing each instrument. Netting is done on ISIN level for all open (i.e. not yet settled) positions.

This chapter describes:

- How the initial margin is calculated for a net position in a single instrument.
- How this methodology is used to calculate the margin on margin account level.
- CCPA's approach towards portfolio margining and correlations between instruments.
- Methods used to avoid procyclicality.

1.1.1 Definition of "potential loss"

In case of a default, CCPA has to close the non-segregated positions of the defaulting clearing member, e.g. sell or buy the respective financial instruments.

In case that the defaulting member has a short position, CCPA has the obligation to deliver (versus payment) securities to the buyer concurrently receiving the original settlement amount from the buyer. If the defaulting member fails to deliver the securities to CCPA, CCPA must buy them on the market. In case that the price is higher than the original price, CCPA will suffer a loss (market risk).

In case that the defaulting clearing member holds a long position, CCPA has the obligation to pay the original settlement amount to the seller concurrently receiving the respective securities. If the ultimate buyer fails to pay the settlement amount to CCPA, CCPA must draw on its liquidity pool to compensate the seller for the purchase. CCPA will then subsequently sell the securities received on the market to cover the liquidation loss. If the price of that sale is lower than the original price, CCPA will suffer a loss.

Accordingly, the ultimate objective of initial margin calculation is to estimate the potential loss, which is due to such a forced liquidation of positions, leaving the central counterparty potentially in deficit.

Definition:

Potential Loss := position parity (+/-) * (initial value of position – liquidation costs), where the position parity is (+1) for a long position (from member's view, e.g. the member was buying) and (-1) in case of a short position.

1.1.2 Risk-based margin components

To estimate the potential liquidation costs, CCPA utilizes standard risk-based margining.

The general margin calculation approach consists of the following steps. The first step is the determination of the initial value ($_{,\prime}$ IV") of the position:

$$IV = Q * Pt$$

where "Q" equals the quantity of the position (negative for short position, positive for long position) and "Pt" is the original price on trading day.

Current liquidation value ("CLV") of the position is determined by using mark-to-market valuation:

$$CLV = Q * P$$

where $_{u}Q''$ equals the quantity of the position (negative for short position, positive for long position) and $_{u}P''$ the last available market price.

The next step is to calculate the additional margin ("AM"), which covers the risk of adverse price movements until the time of liquidation. The calculation is based on the historical volatility of an instrument (estimated extend of future price movements) and the actual market price. With these parameters, the anticipated worst-case price of the instrument can be deduced.

For cash market instruments, the value is linear depending on its market price; therefore, in case of a member's short position, a price up movement will reflect the worst case (from CCPA's view). In case of a member's long position, a price down movement will reflect the worst case for CCPA.

Therefore, the additional margin is calculated as followed:

$$AM = Q * P * RF$$

in case of short positions, assuming an upside price movement and

$$AM = Q * P * (-RF)$$

for long positions, assuming a downside price movement.

"RF" equals the risk factor or margin parameter determined using historic volatility. The risk factor calculation algorithm is described in detail later on.

The liquidation costs ("LC") are determined by adding the additional margin to the current liquidation value of the position:

$$LC = CLV + AM$$

The risk-based margin ("RBM") for a position in a single instrument "i" is then calculated as

$$RBMi = max[(IVi - LCi); 0]$$

1.1.3 Initial margin per member margin account

To compute the margin per margin account, CCPA calculates the risk-based margin amount for each netted position on an instrument level. The sum of these values is the risk-based margin per margin account.

This amount is multiplied by an individual credit risk factor ("CF") per member, which reflects the different risk categories of a member. The risk category is set by CCPA based on yearly member credit assessment and/or on publicly available information on the clearing member and leads to a risk premium ranging between +10% and +30%. The second component, which the credit risk factor ("CF") is composed of, is the anti-procyclicality margin buffer of 25%.

The initial margin "IM" per clearing member's margin account is computed according to the formula

$$IM_{account} = CF * \sum_{i} (RBM_i)$$

for all instruments "i" which are held in the given margin account.

Thus, the initial margin calculation formula above involves the two most important parameters in margining: the risk factor "RF" (used for calculating the additional margin of individual instruments) and the overall credit risk factor "CF" (composed of the individual risk premium per member (10% - 30%) as well as the general margin buffer on market level (25%)).

1.1.4 Portfolio margin and correlations between instruments

The margin is calculated on a member margin account level. CCPA does not consider correlations between instruments. The margin requirement on an instrument level is always equal or greater than zero.

There is no positive offset for margin requirements in case of a profitable position (e.g. a position where the current liquidation would lead to a profit for CCPA).

1.1.5 Procyclicality rules

In their margin calculation policies, CCP's are required to take measures to prevent margin procyclicality – the risk that when volatility rises dramatically, margins rise exponentially in response and this may have an adverse effect on the liquidity of the clearing members.

To limit procyclicality effects, Reg. (EU) 153/2013, Art. 28 suggests the following methods:

- a) Applying a margin buffer of at least 25% to the calculated margin.
- b) Assigning at least 25% weight to stressed observations in the look-back period.
- c) Ensuring the margin requirement is not lower than those using a volatility estimated over a 10-year look-back period.

CCPA has implemented method a). The margin buffer amounts to 25% and is applied on the total calculated margin requirement per margin account. In periods, when calculated margin requirements are rising significantly, this margin buffer can be temporarily exhausted.

CCPA assesses possible procyclical effects of its margin requirements on a regular basis. For this purpose, the market volatility, and changes of the risk factors of the cleared instruments are analysed. Furthermore, significant short-term as well as on long-term changes of the overall margin requirements of the clearing members are detected and evaluated. When determining the potential procyclical effects, CCPA also takes the size of its cleared market and the overall capitalisation of its clearing members into consideration.

In case that the margin requirements have increased significantly due to high volatility and have reached the predefined thresholds, CCPA's General Management will consider exhausting the margin buffer. The exhaustion as well as the subsequent replenishment of the margin buffer shall be discussed with as well as approved by the Risk Committee.

1.2 Model parameters and input data

1.2.1 Risk factor algorithm for equities

The actual calculation of the risk factors is done within the "automatic procedure for margin parameters" ("PAMP"), which was developed by CC&G. This section provides information on the functions and methodologies used. The parameters used by CCPA can be found in section 3.

PAMP calculates the historic volatility taking into account historic price variations (real distribution) and, in addition, the statistic variation following the assumption of normally distributed price variations. Both methods can be applied by using several sets of parameters (look-back period, confidence interval and holding period). Each method and parameter set delivers a respective risk factor.

CCPA can define a range (a cap and a floor) for the final risk factor. This can be applied to groups of instruments or on a single instrument (ISIN) level.

Step 1:

Based on a price history, PAMP calculates the price variation for a given holding period "h" compared to the price at "t". The price variations "PV" are defined as followed:

$$PV \coloneqq \frac{Price_t}{Price_{t-h}} - 1$$

Step 2:

Real distribution approach of price variations: Based on the chosen time series to be analysed (typically 1 year or 600 days) and the confidence level (99%) to be covered through the calculation, the Risk Management Team sets the number of expected price variations in and out of the confidence interval. Depending on the settings, PAMP analyses the price variations starting with the last available price (current CCPA setting) or a different date.

Step 3:

After calculating the series of price variations, they are sorted by their absolute values. From this ordered set the minimum margin value "MinMar" (the highest observed variation inside the confidence interval) and the maximum margin value "MaxMar" (the smallest observed variation outside the confidence interval) is being derived.

Step 4:

Standard distribution approach: In addition to the above analysis, a normal distribution of the price variations is assumed with positive and negative price variations. The standard deviation of the observed distribution " σ " is used to derive the 99 % value of the 'normally distributed' price variations, by multiplying the measured standard deviation " σ " of the observed distribution with the factor 2,57583 (i.e. the 99% quantile of the standard deviation). The parameter derived from this analysis is defined as normal margin value "NorMar".

Step 5:

The risk factor "RF" of a given instrument "i" is then as follows.

$RF_i = \max(MaxMar; NorMar)$

All parameters are rounded as specified in the PAMP parameter rounding precision "RP".

Step 6:

The risk factor analysis is performed simultaneously for an instrument on more than one set of parameters (e.g. for different look-back periods), still delivering one "RF" for the instrument analysed. The respective resulting risk factor is then defined as the maximum of the individual risk factors per parameter set.

Step 7:

Finally, the predefined cap and floor values for the risk factors are applied to the calculated "RF". If the parameter falls in the allowed floor/cap interval for risk factors, then the risk factor, derived through the procedure of steps 1-6, will be fixed. Otherwise, the respective floor or cap settings overwrite the calculated "RF" accordingly.

1.2.2 Example

	Parameter set 1	Parameter set 2
Look-back period	1 year	600 days
Holding period	3 days	3 days
Confidence interval	99%	99%
Risk factor floor (RF_Floor)	5%	5%
Risk factor cap (RF_Cap)	99%	99%
Risk factor default (when price history < 100 days)	25%	25%

CCPA is currently using the following parameters for equities:

Table 1: Risk factor parameters for equities

Remark: EMIR requires a holding period of at least 2 days and a confidence interval of at least 99%.

For a given look-back period of 600 days¹ and a required confidence interval of 99%, there are 594 events of distribution within the confidence interval and 6 outside of the confidence interval.

¹ In case of a look back period of 253 days, the events out would be 3, thus position 3 would deliver the "MaxMar" and position 4 the "MinMar".

The table below shows the sorted price variations "PV" (absolute values). Position 6 (the first outside of the confidence interval) represents the maximum margin value, position 7 (the last inside of the interval) the minimum margin value.

ABS(PV)	Sorted position
16,00%	1
15,40%	2
12,18%	3
11,95%	4
11,45%	5
11,02%	6
10,44%	7
9,04%	8
8,92%	9

Table 2: Price variations

Having defined the rounding precision set to 2 decimals,

Assume the standard deviation of all variations for 600 days is 0,02798, so the

NorMar = 2,5758 * 0,02798 = 7,71%

For comparison, a parallel analysis of the PV series based on a holding period of 253 days delivers the following set of parameters:

Thus (comp. step 7), the final risk factor will be:

$$RF = \max(RF^{600}; RF^{253}) = 12,18\%$$

with $RF^{600} = \max(11,02\%; 10,44\%; 7,71\%)$ and $RF^{253} = \max(12,18\%; 11,95\%; 6,01\%))$

1.2.3 Risk factor algorithm for bonds, certificates and warrants

Approximately 98% of the turnover cleared by CCPA is executed in equities and equity-like instruments. In general, due to their liquidity, equities are attributed with high quality (continuous) time series data. For margin calculation of these most important cash products, CCPA applies the risk factor calculation based on volatility distributions of the single instrument as described in 1.2.1.

Besides equities, CCPA clears the product categories bonds, warrants, and certificates, which are marked by a high number of instruments (> 9.000) but on a very low volume. Due to the poor quality of price data, a dynamic risk factor computation based on price variations of the single instrument will not deliver reliable results. Therefore, CCPA applies a specific bulk risk factor - bulk risk factor per category. For the analysis purposes, the price volatility data of all instruments in a given category were consolidated.

Look-back period

The currently used bulk risk factors have been derived from historical (T+3) analyses of price data during a look-back period, which includes the most extreme market conditions observed during the last 30 years. On the Austrian market, this was the case in Autumn/Winter 2008, the period after the Lehman collapse.

Holding period

CCPA clears all products within T+2. Therefore, margining the products with 99% confidence level for a holding period T+2 would be the minimum as required by EMIR Art. 41. To be on the safe side, CCPA uses a holding period of T+3 for risk factor determination of equities and equity-like instruments.

CCPA has also conservatively chosen to base the risk factor determination of certificates and warrants on the T+3 volatility distributions and for bonds on the T+5 volatility distributions (that means one/three more days for possible close-out).

Bulk risk factors

CCPA compiled volatility data per product category: 0,7 million bond price variations, 4,6 million certificate price variations and 2,5 million warrant price variations² from the beginning of 2008 and derived 99% confidence levels for each of the T+1, T+2, T+3 (equities, certificates and warrants) respectively T+2, T+3, T+4 and T+5³ (bonds) distributions.

In addition, CCPA has analysed the distribution of corporate bonds with maturities above 5 years separately, as long-term corporate bonds are more likely to show higher volatility as the average government bonds⁴.

The historic analyses performed for all the product categories showed that the following bulk risk factors, currently used by CCPA, are conservative and well above the long-time 99% confidence levels:

Category	Bulk risk factor	Holding period	Confidence level
Bonds	9,50%	T+5	99,46%
Certificates	35,00%	T+3	99,238%

² For bonds only, real trading prices were used, for warrants and certificates also Price without Turnover (PwT) prices were used.

³ T+5 holding period was used only for bonds, because of the very low number of prices.

⁴ However, the analysis of the long-term time series (2008-2015) did not show any significant difference in the volatility distributions.

Warrants	99,99%	T+3	99,005%
Table 3: Bulk risk factors			

Outlook

Such analyses are performed on a regular basis⁵. Furthermore, all risk factors per ISIN are subject to regular back testing and, if needed, the bulk risk factors will be adjusted accordingly.

1.2.4 Price feed

For the risk factor calculation, PAMP requires a daily price feed to build up a price history. CCPA imports the daily closing price for each instrument, which is provided by the Vienna Stock Exchange. In case that no actual closing price is available on a given clearing day, the last available price, which has already been imported in PAMP, is used to build the daily price history.

If the historic price series is shorter than the predefined minimum length price series (CCPA's setting is 100 days), the calculation is skipped and the default risk factor of 25% (CCPA setting) is applied.

1.2.5 Credit risk factor

According to the result of the credit rating, each participant is designated to a rating category. CCPA's General Management defines a rating surplus for each risk category.

Additional surpluses to cover additional risks can be added or multiplied to the rating surplus in order to achieve a single credit risk factor per member.

1.2.6 Parameters currently used by CCPA in PAMP

Equities:

	Parameter set 1	Parameter set 2
Look-back period	1 year	600 days
Holding period	3 days	3 days
Confidence interval	99%	99%
Risk factor floor (RF_Floor)	5%	5%
Risk factor cap (RF_Cap)	99,99%	99,99%
Minimum length price series	100 days	100 days
Risk factor default (when price history < 100 days)	25%	25%

⁵ Last review for bonds, warrants and certificates in Jan 2016, back tests on single instrument level are executed monthly.

Table 4: Parameters for equities in PAMP

Bonds:

	Parameter set 1	Parameter set 2
Look-back period	1 year	600 days
Holding period	3 days	3 days
Confidence interval	99%	99%
Risk factor floor (RF_Floor)	9,5%	9,5%
Risk factor cap (RF_Cap)	9,5%	9,5%
Minimum length price series	n.a.	n.a.
Risk factor default (when price history < 100 days)	9,5%	9,5%

Table 5: : Parameters for bonds in PAMP

Certificates:

	Parameter set 1	Parameter set 2
Look-back period	1 year	600 days
Holding period	3 days	3 days
Confidence interval	99%	99%
Risk factor floor (RF_Floor)	35%	35%
Risk factor cap (RF_Cap)	35%	35%
Minimum length price series	n.a.	n.a.
Risk factor default (when price history < 100 days)	35%	35%

Table 6: : Parameters for certificates in PAMP

Warrants:

	Parameter set 1	Parameter set 2
Look-back period	1 year	600 days
Holding period	3 days	3 days
Confidence interval	99%	99%
Risk factor floor (RF_Floor)	99,99%	99,99%
Risk factor cap (RF_Cap)	99,99%	99,99%
Minimum length price series	n.a.	n.a.

Risk factor default (when price history < 100 days)	99,99%	99,99%
Table 7. Parameters for warrants in PAMP		

The credit risk factor per rating category:

Rating category	Rating surplus	Operation	Additional surplus	Credit risk factor
1 to 5	10%	+	25%	35%
6 to 7	20%	+	25%	45%
8	30%	+	25%	55%

Table 8: Credit risk factor per rating category

Example: For a clearing member in rating category 6 the according credit risk factor is CF = 1,45 (i.e. 1 + 20% + 25%), for a member in rating category 3 the following applies CF = 1,35.

1.2.7 Confidence levels

The analysis shows that CCPA's margin methodology is highly effective. The methodology represents a fundamentally conservative approach by applying effective risk factors for the margining process, all having sound confidence levels of well above 99,35% for the margining process.

Calculation of confidence levels for the product categories bonds, warrants and certificates as of January 2016:

		20	08	Vola applied	CL (effect)	Procyclicality Shield		Credit Rating applied	
		99% (T+3)	CL (T+2)		T+2	1,25 applied	1,25 applied CL (eff.) CL (ef		(eff.)
								10%	30%
Equities	RV	21,67	99,163%	indiv.	99,163%	indiv. * 1,25	99,434%	99,543%	99,760%
Bonds (T+5)*	RV	6,80	99,137%	8,0%	99,224%	10,0%	99,371%	99,429%	99,546%
C.Bonds (T+5)*	RV	6,15	99,078%	8,0%	99,160%	10,0%	99,250%	99,286%	99,358%
Certificates	RV	31,86	99,154%	35,0%	99,238%	43,8%	99,471%	99,564%	99,750%
Warrants	RV	122,67	99,231%	100,0%	99,005%	125,0%	99,254%	99,354%	99,552%
*) because of the relatively small dataset (~ 680k prices) CCP.A chooses as reference a longer close out period (t+5 instead of t+3)									

central CCPC counterparty

2 Margin calculation process

Timing and frequency 2.1

The "risk factors" are calculated and updated on a daily basis. The margin calculation is done several times during the day upon each change in open positions (after new trades have been loaded or positions, which have reached the settlement date, have been settled). The margin calls are generated after each margin run.

Currently, CCPA performs two margin runs during the day (IM01 and IM02) and the final margin run (IMFF) at the end of the day. At each margin run the current position is calculated taking into account all trades which are not settled by that time. This includes trades from previous days, pending positions as well as new trades from the current trade date.

Immediately after each margin run the clearing members can view their updated margin and collateral values in the GUI and receive the SWIFT margin reports (ISO messages). The following times are indicative when members will receive details of the completed margin runs. CCPA reserves the right to perform further margin runs if necessary.

- 11:00 1st intraday margin run (IM01)
 - Excluding all balances settled so far and
 - Including all new trades concluded up to that time
 - 14:30 2nd intraday margin run (IM02)
 - Excluding all balances settled so far and
 - Including all new trades concluded up to that time
- 18:30 Final margin run (IMFF)

Daily schedule:

Including all trades of the trading day



Margin call procedures 2.2

After each margin run, the margin requirement is compared with the pledged collateral (valued according to the Collateral Policy Securities Market). The reconciliation ends in one of the following results:

- Margin call
- Margin deficit

• Margin surplus

2.2.1 Margin call

A margin call is created, if

margin requirement - pledged collateral > threshold.

During the final margin run at the end of the day, the threshold is zero, and a margin call is created, whenever the collateral is not sufficient to cover the margin requirement. During intraday margin runs, the threshold is the tolerance limit for intraday margin debit. The parameter is set as an absolute value or as a percentage share of the margin requirement.

The current tolerance limits of CCPA are EUR 50.000,00 (this is the minimum default fund contribution for each participant) or 10 % of the margin requirement.

In case of a margin request and margin calls, the member has to deposit additional collateral to fully cover the margin requirement. Intraday margin calls have to be fulfilled in the timeline specified by CCPA.

2.2.2 Margin deficit

A margin deficit is created after an intraday margin run, if

margin requirement - pledged collateral \leq threshold.

As there is no threshold during the EOD margin run, there are no margin deficits at the end of the day. In case of a margin deficit, the participant receives a warning, but an increase of collateral is not required.

2.2.3 Margin surplus

A margin surplus is created after each margin run, if

margin requirement \leq pledged collateral.

Up to the amount of the surplus, the collateral can be released upon request after the 2nd intraday margin run. A collateral surplus higher than EUR 1.000.000,00 can be released upon request after the 1st intraday margin run. CCPA does not automatically release collateral surpluses.

2.3 Monitoring

The daily processing of each margin run is closely monitored by CCPA via the clearing system. In case of any errors during the process, error notifications are automatically generated and sent to CCPA's Operations Team.

CCPA periodically (at least monthly) generates risk reports to monitor the development of the margin requirements. These reports enable CCPA to identify unusual changes on margin levels (e.g. margin requirements drop or rise significantly during a period) or changes in distribution of margin requirements on member level.

The average margin requirements as well as the number of collateral transactions are monitored by CCPA during the calculation of the collateral management fees according to CCPA's <u>Schedule of Fees Securities</u> <u>Market</u>.

CCPA prepares monthly risk reports for CCPA's General Management, which include figures about the distribution of margin requirements amongst members, the collateral composition and other information.

CCPA publishes figures on the calculated margins and the collateral portfolio on its website as part of the <u>CPMI-IOSCO Public Quantitative Disclosure</u>.

3 Model parameters

Process	Parameter	Effective value	Last update	Last review
Risk factor on ISIN level	Look-back period	600 days, 1 year	Feb 2005	Oct 2024
	Holding period	3 days	Dec 2014	Oct 2024
	Confidence interval	99%	Feb 2005	Oct 2024
	Risk factor floor	5%	Feb 2005	Oct 2024
	Risk factor cap	99,99%	Apr 2013	Oct 2024
	Minimum price length for risk factor calculation	100 days	May 2014	Oct 2024
	Risk factor default (when price history < 100 days)	25%	May 2014	Oct 2024
Anti-procyclicality on market level	Margin buffer	25%	May 2014	Oct 2024
Credit risk factor	Rating surplus per risk category	10 - 30%	2008	Oct 2024
	Operation to generate credit risk factor cash market	+	Apr 2013	Oct 2024
Intraday margin call threshold	Fixed threshold: Amount in EUR	EUR 50.000		Oct 2024
	Dynamic threshold: % of margin requirement	10%		Oct 2024

Table 9: Parameters for calculating margin