

Spotlight on: CCP Risk Management

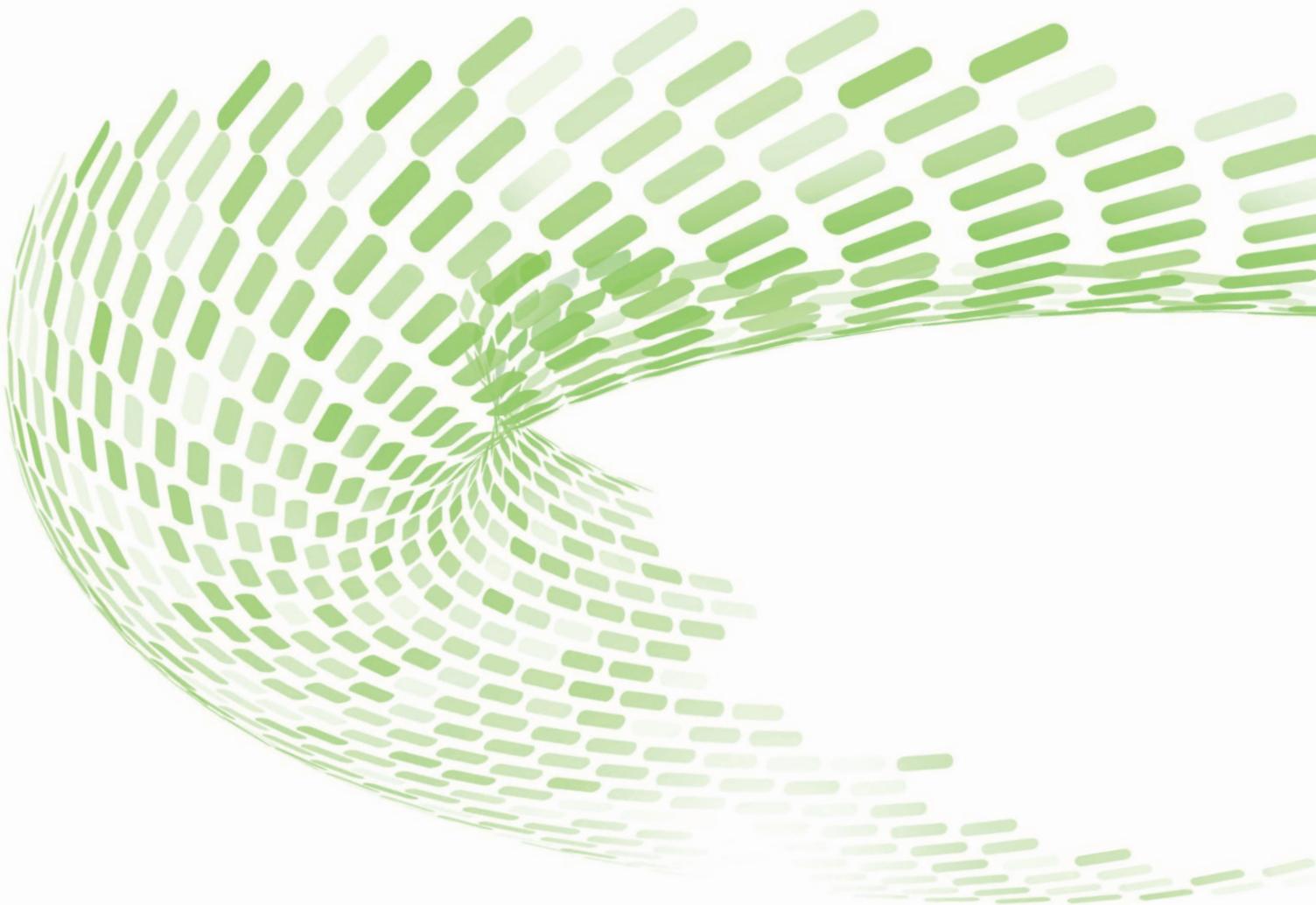


Table of contents

03 Executive summary

06 Financial risks

06 Credit risk

07 Member admission

09 Member monitoring

12 Margining

15 Stress testing

18 Default management

20 Model validation

22 Liquidity risk

24 Market risk

25 Operational risks

27 Contacts

Executive summary

Eurex Clearing's Risk Management approach

Eurex Clearing faces various types of risk and has comprehensive risk management policies and services in place to promote the integrity, transparency, efficiency and the safety of financial markets. While credit risk, related to the core clearing business, is the most significant risk of a central counterparty (CCP), other types of financial and operational risks also require strict management and mitigating measures.

Eurex Clearing is authorized as a CCP under the European Market Infrastructure Regulation (EMIR) since 10 April 2014. The authorization as EMIR-compliant CCP also determines Eurex Clearing as a qualifying CCP (QCCP) under Basel III / CRD IV. Eurex Clearing performed an assessment of its compliance with the "Principles for financial market infrastructures" (PFMI) published by the Committee on Payment and Settlement Systems (CPSS)¹ and the Technical Committee of the International Organization of Securities Commissions (IOSCO) in April 2012. The assessment was conducted in accordance with the CPSS-IOSCO assessment methodology and disclosure framework. Based on the results of this assessment, Eurex Clearing is of the opinion that it fully observes all PFMIs.

The focus of this document is to provide an overview of Eurex Clearing's risk management approach. The risk management framework ensures that all relevant risks are adequately reflected and managed carefully.

CCPs have evolved historically as mechanisms to ensure settlement of trades, including when members default. The carefully designed incentive structure is now also enshrined in legislation and regulation as it is seen as best practice to make financial markets more safe and resilient compared to traditional and bilateral markets. CCPs are risk managers, but not risk takers. Only in a case when a member defaults does the CCP have a position.

The position arising from the inherited portfolio needs to be liquidated quickly in order to be rebalanced again, but without disrupting the wider market.

About Eurex Clearing

Eurex Clearing serves about 207 Clearing Members in 22 countries, managing a collateral pool of EUR 53 billion and clearing trades valued at EUR 10 trillion every month. A broad scope of products is covered under a single framework. The scale and scope of the cleared products ensure that the clearing community benefits from margin efficiencies – making trading capital efficient for a large variety of markets and products:

- Eurex Exchange
- Eurex OTC
- Frankfurt Stock Exchange
- Irish Stock Exchange
- Eurex Repo
- Securities lending

Client asset protection is one of the most important goals of Eurex Clearing. Therefore, Eurex Clearing offers different Clearing and Segregation Models which suit the needs of both sell and buy side. Each model is carefully designed to be flexible, reliant, safe and efficient.

www.eurexclearing.com

¹ In 2014, the CPSS changed its name to Committee on Payments and Market Infrastructures (CPMI).

The daily exchanges of variation margin and initial margin payments ensure that market participants only take on positions for which they are prepared to collateralize. CCPs must therefore ensure a close monitoring of their counterparts and make sure that the models applied capture all risks associated with the members' positions.

Given their central position, CCPs reduce the interconnectedness between different financial institutions, but explicitly link them to mutualize tail-risk in the most extreme circumstances via Default Funds maintained at the CCPs.

Like any other corporation, for a CCP there are two main risk categories: **financial** and **operational** risks it has to manage. Given the nature of the CCP's core business, (counterparty) credit risk is the most significant risk which is also subject to several prudent regulations.

Risk categories

Financial risks

Credit risk

Liquidity risk

Market risk

Operational risk

Financial risks

materialize in case a counterpart defaults on its contractual obligations towards the CCP or in case financial instruments held by the CCP are impaired by unfavourable market conditions. In order to mitigate the impact and possible losses due to **credit risks** out of the primary CCP business, Eurex Clearing defines prudent admission requirements for Clearing Members. This first safeguard ensures that only entities with sufficient credit quality can become a direct counterparty to the CCP and facilitate Eurex Clearing's goal to keep the overall credit quality of the member base high. Margins are the second safeguard as they substantially reduce the losses given a default. Moreover, additional lines of defense including a Default Fund are a third safeguard to reduce the negative impacts as they cover losses exceeding the margin requirements through loss mutualization among the clearing community including the CCP.

Credit risks related to treasury activities are mitigated by placing cash preferably against sufficient and acceptable collateral of the highest quality. Eurex Clearing applies placement limits as well as strict admission criteria on treasury counterparties.

Liquidity risks arise from the inability to meet short-term and long-term payment obligations for example due to potential gaps between liquidity needs and available financial resources. Therefore, liquidity requirements are closely monitored and complemented by regular liquidity stress tests. Early warnings as well as recovery triggers combined with adequate mitigating measures have been defined to detect and prevent potential liquidity shortfalls. In addition to the access to central banks for all clearing currencies, Eurex Clearing has a strict scheme to limit term transformation in place to actively manage its liquidity situation.

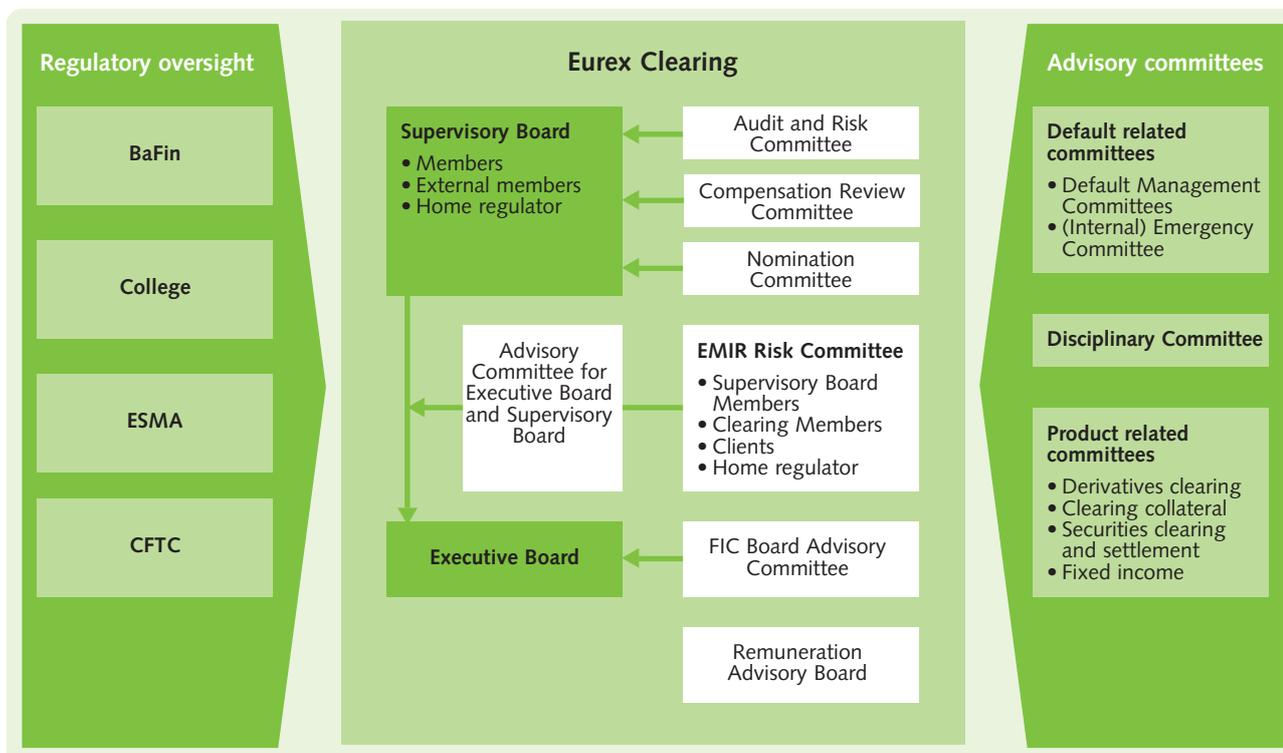
Market risks are mostly related to treasury placements and may arise from holding assets and liabilities with different maturity dates, which create an exposure to changes in the levels of interest rates, foreign exchange rates or market prices. Given its strict investment policy, Eurex Clearing is neither exposed to any material interest rate, nor to foreign exchange and market price risks. Interest differential between cash margins owed to Clearing Members and investments is limited and currency mismatches are to a large extent avoided.

Operational risks

are an integral part of the business model. They result from inadequate or failed internal processes, people and systems or from external events. In particular, the unavailability of systems is mitigated by setting up emergency and contingency plans. Moreover, insurance and other mitigating measures are in place in order to reduce legal and information security risks.

Besides a sound risk management for all cleared markets, Eurex Clearing has a strong and reliable governance framework in place which is essential to honour its systemic role. In the course of the implementation of EMIR, Eurex Clearing revisited the statutes of its well established Risk Committee to advice on risk-related matters in a regulatory framework. Like any other corporation in Germany, Eurex Clearing maintains a two tier board structure (Executive Board and Supervisory Board) to add additional safeguards and to set incentives appropriately. External stakeholders like regulators and advisory committees complete the governance structure and ensure that also clients and policy makers are consulted prior to any material change. Figure 1 depicts this governance structure and further outlines how different committees and bodies are composed:

Figure 1: Eurex Clearing's governance framework



Eurex Clearing publishes its PFMI Assessment and a comprehensive set of quantitative data on its website:

www.eurexclearing.com/clearing-en/about-us/regulatory-standards

Financial risks

Credit risk

Eurex Clearing's business model is to mitigate counterparty credit risks, which is achieved through netting, collateralization and the Default Fund. As risk managers with their neutral position, CCPs can objectively validate and monitor risk positions and substantially reduce systemic risk by dissolving interconnectedness in bilateral markets. Due to their central and thus systemic role, CCPs need to enforce strict risk controls and adequate collateralization of all open positions.

Eurex Clearing is classified as a systemically important Financial Market Infrastructure (FMI) in multiple jurisdictions. To ensure the integrity of financial markets, Eurex Clearing has a prudent counterparty credit risk management framework in place. The cornerstones of this framework are:

CCP risk management functions

Member admission

Monitoring

Margining

Stress testing

Default management

- **Prudent admission requirements** (e.g. regulatory oversight) for all Clearing Members ensure that every counterparty has sufficient credit quality and financial strength. This is achieved by applying proven credit rating models and tight monitoring of the creditworthiness of all active counterparties.
- A timely and **comprehensive monitoring** in order to identify, manage and control credit, concentration and wrong-way risks. A prudent limit model is in place to manage the exposures of counterparties with lower credit quality very carefully and avoid excessive exposure and build up of leverage by such counterparties. In addition, real-time risk calculation and intraday margin call processes, subject to very tight timelines, ensure a prompt identification and mitigation of counterparty credit risks.
- State-of-the-art **margining** models to collect sufficient margin at all times. Variation and initial margin are one of the most important elements in a CCP's risk management toolbox as they significantly reduce counterparty credit risk by sufficient collateralization. Margins are independent of the counterparty's creditworthiness and are hence the same for a fixed portfolio. As each Clearing Member shall be obliged to "pay for its own default", concentrated portfolios generally have a higher margin requirement than diversified portfolios. Again, the real-time risk management system is in place to allow calling for additional margin, intraday, if a margin shortage occurs.
- Additional post default backings (i.e. the lines of defense) to cover risks beyond the confidence level of the applied margining methodology. The adequacy of the lines of defense is validated on a daily basis via **stress tests** and mitigating actions to reduce large stress losses. The stress testing program is in line with the corresponding regulations and ensures that the post default backings are sufficient to cover losses caused by a hypothetical default of the largest two Clearing Member groups ("cover-2").

- A sound **default management process** which is subject to regular fire drills. In case of a Clearing Member default, Eurex Clearing's principle objective is to protect other Clearing Members and minimize the harm to their end clients. A standardized and efficient process helps to quickly rebalance the CCP again without disrupting the wider financial markets.

Eurex Clearing validates all areas of its risk management framework on a regular basis. A dedicated team is responsible to perform **model validation** and uses a comprehensive toolset including Back Testing and Sensitivity Testing.

In the following, all of the elements mentioned above are discussed in more detail in dedicated chapters.

Member admission

Strict admission criteria are the first safeguards and ensure that only entities with the required operational capabilities and sufficient credit quality participate. This ensures a high credit quality throughout the entire member base and reduces the likelihood of utilizing the mutual Default Fund.

Potential Clearing Members have to prove that they fulfil Eurex Clearing's admission criteria across three different areas:

Admission criteria

Regulatory & legal

Operational & technical

Financial

Regulatory & legal prerequisites

The prospect Clearing Member needs to be supervised by the competent authority according to the applicable regulatory standards of the EU or the Swiss Financial Market Supervisory Authority or the competent authorities according to the standards equivalent to the applicable regulatory standards.

In addition, the entity needs to have permission to provide credit to customers in relation to transactions and receive collateral in the form of cash or securities in its country of domicile. Membership is restricted to jurisdictions where Eurex Clearing offers its services.

Operational & technical prerequisites

In order to ensure smooth operations at all times, Clearing Members need to have at least one sufficiently qualified clearing staff member per Clearing License in order to fulfil intraday margin calls and other emergency operations during the complete business day of the respective market.

Additionally, appropriate technical equipment to ensure the orderly recording, booking and supervision of all transactions, as well as the provision of margin and the calculation of margin requirements need to be available. The technical connection to all relevant systems of Eurex Clearing has to be ensured at all times in order to react in a timely manner.

Each prospect Clearing Member needs to prove that it has a securities and/or cash account for the delivery of margin collateral as well as securities settlement accounts in case a Clearing License shall be obtained for a market where physical delivery of securities is possible.

Financial prerequisites

Prior to admission, a comprehensive credit risk assessment is performed for each prospect Clearing Member. For banks, this assessment is based on the CAMELS rating methodology and takes into consideration among others:

- Capital adequacy, which is measured by different capital ratios;
- Asset quality, which is mainly derived from the ratio of impaired loans to total loans;
- Management ability, which is measured by the transparency of the information which is publicly available or is provided upon request;

- Earnings mainly assessed via the cost to income ratio;
- Liquidity, as a measure of loans compared to customer deposits; and
- Sensitivity to market risk, which is estimated by the sensitivity of loans to interest rates.

In order to assess these categories, credit analysts use the FACT scoring model in order to assign an internal credit rating. External ratings are used to benchmark the internal methodology and validate the individual ratings. In addition to qualitative factors, the credit analysts also assess qualitative factors such as:

- Operating environment
- Market position
- Business model
- Transparency

The rating score is mapped to a credit rating scale of eleven main grades, ranked in an ordinal way from the strongest quality (AA) to the weakest (J). These eleven main grades are additionally mapped according to Figure 2 into a colour classification.

Figure 2: Mapping of colour classifications

Internal rating	Risk classification
Investment grade	Green
	Yellow
Sub-investment grade	Orange
	Red

The internal Credit Committee advises the Executive Board on credit risk-related matters and recommends whether or not to grant a clearing licence and which colour classification to assign, based on the comprehensive risk assessment.

This colour classification is required for further risk management functionalities such as credit, concentration and wrong-way risk limits. Please refer to the chapter “Member Monitoring” for a more detailed overview. In addition to the internal credit rating, each prospective Clearing Member also needs to prove sufficiency of funds. The requirement is based on a static component per Clearing Licence and a dynamic component which is a fraction of the average initial margin requirement over the last 30 or 250 business days.

Moreover, each Clearing Member needs to contribute to the Default Fund, which is also determined by the maximum of a percentage of average initial margin requirements and a licence dependent minimum contribution.

Member monitoring

After admission, Eurex Clearing applies a broad range of tools to identify, monitor and mitigate risks. The instruments and products cleared are thoroughly evaluated so that an adequate assessment of the risk position of each Clearing Member is possible and beyond that, concentrations and other unfavourable constellations on the CCP level can be monitored.

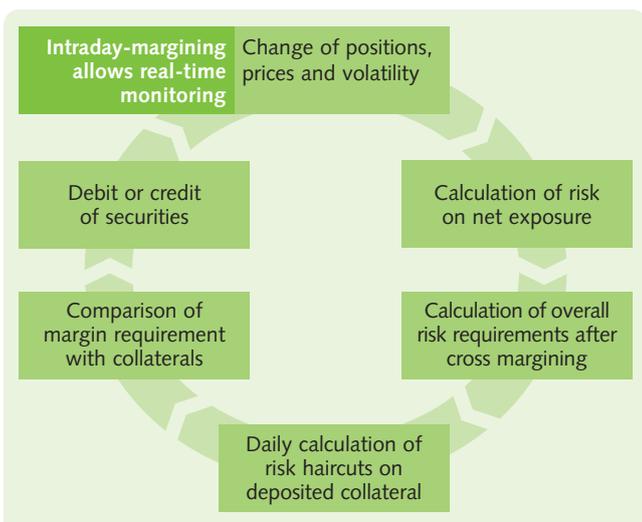
Eurex Clearing has established a comprehensive risk management framework to identify, monitor and effectively mitigate risks in a timely manner:

- Comprehensive risk monitoring
- Real-time risk management
- Exposure monitoring & limits
- Risk mitigating actions

Real-time risk management

Eurex Clearing calculates margin requirements using state-of-the-art margin methodologies (see subsequent chapter “Margining” for more details on the methodology) in real-time and ensures that its members are sufficiently collateralized at all times. Pre-trade risk checks are performed for OTC transactions and only allow novation in case sufficient collateral has been posted. Intraday credit exposures to Clearing Members are reduced to a minimum as margins are also called intraday, with very tight deadlines (see: Figure 3).

Figure 3: Margining process



Once a margin shortfall has been identified, the Clearing Member is contacted immediately and is asked to reduce its risk position or to provide additional collateral within

30 Minutes. If the shortfall is still not remedied after the given timeline, Eurex Clearing debits the respective amount required to cover the shortfall directly from the Clearing Member’s cash account latest after 30 additional minutes.

By offering the “Advanced Risk Protection”, Eurex Clearing offers its Clearing Members to actively manage and control their Non-Clearing Members by setting risk limits. In case such a limit is breached, the Non-Clearing Member might be “slowed down” (i.e. order entering will be delayed) or even suspended from further trading until its Clearing Member releases the block again. In addition, Eurex Clearing has portfolio monitoring tools including stress tests in place. They allow for in-depth analysis and monitoring of each participant.

Exposure monitoring & limits

The credit quality of participants is monitored using detailed credit assessments, which are reviewed at least annually or ad hoc if required. Based on the credit ratings, Clearing Members may get assigned **credit limits** in order to prevent counterparts with lower credit quality to build up excessive exposure. Credit limits are twofold, depending on the particular trading portfolio: credit risk thresholds can be defined either as maximum margin requirement and/ or as maximum notional exposure.

The credit risk limits are complemented by concentration and wrong-way risk limits. While the first set of limits (i.e. concentration limits) is only subject to the credit quality and liquidity of the instrument, wrong-way risk limits consider the dependence of the Clearing Member’s portfolio and collateral pool with its own creditworthiness.

Eurex Clearing assumes a portfolio or collateral pool to be concentrated if the exposure of a particular position exceeds the aggregated market demand during the anticipated liquidation period. Hereby, market demand depends on market capacity and on the credit quality of the particular security or instrument.

If, as a consequence of a counterpart's default, large collateral pools or trading portfolios need to be liquidated, Eurex Clearing might be confronted with a lack in liquidity when winding down the respective positions. To avoid such losses, dedicated **concentration risk limits** are defined, which are applicable to all counterparties.

While concentrations on entity level can relate to an entity's collateral pool and/or trading portfolio, concentrations on CCP level might occur in the overall collateral pool or in disproportional exposure concentration to just a few Clearing Members or types of assets. Concentration limits on entity level are applied on four levels of granularity:

- Issue level,
- Individual issuer,
- Issuer groups, clustered by risk classification,
- Collateral pool diversification per type of assets.

Concentration limits are assessed both on Clearing Member as well as on CCP level (see: Figure 4).

While absolute limits prevent one entity from accumulating a notional exposure in one single name that exceeds a given level of absolute risk, relative limits ensure the diversification of an entity's collateral pool or trading portfolio. Concentrations towards Clearing Members are managed by monitoring of:

- Distribution of margin requirements across the member base;
- Distribution of Default Fund consumption along the member base;
- Distribution of open interest for different products along the member base.

The other risk Eurex Clearing faces in case of a counterpart's default is the one arising from instruments – which when being liquidated – are likely to decrease in value as they are linked to the credit quality of the counterparty. This kind of risk is referred to as wrong-way risk.

The first step in which Eurex Clearing avoids wrong-way risk is that counterparties are not allowed to deposit own issues (or issues of closely linked entities) as collateral. Moreover, counterparties are not entitled to use such instruments as collateral for repo transaction or securities lending transactions. Trading derivatives on a Clearing Member's own shares is in general not prohibited. However the exposure is fully collateralized in order to mitigate this wrong-way risk.

By defining dedicated **wrong-way risk limits**, additional steps are taken to minimize such risk. The limits are applicable to a counterpart's collateral pool and to its notional exposure.

This means that wrong-way risk limits are cross conditional on the credit quality of the Clearing Member and the credit quality of the country in which the issuer of the financial instruments to which the Clearing Member has exposure, is located (see: Figure 5).

In this context, limits are set which consider the home country of a counterpart and the home country of the issuers within the counterpart's collateral pool and portfolio.

- "Own country" is defined as each respective counterparty's home country;
- "Any country" is defined as all countries within the country classification, including the counterparty's home country.

Figure 4: Concentration risk

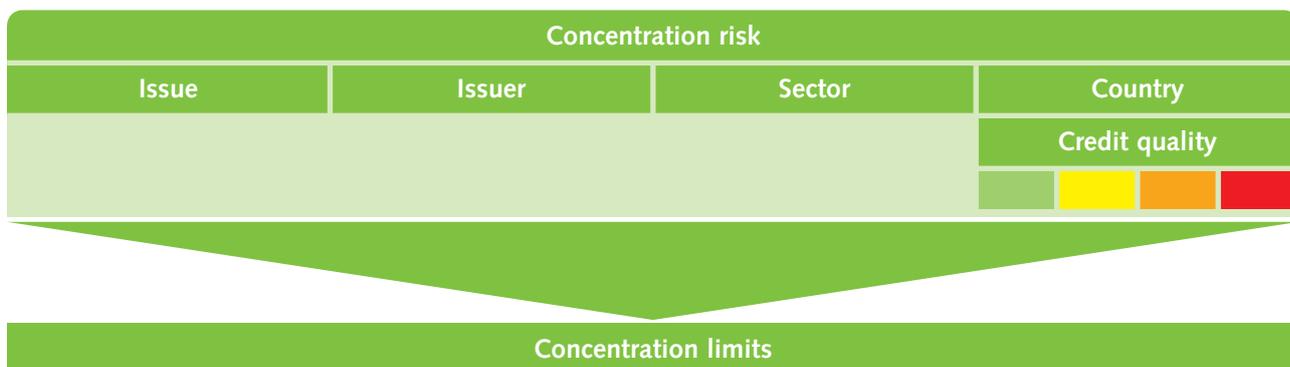
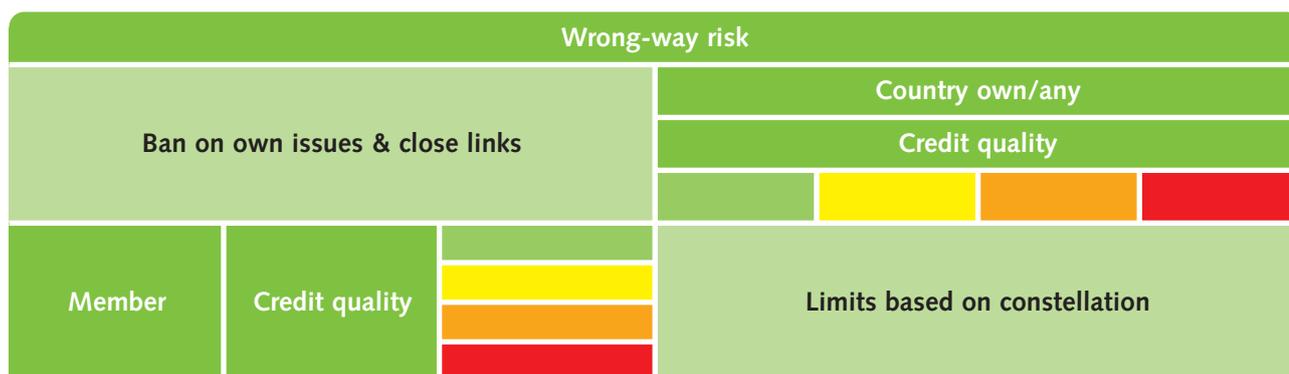


Figure 5: Wrong-way risk



The eligibility of all instruments is monitored regularly in order to ensure that security pools are well diversified and only instruments with low credit risk are eligible.

The most recent concentration and wrong-way risk limits can be found on Eurex Clearing's website².

Risk mitigating actions

Setting limits is an important risk mitigation action in order to avoid that Clearing Members take on too much risk, run highly concentrated portfolios or portfolios whose value is adversely correlated with their own credit quality.

Therefore, all Clearing Members need to comply with all limits at all times and under all circumstances. Eurex Clearing monitors all limits on a near-time basis, has early warning procedures in place and in case a limit is breached, it has risk mitigating measures in place in order to timely mitigate the risks stemming from the limit breach. Affected Clearing Members are approached in due time and the reasons for a potential or a realized risk limit breach is thoroughly and comprehensibly explained to the Clearing Member.

In case of **concentration- or wrong-way risk limit** breaches, Eurex Clearing requires Clearing Members to decrease their exposures in the respective areas by closing positions or, if the collateral composition is the reason for the limit breach, to substitute respective assets with other eligible collateral.

In general, a reasonable time span for a reduction of the respective exposure or a substitution of collateral is granted to the affected Clearing Members, taking into account for instance the credit quality of the Clearing Member, instrument or issuer. If the Clearing Member

does not comply within the communicated grace period to reduce the risk exposure, risk mitigating actions can include:

- Supplementary margin payments,
- Replacement or rejection of collateral.

Supplementary margins are an adequate risk mitigating action as it facilitates the "defaulter pays" principle and protects the mutual Default Fund in case of a default of the Clearing Member that overdrew its risk limit. The ultimate collateral rejection measure may lead to an "undercollateralization", which in turn may result in the termination of the Clearing Member if no sufficient other collateral is posted.

² <http://www.eurexclearing.com/clearing-en/risk-management/credit-concentration-wrong-way-risk>

Margining

Counterparty credit risk is primarily mitigated by margins. By collecting sufficient collateral, CCPs are well enabled to liquidate inherited portfolios even in distressed market conditions. Today's margin models are not only facing numerous regulatory requirements, but are also designed to be robust and reliable while supporting capital efficiency at the same time.

Margin requirements aim to cover potential losses arising during the liquidation of a portfolio of a defaulted Clearing Member. According to the "defaulter pays" scheme, margins should be sufficient in order to cover the losses also in unfavourable market conditions and need to cover two components:

Margin components

Backward looking

Forward looking

A Clearing Member's portfolio typically features a heterogeneous structure, size and/or complexity. Given this complexity, and due to the general principles laid out in the default management process (see chapter Default management) it is usually impossible to liquidate an entire portfolio in one single transaction. Therefore, Eurex Clearing has introduced the concept of **Liquidation Groups** and calculates risk on this level. Cleared products that share similar risk characteristics are assigned to the same Liquidation Group. This allows for a more comprehensive portfolio risk calculation and finally also enables cross margining across Liquidation Groups as long as offsets can be realized during the default management process. Therefore, Eurex Clearing has closely aligned its margining method with its default management process.

Currently ten Liquidation Groups are established with respective holding period assumptions (see: Figure 6). Which instruments are assigned to which Liquidation Group can be found on the Eurex Clearing website³.

Figure 6: Liquidation Groups with holding periods

Liquidation Group	Holding period (days)
Listed Equity (Index) Derivatives	● ● ●
Listed Fixed Income	● ●
OTC Interest Rate Derivatives	● ● ● ● ●
Asian cooperations KOSPI/TAIFEX	● ●
Commodity (Index) Derivatives	● ● ●
Precious Metal Derivatives	● ● ●
Property Futures	● ● ●
FX Derivatives	● ●
OTC FX	● ● ● ● ●
IRS Constant Maturity Futures	● ●
Bond	● ●
Fixed Income ETFs	● ●

Backward looking component

The backward looking margin component collateralizes the present value.

This is done either by a daily exchange of profits and losses among the different Clearing Members via **variation margin (VM)** payments or in case of premium style products by **premium margin (PM)** or by **current liquidating margin (CLM)** for cash market products, respectively. While the variation margin resets the current exposure towards the CCP to zero on a daily basis, premium and current liquidating margin accumulate profits and losses over the lifetime of the transaction. Premium margin and current liquidating margin debits need to be collateralized. A margin credit can be offset with other margin requirements on account level.

Forward looking component

The forward looking component, called **initial margin (IM)** collateralizes potential future exposure making use of the default management's assumption regarding the holding period.

³ www.eurexclearing.com/clearing-en/risk-management/risk-parameters

The margining methodology determines how the respective liquidation costs can be estimated. It is based on a complete view of each Clearing Member's portfolio and takes advantage of correlation effects. Thereby, it determines the initial margin requirement on a portfolio level as opposed to a product-by-product view.

Eurex Clearing Prisma is a state-of-the-art margining methodology and facilitates⁴:

- **Capital efficiency** via a combined simulation of risk factors allowing for portfolio margining and cross margining between listed and OTC positions.
- **Accuracy** based on a full-revaluation scenario approach on top of a unified risk factor universe to allow for correlated risk measurement.
- **Stability** is build-in via volatility floors within the filtered historical simulation and the additional stress period risk measure, both mitigating pro-cyclical margins by ensuring sufficient coverage in calm periods while still sustaining reactivity with respect to adversely changing market conditions.
- **Consistency** among default management process and margining is key to allow for offsets between different asset classes.
- **Flexibility** to quickly adapt to new products, regulations and future developments.
- **Transparency** by following market standard approaches, by offering comprehensive documentation as well as a suite of margin replication tools.⁵

Eurex Clearing breaks down the forward looking component into two main sub-components in order to ensure that margins are accurate, stable and robust:

Elements of forward looking margin component

Market risk

Model adjustments

Market risk over n days

Liquidity risk adjustment

The **market risk** component is designed to hold on a confidence level of 99% for listed products and 99.5% for OTC derivatives and it is calculated based on:

- 75% of filtered historical scenarios with three years look back period and 25% stress period scenarios. The stress scenarios are included to ensure stability and avoid procyclicality. The pure market risk component, i.e. without the model adjustments, is calculated based on the tail risk measure Value-at-Risk. It is individually applied on the profit and loss distributions of the historical and the stress period scenarios.
- Model adjustment account for possible correlation breaks, expiries, compression in modelling risk factors and long option credits.

The **liquidity risk** component is designed to capture the potential additional costs when liquidating portfolios, based on expected adverse price movements of the products:

- The liquidity risk component depends on the relative size of positions. It is a function of position size and total market capacity.
- The liquidity risk component further depends on the current level of market risk of the respective products.
- Even for small position sizes, the liquidity risk component is not zero. In reality, trading does not actually occur at mid prices, but at bid or ask prices. Therefore, the minimum liquidity component is defined by the liquidity premium.
- Market capacities and liquidity risk components are product-specific and unevenly distributed across product sub-groups, i.e. for options the market capacities and bid-ask spreads depend on their moneyness and time to expiry.

⁴ A detailed description of Prisma can be found on Eurex Clearing's website www.eurexclearing.com/clearing-en/resources/publications

⁵ A detailed description of Prisma margin calculators can be found on Eurex Clearing's website www.eurexclearing.com/clearing-en/risk-management/margincalculators/eurexotc-clear-prisma-margincalculator

Figure 7: Margin optimization via cross margining



In order to allow for capital efficient margining, a cross margining allocation algorithm for interest rate derivatives has been developed (see Figure 7). This algorithm is based on the combination of IRS positions, listed fixed income and money market derivatives to offset interest rate sensitivities. The offset is calculated on maturity buckets which assign instruments to the respective parts of the yield curve. For each maturity bucket, the appropriate number of futures and/or options is calculated and if available – allocated to the Interest Rate Swaps (IRS) and Fixed Income (FI) Liquidation Group split.

This process optimizes the portfolio's (Liquidation Group's) in order increase capital efficiency.

In order to cover the margin requirement, Eurex Clearing's applies a comprehensive collateral management policy. Despite strict eligibility criteria, being actively maintained and ensuring that collateral is liquid, accessible and bears little market risk, Eurex Clearing can offer a wide range of

collateral instruments. A complete list of eligible securities can be downloaded from Eurex Clearing's website: <http://www.eurexclearing.com/clearing-en/risk-management/risk-parameters> -> "Admissible Securities".

Furthermore, prudent collateral haircuts are applied together with cross currency haircuts, if required, to cover the risk of mismatching currencies between margin requirements and provided collateral. All haircuts are calculated on a 99.9% confidence level and based on a holding period assumption of five business days.

Stress testing

Testing the portfolios under scenarios which are extreme, but still plausible, yields valuable insights into possible losses beyond what has been covered by margins. Stress test results facilitate the sizing of the CCP's Default Fund, contribute a significant element in determining the lines of defense and ultimately ensure the safety of the clearing business.

Stress tests are performed to ensure that Eurex Clearing's financial resources are sized adequately and in order to identify potentially critical market conditions. While margining aims at confidence levels of 99.5% for OTC derivatives and 99% for all other cleared transactions, stress testing explores the profits and losses in the more severe tails of the distribution. The dimensioning of the Default Fund for example is based on historic and hypothetical scenarios and a target confidence level of 99.9%. Scenarios for portfolio analysis and reverse stress tests even go beyond this.

Stress tests are based on reasonable loss aggregation assumptions which take the different client segregation models into account. Consequently, Eurex Clearing considers the following four components in its stress testing program.

Stress testing

Stress scenarios

Stress loss aggregation

Stress testing total financial resources

Reverse stress testing

Stress scenarios

Stress scenarios are created for each asset class by shifting relevant risk factors in the particular market. The shift size accounts for the assumed stress period of risk for the corresponding asset class. This **stress period of risk** strictly follows the default management process for the corresponding asset class to respect the different risk characteristics and is always at least as long as the corresponding margin period of risk.

Due to different constellations of portfolios across Clearing Members, different types of stress scenarios, like e.g. historical or synthetic scenarios, are required to uncover the risk exposures of all portfolios. **Historical scenarios** replay extreme and well-known relative market movements that occurred over the past 30 years. The historic risk factor movements are taken into account with their full relative magnitudes over the stress period of risk for the particular instruments or securities and with the exact

constellation (correlation) across asset classes, products and risk factors. The following table gives some examples of historic stress events:

Examples for historical stress scenarios

- 1987 Black Monday
- 2001 Twin Towers attack
- 2003 U.S. housing bubble
- 2008 Lehman default
- 2010 Flash crash
- 2011 Fukushima meltdown
- 2011 U.S. down grade
- 2016 Brexit referendum

Historical scenarios are regularly reviewed and new scenarios are included based on qualitative and quantitative analysis.

Hypothetical scenarios are designed to account for the largest risk factor movements with a confidence level of 99.9%. These scenarios simulate extreme risk factor movements for all cleared asset classes and products simultaneously by combining selected constellations of up and down moves across asset classes.

On the one hand, relative shifts move the corresponding risk factor by a specified relative value, which is independent of the current market situation. For OTC products also absolute shifts are applied which are calibrated analogously to the relative shifts.

On the other hand, so called σ -multiplier scenarios consider the current market situation by multiplying the current volatility for each single risk factor with a calibrated fixed value. This also yields a relative stress shift, but the advantage of this type is that the σ -multiplier's magnitude adapts to the current volatility level of the risk factor returns.

Dedicated sub-scenarios also challenge historic correlations by explicitly breaking the observed correlation between different products within an asset class.

In order to condense the information from a large number of asset class-specific hypothetical scenarios to a smaller number of concise “economic scenarios”, the following **global scenario groups** are created (see: Figure 8):

Figure 8: Global scenario groups

S11	Equity Derivatives	↗	and Fixed Income Derivatives	↗
S12	Equity Derivatives	↘	and Fixed Income Derivatives	↘
S13	Equity Derivatives	↘	and Fixed Income Derivatives	↗
S14	Equity Derivatives	↗	and Fixed Income Derivatives	↘

For all other asset classes the worst-case movement over all hypothetical and historical scenarios is applied. While the above mentioned scenarios are used to calibrate the Default Fund, additional scenarios, which go beyond what is extreme, but plausible, exist for analysis purposes. Besides **crash scenarios**, which assume severe market disruptions, additional **FX scenarios** as well as **interest rate scenarios** allow for insights into the sensitivities of the Clearing Member’s portfolios to the tested risk factors. The **underlying/ volatility scenarios** systematically simulate different up and down moves of different magnitudes and directions for underlying vs. volatility risk factors.

Stress loss aggregation

Stress scenarios are based on risk factor movements and translate potential impacts of severe economic developments into monetary figures. This process yields a new product value, called stressed value, using the scenario-specific risk factor values. The differences between stressed values and current values are called **stress P&Ls** and are determined for each scenario. These P&Ls are then aggregated for all products within one risk account. As CCPs collect margin in order to cover potential future losses, these margins can be deducted from the stress P&L and ultimately yield the **stress shortage/surplus per** scenario.

Stress shortages are aggregated per scenario on Liquidation Group and risk account level, offering full netting capacities on these levels. The results are then aggregated in a comprehensive way on three different levels:

- Segregated pool
- Clearing Member
- Corporate group

On **segregated pool level** all stress results belonging to the same segregated asset pool are netted. These segregated asset pools are equivalent to the collateral pools under the selected segregation model, but additionally, the proprietary business of the Clearing Member itself is separated from its standard collateral pool and forms an own segregated pool.

On the second level, the **Clearing Member level**, profits or surpluses stemming from a Clearing Member’s proprietary business can be used to balance shortages stemming from client business, but not vice versa (“one-way netting”). In general, all ultimate surpluses are cut to zero on this aggregation level.

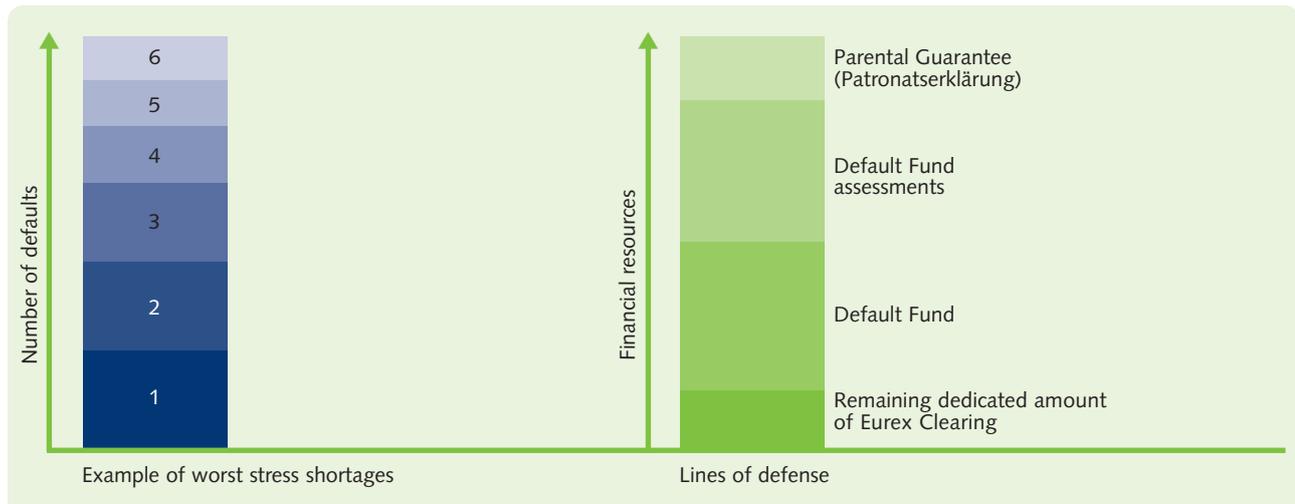
The highest level on which stress results are aggregated is the **corporate group level**. Here, as no surpluses on Clearing Member level are possible, aggregation of stress figures of the different Clearing Members belonging to the same group is required. Stress scenarios on group level assume that all Clearing Members within the same group will be subject to the same stress scenario.

Stress testing total financial resources

One core element of stress testing lies in challenging the CCP’s pre-funded financial resources. It requires the pre-funded financial resources to withstand the simultaneous default of those two Clearing Members, including its corporate group members, which pose the largest credit exposure in extreme, but plausible market conditions. This is referred to as “cover-2” requirement.

The Default Fund calibration is based on stress shortage figures on corporate group level for the corresponding worst-case scenario. The required Default Fund size is then distributed throughout the Clearing Member base according to the initial margin of each individual Clearing Member.

Figure 9: Reverse stress testing methodology



The Default Fund is recalibrated at least monthly and a more comprehensive review and validation of the dimensioning methodology is done on an annual basis. Stress testing is performed on a daily basis and in case the “cover-2” requirement is threatened to be breached, risk mitigating actions could be to:

- Ad-hoc recalibrate the global dynamic percentage in case of changes of overall market conditions or
- Apply corporate group-specific actions (e.g. supplementary margins) in case only specific Clearing Members' stress shortages have increased significantly.

In case one corporate group consumes more than 45% of the current Default Fund size, dedicated mitigating actions are taken against this particular corporate group.

Reverse stress tests

Reverse stress testing challenges the resilience of the CCP under different stress scenarios. In particular, it is analyzed how many Clearing Members can default in a very short timeframe in order to exhaust all financial resources. This analysis is done incrementally along the lines of defense, starting with pre-funded financial resources over additional assessments from all members and ending at the Parental Guarantee as well as the remaining equity capital of Eurex Clearing.

For each historical and hypothetical stress scenario as well as more severe market crash analysis scenarios, the number of possible defaults is estimated by aggregating the credit exposures and comparing the accumulated exposure with the available financial resources at each line of defense. The number of Clearing Members, whose corresponding credit exposure exhaust the different layers of available financial resources, is an indicator of how many defaults can occur under any given scenario until the CCP is not viable anymore as the respective layer of financial resources is exhausted.

More details on the stress testing methodology and framework can be found on Eurex Clearing's website: www.eurexclearing.com/clearing-en/risk-management/stress-testing

More information on liquidity stress tests can be found in the chapter “liquidity risk”.

Default management

If a Clearing Member fails to fulfil its contractual obligations, prudent default management procedures are essential to protect market stability and bring the CCP into a balanced book again. The guiding principle for the design of Eurex Clearing's default management process is to minimize negative effects on non-defaulted Clearing Members, clients and the wider market.

Eurex Clearing's default management process comprises a set of procedures designed to facilitate the orderly liquidation of even large and complex portfolios:

Elements of Eurex Clearing's default management process

Preliminary measures

Hedging

Independent sale

Auction

Default management process

Despite the individual nature of every situation, explicit termination events for a Clearing Member's default have been defined, regardless of product or cleared market. In case that a Clearing Member has been declared to be in default, the Clearing Member's proprietary positions and its client positions may be treated differently.

When a Clearing Member defaults, the principle objectives are to protect customers and to minimize the impact on clients and their positions. The process is designed to enable clients and their positions to be transferred to a new, solvent Clearing Member quickly and smoothly, wherever possible.

The default management process is designed in a way which enables Eurex Clearing to handle portfolios in different Liquidation Groups individually. While it is likely that the liquidation with respect to different Liquidation Groups is conducted overlapping in time, the concrete measures applied may differ.

The following briefly describes key components of the default management process:

- **Preliminary measures** encompass the convention of Default Management Committees (DMCs) to support Eurex Clearing throughout the whole default management process. Each DMC advises and assists the CCP with respect to any relevant matter of the default management process, most importantly hedging of the portfolio and the preparation of auctions, as applicable. Each DMC

is staffed with professional employees of pre-selected Clearing Members. They have sufficient trading and risk expertise in the products belonging to the respective Liquidation Group(s) for which the DMC is convened. DMCs will be convened in case of a Clearing Member's default and for regular default simulations.

- **Hedging** The purpose of hedging within the default management process is to enable Eurex Clearing to reduce market and potential cash-flow risks. Furthermore, hedging reduces the portfolio's sensitivity to market moves and stabilizes it for auctions. Hedging of the defaulted Clearing Member's portfolio is executed as early as possible in order to limit losses immediately. A hedged portfolio is likely to receive better prices in the auction.
- **Independent sale** In order to grant sufficient flexibility during a default situation, positions or groups of positions can be sold independently to individual members, i.e. positions of the defaulted Clearing Member are re-established by the CCP either on-exchange or via bilateral trades, as an alternative to the auction process. If the portfolio is small or if only a few Clearing Members are active in the involved products, bilateral or on-exchange trades can ensure a timely liquidation. The mutual Default Fund will not be utilized, unless Clearing Members have the chance to provide a price in the auction.
- **Auction** The Liquidation Group-specific auction process is the main component of the default management process. An auction enables Eurex Clearing to rapidly transfer risk in bulk to willing absorbers, establishing fair market prices for the particular portfolios. The participation in the auctions is generally mandatory for those Clearing Members who are active in the respective Liquidation Group, and who are capable both from a risk perspective and from an operational perspective to process the relevant portfolio. In addition, clients are allowed to participate, upon permission from their relevant Clearing Member. Default Fund juniorisation and penalty fees set incentives for competitive bidding.

Lines of defense

Eurex Clearing guarantees the fulfilment of every transaction in every market for which it provides clearing services. While the mainstay of this safety system is the margin which Clearing Members have deposited as collateral for open positions, the lines of defense include several additional layers of financial resources, namely:

- The defaulted Clearing Member's Default Fund contribution,
- Own resources of Eurex Clearing, the
- Default Fund contributions of all non-defaulted Clearing Members,
- Assessments of non-defaulted Clearing Members' Default Fund contributions and additional contributions by Eurex Clearing,
- Remaining funds of Eurex Clearing: equity capital of Eurex Clearing backed by a Parental Guarantee provided by Deutsche Börse AG.

Segmented Default Fund

Eurex Clearing maintains a segmented Default Fund, consisting of multiple Liquidation Group-specific Default Fund segments (DFS), and the sum of all DFS is the overall Default Fund.

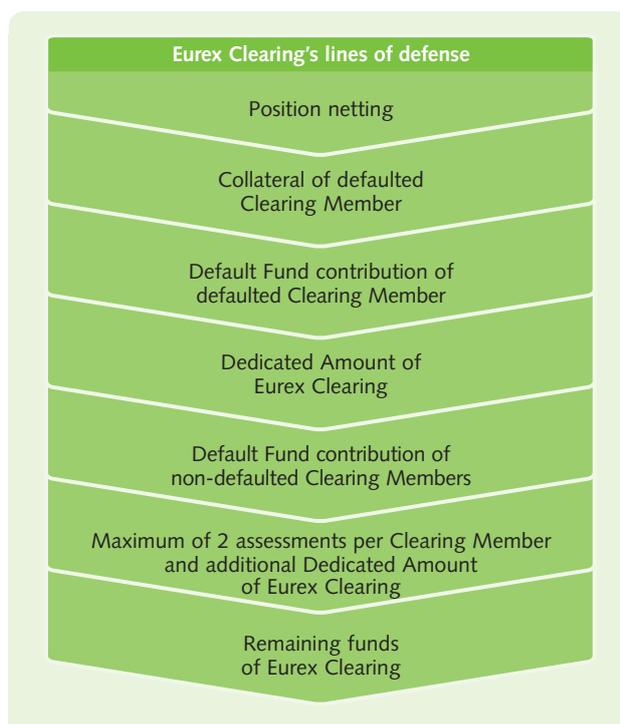
When liquidating a particular portfolio, only funds of the DFS assigned to the respective Liquidation Group can be used to cover losses, unless there is a known surplus from other Liquidation Groups for which the default management process has already been finished.

As such, the segmentation of the Default Fund ensures that Clearing Members which have been active in the Liquidation Group(s) that losses arise from are used first. The segmentation still maintains the capital efficiencies of one joint Default Fund, compared to multiple asset class-specific Default Funds.

Assessments

Eurex Clearing ensures that the liability of a Clearing Member towards the CCP is limited. As such, Eurex Clearing's right to ask for assessments of the Default Fund, i.e. Eurex Clearing's right to request Clearing Members to re-fill their Default Fund contributions once the pre-funded contributions have been utilized, is capped. In any

Figure 10: Eurex Clearing's lines of defense



crisis situation, each Clearing Member is only obliged to provide additional funds up to an amount of two times its pre-funded Default Fund contribution. Eurex Clearing participates with an own capital contribution to each of these assessments.

In the event of a default, these layers are applied in the order illustrated above (see: Figure 10).

This way, the lines of defense help to protect the marketplace as a whole and play an important role in preventing contagion.

Closure of Liquidation Group

As a matter of last resort, Eurex Clearing has the possibility to close an individual Liquidation Group at the end of the lines of defense, while all other Liquidation Groups remain unaffected. This additional recovery option serves to minimize contagion risk to the maximum possible extent. More information on the default management process is available on Eurex Clearing's website: [www.eurexclearing.com/clearing-en/ risk-management/ default-management-process](http://www.eurexclearing.com/clearing-en/risk-management/default-management-process).

Model validation

A sound and independent model validation is essential for running reliable and robust risk management systems and methodologies. A comprehensive model validation framework with strong governance ensures effective identification of potential model risks at Eurex Clearing AG.

Eurex Clearing commits itself to a regular and thorough validation of all risk models and model-related processes along the model landscape. While model owners are ultimately responsible for model development and associated model risk, model validation acts as a second line of defence. To ensure independence from model development, model validation reports directly to the Chief Risk Officer of Eurex Clearing and has an alternative reporting line to the Chair of the Supervisory Board of Eurex Clearing.

Elements of Eurex Clearing's model landscape

Models

Margining

Collateral

Stress testing

Liquidity forecast

Credit, concentration and wrong-way risk

Model-related processes

Data quality assurance

Default management process

Offset monitoring

Application of different validation instruments is governed by the model validation framework along with procedures for regular, ad-hoc validation and findings tracking. Throughout the year, the independent model validation uses a number of validation instruments to regularly validate the conceptual soundness of the frameworks and adequacy of the risk models. Once a year, an **annual comprehensive validation** is performed along the model landscape. In the annual validation report, all validation results obtained within the year are summarized and combined with a fundamental review of the methodology and the model parametrization. This yields an overall review of model performance and appropriateness. The report also assesses the effectiveness of processes and procedures relevant for managing model risks.

Margining

The adequacy of the initial margin is primarily validated by **portfolio backtesting**, which compares the initial margin with the actually realised profits and losses. The results are assessed using statistical tests. Validation at parameter level is performed by means of a **parameter sensitivity analysis**, which is conducted to determine the margin model's response to changes in model parameters.

Results from backtesting and parameter sensitivity analysis are regularly reported to the Risk Committee in a form that does not breach confidentiality.

Collateral

Haircut backtesting is in place to validate the adequacy of haircuts on cash and non-cash collateral on a monthly basis. Results are also assessed using statistical tests. Eligibility criteria for collateral acceptance are also reviewed.

Stress testing

With the **stress testing validation**, the appropriateness of the stress testing methodology with all its components such as scenarios, parameters and assumptions is performed on an annual basis. Specifically, the adequacy of the default fund calibration methodology is verified as a part of the stress testing validation. Anonymized results of the annual review are presented to the Risk Committee.

Liquidity forecast

The performance of the liquidity forecasting model, which is used to predict Eurex Clearing's liquidity needs and to evaluate available liquidity sources in case that one or more clearing members fail to fulfill their obligations, is assessed on an annual basis.

Credit, concentration and wrong-way risk

Eurex Clearing's additionally monitored risks framework is represented by credit, concentration and wrong-way risk limits and validated via qualitative review on annual basis.

Model-related processes

Model-related processes are operational business processes which outcome is of quantitative nature and used as a parameter in one of the risk models with a significant impact on the model output.

The **data quality assurance** process is crucial for Eurex Clearing's model operation as it ensures high quality of input data. General and product-specific outlier detection and correction methods are applied to both raw market data and derived data.

Validation of the **default management process** aims to ensure that the conceptual design of the process is adequate.

Offset monitoring ensures that portfolio diversification benefits granted by the portfolio margining approach stay within regulatory required limits and that Eurex Clearing is not exposed to further potential risks by the margin reduction.

Liquidity risk

CCPs need to balance their liquidity sources and needs. Eurex Clearing's systemic importance requires a prudent liquidity risk management in order to promote the integrity of financial markets.

In order to assess the liquidity situation for Eurex Clearing and to ensure sufficient liquid resources at all times, Eurex Clearing runs a comprehensive stress testing program of its liquid financial resources.

Liquidity risk
Liquidity sources
Stress testing
Stress scenarios
Stress loss aggregation
Stress testing of liquid financial resources
Reverse stress testing

Liquidity sources

Eurex Clearing's main liquidity sources are:

- **Member cash deposits (MCD)**
Cash investments only take place at counterparties with low default risk. Given Eurex Clearing's strict investment policy which has been designed according to EMIR requirements, the Treasury department places cash on a short term basis, mainly overnight, and secured to the extent possible. The preferred instruments are reverse repurchase agreements. For collateral, only central bank eligible highly liquid assets are approved. As an additional safety measure, treasury executes term placements of MCDs in cascades, with trades maturing every day. Term transformation limits are determined to avoid excessive maturity mismatches.
- **Own funds**
Funds representing Eurex Clearing's equity capital.
- **Commercial bank credit facilities**
Committed credit line agreements are in place with several commercial banks.
- **Bundesbank credit facility**
Access to the refinancing facilities of Deutsche Bundesbank further provides Eurex Clearing with the possibility to pledge securities in order to obtain liquidity.

Stress testing

Eurex Clearing as a central counterparty faces the following sources of liquidity risk, which are subject to a comprehensive stress testing program:

- **Withdrawal of member cash deposits** Clearing Members might withdraw significant amounts of their cash deposits to either reduce over-collateralization or swap cash for non-cash collateral.
- **CCP pre-financing activities**
In case one or several Clearing Members have technical issues with their infrastructure or are late in fulfilling their payment obligations, Eurex Clearing is obliged to pre-finance variation margin and option premiums or purchase securities from pending transactions. In principle, pre-financing is only performed intraday. In case a Clearing Member temporarily fails to pay, e.g. due to technical problems, pre-financed amounts would not return intraday
- **Clearing Member default**
Whenever a Clearing Member defaults, Eurex Clearing inherits its portfolio and is responsible to honour all resulting obligations. Therefore, all short-term payment obligations arising out of the defaulter's portfolio need to be pre-financed until the collateral of the defaulted counterpart is liquidated or mobilized. For Eurex Clearing as an EMIR compliant CCP the monitoring of the liquidity requirement resulting from a Clearing Member default is the core aspect of its liquidity stress testing.

Stress scenarios: Within its liquidity stress testing program, Eurex Clearing considers a wide range of liquidity-specific stress scenarios. Both stresses to the exposure and stresses to the liquidity sources are considered. Market disruption scenarios as well as idiosyncratic stress factors are taken into account. The extreme, but plausible assumptions are applied on Member Cash Deposit repayments, term investments, CCP Pre-Financing activities as well as payment obligations resulting from Clearing Member defaults. Multiple roles of a counterpart towards the CCP (e.g. Clearing Member,

settlement institution, treasury counterpart etc.) are taken into account. Eurex Clearing further caps credit lines provided by a Clearing Member to a maximum of 25% of total credit lines, in line with the provisions of EMIR.

Stress loss aggregation: The aggregation methodology in Eurex Clearing's liquidity stress testing allows full netting between client and proprietary business. This is adequate since liquidity is required to pre-finance the liquidity needs, but is not subject to other legal constraints such as client asset segregation in case of calculating the final claim towards a defaulted counterpart. Consequently, while determining the liquidity need in a stress scenario, profits and losses can be offset and only the net cash position needs to be considered.

Exposures are aggregated on Clearing Member, corporate group and settlement institution as well as on clearing institution level. The liquidity need which is required to withstand the default of the largest two counterparts ("cover-2") is determined on corporate group-level.

Stress testing of liquid financial resources: Eurex Clearing's liquid financial resources are tested over the range of liquidity-specific stress scenarios. The core element is

the "cover-2" liquidity exposure which is monitored on a daily basis as required by EMIR. Eurex Clearing aims to ensure sufficient liquid financial resources to cover the liquidity requirement stemming from the simultaneous default of the two largest counterparts at all times.

Reverse stress testing: The stress scenarios described above are complemented by a reverse stress test which determines the largest cash outflow within a fixed assessment period Eurex Clearing could endure. By definition, the reverse stress test challenges the company's viability and goes beyond normal business settings.

Eurex Clearing's liquidity stress testing program is designed to detect critical developments as early as possible. Eurex Clearing has established early warning triggers, as well as recovery limits on important indicators, enabling it to prevent potential liquidity shortfalls. Different action plans including communication processes as well as a range of mitigating measures (e.g. increase of committed standby credit facilities, cash provision of Clearing Members, mobilization of securities, adjustment of investment policy, etc.) for a replenishment of financial resources have been defined and may be initiated, depending on the severity of the situation.

Market risk

Eurex Clearing only takes on low market risks as investments are subject to a very conservative investment policy. Term and cross currency transformations from the general clearing business are monitored and managed prudently and therefore, Eurex Clearing is neither materially exposed to interest rate nor to foreign exchange risk.

Market risk results mainly from interest rate, currency and equity prices fluctuations. Eurex Clearing measures these risks using earnings-based sensitivity analysis for extreme interest rate or exchange rate fluctuations and it avoids open currency positions whenever possible.

Sources of market risk

Interest rate risk

Foreign exchange risk

Interest rate risk

Eurex Clearing earns interest through the placement of customer cash. It pays interest on the cash margin provided to clearing members. The interest rate paid to Clearing Members is based on a benchmark, deducting a fixed margin. The potential deviation of the realised rate and the benchmark rate exposes Eurex Clearing to interest rate risk. This risk is monitored and limited, and contained through the conservative investment policy applied.

Cash deposits by market participants are mainly invested via overnight reverse repurchase agreements and in the form of overnight deposits at central banks, limiting the risk of a negative impact due to a changed interest environment. Eurex Clearing may furthermore invest their own capital and part of stable customer cash balances in high-quality liquid bonds. The bond portfolio consists mostly of variable-rate instruments, which leads to a comparably low interest rate risk for the Eurex Clearing.

The interest rate risk between interest-earning assets and interest-bearing liabilities is monitored on a daily basis and limited by using a system which includes mismatch limits in combination with interest rate risk limits and stop-loss limits. The interest rate risk limits determine the acceptable maximum loss caused by a hypothetical adverse yield curve shift. The stop-loss limits define the fair value of a portfolio triggering an ad hoc review and risk reducing actions.

In order to further mitigate potential market risks, the average time-to-maturity of the securities portfolio may not exceed two years and the maximum remaining time-to-maturity of the individual securities may not exceed five years. Investments are allowed in debt instruments, in particular in floating rate notes with very low market risk, but also in fixed coupon bonds which also have a fairly low market risk, given the **limited time-to-maturity**.

Stop-loss limits are established to limit a negative fair value of the portfolio. A limit breach triggers a prompt review and, ultimately, actions to reduce positions.

Foreign exchange risk

Where Eurex Clearing receives cash collateral in a foreign currency and is therefore obliged to repay in that currency, the funds are placed in the respective currency in order to avoid any currency mismatch. Thus, the foreign exchange exposure is limited to the net interest earned in the respective currency.

Despite the limited materiality, an FX management system is in place and exposures are monitored regularly.

Compliance with all restrictions and limits is monitored on a daily basis and any breaches are rectified in due time.

Operational risks

Eurex Clearing uses several instruments to manage its operational risks related to system availability, processing, physical assets, legal disputes and business practice. The risk inventory is based on operational risk scenarios and internal loss data. The required economic capital for operational risks is based on a Value-at-Risk approach.

Operational risk is defined as the risk of loss resulting from inadequate or defective systems and internal processes, from human or technical failure, from inadequate or defective external processes, from damage to physical assets and from legal risks that could arise from non- or inappropriate compliance with new or existing laws and regulations and all contractual commitments.

Components of operational risks

Sources of operational risks

Availability

Service deficiency

Damage to physical assets

Legal offenses & business

Measuring operational risks

Sources of operational risks

Availability: Operational resources such as the clearing system C7 or the risk system Prisma are essential for the services offered by Eurex Clearing. They should never fail, in order to ensure that market participants can clear their trades at any time and without delay. The longer one of these systems fails, the larger the resulting potential losses would be. Possible root causes for system unavailability are among others:

- Software flaws;
- IT hardware flaws;
- Inadequate information security;
- Cyber crime

In general, availability of systems represents the largest operational risk for Eurex Clearing. Therefore, it is subject to regular recovery and unavailability tests, testing its own systems but also the implications of external systems being unavailable. Strict software rollout processes with highest quality standards are in place in order to mitigate the risk of system unavailability due to software flaws.

Service deficiency: Operational risks can also arise if a service provided to a customer is inadequate and leads to complaints or legal disputes, such as in the settlement of securities transactions due to defective products and processes or erroneous manual entries. As a result, errors could occur, for example, in handling the default of a large Clearing Member.

Eurex Clearing has established dedicated help desks to support its customers and give them a forum to voice their complaints in case a processing error has happened. In this case, it is immediately checked whether the notification is justified.

Other sources of error may be attributable to suppliers or to defective products or mistakes that may lead to the loss of client assets. Eurex Clearing registers all complaints and formal objections as a key indicator of processing risk.

Damage to physical assets: Terrorism or sabotage are also among the operational risks that could, for example, cause a severe damage to a data centre or office building. Business continuity management (BCM) planning aims at averting significant financial damage.

Legal offences & business practice:

Losses can also result from ongoing legal proceedings. They can occur if Eurex Clearing breaches law or requirements, enters into inadequate contractual agreements, or fails to observe case law to a sufficient degree. Legal risks also include losses due to fraud and labour law issues.

They further include losses as a result of insufficient controls to prevent money laundering, breaches of competition law regulations or of banking secrecy. Such operational risks can also apply if government sanctions are not observed or in the event of breaches of other state or higher-order regulatory provisions.

Measuring operational risks

Operational risks are estimated by using a Value-at-Risk concept. Combining a frequency distribution, which models the likelihood of the occurrence of loss events, with a severity distribution describing the size of operational losses, yields a loss distribution which is based on a statistical analysis of relevant data. This loss distribution allows estimating potential operational risks at different confidence levels. The input data for the model are internal loss data, results of a structured scenario analysis and external data.

The Value-at-Risk model serves the purpose to determine the required economic capital for operational risk based on a 99.98% confidence level for a one-year holding. The required economic capital is compared with the available risk bearing capacity for operational risk.

Loss distribution: An actuarial technique is applied by modelling the likelihood of the occurrence of an event (i.e. the frequency) independently from the impact of such an event (i.e. the severity). Combining these two distributions by Monte Carlo simulation gives the required aggregated loss distribution. From the aggregated loss distribution the required risk figures are derived:

- **Expected loss:** The expected loss is generally defined as the actual monthly statistical mean of the aggregated loss distribution
- **Value-at-Risk:** The Value-at-Risk is defined as the amount that is not exceeded in q% cases of all years.

Frequency distribution: Due to the discrete nature of the occurrence of loss events, the frequency is modelled using a discrete probability distribution. A Poisson distribution is usually applied in order to model a time series of rare and independent events. Both conditions are reasonable to assume with respect to operational risk. The Poisson distribution is additive allowing to easily aggregate several events to one cumulated event. The simulated number of different operational risks are assumed to be independent from each other.

Severity distribution: The severity distributions describing the size of the losses are an important part of the operational risk measuring model. The severity is modelled by the uniform distribution with two parameters: minimum and maximum loss. The parameters are estimated by experts in a structured way for each single scenario and supported by statistical analysis and additional information to the maximum possible extent.

Both, mathematical assumptions and derived parameters are subject to the regular model validation.

Contacts

For more information please contact

CCP Risk Management

Risk Exposure Management

T +49-69-211-12452

risk@eurexclearing.com

Visit us at www.eurexclearing.com

or follow us on [Twitter @eurexgroup](https://twitter.com/eurexgroup)

© Eurex 2019

Deutsche Börse AG (DBAG), Clearstream Banking AG (Clearstream), Eurex Frankfurt AG, Eurex Clearing AG (Eurex Clearing) and Eurex Repo GmbH (Eurex Repo) are corporate entities and are registered under German law. Clearstream Banking S.A. is a corporate entity and is registered under Luxembourg law. Deutsche Boerse Asia Holding Pte. Ltd., Eurex Clearing Asia Pte. Ltd. and Eurex Exchange Asia Pte. Ltd are corporate entities and are registered under Singapore law. Eurex Frankfurt AG (Eurex) is the administrating and operating institution of Eurex Deutschland. Eurex Deutschland is in the following referred to as "Eurex Exchange".

All intellectual property, proprietary and other rights and interests in this publication and the subject matter hereof (other than certain trademarks and service marks listed below) are owned by DBAG and its affiliates and subsidiaries including, without limitation, all patent, registered design, copyright, trademark and service mark rights. While reasonable care has been taken in the preparation of this publication to provide details that are accurate and not misleading at the time of publication DBAG, Clearstream, Eurex, Eurex Clearing, Eurex Repo as well as Eurex Exchange and their respective servants and agents (a) do not make any representations or warranties regarding the information contained herein, whether express or implied, including without limitation any implied warranty of merchantability or fitness for a particular purpose or any warranty with respect to the accuracy, correctness, quality, completeness or timeliness of such information, and (b) shall not be responsible or liable for any third party's use of any information contained herein under any circumstances, including, without limitation, in connection with actual trading or otherwise or for any errors or omissions contained in this publication.

This publication is published for information purposes only and shall not constitute investment advice respectively does not constitute an offer, solicitation or recommendation to acquire or dispose of any investment or to engage in any other transaction. This publication is not intended for solicitation purposes but only for use as general information. All descriptions, examples and calculations contained in this publication are for illustrative purposes only.

Eurex and Eurex Clearing offer services directly to members of Eurex Exchange respectively to clearing members of Eurex Clearing. Those who desire to trade any products available on the Eurex market or who desire to offer and sell any such products to others or who desire to possess a clearing license of Eurex Clearing in order to participate in the clearing process provided by Eurex Clearing, should consider legal and regulatory requirements of those jurisdictions relevant to them, as well as the risks associated with such products, before doing so. Eurex derivatives are currently not available for offer, sale or trading in the United States or by United States persons (other than EURO STOXX 50® Index Futures, EURO STOXX 50® Index Quanto Futures, EURO STOXX 50® Index Total Return Futures, EURO STOXX 50® ex Financials Index Futures, EURO STOXX® Select Dividend 30 Index Futures, EURO STOXX® Index Futures, EURO STOXX® Large/Mid/Small Index Futures, STOXX® Europe 50 Index Futures, STOXX® Europe 600 Index Futures, STOXX® Europe 600 Banks/Industrial Goods & Services/Insurance/Media/Travel & Leisure/Utilities Futures, STOXX® Europe Large/Mid/Small 200 Index Futures, DAX®/Mini-DAX®/MDAX®/TecDAX® Futures, SMIM® Futures, SLI Swiss Leader Index® Futures, selected MSCI Futures, TA-35 Index Futures, Eurex Daily Futures on Mini-KOSPI 200 Futures as well as Eurex Volatility, FX, Property and Interest Rate Derivatives).

Trademarks and Service Marks

Buxl®, DAX®, DivDAX®, eb.rexx®, Eurex®, Eurex Repo®, Eurex Strategy WizardSM, Euro GC Pooling®, FDAX®, FWB®, GC Pooling®, GCPI®, MDAX®, ODAX®, SDAX®, TecDAX®, USD GC Pooling®, VDAX®, VDAX-NEW® and Xetra® are registered trademarks of DBAG. All MSCI indexes are service marks and the exclusive property of MSCI Barra. ATX®, ATX five, CECE® and RDX® are registered trademarks of Vienna Stock Exchange AG. IPD® UK Quarterly Indexes are registered trademarks of Investment Property Databank Ltd. IPD and have been licensed for the use by Eurex for derivatives. SLI®, SMI® and SMIM® are registered trademarks of SIX Swiss Exchange AG. The STOXX® indexes, the data included therein and the trademarks used in the index names are the intellectual property of STOXX Limited and/or its licensors. Eurex derivatives based on the STOXX® indexes are in no way sponsored, endorsed, sold or promoted by STOXX and its licensors and neither STOXX nor its licensors shall have any liability with respect thereto. Bloomberg Commodity IndexSM and any related sub-indexes are service marks of Bloomberg L.P. PCS® and Property Claim Services® are registered trademarks of ISO Services, Inc. Korea Exchange, KRX, KOSPI and KOSPI 200 are registered trademarks of Korea Exchange Inc.

The names of other companies and third party products may be trademarks or service marks of their respective owners.

© Eurex, March 2019

Published by

Eurex Clearing AG
Mergenthalerallee 61
65760 Eschborn
Germany

www.eurexclearing.com

ARBN number

Eurex Frankfurt AG ARBN 100 999 764