UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

THE DEFAULT MANAGEMENT PROCESS IN A CENTRAL CLEARING COUNTERPARTY

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IZJAVA O AVTORSTVU

Podpisana Tina Cvitanič, študentka Ekonomske fakultete Univerze v Ljubljani, avtorica predloženega dela z naslovom The Default Management Process in a Central Clearing Counterparty, pripravljenega v sodelovanju s svetovalcem red. prof. dr. Aleš Berk Skok

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CCP	Central Counterparty
CCP RRR	Central Counterparty Recovery and Resolution Regulation
CDO	Collateralized Debt Obligation
CDS	Credit Default Swap
CME	Chicago Mercantile Exchange

DMC	Default Management Committee
DMP	Default Management Process
DVP	Delivery versus Payment
ECAG	Eurex Clearing AG
EMIR	European Market Infrastructure Regulation
ESMA	European Securities and Markets Authority
ESTR	Euro Short-Term Rate
ETD	Exchange Traded Derivative
FX	Foreign Exchange
GCP	General Collateral Pooling
ICE	Intercontinental Exchange
IRS	Interest Rate Swap
ISE	International Securities Exchange
LIBOR	London Interbank Offered Rate
LIFFE	London International Financial Futures and Options Exchange
OTC	Over-the-Counter
REPO	Repurchase Agreement
RTS	Regulatory Technical Standards
SONIA	Sterling Overnight Index Average
SORF	Secured Overnight Financing Rate
VaR	Value at Risk

INTRODUCTION

Central clearing counterparties or CCPs are market intermediaries, which make financial markets safer by interposing themselves between counterparties in a financial contract. As intermediaries they guarantee that terms of every financial contract will be fulfilled, regardless of a potential default by one of the counterparties. As CCPs concentrate counterparty risks in a single entity, their failure could have systemic implications and lead to widespread disruptions in financial markets. CCPs are thus critical elements of the financial system and it is important that the risks related to their activities are adequately managed (Haene & Sturm, 2009).

CCPs became ever more important after the 2007-2008 crisis. Exchange traded derivative markets and over-the-counter derivative markets have developed substantially by 2007, without proper regulation to oversee these transactions. After the crisis that occurred on the back of such derivative transactions, regulators have stepped in and made CCP clearing mandatory for all exchange traded derivatives and for all standardized over-the-counter derivatives (Kuong & Maurin, 2021). Since the introduction of CCP clearing there have been large reductions in counterparty default exposures in major global over-the-counter derivatives markets. That is because CCPs transfer counterparty and default risks from market participants, e.g. buyers and sellers of financial contracts, onto themselves, and are consequently reducing systemic risk. This is achieved with efficient risk management of CCPs through mutualization of counterparty risk and collaterization of cleared positions (Bliss & Steigerwald, 2006).

Cleared positions are collateralized by imposing margin requirements on open positions, which are held in margin accounts of clearing members. Risk mutualization is achieved by mandatory contributions of clearing members to the so-called default fund and held in a separate account (Russo, Hart & Schönenberger, 2002).

This thesis focuses on a particular part of a CCP, that is the mutualization of counterparty risk and the default management process. Default management process represents the last line of defense for the CCP and shows how a particular CCP is handling a default from one or more of its clearing members. A good default management process is of atmost importance as it guarantees that even with interconnected markets of today, a default of one market player does not mean the collapse of the entire system (Poce et al., 2018). Default management process comprises of several components such as preliminary measures, hedging, independent sale, and auction (Eurex Clearing AG, n.d.-k). Hedging and auctioning the defaulted member's portfolio are essential to unwind the portfolio and return the CCP to a matched book without suffering major losses (Committee on Payments and Market Infrastructures, 2020). CCPs themselves design the auction format in order to facilitate the particularities of a default situation. Thoughtful and rigorus mechanisms need to be in place to successfully manage a default scenario without suffering major losses that could threathen the health of the entire financial system (Ferrara & Li, 2017).

In the thesis I examine in more detail the concept of CCPs and their structure. I touch on collaterization of cleared positions, but keep the focus on the default management process and risk mutualization. My objective is to present all the components in the default process, from preliminary measures, independent sale, hedging of the defaulted clearing member's portfolio and liquidating the portfolio in a process called auction. The reader should get a comprehensive picture of a CCP as a market intermediary and understand the importance of the institution. Furthermore, the reader recognizes the specific procedures within the default management process and knows their purpose, benefits and outcomes. By depicting default management process, I wish to emphasize best practices and identify possible shortcomings.

Throughout the thesis I cite the example of one of the largest CCPs in Europe, i.e. Eurex Clearing AG. As procedures and characteristics of CCPs differ amongst each other, I attempt to present practices of Eurex Clearing in more detail.

Chapter 1 gives a general overview of CCPs, including historic developments which lead to regulation of capital markets and mandatory clearing arrangements, regulatory framework for European CCPs, as well as types of risk each CCP is facing.

Chapter 2 represents the types of products that are cleared by CCPs, including exchange traded derivatives and over-the-counter derivatives.

Chapter 3 shows how CCPs are managing the risks overtaken from their clients. CCPs´ risk management includes imposing different kinds of limits and requirements on their clients or members. Main safeguard for CCPs is collateral collected from their members in the form of margin requirements and default fund contributions. Furthermore, they are imposing membership requirements and position limits for their members.

Chapter 4 is a deep dive into default management procedures of CCPs, with special attention given to procedures of Eurex Clearing. Here the whole default management framework is broken down to its components and explicitly presented.

In Chapter 5 we find out how hedging within the default management process would look like in a real-life example. A small portfolio of ETD positions is analyzed, largest risks are identified and hedged accordingly using derivative instruments.

1 CENTRAL CLEARING COUNTERPARTY

Central clearing counterparty (CCP) or clearing house is a designated intermediary in financial markets and represents a buyer to every seller and a seller to every buyer (European Securities and Markets Authority – ESMA, n.d.). A bilateral trade between two counterparties is replaced by two identical trades between the CCP and each of the counterparties in a process called novation (Carter & Cole, 2017). The responsibility of a CCP is to facilitate securities and derivatives transactions by centralizing and standardizing

the entire process leading up to the settlement of the transaction, that includes clearing financial transactions, settling trading accounts, collecting margin payments, regulating delivery of the assets, and reporting trading data.

CCPs foster financial stability with mitigation of counterparty risk to themselves, thereby providing guarantees that the transaction can be completed. By standing between the transacting parties or its members, CCPs are efficient in reducing the impact of any member's default by mutualizing the accompanying losses between clearing members and absorbing some of the losses themselves (Kuong & Maurin, 2021). CCPs clear thousands of financial transactions every single day. Range of financial instruments includes derivatives, equity, repos, bonds, and commodities. CCPs significantly contribute to safer, more efficient and transparent global financial markets (European Commission, n.d.-a).

CCPs can be organized in a variety of forms, such as affiliates to exchanges or as separate legal entities, and they differ regarding to which and how many exchanges they offer services to, as well as the range of products they clear. CCPs clear trades of its clearing members and clients of its clearing members (Riskinstitute, n.d.). CCPs are largely exposed to counterparty risks and have comprehensive risk management procedures in place in order to manage these and other risks to which CCPs are exposed (Haene & Sturm, 2009). More on risk framework in Chapter 3.

Clearing members are a subset of exchange members that must meet financial, operational, and technical standards that exceed regulatory and exchange minimums. This kind of setup creates the need for intermediary relationships between various participants in the clearing process. Members of the exchanges that do not qualify to become a CCP's clearing member, have to arrange for another firm, which is a clearing member to the CCP, to assume financial responsibility for their trades and those of any non-members of the exchange for whom they execute trades. Under this structure, clearing members serve as intermediaries between their clients and the CCP (Riskinstitute, n.d.).

Clearing member's clients include non-clearing exchange members, as well as firms that are not members of the exchange. Relationships between clearing members and their clients are not always clear, it is usually principal-to-principal relationship, but it can also be agency relationship. Meanwhile, relationship between a CCP and its clearing members is a principal-to-principal relationship (Riskinstitute, n.d.).

1.1 History of derivatives trading

The need to introduce CCPs to financial markets arose with growing popularity of financial derivatives trading. A derivative is a financial contract which fate depends on price fluctuation of the underlying asset or basket of assets. Common underlying assets include equities, interest rate instruments, indices or commodities. In theory, derivatives serve as a hedging instrument which helps market participants manage their risks. With the growing

population of derivatives trading, they were not only used to hedge risks but also for speculative purposes (Fernando, 2022).

Warren Buffett called derivatives “financial weapons of mass destruction”. The widespread of financial derivatives trading caused risks on the capital markets to increase by a great margin. Lack of understanding and improper regulation of derivatives trading led to the collapse of financial markets in 2007-2008, which called for new procedures and regulation in the markets (Arnsdorf, 2011).

If we look back, the first recorded example of financial derivatives transaction dates back to 600 BCE in ancient Greece, where they traded call options on olive oil. Arguably, first examples of financial derivatives originated even many years before, between 4500 and 4000 BCE (Origin, 2017-a).

Modern day derivatives trading developed in the 1970s, following the collapse of the Bretton Woods system of fixed exchange rates and the rise of the computer age. Chicago Board of Trade, established in 1848, originally enabled mitigation of price risks on agricultural products and livestock. In 1970s they evolved to offer trading of contracts related to financial products, energy, and precious metals (Pauletto, 2012). Furthermore, after years of research Fischer Black and Myron Scholes published an article entitled “The Pricing of Options and Corporate Liabilities”, in the Journal of Political Economy in 1973. Robert C. Merton expanded the mathematical understanding of the option pricing model and released a paper entitled “Black-Scholes Options Pricing Model” (Black & Scholes, 1973). With that, all the essential components were now in place for expansion of derivatives market, such as pricing methodology, microprocessors, and a market to trade and clear transactions.

Derivatives were traded on the exchange, as well as over the counter (OTC). In 1980s derivatives trading spread on other continents, such as Europe and Asia. In 1990s electronic trading was introduced by Chicago Mercantile Exchange, providing more liquidity, efficiency, and transparency to the markets. Along the way many new derivative products were developed. Particularly interesting role belongs to credit default swaps, which were an answer to rising credit risk in the midst of the financial crisis in 1990s. By 2008, exchange-traded derivatives (ETD) increased in value 100-fold, but OTC activity was even ten times larger than that of exchange-traded derivatives. Total annual notional value of OTC derivatives was hundreds of trillions of dollars (Origin, 2017-b). The big financial crisis of 2007-2008 was caused by subprime mortgages and financial derivatives invented on the back of those mortgages, like collateralized debt obligations (CDO) and credit default swaps (CDS). Increased complexity paired with lack of understanding and misjudgments led to bankrtuptcy of giant OTC players such as Lehman Brothers, Bear Stearns and AIG, and to a general financial collapse (Williams, 2010).

The 2007-2008 financial crisis highlighted the absence of adequate tools to preserve the critical functions provided by failing financial institutions. Moreover, it demonstrated the

lack of frameworks to enable cooperation and coordination between authorities to ensure the taking of swift and decisive action. Without such tools and in the absence of cooperation and coordination frameworks, financial institutions were rescued using taxpayer money in order to stem contagion and reduce panic (Sakelaris, 2014).

As a response to the crisis, strong regulatory reforms came out in an effort to improve counterparty risk management and transparency of OTC derivatives markets. G20 leaders agreed at the Pittsburgh summit of 2009 that all standardized derivatives contracts should be traded on organized exchanges or electronic trading platforms and cleared through central clearing counterparties (CCPs) by the end of 2012. CCPs are intermediaries in the market and as such stand between the transacting parties. CCPs thus ensure that contractual obligations of every derivative contract will be fulfilled. The use of such intermediaries, transfers counterparty and default risk from those engaging in derivatives contracts to the central counterparty itself, and enhances market transparency. Some of the largest CCPs in the world are Eurex Clearing, London Clearing House, TriOptima, ICE Clear, CME Clearing, and OCC (Deng, 2017).

1.2 Regulatory framework

The stability of the EU financial system is governed by European Securities and Markets Authority (ESMA) and European Market Infrastructure Regulation (EMIR), which have been recently complemented by CCP Recovery and Resolution Regulation (CCP RRR).

ESMA stipulates that all sufficiently standardized derivative contracts must be cleared by regulated CCPs. It sets the standards for CCPs that further clarify the provisions under EMIR and CCP RRR. ESMA reviews existing CCP requirements and addresses new developments requiring regulatory intervention. Under EMIR's supervision ESMA issued regulatory technical standards for CCPs, including general requirements, capital requirements, colleges, and records to be maintained by CCPs. Furthermore, it established reporting on efficiency of margin requirements to limit procyclicality, segregation and profitability requirements, possible systemic risks and cost implications of interoperability arrangements, and ESMA input as part of the Commission consultation on the EMIR Review (European Securities and Markets Authority – ESMA, n.d.).

EMIR regulates OTC derivatives, clearing houses, trade repositories, and requires reporting of all derivatives to a trade repository. Trade repositories are central data centers which collect and maintain the records of derivatives. As such, they play a key role in improving the transparency of derivatives markets and enhancing financial stability. Supervision of trade repositories is under ESMA responsibility (European Securities and Markets Authority – ESMA, n.d.).

EMIR came into force in August, 2012. The purpose of the legislation is to reduce systemic counterparty and operational risk, mitigate credit risk, enhance transparency in OTC

derivatives markets, and help prevent future financial system collapses. Furthermore, CCPs must comply with stringent prudential, organisational and conduct of business requirements. EMIR obligates central counterparties to clear certain classes of OTC derivatives, which are privately negotiated and not traded on an exchange. OTC derivatives account for nearly 95% of the derivatives market and have a great impact on the real economy (European Commission, n.d.-a).

Derivatives markets are now more transparent due to introduction of required reporting, which includes detailed information on all derivatives contracts to be reported to trade repositories and made available to supervisory authorities. Trade repositories have the obligation to publish aggregated positions by class of derivatives, this includes OTC and listed derivatives. Counterparty credit risk is mitigated for all standardized OTC derivatives contracts that are cleared through a CCP. For those contracts that are not cleared through a CCP, a risk mitigation technique must be applied. Operational risks, such as fraud and human error, are monitored and mitigated by using electronic means to promptly confirm the terms of OTC derivatives contracts (European Commission, n.d.-c).

Following Brexit, there are 13 CCPs established and authorised in the European Union, and additional 41 third-country CCPs offering their services in the EU under EMIR's equivalence provision (European Securities and Markets Authority – ESMA, 2022).

EMIR's equivalence provision allows EU and non-EU counterparties to use a non EU-based CCP to meet their clearing obligations and a non EU-based trade repository for reporting of their transactions. It needs to be endorsed by the Commission which acknowledges that the legal and supervisory framework for CCPs or trade repositories of a certain country is equivalent to the EU regime. A CCP or trade repository established in a third-country can then apply to obtain EU recognition from ESMA. Once recognition has been granted, the CCP or trade repository can be used by market participants to clear OTC derivatives or report transactions as required by EMIR (European Commission, n.d.-c).

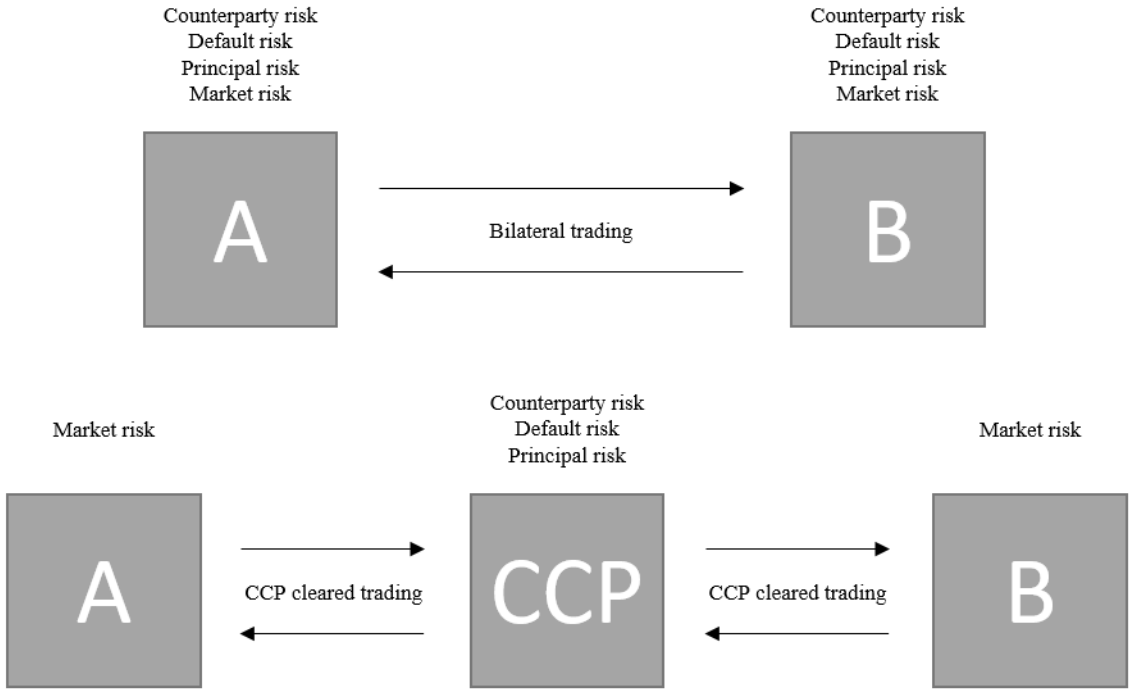
The CCP Recovery and Resolution Regulation came into force in February 2021 to address the challenges posed by the growing importance of CCPs, and the potential risks for financial stability if a CCP were to fail (European Commission, n.d.-b). The CCP RRR contains 19 empowerments to ESMA for development of Regulatory Technical Standards (RTS) and Guidelines. The objective of a credible recovery and resolution framework is to ensure that CCPs set out measures to recover from financial distress, to act decisively in a crisis scenario which means maintaining the critical functions of a CCP which is failing or likely to fail while winding up the remaining activities through normal insolvency proceedings, to preserve financial stability, and to avoid a significant adverse effect on the financial system and its ability to serve the real economy while minimising the cost to taxpayers of a CCP failure (EUR-Lex, n.d.).

1.3 Central counterparty risks

CCPs impose themselves between trading partners and assume a variety of risks that must be managed. CCPs are not subjected to market risks, since they hold a corresponding long position for every short position, and vice versa. However, as a market intermediary they are overtaking counterparty risks, default risks, and are also subjected to liquidity and foreign exchange risks. Whenever contracts indicate delivery instead of just cash settlement, then CCPs are subjected to principal risks (Russo, Hart & Schönenberger, 2002). Depending on what kind of banks CCPs utilize for money settlements, private settlement banks versus central banks, CCPs may be exposed to the possibility of failure of a settlement bank. Typically, CCPs maintain their own financial resources to help cover losses and ensure timely settlements, and the investment of such resources possibly entails some risk of loss or illiquidity. Like other payment and settlement systems, CCPs face various operational risks. Finally, legal risks are also a concern. It is important that the CCPs' default procedures are supported in all relevant legal jurisdictions (Riskinstitute, n.d.).

Figure 1 shows the main inherent risks of two counterparties involved in a bilateral financial contract, and how some of the risks are transferred to a CCP when counterparties trade in a cleared market.

Figure 1: Risk transfer



Source: Own work.

1.3.1 Counterparty and default risk

Counterparty risk is the risk that one of the parties involved in a financial transaction will not fulfill their contractual obligations. Default risk is the chance that the counterparty will be unable to make the required payments on their debt obligations. The terms are essencially interchangeable, however, we mostly associate counterparty risk with derivative contracts and default risk with debt contracts (Murphy, 2020).

Market participants who trade through a CCP therefore do not have any counterparty or default risk, as the CCP ensures the fulfillment of every financial transaction, thus overtaking counterparty and default risk on itself. These are the two most important types of risk a CCP has to manage (Arnsdorf, 2011).

In case of a clearing member default, the CCP would face replacement cost exposure because it has an obligation to the clearing member on the other side of the contract to fulfill contract specifications. The CCP would need to replace the contracts on the open market by finding (buying or selling) identical contracts to those on which the clearing member defaulted. The replacement costs that the CCP faces vary from product to product (Haene & Sturm, 2009).

1.3.2 Liquidity and foreign exchange risk

Liquidity risk refers to CCP's inability to meet its short-term obligations. By imposing itself as a counterparty to its clearing members, the CCP is left exposed to liquidity risks. In case of a default of one or even more clearing members, a CCP must realize its payment obligations to non-defaulting members on schedule. It is crucial that a CCP fulfils its obligations without delay, otherwise questions about solvency might arise (Russo, Hart & Schönenberger, 2002).

In the event of a default, a CCP would look to assets of the defaulting clearing member, default fund, and its own financial resources to raise the necessary funds. Non-cash assets must be converted into cash before the CCP can meet its obligatory transactions. Depending on the timeframe in which the obligations must be fulfilled, it can be difficult and/or costly to complete (Poce et al., 2018).

Moreover, for settlements in multiple currencies, foreign exchange transactions might be necessary to convert cash or asset sales into the required currency. In turn, this would leave a CCP exposed to foreign exchange or FX risk, which is the risk of losses due to currency fluctuations (Russo, Hart & Schönenberger, 2002).

1.3.3 Principal risk

Principal risk is the risk that the seller of a financial instrument will deliver the instrument, but not receive payment, or the risk that the buyer will pay, but not receive delivery.

Therefore, the full value of the securities or funds transferred is at risk. Principal risk is present when the terms of a financial contract call for delivery rather than cash settlement. However, most of the traded products are settled in cash, and principal risk is thereby eliminated (Russo, Hart & Schönenberger, 2002).

For contracts that require physical delivery, a CCP may face principal risk and incur large credit exposures on settlement days when the full principal value of transactions may be at risk. Contracts are settled upon maturity in the case of futures, or when they are excersized or expired in the case of options. A CCP can have large credit exposures if contracts are settled through delivery and delivery versus payment (DVP) is not achieved. DVP is a settlement method which ensures that payment accompanies delivery, and is reducing or eliminating counterparties' exposure to principal risk by limiting the possibility that payments or deliveries would be withheld during periods of stress in the financial markets (Riskinstitute, n.d.).

In case a commodity or underlying instrument is delivered prior to receipt of payment, the deliverer is risking losing its full value. And conversely, in case payment is made prior to delivery, the payer is risking losing the full value of the payment. The sequence of payments and deliveries can be either known in advance or unknown. For the contracts that are settled through physical delivery and a DVP mechanism is not available, CCPs are using other techniques, such as prepayment and third-party guarantees, to limit the size of exposures (Riskinstitute, n.d.).

1.3.4 Risk of settlement bank failure

Upon exercising or maturity of financial contracts, they need to be settled through a settlement bank. We deferenciate between two settlement models, a central bank model and a private settlement bank model. CCPs would use the private settlement bank model for one out of three reasons:

- the CCP or its clearing members lack access to central bank accounts;
- private settlement banks are willing to provide credit to the CCP or its clearing members on terms or amounts that the cental bank is unwilling to provide;
- cental bank's operating hours and finality rules of the payment system do not meet the CCP's agenda to complete settlements with its clearing members (Riskinstitute, n.d.).

CCPs that use central bank settlement model do not run the risk of settlement bank failure. On the other hand, CCPs which utilize private bank settlement model are exposed to the risks of settlement bank failure. Such failure would pose both credit risks and liquidity risks to a CCP (Russo, Hart & Schönenberger, 2002). Credit and liquidity exposures have the potential of being quite significant and they depend on the following factors:

- the timing of the settlement bank's failure;
- the amounts owed to the CCP by its clearing members on the day of the settlement bank's failure;
- the terms of the settlement agreement between the CCP, its clearing members, and the settlement bank (Riskinstitute, n.d.).

The amounts owed to the CCP by its clearing members depend mostly on the positions held by the clearing members and varies considerably day to day. The total exposure of a CCP towards a settlement bank can far exceed the exposure a CCP has towards any of its clearing members because multiple clearing members use the same settlement bank (Russo, Hart & Schönenberger, 2002).

1.3.5 Risk of loss

CCPs typically invest their financial resources like equity, reserves, and other sources of funds in order to generate revenues and partially offset the costs of its operations. The funds are commonly invested in very short-term bank deposits or in highly liquid, short-term securities. Because of characteristics of these investments, that is liquidity and short-term maturity, market risks tend to be negligible. However, a CCP could still face credit and liquidity risks with respect to the banks with which it places funds and possibly also with respect to securities issuers. If a CCP invests collateral from its clearing members, e.g. initial margin, then it could be exposed to custody risks (Riskinstitute, n.d.).

1.3.6 Operational risk

Operational risk is the risk of loss a CCP faces while running its daily business. This could be a result of ineffective or failed internal processes, systems and controls, human error or management failure. With respect to systems, the risk for a CCP lies in the potential breakdown of one or more components of hardware, software or communications systems that are critical to its risk management operations. This is particularly concerning the breakdown of hardware that would impair the CCP's ability to calculate cash settlements and collect margin payments, which could lead to potential liquidity pressures for the CCP and its clearing members (Russo, Hart & Schönenberger, 2002).

Breakdown of a key operational component could also heighten credit risks for a CCP. Firstly, if a CCP does not have real time information on open positions of its clearing members or changes in the market value of open positions, then it cannot precisely measure its credit exposures. This could hinder the CCP's ability to control exposures towards its members and in case of a default suffer from higher replacement costs due to untimely settlements caused by operational problems. Operational risk with respect to human error or management failure refers to the dependence of a CCP on its employees to adhere to the

rules and procedures that are implemented. In case an employee is negligent, the efficacy of a CCP's risk management methods can be compromised (Riskinstitute, n.d.).

1.3.7 Legal risk

Legal risk refers to the loss a CCP may suffer as a result of a legal issue that can arise due to misunderstanding or negligence to meet a legal obligation. In financial services sector, where the regulatory interest is particularly high, participants need to make sure they are adhering to the legal framework.

CCPs face a variety of legal risks that have the potential to significantly increase losses from a default by a clearing member or by a settlement bank. If a CCP's clearing member were to default, then the CCP would be running the risk that the multilateral netting arrangement between clearing members and itself would not be upheld under the national law. However, in many jurisdictions CCPs have been aworded special legislative protection to ensure that their netting is valid (Russo, Hart & Schönenberger, 2002).

Another example of a potential risk source is that bankruptcy administrators might challenge a CCP's right to close or to transfer positions of a defaulting member and the right to liquidate the defaulting member's assets. National legislation seeks to protect CCPs from such challenges, however, in case the defaulting member has the majority of its assets in a foreign jurisdiction, conflicts between different legislations may arise causing difficulties for CCPs.

Moreover, legal disputes might arise between a CCP and a settlement bank over the finality of transfers when a CCP's clearing member defaults. Similarly, if a settlement bank defaults there may be legal disputes between a CCP and its clearing members regarding the finality of transferes. The agreements between the stakeholders, that is the CCP, settlement banks, and clearing members, need to be clear and pricise otherwise it could be challenging to define who bears the risk of defaults, which would in turn cause risks that may be difficult to control (Riskinstitute, n.d.).

2 CLEARED PRODUCTS

Cleared products are in the realm of ETD derivatives, OTC derivatives, and equity instruments. In this section we examine which types of instruments fall under these categories and what are their main characteristics.

2.1 Exchange traded derivatives

As the name suggests, exchange traded derivative is a financial product that is listed and traded on a regulated exchange. In order to be listed on an exchange, ETD derivatives need

to be highly standardized. Consequently, such products are very liquid and always settled through a CCP that is eliminating counterparty risk. Some of the well known derivative exchanges include Chicago Mercantile Exchange (CME), International Securities Exchange (ISE), Intercontinental Exchange (ICE), Eurex Exchange (EX), and London International Financial Futures and Options Exchange (LIFFE).

ETD derivatives are mainly used by retail investors because of their transparency, liquidity, and ease of use. An example of an ETD derivative is a futures or option contract. Underlying assets in a derivative contract can be commodities, foreign exchange, equity instruments, indices, fixed income products, or even other financial derivatives (Manning, 2022).

2.1.1 Futures

In a futures contract parties agree to transact the underlying asset at the predetermined price on a future date. Parties in a futures contract are obligated to buy or sell the underlying asset at maturity of the contract and with respect to predetermined conditions regardless of the current market situation, thus creating risk for a CCP which is liable to execute the transaction even if one of the contracting parties defaults (Hayes, 2021).

Futures contracts are leveraged, which means trading parties do not need to pay upfront the full contract's value amount when entering the trade. Instead, a CCP would charge initial margin requirements to both trading parties. CCP recalculates and requires variation margin amounts to be posted, depending on the market movements (Hull, 2015, pp. 29-31). A detailed examination of margins follows in Chapter 2. Furthermore, parties in a futures contract can reverse their positions by buying or selling the contract before the expiration date.

Contracts will normally be settled in cash, which means that there will be no physical delivery of underlying assets, instead the difference between the futures price and the market price will be netted and paid out in cash (Hull, 2015, p. 38).

2.1.2 Options

Options are financial derivatives that give the holder of the option the right, but not the obligation, to buy or sell the underlying asset at the agreed-upon price and date. We differentiate between call and put options. A call option represents holder's right to buy the underlying asset and enables the holder to profit from price increases of the underlying asset. Put option on the other hand represents the holder's right to sell the underlying asset and to profit from price decreases (Chen, 2022-b).

The main components of an option contract are option's premium, strike price, and expiration date. Premium represents the price per contract, with option's lot size consisting of 100 shares of the underlying asset. Expiration date tells us by when options can be

executed, and it is usually the third Friday of the option's month. Strike price is the price at which the underlying asset can be bought or sold and is different from the market price (Hull, 2015, p. 218-219).

We distinguish between different types of options, most commonly we are talking about European or American options, but there are also many different types of exotic options. European option, also known as vanilla option, can only be exercised on expiration or exercise date. Meanwhile American options can be exercised any time prior to the expiration date of an option (Chen, 2022-b).

Risk of an option contract from a CCP standpoint lies with the seller of an option. The seller of an option contract is required to fulfill obligations arising from the contract should the buyer of the option contract decide to exercise his rights. In case the seller defaults, CCP has to make sure the specified elements of the contract are being honoured. On the other hand, in case the buyer of an option defaults, there are no legal requirements arising and therefore no risk for a CCP (Hull, 2015, p. 224-227).

2.2 Over-the-counter derivatives

An OTC derivative is most commonly a bilateral financial contract that is privately agreed between two parties and does not trade on an exchange. An OTC derivative contract can be concluded also between multiple counterparties. It is preferred amongst institutional investors as it allows for greater flexibility. Terms of an OTC derivative contract can be negotiated and customized to fit the risk profile of the counterparties (Beers, 2021).

OTC derivatives represent 95% of the total derivatives market and thus have a significant impact on the real economy. Furthermore, because they are not traded on an exchange they are not regulated as much as ETD derivatives. The crisis of 2007-2008 was caused due to improper regulation, or lack of regulation, of OTC derivatives, which awoke regulators who agreed that all standardized OTC derivatives must be cleared through CCPs from 2012 onward. The European regulation EMIR was adopted in 2012 to increase transparency in OTC derivatives markets, mitigate credit risks, and reduce operational risks. EMIR dictates that all standardized OTC derivatives are cleared through CCPs or in case they are not, risk mitigation techniques must be applied (European Commission, n.d.-a). More information regarding regulation is discussed in Subchapter 1.2.

Some examples of OTC derivative contracts include forwards, swaps, exotic options, and are used to hedge interest rate risk, currency risk, commodity price risk, and credit risk among others (European Commission, n.d.-a).

2.2.1 Forwards

Forward contracts are very similar to futures, they both involve an agreement to buy or sell an underlying product at a future date and predetermined price. Forward contracts are different from futures because they are not standardized and therefore not traded on an exchange, but rather highly customized and sold over-the-counter. In a forward contract counterparties individually agree on the exact terms of the contract, that is expiration date, number of units of the underlying asset, physical delivery versus cash settlement. Forward contracts are settled only once, at the expiration of the contract (Adkins, 2022).

2.2.2 Swaps

A swap contract represent an agreement made between two counterparties to exchange sequences of cash flows for a set period of time. Cash flows are determined by an uncertain variable, for example interest rate, foreign exchange rate, equity or commodity price. Most commonly we are talking about interest rate swaps (IRS) or currency swaps (Chen, 2022-a). IRS represents approximately 60% of the total OTC derivatives market. Notional value of outstanding US dollar denominated contracts was $193 trillion in 2018, while outstanding notional value of Euro denominated contracts was $129 trillion that same year (BIS, 2018).

The most commonly used swap contract is a plain vanilla interest rate swap. In such an agreement counterparties agree to exchange cash flows based on interest rates, with one party paying a fixed interest rate while the other party pays a variable interest rate. For example, X agrees to pay to Y a predetermined fixed interest rate on a notional principal on set dates for a specified time period. At the same time Y agrees to pay to X payments based on a floating interest rate for the same notional principal on the same dates and for the same time period. Payments occur in the same currency and notional amounts are never exchanged. The dates when payments occur are called settlement dates and the specified period of time is called settlement period (Chen, 2022-a). Frequently used base interest rate for the calculation of floating rate in an IRS agreement was LIBOR or London Interbank Offered Rate. In 2020 the decision was made to phase out LIBOR for all USD denominated derivatives by June 2023, and replace it with SOFR or Secured Overnight Financing Rate (Kurt, 2022). In the UK LIBOR was replaced with SONIA or Sterling Overnight Index Average in 2021 (Marquit, 2022). For all Euro denominated derivatives, the benchmark interest rate is ESTR or Euro Short-Term Rate (Kenton, 2022).

Another commonly used swap agreement is the plain vanilla currency swap. This agreement requires exchanging both principal and fixed interest payments on a loan in one currency for principal and interest payments on a loan in another currency. Principal is exchanged at the beginning and at the end of the contract, while interest payments are exchanged on the specific settlement dates. Principal payments are equal to one another and calculated based on the exchange rate at the time they enter the swap contract. Payments are always netted among each other, which means only one party will make the payment (Chen, 2022-a).

A special role in the financial markets belongs to credit default swaps or CDS. These are credit derivatives and represent an agreement where the seller of a CDS promises to pay principal and interest on a loan to the buyer of a CDS if a borrower defaults on an underlying loan. The buyer of a CDS in turn makes periodic payments to the seller. The total amount paid per year, which is expressed as percent of the principal, is referred to as CDS spread. CDS agreements act as a hedge against credit risk, but were widely used for speculative purposes and contributed to the financial collapse in 2007-2008. Therefore, CDS' are not commonly used anymore and are strictly regulated (Hull, 2015, p. 178).

Swap contracts can be exited before their expiration date in a few different ways. Swaps have a calculable market value and can be sold on an open market, like options or futures. However, if a swap is sold to a third party, the counterparty involved in a swap contract has to agree that the first counterparty sells the swap. Another way to exit a swap is to enter into another swap contract that would offset the first swap. It is also possible to purchase a swaption, which is an option on a swap. This would give the party the right to enter into an offsetting swap at the time they execute the original swap while simultaneously reducing risk of the before-mentioned exist strategy (McCaffrey, 2022).

As with forwards and futures, also swaps represent an obligation to both counterparties involved in the contract, and therefore also for a CCP that acts as an intermediary and eliminates counterparty risk.

2.2.3 Repurchase agreements

Repurchase agreement or repo is a money market instrument and represents a form of short-term borrowing. Underlying instruments are government bonds. In a repo transaction the seller (cash taker) sells the underlying securities to the buyer (cash provider), and promises to buy them back the following day at a slightly higher price. Tenor of a repo is usually overnight to 48 hours, with the longest possible tenor being 2 years. The difference in price is represented by the repo rate, which is set by the central bank. Repos are used to manage liquidity and are a common tool of central bank open market operations (Reiff, 2022).

Repos are a safe investment because they are collateralized with the underlying security and have short tenors. Even though repos are considered to be safe investment vehicles, default risk is still present. The risk arises from price movements of the underlying security. In case the underlying bond appreciates in value, CCP's risk at the cash provider's side will increase. Oppositely occurs when the underlying bond depreciates in value, CCP's exposure on the cash taker's side increases (Vintovkina, 2019).

2.2.4 Genreal Collateral Pooling

GC Pooling is similar to repo agreements. It is also a short-term money market instrument which is collateralized with a basket of bonds and is used for high-volume trades. GC Pooling works on the same principles as repo agreements. The main difference between the two is the number of underlying instruments. GCP has many underlyings, whereas repo only has one (Eurex Clearing AG, n.d.-n).

2.3 Equity instruments

Equity instruments are also known as stocks or shares and represent ownership of a company. They are often the underlying product in a financial derivative contract. Equities are not as risky as financial derivatives, but carry higher risks than fixed income products for the owner of the instruments. From a CCP standpoint, however, they represent lower risk compared to other types of instruments.

Equity instruments are traded on organized exchanges. Clearing is done by a CCP which takes care of correct and timely transfer of funds to the seller and securities to the buyer. Risk for a CCP exists only for the period of time that is needed for this exchange to happen (Eurex Clearing AG, n.d.-d).

3 RISK FRAMEWORK

The main job of a CCP is to efficiently manage risks in order to keep markets efficient and transparent. A CCP manages these risks by decreasing the likelihood of defaults, limiting potential losses and liquidity pressures that it would face if a default were to occur, as well as making sure it has sufficient resources to cover any losses and to continue with its daily business (Riskinstitute, n.d.).

To avoid that CCPs themselves fail and become a source of systemic risk, they need a strong risk management framework (Haene & Sturm, 2009). Risk frameworks differ from a CCP to a CCP, in general however, they employ the following types of safeguards:

- membership requirements,
- margin requirements,
- default procedures,
- maintenance of additional CCP resources,
- position limits.

To ensure that CCPs have adequate assets to cover potential losses in case of a member default, they rely on two types of financial resources. We can group these resources based on two principles, the defaulter-pays principle and the survivor-pays principle.

We talk about the defaulter-pays principle when each member is required to provide collateral in form of margins to cover its current risk exposure. The survivor-pays principle is applied by requiring all members to pay into a pre-funded collective default fund. In case of a default, a CCP would rely on the margins provided by the defaulting party and on the default fund to cover any potential losses. The idea behind the principles is that margin requirements would cover losses in case a member would default under normal market circumstances, while default fund would cover any losses in excess of margins.

It is crucial that CCPs have the right balance between margin requirements and default fund contributions. On one hand, requirement to deposit margins based on current risk exposures will likely limit members' leverage and risk appetite, while on the other hand a collective default fund might create less incentives for members to avoid default, since the cost of default would be partially borne by other members of a CCP through their default fund contributions (Haene & Sturm, 2009).

3.1 Membership requirements

In order to become a clearing member of a CCP, companies must meet a list of requirements proving they are creditworthy counterparties (Eurex Clearing AG, n.d.-a). Membership requirements imposed by CCPs usually include minimal capital requirements, and for clearing members that carry client accounts additional capital standards are enforced which are more stringent than regulatory minimal requirements. These are set to ensure members can fulfil their liquidity demands even in times of high volatility. Specific requirements on liquidity are not imposed by CCPs, however, some CCPs periodically review their clearing members' access to funding (Russo, Hart & Schönenberger, 2002).

Furthermore, clearing members must meet operational and technical capabilities. CCPs impose strict deadlines for the submission of trading data and completion of settlement obligations. If a member fails to meet these requirements, a CCP would be left exposed to risk towards that and possibly also other clearing members. Therefore, CCPs monitor compliance with operational deadlines on a daily basis. To ensure operational tasks are running smoothly, clearing members have to have good technical infrastructure in place. CCPs pay attention to the backup systems that clearing members would have available if their primary operating systems were disrupted.

Clearing members are being diligently monitored for on-going compliance with rigorous capital, operational, and technical requirements. While membership requirements are an extremely important component of CCPs' risk framework, they are not intended or expected to eliminate the possibility of a clearing member's default. Capital requirements are not meant to cover potential losses from possible price movements, and it is understood that such requirements and surveillance techniques cannot predict, much less prevent, financial problems of every clearing member (Riskinstitute, n.d.).

3.2 Margin requirements

Margining methodology differs between CCPs. Some require posting of higher margins and some lower, but in general CCPs try to be as efficient as possible with their margin requirements (Carter & Cole, 2017).

Every clearing member of a certain CCP holds a large portfolio with thousands of different financial products. CCPs have the option to calculate risk of such products on product level or alternatively, on portfolio level. Risk calculated on portfolio level would take into account risk offsets between certain products making the overall risk, and therefore margin requirements, lower compared to product-based risk calculation (Russo, Hart & Schönenberger, 2002).

In Eurex Clearing they use Prisma margining methodology, which is a portfolio-based risk calculation. Cleared products with similar risk characteristics are assigned to the same liquidation group. Liquidation group splits group the products that have similar probability of risk occurance, size of the risk impact, FX exposure, interest rates exposure, etc. These groups are then jointly liquidated in case of a clearing member default and have assigned the same holding period, which is the number of days necessary to liquidate the products. Prisma calculates risk on liquidation group level, allowing for more comprehensive risk calculation due to margin offsets within liquidation groups, as well as cross-margining across different liquidation groups (Eurex Clearing AG, n.d.-g).

There are two main margin components:

- backward-looking margin or mark-to-market margin and
- forward-looking margin or initial margin.

3.2.1 Mark-to-market margin

Mark-to-market margin aims to cover losses arising if the positions would be closed out today. We separate between two types of mark-to-market margins, that is premium margin and variation margin.

Premium margin applies to options which are subject to premium-style margining and is deposited only by the seller of the option. With options, CCPs have exposure towards the seller of the option and not to the buyer, as the buyer has the right, but not the obligation, to exercise the option. Meanwhile, the seller has the obligation to fulfill the terms of the contract if the buyer decides to exercise. Premium margin is continuously adjusted, from the inception of an option's contract until the positions are closed, exercised or expired. Premium margin is equal to the option's present (market) value at all times.

Variation margin applies to financial derivatives that are not premium-style margined products, such as futures. At inception of a futures contract a CCP has no replacement cost

exposure as the contracts are struck at prevailing market prices, therefore, variation margin equals zero. Over time market prices will move away from the prices at which the deal was made, exposing the CCP to either the buyer, if the market value of the contract decreases, or to the seller, if the market value of the contract increases. These profits and losses that arise due to price fluctuations need to be collateralized in cash and settled daily in the respective product currency (Eurex Clearing AG, n.d.-h).

3.2.2 Initial margin

Initial margin collateralizes potential future exposure that a CCP would face during the liquidation of a portfolio of a defaulting clearing member over the holding period. It captures market and liquidity risks. A good initial margin model should set margin requirements high enough to absorb price fluctuations, up to a predetermined confidence interval, over a time horizon long enough to liquidate or hedge the defaulted member's positions (Woodall, 2020).

If initial margin is calculated on portfolio or liquidation group level, it recognizes potential correlations and netting offsets between products. Commonly, initial margins are calculated using some form of Value-at-Risk methodology. Value at Risk or VaR is the maximum expected amount to be lost over a given time horizon and at a predefined confidence level. There are several techniques for calculating VaR, including historical method, parametric (variance-covariance) method, and Monte Carlo simulations (Hull, 2015).

Every CCP has its own procedures and methodologies for VaR calculation. In the thesis I present the approach used by Eurex Clearing.

Initial margin is the result of a simulation based VaR methodology with four main components:

- filtered historical scenarios,
- stress period scenarios,
- event scenarios,
- model adjustments to account for correlation breaks, compression, liquidity, and long option credit.

Historical method is used to calculate VaR for filtered historical scenarios. The 3-year lookback period gives us 750 historical observations. Stress period scenarios consist of 250 observations. It is important to include stress period risk to ensure stability of the model and avoid procyclicality. Both historical and stress scenarios are divided into several subsamples for which risk is calculated separately and then aggregated together. This is important to avoid certain artificial statistical effects from overlapping time periods which would violate the assumptions of risk figures. Risk is calculated based on the tail-risk measure VaR and

individually applied to the profit and loss distributions of filtered historical and stress period scenarios.

Event scenarios are sudden, independent market events. It is not a VaR measure, but a sum of worst N scenario losses.

The model is additionally adjusted for correlation breaks, compression, and long option credit.

Above describes market risk component of the model. Additionally, liquidity risk is also modeled. Liquidity risk component is included to capture potential additional costs when liquidating portfolios. The lowest liquidity risk component is defined by the liquidity premium. Liquidity component in excess of the liquidity premium depends on the position size of a product held by a clearing member relative to the total daily traded volume and on the level of market volatility. The higher the clearing member's position relative to the total market capacity, the higher the liquidity risk component. Increasing volatility of a product is accelerating the growth of liquidity risk component. Liquidity risk component is very product specific and is unevenly distributed across product groups.

All the components of initial margin need to be aggregated together in order to get the consolidated initial margin for each clearing member. Firstly, VaR figures for each subsample of filtered historical and stress period scenarios are aggregated by taking the mean VaR figures of the subsamples separately for filtered historical and stress period scenarios. This figure includes also model adjustments for correlation breaks, compression, and long option credit. For each liquidation group the highest risk figure is then chosen between maximum filtered historical VaR, scaled stress period VaR, and sum of worst N scenario losses for event risk. Consolidated initial margin for each clearing member is the sum of all initial margins by liquidation groups (Eurex Clearing AG, n.d.-h).

3.2.3 Cross-margining

Cross-margining is an additional benefit of the risk model, as it accounts for risk offsets across different liquidation groups, making margining more efficient for the clearing house as well as for its clearing members.

Eurex Clearing allows for offsetting interest rate sensitivities between interest rate derivatives liquidation group and listed fixed income derivatives liquidation group (Eurex Clearing AG, n.d.-h).

3.3 Default procedures

While margin requirements provide considerable protection to a CCP, potential default of a clearing member could still lead to losses beyond the value of the collateral the member had posted to fulfil its margin requirements (Poce et al., 2018).

In case one of CCP's clearing members would default on its obligations, the CCP would be liable to fulfill the terms of the financial transactions from the defaulted clearing member's portfolio. Therefore, the CCP would no longer have a matched book of transactions. The goal of the CCP is to return to a matched book as quickly and as cost-efficiently as possible (Committee on Payments and Market Infrastructures, 2020). That is why CCPs have developed risk management practices specifically designed to deal with default procedures.

Default procedures consist of preliminary measures, hedging, and auctioning the defaulted clearing member's portfolio. During preliminary measures CCPs review the portfolio and convene default management committees, which will assist with hedging (Eurex Clearing AG, n.d.-k). CCPs would usually seek to transfer the defaulting clearing member's client's open positions and margin collateral to other non-defaulting clearing members (Riskinstitute, n.d.).

During hedging, CCPs prepare the portfolio for auctioning by reducing market risk. A process which is also known as "stop the bleeding". Hedged portfolio will receive better prices in the next step of the default process, which is the auction. Auction is the most important step in the default management process, as it is with auctions that CCPs liquidate the defaulted clearing member's portfolio and finally return to a matched book (Committee on Payments and Market Infrastructures, 2020).

In Chapter 4 we closely inspect default management processes of CCPs.

3.4 Maintenance of additional CCP resources

Losses resulting from a clearing member's default have the potential to exceed the value of margin collateral posted by that member. For this reason, CCPs maintain additional financial resources intended to cover such uncollateralized losses and to ensure they remain liquid during the period before they manage to sell of the defaulting member's assets. The aim of additional CCP resources is to mutualize uncollateralized losses among all clearing members. These resources can take on different forms, for example they can be in the form of capital and reserves, default funds, lines of credit, insurance policies, guarantees provided by members, etc. (Riskinstitute, n.d.).

Default funds are collateral pools where clearing members contribute funds or securities in accounts separate from margin accounts and that are then under the control of the CCP. Each clearing member is required to contribute to the default fund with the contribution depending

on the risk level they bring to the CCP and utilization of CCP's services (Eurex Clearing AG, n.d.-i).

The size of additional CCP resources varies considerably from one CCP to another. It is possible that such resources available to the CCP are not sufficiently liquid to ensure that the CCP meets its obligations without delay. Credit lines' and guarantees' liquidity depends on how promptly banks make the funds available. Capital and reserves are usually invested and therefore illiquid if the investments have not yet matured (Russo, Hart & Schönenberger, 2002).

3.5 Position limits

Exchanges or CCPs impose some form of position limits. With position limits a CCP limits the number of contracts or the percentage of total open interest in a contract that a single clearing member or its client is allowed to hold. The primary objective of such limits is to prevent the ability of market participants to manipulate prices. However, position limits do not apply to those contracts that have large or unlimited deliverable supply or to non-speculative positions.

CCPs monitor clearing members' positions regarless of whether position limits are imposed. Moreover, if clearing members' positions could induce prudential concerns, CCPs have the authority to require reductions in such positions. In case a clearing member would exceed their position limits, a margin surcharge would be collected. CCPs often implement risk-based position limits related to individual contracts that may differ across clearing members. The limits are applied to a specific clearing member and are proportional to the member's capital (Russo, Hart & Schönenberger, 2002).

4 DEFAULT MANAGEMENT PROCESS

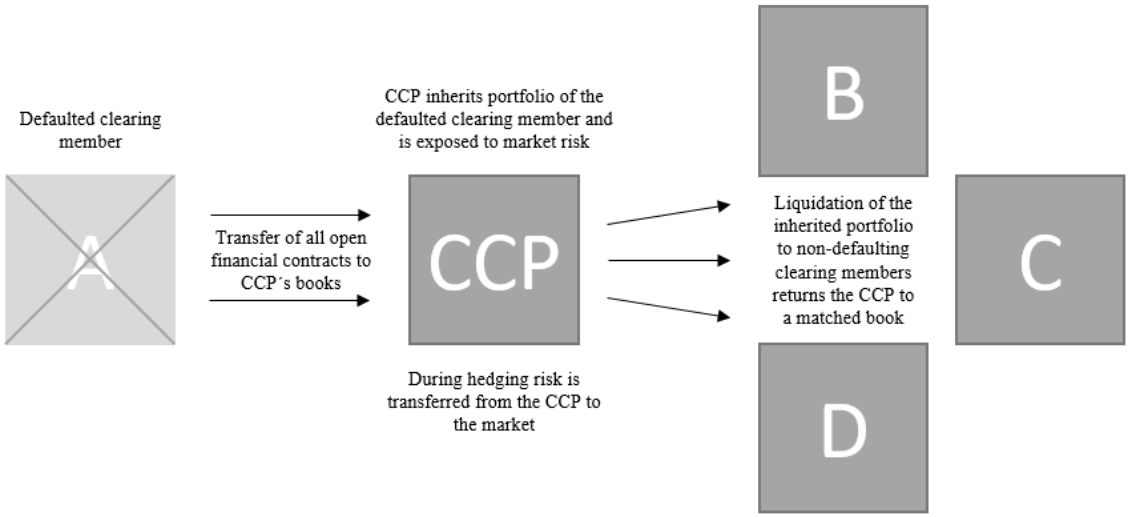
Financial services industry is highly regulated with many big players on the market. Regulation aims to provide safety and security to the markets, however, even with rigorous adherence to rules many risks still persist. A CCP, as a market intermediary, has a very important task of maintaining stability in financial markets and mitigating systemic risk should the default of a clearing member occur (Committee on Payments and Market Infrastructures, 2020).

As discussed in Chapter 1.3., the main risk facing any CCP is counterparty or default risk. A clearing member default would cause massive disruption in financial markets, effecting not only the clearing member in question, but would have a domino effect on every other player in the market and could therefore be seen as a source of systemic risk (Pirrong, 2009).

It is important that CCPs have robust measures and procedures in place to deal with such situation, should it occur. We call this default management process. The framework of the

default management process or DMP is similar across all CCPs, although there are some differences between them. The main objective of the default management process is to re-balance the CCP (Riskinstitute, n.d.).

Figure 2: Clearing member default



Source: Own work.

With each default scenario being unique, it is vital that CCPs maintain flexibility around their procedures to accommodate the individual features of each default, meanwhile staying consistent with local and global regulatory standards (Ferrara & Li, 2017).

4.1 Trigger events

Despite of individual nature of each default event, we can explicitly define trigger events which lead to a clearing member's default, regardless of product or cleared market (Eurex Clearing AG, n.d.-k):

- Initiation of insolvency proceedings over a clearing member's estate.
- Failure to pay or deliver margin, failure to comply with clearing conditions, reorganization or restructuring proceedings.

The first trigger event would result in an automatic termination of all transactions between the CCP and the clearing member, and commencement of the default management process. The second trigger event implies a non-automatic termination, where a certain grace period is granted to the clearing member in order to remedy the respective breach or failure before declearing that clearing member to be in default.

When a clearing member goes in default, their propriatery positions and its client positions may be treated differently (Eurex Clearing AG, n.d.-k).

4.2 Preliminary measures

Preliminary measures taken at the start of each default management process are a way of assessing the given situation and to take quick and decisive actions to limit the undesirable consequences.

Firtstly, there is a convention of default management committees to support the CCP throughout the default management process (Eurex Clearing AG, n.d.-j).

CCPs' clearing members all hold very large portfolios of positions, some of which are their propriatery positions, others are client positions. Therefore, it is crucial that the CCP, as a guarantor of market safety and security, protects clients and contractual counterparties of the defaulting clearing member. It does so by transferring clients' positions and collateral whenever possible (Ferrara & Li, 2017).

Portfolio of the defaulting clearing member has to be evaluated in preparation of liquidation. As positions differ in their maturity, special attention has to be given to the positions that expire shortly (Committee on Payments and Market Infrastructures, 2020).

4.2.1 Default management committees

Default management committees or DMCs convene whenever a default is decleared, to support the CCP throughout the entire default management process. DMCs advise and assist the CCP on any relevant matter of the default management process, especially when it comes to hedging of the defaulting member's portfolio and preparation for auctioning the hedged portfolio to other non-defaulting clearing members of the CCP.

DMCs consist of highly skilled and knowledgable professional employees of pre-selected clearing members. Members of DMCs have to possess sufficient trading as well as risk expertise in the products that make up the defaulting member's portfolio. In case of Eurex Clearing, which splits every portfolio into several liquidation groups depending on the products' risk characteristics, one DMC is implemented per each liquidation group, consisting of two to four DMC members.

Default management committees are convened in case of a default event and in addition at least once per year for default management process simulation (Eurex Clearing AG, n.d.-j).

4.2.2 Client positions

A clearing member can trade for its own proprietary account as well as for its clients' accounts. Clients include non-clearing members of the exchange, as well as firms that are not members of the exchange. When there is a default by a clearing member, one of the primary objectives is to protect customers and to minimize the impact on clearing member's

clients and their positions. This is achieved by porting clients and their positions, assets, and collateral to another, solvent clearing member (Committee on Payments and Market Infrastructures, 2020).

It is also important to mention, that because of principal-to-principal relationship between a CCP and its clearing members, CCPs only have to deal with a potential default by its clearing members and not clients of those clearing members. In case a clearing member's client would go in default, that would be handled by the clearing member itself (Russo, Hart & Schönenberger, 2002).

4.3 Hedging

Hedging is a way of reducing risk. It is defined as a risk management strategy for insuring or protecting investments from losses by taking an opposite position in a related asset. It typically involves financial derivatives, such as options and futures contracts (Investopedia, 2022).

Hedging is an important part of the default management process as it protects the CCP from market risks and potential cash-flow risks. Moreover, hedging reduces the portfolio's sensitivity to market moves and stabilizes it for auctions, and is, as such, likely to receive higher prices in auctions (Vintovkina, 2019). CCPs are supported by the expertise of default management committees when defining hedging strategies.

Hedging can be executed in two separate ways:

- Closing out certain concentrated positions within the defaulting clearing member's portfolio.
- Entering into additional, one-sided transaction, which are added to the defaulting clearing member's portfolio and will be jointly liquidated.

Executive board of the CCP makes final decisions regarding hedging transactions, therefore, the individual DMC members are not liable for the outcome of the proposed hedging strategies (Eurex Clearing AG, n.d.-o).

4.3.1 Hedging strategies

There are many hedging strategies available when it comes to reducing risk of a product or a portfolio. CCPs establish a framework for their approach to hedging risks arising from the defaulted clearing member's portfolio prior to a default. Hedging framework provides guidance to the default management team and promotes quicker reaction to and navigation of a potential default scenario. By integrating a part of their framework in the rulebook, CCPs disclose certain procedures and guidance to their clearing members in order to facilitate clearing members' preparedness. It is important that CCPs maintain flexibility in

their frameworks, as it will allow them to respond to individual default scenarios and market conditions with appropriate hedging strategy (Committee on Payments and Market Infrastructures, 2020).

The goal of a hedging strategy is to reduce exposure a CCP has towards the defaulted clearing member's portfolio and to mitigate the overall risk the defaulted portfolio poses to the CCP and other market participants. A hedged portfolio reduces CCP's liquidity risk by balancing its payment flows, i.e. variation margin, until the portfolio liquidation is completed (Vintovkina, 2019). As already mentioned, a hedged portfolio is likely to receive more competitive bids as the inherent risk is lower.

CCPs consider the following when designing a hedging strategy:

i. Timing for hedging:

CCPs start hedging immediately after the declaration of default and approval of hedging strategy by the executive board (Eurex Clearing AG, n.d.-o). However, there may be a delay to preform an adequate analysis of the portfolio and market conditions. Liquidity of hedging instruments needs to be assessed, as in some cases hedging can prove to be more costly than going directly to auction. In addition, hedging could be delayed until porting of the defaulting clearing member's clients and their positions is complete (Committee on Payments and Market Infrastructures, 2020).

ii. The portion of the risk to be hedged:

A precise portfolio and market analysis is needed to determine which portion of the risk to hedge (Vintovkina, 2019). Here CCPs consider factors such as portfolio size, complexity, liquidity, cleared product types, market conditions, margin offsets within the portfolio, and the potential splitting of the portfolio for auctions. In certain cases, a CCP will decide to hedge the portfolio with regards to up and down movements of major risk factors, in other cases it will hedge the delta exposures or currency exposure of the portfolio using instruments in a liquid market. Some exposures are better left unhedged and go straight to auction to achieve a better outcome (Committee on Payments and Market Infrastructures, 2020).

iii. The instruments to use for risk reduction

When a CCP decides which exposures it will hedge, it proceeds to choosing which instruments it will use to conduct hedging. The hedging instruments or products can be listed on an exchange or bought or sold OTC. An important factor to consider is the liquidity of the hedging instrument as in some cases it may be more efficient and cost-effective for a CCP to use a more liquid, proxy instrument for hedging. CCPs also pay attention to the basis risk between the products that need to be hedged and the hedging instruments in order to make sure the residual risk after hedging is appropriately managed (Committee on Payments and Market Infrastructures, 2020).

iv. The execution method for transactions

Most commonly, hedging is executed through a broker for market transactions or directly with auction participants through a hedging auction or a direct offer. However, execution methods may vary and depend on the choice of hedging instruments. The aim of every CCP is to to choose the execution method which will facilitate competitive bidding. CCPs communicate the execution methods to their clearing members in advance of a default and thus ensure timely execution (Committee on Payments and Market Infrastructures, 2020).

In the section below we discuss some of more sophisticated hedging strategies with respect to greeks, in use by experienced traders.

4.3.1.2 Delta hedging

Delta measures price sensitivity of the option relative to the underlying asset and it is defined as the rate of change of the option price with respect to the price of the underlying. It tells us how much will the option's price change if the price of the underlying asset changes by 1 unit. We can write this as

$$\Delta = \frac{\partial c}{\partial S} \tag{1}$$

where c stands for option price, and S represents stock price. The delta of a call option can take on values between 0 and 1, meanwhile the delta of a put option has a range between 0 and -1.

With delta hedging, a trader must create a delta neutral position. In this sense, delta can be understood as the optimal hedge ratio. For example, let us assume that the delta of a call option on a stock is 0.6, which means that when the stock price increases by 1 unit, the option price would increase by 0.6 units. Now imagine an investor sold 20 such call option contracts with a lot size of 100. The investor's position could be hedged by buying $0.6 * 2{,}000 = 1{,}200$ shares of the underlying stock. Therefore, the gain or loss on the stock position would be offset by a gain or loss on the option position.

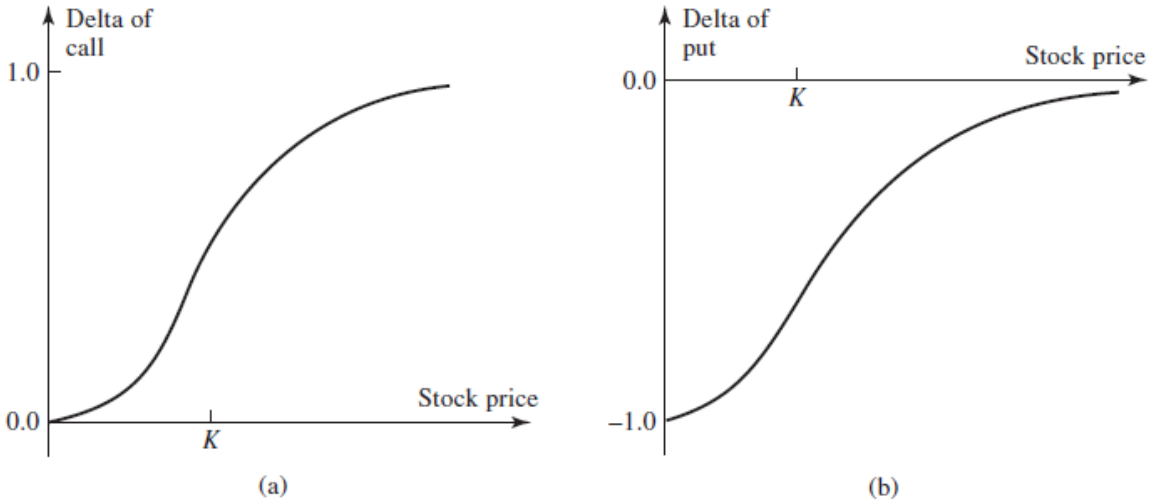
However, the delta of an option does not remain constant over time and the delta hedged or delta neutral position would remain hedged only for a short period of time. Therefore, the hedge has to be adjusted on a regular basis, which is known as dynamic hedging.

A short position in a European call option can be delta hedged by taking a long position in the underlying for each option sold. Oppositely, a long position in a European call option can be delta hedged by taking a short position in the underlying for each option purchased.

Delta of a put option will be negative, meaning that a short position in a European put option should be hedged by taking a short position in the underlying asset for each option sold. And a long position in a put option can be delta hedged with a long position in the underlying.

On Figure 3 we can observe the variation of delta of a call and a put option with the changing stock price.

Figure 3: Variation of delta with the stock price for a call option (a) and a put option (b) on a non-dividend paying stock.



Source: Hull (2015).

The preformance of a delta hedging strategy gets better with more frequent hedge observation and hedge rebalancing. If hedging worked perfectly, then the cost of hedging after discounting would be exactly the same as the Black-Scholes-Merton option price.

So far we have discussed delta hedging for one single asset. However, we can also calculate delta of a portfolio of options or other derivatives that are dependent on one underlying asset with price S

$$\frac{\partial \Pi}{\partial S} \tag{2}$$

where Π is the value of a portfolio. The portfolio delta can be calculated from the individual deltas of the options in the portfolio.

$$\Delta = \sum_{i=1}^{n} \omega_i \Delta_i \tag{3}$$

where ω_i is quantity of option i $(1 \leq i \leq n)$ and Δ_i is the delta of the i^{th} option. This formula can be used to calculate the position a hedger ought to take in the underlying asset to make the delta of a portfolio equal to 0, i.e. to be delta neutral (Hull, 2015, pp. 402-409).

Delta hedging can be used also for forward and futures contracts. The value of a forward contract is defined as

$$f = S_0 - Ke^{-rT} \tag{4}$$

where S_0 is the price of the asset underlying the forward contract, K is the delivery price, r is the risk-free rate, and T is time to maturity.

When the underlying asset does not pay a dividend yield, then the value of a forward contract changes for the same amount as the underlying asset, ΔS. The delta will therefore always be equal to 1, meaning that a long forward contract on one share can be hedged by shorting one share, and a short forward contract on one share can be hedged by purchasing one share. When the underlying asset pays a dividend yield at rate q, the delta of a forward contract is e^{-qT}.

$$f = S_0 e^{-qT} - Ke^{-rT} \tag{5}$$

Futures price on a non-dividend paying asset is defined as

$$F_0 = S_0 e^{rT} \tag{6}$$

It is seen from the above equation, that when the price of the underlying changes by ΔS, the futures price changes by $\Delta S e^{rT}$. Unlike forward contracts, futures contracts are settled every day, with daily profit and loss of a contract being collected in the form of variation margin by a CCP. This makes delta of a futures contract e^{rT}. In cases where the underlying assets of a futures contract provide a dividend yield at rate q, the delta is $e^{(r-q)T}$

$$F_0 = S_0 e^{(r-q)T} \tag{7}$$

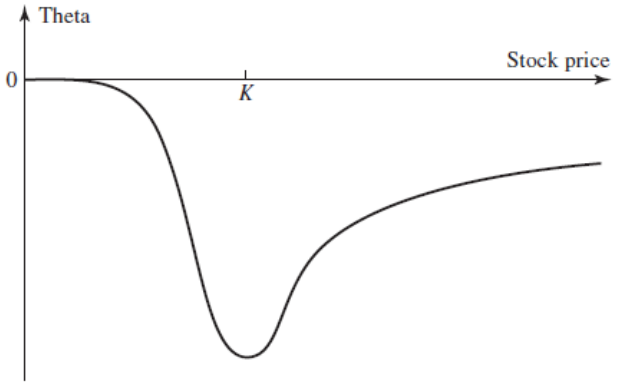
(Hull, 2015, pp. 420-421).

4.3.1.3 Theta hedging

Theta is known as the time decay of an option or a portfolio. It represents the rate of change between the option price and the passage of time. Theta indicates the amount an option's price would decrease as time to expiration decreases, with all else staying equal.

Theta values are usually negative for options, because with everything else staying equal, as time passes the option tends to become less valuable. Theta tends to increase when options are at-the-money, and decrease when options are in-the-money or out-of-the-money, which can be observed on Figure 4.

Figure 4: Variation of theta with the stock price for a European call option



Source: Hull (2015).

As the stock price rises, theta tends to approach $-rKe^{-rT}$. Options that are closer to its expiration have accelerating time decay.

Hedgers do not hedge theta of a portfolio as they do with delta. There is no uncertainty about the passage of time, therefore, it does not make sense to hedge against it. However, theta is still a useful descriptive statistic of a portfolio as it can be used as a proxy for gamma in a delta neutral portfolio (Hull, 2015, pp. 409-411).

4.3.1.4 Gamma hedging

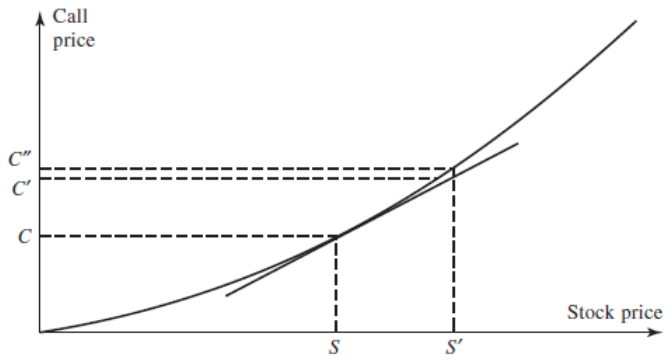
Gamma represents the rate of change of the portfolio's delta with respect to the price of the underlying asset. We refer to it as the second-order price sensitivity. Gamma indicates the change in delta when the price of the underlying asset changes by 1 unit.

$$\Gamma = \frac{\partial^2 \Pi}{\partial S^2} \tag{8}$$

A small gamma value indicates that the rate of change in delta is slow, which suggests that the delta hedge has to be rebalanced rather infrequently. However, highly positive or highly negative gamma values indicate that delta of a portfolio is very sensitive to the price movements of the underlying asset and the delta hedge ought to be rebalanced frequently.

Gamma corrects for the hedging error which is caused by non-linearity of the option price. We can see the relationship between the stock price and the price of a call option depicted on Figure 5. Hedging error occurs because delta hedging assumes that the option price will move from C to C' when the stock price moves from S to S'. In reality, the option price moves from C to C''.

Figure 5: Hedging error



Source: Hull (2015).

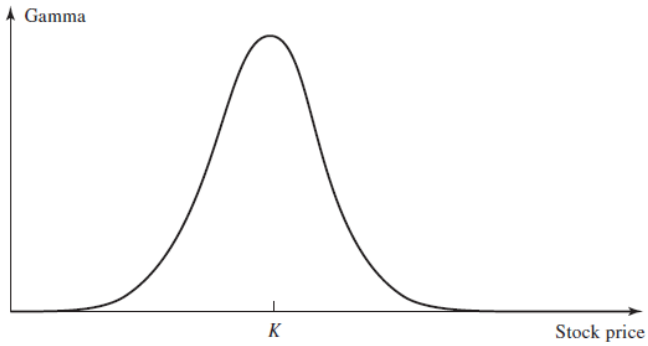
A portfolio can be made gamma neutral by acquiring a position in an instrument that is not linearly dependent on the underlying asset. The size of that position is determined by $-\frac{\Gamma}{\Gamma_T}$, with Γ representing portfolio's gamma and Γ_T representing gamma of the added instrument. Of course, adding an additional instrument to the portfolio will likely change the delta of that portfolio. To maintain delta neutrality, the position in the underlying asset then needs to be adjusted.

A portfolio that is delta as well as gamma neutral is corrected for the hedging error. Gamma neutrality provides protection against larger movements in the underlying asset price compared to delta neutrality, which offers protection against relatively small stock price moves between rebalancing.

On Figure 6 we can observe that at-the-money options have the highest gamma values. For at-the-money options it holds that gamma increases as time to maturity decreases. Gamma of a long position is always positive. There is a special relationship between gamma and theta of a portfolio. When gamma is positive, theta is usually negative and vice versa.

Another interesting observation is for a portfolio with a positive gamma and no changes in the underlying price, the portfolo will decrease in value, but increase in value for large positive or negative changes in the underlying price. The opposite is also true. A portfolio with negative gamma will increase in value for no changes in the underlying price, but decrease in value if there is a large positive or negative change in the underlying price (Hull, 2015, pp. 411-415).

Figure 6: Variation of gamma with the stock price for a European call option



Source: Hull (2015).

4.3.1.5 Vega hedging

Vega represents the rate of change of the value of an option or a portfolio with respect to the implied volatility of the underlying asset.

$$V = \frac{\partial \Pi}{\partial \sigma} \tag{9}$$

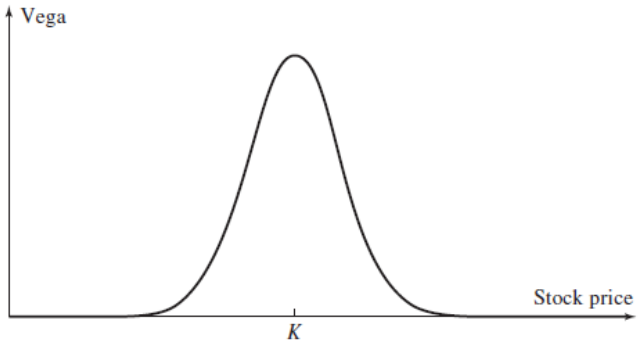
A highly positive or negative vega values imply that the portfolio's value is very sensitive to small changes in volatility. Vega values that are close to zero imply that portfolio is insensitive to changes in volatility. Implied volatility is a forward-looking measure that indicates where volatility of the asset should be in the future.

Vega hedging works similarly to gamma hedging. As a position in the underlying asset has zero vega, another instrument has to be added to the portfolio. The size of the position in a new instrument, i.e. a traded option, is determined by $-\frac{V}{V_T}$. Vega of the portfolio is represented by V and vega of the traded option is V_T. If the hedger aims to make the portfolio both gamma and vega neutral, at least two traded derivatives dependent on the underlying asset must be used.

The Black-Scholes-Merton model has an underlying assumption that the volatility is constant. However, vega calculated from a stochastic volatility model is very similar to the Black-Scholes-Merton vega.

A long position in a European call or put option will always have a positive vega value, and it is the highest for at-the-money options. A short position in options will result in a negative vega (Hull, 2015, pp. 415-417).

Figure 7: Variation of vega with the stock price for a European call option



Source: Hull (2015).

4.3.1.6 Rho hedging

Rho of an option or a portfolio indicates the rate of change of portfolio's value with respect to 1% change in the interest rate (Hull, 2015, p. 417).

$$\rho = \frac{\partial \Pi}{\partial r} \tag{10}$$

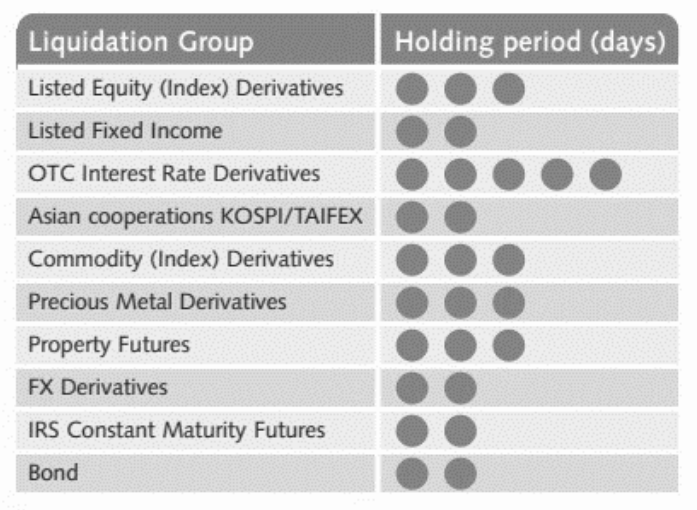
4.3.2 Heding in Eurex Clearing

We have previously mentioned, that Eurex Clearing AG groups the products it clears into several liquidation groups. Products assigned to individual groups share similar risk characteristics, such as probability of risk occurrence, impact of risk occurrence, FX rates, interest rates etc. There are nine defined liquidation groups and each of them is assigned a specific holding period, ranging from two to five days, based on assumption of how many days it will take to analyze, hedge, and liquidate the respective products.

Eurex Clearing AG, or ECAG for short, uses the concept of liquidation groups to calculate risk and margin requirements, and therefore enable margin offsets within liquidation groups as well as cross-margining across liquidation groups. ECAG also designed its default management process to accommodate the concept of liquidation groups, therefore closely aligning its margining method with its default management process.

Portfolios of clearing members normally have a heterogeneous structure in their size and complexity, which makes it difficult to liquidate the entire portfolio at once. Products that are in the same liquidation group will be jointly liquidated in case of a clearing member default.

Figure 8: Liquidation groups of Eurex Clearing



Source: Eurex Clearing AG (n.d.-g).

As aforementioned, hedging is a crucial part of the default management process, which reduces market and cash-flow risks for the clearing house and prepares the portfolio for liquidation by reducing its sensitivity to market moves. The default management team of ECAG consists of former traders that define hedging strategies. Internal traders are supported by the expertise of default management committees that convene for each separate liquidation group.

Together they prepare a hedging proposal that needs to be approved by the executive board of ECAG. As soon as the approval is given, hedging can commence. Firstly, the defaulted clearing member's portfolio is analyzed and the products grouped in the respective liquidation groups. Positions that have short times to expiery or illiquid instruments are recognized and separated from the portfolio. Such positions are treated individually and sold OTC. Internal traders and DMC members analyze each liquidation group separately and hedge each group with respect to delta and vega, which were described in the previous section.

With each default scenario being unique in terms of market conditions and defaulting clearing member's portfolio, ECAG does not define any hedging thresholds that need to be met. In fact, it is even possible to liquidate certain liquidation groups without hedging them first.

One hedging channel introduced by ECAG is called mandatory hedging auctions. Mandatory hedging auctions are conducted on liquidation group level and represent a way to mitigate the market risk for the positions inherited from the defaulted clearing member. To ensure there are enough suitable hedging counterparties, ECAG formalized two forms of participation:

i. Optional participation: Clearing members can volunteer to participate in hedging auctions.
ii. Mandatory participation: In case not enough clearing members volunteered, ECAG obligates those clearing members that have the highest propriatery trading volumes to participate in hedging auctions (Eurex Clearing AG, n.d.-o).

4.4 Independent sale

Independet sale is a way to liquidate the defaulting clearing member's portfolio as an alternative to auctions. It is used to liquidate particularly special or small portfolios and thus ensuring that good prices are achieved. Independent sale is not a mandatory component of the default management process, but it is something that ECAG implemented in order to be as efficient as possible in its liquidating practices. Participation for clearing members is voluntary (Eurex Clearing AG, n.d.-p).

Liquidation groups including exchange traded derivatives, such as listed fixed income, FX and equity derivatives, most commonly represent a big portion of clearing members' portfolios and are best liquidated in auctions. However, for other products such as those in bond liquidation group, independent sale is the most relevant liquidation measure (Vintovkina, 2019).

Liquidating positions through an independent sale is handled either on exchange via the order book or bilaterally by contacting potential counterparties and conducting back-office to back-office transactions. It is important to mention that unless the costs resulting from an independent sale are covered by the defaulting clearing member's resources, an independent sale is not conducted. Contributions of non-defaulting clearing members to the default fund are not used to cover losses resulting from an independent sale, and are only utilized when all clearing members have the chance to participate in respective auctions (Eurex Clearing AG, n.d.-p).

4.5 Auctioning of defaulting clearing member´s positions

Auctions are the last component of the default management process. By this stage in the default management process, a CCP would be able to limit its exposure to market moves. However, a CCP cannot keep the portfolio of the defaulting clearing member on its own books. Therefore, CCPs use auctions as a tool to transfer the defaulting clearing member's position to non-defaulting clearing members and return to a matched book. The objective of a CCP is to liquidate the portfolio at a reasonable estimate of its market value in an auction, while at the same time limiting disruptions to the market (Ferrara & Li, 2017).

4.5.1 Auction participants

In an auction, CCPs make sure that participation is sufficiently broad to ensure the auction's success. With more participants, the submitted bids are expected to be more competitive. However, there are several factors determining the appropriate participants for a respective auction.

Firstly, CCPs assess participants' ability to take on the positions in the auctioned portfolio. With regulatory requirements as well as internal risk and position limits, participants' ability to bid on certain auctioned portfolios may be restricted. It is important that auction participants structure their bids in a way that they are not in violation of applicable regulatory requirements, in case they win the auction (Committee on Payments and Market Infrastructures, 2020).

Secondly, CCPs consider business models of participants eligible for an auction. They include those clearing members that are more relevant to an auction due to their role in that particular market. Alternatively, they include participants that have the tolerance and capacity to absorb financial risk due to their risk appetite and nature of their business, even if they do not participate in the relevant market (Oleschak, 2019).

Thirdly, CCPs consider the nature of the product types to be auctioned. Defaulting clearing member's portfolio may include certain assets that require special permission or capabilities regarding settlement or position limits. This should be addressed by auction participant prior to the respective auction.

And lastly, CCPs also consider adapting the type and number of participants in order to accommodate the way the portfolio is split and hedged (Committee on Payments and Market Infrastructures, 2020).

4.5.2 Bidding requirements and incentives

CCPs impose mandatory auction participation for its non-defaulting clearing members. In the event of multi-unit or multi-asset auctions, the mandatory obligation to participate may be for the entire portfolio or portions of it. Minimum bid size obligations may be proportionate to each clearing member's activity in the relevant product or asset class. CCPs also distinguish between clearing members' propriatery and client activity when imposing mandatory auction participation (Ferrara & Li, 2017).

Bidding participation are incentivized by introducing fines or other disciplinary actions for those clearing members that do not adhere to bidding obligations. Moreover, to make sure the entered bids will be competitive, CCPs establish a system where competitive bids are rewarded. Such incentive is to juniorize the default fund contributions of those clearing members that did not submit a bid or that submitted non-competitive bids. This means that

the default fund contributions of juniorized clearing members will be used sooner, and the default fund contributions of other clearing members will be used only after the juniorized contributions are fully consumed (Committee on Payments and Market Infrastructures, 2020).

4.5.3 Auction timing

A CCP aims to provide sufficient time to auction participants to submit an auction bid. There are several factors influencing the amount of time each auction participant needs to evaluate and price the auctioned portfolio. The type of financial products included in the auctioned portfolio have an effect on the timing of portfolio evaluation, with less liquid products being more difficult to evaluate. Auction formats, which are described in Chapter 4.5.5., are another factor influencing the timing, as multi-unit auctions or two-way pricing auctions require more time for pricing the portfolio and making a bid. Additionally, markets for certain products in the auctioned portfolio could be located in a different time zone, in which case a CCP holds an auction when the markets in the respective region are open (Committee on Payments and Market Infrastructures, 2020).

4.5.4 Portfolio allocation

When preparing for an auction, a CCP considers whether the portfolio of the defaulting clearing member should be auctioned as a whole or rather split into smaller segments. This depends on portfolio composition and size, as smaller segments of the portfolio may be easier to price and absorb. Additionally, auction participants could be subject to capital and risk restrictions, in which case splitting the portfolio would increase auction participation. Criteria for splitting the portfolio are various and include size, asset class, product type, segment, currency, settlement method or time to maturity. Furthermore, a CCP also considers netting, margin offsets and cross-margining arrangements when splitting the portfolio. Hedged transactions must be included in the auction portfolios in order to integrate risk reduction benefits (Committee on Payments and Market Infrastructures, 2020).

4.5.5 Bid submition and winning bids

The process for bidding can take the form of a single-unit auction, multi-unit auction or a multi-asset auction. In a single-unit auction, auction participants are required to bid for the auction portfolio as one single unit. A CCP allocates the portfolio to one single bidder. In a multi-unit auction, a CCP divides the auction portfolio into multiple identical units, where auction participants would be able to bid for one or more of these units. In a multi-asset auction, a CCP splits the auctioned portfolio into multiple non-identical items with auction participant bidding for one or several items.

Choosing the winning bid can take on different forms as well. A CCP could choose the highest price or the second highest price. In an auction where the second highest price is chosen, the auction participant that submits the highest price wins but pays the price of the second highest bidder (second price). This results in more competitive bids. In a multi-unit auction, a CCP may choose to apply the same price to all winning bidders, which is called a uniform price, or alternatively, a CCP may apply a different winning bid to individual units, which is known as a discriminatory price.

Most commonly utilized auction formats are the single unit first price auction, known as "Signle unit pay your price" auction, and the multi-unit uniform price auction, known as "Modified Dutch" auction. Other types of auctions include "Two-way pricing" and "Reserve price". The decision regarding auction formats used for each relevant asset class should be disclosed to auction participants before the auction begins (Committee on Payments and Market Infrastructures, 2020).

4.5.5.1 Single unit pay your price

This is a single-unit auction where each participant bids for the entire portfolio. The winning bid will belong to the participant providing the highest price. This format is commonly used for interest rate swaps or other hedged portfolios with low residual risk (Committee on Payments and Market Infrastructures, 2020).

4.5.5.2 Modified Dutch

Modified Dutch auction is a multi-unit auction where each participant bids for a percentage of the entire portfolio. The winners are chosen on a cumulative basis from the highest to the lowest bid price, up to the size of the portfolio. The lowest accepted bid price is applied to all winning bidders. This is a common format for portfolios with high residual risk, which is left after hedging (Committee on Payments and Market Infrastructures, 2020).

4.5.5.3 Two-way pricing

Two-way pricing is used to anonymize the defaulting clearing member's portfolio. A CCP requires all auction participants to submit both buy and sell portfolio bids, and imposes a maximum bid-ask spread. A CCP could delay revealing the direction of the auction portfolio until the results of such auction are determined. In such case, auction participants require additional time to price both portfolios and submit their bids (Committee on Payments and Market Infrastructures, 2020).

4.5.5.4 Reserve price

The reserve price is defined as the lowest accepted bid, and it can be known to the CCP only or be provided to all auction participants. A CCP may use the reserve price to indicate the auctioned portfolio's economic value. Although it can be used as a way to limit auction losses, it has several disadvantages. The reserve price is not necessarily a good indicator of the market value, as it can be based on statistical models used to calibrate the default fund which is less reactive to changes in the market. Additionally, the reserve price can affect bidding behavior, if it is revealed to all auction participants, and discourage more competitive bids (Committee on Payments and Market Infrastructures, 2020).

4.5.6 Auction in Eurex Clearing

In this section we research the auction process in ECAG. Like margining and hedging, also auction process is liquidation group-specific. Meaning different auction formats have been defined for different liquidation groups.

Each auction participant is provided with the relevant auction portfolio and informed of the applicable bidding window prior to an auction. During the bidding window the clearing members can price the portfolio and enter auction prices in the auction tool. The timeframe they are given is generally between a few hours to up until a full day. The exception is a bond portfolio auction which is preformed on an ISIN by ISIN basis, and the pricing window given is between 30 minutes and one hour.

The auction tool ECAG uses is called the Prisma auction tool and it is web-based. All auction participants are provided with the log-in credentials prior to an auction.

Auction participation is mandatory for those clearing members that hold a clearing license for all products included in the relevant auction portfolio, and that are capable to process the auction portfolio from a risk and from an operational perspective. Clients of clearing members are not obligated to participate in an auction, but can do so on a voluntary basis. When ECAG determines whether a specific clearing member has fulfilled its bidding obligation, clients' bids of that clearing member are considered to be prices provided by that clearing member.

In case more clearing members provide the same bid in an auction, the price which was provided first prevails over other equivalent prices (Eurex Clearing AG, n.d.-c).

4.5.6.1 Auction process for listed fixed income derivatives and interest rate derivatives liquidation groups

Auction for listed fixed income liquidation group and interest rate swaps is a single unit auction for each currency that is included in the defaulted clearing member's portfolio. The

auction portfolio is disclosed to all auction participants who provide prices for the entire portfolio, and the highest price wins the auction. Participation is mandatory only for those clearing members that clear currencies included in the auction portfolio.

We mentioned in Chapter 3.2.3. that cross-margining is possible between listed FI derivatives liquidation group and interest rate derivatives liquidation group. If the defaulted clearing member enjoyed margin offsets between these two liquidation groups, the relevant products will be liquidated simultaneously.

In case the auction portfolio contains only listed FI derivatives, ECAG conducts a multi-unit auction to allow for the broadest possible range of auction participants. Such auction format is described for listed equity derivatives liquidation group in Chapter 4.5.6.2.

Clearing members that did not conduct any transactions in the listed FI liquidation group within the last three months prior to the default, are exempted from participation.

Products within the listed FI liquidation group are either options or futures. All products that have future style margining, which could also include options, have a value of zero beginning of each day. Therefore, auction participants should not price in the face value of such positions, but rather variation margin payments, i.e. profit or loss, that will become due at the end of the auction day.

ECAG incentivizes competitive bidding by rewarding good/high bids and punishing bad/low bids. To determine the relative quality of the prices submitted by clearing members, ECAG categorizes each price as “sufficient”, “medium” or “insufficient”. The criteria that ECAG uses for such categorization is based on the difference between the winning auction price and the prices submitted by other clearing members, relative to initial margin requirement of the auction portfolio. A price would be categorized as “sufficient” if the difference between that price and the winning auction price is less than 0,5 times the initial margin requirement. A price would be “insufficient” if that difference was more than 1,5 time the initial margin requirement. The price would be categorized as “medium” if it is anywhere between these thresholds.

Clearing members that submitted sufficient prices will have their default fund contributions seniorized, and those that submitted insufficient prices will have their default fund contributions juniorized. Default fund contributions of clearing members who submitted medium prices are partly juniorized and partly seniorized (Eurex Clearing AG, n.d.-c).

4.5.6.2 Auction process for listed equities derivatives liquidation group

Auction for equities derivatives liquidation group is in the format of multi-unit auctions with the winning bid being the highest price for the respective auction unit.

Listed equity derivatives liquidation group includes products such as

- equity and equity index derivatives,
- dividend derivatives,
- volatility derivatives,
- total return futures.

ECAG generally conducts a separate auction for each of these product groups, or alternatively, it conducts a pooled auction on listed equity derivatives liquidation group level, including any of the products assigned to this liquidation group.

Before the auction starts, ECAG discloses a portfolio reflecting the size of one auction unit to all auction participants. This portfolio could be the actual auction portfolio or the inverse of the actual auction portfolio. This is a two-way pricing auction where the auction participant need to provide to ECAG both bid and ask prices for their minimum number of auction units. ECAG defines the maximum permissible spread between the bid and ask price. ECAG either consults the relevant DMC or asks for recommendation from all auction participants regarding maximum permissible spread, and then defines the average of such recommendations as the maximum spread. Any price that acknowledges the maximum permissible spead, qualifies as economically reasonable.

Auction participants have to provide prices for a pre-defined number of auction units. They are welcome to provide bids for more auction units than indicated as their minimum requirement by ECAG. It is in auction participants' discreation whether they provide the same price or different prices for the respective auction units.

When pricing an auction portfolio, auction participants need to consider which type of derivatives is underlying a certain contract. Within equity derivatives liquidation group that can be either options or futures. An important component of any option contract is the option premium, which has to be considered by the auction participants when pricing a portfolio.

In the case of futures contracts, the relevant cash flow comes from the variation margin (profit or loss) at the end of each day, as futures positions have a value of zero at the beginning of the day. Therefore, it is crucial that auction participants do not price in the face value of the futures positions in an auction, but rather their expectations regarding the development of these positions during the auction day.

In case equity derivatives are denominated in a different currency, auction participants are advised to take into account currency conversions and potential conversion rates when pricing the auction portfolio (Eurex Clearing AG, n.d.-c).

4.5.6.3 Auction process for bond liquidation group

Bond liquidating group encompasses bonds that are underlying repo or GC Pooling transactions. Auctions for the bond liquidation group are multi-unit auctions, where ECAG accepts the highest price per auction as the winning price, and no minimum prices are defined. Generally, liquidation of bonds is on an ISIN by ISIN basis, which means that a dedicated auction is held for each ISIN. In exeptional cases, where it is advisable from a risk perspective, ECAG may auction a hedged bundle of bonds.

ECAG has divided bonds that are underlying repo or GC Pooling transactions into what they call bond clusters. They use these bond clusters to determine which clearing members have to participate in the respective auctions. Additionally, it is also relevant in which currencies clearing members are active within the bond liquidation group. Therefore, auction participation is mandatory for those clearing members that have been active in the respective bond cluster over the last three months and if the auctioned bonds are denominated in a currency for which clearing members have trading capacities.

ECAG carefully examines clearing members' behavior throughout the default management process in order to determine whether they have complied with the bidding requirements. Failure to comply would result in a juniorization of that clearing member's default fund contributions.

Bids for each auction are examined separately. ECAG defines the reference price by taking the weighted average of all prices at which auction units were sold in the respective auction and subtracts 0,5 times the applicable margin parameter for the respective bond. Auction participants that submitted a bid that was above or equal to the reference price receives credits. Oppositely, auction participants that submitted a bid that was below the reference price receive debits. In case an independent sale was held, only the clearing member with the winning bid receives credits.

If a clearing member's debits exceed its credits, and if the losses arising in the bond liquidation group cannot be covered in full by the defaulted clearing member's resources, a part of default fund contribution of that clearing member will be juniorized. In case a clearing member fails to provide a bid, and the losses cannot be covered in full by the defaulting member's resources, it will be given a monetary fine. The size of a monetary fine is capped at 5 million EUR, and is additionally reduced by the clearing member's juiorized default fund contribution. Received monetary fines are added to ECAG's own contribution to the default fund, which is called dedicated amount.

The process described above is applicable in case ECAG has to sell an underlying bond to a terminated repo or GC Pooling transaction. In case ECAG has to buy an underlying bond, ECAG invited all clearing members to participate in a respective bond purchase on a voluntary basis. ECAG defines the maximum price it is willing to pay for each bond, which it also discloses to its clearing members. If the attempt to buy a bond in the open market

fails, ECAG can preform a cash settlement at the pre-defined maximum price (Eurex Clearing AG, n.d.-c).

4.6 Default fund

CCPs collect two different types of guarantees from its clearing members. One is in the form of margins, which are collected on a daily basis to cover the theoretical liquidation costs if the positions were closed out today. The other type of guarantee is in the form of a default fund, which aims at covering market risks beyond those covered by margins. Risk mutualization is ensured by mandatory contributions to the default fund by all clearing members of the respective CCP. Therefore, if one clearing member defaults there is a potential spill-over effect to non-defaulting clearing members. Size of the contribution to the default fund by the respective clearing member depends on the risk that clearing member represents to the CCP and is therefore proportional to their initial margin requirements (Poce et al., 2018).

Default fund is the last line of defense and thus it is important that it is resilient against market shocks. CCPs must regularly perform stress tests to calibrate their default funds. Stress tests are used to determine whether the CCP has large enough resources to cover losses arising from the default of at least two largest clearing members of the respective CCP. This is mandatory under EMIR and it is known as cover 2 requirement (Murphy & Nahai-Williamson, 2014).

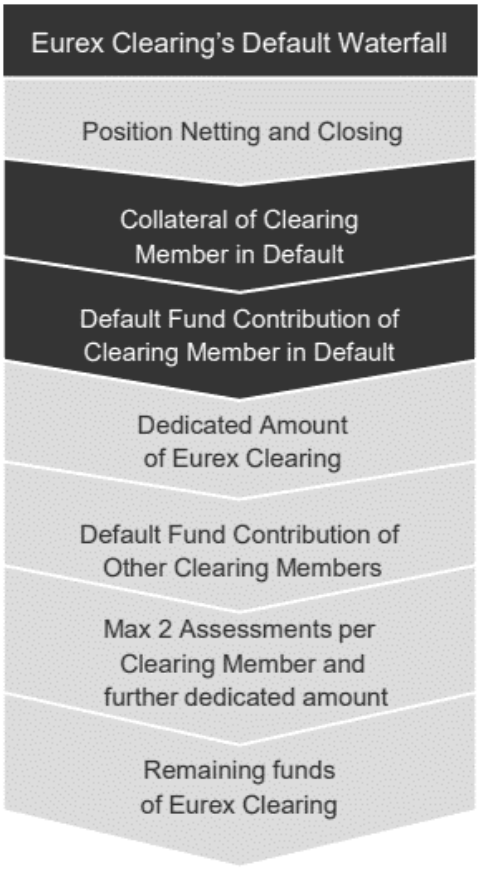
4.7 Default waterfall

Default waterfall determines in what order the contributions to the default fund are used. In case of a default by a clearing member, a CCP would first use the initial margin posted by the defaulted clearing member as well as their contributions to the default fund, in order to cover potential losses that CCP would be facing. However, if the losses are severe, resources from the defaulted clearing member alone may not be enough. Thus, a CCP would use a dedicated amount from their own capital to cover losses, concept which is known as “skin in the game” (Eurex Clearing AG, n.d.-f). This concept is intended to reduce moral hazard on the part of the CCP. Lastly, the default fund contributions of non-defaulting clearing members would be used resulting in spill-over losses for non-defaulting clearing members. Contributions of non-defaulting clearing members are usually used on a pro-rata basis, however, the CCP has the power to seniorize or juniorize the contributions of particular clearing members. Seniorization of default fund contributions is used as incentive to foster competitive bidding in auctions (Ferrara & Li, 2017).

In case that the above mentioned resources are fully deployed, there are some alternative mechanisms CCPs can implement to raise new funds, i.e. assessments (Eurex Clearing AG, n.d.-b). Assessments allow CCPs to raise additional funds from non-defaulting clearing

members, however, it has been rarely used in practice (Paddrik & Zhang, 2020). Figure 9 shows the default waterfall of Eurex Clearing AG.

Figure 9: Default waterfall



Source: Adapted from Eurex Clearing AG (n.d.-m).

5 DEFAULT MANAGEMENT PROCESS SIMULATION

CCPs in Europe, which are regulated under EMIR, have to conduct at least one simulation of their default management process each year. For each such simulation, a CCP will nominate a few of their clearing members for which participation in the upcoming simulation will be mandatory. When auctioning portfolios, CCPs encourage all of their clearing members to participate, on a voluntary basis (Eurex Clearing AG, n.d.-l).

DMP simulations are of high importance to test the robustness of CCPs' default procedures, but also to validate whether clearing members can access the aution tool, whether auction file formats are compatible with clearing members' internal systems and if the auction format is clearly understood.

For the purposes of this Master's thesis, I try to demonstrate how the default management process would work by simulating the defaulted clearing member's portfolio and focusing on the portfolio hedging.

In reality, clearing members have massive portfolios with thousands of positions in various asset classes that need to be hedged and liquidated. Clearing members do not trade only on their own propriatery account, but also on account of their clients. In case of a default situation, CCP makes sure to firstly separate clearing member's propriatery positions from client positions and port or transfer client positions to a solvent clearing member. In my example, I constructed a simplified portfolio consisting of 98 positions of exchange traded derivatives. I had included long and short positions on call and put options on stocks and indices, long and short positions on single stock dividend futures, equity index dividend futures, and standard futures on stocks and indices. The outstanding positions in the portfolio are valued as of May 31, 2022. The composition of the portfolio is included in Appendix 2. Products included in the portfolio are shown in Table 1.

In my example I relate to Eurex Clearing's approach to the default management process, where hedging, auctioning and liquidation processes take into account the specified liquidation groups. The products included in the simulated portfolio all belong to the listed equity derivatives liquidation group, with the specified holding period of 3 days. Products belonging to the same liquidation group would be hedged and auctioned together.

The hedging process begins by breaking down the defaulted clearing member's portfolio. Since all the positions in the simulated portfolio belong to the same liquidation group, that means the entire portfolio will be hedged at once and auctioned in one auction. Special attention needs to be paid to short maturity positions and special illiquid products, which would need to be separated from the portfolio and sold off in an independent sale. Alternatively, short maturity positions could also be rolled-over in the highly liquid roll-over market and then be hedged as part of the portfolio.

The portfolio has to be analyzed with respect to its exposure to the greeks, e.g. delta, gamma, vega, rho, and theta. When trying to determine portfolio's exposure to the greeks, individual position's greeks are not very informative, since the individual position sizes and values vary greatly amongst each other. Therefore, the so-called "cash-greeks" are calculated. Cash delta, for example, is calculated by multiplying the position size with the position multiple (i.e. the number of underlyings in one derivative contract), the settlement price (in the case of futures) or the spot price (in the case of options), and the delta of that position. The same logic is followed when calculating cash gamma, cash vega, cash rho, and cash theta.

$$cash\ \Delta_i = Q_i * TUV_i * P_i * \Delta_i \tag{11}$$

where Q represents position size, TUV is the total unit value or the multiple, P is the settlement or spot price, Δ is the delta, and i denotes the respective position.

Table 1: Products in the simulated portfolio

Product ID	Product name	Instrument type	Instrument details
A2DS	ADIDAS AG DIVIDEND FUTURE	Future	Single stock dividend future
A2LV	ALLIANZ DIVIDEND FUT	Future	Single stock dividend future
BASE	OPT E ON BASF	Option	Standard option on stock
BASG	FUT ON BASF AG	Future	Standard future on stock
DAI	OPT ON MERCEDES-BENZ GROUP	Option	Standard option on stock
DAIG	FUT ON MERCEDES-BENZ GROUP	Future	Standard future on stock
F3TE	ORANGE DIVIDENDS FUT	Future	Single stock dividend future
FD3D	FUT ON ESTX SEL. DIV30 IDX DIV	Future	Equity index dividend future
FDAX	FUT ON DAX INDEX	Future	Standard future on indices
FEBD	EURO STOXX BANKS IND.DIV. FUT.	Future	Equity index dividend future
FESB	FUT ON EURO STOXX BANKS	Future	Standard future on indices
FESU	FUT ON EURO STOXX UTILITIES	Future	Standard future on indices
FESX	FUT ON EURO STOXX 50	Future	Standard future on indices
FEXD	FUT ON EURO STOXX 50 INDEX DIV	Future	Equity index dividend future
FMEA	FUT ON MSCI EM ASIA (NTR)	Future	Standard future on indices
FMED	FUT ON MSCI EUROPE (NTR,USD)	Future	Standard future on indices
FMEE	FUT ON MSCI EM EMEA (NTR)	Future	Standard future on indices
FMFP	FUT ON MSCI EAFE (P,USD)	Future	Standard future on indices
FMGS	FUT ON MSCI USA (USD / GTR)	Future	Standard future on indices
FMSM	FUT ON MSCI EM ESG SCREENED	Future	Standard future on indices
FMWN	FUT ON MSCI WORLD (NTR, EUR)	Future	Standard future on indices
FMWO	FUT ON MSCI WORLD (NTR,USD)	Future	Standard future on indices
FSMI	FUT ON SWISS MARKET INDEX	Future	Standard future on indices
FSTE	FUT ON STOXX E 600 OIL & GAS	Future	Standard future on indices
OESX	OPT ON EURO STOXX 50	Option	Standard option on indices
OMWN	OPT ON MSCI WORLD (NTR, EUR)	Option	Standard option on indices
OMWO	OPT ON MSCI WORLD (NTR,USD)	Option	Standard option on indices
OMWP	OPT ON MSCI WORLD (PRICE, USD)	Option	Standard option on indices
T2OT	TOTALENERGIES SE DIVIDEND FUT	Future	Single stock dividend future

Source: Own work.

Cash delta, gamma, vega, rho and theta are then summed together respectively, and portfolio's exposure to the specific risks is determined. The exposure to cash greeks is calculated in EUR. For products denominated in another currency, the respective FX rate from May 31, 2022 is applied and converted to EUR.

Table 2: Cash Greeks

Cash greeks	Exposure
Euro delta	1,335,929,156
Euro gamma	-308,031
Euro rho	7,022,436
Euro theta	46,320
Euro vega	-2,241,872

Source: Own work.

Table 2 shows the cash value of portolio's exposure to the greeks. We can observe that the portfolio has by far the largest exposure to delta in the value of 1,335,929,156 EUR. The interpretation is that the portfolio would increase in value by 13.4 million EUR if the price of the underlyings increases by 1%. The cash values of gamma, which represents second derivative of price sensitivity, vega representing volatility risk, rho representing interest rate risk, and theta representing time decay, are negligible. Therefore, hedging will be aimed at reducing delta of the portfolio.

In reality, CCP's internal traders prepare a hedging proposal and review it with the respective default management committee (DMC). This proposal is then presented to the board of the CCP that makes the final decision regarding the deployment of a hedging strategy.

The hedging process in a default scenario is referred to as macro-hedging. Macro-hedging involves using derivative contracts to take inverse positions on targeted assets. I have identified the positions with the largest delta exposure and then determined which derivatives could be used to offset the risks. If two or more derivative contracts in the portfolio have the same or similar underlying, the chances that taking an opposite position in one of those derivative contracts will offset the risks to a certain degree, depending on the maturity and payout schedule, are great. I had paid attention to the correlation coefficient when choosing the appropriate products. My hedging strategy involves using six derivatives contracts to balance the delta of the portfolio. The number of each hedging instrument is determined by summing the Euro delta of the products to be hedged and dividing it by the

Euro delta of one single hedging instrument. The products used for hedging are shown in Table 3.

Table 3: Hedging instruments

Hedging instruments	Expiry	Currency	Quantity	Cash delta impact
FESX	20220617	EUR	-20258	-767,604,827
FMEA	20220620	USD	-11092	-647,245,586
FMSM	20220620	USD	-15700	-224,746,094
FMWN	20220620	EUR	5242	213,296,980
FSMI	20220617	CHF	2100	237,174,380
FMGS	20220620	USD	-865	-146,372,324

Source: Own work.

First derivative contract used for hedging is FESX or Futures on Euro Stoxx 50. I went short on 20,258 FESX contract with June 2022 expiry. Portfolio contains several contracts where the underlying instrument is the Euro Stoxx 50 index, such as FESX and OESX. Additionally, some other contracts in the portfolio are highly correlated with FESX, making the chosen hedging instrument an appropriate choice for risk reduction. These products are FDAX or Futures on Dax Index and FMED or Futures on MSCI Europe. Correlation between FDAX and FESX is 98.5% and correlation between FMED and FESX is 97%. By adding 20,258 short positions in FESX to the portfolio, a reduction of 767,604,827 EUR in Euro delta is achieved.

Second derivative that I used for hedging is FMEA or Futures on MSCI Emerging Markets Asia. Portfolio contains four different positions in FMEA with combined exposure to Euro delta of 647,245,586 EUR. This exposure can be neuteralized by taking a short position in 11,092 FMEA contracts expiring in June 2022.

Notice that the portfolio has a single position in FMSM or Futures on MSCI Emerging Markets ESG Screened. The defaulted clearing member has a long position of 15,700 FMSM contracts with Euro delta exposure of 224,746,094 EUR, which is one of the largest contributors to high delta risk. Therefore, this can be hedged by adding a short position of 15,700 FMSM contracts with June 2022 expiry to the portfolio. The same applies for FSMI or Futures on Swiss Market Index. Short position in the portfolio is reversed by going long on 2,100 FSMI June 2022 contracts and neutralizing Euro delta by 237,174,380 EUR.

Furthermore, portfolio contains two short positions in FMWN or Futures on MSCI World with June 2022 and December 2022 expiry, consisting of 4,706 and 536 contracts respectively. For hedging purposes, I add 5,242 long June 2022 FMWN contracts to the portfolio, thus neutralizing Euro delta by 213,296,980 EUR.

Lastly, a short position in FMGS or Futures on MSCI USA is added to the portfolio, which neutralizes Euro delta by 146,372,324 EUR. The short position consits of 865 FMGS June 2022 contracts. Currently, the unhedged portfolio includes three FMGS positions expiring in June 2022, September 2022, and December 2022 and containing 205, 507, and 153 contracts respectively.

Table 4 shows the total reduction in Euro exposure to the greeks. With efficient hedging strategy delta exposure was successfully reduced from 1,335,929,156 EUR down to 431,685 EUR. The portfolio is considered to be sufficiently hedged and prepared for the next step in the default management process, the auction. Portfolio composition after hedging was executed, is included in Appendix 3.

Table 4: Cash greeks after hedging

	Euro delta	**Euro gamma**	**Euro rho**	**Euro theta**	**Euro vega**
Before hedging	1,335,929,156	-308,031	7,022,436	46,320	-2,241,872
Hedging impact	-1,335,510,805	0	-684,451	0	0
After hedging	**418,351**	**-308,031**	**6,337,984**	**46,320**	**-2,241,872**

Source: Own work.

Default management process would be considered successful if the defaulted clearing member's portfolio would be liquidated with losses that are smaller than the collateral posted by that clearing member (per their margin requirements) and their contributions to the default fund. Therefore, the first objective of hedging is to reduce margin requirements, i.e. initial margin, of the portfolio.

The initial margin of the unhedged portfolio is 148,460,914.36 EUR. The margin was calculated using ECAG's cloud Prisma Margin Estimator based on their propriatery margining methodology (Eurex Clearing AG, n.d.-e). With hedging I managed to lower intial margin of the portfolio to 19,165,094.18 EUR. This represents a margin reduction of 87%.

CONCLUSION

This thesis describes the role of CCPs in today's interconnected financial markets. It shows how CCPs are structured, how they concentrate counterparty risk in a single entity and how they effectively manage this risks to prevent systemic failure of the financial markets.

There are two mechanisms CCPs use to effectively preform risk management. Firstly, CCPs collect prefunded resources from their clearing members in the form of margins. There are several different types of margins that CCPs require from their clearing members, which depend on the products clearing members have in their portfolio. Mainly we talk about the initial margin as the forward-looking margining component, and the variation margin or premium margin as the backward-looking margining components.

Secondly, CCPs achieve efficient risk management by mutualizing risks of a counterparty default through default fund contributions of all clearing members. Therefore, in the event of a clearing member default, all uncollateralized losses arising from the liquidation of the defaulted clearing member's portfolio will be shared pro-rata amongst the surviving clearing members. Clearing members must meet any margin requirements and contributions to the default fund by posting collateral, cash or high-quality liquid assets, with the CCP.

CCPs have developed a set of procedures that they follow whenever a default scenario presents itself. These procedures are part of a process called default management process or DMP. DMP is the last line of defense for a CCP and it consists of multiple layers such as preliminary measures, independent sale, hedging, and auction. Successful default management process manages to liquidate the defaulted clearing member's portfolio and return the CCP to a matched-book by using only the funds posted by the defaulted clearing member at the CCP, without using default fund contributions of surviving clearing members or CCPs own funds.

Hedging is an optional part of the DMP, however, with hedging portfolio is secured against market risks and is as such likely to receive better prices in the auction process. Auctions are a mandatory and a crucial component of the DMP, as they represent a way to liquidate the defaulted clearing member´s portfolio and return the CCP to a matched book.

In the thesis I focused on specifically on the hedging part of the DMP by simulating a portfolio of various ETD positions which I then proceeded to delta hedge in preparation for auction. For hedging I used six different derivative instruments that were offsetting delta risk of multiple positions in the portfolio. As positions are of different sizes and values, I transformed relative deltas into so-called cash deltas. With hedging I managed to reduced cash delta from 1,335,929,156 EUR to 418,351 EUR.

Hedging also had an impact on the initial margin requirement for the defaulted clearing member´s portfolio. Intial margin requirement of the portfolio decreased from

148,460,914.36 EUR to 19,165,094.18 EUR, representing a margin reduction of 87%. Such hedging result would be deemed as successful in a real life scenario.

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APPENDICES

Appendix 1: Abstract in Slovenian

Magistrsko delo govori o pomenu centralno klirinških depotnih družb, še posebno o postopkih, ki jih centralno klirinške depotne družbe uporabljajo v primeru neizpolnjevanja obveznosti člana (t.i. clearing member). Centralno klirinške depotne družbe predstavljajo pomemben del današnjih kapitalskih trgov, saj prevzemajo tveganja neizpolnjevanja obveznosti nasprotnih strank v finančnih transakcijah. Da lahko učinkovito obvladujejo prevzeta tveganja, centralno klirinške depotne družbe od svojih članov vnaprej pobirajo finančna sredstva (t.i. margins), ki jih uporabijo v primeru, da eden izmed članov sproži insolvenčni postopek in ne izpolni obveznosti, ki izvirajo iz sklenjenih finančnih pogodb. Centralno klirinške depotne družbe so razvile posebej zasnovane postopke, ki jih upoštevajo kadarkoli nastopi prej omenjen scenarij (t.i. default management process). Cilj centralno klirinških depotnih družb je, da uspešno likvidirajo portfelj člana, ki je sredi insolvenčnega postopka ter pri tem ne vplivajo negativno na preostale udeležence na kapitalskih trgih.

Appendix 2: Portfolio before hedging

PRODUCT ID	INSTRUMENT TYPE	CALL PUT	QUANTITY	EXPIRY	TUV	STRIKE	SPOT PRICE	UNDERLYING PRICE	SETTLEMENT PRICE	VALUE	CCY	FX RATE TO EUR	INTEREST RATE	DELTA	GAMMA	RHO	THETA	VEGA	EURO DELTA	EURO GAMMA	EURO RHO	EURO THETA	EURO VEGA
A2DS	Future		58	20221216	1000	0	3.30	184.46	3.30	-	EUR	1	-0.01%	0.08098	-	0.01799	0.00000	-	15,499	0	1,043	0	0
A2DS	Future		63	20231215	1000	0	3.25	184.46	3.25	-	EUR	1	0.69%	0.25697	-	0.05145	-0.00006	-	52,614	0	3,241	-4	0
A2LV	Future		245	20221216	1000	0	10.80	195.02	10.80	-	EUR	1	-0.01%	0.08098	-	0.05888	0.00000	-	214,268	0	14,426	1	0
A2LV	Future		-638	20231215	1000	0	10.52	195.02	10.52	-	EUR	1	0.69%	0.25697	-	0.16837	-0.00021	-	-1,724,708	0	-107,420	132	0
A2LV	Future		855	20241220	1000	0	10.24	195.02	10.24	-	EUR	1	1.03%	0.36539	-	0.28374	-0.00031	-	3,198,769	0	242,598	-267	0
BASE	Option	P	112	20220617	100	60	51.29	51.29	8.74	97,888	EUR	1	-0.67%	-0.99059	0.00721	-0.02773	-0.00285	0.00382	-569,044	2,124	-311	-32	43
BASE	Option	C	-4966	20220916	100	64	51.29	51.29	0.12	-59,592	EUR	1	-0.67%	0.04584	0.01465	0.00660	-0.00238	0.02844	-1,167,561	-191,421	-3,278	1,182	-14,121
BASE	Option	P	384	20220916	100	64	51.29	51.29	12.94	496,896	EUR	1	-0.67%	-0.95880	0.01381	-0.18380	-0.00348	0.02604	-1,888,387	13,955	-7,058	-134	1,000
BASE	Option	C	-2107	20221216	100	52	51.29	51.29	3.66	-771,162	EUR	1	-0.41%	0.50706	0.03983	0.12184	-0.00984	0.15071	-5,479,734	-220,773	-25,671	2,074	-31,754
BASE	Option	C	-3464	20221216	100	60	51.29	51.29	0.92	-318,688	EUR	1	-0.41%	0.20070	0.03195	0.05111	-0.00571	0.10769	-3,565,849	-291,189	-17,704	1,978	-37,302
BASE	Option	C	-8553	20230616	100	64	51.29	51.29	1.00	-855,300	EUR	1	0.43%	0.17162	0.02127	0.08151	-0.00456	0.13007	-7,528,478	-478,536	-69,718	3,901	-111,245
BASE	Option	P	-1874	20230616	100	64	51.29	51.29	15.66	-2,934,684	EUR	1	0.43%	-0.82759	0.02128	-0.60373	-0.00381	0.13040	7,954,543	-104,885	113,140	715	-24,438

BASG	Future		-8104	20220617	100	0	51.29	51.29	51.27	-	EUR	1	-0.67%	0.99969	-	0.02388	0.00094	-	-41,552,490	0	-19,353	-760	0
DAI	Option	P	-797	20221216	100	52	66.20	66.20	2.17	-172,949	EUR	1	-0.01%	-0.17186	0.01271	-0.07386	-0.01389	0.12575	906,754	-44,389	5,887	1,107	-10,022
DAI	Option	C	-4871	20221216	100	68	66.20	66.20	5.19	-2,528,049	EUR	1	-0.01%	0.49775	0.02687	0.13896	-0.01500	0.19411	-16,050,407	-573,492	-67,688	7,306	-94,550
DAI	Option	C	-521	20221216	100	72	66.20	66.20	3.46	-180,266	EUR	1	-0.01%	0.38811	0.02716	0.11283	-0.01355	0.18694	-1,338,616	-62,004	-5,878	706	-9,740
DAI	Option	P	1749	20221216	100	72	66.20	66.20	9.27	1,621,323	EUR	1	-0.01%	-0.61163	0.02712	-0.27129	-0.01358	0.18698	-7,081,694	207,902	-47,449	-2,375	32,703
DAI	Option	C	-1302	20221216	100	80	66.20	66.20	1.34	-174,468	EUR	1	-0.01%	0.19803	0.02114	0.06095	-0.00892	0.13767	-1,706,874	-120,602	-7,936	1,161	-17,925
DAI	Option	P	-277	20231215	100	52	66.20	66.20	5.29	-146,533	EUR	1	0.43%	-0.25116	0.01162	-0.29763	-0.00766	0.24870	460,565	-14,110	8,244	212	-6,889
DAI	Option	C	-1100	20231215	100	68	66.20	66.20	7.90	-869,000	EUR	1	0.43%	0.52759	0.01853	0.33954	-0.00860	0.31756	-3,841,904	-89,307	-37,349	946	-34,932
DAI	Option	P	-1509	20231215	100	68	66.20	66.20	12.15	-1,833,435	EUR	1	0.43%	-0.50255	0.01721	-0.57332	-0.00801	0.31110	5,020,238	-113,815	86,514	1,209	-46,945
DAIG	Future		96	20221021	100	0	66.20	66.20	66.18	-	EUR	1	-0.06%	0.99976	-	0.25930	0.00011	-	635,371	0	2,489	1	0
F3TE	Future		-1957	20220617	1000	0	0.40	11.65	0.40	-	EUR	1	-0.06%	0.00170	-	0.00033	0.00000	-	-1,331	0	-636	-2	0
F3TE	Future		1091	20221216	1000	0	0.70	11.65	0.70	-	EUR	1	-0.01%	0.08098	-	0.00380	0.00000	-	61,754	0	4,151	0	0
F3TE	Future		174	20231215	1000	0	0.66	11.65	0.66	-	EUR	1	0.69%	0.25697	-	0.01088	-0.00001	-	29,376	0	1,893	-2	0
F3TE	Future		6828	20241220	1000	0	0.64	11.65	0.64	-	EUR	1	1.03%	0.36539	-	0.01834	-0.00002	-	1,596,735	0	125,194	-138	0
F3TE	Future		-1698	20261218	1000	0	0.60	11.65	0.60	-	EUR	1	1.31%	0.58936	-	0.03373	-0.00003	-	-601,445	0	-57,265	45	0

FD3D	Future		788	20221216	100	0	94.00	1717.77	94.00	-	EUR	1	0.00%	0.08098	-	0.51249	-	-	599,843	0	40,384	0	0
FD3D	Future		-643	20231215	100	0	91.00	1717.77	91.00	-	EUR	1	0.00%	0.25425	-	1.40364	-	-	-1,487,673	0	-90,254	0	0
FD3D	Future		418	20241220	100	0	86.00	1717.77	86.00	-	EUR	1	0.00%	0.35589	-	2.20066	-	-	1,279,355	0	91,987	0	0
FD3D	Future		1081	20251219	100	0	80.30	1717.77	80.30	-	EUR	1	0.00%	0.45562	-	2.85560	-	-	3,954,947	0	308,690	0	0
FDAX	Future		370	20220617	25	0	14388.35	14388.35	14377.00	-	EUR	1	0.00%	1.00000	-	6.69614	-	-	133,092,238	0	61,939	0	0
FEBD	Future		1800	20221216	500	0	5.15	91.75	5.15	-	EUR	1	0.00%	0.08098	-	0.02808	-	-	375,348	0	25,270	0	0
FEBD	Future		8649	20231215	500	0	4.74	91.75	4.74	-	EUR	1	0.00%	0.25425	-	0.07311	-	-	5,211,579	0	316,177	0	0
FEBD	Future		6909	20241220	500	0	4.45	91.75	4.45	-	EUR	1	0.00%	0.35589	-	0.11387	-	-	5,470,934	0	393,368	0	0
FEBD	Future		9385	20251219	500	0	4.23	91.75	4.23	-	EUR	1	0.00%	0.45562	-	0.15043	-	-	9,043,656	0	705,873	0	0
FESB	Future		18751	20220617	50	0	91.75	91.75	91.60	-	EUR	1	0.00%	1.00000	-	0.04266	-	-	86,020,213	0	39,999	0	0
FESU	Future		-71	20220617	50	0	372.23	372.23	371.00	-	EUR	1	0.00%	1.00000	-	0.17279	-	-	-1,321,417	0	-613	0	0
FESX	Future		23550	20220617	10	0	3789.21	3789.21	3784.00	-	EUR	1	0.00%	1.00000	-	1.76241	-	-	892,358,955	0	415,048	0	0
FESX	Future		573	20221216	10	0	3789.21	3789.21	3759.00	-	EUR	1	0.00%	1.00000	-	20.49427	-	-	21,712,173	0	117,432	0	0
FEXD	Future		-2709	20221216	100	0	120.70	3789.21	120.70	-	EUR	1	0.00%	0.07045	-	0.65806	-	-	-2,303,394	0	-178,269	0	0
FEXD	Future		286	20231215	100	0	116.80	3789.21	116.80	-	EUR	1	0.00%	0.41798	-	1.80160	-	-	1,396,247	0	51,526	0	0

FEXD	Future		-2308	20241220	100	0	111.20	3789.21	111.20	-	EUR	1	0.00%	0.76528	-	2.84550	-	-	-19,640,937	0	-656,742	0	0
FEXD	Future		-1329	20251219	100	0	107.60	3789.21	107.60	-	EUR	1	0.00%	0.91328	-	3.82643	-	-	-13,059,933	0	-508,533	0	0
FMEA	Future		11190	20220620	100	0	625.13	625.13	620.60	-	USD	0.933445347	0.00%	1.00000	-	0.34005	-	-	652,964,128	0	355,196	0	0
FMEA	Future		-12819	20220919	100	0	625.13	625.13	621.70	-	USD	0.933445347	0.00%	1.00000	-	1.89065	-	-	-748,020,300	0	-2,262,320	0	0
FMEA	Future		1675	20221219	100	0	625.13	625.13	623.00	-	USD	0.933445347	0.00%	1.00000	-	3.44784	-	-	97,740,386	0	539,076	0	0
FMEA	Future		11046	20230320	100	0	625.13	625.13	624.20	-	USD	0.933445347	0.00%	1.00000	-	5.01070	-	-	644,561,372	0	5,166,453	0	0
FMED	Future		-992	20221219	10	0	7741.86	7741.86	7742.20	-	USD	0.933445347	0.00%	1.00000	-	42.84724	-	-	-71,687,904	0	-396,756	0	0
FMEE	Future		1133	20220620	100	0	303.66	303.66	302.70	-	USD	0.933445347	0.00%	1.00000	-	0.16586	-	-	32,114,887	0	17,542	0	0
FMEE	Future		633	20220919	100	0	303.66	303.66	304.10	-	USD	0.933445347	0.00%	1.00000	-	0.92480	-	-	17,942,386	0	54,644	0	0
FMEE	Future		2337	20221219	100	0	303.66	303.66	306.00	-	USD	0.933445347	0.00%	1.00000	-	1.69348	-	-	66,242,268	0	369,426	0	0
FMFP	Future		-1660	20220620	50	0	2039.66	2039.66	2034.00	-	USD	0.933445347	0.00%	1.00000	-	1.11452	-	-	-158,024,624	0	-86,349	0	0
FMFP	Future		299	20220919	50	0	2039.66	2039.66	2035.00	-	USD	0.933445347	0.00%	1.00000	-	6.18863	-	-	28,463,471	0	86,362	0	0
FMFP	Future		-295	20221219	50	0	2039.66	2039.66	2037.00	-	USD	0.933445347	0.00%	1.00000	-	11.27326	-	-	-28,082,689	0	-155,214	0	0
FMFP	Future		329	20240318	50	0	2039.66	2039.66	2055.00	-	USD	0.933445347	0.00%	1.00000	-	36.99000	-	-	31,319,338	0	567,988	0	0
FMGS	Future		205	20220620	10	0	18128.17	18128.17	17995.00	-	USD	0.933445347	0.00%	1.00000	-	9.86027	-	-	34,689,395	0	18,868	0	0

FMGS	Future		507	20220919	10	0	18128.17	18128.17	18070.00	-	USD	0.933445347	0.00%	1.00000	-	54.95260	-	-	85,792,796	0	260,067	0	0
FMGS	Future		153	20221219	10	0	18128.17	18128.17	18107.00	-	USD	0.933445347	0.00%	1.00000	-	100.20860	-	-	25,890,134	0	143,115	0	0
FMSM	Future		15700	20220620	10	0	1533.57	1533.57	1522.50	-	USD	0.933445347	0.00%	1.00000	-	0.83425	-	-	224,746,094	0	122,260	0	0
FMWN	Future		-4706	20220620	100	0	406.90	406.90	404.55	-	EUR	1	0.00%	1.00000	-	0.22167	-	-	-191,487,140	0	-104,318	0	0
FMWN	Future		-536	20221219	100	0	406.90	406.90	402.75	-	EUR	1	0.00%	1.00000	-	2.22892	-	-	-21,809,840	0	-119,470	0	0
FMWO	Future		-5509	20220620	10	0	8477.53	8477.53	8481.00	-	USD	0.933445347	0.00%	1.00000	-	4.64712	-	-	-435,944,299	0	-238,971	0	0
FMWO	Future		55	20220919	10	0	8477.53	8477.53	8515.00	-	USD	0.933445347	0.00%	1.00000	-	25.89493	-	-	4,352,321	0	13,294	0	0
FMWO	Future		5453	20221219	10	0	8477.53	8477.53	8563.00	-	USD	0.933445347	0.00%	1.00000	-	47.38975	-	-	431,512,845	0	2,412,175	0	0
FSMI	Future		-2100	20220617	10	0	11611.38	11611.38	11598.00	-	CHF	0.972668028	0.00%	1.00000	-	5.40181	-	-	-237,174,380	0	-110,337	0	0
FSTE	Future		3754	20220617	50	0	351.10	351.10	350.00	-	EUR	1	0.00%	1.00000	-	0.16301	-	-	65,901,470	0	30,598	0	0
OESX	Option	C	-3628	20221216	10	3650	3784.00	3784.00	316.50	-11,482,620	EUR	1	-0.25%	0.60103	0.00059	10.60792	-0.62994	10.68811	-82,071,687	-3,043,440	-384,855	22,854	-387,765
OESX	Option	P	5521	20221216	10	3650	3784.00	3784.00	207.70	11,467,117	EUR	1	-0.25%	-0.39896	0.00059	-9.31930	-0.65514	10.68810	-82,904,690	4,631,801	-514,518	-36,170	590,090
OESX	Option	C	-717	20221216	10	3700	3784.00	3784.00	284.50	-2,039,865	EUR	1	-0.25%	0.57049	0.00062	10.15565	-0.61940	10.87035	-15,395,533	-626,748	-72,816	4,441	-77,940
OESX	Option	P	-54	20221216	10	3700	3784.00	3784.00	225.80	-121,932	EUR	1	-0.25%	-0.42951	0.00062	-10.04483	-0.64506	10.87035	872,961	-47,199	5,424	348	-5,870
OESX	Option	P	631	20240621	10	3000	3784.00	3784.00	225.80	1,424,798	EUR	1	0.77%	-0.23883	0.00024	-22.27722	-0.25709	15.94953	-5,398,027	192,053	-140,569	-1,622	100,642

OESX	Option	P	635	20240621	10	3200	3784.00	3784.00	277.80	1,764,030	EUR	1	0.77%	-0.29303	0.00028	-27.34851	-0.24704	17.71602	-6,665,052	228,042	-173,663	-1,569	112,497
OESX	Option	C	-1579	20240621	10	3500	3784.00	3784.00	514.20	-8,119,218	EUR	1	0.77%	0.61048	0.00034	34.45780	-0.32327	19.66423	-34,527,641	-690,607	-544,089	5,104	-310,498
OESX	Option	P	-721	20240621	10	3500	3784.00	3784.00	377.50	-2,721,775	EUR	1	0.77%	-0.38952	0.00034	-36.52304	-0.25102	19.66425	10,059,586	-315,399	263,331	1,810	-141,779
OESX	Option	P	1325	20240621	10	3700	3784.00	3784.00	460.90	6,106,925	EUR	1	0.77%	-0.46278	0.00037	-43.64751	-0.23810	20.32938	-21,963,576	635,103	-578,329	-3,155	269,364
OESX	Option	C	-88	20240621	10	3800	3784.00	3784.00	349.40	-307,472	EUR	1	0.77%	0.49815	0.00039	29.56304	-0.31051	20.45228	-1,570,195	-43,549	-26,015	273	-17,998
OESX	Option	P	4690	20240621	10	3800	3784.00	3784.00	508.10	23,829,890	EUR	1	0.77%	-0.50185	0.00039	-47.50336	-0.23213	20.45228	-84,306,647	2,320,965	-2,227,908	-10,887	959,212
OESX	Option	P	-7664	20240621	10	4000	3784.00	3784.00	614.00	-47,056,960	EUR	1	0.77%	-0.58200	0.00040	-55.60034	-0.19778	20.03111	159,768,996	-3,920,725	4,261,210	15,158	-1,535,184
OESX	Option	P	228	20240621	10	4200	3784.00	3784.00	737.00	1,680,360	EUR	1	0.77%	-0.66208	0.00039	-64.04345	-0.15009	18.91525	-5,407,034	114,775	-146,019	-342	43,127
OESX	Option	C	-3578	20240621	10	4300	3784.00	3784.00	154.00	-5,510,120	EUR	1	0.77%	0.29933	0.00038	18.91707	-0.23274	17.91907	-38,362,096	-1,749,532	-676,853	8,327	-641,144
OMWN	Option	P	-2668	20231218	100	270	404.55	404.55	7.30	-1,947,640	EUR	1	0.70%	-0.09482	0.00121	-0.69791	-0.02283	0.85489	10,060,389	-512,286	186,203	6,091	-228,085
OMWN	Option	P	200	20240318	100	450	404.55	404.55	71.40	1,428,000	EUR	1	0.83%	-0.62090	0.00372	-5.70819	-0.02382	2.022000	-4,914,423	116,395	-114,164	-476	40,440
OMWN	Option	P	-370	20241223	100	200	404.55	404.55	3.70	-136,900	EUR	1	1.04%	-0.04101	0.00048	-0.50843	-0.00679	0.57670	595,917	-27,448	18,812	251	-21,338
OMWN	Option	P	-284	20241223	100	270	404.55	404.55	13.80	-391,920	EUR	1	1.04%	-0.12883	0.00122	-1.65301	-0.02018	1.346000	1,436,796	-53,512	46,945	573	-38,226
OMWN	Option	P	73	20241223	100	280	404.55	404.55	15.80	115,340	EUR	1	1.04%	-0.14511	0.00134	-1.86851	-0.01997	1.446 26	-415,994	15,120	-13,640	-146	10,558
OMWO	Option	P	-193	20220620	10	7800	8481.00	8481.00	33.50	-60,352	USD	0.933445347	1.76%	-0.10985	0.00032	-0.52835	-4.44486	3.905 39	1,676,759	-410,096	952	8,008	-7,036

OMWO	Option	P	-68	20220620	10	8000	8481.00	8481.00	55.10	-34,974	USD	0.933445347	1.76%	-0.17584	0.00047	-0.84653	-0.96085	5.33573	945,652	-216,215	537	610	-3,387
OMWO	Option	P	1610	20220620	10	8800	8481.00	8481.00	365.40	5,491,403	USD	0.933445347	1.76%	-0.78668	0.00077	-3.85250	-1.57499	5.93101	-100,170,828	8,258,576	-57,897	-23,670	89,134
OMWO	Option	C	1379	20220620	10	11000	8481.00	8481.00	0.10	1,287	USD	0.933445347	1.76%	0.00051	0.00000	0.00231	-0.01187	0.06460	55,667	22,947	30	-153	832
OMWO	Option	P	1035	20220919	10	9200	8481.00	8481.00	807.70	7,803,318	USD	0.933445347	1.84%	-0.75269	0.00036	-21.83770	-1.00275	14.87604	-61,572,137	2,461,449	-210,978	-9,688	143,720
OMWO	Option	P	-3247	20221219	10	8000	8481.00	8481.00	393.40	-11,923,549	USD	0.933445347	2.17%	-0.32753	0.00022	-17.51264	-1.22773	22.85804	83,986,597	-4,817,482	530,790	37,211	-692,804
OMWO	Option	P	-379	20221219	10	9000	8481.00	8481.00	786.10	-2,781,031	USD	0.933445347	2.17%	-0.59570	0.00029	-32.24189	-0.91723	24.33619	17,829,551	-746,518	114,064	3,245	-86,096
OMWP	Option	P	-837	20220620	10	1800	2783.50	2783.50	0.10	-781	USD	0.933445347	1.76%	-0.00081	0.00001	-0.00128	-0.04892	0.02809	17,502	-3,958	10	382	-219
T2OT	Future		4267	20220617	1000	0	1.32	55.59	1.32	-	EUR	1	-0.06%	0.00170	-	0.00124	0.00000	-	9,575	0	5,306	19	0
T2OT	Future		-202	20221216	1000	0	2.67	55.59	2.67	-	EUR	1	-0.01%	0.08098	-	0.01456	0.00000	-	-43,675	0	-2,940	-0	0
T2OT	Future		-1016	20231215	1000	0	2.63	55.59	2.63	-	EUR	1	0.69%	0.25697	-	0.04162	-0.00005	-	-687,162	0	-42,291	52	0
T2OT	Future		-6192	20241220	1000	0	2.55	55.59	2.55	-	EUR	1	1.03%	0.36539	-	0.07015	-0.00008	-	-5,762,609	0	-434,349	479	0

Appendix 3: Portfolio after hedging

PRODUCT ID	INSTRUMENT TYPE	CALL PUT	QUANTITY	EXPIRY	TUV	STRIKE	SPOT PRICE	UNDERLYING PRICE	SETTLEMENT PRICE	VALUE	CCY	FX RATE TO EUR	INTEREST RATE	DELTA	GAMMA	RHO	THETA	VEGA	EURO DELTA	EURO GAMMA	EURO RHO	EURO THETA	EURO VEGA
A2 DS	Future		58	20221216	1000	0	3,30	184,46	3,30	-	EUR	1	-0,01%	0,08098	-	0,01799	0,00000	-	15.499	0	1.043	0	0
A2 DS	Future		63	20231215	1000	0	3,25	184,46	3,25	-	EUR	1	0,69%	0,25697	-	0,05145	-0,00006	-	52.614	0	3.241	-4	0
A2 LV	Future		245	20221216	1000	0	10,80	195,02	10,80	-	EUR	1	-0,01%	0,08098	-	0,05888	0,00000	-	214.268	0	14.426	1	0
A2 LV	Future		-638	20231215	1000	0	10,52	195,02	10,52	-	EUR	1	0,69%	0,25697	-	0,16837	-0,00021	-	-1.724.708	0	-107.420	132	0
A2 LV	Future		855	20241220	1000	0	10,24	195,02	10,24	-	EUR	1	1,03%	0,36539	-	0,28374	-0,00031	-	3.198.769	0	242.598	-267	0
BASE	Option	P	112	20220617	100	60	51,29	51,29	8,74	97.888	EUR	1	-0,67%	-0,99059	0,00721	-0,02773	-0,00285	0,00382	-569.044	2.124	-311	-32	43
BASE	Option	C	-4966	20220916	100	64	51,29	51,29	0,12	-59.592	EUR	1	-0,67%	0,04584	0,01465	0,00660	-0,00238	0,02844	-1.167.561	-191.421	-3.278	1.182	-14.121
BASE	Option	P	384	20220916	100	64	51,29	51,29	12,94	496.896	EUR	1	-0,67%	-0,95880	0,01381	-0,18380	-0,00348	0,02604	-1.888.387	13.955	-7.058	-134	1.000
BASE	Option	C	-2107	20221216	100	52	51,29	51,29	3,66	-771.162	EUR	1	-0,41%	0,50706	0,03983	0,12184	-0,00984	0,15071	-5.479.734	-220.773	-25.671	2.074	-31.754
BASE	Option	C	-3464	20221216	100	60	51,29	51,29	0,92	-318.688	EUR	1	-0,41%	0,20070	0,03195	0,05111	-0,00571	0,10769	-3.565.849	-291.189	-17.704	1.978	-37.302
BASE	Option	C	-8553	20230616	100	64	51,29	51,29	1,00	-855.300	EUR	1	0,43%	0,17162	0,02127	0,08151	-0,00456	0,13007	-7.528.478	-478.536	-69.718	3.901	-111.245
BASE	Option	P	-1874	20230616	100	64	51,29	51,29	15,66	-2.934.684	EUR	1	0,43%	-0,82759	0,02128	-0,60373	-0,00381	0,13040	7.954.543	-104.885	113.140	715	-24.438

BASG	Future		-8104	20220617	100	0	51,29	51,29	51,27	-	EUR	1	-0,67%	0,99969	-	0,02388	0,00094	-	-41.552.490	0	-19.353	-760	0
DAI	Option	P	-797	20221216	100	52	66,20	66,20	2,17	-172.949	EUR	1	-0,01%	-0,17186	0,01271	-0,07386	-0,01389	0,12575	906.754	-44.389	5.887	1.107	-10.022
DAI	Option	C	-4871	20221216	100	68	66,20	66,20	5,19	-2.528.049	EUR	1	-0,01%	0,49775	0,02687	0,13896	-0,01500	0,19411	-16.050.407	-573.492	-67.688	7.306	-94.550
DAI	Option	C	-521	20221216	100	72	66,20	66,20	3,46	-180.266	EUR	1	-0,01%	0,38811	0,02716	0,11283	-0,01355	0,18694	-1.338.616	-62.004	-5.878	706	-9.740
DAI	Option	P	1749	20221216	100	72	66,20	66,20	9,27	1.621.323	EUR	1	-0,01%	-0,61163	0,02712	-0,27129	-0,01358	0,18698	-7.081.694	207.902	-47.449	-2.375	32.703
DAI	Option	C	-1302	20221216	100	80	66,20	66,20	1,34	-174.468	EUR	1	-0,01%	0,19803	0,02114	0,06095	-0,00892	0,13767	-1.706.874	-120.602	-7.936	1.161	-17.925
DAI	Option	P	-277	20231215	100	52	66,20	66,20	5,29	-146.533	EUR	1	0,43%	-0,25116	0,01162	-0,29763	-0,00766	0,24870	460.565	-14.110	8.244	212	-6.889
DAI	Option	C	-1100	20231215	100	68	66,20	66,20	7,90	-869.000	EUR	1	0,43%	0,52759	0,01853	0,33954	-0,00860	0,31756	-3.841.904	-89.307	-37.349	946	-34.932
DAI	Option	P	-1509	20231215	100	68	66,20	66,20	12,15	-1.833.435	EUR	1	0,43%	-0,50255	0,01721	-0,57332	-0,00801	0,31110	5.020.238	-113.815	86.514	1.209	-46.945
DAIG	Future		96	20221021	100	0	66,20	66,20	66,18	-	EUR	1	-0,06%	0,99976	-	0,25930	0,00011	-	635.371	0	2.489	1	0
F3TE	Future		-1957	20220617	10000	0	0,40	11,65	0,40	-	EUR	1	-0,06%	0,00170	-	0,00033	0,00000	-	-1.331	0	-636	-2	0
F3TE	Future		1091	20221216	10000	0	0,70	11,65	0,70	-	EUR	1	-0,01%	0,08098	-	0,00380	0,00000	-	61.754	0	4.151	0	0
F3TE	Future		174	20231215	10000	0	0,66	11,65	0,66	-	EUR	1	0,69%	0,25697	-	0,01088	-0,00001	-	29.376	0	1.893	-2	0
F3TE	Future		6828	20241220	10000	0	0,64	11,65	0,64	-	EUR	1	1,03%	0,36539	-	0,01834	-0,00002	-	1.596.735	0	125.194	-138	0
F3TE	Future		-1698	20261218	10000	0	0,60	11,65	0,60	-	EUR	1	1,31%	0,58936	-	0,03373	-0,00003	-	-601.445	0	-57.265	45	0

FD 3D	Future		788	2022 1216	100	0	94,00	1717,77	94,00	-	EUR	1	0,00%	0,08098	-	0,51249	-	-	599.843	0	40.384	0	0
FD 3D	Future		-643	2023 1215	100	0	91,00	1717,77	91,00	-	EUR	1	0,00%	0,25425	-	1,40364	-	-	-1.487.673	0	-90.254	0	0
FD 3D	Future		418	2024 1220	100	0	86,00	1717,77	86,00	-	EUR	1	0,00%	0,35589	-	2,20066	-	-	1.279.355	0	91.987	0	0
FD 3D	Future		1081	2025 1219	100	0	80,30	1717,77	80,30	-	EUR	1	0,00%	0,45562	-	2,85560	-	-	3.954.947	0	308.690	0	0
FD AX	Future		370	2022 0617	25	0	14388,35	14388,35	14377,00	-	EUR	1	0,00%	1,00000	-	6,69614	-	-	133.092.238	0	61.939	0	0
FE BD	Future		1800	2022 1216	500	0	5,15	91,75	5,15	-	EUR	1	0,00%	0,08098	-	0,02808	-	-	375.348	0	25.270	0	0
FE BD	Future		8649	2023 1215	500	0	4,74	91,75	4,74	-	EUR	1	0,00%	0,25425	-	0,07311	-	-	5.211.579	0	316.177	0	0
FE BD	Future		6909	2024 1220	500	0	4,45	91,75	4,45	-	EUR	1	0,00%	0,35589	-	0,11387	-	-	5.470.934	0	393.368	0	0
FE BD	Future		9385	2025 1219	500	0	4,23	91,75	4,23	-	EUR	1	0,00%	0,45562	-	0,15043	-	-	9.043.656	0	705.873	0	0
FE SB	Future		18751	2022 0617	50	0	91,75	91,75	91,60	-	EUR	1	0,00%	1,00000	-	0,04266	-	-	86.020.213	0	39.999	0	0
FE SU	Future		-71	2022 0617	50	0	372,23	372,23	371,00	-	EUR	1	0,00%	1,00000	-	0,17279	-	-	-1.321.417	0	-613	0	0
FE SX	Future		3292	2022 0617	10	0	3789,21	3789,21	3784,00	-	EUR	1	0,00%	1,00000	-	1,76241	-	-	124.740.793	0	58.019	0	0
FE SX	Future		573	2022 1216	10	0	3789,21	3789,21	3759,00	-	EUR	1	0,00%	1,00000	-	20,49427	-	-	21.712.173	0	117.432	0	0
FE XD	Future		-2709	2022 1216	100	0	120,70	3789,21	120,70	-	EUR	1	0,00%	0,07045	-	0,65806	-	-	-2.303.394	0	-178.269	0	0
FE XD	Future		286	2023 1215	100	0	116,80	3789,21	116,80	-	EUR	1	0,00%	0,41798	-	1,80160	-	-	1.396.247	0	51.526	0	0

FEXD	Future		-2308	20241220	100	0	111,20	3789,21	111,20	-	EUR	1	0,00%	0,76528	-	2,84550	-	-	-19.640.937	0	-656.742	0	0
FEXD	Future		-1329	20251219	100	0	107,60	3789,21	107,60	-	EUR	1	0,00%	0,91328	-	3,82643	-	-	-13.059.933	0	-508.533	0	0
FMEA	Future		98	20220620	100	0	625,13	625,13	620,60	-	USD	0,93344534 7	0,00%	1,00000	-	0,34005	-	-	5.718.542	0	3.111	0	0
FMEA	Future		-128819	20220919	100	0	625,13	625,13	621,70	-	USD	0,93344534 7	0,00%	1,00000	-	1,89065	-	-	-748.020.300	0	-2.262.320	0	0
FMEA	Future		1675	20221219	100	0	625,13	625,13	623,00	-	USD	0,93344534 7	0,00%	1,00000	-	3,44784	-	-	97.740.386	0	539.076	0	0
FMEA	Future		11046	20230320	100	0	625,13	625,13	624,20	-	USD	0,93344534 7	0,00%	1,00000	-	5,01070	-	-	644.561.372	0	5.166.453	0	0
FMED	Future		-992	20221219	10	0	7741,86	7741,86	7742,20	-	USD	0,93344534 7	0,00%	1,00000	-	42,84724	-	-	-71.687.904	0	-396.756	0	0
FMEE	Future		1133	20220620	100	0	303,66	303,66	302,70	-	USD	0,93344534 7	0,00%	1,00000	-	0,16586	-	-	32.114.887	0	17.542	0	0
FMEE	Future		633	20220919	100	0	303,66	303,66	304,10	-	USD	0,93344534 7	0,00%	1,00000	-	0,92480	-	-	17.942.386	0	54.644	0	0
FMEE	Future		2337	20221219	100	0	303,66	303,66	306,00	-	USD	0,93344534 7	0,00%	1,00000	-	1,69348	-	-	66.242.268	0	369.426	0	0
FMFP	Future		-1660	20220620	50	0	2039,66	2039,66	2034,00	-	USD	0,93344534 7	0,00%	1,00000	-	1,11452	-	-	-158.024.624	0	-86.349	0	0
FMFP	Future		299	20220919	50	0	2039,66	2039,66	2035,00	-	USD	0,93344534 7	0,00%	1,00000	-	6,18863	-	-	28.463.471	0	86.362	0	0
FMFP	Future		-295	20221219	50	0	2039,66	2039,66	2037,00	-	USD	0,93344534 7	0,00%	1,00000	-	11,27326	-	-	-28.082.689	0	-155.214	0	0
FMFP	Future		329	20240318	50	0	2039,66	2039,66	2055,00	-	USD	0,93344534 7	0,00%	1,00000	-	36,99000	-	-	31.319.338	0	567.988	0	0

FMGS	Future		-660	20220620	10	0	18128,17	18128,17	17995,00	-	USD	0,93344534 7	0,00%	1,00000	-	9,86027	-	-	-111.682.929	0	-60.747	0	0
FMGS	Future		507	20220919	10	0	18128,17	18128,17	18070,00	-	USD	0,93344534 7	0,00%	1,00000	-	54,95260	-	-	85.792.796	0	260.067	0	0
FMGS	Future		153	20221219	10	0	18128,17	18128,17	18107,00	-	USD	0,93344534 7	0,00%	1,00000	-	100,20860	-	-	25.890.134	0	143.115	0	0
FMWN	Future		536	20220620	100	0	406,90	406,90	404,55	-	EUR	1	0,00%	1,00000	-	0,22167	-	-	21.809.840	0	11.882	0	0
FMWN	Future		-536	20221219	100	0	406,90	406,90	402,75	-	EUR	1	0,00%	1,00000	-	2,22892	-	-	-21.809.840	0	-119.470	0	0
FMWO	Future		-5509	20220620	10	0	8477,53	8477,53	8481,00	-	USD	0,93344534 7	0,00%	1,00000	-	4,64712	-	-	-435.944.299	0	-238.971	0	0
FMWO	Future		55	20220919	10	0	8477,53	8477,53	8515,00	-	USD	0,93344534 7	0,00%	1,00000	-	25,89493	-	-	4.352.321	0	13.294	0	0
FMWO	Future		5453	20221219	10	0	8477,53	8477,53	8563,00	-	USD	0,93344534 7	0,00%	1,00000	-	47,38975	-	-	431.512.845	0	2.412.175	0	0
FSTE	Future		3754	20220617	50	0	351,10	351,10	350,00	-	EUR	1	0,00%	1,00000	-	0,16301	-	-	65.901.470	0	30.598	0	0
OESX	Option	C	-3628	20221216	10	3650	3784,00	3784,00	316,50	-11.482.620	EUR	1	-0,25%	0,60103	0,00059	10,60792	-0,62994	10,68811	-82.071.687	-3.043.440	-384.855	22.854	-387.765
OESX	Option	P	5521	20221216	10	3650	3784,00	3784,00	207,70	11.467.117	EUR	1	-0,25%	-0,39896	0,00059	-9,31930	-0,65514	10,68810	-82.904.690	4.631.801	-514.518	-36.170	590.090
OESX	Option	C	-717	20221216	10	3700	3784,00	3784,00	284,50	-2.039.865	EUR	1	-0,25%	0,57049	0,00062	10,15565	-0,61940	10,87035	-15.395.533	-626.748	-72.816	4.441	-77.940
OESX	Option	P	-54	20221216	10	3700	3784,00	3784,00	225,80	-121.932	EUR	1	-0,25%	-0,42951	0,00062	-10,04483	-0,64506	10,87035	872.961	-47.199	5.424	348	-5.870
OESX	Option	P	631	20240621	10	3000	3784,00	3784,00	225,80	1.424.798	EUR	1	0,77%	-0,23883	0,00024	-22,27722	-0,25709	15,94953	-5.398.027	192.053	-140.569	-1.622	100.642

OESX	Option	P	635	20240621	10	3200	3784,00	3784,00	277,80	1.764.030	EUR	1	0,77%	-0,29303	0,00028	-27,34851	-0,24704	17,71602	-6.665.052	228.042	-173.663	-1.569	112.497
OESX	Option	C	-1579	20240621	10	3500	3784,00	3784,00	514,20	-8.119.218	EUR	1	0,77%	0,61048	0,00034	34,45780	-0,32327	19,66423	-34.527.641	-690.607	-544.089	5.104	-310.498
OESX	Option	P	-721	20240621	10	3500	3784,00	3784,00	377,50	-2.721.775	EUR	1	0,77%	-0,38952	0,00034	-36,52304	-0,25102	19,66425	10.059.586	-315.399	263.331	1.810	-141.779
OESX	Option	P	1325	20240621	10	3700	3784,00	3784,00	460,90	6.106.925	EUR	1	0,77%	-0,46278	0,00037	-43,64751	-0,23810	20,32938	-21.963.576	635.103	-578.329	-3.155	269.364
OESX	Option	C	-88	20240621	10	3800	3784,00	3784,00	349,40	-307.472	EUR	1	0,77%	0,49815	0,00039	29,56304	-0,31051	20,45228	-1.570.195	-43.549	-26.015	273	-17.998
OESX	Option	P	4690	20240621	10	3800	3784,00	3784,00	508,10	23.829.890	EUR	1	0,77%	-0,50185	0,00039	-47,50336	-0,23213	20,45228	-84.306.647	2.320.965	-2.227.908	-10.887	959.212
OESX	Option	P	-7664	20240621	10	4000	3784,00	3784,00	614,00	-47.056.960	EUR	1	0,77%	-0,58200	0,00040	-55,60034	-0,19778	20,03111	159.768.996	-3.920.725	4.261.210	15.158	-1.535.184
OESX	Option	P	228	20240621	10	4200	3784,00	3784,00	737,00	1.680.360	EUR	1	0,77%	-0,66208	0,00039	-64,04345	-0,15009	18,91525	-5.407.034	114.775	-146.019	-342	43.127
OESX	Option	C	-3578	20240621	10	4300	3784,00	3784,00	154,00	-5.510.120	EUR	1	0,77%	0,29933	0,00038	18,91707	-0,23274	17,91907	-38.362.096	-1.749.532	-676.853	8.327	-641.144
OMWN	Option	P	-2668	20231218	100	270	404,55	404,55	7,30	-1.947.640	EUR	1	0,70%	-0,09482	0,00121	-0,69791	-0,02283	0,85489	10.060.389	-512.286	186.203	6.091	-228.085
OMWN	Option	P	200	20240318	100	450	404,55	404,55	71,40	1.428.000	EUR	1	0,83%	-0,62090	0,00372	-5,70819	-0,02382	2,02200	-4.914.423	116.395	-114.164	-476	40.440
OMWN	Option	P	-370	20241223	100	200	404,55	404,55	3,70	-136.900	EUR	1	1,04%	-0,04101	0,00048	-0,50843	-0,00679	0,57670	595.917	-27.448	18.812	251	-21.338
OMWN	Option	P	-284	20241223	100	270	404,55	404,55	13,80	-391.920	EUR	1	1,04%	-0,12883	0,00122	-1,65301	-0,02018	1,34600	1.436.796	-53.512	46.945	573	-38.226
OMWN	Option	P	73	20241223	100	280	404,55	404,55	15,80	115.340	EUR	1	1,04%	-0,14511	0,00134	-1,86851	-0,01997	1,44626	-415.994	15.120	-13.640	-146	10.558

OMWO	Option	P	-193	20220620	10	7800	8481,00	8481,00	33,50	-60.352	USD	0,93344534 7	1,76%	-0,10985	0,00032	-0,52835	-4,44486	3,90539	1.676.759	-410.096	952	8.008	-7.036
OMWO	Option	P	-68	20220620	10	8000	8481,00	8481,00	55,10	-34.974	USD	0,93344534 7	1,76%	-0,17584	0,00047	-0,84653	-0,96085	5,33573	945.652	-216.215	537	610	-3.387
OMWO	Option	P	1610	20220620	10	8800	8481,00	8481,00	365,40	5.491.403	USD	0,93344534 7	1,76%	-0,78668	0,00077	-3,85250	-1,57499	5,93101	-100.170.828	8.258.576	-57.897	-23.670	89.134
OMWO	Option	C	1379	20220620	10	11000	8481,00	8481,00	0,10	1.287	USD	0,93344534 7	1,76%	0,00051	0,00000	0,00231	-0,01187	0,06460	55.667	22.947	30	-153	832
OMWO	Option	P	1035	20220919	10	9200	8481,00	8481,00	807,70	7.803.318	USD	0,93344534 7	1,84%	-0,75269	0,00036	-21,83770	-1,00275	14,87604	-61.572.137	2.461.449	-210.978	-9.688	143.720
OMWO	Option	P	-3247	20221219	10	8000	8481,00	8481,00	393,40	-11.923.549	USD	0,93344534 7	2,17%	-0,32753	0,00022	-17,51264	-1,22773	22,85804	83.986.597	-4.817.482	530.790	37.211	-692.804
OMWO	Option	P	-379	20221219	10	9000	8481,00	8481,00	786,10	-2.781.031	USD	0,93344534 7	2,17%	-0,59570	0,00029	-32,24189	-0,91723	24,33619	17.829.551	-746.518	114.064	3.245	-86.096
OMWP	Option	P	-837	20220620	10	1800	2783,50	2783,50	0,10	-781	USD	0,93344534 7	1,76%	-0,00081	0,00001	-0,00128	-0,04892	0,02809	17.502	-3.958	10	382	-219
T2OT	Future		4267	20220617	1000	0	1,32	55,59	1,32	-	EUR	1	-0,06%	0,00170	-	0,00124	0,00000	-	9.575	0	5.306	19	0
T2OT	Future		-202	20221216	1000	0	2,67	55,59	2,67	-	EUR	1	-0,01%	0,08098	-	0,01456	0,00000	-	-43.675	0	-2.940	-0	0
T2OT	Future		-1016	20231215	1000	0	2,63	55,59	2,63	-	EUR	1	0,69%	0,25697	-	0,04162	-0,00005	-	-687.162	0	-42.291	52	0
T2OT	Future		-6192	20241220	1000	0	2,55	55,59	2,55	-	EUR	1	1,03%	0,36539	-	0,07015	-0,00008	-	-5.762.609	0	-434.349	479	0