Assessing the Impact of EMIR's Clearing Requirement on End-Users

A study on the cost-efficiency of using central clearing to eliminate counterparty credit risk in OTC interest rate derivatives

Master's Thesis by Christian Friis Jensen

MSc. Applied Economics and Finance

Copenhagen Business School, 2014

Hand-in date: 27.03.2014

Academic Supervisor: Bjørn Rothaus

Number of pages: 77

Number of characters: 181,410

This thesis has been typed with Computer Modern 11p

The author would like to thank the people at Ernst & Young for probing the initial question that inspired the topic of this thesis. The patient and valuable insights from Robert Kielerstajn, Richard Hunter, and Jim Gustaffson of the advisory team deserve a special mention. I would like to thank my academic supervisor Bjørn Rothaus for always patiently accomodating my, at times, peculiar questions. Last but not least, my family and friends deserve thanks for humoring my tales from the land of counterparty credit risk.

Abstract

Seeking to eliminate counterparty credit risk, the recent European Market Infrastructure Regulation mandates central clearing of all eligible over-the-counter derivatives. Focusing on interest rate derivatives, this thesis develops a framework for analysis to compare end-user costs of clearing to the costs associated with the counterparty credit risk present in pre-EMIR bilateral contracts. The overall framework structure is based on transaction cost economics theory, and divides the cost factors into direct and indirect end-user costs. For each type of costs, key cost factors specific to either the clearing process or bilateral counterparty credit risk are identified based on available literature and market player evidence.

The costs associated with bilateral counterparty credit risk are based on (i) the expected counterparty exposure on a given contract, which must be modeled, and (ii) the counterparty propensity for default, which is available through market credit spreads. The thesis develops an econometric tool to model counterparty exposure under standard bilateral collateral agreements. As dealers must remain profitable, the end-user should expect to cover their own as well as dealer expenses.

The costs specific to central clearing are found to be based on clearing house risk management requirements and fees paid to cover expenses incurred by the clearing member who facilitates the clearing process. The risk management requirements and fees are estimated based on available market-player data.

The framework was applied to a case study to illustrate potential present day end-user costs. As the framework includes both direct and indirect costs, the case study considered costs in terms of portfolio drag on a modeled end-user. The end-user hedges an interest rate exposure through respectively bilateral and cleared interest rate swaps, removing funds from the portfolio to meet risk management requirements and cover expenses. The results show that in the illustrated situation, the portfolio drag associated with central clearing exceeds the drag associated with bilateral counterparty credit risk by a factor of 63. The framework was also applied to a scenario where the end-user and dealer alike faced historically high credit spreads. In this case, the portfolio drag from central clearing exceeded the drag from bilateral counterparty credit risk by a factor of 24.

As the clearing industry structure is still in its infancy, long-term costs are investigated through potential future scenarios for the clearing industry structure. The consequences of identified scenarios are suggested through changes to the framework cost factors. The industry structure analysis suggests that the ownership structure of clearing houses is likely to be of importance, and that the potential for reductions in end-user costs of clearing is limited.

Key Words: *EMIR, Clearing, Bilateral, Counterparty Credit Risk, End-User, Credit Value Adjustment, Portfolio Drag*

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Nomenclature

BERC	Bloomberg EUR Investmet Grade European Bond Index
CCP	Central Counterparty
CDS	Credit Default Swap
CM	Clearing Member
CRC	Cost of Regulatory Capital
CVA	Credit Value Adjustment
DV01	Dollar Duration
DVA	Debt Value Adjustment
EMIR	European Market Infrastructure Regulation
EONIA	Euro OverNight Index Average
EPE	Expected Positive Exposure
ERV	Exposure Risk Valuation
ESMA	European Securities and Market Authority
IM	Initial Margin
ISDA	International Swap Dealers Association
MC	Marginal Cost
MtM	Mark-to-Market
OAD	Option Adjusted Duration
OTC	Over-The-Counter
VM	Variation margin

1 Introduction

Facing increasingly volatile business environments, financial and non-financial corporations alike have especially in the last decade seen an increasing need to manage financial and operational risks, to decrease the cost of doing business. Such risks are commonly managed through options, swaps, futures and other derivatives. (Hull, 2012a) (Sidanius and Wehterilt, 2012) The most standard derivatives are traded on exchanges, offering contracts on underlying assets such as foreign currencies, stocks and stock indices. However, only a fraction of derivatives trading happens through exchanges. The over-the-counter (OTC) market is an important alternative several times the size of the exchange traded market. Here, trades are executed over the phone between the dealer, who acts as market maker, and the end-user (Hull, 2012a). A key advantage of OTC trading is the creation of tailored contracts matching the client's exact need in e.g. size and maturity. The main disadvantages include the involved counterparty credit risk, potential lack of market liquidity and limited transparency (Hull, 2012a).

Due to the low transparency, the OTC market received immediate attention following the financial crisis of 2007. Seeking to resolve the market's perceived issues, G20 leaders agreed at a 2009 meeting in Pittsburg, USA, that:

> All standardised OTC derivative contracts should be traded on exchanges or electronic trading platforms, where appropriate, and cleared through central counterparties by end-2012 at the latest. OTC derivative contracts should be reported to trade repositories. Noncentrally cleared contracts should be subject to higher capital requirements. (FSB, 2013)

The introduction of mandatory clearing through central counterparties (CCPs) was based on the performance of cleared versus non-cleared contracts during the major bankruptcies at the beginning of the financial crisis. AIG had to raise money for increased collateral as the company took on massive amounts of debt to pay off bad credit default swaps (CDSs). As AIG took on additional debt, agencies downgraded their creditworthiness, which meant that the company faced billions of dollars in collateral requirements on existing contracts. AIG were unable to meet the increased collateral requirements following the downgrade, and received a government bailout to ensure that their counterparties were not hurt by a default. It was argued that if AIG had been required to clear the CDS contracts upon initiation, then sufficient collateral would already have been posted during stable times, and AIG would not have had to borrow - thereby preventing the credit downgrade (Nosal, 2010). The Lehman Brothers collapse also caused heavy losses to its counterparties, though the trades backed by a central clearinghouse, LCH.Clearnet, were covered and the losses were absorbed by the margin already posted by Lehman, containing the default. (Murphy, 2013)

The G20 Pittsburg agreement led to the development of legislative measures. In Europe the legislation is titled the 'European Market Infrastructure Regulation' (EMIR), purposed to reduce systemic counterparty credit risk and increase transparency on the OTC market (ESMA, 2013a). EMIR is expected to enter into full force in Q2 2014, enforcing mandatory clearing of eligible contracts and full collateralization of non-cleared trades (ESMA, 2013a). The clearing and collateral requirements are of academic and practicioner interest, as these requirements will create significant changes in the financial system. The costs imposed by clearing to dealers and clients are expected to be significant, and clearing will pose its own risks to market participants. Last but not least, as the process is hastily implemented it is urgent for marketplayers to develop efficient measures for optimization. As the European clearing industry before the EMIR rollout remains fragmented (Hasenpusch, 2009), the potential outcomes of the restructuring are many. While some the clearing houses and their members do have a say in the industry development, end-users are for now kept in the dark, with little opportunity to adapt their business processes.

This thesis hopes to clarify how the new clearing requirements will affect end-users.

1.1 Problem Statement

The thesis proposes the following general hypothesis:

- *The EMIR clearing requirements will lead to more expensive business processes.*

The central question in the thesis following the above hypothesis is:

- *How can end-users of OTC derivatives assess the short- and long-term impact of the EMIR clearing requirements on their business, and what is the expected severity?*

The main goal is to establish a framework for analysing considering the impact of the EMIR requirements both in the short and long term. To answer the research question in an approachable and useful manner, a few sub-questions are considered:

- *How large is the typical counterparty exposure that clearing is meant to offset?*
- *What are the additional costs associated with cleared OTC derivative trading?*
- *How does the clearing requirement affect end-user counterparty credit risk, and how can we price the effect?*
- *What drivers are instrumental in determining the long-term end-user costs of clearing?*
- *What are potential scenarios and end-user consequences of these drivers?*
- *How can end-users optimise their derivative usage following the clearing requirement?*

Together, answers to these questions should help provide end-users with a blueprint for assessing their current opportunities and challenges within the OTC derivatives market and their potential impact.

1.2 Critical Literature Review

In the following section, an overview of relevant scholarly literature is given to clarify the current state of research and the gap that this thesis seeks to fill. As EMIR's clearing requirement is mainly a response to systematic counterparty credit risk, its impact on end-users in this thesis is investigated through the expected net costs and change in counterparty credit risk profile as outlined by the research questions. This section will therefore focus on academic research that deals with these issues. The amount of literature on end-user consequences of mandatory clearing is limited, as academia has focused primarily on the mechanics of cleared and bilateral contracts, as well as the significance and optimal economic outcome of clearing industry scenarios. As the absensce of literature on end-user impact of mandatory clearing is difficult to prove, this literature review will focus on identifying useful literature and trends of scholarly interests on the subject.

Duffie and Huang (1996) are first to analyse the role of credit risk in pricing of interest rate and currency swaps by considering the credit spread pricing of standardized swaps to counterparties with different bond yields. In other words, they consider the pricing of the credit risk that cleared contracts seek to eliminate. They realize that risk mitigation techniques such as collateral should also be considered in the derivative pricing. This study lays a foundation for credit risk pricing.

Longstaff et. al (2012) empirically contribute to the knowledge on the effect of counterparty credit risk on derivatives valuation. They investigate how much if at all clearing can be expected to reduce spreads. The paper provides empirical results to support conclusions that a central clearing counterparty might actually increase the amount of credit risk in the market. Longstaff et. al find that when dealers sell CDSs on other financial firms, the counterparty credit risk faced by the client is not priced. However, the dealer's own credit is priced as a rebate to a small extent in CDS contracts on non-financial firms. They conclude that this difference is likely explained by the market expecting a bailout of the CDS dealer in case insured financial firms go bankrupt, suggesting a formal model of the 'too-large-to-fail phenomenon.'

Culp (2010) argues that the cost of margin and collateral required from central clearing is higher in periods where derivatives participants are already stressed on liquidity. He points out that the most serious end-user cost of collateral stem from the risk of facing collateral calls during a period where liquid assets are heavily depleted and access to short-term loans is scarce due to market volatility. In light of this study, liquidity risk changes following the clearing requirement could be of interest to end-users.

Koeppl (2012) provides a formal comparison of the costs and benefits of CCP clearing along the dimension of costly collateral and the incentives for risk taking. The paper argues that while CCP clearing can lower default risk through higher collateral requirements, there is a feedback effect from a subsequent decrease in market liquidity that will amplify the collateral costs. Koeppl further argues that since CCPs novate large quantities of trades, their exposure to credit default risk is sufficiently diversified. The risk management requirements could then, it is argued, be regarded as a mechanism serving to incentivise proper conclusion of trades rather than a risk-reducing mechanism.

Academic researchers early agreed that the development in the clearing industry structure is a critical driver for end-user costs and risks associated with clearing (Milne, 2007), and various researchers have applied tools of industrial organisation, theoretical and empirical, to improve this understanding. The literature on developments in this area is helpful in assessing the long-term end-user impact of the clearing requirement.

Amongst the pioneers of institutional analysis are Van Cayseele (2004), who investigates the level of competition and the organisation of the clearing industry. Van Cayseele clarifies that the trade costs are given by the fees charged by involved parties, which in turn depend on the real costs necessary to undertake the operation and the markups taken. Both of these factors are dependent on the CCP industry structure. To offer an academic perspective to the debate regarding optimal industry organization, Van Cayseele concludes that a contestable quasi-monopoly is preferable over an overall monopoly market-wise. While not directly considering the end-user perspective, insights are given to the industry structure driver mechanics.

Van Cayseele and Wuyts (2005) provide insight to the expected CCP industry movements. They find that the industry exhibits economies of scale and scope. The authors conclude on this basis that further consolidation should be expected, and that separating certain CCP activities from others can only be done at a cost in terms of efficiency.

Serifsoy and Weiss (2007) take the strategic decision making of industry participants into account to explore three feasible industry configurations: a single regulated monopoly, a competitive market with minimum intervention allowing market forces to determine the outcome, and a competitive market also allowing market forces to determine industry structure though guided by some intervention to ensure that resulting monopolies are contestable. They conclude in line with Van Cayseele that the latter configuration is the most desirable, as it delivers the maximum efficiency, though noting that stability in this configuration depends largely on the assigned regulators. The significant contribution of this paper lies in considerations on systemic efficiency, which is the stability of the industry when a bad event for one market participant has repercussions for others.

Bliss and Papathanassiou (2007) examine the economic implications of derivatives clearing. They find that cleared contracts are structurally better suited to contain systemic risk and provide greater market liquidity than non-cleared contracts. They find that the CCP industry is a natural monopoly, arguing for antitrust rules in line with Van Cayseele (2004) to ensure fair user access and fees. Finally, they consider the possibility of an interoperable industry, where switching costs are eliminated and CCPs pool their positions to act as one, arguing that such an industry structure may lower end-user costs of clearing and increase market liquidity.

Following regulatory interest in mandatory clearing, Koeppl and Monnet (2009) investigates CCP collateral policies. They find that these policies might differ depending on level of competition and whether the CCP is for-profit or user-owned.

Duffie and Zhu (2011) considers the total collateral required under different clearing industry structures, arguing that e.g. separation of asset classes across multiple CCPs would increase collateral requirements, since fewer offsetting positions can be netted against each other. They conclude that it is always more efficient to clear on a single CCP rather than multiple, though conceding that an interoperable industry could potentially match the efficiency of a single CCP.

Regarding interoperability, Nielsson (2010) takes a first step to assess whether it is advisable to enact a European Code of Conduct aimed towards facilitating developments towards an interoperable clearing industry in order to increase competition and customer choice. This research is of special importance, as it laid an initial foundation for considerations on the issue. Nielsson concludes that a code of conduct is advisable given that other initiatives to increase competition proved ineffective.

Miller (2011) contributes to the academic knowledge of the clearing industry structure by examining the conflicts of interest in derivatives clearing. More specifically she argues that if large swap dealers dominate a clearinghouse, they might directly or indirectly restrict access to the clearinghouse to reduce competition in the swap market. Also, as the large swap dealers and they might influence a clearinghouse to lower margin requirements.

Cont and Kokholm (2012) investigates the exposure reduction of cleared compared to non-cleared products depending on the clearing structure. The authors arrive at different results compared to Duffie and Zhu (2011) on some sub-points, but also conclude that a single CCP clearing all assets is most efficient in terms of reducing credit exposure. However, they argue that such a scenario leads to high systemic and operational risk within the CCP. The overall finding is then that the benefits and drawbacks of having multiple CCPs is not described fully based on expected exposures. In other words, the results of Duffie and Zhu (2011) only explain part of the picture.

Finally, Calès et al (2012) considers the competition between European clearing houses to clarify the most likely outcome. Based on the modeling of an industry consisting of a pan-European CCP and two incumbent local CCPs, they conclude that interoperability agreements are never achieved in industry equilibrium, despite implementation of a code of conduct to incite these types of arrangements, as considered by Nielsson (2010). However, they also find that mergers towards a single CCP can occur under some circumstances.

In summary, academic literature has only scarcely considered end-user implications of mandatory clearing and collateral posting, though some studies are very relevant for explaining the circumstances faced by end-users and likely developments of the industry structure, which is useful for assessing long-term expectations. Literature is available on the extent market players previously valued the counterparty credit risk that clearing is meant to offset. Academic research does provide a discussion of the potential factors impacting end-user bottom line and risk profile following the introduction of EMIR. However, these factors are considered in a macro-economic context aimed at providing a point of view on optimal industry structure. End-users are likely concerned less with the optimal macro-economic scenario and more with the most likely scenarios and their consequences. A body of academic literature identifies the CCP industry structure developments as a defining driver for costs and risks associated with clearing, though available research on most likely scenarios is primarily based on theoretical studies of industrial models that do not necessarily represent the clearing industry on the OTC derivatives considered for this thesis. An academic framework for assessing the expected short- and long-term impact of the clearing requirement on end-users is then both useful and currently absent. The purpose of this thesis is to provide a contribution to closing this research gap.

While academic studies tend to focus more on a macro-economic perspective, it should be noted that a plethora of reports from stakeholders analyse the costs of European securities post-trading. Amongst the more influential stakeholder reports is research commissioned by national banks, the International Monetary Fund, and the Bank for International Settlements. Other market players such as consulting firms and dealer have also offered their insights on the impact of the clearing requirement, also on end-users. As their results are often based on non-disclosed data, they are difficult to verify. The second-hand research is sometimes initiated by the European Commission itself, e.g. Oxera (2011). Further, the research body offered by these participants contain a great body of knowledge relevant for end-users, why their usage in this thesis will be discussed further in section §3.

1.3 General Delimitations

The scope of the thesis is naturally limited by a number of factors. The analysis including data retrieval is conducted as of October 1st, 2013. Necessary assumptions are therefore made given the best information available at this time, and the thesis will not reflect potential changes occurring between this date and the date of publication. As the motivation for the clearing requirement was to eliminate counterparty credit risk in bilateral contracts, the analysis will be restricted to compare a pricing of this counterparty risk to the costs associated with the clearing process. Context-specific delimitations are stated throughout the thesis where necessary.

1.4 Scope

As the OTC market is very diverse, the thesis will focus on OTC interest rate derivative contracts to ensure depth of analysis. The reason for choosing interest rate derivatives over other derivatives is that they are used across large companies in most industries (ISDA, 2009), and is by far the largest segment within the global and european OTC derivatives market (ECB, 2009) (IMF, 2013). Choosing to narrow the scope of the thesis to only consider interest rate derivatives will have some impact on the generalisability of the impact framework to function on firm-level, as e.g. cross margining (the practice of netting out margin requirements with negatively correlated positions on different assets) will not be considered.

As shown in section 1.2, a focal point of scholars for assessing long-term clearing efficiency has been the CCP industry structure. The thesis will seek to leverage and expand on this knowledge by focusing on the potential constellations of the clearing industry and their consequences as the key driver for assessing the long-term end-user costs of clearing. The clearing industry structure is likely not the only driver relevant for long-term assessment, as academic scholars have also suggested that e.g. market liquidity changes could reasonably be expected to influence the profit margin available to dealers and therefore the final end-user price of derivatives.

1.5 Structure

The thesis is presented through the following parts: Section 2 introduces relevant theoretical and practical background knowledge on the current bilateral landscape for end-user OTC trading, the EMIR requirements, and the concept of clearing including an overview of associated factors of costs, savings and risk. Section 3 outlines the choice of method used throughout the thesis and its significance for the results. Section 4 builds on the background knowledge to identify key cost and risk factors, clarify their mechanics and offer factor size estimates through market player data and modeling as applicable. The end-result is a framework for estimating cost differences between cleared and bilateral contracts. Section 5 analyses the clearing industry structure to assess potential long-term industry structures and their estimated effect on the previously identified cost and risk factors. Section 6 clarifies how the framework is applied to obtain results on cost differences, providing intermediary results on the credit exposure associated with interest rate swaps. Section 7 presents the obtained results in terms of portfolio drag from cost factors specific to cleared and bilateral contracts respectively. Section 8 discusses the significance of the results and offers critical perspective on their reliability, revising the necessary assumptions and their significance. Finally, Section 9 concludes on the results and offers recommendations on potential future research.

2 Background

This chapter initially provides an introduction to the current trading landscape faced by end-users for OTC interest rate derivatives. Then, an introduction to the EMIR requirements is given, focused on the clearing requirement. Finally, the concept of clearing is introduced to hopefully demystify the process. Since most concepts introduced in this chapter are subject to further analysis, they will be covered more in-depth in subsequent chapters. The goal of this section is to clarify the practical processes and provide sufficient background knowledge to facilitate development of an appropriate method for answering the research questions.

2.1 Bilateral Contracts

To assess the impact of new requirements, it is necessary to clarify the current base case, also known as bilateral trading. The current standard trading process is introduced briefly, followed by an introduction to relevant risks and the measures taken to reduce them. Finallyf the factors considered by dealers when calculating spreads are clarified.

2.1.1 Process, Execution and Confirmation

The current bilateral trading process is fairly straightforward. At its core, 'bilateral' simply means that two parties who agree on a transaction can enter into it without involving any third parties. The trade documentation is agreed upon between the dealer and end-user, though a standard has been developed by the International Swap Dealers Association (ISDA), which is widely used today. Traditionally, bilateral trades were conducted per phone, with the dealer and the buyer agreeing on a price and executing. As OTC markets have not typically included trade reporting, the only price information available to buyers was the prices advertised by dealers. These days, electronic platforms allow end-users to compare dealer advertisements and engange in transactions, offering multiple methods of execution. A screen shows the buyer best prices for a matrix of benchmark trades, and the buyer can then request firm-specific prices from dealers. After agreeing upon a trade, the details must be exchanged and contractually verified, which today is most commonly performed through the MarkitSERV service, why almost all trades are currently performed through an electronic platform. (Murphy, 2013)

2.1.2 Counterparty Credit Risk

The dealer and the end-user alike face a number of risks associated with bilateral trading. Market risk is the most obvious risk concerned with derivative contracts, as the contracts alter the risk profile of each party. This is all part of the plan for the end-user who initiate the contract, but the dealer might now incur an unwanted exposure. The dealers try to hedge these exposures by trading in different directions with a plethora of counterparties (Murphy, 2013), which explains why a large part of contracts are intra-dealer trades. However, if one of these counterparties defaults, the new position will be unhedged, and the dealer will have to engage in new trades. The second risk is then counterparty credit risk, which is present in any situation where one party is owed money by another who might not be able or willing to pay, which occurs most often in case of bankruptcy (Murphy, 2013). As each of the parties are uncertain of how long it will take to replace lost transactions, or what the price will be to do so, counterparty credit risk is difficult to price. Different classes of derivatives creates counterparty risk of various degrees and types, but the risk is usually assessed based on the expected exposure on a contract (Murphy, 2013)

2.1.3 Cost and Risk Mitigation

To reduce the risks counterparties pose to one another, a few mitigative measures have become standard practice. Two of these, netting as well as margin and collateral agreements, are of importance for establishing the attractiveness between using cleared and bilateral contracts for end-users under different circumstances.

Netting is the process of replacing gross contracts and their involved payments with a single net position. There are two different types of netting used in the derivatives market (Gregory, 2012). The first is payment netting, which is the netting of periodic cash flows. The second is close-out netting, which covers the value of contracts in the event of a counterparty defaulting in the future. While netting does decrease overall risk substantially, it is more difficult to analyse netted positions, as the overall exposures are now non-additive. This means that the pricing of counterparty risk is more complex when netting is introduced. To exemplify the netting process, consider transactions with current market values of +6, -3, +3, +5, and -3. The total counterparty exposure is +14 without netting and +8 with netting.

Netting in bilateral derivative contracts is usually undertaken following the ISDA Master Agreement, which is a documentation that specifies general questions including netting procedures. The Master Agreement stipulates that multiple transactions between two counterparties can be summed into one net contract of indefinite length. Because of the advantages offered by netting, it is used widely today. Netting was in 2011 estimated to reduce gross credit exposure to 14% of gross market value across OTC derivative classes. (ISDA, 2012)

Collateral is another way counterparties can reduce their credit exposure to one another, and its introduction has reduced overall credit exposure across OTC derivative classes by around 80% (Gregory, 2012). The fundamental idea of collateralisation is very simple; cash or securities are passed from one counterparty to another as security for credit exposure. The practice of posting collateral serves to firstly reduce the credit exposure, but also benefits the market by allowing dealers to trade with low-rated counterparties, reduce capital requirements and give a more competitive pricing of counterparty credit risk. Bilateral ISDA Credit Support Annexe are standardised collateral agreements, which normally stipulate day-to-day variation margining (VM) with zero treshold and minimum transfer amount (Murphy, 2013). According to a 2005 ISDA estimate, 73% of all collateral is posted in cash (Gibson, 2005).

Dealers do typically not require nonfinancial end-users to post collateral. (Chicago Fed, 2010) (IMF, 2010). The reason is mainly that the operational costs of calculating and posting collateral exceeds the benefits, why corporates would rather pay a risk premium to the dealer (EACT, 2013).

2.2 EMIR

This section will first quickly clarify who the responsible parties are for the EMIR implementation followed by an overview of the main EMIR requirements, their scope, timing and exemptions.

The European System of Financial Supervision is the EU's overall instutional framework for financial supervision created in 2009 following the crisis (EC, 2009). This system includes three European Supervisory Authorities, of which the European Securities and Markets Authority (ESMA) is the relevant authority here, as they are in charge of developing and fine-tuning EMIR's technical standards (ESMA, 2014a).

The *"Regulation (EU) No 648/2012 of the European Parliament and of the Council of July 4th, 2012 on OTC derivatives, central counterparties (CCPs) and trade repositories"*, EMIR for short, was entered into effect from August 16th, 2012. The *"Commission Delegated Regulations (EU) No 148/2013 to 153/2013 of December 19th, 2012"*, which is a supplement to EMIR, entered into effect from March 15th, 2013. The technical standards for implementation were published on December 21st, 2012. (ESMA, 2014)

The main EMIR requirements are (ESMA, 2014):

1. Central clearing for eligible classes of OTC derivatives
2. Application of risk mitigation techniques for non-cleared OTC derivatives
3. Reporting to Trade Repositories
4. Requirements to CCPs on organisation, conduct of business and prudence
5. Requirements to Trade Repositories

The first requirement of central clearing is the explicit focus of the thesis. The second requirement involves the exchange of collateral for non-cleared OTC derivatives. This requirement is of relevance for end-users exempt from the clearing requirement or for derivatives that are not eligible for clearing. The fourth set of requirements is also of importance, as these requirements shape the future clearing industry structure. The requirements on reporting to trade repositories are purposed to increase transparency in the OTC industry, but are not related to counterparty credit risk or the cleairng process. The EMIR requirements differentiate between three types of entities, who are each required to fulfill a certain set of requirements (ESMA, 2014), as outlined in Table 1.

Table 1: EMIR Requirements

Entities	**Requirements**
Financial Counteparties and Non-Financial Counterparties above the Clearing Threshold	Clearing Obligation, Risk Mitigation Techniques, Reporting Obligation
Non-Financial Counterparties below the Clearing Treshold	Reporting Obligation, Certain Risk Mitigation Techniques
CCPs	CCP Requirements

(ESMA, 2014)

The mandatory clearing thresholds for non-financial counterparties are between 1-3 billion Euro depending on the derivative type. (EC, 2013) The thresholds are not based on total positions, as contracts entered to reduce commercial or treasury risks are excluded from the threshold calculation. When the threshold amount for one of the categories is exceeded, a non-financial corporation is considered above the threshold for *all subsequent* OTC derivative trades regardless of purpose, including those undertaken for risk management purposes. (ESMA, 2012) While EMIR entered into force Q3 2012, the clearing requirement is expected to enter into effect in Q2 2014, though ESMA recognises that the obligation might be postponed to Q2 2015 (ESMA, 2013a). A few end-user types are currently exempt from the clearing requirement, as shown in Table 2.

Table 2: EMIR Exemptions

	Clearing Requirement, EMIR Article 4
Pension Scheme Arrangements	Exempt until 15/08/2015
Intragroup Transactions	Exempt at authority discretion

(ESMA, 2012)

2.3 Cleared Contracts

This part provides an overview of the clearing process followed by the associated requirements and services relevant to end-users.

The central element to CCP clearing is the process of *novation*, which is the legal substitution of the CCP for the original counterparties' obligations to one another. In other words, where the two counterparties of the OTC contract were before liable and exposed to one another, they are now liable and exposed to the CCP. (McPartland, 2005) The idea is that the creditworthiness of the CCP is kept at a very high level, to ensure that the CCP can absorb contractual defaults of some counterparties without affecting others. In order to do so, the CCPs are structured in a certain way, and there are certain requirements to the counterparties dealing with the CCP.

To clarify the process, first a brief explanation of the functional structure of CCPs. A disctinction is here made between end-users with direct and indirect access to the CCP, as CCPs only allow few institutions as members to ensure creditworthiness of those enabled to directly participate in the clearing process. This means that most derivative users are in fact not expected to be CCP members, leading to a two-tiered network structure. The first tier is the the CCP and its members, and the second tier includes those who gain access through using a clearing member as intermediary. (Hasenpusch, 2009)

The *first tier*, clearing members (CMs), have direct access to the CCP. There are two categories of clearing members; general CMs and individual CMs. The general CMs are allowed to clear both their own and their customer's positions (proprietary activity) as well as offer clearing services for other participants without clearing licenses (agency acitivity). The individual CMs are allowed to clear only trades undertaken by themselves and their customers. It follows that general CMs have to comply with stricter rules than the individual CMs to ensure the stability of the CCP. (Hasenpusch, 2009)

The *second tier* consists of the participants without clearing licenses. To clear their trades, these participants then need a general CM to act as clearing intermediary for them (Murphy, 2013).

The end-user can then employ both first and second tier dealers as their broker. First tier dealers can clear their own and the end-user's contract, while second tier dealers must employ the service of a general CM. Thereby, the broker and the CM is not necessarily the same corporation. Even when they are, the trading desk and the clearing desk might be separate entities.

2.3.1 Process, Execution and Confirmation

Cleared trades are still executed following the methods used for bilateral trading. The clients elect which CCP and CM they wish to clear the contract through, given that the CM has the credit capacity to undertake the trade and accepts doing so. The CCP then measures the additional exposure generated by the new trade, calculates the required margins and accepts the trade. The end-user now faces the CM, who in turn settles with the CCP. (Murphy, 2013)

2.3.2 Cost and Risk Mitigation

To ensure high creditworthiness, the CCPs have a number of requirements and processes that the CMs must adhere to, ultimately influencing end-user costs and risks. It is the responsibility of the CM to meet the CCP requirements, and the end-user then faces requirements passed on by the dealer (Murphy, 2013). The CCPs have multiple lines of defense that CMs must contribute to, known as the "CCP waterfall", which are meant to ensure coverage in the event of a clearing member default. (Murphy, 2013) The typical CCP waterfall is outlined in Table 3.

Table 3: CCP Waterfall

Level	**Protection**
1	Defaulter's variation margin (VM)
2	Defaulter's initial margin (IM)
3	Defaulter's default fund (DF) contribution
4	Fixed amount of CCP equity
5	Non-defaulting CM's default fund contributions
6	Capital calls on non-defaulting CMs
7	The rest of CCP equity

(Murphy, 2013)

The CMs post variation margin (VM) and initial margin (IM) on their own and their clients' contracts to cover a large portion of the risk their potential default poses to the CCP. CMs pass the margin requirements from agency contracts on to their client, but are ultimately liable to meet their obligation to the CCP regardless of client performance. CMs also contribute to a default fund. This fund serves as further protection for the CCP in case the CM defaults, as well as a fifth line protection in case the default of another CM is not covered by their own default contribution. If the entirety of the CCP's default fund is depleted, the CCP normally retains the right to call for non-defaulting CMs to post additional capital to the default fund. This right might be limited to i.e. the original default fund amount, but in some cases the CCP retains the right to call for an in principle unlimited amount. (Murphy, 2013) Compared to the bilateral base case, the VM requirement is new to only non-financial corporations, while the IM requirement will be new both to financial and non-financial end-users.

Cleared contracts are also netted, although the process is different. Bilateral netting is constrained to pairs of counterparties in the market. For instance, an end-user cannot net the positions they have with bank A and bank B into a single position. Cleared contracts are netted multilaterally, where the CCP as the central element nets out all positions held by a given counterparty. (Gregory, 2012) This means that while the end-user can net across dealers, they cannot necessarily net across CCPs, unless interoperability agreements to do so are in place.

3 Research Method

The following section will establish and discuss the research approach and employed methods. The aim of this section is to ensure that all thesis research complies with the three core features of scientific knowledge; *systematic observation*, *control* through systematic elimination of alternative explanations and *replication* in that other researchers should obtain the same results using the methods employed in this thesis. (Welman and Kruger, 2001) To achieve this goal, a pragmatic research approach is taken, focused on "keeping it simple, getting it right and making it plausible" as per Williamson (2007).

Simplicity is achieved by disregarding non-primary effects of clearing to focus on the main purpose of eliminating counterparyt credit risk. The idea is that by keeping the investigation as simple as possible, the author is forced to prioritize isolating a few central impact factors. Getting it right involves translating relevant economic concepts into accurate descriptions of reality, and making sure that logical operations are correctly performed and can be verified. Plausibility will be ensured by using market player estimates where possible and by testing whether modeled estimates provide sensible results. (Williamson 2007)

The thesis seeks to explain the impact of the clearing requirements as a dependent variable through a number of independent variables, or factors. All in all, the idea is to identify, describe and estimate these factors. To assess the long-term impact, the change in factors from likely outcomes of the clearing industry is investigated. The resulting framework consisting of the identified cost factors is then applied to the framework provides sensible, valid and significant results upon application. Further, applying the framework also enables assesment of potential mitigation techniques. This section will initially consider the overall use of literature and theory, and then discuss the method of analysis. However, the precise method of factor and industry structure analysis is covered in their respective sections. The thesis is then departing from the classical positivistic approach of deciding fully on the research design before data collection, in favor of an emergent design where the methods of analysis are dependent on findings.

3.1 Research Design

At the core, the EMIR clearing requirement introduces a new mandatory trading process aimed at eliminating counterparty credit risk (ESMA, 2013a). To evaluate the costs associated with the clearing process in an approachable manner, the thesis will price the counterparty credit risk currently prevalent in bilateral trades, and identify the costs involved with offsetting this risk through central clearing, enabling a comparison between the two. The impact factor analysis is then limited to consider only the costs directly associated with bilateral counterparty credit risk and offsetting this risk through clearing, why the result should not be mistaken for an assessment of the total costs under each trading paradigm. Even though not all costs are considered for analysis, some important omitted factors are outlined to facilitate later discussion on how the framework can be expanded.

Transition costs from moving to cleared trades are likely to involve significant one-off expenses. However, the significance of these costs is exceedingly firm-specific as they vary depending the amount of OTC trades undertaken by the endu-user (Hasenpusch, 2009). As such, transition costs are much less comparable than per-contract factors, and are considered out of scope for analysis. As operational costs too are highly idiosyncratic (Hasenpusch, 2009), these costs do not lend themselves well to a generalisable estimate either. Operational costs are expected to play a large role in explaining total non-financial end-user costs, especially regarding collateral agreements as explained in (EACT, 2013). However, financial end-users typically already have low-cost procedures in place for these types of agreements, why it makes sense to restrict the research to financial end-users.

First, the key impact factors are identified based on the processes outlined in Section 2: Background. Then, factor mechanics are clarified using available academic literature. Finally, factor sizes are estimated directly from real-world data where possible, otherwise through modelings.

An alternative research strategy was preliminarily pursued, and was to gather empirical insight by asking relevant end-users to identify the key factors and estimate their sizes. Such an approach would ensure results that represent a broad perception amongst end-users, comparable across industries. However, the strategy unfortunately proved infeasible. The amount of end-users knowledgeable regarding the problems of this thesis were found to be few, seated in senior positions, and difficult to identify within the contacted organisations. Knowledgeable people in financial corporations, although identifiable, unfortunately cited blanket bans on discussing the topic with thesis students. The market player insights used in this thesis are therefore based on existing reports and surveys from reputable sources.

For the long-term impact assessment, the current state of the clearing industry organisation is clarified using available market player reports and data. The objective of the industry analysis is to identify possible scenarios and the impact of these scenarios on the identified cost factors associated with cleared trades.

To accomplish the above within the thesis scope, this thesis will take the point of view of a model financial end-user who seeks to hedge the interest rate exposure on an index portfolio through trading OTC plain vanilla interest rate swaps. As not all costs lend themselves to direct estimation, a backtest on previous market data is conducted to obtain portfolio drag from bilateral counterparty credit risk versus clearing expenses. A portfolio drag estimate allows for cost of capital considerations following e.g. margin agreements.

Specifically, the modeled end-user has decided to invest in the Bloomberg EUR Investment Grade European Bond Index (BERC), which is an index engineered to measure investment grade, fixed-rate securities publicly issued in the European bond market denominated in Euro (Bloomberg, 2013). The end-user uses an active duration management strategy to limit their duration exposure to two percentage points below the index level by trading five-year OTC swaps on monthly rebalancing dates. The key factors are estimated based on the swap notionals needed for each rebalance. The backtest will be using Bloomberg market data on swap values to ensure that durations, and thereby required swap notionals, are representative of reality.

3.2 Literature

The approach to literary sources used in this thesis has necessarily been pragmatic though focused on theoretical validity. The thesis has aimed to rely on original academic articles or working papers for in-depth knowledge on specific issues and text-books for established general market practices. These articles have generally been retrieved through the databases provided by Copenhagen Business School, such as ScienceDirect, JSTOR and Ebscohost. While academic literature has been a good ressource for establishing the mechanics of relevant impact factors and methods of analysis, it has been necessary to find some crucial knowledge elsewhere. The thesis has used original authority papers on the EMIR requirements, and non-academic sources of research and market statistics have been of particular relevance to support the scarce scholarly literature on factor sizes.

Regarding non-academic sources, it has been a priority to use mainly research commissioned by accredited insitutions when possible, e.g. working papers from national banks or clarifying documents from the CCPs. While the decision to include individual second-hand literature pieces is then dependent on the source, the findings in accepted literature are taken at face value to avoid projecting any further bias. Useful survey statistics are also offered by other market players such as industry organisations. When necessary results are unavailable through academic or similarly accredit institutions and difficult to obtain first hand, the thesis will leverage market player results. To enable validity checks, it has been a priority to note any commisioning party in the bibliography. Empirical market-data has been retrieved from Bloomberg Professional Service.

The main areas where academic literature has been applied are the identification of impact factors, factor mechanicsm and econometric theory necessary for conducting the backtest. Second-hand literature has been used mainly to identify the current landscape faced by end-users and to leverage market player opinions on future developments as support to the theoretical industry structure analysis.

4 Impact Factors

This section will expand on the established background knowledge to identify and analyse current trade practices and suggest the key factors, which end-users should consider when assessing the impact of the clearing requirement. The cost factors are considered using transaction cost economics as used in the context of clearing by Hasenpusch (2009). The main idea is that economic organisations emerge from cost-minimising behavior, thus transaction costs are the basic constituents for the existence of firms. This approach serves as a method of analysis of comparative costs under different structures, using the transaction as unit of analysis. The transaction costs can arise both for *ex ante* and *ex post* reasons, and are triggered by two human and three environmental factors. The two human factors are bounded rationality and opportunism, where bounded rationality refers to the inability to correctly consider every outcome that might occur following the transaction, and opportunism refers to the participants acting to maximize self-interests. The environmental factors are uncertainty, small numbers, and asset specificity. The uncertainty factor aggravates problems associated with rationality and opportunism. If e.g. the OTC derivatives market contains only a limited number of dealers, it might be difficult for an end-user to find a transaction partner, and thereby to punish any current partner's opportunistic behavior by taking business elsewhere. (Hasenpusch, 2009)

4.0.1 Specifications on Model Environment

To simplify considerations on the impact factors, a few overall considerations are made regarding the circumstances surrounding the modeled end-user.

As touched upon in Section 2: Background, the netting process will have a significant impact on the overall costs both in the bilateral and cleared trading environment. As netting is different for cleared and bilateral trades, the respective processes can therefore yield different degrees of netting based on a number of factors. If trades are netted, the counterparty exposure is reduced, and savings can be achieved on the costs associated with counterparty credit risk and risk mitigation techniques (Koeppl, 2012). The key difference is that under bilateral netting, the exposure to any one counterparty is netted, but exposures to different counterparties cannot be netted (Duffie and Zhu, 2011). A CCP can net exposure across counterparties and assets covered by the CCP, but exposures towards different CCPs cannot be netted unless interoperability agreements between the CCPs are in place (Duffie and Zhu, 2011). All in all, the degree of netting under each environment is highly circumstantial, depending on current offsetting positions and the number of dealers and CCPs that the end-user trades with.

A few preliminary decisions therefore must be made regarding the modeled trade environment. The modeled end-user of this study is trading through a single dealer, clearing through a single CM at a single CCP. Prior to the trades at the initial date, the end-user has no business with either the dealer or the CM. In this scenario, differences in netting structures are irrelevant to our end-user, as no netting benefits are realised on the initial trade while full netting of offsetting rebalancing trades is applied in both the bilateral and cleared scenario. This is reminiscent of financial end-users with highly directional portfolios such as pension funds.

The clearing requirement was established in order to eliminate counterparty risk in OTC derivatives. While CCPs are very robust, they are not completely immune to defaulting (Gregory, 2012). However, end-user and dealer counterparty risk in cleared contracts is for simplicity assumed economically insignificant. Therefore, counterparty credit risk is only relevant for bilateral trades. However, it should be noted that following Basel III rules, dealers must apply a flat 2% risk weight to trade exposures when calculating regulatory capital requirements (Gregory, 2012). In other words, regulators have realised that the CCPs are not completely risk-free.

It is assumed that the dealer is immediately succesful in managing market risk by offsetting trades with opposite trades to another counterparty. This means that the dealer's net outstanding collateral is zero at all times. Also, these opposite trades are assumed fully netted under standard multilateral netting when clearing, why the dealer's marginal exposure towards the CCP does not increase following the trade. This means that the dealer is not required to pay additional IM to the CCP following a new position with our end-user.

Finally it is necessary to make a statement on the assumed dealer costs of clearing, since any such costs must be passed on to the end-user to ensure that the dealer remains profitable. Unfortunately, no information has been available regarding whether or not the dealer incurs fees when clearing their end of the contract through a CM. The primary argument why the dealer would be exempt from clearing fees is that clearing of the dealer's position brings an attractive offsetting position to the CM that can be netted against the end-user's position. Therefore, the CM can reduce their smaller risk management requirements by taking on the position of the dealer. It is on this basis assumed that the dealer does not contribute any fees to the CM.

In summary, the dealer is assumed to incur no costs from risk management practices or clearing-related fees, why such costs will not be priced.

4.0.2 Structure of the Impact Factor Analysis

Prior to identifying the cost factors faced by end-users, a quick categorisation of transaction costs experienced during a cleared versus bilateral trade is useful. The transaction cost economics framework commonly distinguishes between five cost components, though a more simple framework distinguishing between only two components will be used here.

Transaction costs are categorised following the two dimensions used by Hasenpusch (2009); mode of measurement and origin of costs. The mode of measurement dimension distinguishes between whether or not these costs are generally quantifiable and can be measured explicitly. The quantifiable costs are e.g. the fees directly imposed on the end-user or differences in swap prices, and are from here on referred to as *direct costs*. Some of the remaining costs that are not directly quantifiable, such as opportunity costs associated with trade requirements, are important to consider as well though they often are highly firm specific (Hasenpusch, 2009). These costs are referred to as *indirect costs*. Direct costs lend themselves to explicit measurements, while the indirect costs can be more difficult to estimate.

The two cost types, (i) direct costs and (ii) indirect costs, will constitute the framework for cost comparison. Some cost factors are realised on a per-contract basis while some factors depend on the size of the trade. Since netting effects are supposed similar for the end-user, it is reasonable to base estimates of size-dependent factors on the notional value of the swap.

4.1 Identification of Direct Cost Factors

This part will identify the direct cost factors that will be used for analysis in the thesis. The focus is restricted to consider counterparty credit risk in bilateral trades and the costs of clearing to offset this risk. However, it is useful for later discussion to briefly consider other potential differences in dealer spreads across cleared and bilateral contracts. For any given trade, the 'mid-market' swap rates represent the model-value of the swap based on hypothetical counterparties of AA-rated quality or better (Xiao, 2012). Dealers reference this market rate to quote an actual swap rate to a client including a swap premium, which is realised through an increase in the spread. Since dealer expenses are likely to differ between cleared and bilateral trades, theese spreads should first and foremost be considered.

If risk management practices are assumed costless to the dealer, the spreads must still cover (i) operational costs/risks, (ii) liquidity costs/risks, (iii) market risks, (iv) credit risks, (v) funding costs, and (vi) a profit margin (Hull, 2012). End-users can estimate the difference in spread pricing themselves. After all, they can ask for quotes for a cleared and non-cleared swaps with the same dealer to discover the difference. However, estimating the expected sizes of relevant spread components allows for better insight as to *why* the spreads might be different and thereby whether or not spreads are fairly priced. Also, it is plausible that the current environment reflects a transitional period, why current spreads might not truly reflect the new scenarios, e.g. following strategic pricing. Therefore, spread components are estimated as their expected sizes taken at face value.

(i) (ii) (iii) As the dealer is assumed to offset trades immediately by engaging in opposite positions with another counterparty, dealer market risk is zero. In this thesis, it is assumed

that operational and liquidity risks and costs are unaffected by whether the swap is cleared or traded bilaterally. Therefore, these spread elements were not be considered for further analysis.

(v) Differences in funding costs are potentially interesting. During the financial crisis, the borrowing cost of banks increased from just a few basis points to at some times beyond a hundred basis points following the market instability. It then became clear that dealers should also calculate their borrowing cost when pricing the derivative spread, which led to the implementation of the Funding Value Adjustment. This adjustment depends on the risk mitigation techniques used; the dealer faces funding requirements from hedging market risk associated with c contract by taking an opposite position with another financial institution. However, bilateral funding requirements are primarily relevant in cases where discrepancies occur as the counterparty to the original deal posts no collateral, but the hedging trade involves a collateral agreements. (Gregory, 2012) Given that VM agreements are in place for standard bilateral trades, funding discrepancies should be of minimal concern to the dealer.

(vi) Profit margins are also of interest as a number of market-players and academic scholars expect market liquidity of the cleared market to exceed that of the bilateral market (Hasenpusch, 2009), compressing the dealer profit margins for cleared trades. Market-players estimate that the dealer profit margin in cleared trades are only 40-65% of that realized from bilateral trades (McKinsey, 2012 (Deloitte, 2012). However, expectations of increased market liquidity in cleared markets are primarily based on the standardisation of cleared derivatives and more efficient platforms (Hasenpusch, 2009) (Deloitte, 2012). As such, the expected increase in market liquidity is a derivative effect of the clearing requirement, and not directly caused by the clearing process. After all, similar standardization and trading platforms could be implemented in the bilateral market. As the spread component allocation is unknown (Xiao, 2012), an estimate of the profit margin component portions of the spread is exceedingly difficult. Therefore, while market-player reports indicate that the profit margin component of the spread is likely to be very interesting, the modeling of this component was unfortunately considered out of scope.

As cleared contracts were assumed absent counterparty risk, the spread analysis is restricted to cover dealer counterparty risk only for bilateral contracts.

When clearing a swap the end-user can expect to cover the CM's expenses associated with the procedure. As outlined in Section 2: Background, these costs typically include a clearing fee to ensure CM profitability, a maintenance fee from the CCP and coverage of expenses associated with the marginal increase in the CM's default fund contribution. The clearing fee is charged for each contract. The maintenance fee is a monthly or quarterly fee to maintain the portfolio of cleared positions. These fees are in practice charged by the CCP to the CM and are then passed on to the client. (Murphy, 2013) Fees to cover of CM expenses from the default fund contribution can take multiple forms, although standard practice will be explained in the subsection concerned with direct clearing cost factor mechanics.

Table 4: Direct Cost Factors

Direct Cost Factors: Bilateral Contract	**Direct Costs Factors: Cleared Contract**
Spread (Dealer Counterparty Risk)	Clearing Fee
	Maintenance Fee
	Default Fund Contribution Fee

4.2 Direct Cost Factor Mechanics

This part aims to provide direct estimates or methods of estimation on the considered direct cost factors. To do so, we first consider how the dealer should price expenses related to bilateral counterparty credit risk into the spread. As we shall see, all these expenses depend on the counterparty exposure associated with the contract. Second, the clearing fee, maintenance fee and default fund contribution fee under cleared trades by fees associated with cleared trades are estimated based on data from relevant CCPs.

4.2.1 Bilateral Direct Factor 1: Spreads

Today, counterparty credit risk is formally expressed through Credit Valuation Adjustment (CVA). Prior to the financial crisis, CVA was either ignored by dealers or was such a small slice of the cost that customers did not notice. However, after the financial crisis, it has become the norm for dealers to price CVA into trades as spreads, with most banks building designated CVA desks (Wood, 2010) (Gregory, 2012) (BNP Paribas, 2012). The 2009 Basel III global regulatory standard was developed in response to the crisis, and contains requirements to dealer calculation of risks associated with bilateral trades. These requirements serve as basis for calculating the spread pricing (Gregory, 2012). Financial end-users, who before the financial crisis scarcely posted any collateral due to liquidity or operational considerations, started to consider doing so both to avoid large CVA premiums and prevent bank hedging from driving up their credit spread. (Gregory, 2012) While Gregory notes that face-value CVA is normally used for pricing, this is not necessarily the case for all dealers. However, as CVA is the valuation of credit risk, it is here assumed that the dealers price this risk in full.

The dealers face regulatory requirements on the capital that must be preserved to back a given trade. The opportunity Cost of Regulatory Capital (CRC) should therefore also be priced into the trade premium by the dealer (Hull, 2012a) (Douglas and Pugachevsky, 2012). While these opportunity costs are indirect costs to the dealer, the pricing is expressed through the spreads faced by the end-user, why dealer CRC considerations in this study is considered as part of end-user direct costs. In this study, only the regulatory capital requirements associated with credit risk are investigated under the assumption that requirements on derivatives traded in a bilateral and cleared environment are otherwise equivalent.

As dealers faced capital requirements based on their CVA exposure, they developed the Debt Value Adjustment (DVA) measure, which was used to reduce reported CVA by accounting for the banks' own potential default. (Gregory, 2012) Basically, DVA can be thought of as CVA from the client perspective. Regulators did not agree that such a measure represented a reduction in the dealers' risks, and DVA benefits to capital requirements were voided by the Basel III rules (Gregory, 2012). The reason for voiding DVA benefits is that DVA results in lower capital requirements to dealers with higher credit spreads. This is counter-intuitive as these dealers are more likely to default. However, although DVA considerations on the dealer's own creditworthiness are not included in the calculation of regulatory capital, the concept is still interesting. After all, we could reasonably expect end-users to demand a rebate based on the creditworthiness of the dealers in a competitive market. This rebate, here referred to as DVA, is also known as bilateral CVA, where the dealer's credit risk is priced into the CVA, as opposed to unilateral CVA.

In summary, spreads are considered through three components related to counterparty credit risk; an expected premium to cover counterparty credit risk faced by the dealer (CVA), an expected premium to cover dealer expenses from counterparty-based regulatory capital (CRC), and expected rebates to cover reverse counterparty credit risk (DVA).

CVA can be wildly different from one bank to another, depending on four big variables; competition, credit mitigation used in the deal, the bank's existing portfolio of trades, and the methodology used to work out the size of the exposure (Wood, 2010). For a correct measure, the dealer should price the credit risk using incremental measurements, which takes into account netting benefits (Gregory, 2012). Netting and competitive effects make the treatment of CVA a complex and multi-dimensional problem that should consider the correlations between the undertaken trades, the dealer's existing portfolio, and the relative size of the new trade to the existing portfolio, which even some of the largest dealers have difficulties getting right (Wood, 2010). Incremental CVA, as opposed to stand-alone CVA, can be negative if netting effects are sufficiently beneficial (Gregory, 2012), in which case it could be reasonable for a dealer to provide a CVA rebate, depending on the level of competition. Also, a reverse effect could happen; since the dealer knows that clients are able to net trades, they know that clients are more likely to trade with them again following the first trade. If this is the case, it could make sense for the dealer to underprice the exposure on the first trade, expecting the ability to overprice exposure on future trades following the lock-in effect of netting.

Therefore a decision must be made as grounds for our CVA estimate. It is assumed that positive CVA is priced at face value while negative CVA on subsequent offsetting trades is not priced into the spread. The stand-alone CVA is estimated first, after which netting effects are taken into account.

Stand-alone CVA is calculated by first dividing the maturity T, starting at time zero, into a number of intervals e.g. months. With n intervals where each time interval i runs from $t_{i-1}$to t_i, the following definitions apply:

> q_i: The risk-neutral probability of a loss from a counterparty default during interval i.
>
> v_i: The present value of the expected net exposure of the dealer to the counterparty after collateral, at the midpoint of interval i, conditional on default.
>
> R: The dealer's recovery rate in case of client default

If the net exposure is independent of the probability of default, the present value of the expected losss from a default during the ith interval can then be expressed as

$$L_E = (1 - R)q_i v_i$$

and the expected loss throughout the entire period is then

$$CVA = \sum_{i=1}^{n}(1 - R)q_i v_i$$

where q_i are estimated from the counterparty's credit spreads, S_C, (Hull, 2012a), why the CVA charge can also be thought of as the risk-neutral default probabilities derived from credit spreads observed in the market. The v_i are considered through the dealer's Expected Positive Exposure (EPE) following the trade (Gregory, 2012). For estimation purposes the counterparty default probability, or hazard rate, is assumed constant over time. To find the EPE, first the expected exposure, which is the average of all simulated exposure values after collateral at a given point in time, must be computed. Expected exposure is calculated using only the positive values, as negative values (representing out-of-the-money swaps) carry no counterparty risk. The EPE is then defined as the average exposure across all time horizons, and is represented as the weighted average of the expected exposure across time. This single EPE number is referred to as a "loan equivalent", as the EPE from a dealer point of view can be represented as a loan to the counterparty. (Gregory, 2012) The CVA calculated in this fashion then provides a final value, which the end-user must bear. To approximate CVA expressed as a spread for our end-user, the end-user credit spread is used. This credit spread takes the expected recovery rate into account (Gregory et. al., 1998). If the expected exposure is assumed constant over time and equal to its average value (EPE), the following simple approximation can be made, which tends to be reasonably accurate for swaps (Gregory, 2012):

$$CVA_{spread} \approx S_C * EPE$$

EPE can be estimated through analytical approximation or Monte Carlo simulation. This thesis will use Monte Carlo simulation, which is the most reliable of the two methods as future exposure is stochastic (Gibson, 2005). The end goal is to approximate or simulate the future value of the OTC derivative positions held by the counterparties, which translates to the problem of estimating the dealer's EPE after the VM agreement is taken into consideration. The process used here for modeling EPE after collateral will follow that proposed by Gibson (2005), which is restricted to consider four key terms; margin threshold, grace period (days to liquidate a defaulted counterparty's position), remargin period, and minimum transfer amount (Gibson, 2005). The simulation takes the following steps. At first, daily sample paths for the interest rates $r_{i,t}$ and their respective grace period movements $r^g_{i,t}$ are simulated. Then, the Mark-to-Market (MtM) value of the swap to the dealer along each sample path ($MtM_{i,t}$) is computed along with the grace period MtM value ($GMtM_{i,t}$). Third, to consider the VM agreements, the model must include the correct margin parameter values, which will be identified in Section 6: Backtest Application. Fourth, the exposure value is computed as the MtM value if positive and zero if negative. Finally, the exposure is averaged across sample paths and time to calculate EPE.

The interest rate values $r_{i,t}$ and grace period interest rate values $r^g_{i,t}$ are here estimated through a Vasicek model, as this model while simple allows us to find $MtM_{i,t}$ and $GMtM_{i,t}$ through bond prices (Hull, 2012). The Vasicek model is an equilibrium model of the short rate, which uses assumptions about economic variables to derive a process for the short-term rate interest rate, r. In Vasicek's model, the risk-neutral process for r is expressed on the following form:

$$\Delta r = \kappa(\theta - r)\Delta t + \sigma \Delta z$$

where a, b, and σ are constants; κ represents the mean-reversion factor, the effect by which the interest rate is pulled back to a long-run equilibrium rate. θ represents this equilibrium rate while σ represents the volatility rate. In other words, r is pulled to θ at rate κ, superimposed a stochastic term $\sigma\Delta z$. (Hull, 2012) Vasicek shows that the following expression can be used to obtain the price at time t of a zero-coupon bond that pays one

Euro at time T (Hull, 2012), which is the discount factor $d(t,T)$ used for valuing the swap legs (Gregory, 2012):

$$d(t,T) = A(t,T)e^{-B(t,T)r(t)}$$

where $r(t)$ is the value of r at time t, $B(t,T)$ is expressed as

$$B(t,T) = \frac{1 - e^{-\kappa(T-t)}}{\kappa}$$

and $A(t,T)$ is expressed as

$$A(t,T) = exp\left[\frac{(B(t,T) - T + t)(\kappa^2\theta - \sigma^2/2)}{\kappa^2} - \frac{\sigma^2 B(t,T)^2}{4\kappa}\right]$$

The discount factors are used to calculate the values of the swap's fixed and floating legs. The value of the fixed leg (V_{fixed}) at time t for a one Euro notional is given by the present value of fixed swap rate r_S payments:

$$V_{Fixed,t} = r_S * \sum_{i=1}^{n} d(t,T) * \Delta t$$

where n is the number of fixed payments. The value of the floating leg (V_{Float}) at time t for a one Euro notional is given by the present value of the expression:

$$V_{Float,t} = 1 - d(t, T-t)$$

where $d(t, T-t)$ is the discount factor at time t for the zero-coupon bond with maturity at $T - t$ (Gregory, 2012). The swap MtM at time t is then given by:

$$MtM_t = V_{Float} - V_{Fixed}$$

for a swap that receives floating and pays fixed, and vice versa (Hull, 2012). The $GMtM_t$ estimation follows the same process, except the discount rate used for the valuation is $r^g_{i,t}$. The main general disadvantage of equilibrium interest rate models is normally said to be the risk of generating negative interest rates (Hull, 2012), though negative short rates have occured recently following extreme conditions (Danmarks Nationalbank, 2013). Lastly, estimating the parameters correctly can be very complicated depending on the equilibrium model of choice.

Also, usage of the simple Vasicek model poses a challenge to EPE estimates, as the model does not include considerations on forward rates and therefore does not fit the retrieved swap term structures. The Vasicek model considers a swap fairly valued only when the spot rate and swap rate are equal, why the model will not recognize the swaps retrieved from Bloomberg as fairly valued. This means that the Vasicek model suggests a non-zero starting value for the swap. This problem could potentially be averted by using a more sophisticated short rate model, such as the Hull-White model, which bases the drift parameter on the initial term structure using a time-dependent reversion parameter (Hull, 2012). However, calibrating this parameter to fit the Bloomberg valuation is exceedingly complicated as the Bloomberg forward rate model must be replicated to obtain partial derivatives of the forward rate, why a decision has been made to use the simpler Vasicek model. Section 6: Backtest Application will elaborate on this problem and offer a practical solution.

The simulation algorithm used for estimating margined EPE is now as follows. Notations are outlined in Table 5.

Table 5: Simulation Parameter Notations

Notation	**Meaning**
V_0	Current MtM value
E	Exposure gross of collateral
D	Threshold
C_0	Initial collateral held: $max(0, V_0 - D)$
$C_{it}\|default$	Collateral available condition on the counterparty's default at time t
$E_{it}\|default$	Mean exposure, net of collateral, conditional on default at t, taking movements over m into account.
$Call_{it}$	Collateral called at time t
T	End-point of simulation
N	Number of simulations

1. **for** $i = 1$to N **do**

   Perform the following from start to end for each simulation

2. $V_{i0} = V_0$, $C_{i0} = C_0$

   Set the first MtM value equal to the current MtM, zero, and set the first collateral value equal to the initial collateral held

3. **for** $t = 1$ to T **do**

   Perform the following from start to end for each time point until maturity

4. $V_{it} = MtM_{it}$

   Set V_{it} *to the swap MtM at time* t *estimated using the Vasicek model*

5. $E_{it} = max(0, V_{it})$

   If V_{it} *is a positive number, then use that one. If it is negative, insert zero, as negative exposure is of no concern*

6. $C_{it} = C_{it-1} + Call_{it-1}$

   Set C_{it} as collateral from last time point plus the collateral called for at last time point

7. **if** t is a remargining day **then**

   Only perform next step for rebalancing days

8. $Call_{it-1} = max(E_{it} - D, 0) - C_{it}$

   Set the collateral called for as the maximum between the exposure and zero minus the current collateral held

9. **if** $|Call_{it}| <$minimum transfer amount **then**

   Only perform next step if the collateral call value is below the minimum transfer amount

10. $Call_{it} = 0$

    Do not call for any collateral

11. **end if**

12. **end if**

13. $C_{it}|default = C_{it}$

    Set collateral conditional on default as current collateral

14. $E_{it}|default = max(0, V_{it} + GMtM_{it} - C_{it}|default)$

    Set exposure conditional on default for the time point as as V_{it} plus graceperiod random movement minus current collateral conditional on default, counting negative exposures as zero.

15. **end for**

16. $EPE_i = \frac{1}{T}\sum_{t=1}^{T} max(0, E_{it}|default)$

    Set expected positive exposure for the time point as the average of exposure conditional on default

17. **end for**

18. $EPE = \frac{1}{N}\sum_{i=1}^{N} EPE_i$

    Set total expected exposure as the average of EPE_i across all simulations

The definition of $C_{it}|default$ in line 10 assumes that collateral posted on $t-1$ is delivered on t, even though the counterparty defaults on this day. As minimum transfer amount is zero, line 9 to 11 are only included to facilitate later expansion. Likewise, as the threshold is zero, line 8 can be simplified to $Call_{it-1} = max(E_{it}, 0) - C_{it}$.

The simulation procedure allows for estimation of the stand-alone CVA. To find the incremental CVA, the bilateral netting procedure is applied to trades undertaken at rebalancing dates. The effect of potential correlation between the default risk of the modeled end-user and other counterparties on the dealer's books is not considered in the CVA calculation.

It would be intuitive to price the DVA rebate similarly to the CVA premium so that $DVA_{spread} \approx -ENE * S_{C,Dealer}$, where ENE is the expected negative exposure. However, CVA poses a cost to the dealer, which has become unavoidable through recent regulatory formalisation of the concept for regulatory capital calculation, and must be covered for profitability (Gregory, 2012). On the other hand, DVA rebates are not offsetting any costs or risks from a dealer perspective, and should therefore be priced along other dealer profitability considerations, much like negative CVA values, taking level of competition and potential lock-in effects into account. Perhaps therefore, it has not been possible to find credible recent information on how dealers price DVA for interest rate swaps, though Gupta and Subrahmanyam (2000) finds that the effect of counterparty credit risk on swaps is economically insignificant. A recent empirical study on the prevalence of DVA in CDS contracts is available from Longstaff et. al (2012), who refer to DVA as 'end-user rebates from dealer credit risk'. They investigate whether dealers with high credit-worthiness price the contracts higher than other dealers, finding a significant but very small effect (Longstaff et. al, 2012). The rating-price regression slope coefficient based on data after 2008 is found to be -0,001705, which implies that the credit spread of the dealer has to increase by around 585 basis points to result in a 1 basis point decline in the spread offered to the end-user. Since the notional amount of an interest rate swap is not exchanged unlike a CDS, the expected exposure on interest rate swaps is significantly smaller (Longstaff et. al, 2012). The dealers themselves state that American dealers price DVA into the spread, as their accounting standards require them to do so, while European dealers claim to price DVA competitively (Wood, 2010). If DVA is indeed priced due to competitive considerations, dealers are likely concerned less with their absolute credit spread, and more with their credit-spread relative to the most creditworthy competitor, which further complicates reasonable estimation. As current evidence points towards a negligible empirical effect and estimation is exceedingly difficult, DVA rebates are here set to zero, implying unilateral CVA calculation.

Bilateral counterparty CRC depends on the capital reserve required from the trade. The Basel III requirements build on the *counterparty credit risk charge* from the first pillar of Basel II and adds a *CVA capital charge*, which is a charge introduced for CVA volatility (Gregory, 2012). The credit risk charge can be calculated through the *standardised approach*, or the *internal ratings-based approach*, where the internal ratings-based approach is most relevant as it used by large dealers (Hull, 2012a). This approach is dependent on the estimated *exposure at default*, which in turn can be calculated using three methods offering different levels of sophistication, with the *internal model method* being both the most sophisticated and widely used (Gregory, 2012). These exposure at default models are difficult to replicate, as they are based on credit portfolio models of the dealer's exposures. Credit portfolio models include considerations on correlations between default events of all counterparties on the banks' books (Hull, 2012a), which is not accessible information to the end-user. Further, the dealer's pricing of CRC into the spread will depend on their cost of capital, which is also unknown. However, while it is therefore unfeasible to estimate the spread charge covering the dealer's CRC by replicating the Basel methods, it would be a shame to leave the factor out of the framework, as the Basel II and Basel III requirements distinguish credit capital requirements based on whether trades are cleared or not, thereby imposing costs to dealers for bilateral trades in order to encourage clearing (Gregory, 2012).

Therefore, it is worth leveraging empirical findings. While it has not been possible to find empirical academic literature considering pricing of CRC into swap spreads, a survey study published by Lloyds Banking Group reports how much dealers are willing to pay to mitigate regulatory capital charges in terms of the counterparty's credit spread. They find that a bank using the internal model method would pay 36% of the counterparty's CDS spread to mitigate the credit risk charge, and 26% of the CDS spread to mitigate the CVA risk capital charge. (Carver, 2013) In other words, banks on average estimate their total costs from regulatory capital associated with counterparty risk for a given exposure as around 62% of the counterparty's credit spread on that exposure. The previously estimatedCVA_{spread} considers exactly the size of expected exposure on the swap and the credit spread of the client, why it is reasonable to approximate the CRC_{spread} on a swap contract through the following expression:

$$CRC_{spread} \approx 0.62 * CVA_{spread}$$

This is a best-guess based on far from optimal information. However, due to the likely significance of CRC in spread pricing, a framework omitting this component could conceptually fail to consider a key aspect of best practice pricing. The available approximation is therefore preferable to omission.

4.2.2 Cleared Direct Factor 1: Fees

When clearing a trade, the end-user is charged a per-ticket clearing fee, a maintenance fee, and a marginal default fund contribution (Murphy, 2013). The clearing fees are charged to the CM, who in turn collects a total fee from the end-user to cover their expenses (Xiao, 2012). CCPs charge CMs around 25 Euro per contract for client clearing (CME, 2013a), (Eurex, 2013), while the CMs typically charge end-users around 300 Euro per ticket to cover their expenses (Rennison, 2013). The maintenance fee and marginal default fund contribution are assumed passed on at face-value to the end-user.

While the clearing fee and maintenance fee are rather straightforward to estimate, the default fund contribution is a bit more complex. The size of the default fund at a CCP is typically computed using a wide set of stress scenarios. A worst-case loss is calculated using a gain-loss distribution generated for each CM's outstanding portfolio, and the difference between this worst case loss and IM posted by the CM is called the unmargined worst-case loss. The total default fund is the sum of the largest and second largest unmargined worst case losses (under the same scenario), which means that the largest and second largest CM default at the same time, plus a 10 percent buffer. The default fund contribution is mutualized across all the CMs proportionally using the size of their IM on the form:

$$DF(i) := \frac{IM_i(q_{t-1.t})}{\sum IM_j(q_{t-1.t})} DF$$

where $DF(i)$ is the default fund contribution of an individual CM, IM_i is the CM's average IM posted during the last quarter and DF is the total size of the default fund. (Lin and Surti, 2013)

Depending on the number of CMs associated with the CCP, a CM then has limited influence on the total default fund size, though the contribution is directly related to the size of outstanding IM. As calculating the marginal IM added by a client to the CM's portfolio is a complex procedure, clients are instead charged a fee based on the initial margin associated with the trade. (Rennison, 2013) For this thesis, the marginal default fund contribution from a trade is therefore also estimated as a set proportion of the IM requirement, which according to Mariam Rafi, head of clearing at Citi New York, is indeed the current practice. She notes that a typical ratio of default fund contribution to IM is in the 10-15% range, in which case CMs charge 20-45 basis points of IM as a fee (Rafi, 2012). It is supposed that the end-user is charged a middle range value of 30 basis points of IM as default fund contribution fee.Table 6 outlines the estimated end-user fees from clearing.

Table 6: CCP Client Fees

	Clearing Fee[1]	**Maintenance Fee**[2]	**DF Contribution**[3]
Estimate	*300*	*10*	*30*

[1]Per ticket
[2]Basis points of IM, annualized
[3]Basis points of IM, rough estimate

4.3 Identification of Indirect Cost Factors

There are a number of indirect costs associated with derivatives trading, collateral agreements receiving the most academic attention. Financial end-users normally have VM agreements in place for bilateral trades (Gregory, 2012). If VM agreements are in place, then assets posted as margin represent an opportunity cost of capital to the firm, which is the expected profit from available investments foregone to post the required margin. As the expected value of an interest rate swap is zero at initiation, the expected assets posted as margin will equal the expected assets received. However, if there are restrictions on how assets received as margin can be used, then while the asset in/out-flow remains symmetrical, the utilisation from margin received no longer necessarily matches the cost of capital from margin posted. If these restrictions are significantly different for cleared and bilateral trades, then expected cost of the VM agreement in each case should be modeled. It is therefore interesting to look into the differences between of cleared and bilateral VM.

Bilateral contracts normally involve day-to-day VM with zero treshold and minimum transfer amount following marked-to-market value of the position changes (Cont et. al, 2011). In bilateral trades, a party posting collateral maintains ownership of the assets, and receives interest on them from the recipient. (Xiao, 2012). The recipient of the collateral is normally free to re-invest it (Murphy, 2013). CCPs also require marked-to-market VM with zero treshold and minimum transfer amount (Murphy, 2013). In cleared trades, the party receiving VM owns the funds and may withdraw them from the clearing house for re-investment (Xiao, 2012). CCPs typically use *price alignment interest* adjustment - a daily cash payment - to correct for the difference in interest on VM between cleared and bilateral contracts and thereby minimise the effect of VM on swap pricing (LCH.Clearnet, 2014c) (Xiao, 2012). This resembles the scenario outlined for bilateral VM. And indeed, when the price alignment interest is applied, cleared VM agreements are shown to be economically equivalent to bilateral agreements (Cont et. al, 2011), why the expected costs from cleared and bilateral VM agreements are equal.

However, VM agreements are an integral part of counterparty risk management. As cash is removed from a portfolio to cover either clearing expenses or spread premiums, smaller swap notionals are needed to reach the portfolio target duration, which in turn reduces the amount of collateral. This means that even though expected cost or benefits from VM agreements are equal on a per-notional basis, the impact of VM agreements might be different in cleared and bilateral trades. Therefore, when seeking to compare the total costs incurred from counterparty credit risk and risk management in bilateral and cleared trades, this factor should not be omitted.

IM is an additional one-way margin requirement that locks up capital until conclusion of a cleared trade. It *is* possible to include IM arrangements in a bilateral trade, usually as two-way IM posted by each counterparty to a custodian (BIS, 2013). However, these agreements are not standard practice, as the total amount of IM being held by dealers across bilateral trades is around 0,03% of the gross notional exposure (BIS, 2013). Since bilateral IM agreements are not standard market practice they are not included here, while costs arising from IM requirements on cleared trades are considered.

In this thesis, clearing is considered to completely eliminiate counterparty credit risk, whereas other potential risks are assumed similar between cleared and bilateral trades. The end-user value from eliminating counterparty credit risk towards the dealer through central clearing should therefore be priced. Information on the negative value presented by the counterparty credit risk from bilateral trades can also aid the end-user in deciding between contracts offered by dealers of different creditworthiness. The pricing of this risk will be added to the bilateral costs. The argument for doing so is twofold. First, the risk problem exists due to an inefficiency in the bilateral trading system, and second, these risks are over time realised as costs in the bilateral environment as the end-user experiences dealer defaults.

Table 7: Indirect Cost Factors

Indirect Cost Factors: Bilateral Contract	**Indirect Cost Factors: Cleared Contract**
Variation Margin	Variation Margin
Counterparty Credit Risk	Initial Margin

4.4 Indirect Cost Factor Mechanics

This subsection aims to clarify the mechanics used for calculating the size of key indirect cost factors associated with trading in a bilateral contra cleared environment. Variation margin, being the current value of the swap, is a quite simple concept that by now has been sufficiently introduced. This section is therefore concerned with estimating IM requirements and the pricing of counterparty credit risk in bilateral contracts. At first, a method for pricing bilateral counterparty credit risk is suggested. Hereafter, the size of IM requirements for cleared trades are be estimated.

4.4.1 Bilateral Indirect Factor 1: Counterparty Credit Risk

Rather than credit risk, which is concerned with the exposure at time of default as, end-user replacement cost risk is worth considering instead (Russo et. al, 2002). If the defaulted contract needs to be replaced, this replacement is likely not instantaneous, why the derivative's value might have changed at time of replacement. Further, it is possible that the bid-ask spreads on the derivative at the time of default are different to those at initiation of the original contract (Gregory, 2012). The importance of this point is larger if counterparty default risk is correlated with disruptions that result in higher spreads through e.g. reduced market liquidity. This point is supported by Ericsson and Renault (2005), who find that as default becomes more likely, the components of bond yield spreads attributable to illiquidity increase. The replacement cost risk pricing process is then similar to that of the CVA_{spread}, though with two key differences. The first difference is that the dealer's rather than the end-users own credit spread, $S_{C,D}$, is used. The second difference is that the ERV simulation should take movements in the bid-ask spreads into account. However, modeling movements in bid-ask spreads is complex, as the correlation between spreads and likelihood of dealer default should be taken into account. Therefore, modeling bid-ask spread spread movements is considered out of scope for now. Not considering the risk of movements in the bid-ask spreads means that the risk pricing will merely consider the exposure risk, and therefore will not reflect actual replacement cost risk. The approximation of this exposure risk valuation (ERV) can be expressed on the following form:

$$ERV_{Spread} \approx S_{C,D} * ENE$$

where EPE is the expected positive exposure calculated for the CVA approximation.

4.4.2 Cleared Indirect Factor 1: IM

IM requirements are normally calculated from a distribution of standardised returns on the derivative, generated using a look-back sampling window of 1250 working days. The obtained relative interest rate moves are then scaled by a volatility parameter estimated by the CCP when applied to the current interest rate. A gain-loss distribution is finally generated from the volatility-corrected gain-loss scenario, and the 99,5-100% worst-case loss over a five to ten day holding period is used as the IM. (Lin and Surti, 2013) (ESMA, 2012) However, replicating the model process is complex, why the IM is here estimated as a percentage of the notional. The BIS Basel Committee has proposed a conservative standardised schedule directed at smaller market participants for IM calculation on, shown in Table 8. The schedule is for non-cleared derivatives and therefore not directly applicable in terms of IM sizes, but it does allow some inference on proportions between IM and maturity. Market player estimates indicate that actual IM requirements for cleared swaps are roughly half of the standard values (BNY Mellon, 2013) (Cameron, 2011).

Table 8: IM Schedule

Maturity	**IM: Standardised**[1]	**IM: Cleared, Estimated**[1]
0-2 Years	1	0,5
2-5 Years	2	1
5+ Years	4	2

[1] % of notional
(BIS, 2013)

The IM requirement is based on expectations on the risk from exposure not covered by VM at the time of default, why the IM requirements should therefore also be based on the net position between the end-user and the CCP. This is also indeed the current practice for the CCPs who offer clearing of interest rate swaps, as the IM requirements take netting into account (Singh, 2010) (Eurex, 2013). The CCPs do pay interest on IM payments to offset the expense, although the interest rates are necessarily small as CCPs do not reinvest the IM . The interest rate on IM posted by clients at the largest relevant CCP is calculated as the effective overnight reference rate for the euro (EONIA) minus 30 basis points, floored at zero. (LCH.Clearnet, 2014) This is the rate that will be used for the backtest.

4.5 Framework Overview

Table 9 provides a summary of the factors considered for analysis. The framework is constructed to provide estimates on the costs associated with counterparty risk under bilateral trading, and the costs of eliminating this risk through central clearing. The results obtained from this framework are therefore not indicative of the total expenses related to trading in either environment.

Table 9: Key Factors

	Bilateral	**Cleared**
Direct Cost Factors:	CVA_{Spread}	0
	CRC_{Spread}	0
	0	$Fee_{Clearing}$
	0	$Fee_{Maintenance}$
	0	$Fee_{DFContribution}$
Indirect Cost Factors:	VM	VM
	ERV_{Spread}	0
	0	IM

5 CCP Industry Structure

The clearing industry is still in its infancy (Murphy, 2013), why further developments in the industry structure should be expected. Building on the framework developed in Section 4: Impact Factors to assess the immediate end-user costs associated with the clearing requirement, this section will consider potential outcomes of the clearing industry to offer an estimate of potential end-user costs of clearing in the long-term. As Section 4 offered estimates on the size of each impact factor, so will this section offer suggestions on factor sizes under potential identified industry structure scenarios. To ensure depth of analysis, this section will focus specifically on the industry for client clearing of OTC interest rate derivative contracts.

In industrial organisation theory, the competitive interaction between firms is generally considered through an expansion on one of two basic interaction models. The first basic model is Cournot competition, where firms compete on the amount of output produced. The firms here make simultaneous output decisions indpendent of one another. The second basic model is the Bertrand competition, where firms compete on price. Also here, the firms make their pricing decision independently and simultaneously. Neither of the two models are likely to describe the clearing industry perfectly, but it is useful to consider the basic nature of how CCPs can be expected to compete.

Once a CCP has been constructed, there are very few limitations to the amount of contracts it is able to clear (Hasenpusch, 2009), why all CCPs should have the capacity to supply the entire market without making any output decisions. Therefore, the Cournot model is a poor representation, and the Bertrand model represents the clearing industry better between the two.

At its basic form, the Bertrand model equilibrium price is the competitive price, which is when the marginal CCP profit is equal to the marginal cost (**Source**). However, the basic Betrand model rests on some extreme assumptions. The first important assumption is that the CCPs have identical cost structures. If they do not, then the CCP with the lowest average costs will charge a price directly below the average cost of its closest competitor to win the entire market. The second important assumption is that customers strictly choose the firm offering the cheapest price, disregarding considerations on e.g. non-price costs and product differentation. Based on Section 4: Impact Factors, it is clear that rational end-users should price multiple costs associated with clearing at a specific CCP, including expenses from risk management requirements. Therefore, the Betrand model should be expanded to consider CCPs as competing to offer the lowest total costs rather than the lowest price.

The product offered by CCPs is rather simple at its core as the clearing house merely replaces the dealer as the end-user's legal counterparty, though there are means of differentiation. While this section considers the industry structure of CCPs offering services on a specific type of derivative - interest rate swaps - it is worthwhile to briefly consider the potential for end-users to net their outstandings across derivative classes. In case a CCP is able to offer netting across asset classes with correlated exposure, then this CCP is able to offer end-users a lower net outstanding position compared to its competitors. This means that the end-user will be subject to smaller risk management requirements, which in turn reduces the total costs associated with using this CCP relative to its competitors. Margining across asset classes, e.g. across credit and interest rate derivatives, is not currently possible for OTC products due to their complex nature. In fact, even the ability to net positions on interest rate swaps denoted in different currencies has yet to be implemented (Woolner, 2013). However, netting of similar derivatives that are traded OTC and on-exchange, known as portfolio margining, has become a recent possibility (Eurex, 2014b) (CME, 2014) (LCH.Clearnet, 2014a). To enable a reasonably simple foundation for discussing potential industry scenarios, this section will consider portfolio margining between exchange-traded and OTC derivatives as the only current and future cross-netting possibility.

There are also potential differences in the amount of dealers and CMs associated with a CCP. To understand why this is a significant point of differentiation, consider a scenario where each CCP is only associated with a single CM and a single dealer. In this scenario, both the CM and the dealer have no competitors and will are able to extract a high price from the end-user. Therefore, it is important for end-users that a given CCP has enough dealers and CMs associated that the end-users are guaranteed competitive prices on both dealer and CM services.

A third product mechanic worthy of consideration is the lock-in effect from netting opportunities. If an end-user has a current oustanding with a certain CCP then it is advantageous to clear future offsetting trades through the same CCP in order to realise netting benefits. If end-users could freely switch their outstanding trades to other CCPs, the lock-in effect would be mitigated. However, there are potentially large switching costs associated with unwinding positions at one CCP and re-initiating them at another (Serifsoy and Weiss, 2007). Beyond the cost of unwinding positions, switching costs potentially include expensing new interfaces and coping with different standards, practices and clearing rules. (Russo et. al, 2002)

Finally, while the creation of a CCP including IT infrastructure is expensive, the variable costs from clearing each contract are negligible. The average cost of clearing per transaction then decreases as a CCP brings in more business, which means that the industry is characterised by economies of scale (Hasenpusch, 2009) (Russo et. al, 2002). Indeed, a relevant CCP estimates that only five percent of their average costs vary with the clearing volume (LCH.Clearnet, 2006). A single CCP may therefore be able to provide clearing at a lower cost compared to multiple CCPs providing segregated clearing (Duffie and Zhu, 2011), why the clearing industry has often been described as a natural monopoly that absent outside influence can be expected to consolidate towards a single firm structure (Nielsson, 2010) (Koeppl, 2009) .

However, industry consolidation involves inefficiencies and risks due to the lack of competition (Hasenpusch, 2009). Therefore, while consolidation helps to increase network effects and economies of scale in the short term, the lack of competition might pose a long-term problem. These considerations are relevant, as they are deciding factors in policy-making. Regulators might take an active role in developing the cleairng industry structure, seeing how former natural monopolies in e.g. telecommunications and transportation have increasingly been dismantled in previous years (Russo et. al, 2002).

Interoperability agreements can be an efficient alternative to a monopoly. Interoperability enables users to net trades cleared across CCPs, which severely decreases or eliminates trade-for-trade switching costs (Murphy, 2013). An interoperable industry then offers the same benefits to end-users as a monopoly while forcing CCPs to compete, which removes concerns of monopoly pricing. Regarding the current opportunities for interoperability agreements, it is worth noting that a European code of conduct for clearing was developed in 2006. Here, the clearing houses agreed to work towards increased interoperability, each agreeing to accommodate potential requests for interoperability agreements (EACH, 2006).

In summary, CCPs should be expected to compete on offering end-users the cheapest overall way to secure a derivative from counterparty credit risk, disregarding capacity constraints. When assessing which CCP that presents the cheapest option, the end-user must consider opportunities to net the new derivative against currently outstanding positions. To maximise netting opportunitiess, rational end-users will trade through a single CCP when possible. If a new CCP presents the cheapest overall option, the end-user must consider whether the savings realised from switching current outstandings to the new CCP exceeds the costs of switching. Therefore, it is argued that the clearing industry is best described through dynamic Bertrand competition, where switching costs and economies of scale are present. If the clearing industry becomes interoperable, then the end-user decision making process is different, as the end-user can realise the same netting opportunities regardless of which CCP current outstandings are located at. The rational end-user will choose to do business with the CCP that presents the cheapest option for all new derivatives. In this case, the clearing industry is therefore best described through dynamic

Bertrand competition with economies of scale.

Building on the above, industrial organisation theory can provide valuable insight to the competitive equilibrium states of the industry. Consider a dynamic Bertrand game where two CCPs have identicial marginal cost (MC) structures and cannot differentiate prices between customers. In each period, a number of new end-users will bring business to the industry along with the old end-users that have already joined a CCP. As end-users rationally seek to maximise their netting benefits, they only do business with one CCP. Supposing that new customers are identical, then all new customers will do business with the same CCP. The CCP with the largest marketshare is referred to as CCP_A, the CCP with the second largest marketshare as CCP_B. In a Bertrand game, CCP_A and CCP_B compete on prices p and q respectively.

Switching costs are introduced first. If customers at either CCP must pay a switching cost s to switch, then as long as prices are $p = mc + s$ these customers will choose to stay at their current CCP. If the CCPs cannot price discriminate, then CCP_A must consider whether to price to only keep existing customers at price $p = mc + s$ or also compete for new customers at price $p = mc$. Since CCP_A will earn zero profits at $p = mc$, it is most profitable toa cater only to existing customers at $p = mc + s$. CCP_Bwill then cater to both its existing and new customers at a price slightly below CCP_A. The introduction of switching costs to Bertrand competition then leads to an interesting point; given a large enough existing customer base or switching costs, the market share leader can be expected to exploit its current customers and leave new customers to its competitor. In time, CCP_B will then catch up in market share to become the industry leader. In this simple game, CCP_A was assumed to set its price first. However, the outcome is shown by Farrell and Shapiro (1988) to be similar if firms move at the same time. Switching costs therefore enables profitability in a Bertrand game and, perhaps counter-intuitively, aid the industry challenger in accumulating additional market share. If the switching costs are removed, then both CCPs are again forced to compete solely on price. As the removal of switching costs therefore eliminates profitability for both CCPs, interoperability is not an industry equilibrium in this case.

Economies of scale is a prerequesite for many natural monopolies. Indeed, when introducing economies of scale to the switching cost game, Farrell and Shapiro (1988) show that as long as the per capita fixed costs are below switching costs, then the equilibrium outcome is the same as described above. If the per capita fixed costs are above switching costs, then the market leader's best response is to exclude the competitor. In other words, the outcome of the industry structure depends largely on the magnitude of both economies of scale (pulling towards a monopoly) and switching costs (pulling towards an alternating oligopoly).

This section has so far described the basic competitive interaction of CCPs and shown that both monopoly and oligopoly can exist as equilibria depending on the size of scale economies and switching costs. It has not been possible to find reliable estimates regarding the size of end-user switching costs or the CCP cost structures, why continuation of a formal analysis of the clearing industry is unfeasible. Recent academic literature has formally investigated the competition between clearing houses on the European market (Calès et al., 2012), but the industrial situation is significantly more complex than what is modeled by current literature, as we shall see below. Therefore, the preliminary formal analysis is concluded here, suggesting that both monopoly and oligopoly are potential equilibrium states of the industry.

It is however possible to introduce the current market structure, stakeholder incentives and potential stakeholder influence on the industry development. An introduction of stakeholder preferences and their respective bargaining power will help nuance considerations on potential industry outcomes and their consequences. The goal is to clarify how different ownership structures can be expected to bear different consequences to the end-user. To this end, an inductive approach is taken, which means that general assumptions are made based on recent key developments and survey results on relevant sample groups. In considering key events and opinions, an inductive approach lends itself well to identify relevant complexities.

Three additional parts therefore remain in this section. The first part aims to provide a solid understanding of the current industry structure and potential stakeholder influences. To this end, the relevant stakeholders and their basic incentives are introduced first, after which the market shares of each CCP and the current bargaining power of relevant stakeholders are estimated to make inferences on the current level of industry competitiveness. The second part will build on the stakeholder analysis to identify likely future industry scenarios, including considerations on ownership structures. The third part will consider CCP incentives and bargaining power of stakeholders under each identified industry scenario to make suggestions on their respective consequences for end-user costs.

5.1 Current Industry Structure

The European clearing industry for OTC interest rate derivatives currently consists of three notable marketplayers (Rennison, 2013). The first is CME Clearing Europe, which is owned by the CME Group. CME Clearing launched the clearing service for interest rate derivatives in 2013. The second is EurexOTC Clear, which is owned by Eurex Clearing and in turn Deutsche Börse. EurexOTC Clear is also a new entrant, having launched their clearing service for interest rate derivatives in 2012. The third player is LCH.Clearnet's

SwapClear, which is owned jointly by its affiliated CMs and the London Stock Exchange. It is interesting to note that SwapClear's affiliated CMs, who take up 43% ownership, include the largest European OTC derivative dealers. SwapClear was launched in 2009 and is globally the largest clearing service for OTC interest rate derivatives. (Eurex, 2012) (CME, 2012) (CME, 2013) (LCH.Clearnet, 2012) (LCH.Clearnet, 2014c). The distribution of marketshares between the three CCPs is not readily available, but end-user surveys shows that there is no clearly dominant CCP for the dealer-to-client market (Zazzara, 2013) (Rennison, 2013).

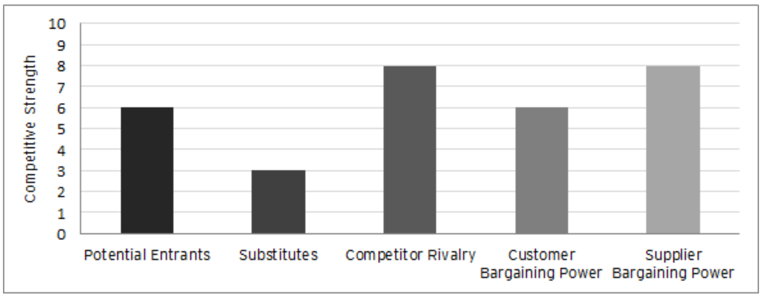
Since the considered CCPs are owned in part or in full by exchange groups, it is relevant to briefly introduce the relevant exchanges. There are three large interest rate derivative exchanges currently active in Europe, the Germany based Eurex Exchange owned by Deutsche Börse, the pan-European NYSE Euronext, and the also pan-European Nasdaq OMX NLX. These three exchanges all offer portfolio-margining between derivatives traded OTC and on their exchange. The Eurex exchange offers portfolio-margining through Eurex Clearing, while NYSE Euronext and Nasdaq OMX NLX offer portfolio-margining through an agreement with SwapClear. (Eurex, 2014) (NYSE Euronext, 2013) (Nasdaq OMX, 2014)

Two additional exchanges are worth an introduction. The first is America-based CME exchange who currently offers interest rate derivatives for American clients, including the possibility of portfolio-margining between interest rate derivatives bought OTC and the on the exchange through CME Clearing USA. CME has recently launched a European exchange, although this exchange is in its current stage limited to other derivatives. The second is the London Stock Exchange who, while owning the majority of SwapClear, does not offer exchange-traded interest rate derivatives. (CME, 2014a) (LSE, 2014)

The level of industry competition is here considered through Porter's *five forces* framework (Fleisher and Bensoussan, 2007). The five forces framework is usually used by firms as a measure of market opportunities, but it also allows for a formal comparison of the CCPs' incentives and abilities to extract profit from the end-users under different scenarios. Figure 1 shows the perceived current competitive strength of the clearing industry on a scale from one to ten, where ten is the maximum competitive strength.

Potential Entrants (6): The clearing industry exhibits high barriers to entry given the fixed costs required for establishment. However, both Nasdaq OMX and NYSE Euronext have announced plans to build their own CCP for interest rate derivatives, though these plans are officially on hold for now (Wood, 2011) (NYSE Euronext, 2012). Also, CCPs based outside Europe might already have the necessary set-up to commence clearing for European counterparties, though there may be large costs

Figure 1: Industry Competitiveness Factors



(Own Contribution)

and operational challenges associated with aligning the CCP to comply with EMIR standards and practices.

Substitutes (3): The current alternative to clearing is to continue using bilateral contracts. While EMIR does prescribe mandatory clearing, the requirement is for products that are sufficiently standardised to be cleared at a CCP (ESMA, 2012). Therefore, if clearing becomes too expensive, end-users could use overly complex contracts to avoid the obligation. However, this is likely a both a costly and risky strategy due to limited liquidity on such contracts and potential legal backlash. Exchange-traded products could also be argued as potential substitute, although the end-user rationale for choosing OTC products is usually based on trade requirements that the exchanges do not fulfill, e.g. the ability to perform large deals without changing the prevailing market price. (EC, 2012)

Competitor Rivalry (8): Given the natural economies of scale in the industry and the current market share estimates, competitor rivalry in the current oligopoly state should be strong. As the clearing requirement is not yet enforced, a portion of future profit stems from end-users are not currently clearing their trades. The CCPs compete to attract these clients in order to ensure market-share, as exemplified by Eurex's recent intiative to waive all client fees until 2016 for early adopters. (Eurex, 2013a)

Supplier Bargaining Power (8): CMs have previously boycotted CCPs when margin requirements were perceived as too small (Cameron, 2011). Most recently, both CME and SwapClear have been required to increase their margin standards, which were already well above regulator requirements (Cameron, 2011) (Cameron, 2012). In other words, the CMs have appeared organised and influential on the CCP risk management structure. It is interesting to note that the pressure applied by CMs have been towards more robust structures.

Customer Bargaining Power (6): End-users not currently on board with clearing have very a strong bargaining position as CCPs compete for their business. However, the bargaining power is reduced once lock-in effects have cummulated and end-users are faced with switching costs.

In addition to the five forces framework, it is useful to consider regulators as a final stakeholder. While regulators have expressed a preference towards letting market forces decide the outcome of the industry, they have acknowledged that intervention might be needed if the outcome is deemed inefficient or risky (Tumpel-Gugerell, 2006). Indeed, the European Commission has expressed willingness to take an active role in deciding industry outcome regarding whether or not to approve interoperability agreements (EC, 2010). While regulators have yet to oppose specific developments in the clearing industry, it is worthwhile to consider recent regulator actions on European derivative exchanges as a proxy. The reasons are that (i) the derivative exchange industry resembles the clearing industry, in that both are integral to the European financial infrastructure and exhibit similar economies of scale and scope, and (ii) the considered CCPs are owned partially or fully by exchanges. In 2012, NYSE Euronext and Deutsche Börse filed for permission to merge. However, the European Commission rejected the merger request due to anti-trust issues, as the merged company at the time would enjoy a marketshare of over 90% of European exchange-traded derivatives (EC, 2012), indicating that plans to unite competing exchanges are likely to be blocked. Given this decision and the expressed interests of the Commission, it seems unlikely that the CCP industry will be allowed to reach structures that enable uncontested rent seeking by any party.

In summary, the overall level of competition between CCPs is currently perceived as high, though there is room for increased competition. It is clear that the CMs play a very active role in determining the CCPs' margin standards. While customer bargaining power is currently perceived as reasonably high, industry structures such as a monopoly could occur where end-users have low bargaining power. Under these structures the CCPs could reasonably be expected to increase the maintenance fee charged to end-users. In scenarios with low customer bargaining power, the CCPs should be expected to strengthen the risk management requirements. The reason is that the CCPs themselves do not incur costs from stricter requirements, but are benefited through additional stability. However, as CMs are also subject to the risk management requirements they should be expected to react against excessively high levels, since e.g. high IM requirements represent increased costs to CMs and end-users alike.

5.2 Scenario Analysis

The previous part explained the current stakeholder incentives and bargaining power. This part will discuss how these two factors can compliment the competitive forces in shaping the future clearing industry structure. If a specific stakeholder enjoys large bargaining power, they could be expected to influence the development towards their favored structure. As some of these stakeholders have indeed been found to possess and excerise veto rights against certain developments, this part will expand on the stakeholder analysis to suggest future industry scenarios.

The current industry structure was described as an oligopoly with switching costs and economies of scale. Two additional structures are considered; monopoly and interoperable competition with no switching costs. A recent study identifies a third option through establishment of a meta-CCP, which is a CCP that sits on top of all the other CCPs to collect and allocate margin across the fragmented market. However, the complexities involved in the creation of such an organisation in terms of commercial, regulatory and political implementation are found to be too great to provide a realistic option (Mägerle and Nellen, 2012). To simplify the analysis of CCP incentives, this section will consider OTC derivatives and listed derivatives as complimentary rather than competing products, following the view of the European Commission (EC, 2012).

A monopoly can develop organically through steady accumulation of additional market shares by a given player, but this development can be supported or disrupted through mergers and acquisitions. This possibility brings up an important dynamic, as two of the three CCPs are owned by exchanges. The OTC market is much larger than the market for listed interest rate derivatives (Gyntelberg, 2013). Therefore, while users of OTC products are found to be unconcerned with whether they can cross-margin with listed products (Rennison, 2013), this indifference might not hold the other way round. In other words, end-users could be expected to consider how their on-exchange trades can be netted against their OTC portfolio. Also, products traded on exchanges are standardised to a large degree, why end-user switching costs are likely lower for exchange-traded portfolios compared to the OTC market. Exchanges could therefore likely consider the ability to offer clients cross-margining between their products and the customer's existing OTC portfolios as a key differentiator. The competitive importance to exchanges of ensuring access to portfolio margining with OTC trades might help explain previously announced plans of NYSE Euronext and Nasdaq OMX's to establish their own CCP, as well as the long-term contracts that NYSE Euronext exchanges subsequently established with SwapClear. (NYSE Euronext, 2013) (Wood, 2011)

Therefore, if a monopolist CCP were to be owned by either of the exchanges, the remaining exchanges would lose competitive footing. The reason is that the monopolist in this case can limit the possibility for end-users to net their OTC positions with products traded through other exchanges. In case the exchanges were to consolidate, then a single-exchange monopoly becomes more plausible. However, such a consolidation has already been denied by regulators. Developments towards a monopolist CCP owned by a single exchange are should therefore be heavily influenced by interests of the remaining exchanges, who could be expected to revert to previous plans of establishing their own CCPs.

Therefore, a sustainable monopoly is likely only when derivative exchanges benefit equally. This criterion can be met through at least four monopoly structures:

1. Monopolist CCP jointly owned by exchanges (or other non-users)

2. Monopolist CCP owned by CMs

3. Monopolist CCP owned jointly by exchanges and CMs

4. Monopolist CCP owned or heavily influenced by regulators

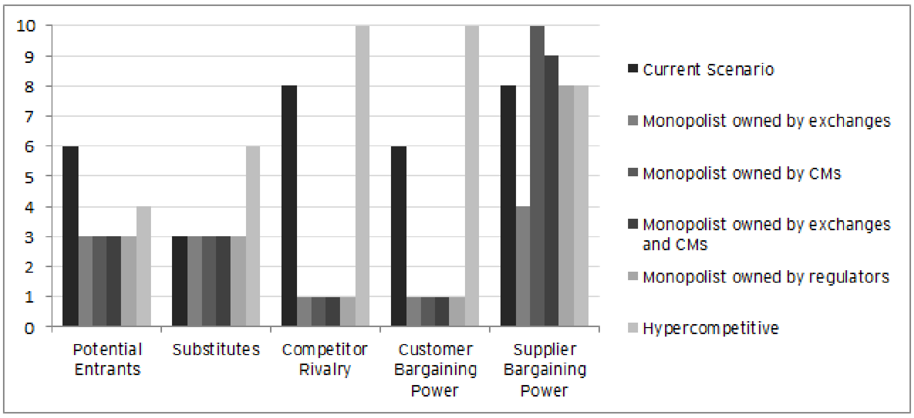
The initial Bertrand analysis showed that it is not in the interest of either the market leader or trailing competitiors to eliminate switching costs. Therefore, interoperability agreements are not a competitive equilibrium. Also, interoperability agreements might despite the European code of conduct be difficult to establish due to legal and risk concerns around a potential CM or CCP default. This is especially true in the OTC market, where products are more complex (Sawyer, 2011). However, as switching costs represent economic inefficiencies (Farrel and Shapiro, 1988), regulators concerned with creating a competitive industry could consider forcing the issue. Switching costs can also be reduced by other means such as a standardisation in OTC products, which would make it easier for customers to replicate their existing contracts when switching to a new CCP. Since the ultimate interest here lies with with end-user costs, it still makes sense to also consider a hyper-competitive situation where switching costs dissappear.

5.2.1 Scenario Consequences

As the end-user ultimately deals through a CM, some expenses are related more to the industrial structure of CMs than the structure of CCPs. Most notably, the clearing fee realised by the end-user were found in Section 4: Impact Factors to be primarily based on CM rather than CCP expenses. Therefore, clearing fees are kept constant across possible CCP industry structures. However, potential changes in the CCP risk management structures are considered under each possible scenario, why potential changes to the IM or default fund contribution fee are considered. Section 4 estimated the default fund contribution fee as a proportion of the IM. This is a sensible approach, since a CM's default fund contribution is based on their proportion of the total IM posted to the CCP. However, the CM's default fund contribution does therefore not increase with the CCP's total IM requirements, since each CM's proportion of total IM is unchanged. Changes in the default fund contribution fee and IM requirements are therefore treated separately. Also, maintenance fees are supposed set by the CCP and passed on in full by the CM. Therefore, potential changes in maintenance fees are also considered for each scenario.

Five possible scenarios were identified, (i) hyper-competitive oligopoly (ii) regulated monopoly (iii) CM-owned monopoly, (iv) exchange-owned monopoly. For each scenario, the directional influence can reasonably be identified although the exact impact is difficult to quantify. However, a quantified estimate is valuable even if not precise, as it allows for inference on how important changes in each impact factor are in terms of end-user costs. Therefore, suggestions are made on the change in factor sizes under each scenario. Figure 2 shows the estimated strength of the five forces in each scenario, including the current structure for comparison.

Figure 2: Scenario Competitiveness Factors



(Own Contribution)

In a hyper-competitive oligopoly, the CCPs are competing to offer the lowest total costs as customer bargaining power is high. However, the bargaining power of CMs remains unchanged, as they too can opt to become clearing members at other CCPs. Therefore, the IM and default fund contribution requirements are argued as unchanged in this scenario. Due to the competition amongst the clearing houses, it is reasonable to suggest that CCPs would no longer require clients to pay maintenance fees.

In a regulated monopoly, the regulators as owners should be concerned with balancing CCP robustness and market efficiency. Since CCP robustness is currently above regulator requirements (Cameron, 2011), the risk management requirements are argued to remain at current level. The maintenance fees will also be low, since ensuring that economies of scale are passed on to the clearing clients is a primary reason for regulator intervention. Therefore, it is reasonable to suggest that a regulated monopoly and hyper-competitive oligopoly will have similar consequences for end-user costs.

In a CM-owned monopoly, the CMs are increasingly influenced by the default from another CM, as also their joint stake in the CCP is now at risk. However, the CMs are also using the service themselves, and are therefore not interested in risk management practices that lock up excessive volumes of capital. As the CMs currently enjoy a large influence on CCP risk management requirements, risk management requirements are also here argued to remain around current level. However, the CCP is absent competition able to charge higher maintenance fees for client clearing, though regulators could be expected to react against extreme rent extraction and differential pricing. To consider the effect of potential fee increases, it is suggested that maintenance fee rates are tripled under this scenario.

In a monopoly owned jointly by exchanges, the CCP has an incentive to be overly protective against defaults by increasing risk management requirements, as the owners themselves are not subject to these requirements. Also, due to a lack of alternatives, the bargaining powers of both end-users and CMs are low in this scenario. Therefore, end-users should expect high risk management requirements under this scenario, although regulators could be expected to react in case of too strict requirements. For the high risk management requirements, it is suggested that the exchange-owned monopoly will resort to an IM level similar to the BIS standard rates from Table 8. Also, the default fund size is suggested increased by a similar proportion. Due to low customer bargaining power, the exchange-owned monopoly is also able to extract profit from the end-users through increased fees. Maintenance fee rates are therefore also suggested to triple in this scenario, further increased by the higher IM.

6 Backtest Application

Having identified the key end-user cost factors and a range of potential industry scenarios, this section will serve to quantify the impact of EMIR's clearing requirement on end-user costs. To this end, we consider the modeled end-user who seeks to hedge interest exposure on a bond portfolio. A backtest on portfolio drag from using bilateral and cleared interest rate swaps is performed over the course of one year, using historical data from 01.11.12-01.10.13. The pricing of credit risk is calculated assuming daily margining, though the backtest for simplicity will recalculate VM and IM only on portfolio rebalancing dates. The cash needed to cover hedging expenses are met from selling off a piece of the BERC portfolio, and any excess cash left over after meeting VM and IM requirements are reinvested into the portfolio.

The mechanics of the framework developed in Section 4: Impact Factors bring two interesting points. First, as the bilateral costs are dependent on the end-user's credit-spreads it is interesting to see what happens if these are changed. Therefore, results are provided on a scenario where credit spreads are increased to represent stressed conditions. Second, as the CVA and CRC are based on expected exposure of the contract, it could also be interesting to investigate the effect of using swaps with different maturities. Therefore, while the base case will be using five year swaps, scenarios using two and eight year swap maturities are also considered.

6.1 BERC Duration Hedge

This section will cover the main elements of a duration hedge, including how swaps are used for the purpose. The duration measures the sensitivity of percentage changes in the BERC index price to changes in its yield. Duration is calculated as a weighted average of the times when payments are made, with the weight applied to time t_i being equal to the proportion of the index's total present value provided by the cash flow at time t_i (Hull, 2012). In general, the higher duration, the more sensitive the index price is to interest rates movements. The duration of a bond or bond portfolio is a measure of how long on average the holder of the bond must wait to receive cash payments, discounting the value of the cash payments with time at the bond yield rate of interest (Hull, 2012). This can be expressed as:

$$D = \sum_{i=1}^{n} t_i \left[\frac{c_i e^{-yt_i}}{B} \right]$$

where the term in square brackets is the ratio of the present value of the cash flow at time t_i to the bond price B. The bond price is the present value of all payments, why the duration is a weighted average of the times when payments are made, with the weight applied to time t_i equal to the proportion of the bond's total present value provided by the cash flow at time t_i. All discounting uses the bond yield rate of interest, y. (Hull, 2012) For small changes in y, it is approximately true that $\frac{\Delta B}{B} = -D\Delta y$, which is a relationship between percentage changes in bond price and changes in its yield. (Hull, 2012) Duration is only an approximate measure for the effect of changes in the bond yield on price, as the duration itself changes significantly from large movements in the yield (Hull, 2012). This explains why the BERC duration is not constant over time, and hence why rebalancing the duration is hedge is necessary. For the BERC index, the duration is defined as a weighted average of the durations of the individual bonds in the portfolio, where the weights are proportional to the bond prices. The bonds in the BERC index contain embedded options (Bloomberg, 2013), e.g. callable bonds. Therefore, the duration measure must be adjusted to account for the fact that the index's embedded options may change the expected cash flows, which could for example occur if a bond is called and principal is returned earlier than the expected maturity. The option-adjusted measure of duration is called Option Adjusted Duration (OAD), and is retrieved for each rebalancing date from Bloomberg Market Data (Bloomberg, 2013e).

To achieve the desired portfolio duration, plain vanilla interest rate swaps are used. These swaps are contracts to pay (receive) cash flows equal to interest at a predetermined fixed rate on a notional principal for a predetermined number of years. In exchange, the buyer of the swap receives (pays) interest at a floating rate on the same notional principal for the same period of time. The value of a swap is characterized as the difference between the fixed-rate bond and the floating-rate bond underlying the considered swap (Hull, 2012). The floating rate used for our swaps is the EURIBOR rate. The swap rates for given maturities are averages between bid and offer fixed rates, which are then based on the current EURIBOR rate and the projected interest rate movements until maturity. The duration of a vanilla pay floating (receive fixed) swap purchased at time t is defined as (Hull, 2012):

$$D_{IRS,t} = D_{fix,t} - D_{float,t}$$

To identify the notional swap needed to perform the desired hedge, the dollar durations, $DV01_t$, of the swaps are matched to reach the desired outcome. $DV01_t$are not necessarily denominated in dollars, but are measures of how the positions in BERC and the swap change following a one basis-point change in the yield, expressed formally as:

$$DV01 = V * \frac{D}{10000}$$

where V is the value of the position. As $D_{float,t}$ is likely to vary across time due to convexity mismatches so will $D_{IRS,t}$. It is therefore necessary to recalculate the durations of previously traded swaps at each rebalancing date.

6.2 Model Description

The backtest follows the procedure outlined here:

1. An investment is made in a portfolio equivalent to the BERC
2. An OTC interest rate swap is traded with notional set to meet the portfolio duration target
3. The traded swap is valued at zero added the estimated key cost differences. A portion of the portfolio must be sold off to meet the hedging expenses and margin requirements, reducing the portfolio market value.

After the initial procedure, the rebalancing of the portfolios take the following form:

4. The bond portfolio value is adjusted according to the return of the BERC between rebalancing dates.
5. Durations for the portfolio including previously traded derivatives are established for the rebalancing date, and a new swap is traded to maintain the target duration.
6. The key factors are calculated for the portfolio of swaps following the procedures outlined in Section 4: Impact Factors. Expenses are funded by selling off part of the portfolio and vice versa.
7. The backtest moves to the next rebalancing date and readjusts the portfolio value continuing until the final rebalancing date.

6.3 Data Description

This part outlines the data used for the application and how it is obtained. At first, the considered credit spread profiles and their values are outlined. Second, the method for calculating the required swap notionals is clarified. Last, the practical method expected exposure simulation is clarified upon, and the Gibson key term and Vasicek parameter values are outlined.

6.3.1 Credit Spreads

As hazard rates were assumed constant to facilitate EPE simulation, as are the credit rates kept constant. Credit spreads used for the estimations are matched to the maturity of the traded swaps. The end-user base case is the five year credit spread of Allianz, a large German insurance company, retrieved for the initial trading date. The dealer base case is the five year credit spread from Barclays Plc also retrieved for the initial date. For the volatile scenario, the end-user credit spread is based on Assicurazioni Generali, a large

Italian insurance company whose credit spread was influenced sharply by the aftermath of the financial crisis (Bloomberg, 2013b). The volatile end-user credit spread is then the highest five-year credit spread on Assicurazioni Generali during the period 01.10.02-01.10.12. The volatile dealer credit spread is the highest five-year credit spread on Barclays during the period 01.10.02-01.10.12. Table 10 shows the retrieved credit spreads in basis points.

Table 10: Credit Spreads from Bloomberg

Entity	5Y Credit Spreads, bp
End-User: Base Case (Allianz 01.10.12)	116,9
End-User: Volatile (Generali 25.11.11)	451,6
Dealer: Base Case (Barclays 01.10.12)	188,3
Dealer: Volatile (Barclays 25.11.11)	278,6

(Bloomberg, 2013a) (Bloomberg, 2013b) (Bloomberg, 2013c)

6.3.2 Rebalancing Trades

At rebalancing dates, the dollar duration (DV01) target is found as:

$$DV01_t = PV_{Portfolio,start} * \frac{OAD_{BERC,t} - (OAD_{BERC,t} - 2)}{10000}$$

The swap needed to perform the desired hedge is identified by first obtaining the correct swap rate to create a swap with zero MtM value for the date. Then, based on the duration for this swap, the notional swap that meets the duration goal is traded. At rebalancing dates, the duration of BERC position and swaps are updated, and the duration needed to reach the target is identifed, after which a swap with notional identified as previously is traded. Monthly swap data is retrieved from the Bloomberg Professional Service using 360 trading days per year (Bloomberg, 2013e).

6.3.3 EPE Estimates

To include collateral agreements in the EPE calculation, simulations are performed as explained in Section 4: Impact Factors. A simulation includes the expected exposure after collateral for each day until maturity is simulated, which takes a large amount of computational power. Therefore, the following simulation counts are based on processing power limitations. The expected EPE for a given day, referred toEPE_t, is found as the average of the performed simulations, EPE_i.

Due to limitations in available software, the simulations were performed in Excel. No statement has previously been made on the assumed probability distribution of short-term interest rate movements, which should be chosen to best match real expected rate movements. It is possible to generate random integers from multiple probability distributions in

Excel, but it was only feasible to draw from the normal distribution due to limits in computational power. Therefore, it is for practical purposes necessary to assume that the short term interest rate movements follow a normal distribution. When drawing from a normal probability distribution means the short term interest rate movements are symmetrical, which means that while expected negative exposure is the strictly correct measure for ERV calculation, the EPE estimates are for practical purposes also used here. The analysis will be using Excel's $NORM.S.INV$ function to draw random movements following a normal distribution by the formula $NORM.S.INV(RAND())$. Note that Excel is not completely accurate statistical software, as the software uses pseudo-random generators (Microsoft, 2014). This means that if a long sequence of random numbers is produced, the sequence will eventually repeat itself. However, the current generation procedure (the Wichman-Hill procedure) guarantees that repetition does not occur before more than 10^13 numbers are generated (Microsoft, 2014). This procedure is therefore acceptably close for the purpose of this thesis.

Most values chosen by Gibson (2005) for the model EPE terms are in agreement with the industry standards identified in Section 2: Background, and are therefore used here as well. While CCPs typically collect IM to cover a 5-day period between default and unwind on cleared swaps, though regulators estimate that un-cleared swaps are subject to a 10-day grace period (ISDA and CC, 2012).

Table 11: Margining Parameter Values

Parameter	**Explanation**	**Value**
Threshold	Exposure amount below which no margin is held	0
Grace period	Amount of days to liquidiate a defaulted counterparty's positions.	10 days
Remargin period	Interval (in days) at which margin is monitored and called for	1 day
Minimum transfer amount	Amount below which no margin transfer is made	0

The Vasicek r simulation requires an estimation of the model constants. To arrive at these estimates, we first write a stochastic difference equation to descibe the behavior of the short rate in the Vasicek model:

$$\Delta r_t = \kappa(\theta - r_{t-1}) + \sigma\epsilon_t$$

where $\kappa \in (0,1)$ is the speed of mean reversion, θ is the equilibrium rate and σ is the volatility. For statistical estimation, the equation is rewritten as

$$r_t = a + br_{t-1} + u_t$$

where $b = 1 - \kappa$ and $a = \kappa\theta$. We can now estimate b as the slope coefficient from an AR(1) regressing r_t on r_{t-1} and a constant a. σ is given as the regression's standard deviation, and θ is set to the historical average interest rate. The historical EURIBOR six month interest rate, which is the index that the Bloomberg swap rates are based on, is used for the estimation based on a sample period from 01.01.99-01.10.12 (Bloomberg, 2013d). The average daily interest rate (θ) for this sample period was 2,83%. To adjust for collateral, rates must be simulated on a daily basis, which calls for daily sampling intervals. The regression with daily sampling intervals yields results as shown in Table 12.

Table 12: AR(1) Results, Daily Sampling

Parameter	Value
a	-0,0017
b	1,0004
σ	0,1883

The b parameter takes an unexpected value, which means that $\kappa = 1 - b = -0,0004$. This breaks the assumption that $\kappa \in (0, 1)$ and implies negative mean reversion; or that the short rate should move away from the equilibrium rate in time. In search of applicable parameters, we therefore perform the AR(1) on the same dataset with monthly sampling intervals. The obtained parameters do not break the assumption of positive mean reversion. We find that $\kappa_M = 0,00076$, $\theta = 2,83222$, and $\sigma_M = 0,19223$. Parameters are converted to daily as $\kappa_D = \frac{1}{30}\kappa_M$ and $\sigma_D = \frac{1}{\sqrt{30}}\sigma_M$ (Hull, 2012). The obtained Vasicek parameter estimates are then as shown in Table 13. Please refer to the *Vasicek Parameter Estimation* spreadsheet for the regression data.

Table 13: Vasicek Parameters

Parameter	Value
κ_D	0,000025
$\theta(\%)$	2,832223
$\sigma_D(\%)$	0,035096

To check how well the Vasicek model performs with these parameters, an out-of-sample forecasting is performed on the period 01.10.12-01.10.13. The idea is to see how consistently the model performs for daily prediction outside the sample and gauge the accuracy of the estimates in how close the 01.10.13 estimated yield is to the real value. Dynamic forecasting is used based on the average of 10.000 simulations. In dynamic forecasting, only the first forecast is based on an actual value for r_{t-1}, as opposed to static forecasting, where every forecast is based on actual values. The reason for using dynamic rather than static forecasting is that this method mimics the forecasting procedure used in the EPE estimation, as we are here using daily-on-daily forecasts to forecast an annual drift. The results are shown in Table 14.

Table 14: Backtest Results

	Result: 01.10.13
Model Rate	0,443%
Model Standard Deviation	0,563%
Actual Rate	0,338%
Actual Standard Deviation	0,030%

As the simulations are both based on normal distributions using the same volatility estimate, and the sample sizes for each estimate is equal, the following independent two-sample t-test with 95% significance level is applied to the spot and swap rate based EPE estimates. A one-sample t-test with 95% level is applied to investigate the statistical difference between the actual interest rate and the forecasted interest rate at 01.10.13:

$$t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}}$$

where $\bar{X}$ is the forecasted interest rate, μ_0 is the actual interest rate, s is the forecast standard deviation, and n is the sample size. The degrees of freedom used in this test are $n-1$. Based on the t-value and corresponding p-value shown in Table 17, the null hypothesis of no difference between actual and forecasted interest rate is rejected. However, the estimate is still reasonably close, being around 0,05 percentage points from the actual value.

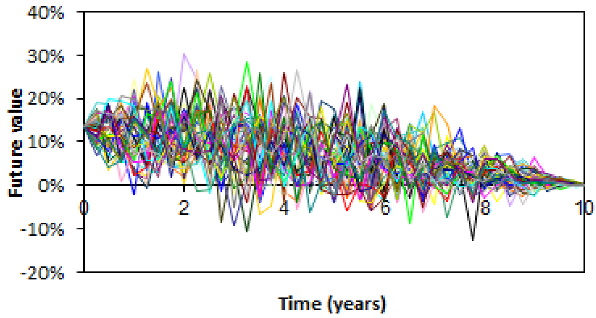
Table 15: Student t-test: Forecasted versus Actual 6M Euribor

	Output
t-value	18,639
p-value	0,000

As mentioned in Section 4: Impact Factors, a swap MtM valuation based on the Vasicek model does not fit the actual term structure. Therefore, the model provides simulated future exposure values as shown in Figure 3, as long as the spot rate r_{spot} is not equal to the swap rate r_{swap}.

This is an issue, since the real exposure at swap initiation is always zero. This issue can, perhaps crudely, be mitigated by using equal inputs for the two rates, which can be achieved either by using the swap rate, the spot rate or an average between the two. The Vasicek EPE simulation is concerned with the average movements of the swap away from fair value as a percentage of the notional, given by the interest rate standard deviation. However, given the model's mean reversion characteristic, we could expect the interest rate levels to influence the estimate. The reason is that simulations with interest levels closer to the equilibrium rate would reach the equilibrium faster, thereby changing the pull from the

Figure 3: Future Exposure Values: Initial Simulation



(Own Contribution) (Gregory, 2012)

mean reversion. To investigate the significance, we consider the spot and eight year swap rates from 01.09.13, the rebalancing date and maturity at which the difference between the two is largest, with $r_{spot} = 0,345$ and $r_{swap} = 1,931$. The differences are shown shown by Table 16. Please refer to the *EPE Vasicek Monte Carlo 8Y 360* spreadsheet for regression data.

Table 16: EPE Estimates: 10.000 Simulations

	Spot Rate	Swap Rate
EPE 8Y Swap	0,02764%	0,02726%
Standard Deviation	0,01922%	0,01898%

As the simulations are both based on normal distributions using the same volatility estimate, and the sample sizes for each estimate is equal, the following independent two-sample t-test with 95% significance level is applied to the spot and swap rate based EPE estimates:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{x_1 x_2}\sqrt{\frac{2}{n}}},$$

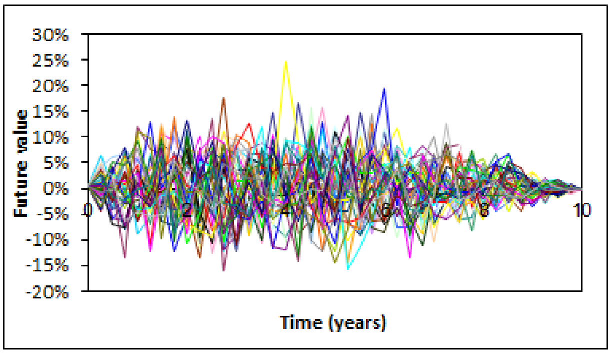
where $\bar{X}_m$are the EPE values, n is the number of simulations, $s_{x_1 x_2} = \sqrt{\frac{1}{2}(s_{x_1}^2 + s_{x_2}^2)}$and $s_x^2$are the two sample variances. The degrees of freedom are $2n - 2$. The$t$-value is then the standard error of the difference between the two EPE estimates (Gujarati and Porter, 2009). Based on the t-value and corresponding p-value between the spot and swap rate EPE simulations shown in Table 17, the null hypothesis of no difference between the two EPE estimates cannot be rejected.

Table 17: Student$t$-test: Spot vs Swap Rate

	Output
t-value	1,3866
p-value	0,1656

The average rate, $r_{average}$, is used for the estimates as it allows for conceptual inclusion of both current rate and future expectations. Figure 4 shows how the ten-year swap's future value now correctly starts at zero when using the average rate as input.

Figure 4: Future Exposure Values: Corrected Simulation



(Own Contribution) (Gregory, 2012)

With the input parameters at hand, the expected EPE of a contract initiated at a given date is simulated using the procedure developed in Section 4: Impact Factors. For the exact procedures please refer to the *EPE Vasicek Monte Carlo xY 360* spreadsheets. Seeing that the differences between EPE estimates based on spot and swap rates are statistically insignificant, it is for practical reasons worthwile to investigate the significance in differences between EPE values across rebalancing dates. A t-test is performed based on the smallest and largest $r_{average,t}$ rates; 01.01.13 at 0,81% and 01.09.13 at 1,14%. Based on the t-values, shown in Table 18, the null hypothesis of zero difference between EPE estimates based on $r_{average,t}$ cannot be rejected here either.

Table 18: Student t-test: Largest vs Smallest Average Rate

	Output
t-value	0,3092
p-value	0,7572

As the differences between the modeled EPE for rebalancing dates are found to be insignificant, a single EPE estimate is for practical reasons made for each maturity based on time-averages of $r_{average,t}$, which is then used for every rebalancing date. The average rates for each considered swap maturity and the associated time-average EPEs after collateral, EPE_a, are given in Table 19.

Table 19: Time-Average EPE: 10.000 Simulations

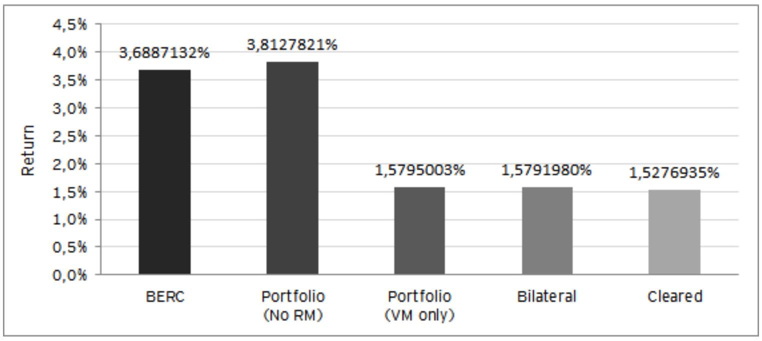
	2Y IRS	**5Y IRS**	**8Y IRS**
$r_{a,a}$	0,4253%	0,6862%	0,9498%
EPE_a	0,00661%	0,01704%	0,02717%

7 Results

This section provides the backtest results, comparing the estimated drag from bilateral counterparty risk and the estimated drag from clearing-related expenses meant to offset this risk. The drags are first estimated for a base case current situation. Then, the significance of potential factor changes is investigated through a number of circumstances. The circumstances are (i) change in credit spread, (ii) change in swap durations, and (iii) potential future clearing industry structures.

The base case results are displayed in Figure 5. The figure shows the return on the original BERC portfolio, and the returns on the portfolio under different risk management practices after cost factors are subtracted. The drag specific to bilateral counterparty credit risk is estimated through risk related premia paid to the dealer and pricing of the end-users counterparty risk towards the dealer. The drag specific to cleared swaps is estimated based on the clearing fee, maintenance fee, default fund contribution fee and IM requirement. Readers interested in the calculation process are referred to the *Portfolio Drag Estimation* spreadsheet.

Figure 5: Portfolio Returns: Base Case

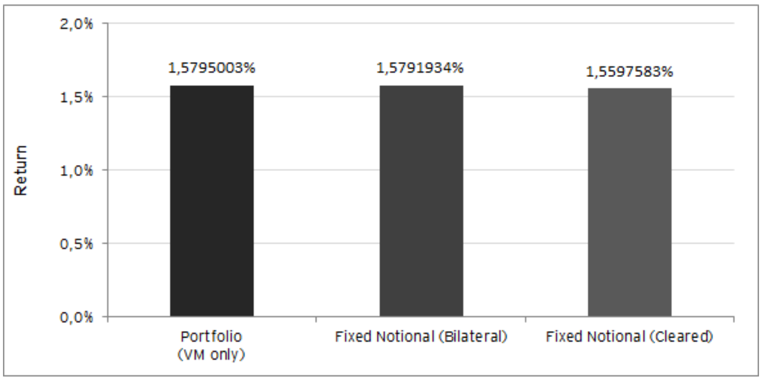


(Own Contribution)

The accumulated return on the BERC index is 3,69% over the backtest period. Return on the duration hedge portfolio exceeds the return on the BERC index absent risk management practices, indicating that the interest rate swaps were profitable. The results show that the VM agreement common to cleared and bilateral contracts in this case has a large negative influence on portfolio returns. The reason is that while the interest rate swaps turned out to be profitable at the end of the period, their market values were highly negative at most rebalancing dates, removing a large portion of cash from the portfolio.

As variation margin is common across all types of derivative contracts, the best estimate of drag costs from bilateral counterparty credit risk and costs of clearing is the drag compared to the portfolio *VM only* portfolio, which excludes counterparty risk considerations. From Figure 6 we see that the drag from counterparty credit risk under standard bilateral contracts is small, as the portfolio return under bilateral contracts offers a return that is only 0,0302 basis points lower than the *VM only* portfolio. The drag from clearing specific expenses is much larger at 5,1807 basis points. The large drag differences indicate that the risk benefits of clearing are far outmatched by the extra costs for the end-user. However, the portfolios all have different amounts of cash at rebelancing dates, why the swap notionals required to match the target dollar durations are different across the three portfolios. To ensure a fair comparison, it is therefore interesting to consider portfolio drags under similar swap notional values, as doing this enables conclusions on expected drag from using cleared versus bilateral swaps on a per notional basis. Therefore, Figure 6 shows the returns on portfolios where the swap notionals on bilateral and cleared trades are fixed to equal those of the *VM only* portfolio.

Figure 6: Portfolio Returns: Fixed Swap Notionals

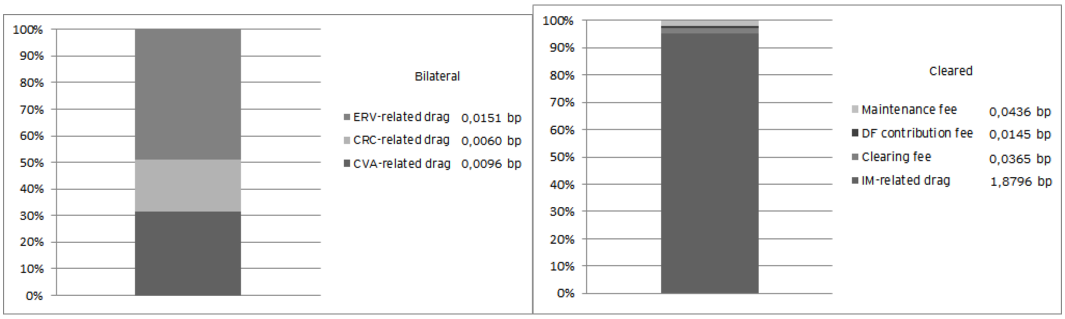


(Own Contribution)

When comparing across fixed swap notionals, the drags from bilateral counterparty credit risk and the clearing procedure are 0,031 and 1,974 basis points, respectively. Therefore, end-user costs of clearing are estimated to outweigh the benefits of eliminating counterparty credit risk by a factor of 63. These drag estimates are influenced by the monthly return structure of the BERC index, and are therefore not completely generalisable.

Lastly, Figure 7 shows the drag contribution from each of the framework factors. It is interesting to see that the IM requirement constitutes more than 95% of the total drag specific to cleared swaps. Also worth noting is that even though the maintenance, default fund contribution and clearing fees represent only a small portion of total drag from clearing, the drag from these fees is still approximately three times larger than the total drag from bilateral swaps.

Figure 7: Factor Drag Contribution: Fixed Notional

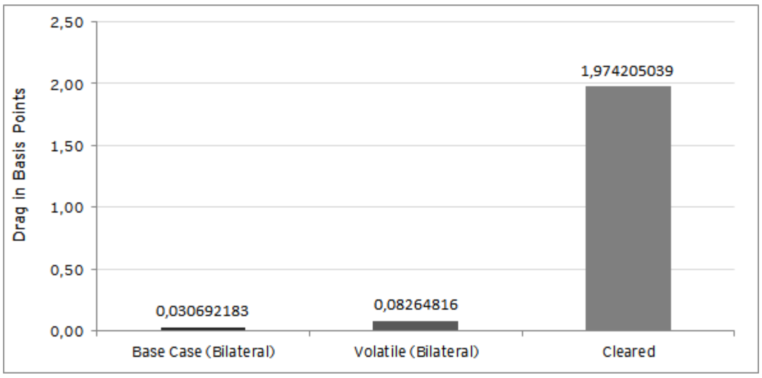


(Own Contribution)

7.1 Changing Credit Spread

The cost of bilateral counterparty risk depends on the creditworthiness of the players involved. Therefore, it is worth investigating the expected drag under a volatile trading environment, to see whether clearing becomes a cost-efficient solution to counterparty credit risk in volatile times. Figure 8 shows the drag from cleared and bilateral swaps under high credit spreads for both the dealer and end-user compared to the *VM only* portfolio, using fixed swap notionals.

Figure 8: Changing Credit Spread: Fixed Notionals



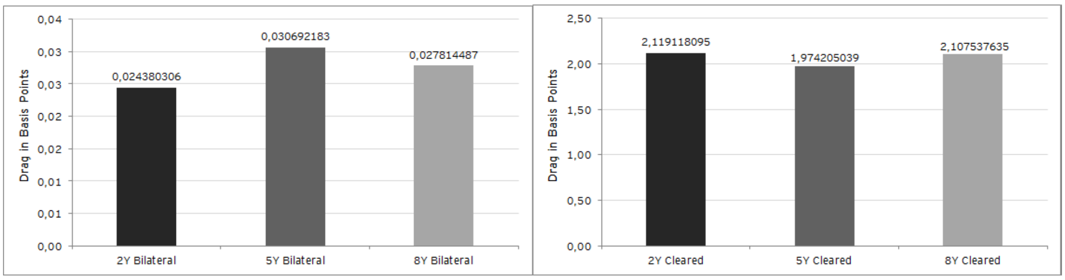
(Own Contribution)

The estimated drag from bilateral counterparty risk in the volatile scenario is approximately twice the base case drag, which is still dwarfed by the drag from using cleared swaps. In other words, even in a scenario constructed to represent counterparty credit risk under stressed circumstances, clearing is not a cost efficient solution for the end-user in terms of eliminating counterparty risk. In fact, the costs of clearing are still approximately 24 times larger than the costs from bilateral counterparty credit risk in the volatile scenario. It is worth noting that the IM as a percentage of the notional has been kept fixed in this scenario. In reality, IM requirements would increase under volatile scenarios, which in turn would further increase the costs of clearing.

7.2 Changing Swap Maturity

Swap durations vary across maturities why a specific interest exposure can be covered by a smaller swap notional if maturity is increased. It is therefore interesting to examine whether the end-user can expect lower or higher portfolio drags depending on the choice of swap maturity. Figure 9 shows the estimated drag compared to the *VM only* portfolio from swaps with different maturities. The bilateral and cleared portfolios use the same notionals as the *VM only* portfolio.

Figure 9: Changing Swap Maturity: Fixed Notionals



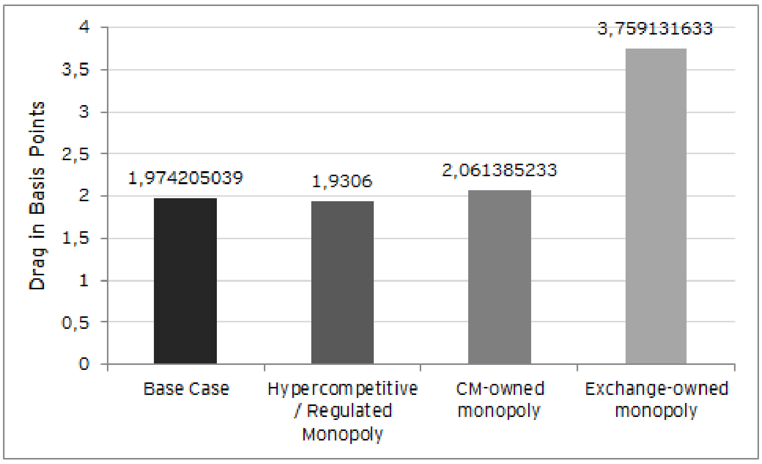
(Own Contribution)

For bilateral swaps, the drag from both two and eight year maturities are below the five year base case. Interestingly, the effect is opposite for cleared swaps, as the base case offers the smallest drag. The results therefore show that there is an effect from using different maturities, although the effect is not linear in this situation. A potential explanation is that the obtained swap durations were are not proportionate across maturities, i.e. a one-year swap did not have half the duration of a two-year swap, which in turn means that the required notionals were not proportionate either.

7.3 Clearing Industry Scenarios

Figure 10 shows the suggested drag from clearing under the considered clearing industry scenarios compared to the *VM only* portfolio, again using fixed notionals. The results reflect that the potential for decreases in end-user costs of clearing based on developments in the CCP industry are perceived as limited, as risk management requirements were argued to remain at similar levels. The drag from scenarios excempt from CCP fees was only 0,0436 basis points below the current scenario. The most expensive scenario to end-users was found to be a monopolist CCP who is incentivised to extract as much rent as possible from its users. If such a monopolist triples fees and prefers strict risk management practices, here modeled as BIS standard rates, the portfolio drag is almost two times higher than the current scenario.

Figure 10: Clearing Industry Scenarios: Fixed Notionals



(Own Contribution)

8 Discussion

The focus of this thesis has been on comparing the costs faced by end-users due to counterparty credit risk in bilateral contracts to the expenses associated with offsetting this counterparty risk through central clearing. To this end, the thesis investigated the portfolio drag from using cleared and bilateral swap contracts to hedge interest rate exposure on a bond portfolio. The obtained portfolio drags strongly suggest that clearing is not a cost-efficient solution to mitigating counterparty credit risk on interest rate swaps.

However, further discussion is in order as the results are based on a simple framework containing rough estimates. This section will comment and perspectivise on the economic relevance of the estimates and their implications. Also, this section will include a critical discussion of the methods as well as the results and their validity.

A key goal of this thesis was to enable managers to consider the expected impact of the EMIR clearing requirements on the cost of using OTC derivatives. The thesis initially explained the core principles involved with OTC derivative trading and the differences faced by end-users depending on whether the derivative is traded bilaterally or cleared through a CCP. After establishing the key differences between the two trading environments, a key contribution of this thesis has been the creation of a framework that enables end-users to assess the expected impact of the clearing requirement by comparing costs specific to bilateral and cleared swaps in an intuitive manner. Providing their own data to the framework, end-users are able to assess the implications of EMIR's clearing requirement on their portfolios. The framework has been constructed with interest rate swaps in mind, but the basic principle extends to other derivative types as well. First, end-user and dealer expenses related to bilateral counterparty credit risk are priced per notional through considerations on probability of counterparty credit spreads and the expected positive contract values. While the intuition is simple, modeling of contract counterparty risk can be very complex depending on the required precision. The portfolio drag from this estimate is then compared to the drag from risk management processes and fees specific to the clearing process. The comparison should be performed based on the net outstanding notional. Therefore, if netting arrangements between cleared and bilateral contracts yield different degrees of efficiency, the notionals required for cleared and bilateral contracts should simply be adjusted to accurately reflect the net outstandings. The framework includes a practical although simple tool for estimating the expected positive exposure on interest rate derivatives under standard bilateral trading practices.

The results indicated that clearing us not a cost-efficient solution to eliminating counterparty credit risk in bilateral contracts, even when counterparty credit spreads are high.

A fairly strong argument can be made that if central clearing indeed was a cost efficient solution to offsetting counterparty credit risk, then the market would have adopted the practice without regulator intervention. What is evident at current time is that EMIR's clearing requirement will bring the following:

1. Large changes to the OTC derivatives industry
2. Significant costs to OTC derivatives end-users
3. Profits for the clearing houses, which are private entities

In terms of end-user potential for mitigation, the analysis showed no linear advantage from choosing one maturity over another to hedge the interest rate risk. However, the findings did show the choice of maturity was not without significance in the modeled situation. To reduce the costs of hedging, a derivative end-user could also consider reducing the positions in OTC interest rate derivatives in favor of alternative products. Such a procedure could for instance be to hedge the majority of interest rate risk through listed futures and cash bond positions, only to fine-tune the risk management using OTC derivatives. When investigating whether to use alternative hedging instruments, the end-user should consider the total costs involved with using each instrument, including a pricing of potential hedging inaccuracies inolved with product standardisations.

The industry competition was found best described as a Bertrand problem with switching costs and economies of scale. It was shown that the incentives and abilities of the CCP to extract rent from its users and balance risk management requirements were dependent on their ownership structure, supporting the conclusions of Koeppl and Monnet (2009). It was also found that the clearing members actively participate in ensuring adequate risk management requirements, which goes against the suggestions of Miller (2011) and Cayseele (2004). This dynamic should be of positive interest for regulators. The most expensive industry scenario for end-users were found to be when a CCP is incentivised to increase clearing fees and risk management requirements. This scenario could likely occur under a non-user monopolist. If the monopolist reverted to levels mimicing the BIS standard risk management requirements and tripled their fees, the end-user costs of clearing were found to be almost twice as high as the current scenario. Based on the ranges in potential costs, it should certainly be of interest for both end-users and regulators alike to identify the optimal CCP industry structure, weighing risks and user costs.

From an economical point of view, a main area of interest lies in the potential market inefficiency caused by central clearing. As long as funds are reinvested efficiently, it is less important who reaps the profits. The question is then whether central clearing is the most efficient method for reducing counterparty credit risk. If end-users were to reduce their counterparty risk towards a specific dealer, they could buy insurance on the contract from another dealer. In this case it is necessary to consider wrong-way risk, which is the potential increased probability that the insurer defaults on their end of the contract once it is needed. However, regulators themselves seem to think that wrong-way risk is also present in cleared contracts, as these contracts are still subject to capital requirements. In bilateral contracts, the variation margin and insurance premiums do not constitute economic inefficiencies as the recipient is free to reinvest. However, regulatory capital requirements towards the dealers do, as locking up these funds represents an opportunity costs. In cleared contracts, variation margin and clearing fees also do not constitute economic inefficiencies, but the initial margin and default fund contributions do, as these funds are not reinvested. An interesting question then remains; how much capital is locked up for a cleared OTC swap compared to a bilateral swap insured through a CDS, and what is the actual counterparty credit risk for each contract after taking wrong-way risk into account?

It is not clear at this point whether the capital locked up as initial margin and default fund contribution fairly offsets counterparty credit risk and dealer regulatory capital under bilateral contracts, but given the amounts of cash considered, it is suprising that the area still lacks sufficient quantitative research.

8.1 Critique

To answer the research questions in an approachable manner within the thesis scope, it has been necessary to make a range of assumptions. The thesis stated the assumption as they became necessary, why a list of key assumptions has been compiled in Appendix A for reader convenience. An overall goal was to arrive at the results through systematic observation, control and replication. As this thesis has been exploratory in multiple areas, systematic observation and elimination of alternative explanations has not always been possible. An attempt was made to ensure that framework explanations, but at times only few representative data points were available. At such times, the limitations in data were stated to hopefully allow other researchers to expand on the data pool. To enable replication of the findings, the data sets used throughout the thesis have been added to Appendix B. This part will initially revisit the overall choice of method for each of the three sections; Section 4: Impact Factors, Section 5: CCP Industry Structure, and Section 6: Backtest Application to evaluate the robustness of results, and how well they lend themselves to generalisation. Then, the key assumptions are considered for each section to assess their severity and consequences for the validity of the results.

Concerning Section 4: Impact Factors

In building a generally applicable framework for impact assessment, the thesis aimed towards high external validity, focusing on identifying the core factors associated with counterparty credit risk and the costs of clearing. Doing so may have come at the expense of internal validity and application of the framework in highly specific contexts. For instance, the framework does not consider operational costs associated with moving from bilateral to cleared contracts nor the differences in liquidity risks, which may very well be amongst the most important issues for end-users who must expense substantial changes to their current setup or who run tight cash management strategies.

To provide a simple estimation method, this section has contained a number of assumptions on the end-user and dealer trading environment, on the OTC interest rate swap contracts themselves, and finally on dealer expenses, risks and their pricing.

The first assumption on end-user and dealer trading environment supposes that the modeled end-user trades through a single dealer, using a single CM at a single CCP. In actuality the end-user might be using multiple dealers for bilateral trades, or multiple CCPs for cleared trades, which in both cases would reduce the netting efficiency, which in turn would increase the costs associated with either trading environment. The end-user was also assumed to have no prior trades outstanding at time of first contract, which again is related to netting. The assumption allows for a simpler and perhaps more fair comparison between the two trading systems, as the initial expenses from moving outstanding contracts are not considered. However, such a transitional procedure is likely to represent a one-off cost for the end-user that is worth considering.

It was assumed that counterparty credit risk from cleared contracts was zero. Given the Basel III capital requirements on cleared contracts, it is clear that regulators do not share this assumption. In any case where the probability of a CCP default is non-zero, the end-user should price the issue similar to the bilateral risk valuation (ERV). This assumption therefore leads the framework to underestimate the costs of clearing, although the significance depends largely on the actual probability of a CCP default. Also, counterparty hazard rate was for modeling simplicity assumed to be constant across the maturity of the interest rate swap. This assumption certainly leads to imprecision in the modeling of costs of counterparty credit risk, although its effect depends on whether hazard rates fall or rise. Hazard rates were proxied through credit spreads for the swap maturity, which should include the market interpretation of likely changes in default probabilities across the time period. Therefore, the assumption of constant hazard rates should be of limited significance. The expected exposure was also assumed to be constant over time. While this simplification is a source of imprecision, using the time-average expected exposure should not have any predictable impact on whether the exposure estimates are too large or too small.

The dealer was assumed to not incur costs from risk management practices or clearing-related fees. If the dealer incurs costs associated with clearing their end of the contract, then these costs should be priced to the end-user to ensure dealer profitability. In that case it is likely that the costs of clearing are underestimated. It was also assumed that dealer market risk, operational risk, liquidity risk and funding costs were similar for cleared and bilateral contracts. In actuality, the liquidity risk from cleared contracts is likely higher than for bilateral contracts, as the CCPs require intra-day margining as opposed to usual daily margining in bilateral contracts (Murphy, 2013), which means that the dealers must ensure that cash can be ready at shorter notices for cleared trades. If this requirement is at a cost for the dealer, it should also be priced to the end-user, in which case the current framework would underestimate the costs of clearing.

Dealer profit margins were assumed similar for cleared and bilateral contracts, which was necessary as no information was available on their sizes under each type of contract. Market players were found to generally estimate that the dealer profit margins would decrease following increased pricing transparency from electronic trading platforms and standardisation associated with cleared trades. In this case, the current framework likely overestimates the costs of clearing significantly, as the reduction in profit margin for cleared trades should be modeled. However, while these factors might be spurred by the move towards clearing, there is little reason why efficient trading platforms and increased standardisation should not also be possible for bilateral contracts.

It was assumed that while positive counterparty credit risk (CVA) is priced into the spread at face value, negative dealer CVA on subsequent offsetting trades is not priced. Similarly, it was assumed that end-user rebates from dealer probability of default (DVA) was not priced into the spread, as these rebates should be considered not at absolute value but in relation to other possible dealers. If negative CVA and DVA is indeed priced into the spread, then the framework significantly overestimates end-user costs related to counterparty risk in bilateral contracts. It was also assumed that dealer regulatory capital requirements were equivalent bar the difference in capital requirements from counterparty credit risk. This assumption does seem to hold (Hull, 2012a), as long as netting is equally efficient for bilateral and cleared contracts. However, if netting is not equal, then all capital requirements should be considered to adjust for exposure differences, which would complicate the framework. Since it is not clear whether cleared or bilateral contracts will enjoy the greatest netting efficiency, the directional effect of this assumption is unknown.

Finally, when assessing the end-user counterparty credit risk, potential changes in bid-ask spreads around dealer defaults were not considered. It is reasonable to propose that dealer defaults would reduce market liquidity, in which case the bid-ask spreads would increase at a cost for the end-user. In that case, the framework underestimates the costs associated with bilateral counterparty credit risk.

Some cost factors, especially those associated with locking up second party funds (CRC and default fund contribition), proved exceedingly difficult to estimate as they depend heavily on second party overall portfolio positions and costs of capital. These factors were estimated as best as possible through market player reports, although estimate precision is likely to be poor. All in all, the framework precision is severely limited by the amount of assumptions and lack of available data, meaning that the output should be regarded only as rough estimates.

Concerning Section 5: CCP Industry Structure

The clearing industry structure analysis attempted to identify the nature of competition between the CCPs to make inferences on likely industry equilibria. All CCPs were assumed able to supply the entire market, and CCPs were assumed unable to price discriminate. Further investigation of these assumptions and subsequent modeling might help exclude some of the considered scenarios, bringing better precision to the range of potential developments in end-user costs of clearing. The suggested factor impacts of each industry scenario were based on related practices where available. However, in most cases the suggestions were unfortunately backed up by little to no evidence. Therefore, the scenario consequences should rather be perceived as a sensitivity analysis of end-user costs associated with factor changes.

Concerning Section 6: Backtest Application

The framework was applied to an illustrative case study to exemplify how end-user cost differences between using cleared and bilateral contracts in terms of portfolio drag. The costs in terms of portfolio drag depends on the return structure of the original portfolio, and how the value of the traded swaps changes during the period of analysis. Therefore, the results obtained through the case study should be seen as indicative though not generally representative. As IM requirements withdrew significant amounts of cash from the cleared portfolio, the required dollar duration and thereby notional of subsequent swaps was different between rebalancing dates for cleared and bilateral contracts, which in turn caused the shared VM requirements to have different effects. The effect of VM requirements was negative in this case, but can be positive if swaps are in the money for the duration. To provide a more generally fair cost comparison, notionals were kept fixed across rebalancing dates for both the bilateral and cleared contract. To provide generalisable drag estimates, the framework should be applied across multiple cases to find an estimated average effect.

The backtest also included three necessary assumptions. Short term interest rate movements were for processing reasons assumed represented by the normal distribution. In reality, the normality assumption does not apply well to the changes in market value of many derivatives positions, as derivatives often exhibit heavily skewed and fat-tailed market values primarily due to jump-to-default risk (Duffie and Zhu, 2011). If a distribution with fatter tails is used, such as the t-distribution, then the expected EPE estimates should be larger, which means that the costs associated with bilateral counterparty credit risk are underestimated. Also, it was based on market player reports assumed that the unwinding of defaulted contracts were subject to a ten-day grace period. If this period is smaller (larger) in reality, then the expected EPE estimates should be larger (smaller), which would imply that costs associated with bilateral counterparty credit risk were underestimated (overestimated). Finally, the daily interest rate movements were calibrated by using monthly rather than daily data. This is a cause of imprecision, as the modeled daily interest rate movements and mean reversion was not consistent with actual daily movements, but rather an average daily movements based on monthly characteristics. The fact that the original daily dataset broke the mean reversion assumption indicates that the Vasicek model in its simplicity is a poor indicator of actual interest rate movements. The Vasicek model was also shown to lend itself poorly to valuation of interest rate swaps, as it did not take into account that forward rates are different from the spot rate. A more sophisticated model of the short term interest rate, such as the Hull-White model, would therefore likely yield more precise results.

In summary, the backtest application allowed for testing of the framework on a specific situation, which provided valuable learning points on interest rate and exposure modeling. The backtest also showed that the framework was able to provide an intuitive comparison of end-user costs from the clearing requirement. However, in applying the framework to a single situation, the results are indicative but not generalisable. However, using the framework to investigate an average effect through additional cases should now be a straight forward if perhaps time consuming process.

9 Conclusion

The goal of this thesis has been to shed light on the end-user impact of the European clearing requirement. In order to do so, the end-user costs of clearing were compared to the expenses associated with counterparty credit risk in standard bilateral interest rate swap contracts. The indicative results could not reject the hypothesis that EMIR's clearing requirement will lead to more expensive business processes for the end-user. In fact, the results suggested strongly that clearing is not a cost-efficient solution to reducing counterparty credit risk in bilateral contracts.

A framework for end-user assessment of the immediate impact was developed based on transaction cost economics theory and current standard practices for bilateral and cleared contracts. For assessment of the costs associated with counterparty credit risk in bilateral contracts, the framework considered standard bilateral risk management practices and offered a tool for estimating remaining dealer and end-user expected counterparty exposure and pricing these exposures into a per-notional spread. It was estimated that the expected positive exposure of a five year interest rate swap contract with a standard daily variation margin agreement was around 0,017% of the notional value given daily variation margin and a ten-day grace period for liquidating defaulted contracts.

To estimate the costs associated with eliminating counterparty credit risk through clearing, the framework considered the additional management requirements and fees specific to cleared contracts, under the assumption that clearing completely offsets any counterparty credit risk. Through a backtest application, an estimate was made on the portfolio drag associated with removing portfolio cash to meet bilateral risk management requirements, to cover dealer expenses related to counterparty credit risk (CVA and CRC), and to cover end-user expenses related to counterparty credit risk (ERV). This estimate was compared to the drag associated with removing cash from the portfolio to meet CCP risk management requirements and cover clearing fees. The backtest base case considered credit spreads from a mainstay insurance company (Allianz) and dealer (Barclays) on the initiation date. In this case, the portfolio drag from clearing was found to exceed the drag associated with bilateral counterparty credit risk by a factor of 63. The initial margin requirement was found to be the primary contributor to clearing-specific portfolio drag. It should be noted that the results were obtained based on a single situation case study and is therefore indicative though not representative of general costs. However, to provide information on the efficiency of clearing under stressed market conditions, bilateral drag from ten-year high credit spreads of an insurance company affected heavily by the financial crisis (Assicurazioni Generali) and the dealer (Barclays) were investigated. In this situation, end-user portfolio drag from clearing exceeded the drag associated with bilateral counterparty credit risk by a factor of 24.

As the clearing industry is still in its infancy, long-term costs of clearing were suggested based on a CCP industry structure analysis. Starting with a formal analysis, it was clarified that whether the long-term equilibrium structure is a monopoly or oligopoly depends on the ratio of switching costs to economies of scale. It was also shown that as long as CCPs were unable to price discriminate, switching costs were beneficial to both the market leader and its competitors, why interoperability agreements to remove these costs were seen as unlikely. To build on the formal analysis, a more qualitative approach was taken to introduce bargaining power and incentives of relevant stakeholders, who were the end-users, the clearing members, regulators, and finally the derivative exchanges who own the three current interest rate CCPs in part or in full. The stakeholder bargaining power analysis was used to both identify potential scenarios, including different monopoly ownership structures, and describe the competitive situation under each scenario to suggest potential end-user consequences in terms of increases or decreases in the key impact factors identified in the cost framework. An exchange-owned or other rent seeking monopolist was argued to be the most expensive industry structure for end-users, as such a CCP would have a clear incentive to increase both risk management requirements and clearing fees. If risk management requirements were set to BIS standard levels and fees were tripled, the portfolio drag from the clearing process was found to exceed the drag related to bilateral counterparty credit risk by a factor of 121. In industry scenarios where end-users were found to enjoy high bargaining power, the bargaining power of regulators and clearing members was also high. Clearing members have through boycotts shown strong reluctance against decreases in risk management requirements, why it was suggested that a competitive scenario would not result in lower risk management requirements. If fees are removed but risk management requirements stay the same, the portfolio drag from clearing was still found to exceed the bilateral drag by a factor of 62.

Following these results, the end-user should consider whether OTC interest rate swaps are still the most cost-efficient solution to hedging unwanted interest rate exposure. An alternative strategy could be to use cash bonds or standard listed interest rate futures to hedge the bulk of the exposure, and only use OTC derivatives to fine-tune the exposure hedge. If considering a change of hedging strategy, the end-user should consider all costs associated with using the available instruments. Some of these costs are not included in the framework developed in this thesis, e.g. operational costs and dealer profit margins.

9.1 Potential for future research

As outlined in Section 8.1: Critique, this thesis contains a number of inaccuracies that lead to imprecise results. To ensure that the estimates obtained by the framework are accurate, a logical step for further research would be to test the assumptions made throughout the thesis. If an assumption is found to influence factor sizes, the framework should be corrected to ensure fair estimates. To ensure better estimates of difficult-to-model cost factors, three things should be known; (i) the marginal contribution of an interest rate swap contract to dealer and clearing member portfolio, (ii) the capital requirements associated with on this contribution, and (iii) the cost of capital of the dealer or clearing member. Further, the framework did not consider all potentially relevant cost factors. An expansion of the framework to compare total costs across derivative and contract types could aid end-users to identify the most efficient use of risk management instruments.

The potential clearing industry structure scenarios and their consequences for end-user costs are worthy of additional investigation. Theoretical studies are already available on the relative efficiency of different industry structures, but it is not yet clear what the likely outcomes are and how they influence end-user costs of clearing. Now that the clearing industry is definitely here to stay, a comprehensive study could provide regulators with valuable insight as to how the industry can reach highest efficiency in terms of low user costs while maintaing reasonable robustness.

Once the cost comparison framework and industry structure analysis brings a sufficient level of accuracy, a generalisable study based on multiple case studies could provide regulators and end-users with clear estimates on the costs associated with clearing and counterparty credit risk. Such information is valuable, as it (i) facilitates cost-benefit analyses on developments in the clearing industry structure and (ii) it enables end-users to more accurately consider the costs associated with using derivaives as risk management instruments.

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Appendix A: List of Assumptions

4. Impact Factors

Assumptions on end-user and dealer trading environment

1. The modeled end-user trades through a single dealer, using a single CM at a single CCP.
2. The modeled end-user has no prior trades outstanding at time of first contract
3. The dealer is able to offset immediately offset market risk for any position.

Assumptions on dealer costs, risks and pricing

1. Dealer does not incur costs from risk management practices or clearing-related fees.
2. Dealer market risk, operational risk, liquidity risk and funding costs are assumed similar for cleared and bilateral contracts.
3. Dealer profit margins are assumed similar for cleared and bilateral contracts
4. The dealer prices positive counterparty credit risk (CVA) at face value, while negative CVA on subsequent offsetting trades is not priced into the spread.
5. End-user rebates from dealer probability of default (DVA) is not priced into the dealer spread.
6. Dealer capital requirements are equivalent bar the difference in counterparty credit risk.

Assumptions on interest rate swap contracts

1. Counterparty credit risk from cleared derivatives is zero.
2. Counterparty default probability constant over time.
3. Expected exposure constant over time.
4. Symmetrical distributions for exposure; expected negative exposure equals expected positive exposure.

5. CCP Industry Structure

Assumptions on CCP competition

1. All CCPs have the capacity to supply the entire market.
2. CCPs cannot price discriminate.

6. Backtest Application

Assumptions on interest rate swap contracts

1. Short term interest rate movements are represented by the normal distribution.

2. Ten-day grace period for unwinding defaulted contracts.

3. Mean reversion in short-term interest rate movements;$\kappa \in (0, 1)$

Appendix B: Tools and Datasets

For tools and datasets developed and used throughout this thesis, please refer to the attached CD. The CD contains the following spreadsheets used to arrive at the estimates presented in this thesis:

- *EPE Vasicek Monte Carlo 2Y 360.xlsm*
- *EPE Vasicek Monte Carlo 5Y 360.xlsm*
- *EPE Vasicek Monte Carlo 8Y 360.xlsm*
- *Portfolio Drag Estimation.xlsm*
- *Vasicek Parameter Estimation.xlsm*

The CD also contains the datasets extracted from the Bloomberg Professional Service. These spreadsheets are:

- *BERC Index HP.xlsx*
- *EURIBOR 6M HP Daily.xlsx*
- *IRS Durations.xlsx*
- *Swap Rates.xlsx*