Central clearing configurations: implications for South African derivative markets

by

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Submitted in fulfilment of the requirements
for the degree
Master of Science in Financial Engineering

in the Faculty of Natural & Agricultural Sciences

University of Pretoria
Pretoria

February 2021

SUMMARY

CENTRAL CLEARING CONFIGURATIONS: IMPLICATIONS FOR SOUTH AFRICAN DERIVATIVE MARKETS

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Keywords:	Central counterparty, counterparty credit, over-the-counter derivatives, netting, central clearing, exchange traded derivative.

After the financial crisis of 2008-2009, central counterparties (CCPs) emerged as an important mechanism to mitigate against counterparty credit risk and stem the spread of contagion in a time of crisis. Trading in derivative instruments, especially opaque, illiquid and complex instruments, were seen as the cause of much of the quagmire in which the global economy found itself. At the Pittsburgh summit in 2009, the Group of 20 Nations (G20) made some fundamental commitments on the reform of international derivatives markets. One of the main commitments was to have standardised OTC derivatives cleared through central counterparties by the year 2020. In South Africa, the only CCP is the clearing house for exchange traded derivatives operated by the Johannesburg Stock Exchange (JSE); five major South African banks are direct clearing members of JSE Clear. Most of the standardised OTC derivative transactions are interest rate, and to a much lesser degree forex, in nature. The London Clearing House (LCH) clears the vast majority of centrally cleared ZAR interest rate swaps. All South African banks clear most of their trades executed with foreign counterparts at LCH but only one has a subsidiary that is a direct clearing member of LCH. There is a large amount of ZAR interest rate swap activity in SA which is not centrally cleared. This study examines the efficiency and dynamics of central clearing in this setting. It further notes the recent developments in the current central clearing landscape and compares aspects thereof in South Africa to international CCPs. The framework developed by Duffie & Zhu (2011) is then used to examine efficiencies of different configurations of central clearing of derivatives in the South African context.

To my wife

Michelle Saayman

for her patience and support;
for believing there is more in me than what there is.

“Put all your eggs in one basket and watch that basket.”

Andrew Carnegie (1835-1919)

American industrialist

DECLARATION

I, Terence Saayman, declare that the dissertation, which I hereby submit for the degree Master of Science at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Signature: 

Student name: Ammi Terence Saayman

Month Year: February 2021

ETHICS STATEMENT

The author, whose name appears on the title page of this dissertation/thesis, has obtained, for the research described in this work, the applicable research ethics approval.

The author declares that he has observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for Researchers and the Policy guidelines for responsible research.

Signature:

Student name: Ammi Terence Saayman

Month Year: February 2021

ACKNOWLEDGEMENTS

Immeasurable appreciation and profound gratitude are owed to the following persons who through generous support in one way or another have contributed in making this research possible.

Ammi and Elizabeth Saayman, without whose stimulation and encouragement this research would not have been contemplated.

Prof. van Vuuren, Supervisor, guide and enthusiastic supporter, for his wisdom, proactive engagement and encouragement.

Prof. Mare, Senior lecturer and financial risk professional, for his mentorship prior to post-graduate study and practical support throughout the course of this degree.

Charlotte Saayman, for assistance in hedging.

Friends in the business of clearing, particularly L. Cockeran, P. du Preez and W.K. Kuys whose debates on central clearing, the South African financial market, human behaviour and philosophy have all been both edifying and entertaining.

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GLOSSARY OF TERMS AND ABBREVIATIONS

Term	Meaning
BCBS	Basel Committee on Banking Supervision
BIS	Bank for International Settlements
bn	billion
CBOT	Chicago Board of Trade
CCP	Central counterparty
Central clearing	The process by which a single corporation interposes itself between counterparties to trades and ensures net settlement
Clearing	As it pertains to financial transactions, the process of aggregating, netting and underwriting transactions in financial markets
CLAM	Caisse de Liquidation des Affaires de Merchendises
CME	Chicago Mercantile Exchange
Counterparty	The person with whom a transaction is concluded and who has to fulfil obligations of the contract
CPMI	Committee on Payments and Market infrastructures
CSA	Credit Supplement Agreement
CSD	Central Securities Depositary
Derivative	A contract, the pay-off and value of which is derived from an underlying asset
DF	Default Fund
ES	Expected Shortfall, the amount an investor expects to lose when the loss is greater than the VaR at the same parameters
ETD	Exchange traded derivatives
FMA	Financial Markets Act No. 19 of 2012, provided for the regulation of financial market and the licencing of FMIs
FMI	Financial Market Infrastructure, a term used to collectively refer to the institutions that facilitate the function of financial markets, namely exchanges, clearing houses and central counterparties, central securities depositories and trade repositories
Forex	Foreign exchange
FRA	Forward rate agreement
FSCA	Financial Sector Conduct Authority, formed by the FSRA and preceded by the Financial Services Board. The FSCA is responsible for the conduct regulation of financial institutions in South Africa, including FMIs
FSRA	Financial Sector Regulation Act, establishing a "twin peaks" (prudential and conduct) regulatory system in South Africa
G20	Group of 20 Nations

G30	Groups of 30 Nations
GDP	Gross domestic product, the value of the goods and services produced over a period (most commonly a year)
ICE	Intercontinental Exchange
IM	Initial margin, the amount of financial resources required to secure future performance on a single or group of financial transactions
IMF	International Monetary Fund
IOSCO	International Organisation of Securities Commissions
ISDA	International Swaps and Derivatives Association
JSCC	Japan Securities Clearing Corporation
JSE	Johannesburg Stock Exchange
LCH	London Clearing House
LTCM	Long-Term Capital Management, a large hedge fund that lost most of its value in 1998
m	Million
OTC	Over-the-counter; in the context of financial markets, refers to transactions and contracts, the terms of which are negotiated and traded between two counterparties, away from an exchange
PA	Prudential Authority, formed by the FSRA and preceded in part by the banking supervision division of the SARB. The PA is responsible for the prudential regulation of financial institutions in South Africa, including FMIs
PFMI	Principles for Financial Market infrastructures
PTU	Partial tear-up
SARB	South African Reserve Bank
SSA	Securities Services Act No. 36 of 2004, repealed by the FMA. The SSA consolidated the laws regarding exchanges and securities trading and provided for the licensing of a clearing house
tn	trillion
VaR	Value at Risk, specified for a given confidence interval and holding period. For a 95% 5-day VaR of 1,000; the investor does not expect to lose more than 1,000 over a 5-day period 95% of the time
VM	Variation margin, profit and losses regularly exchanged between parties
VMGH	Variation margin gains haircutting

CHAPTER 1 CENTRAL COUNTERPARTY CLEARING

A CCP is a type of market infrastructure that interposes itself between trades. Upon acceptance of a trade, the CCP becomes the buyer to the seller and the seller to the buyer; the original trade is novated by the CCP and two new contracts are created, one for the seller and one for the buyer. The CCP is then a counterparty to every trade that it clears and has a net position of zero in each contract it clears.

In a bilateral setting each counterparty nets exposures between each other counterparty across asset classes. Netting occurs at an entity level and hence a CCP has the potential to dramatically reduce the amount of exposure between entities through netting offsetting exposures. Collateral will be exchanged between the counterparties depending on the amount of residual risk between them. From time to time, normally daily, this amount will be recalculated and exchanged to reduce exposure. Figure 1.1 shows the exposures and flows of collateral in a bilateral clearing setting.

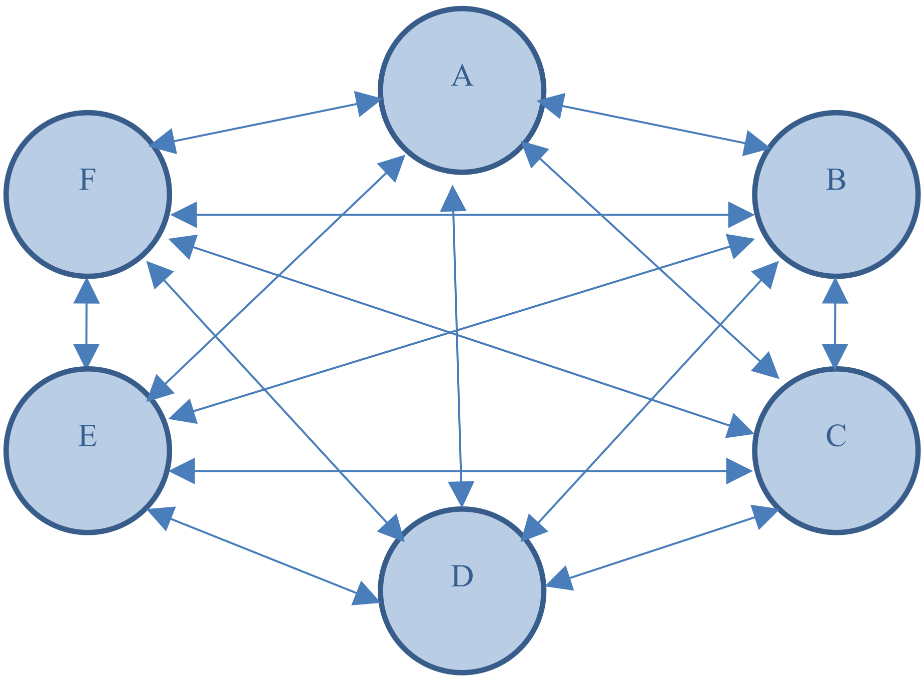

***Figure 1.1*:** Bilateral exposures and collateral flows. Circles A-F represent counterparties to derivative transactions that trade with multiple other counterparties; arrows represent the netting relationship and flow of collateral.

Each counterparty deals with every other counterparty in the market. In the presence of N counterparties there are then $N(N-1)/2$ counterparty pairs. Where there are six counterparts and profits and losses are exchanged daily, there are 15 exchanges of money and collateral daily with the appropriate supporting teams of operational staff and reconciliations being performed.

In a cleared market, collateral is posted to the CCP and daily the mark-to-market profits and losses are exchanged. Where there are six counterparts and profits and losses are exchanged daily, there are now only six exchanges of money and collateral daily. This limits the build-up of exposure. The number of counterparty pairs reduces to N. Figure 1.2 shows the resulting exposures and flows.

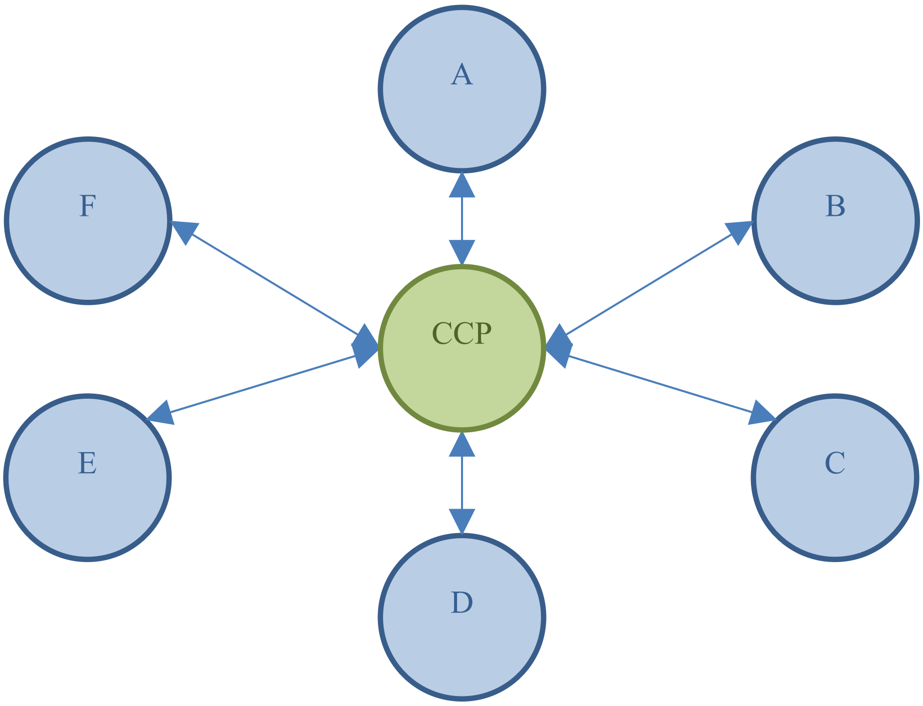

Figure 1.2: Exposures and flows in a CCP setting. Circles A-F represent counterparties to trades, Circle CCP represents the CCP that novates trades with each counterparty, arrows represent netting relationships, flow of collateral and daily mark-to-market profit and loss exchange.

It is clear that the presence of a CCP reduces the number of counterparty pairs when whole markets are cleared. When only some of the exposures between counterparties are cleared, existing netting sets are disturbed and new ones created (Pirrong, 2009). Pirrong (2009) and Duffie & Zhu (2011) show that the introduction of a CCP does not always reduce aggregate exposure.

Figures 1.1 and 1.2 show there is a benefit in terms of operational risk in reducing the number of counterparty pairs. The reduction in the number of counterparty connections means that there are fewer payments, reconciliations and records required. The investigation and quantification of this benefit, however, falls outside the scope of this study. We will investigate the potential benefit of netting across counterparties for a portion of asset classes is investigated against netting across asset class per counterparty.

Bernsden (2020) found that 60% of the literature regarding CCPs has been published since 2015 and argues that this literature addresses five important questions. These are: whether to clear, determining the optimal number of CCPs in a market, establishing whether the default waterfall is sufficient, market consequences if the waterfall is exhausted and the role of the degree of skin-in-the-game. This study focuses on the first of these two questions.

1.1. OBJECTIVES

1.1.1. Considerations for CCPs in the South African derivatives market

We study central counterparty clearing in derivatives markets and highlight issues pertaining to the South African market. The study first aims to highlight considerations for CCPs as financial institutions in South Africa and their risk management.

1.1.2. Counterparty exposure measurement

The second main objective is to measure the effect on counterparty credit exposure of various clearing configurations in the South African milieu.

1.1.2.1. Increased clearing in South Africa

When measuring the impact of different clearing configurations, we aim primarily to determine whether, in the South African context, it will benefit participants to increase the level of clearing of OTC derivatives.

1.1.2.2. Specific asset class clearing

We aim to determine which asset class derivatives, when cleared, would provide the greatest benefit to exposures across the system.

1.1.2.3. Clearing location

Further, we investigate whether the location of clearing has a material impact on the exposures between dealers.

1.1.2.4. Concentration and market volatility

We also aim to determine whether some characteristics of the South African market, including concentration and market volatility, affect the results.

1.2. DISSERTATION STRUCTURE

This dissertation is structured as follows: in Chapter 2 we will briefly discuss the history of derivatives central clearing Some CCP failures are described and reasons for their failure are highlighted. The chapter concludes with a short description of the clearing environment in South Africa and the IMF's recommendation to mandate central clearing. This is followed by a short description of counterparty credit risk in Chapter 3 along with an overview of the business of central clearing. Chapter 3 concludes by highlighting some important differences between CCPs and other financial institutions that require unique tools for the risk management and regulation of CCPs.

Chapter 4 describes the CCP environment and its stakeholders in more detail. The participants involved in central clearing are discussed after which incentives involved in clearing are considered. Some issues regarding the structure of a CCP and a cleared markets are considered A description of CCP risk management follows in Chapter 5. The various aspects of counterparty credit risk management within a CCP are investigated which provides insight into CCP resilience.

A short description of the financial crisis is provided in Chapter 6 as background for the subsequent reforms in CCP regulation. This is followed by an introduction of netting efficiencies and the South African market.

In Chapter 8 the data used to implement the model of Duffie & Zhu (2011) are described. This is followed by a description of the model in Chapter 9 and a discussion of the results in Chapter 10. Chapter 11 concludes and provides suggestions for further research opportunities.

CHAPTER 2 HISTORICAL CONTEXT

2.1. A BRIEF HISTORY OF CENTRAL COUNTERPARTY CLEARING

It is unclear when the practice of clearing began. Babylonian archaeological discoveries describe how commodity derivatives were traded about 1750 BC. The tablets of Hammurabi show that these derivatives (like current futures contracts) were traded and that some even had embedded option characteristics. The tablets describe in detail the terms of the contract and solidified a common understanding of what was agreed (Kummer & Pauletto, 2012).

Various forms of netting and clearing have existed alongside active markets for a considerable time. Norman (2011) puts forward the *loges des Changes* in Lyons – built around 1630 – as the first CCP. Further, Norman (2011) notes that the LCH had its beginnings in meeting room alongside a pub in 1773 where bankers exchanged cheques, bills and notes, thus negating the need for clerks to visit each counterparty bank. While this did not start out as a clearing house with netting arrangements, it was the beginnings of settlement agents meeting to make the process of cross settlement efficient in a multi-party market.

In Japan, the Dojima Rice Exchange was officially recognised as an exchange by the authorities in 1715 after being operational for some time (Kummer & Pauletto, 2012). The exchange required formal trader registration and the requirement of a license to trade which was given for a fee. Clearing houses were established to support the Dojima Rice Exchange. These clearing houses guaranteed the settlement of rice derivative contracts traded on the exchange. There were 60 clearing houses registered in the first half of the 18^{th} century (Kummer & Pauletto, 2012). In the 19^{th} century the Dojima rice market ran into difficulties and the number of clearing houses had shrunk to just four (Norman, 2011).

The first derivatives exchange to appear in America was the Chicago Board of Trade (CBOT) in 1848 (Kummer & Pauletto, 2012), established for the trading of grain. It is the oldest organised futures market still operating in the world although it merged with the Chicago Mercantile Exchange (CME) in 2007. During the second half of the 19^{th} century a clearing house was introduced to reduce counterparty risk.

Vuillemey, (2018) asserts that first real modern day central counterparty was the coffee market in France at La Havre established in 1882. The success of the CCP in reducing price volatility and stabilising production prompted nine other European exchanges to adopt a central clearing model within a decade.

CCPs developed differently in different parts of the world due to varying rates of innovation, levels of regulation and underlying economic activity. The Bank for International Settlements (BIS) emerged as the standard setter for bank regulators and the International Securities Commission (IOSCO) for exchanges and securities firms. Together they have collaborated to set standards for other financial market infrastructures including CCPs (BIS, 2012b).

CCPs have proved to be a robust way of managing counterparty credit risk (Norman, 2011). There have been crises within the central clearing industry, even involving CCP failuers as noted below. However these must be noted against the background of the number of counterparty failures central counterparties have handled successfully, the consequences of not having had a CCP in the situations in which they failed and the day-to-day benefits and efficiencies these infrastructures provide to the financial markets.

The existence of CCPs has also enabled technological developments in trading. Without a central counterparty price discovery quickly becomes inefficient as counterparties require the consideration of the credit quality of their trading partners to be incorporated into the price of every transaction. CCPs standardise credit quality of counterparts and management of collateral and, to a large degree, the cost of trade management.

2.1.1. Central counterparty failures

A CCP failure is an uncommon event. This is partly because there are fewer CCPs relative to other financial institutions and the CCP structure itself reduces risk and hence the probability that the firm will fail is, as a rule, smaller than that of other financial institutions.

2.1.1.1. Caisse de Liquidation des Affaires en Merchandises

The first notable failure of a modern central counterparty was that of the Caisse de Liquidation des Affaires en Merchandises (CLAM) in 1974. The CLAM was set up in La Havre in France in 1882 for the clearing of coffee futures (Vuillemey, 2020). By the 1970s the CLAM's main business was clearing commodities and in particular it cleared a large number of sugar futures. White sugar prices had increased more than fourfold in the first 11 months of 1974 as several countries experienced a shortage of sugar. Market consensus was that this shortage was structural in nature and that it would be sustained. By the end of October Maurice Nataf had a position of approximately 30% of the open interest in sugar cleared through the CLAM. By the end of November Nataf and his clients had increased the size of that long position to approximately 56% of the open interest with the CLAM. The position was held in various unsophisticated retail investors' accounts which, when the price began to fall, could not make variation margin calls on their positions. Further to the simple magnitude of the position and inability to meet variation margin calls, the CCP had not increased initial margin requirements when the volatility in the sugar price increased (Bignon & Vuillemey, 2020).

In November of 1974 there was a precipitous correction to the sugar price. At the beginning of December of that year Nataf informed the CCP that he was unable to honour margin payments after suffering large losses (Bignon and Vuillemey, 2020). It soon became clear that the CLAM would not be able to find participants to take the positions of those who were unable to make margin calls. This ultimately led to the closure of the market and the failure of the CCP (Norman, 2011).

Besides risk management failures regarding the size of positions and margin maintenance, the management of the default process has been highlighted as inadequate by the Bank of England (Norman, 2011). The CLAM delayed the declaration of default in the hope that the price move would reverse. This was a call by the CCP to exchange a certain loss for a bet in which the loss could be greater than presented them at the time or potentially zero. The CCP lost the bet. Should the default have been called earlier, the CCP would have been able to absorb the losses up to that stage. By delaying the default, the loss to be absorbed by the CLAM simply became larger than they could fund (Norman, 2011).

2.1.1.2. Kuala Lumpur Commodities Clearing House

The Kuala Lumpur Commodities Clearing House was established in 1980 to clear trades executed on the Kuala Lumpur Commodity Exchange. In 1983 a crash in palm oil futures led to the default of six large brokers. At the time of their default these six brokers had amassed extremely large long positions in palm oil and when the price declined, they could not meet their variation margin calls. Like the CLAM, the CCP had not increased initial margin requirements in response to increased volatility in prices (Norman, 2011).

Over the period of the default there was insufficient coordination between the clearing house and the exchange and trading could continue despite a clearing crisis unfolding. Other lax back-office procedures concerning trade confirmation and registration resulted in delays in determining the true size of the defaulting and non-defaulting positions and in fact who owed what to whom (Hills, et al., 1999).

The Malaysian Kuala Lumpur Commodity Clearing House was closed as a result.

2.1.1.3. The Hong Kong Futures Exchange Clearing House

In October 1987 worldwide stock markets sunk off the back of bull market that had lasted several years. On Black Monday, October 19, 1987, the stock market collapsed. The Dow Jones Industrial Average plunged an astonishing 23%, the biggest one-day percentage loss in history; even bigger than the 1929 stock market crash, just before the Great Depression (Norman, 2011).

The Hong Kong Stock market was not immune to the price falls occurring across the globe at the time. There was a crash in Hong Kong in the Hang Seng index and the market was closed for the next four days. In the derivative market, there was not a commensurate increase in initial margins when volatility in the underlying stock prices increased. Further, some brokers were less than diligent in collecting initial margin from their clients to support the risk inherent in their traded positions. The structure and ownership of the market infrastructure in Hong Kong led to a dislocation in the monitoring and ownership of risk. Incentives to manage risk appropriately broke down due to the separate ownership of the exchange, CCP and guarantee fund. As in the previous two examples of a CCP default, position limits were monitored, and market risk became extremely concentrated (Norman, 2011)

Before the market was reopened it was feared that brokers would not make margin calls following the imminent further decrease in the Hang Seng. Moreover, the amount of financial resources that would be required to sustain that non-performance was feared to well exceed the default fund. The government and private institutions prepared a rescue package and resolution plan for the default fund and CCP which was used when the market was re-opened and the brokers did in fact default (Norman, 2011 and Henkel, 2019).

2.1.1.4. National Spot Exchange

In 2013 the operations of the National Spot Exchange, which facilitated the trade in commodities in India, and its clearing house were closed after there was a payment default and widespread fraud was discovered. The default fund, which was reported to be approximately $140 million, did not in reality exist. The cause of the failure was incompetent and fraudulent management who did not implement an efficient and appropriate risk management framework. This was not identified due to regulatory negligence, auditor's incompetence and a lack of corporate governance (Islam & Khan, 2016, Henkel, 2019 and Thota & Shah, 2019).

2.1.1.5. Near fails

In the wake of the 1987 crash both the CME and OCC faced difficulties in maintaining an orderly cleared market. The CME had to adjust the timing of payments from clearing members off the back of the event as the rules at that time allowed the clearing members much discretion at the expense of the CCP. The OCC found themselves in similar situation as some of the cases mentioned above with a large concentrated position. The clearing member posing a material threat to the health of the CCP successfully sourced an emergency credit line (Henkel, 2020).

2.1.1.6. Other notable clearing member defaults

In 2008 Lehman Brothers defaulted on their margin calls to LCH in London (Norman, 2011). The position was wound down quickly, and non-defaulting clients were ported to performing clearing members and Lehman's initial margin was used to fund losses in restoring a matched book. Their remaining initial margin and default fund contribution was returned to the insolvency practitioner. For a more extensive review of the default and LCH's management thereof (see Norman, 2011 and Faruqui, Huang & Takáts, 2018).

On 10 September 2018 a Norwegian trader, Einar Aas, failed to pay margin to the commodities clearing division of Nasdaq Clearing in Sweden on a very concentrated electricity arbitrage. According to Aas the prices were dislocated and would converge. Prices however spread further apart on updates summer weather forecasts and a change in German carbon policies. Aas was put into default and the portfolio sold in an auction with only four of Nasdaq's healthy clearing members. The loss amounted to EUR 114 million while Aas had only posted EUR 7 million in initial margin (Bell & Holden, 2018). This meant that the default fund of EUR 166 million, largely made up of member's contributions, was used to fund the loss. Significant changes were made to the CCP's risk management framework, specifically to its initial margin calculation, Nasdaq increased its own skin-in-the-game in the default fund, Nasdaq has tightened the membership and credit assessment framework for accepting new clearing members and has changed its default management framework involving auctions for defaulting portfolios (Nasdaq, 2021).

On January 27, 2021, two and a half years after the event, Nasdaq was given an administrative fine of $36m by the Swedish Financial Supervisory Authority regulator for the manner in which it dealt with the default. The fine followed a supervisory review (Nasdaq, 2021).

2.2. CLEARING IN SOUTH AFRICA

The South African financial derivative market is, like the financial sector in general, dominated by South Africa's five large banks (Financial Sector Conduct Authority and Prudential Authority 2020). This creates a concentration of activity and exposure. In the deposit market, individuals and institutions are not acutely concerned with the concentration as they are able to diversify their risk among local and international institutions and rely on the strong regulation imposed by the South African Reserve Bank. In the borrowing market, players who are looking to access large sums generally have access to international funders and are not concerned with the credit quality of people from whom they are receiving money. In the derivative market however, only a small number of local players make markets in large size and by trading with each other (to manage their own risk) they are exposed to one another. Some large international banks are active in the South African derivative market and trading between South African and international banks makes a significant part of OTC transactions (International Monetary Fund (IMF), 2015). There are six firms which have established a clearing capability in South African listed derivatives in more than just the equity derivative market, and seven in the equity derivative market, fewer in the interest rates, foreign exchange and commodity derivative markets. Currently JSE Clear collects R49bn in initial margin (JSE Clear, 2021) and has not had a clearing member default to date.

The IMF (2015) notes that for OTC derivative transactions, margining practices are unevenly adopted in South Africa. There is no CCP currently registered in South Africa although JSE Clear has an Associated Clearing House licence for exchange traded derivatives listed on the JSE. JSE Clear has been approved as a qualifying CCP for listed derivatives by the Registrar of Security Services in 2012 on the basis that it complied with the BIS's Principles for Financial Market Infrastructures (South Africa 2020b).

The IMF (2015) recommended mandating central clearing of standardised OTC derivatives to stop contagion following a default of a large counterparty in the South African markets. The recommendation clarifies that the mandate should still leave participants with a choice regarding through which CCP they clear.

CHAPTER 3 COUNTERPARTY CREDIT RISK AND CENTRAL CLEARING

3.1. A BRIEF LOOK AT COUNTERPARTY CREDIT RISK

A market is based on and exists for the exchange of goods, services or money or one for the other. This is the basis of an exchange economy, a foundation of which is a single accepted currency. However, the market mechanism fails when one party does not deliver fully on their side of the bargain. While this is true for all markets (from vegetable markets to oil markets, to currency markets) this study will focus on markets in financial instruments and particularly in financial derivative instruments.

The London Stock Exchange, one of the world's oldest stock exchanges, has written in its crest their motto: *dictum meum pactum*; which is Latin for "my word binds". Participants in financial markets acknowledge that they must perform on what they agree for the market to function, irrespective of how the situation changes. If trader A agrees on a day to sell to investor B 1,000 shares for R100 per share in three days' hence and at that time trader A can then sell them for R110 per share, trader A still must deliver the shares to investor B for the price agreed even though trader A can get a better price at that time if she sold it to someone else. Likewise, investor B must still deliver to trader A even if he can get a better price at the time of delivery. The potential of a failure by a party to deliver on market securities contracts is known as counterparty credit risk.

It is clear from the example above that counterparty credit risk exists for a participant when the market has moved in their favour. The opposite is not true for the counterparty. On delivery date there is no more uncertainty on the value of the transaction, one can say there is no more market risk, but simply an uncertainty on whether the counterparty will perform and to what extent, counterparty credit risk now exists for the party whose position is in the money. If the position is a losing position for trader A, there is no counterparty credit risk for her as, even if investor B becomes insolvent and does not have cash immediately available to pay for the shares, investor B's insolvency practitioner will loan money to pay for the shares, pay for them and immediately sell them in the market for a profit to pay back the loan and pocket the profit. Counterparty credit risk is therefore the maximum of zero and value of the position.

We can express the above in notation that will aid the measurement of counterparty credit risk. It is convenient to introduce some notation which will be used in Chapter 9. For entity i and entity j, let X_{ij} be the amount that j will owe i on a position. Because different sets of derivatives have different characteristics, we will define X_{ij}^k as the amount j will owe i in derivative class k. This means that the counterparty credit risk exposure of i to j in derivative class k is $\max(X_{ij}^k, 0)$. Netting between counterparts not only happens for derivatives of one type but across derivative types and asset classes. An International Swap Dealers Association Agreement (simply referred to as an ISDA) is normally signed between counterparts (Gregory, 2014) which set out the standard terms and conditions of trading between the counterparts. The term sheet of each new transaction describing the details of that specific trade using the language and terms defined in the ISDA. Netting of exposures then occurs between two counterparts across all derivative classes traded to determine payment and collateral obligations.

There are several ways that companies protect themselves from counterparty credit risk, the most common of which is requiring collateral, in depth credit analysis of the counterparty and substituting a dubious counterparty for one of greater credit quality. The last method in many cases has led to the establishment of central counterparties where one party is substituted as the buyer and seller for transactions and thereby is price-neutral as long as everyone performs on their obligations.

3.2. THE BUSINESS OF CENTRAL CLEARING

A central counterparty (CCP) is an entity that interposes itself between transacting parties, becoming the buyer to the seller and the seller to the buyer. In most markets the original transaction contract between the buyer and the seller is effectively torn up and two new contracts are established, one between the buyer and the CCP and another between the seller and the CCP. Each of the two new contracts is now independent and does not rely on the performance of the other contract to ensure completion. This process of interposing is generally termed novation.

It is the process of novation that allows for netting of exposures which is fundamental to risk management by the CCP and the efficiency of cleared markets. The concept of netting can be traced back to early forms trading and finance. In Roman law the principle of *compensatio* recognised the setting-off of payments due when settling disputes between debtors and creditors (Norman, 2011).

CCPs do not make risk disappear; but rather transform and transfer risk. CCPs are not risk-taking institutions in the sense that they initiate risk taking. CCPs make money from managing risk of trades initiated by others. Through CCPs, risk is transformed from counterparty credit risk to liquidity risk (Cont, 2017). CCPs also mutualise default risk among clearing members (Pirrong, 2011). Counterparty credit risk does not disappear, it is transformed and reallocated. Insurers and banks generate value by compiling and managing a large portfolio of risky positions (assets and liabilities) that on average make money. CCPs have relatively few, concentrated positions (clearing members). The law of large numbers does not apply to a CCP's individual loss scenarios as they are few and exist in the tail of an unknown distribution. CCPs are risk managers, risk re-allocators and are mechanisms by which risk is transferred. CCPs provide risk sharing mechanisms ensuring that incentives are placed appropriately for all players to manage the risk they bring and to collectively lessen the risk in the system. A CCP mitigates risk by making provision for extreme but plausible market events. The only guaranteed way to mitigate the full quantum of risk is to have prefunded resources to cover all potential losses; this effectively prevents participants from gearing.

Deng (2017) constructs a counterparty credit exposure model which shows that a CCP can fully insure against counterparty credit risk. In addition, he presents a case where, using a binomial model assembled implicitly on the clearing of credit default swap contracts, the CCP does not fully insure against counterparty risk. This model is considerably different to the model used by Duffie & Zhu (2011) which is investigated in more detail in this study.

CCPs allow for the efficient management of market risk and the simplification of counterparty credit risk. This allows for significant efficiencies to be introduced in the management of counterparty credit risk. When a participant trades through a CCP, because the trade is novated, it no longer faces its original counterpart but rather the CCP. This allows for all participants to be viewed as having equal credit risk (for the purposes of trading and settlement). It effectively divorces the management of counterparty credit risk and market risk. Without a CCP each institution must manage the counterparty credit risk of each of their counterparties. In a CCP the counterparty credit risk of each counterparty is managed by their clearing member and the counterparty credit risk of the clearing members is managed by the CCP.

A CCP takes no market risk; it must be market neutral so that it cannot be accused of being partisan in determining market prices of instruments and in implementing its risk management framework. It manages counterparty credit risk in a standardised and transparent manner for the market for which it clears. It does so by requiring counterparty credit risk positions to be collateralised and by marking-to-market these positions at least daily. This has the effect of requiring collateral capital to sustain market risk taking activities (protecting the risk taker from counterparty credit risk) as well as transforming counterparty credit risk into liquidity risk due to the requirement to fund daily mark-to-market losses with cash (Cont, 2017).

Clearing members and the CCP are directly connected and are exposed to each other's management of the sum and individual risks run within each enterprise. Clearing member entry criteria are set by the CCP to enable fair access and are set sufficiently high to give comfort to all clearing members that other clearing members can and will continue to fulfil their obligations to the CCP (BIS, 2012b). The main criteria set as an entry requirement is capital, trading capability and clearing operations, including credit extension. However, one of the main risks faced by clearing members is liquidity management. Access to liquidity by its clearing members is paramount for the continued functioning of the CCP. The CCR management of a CCP is standardised and transparent. It is clear that banks are a natural fit for the role of a clearing member.

The confidence interval used to quantify initial margin can be seen as the collective risk appetite of the regulator (or custodian of systemic risk), clearing members and the CCP. Clearing members and CCPs are the guarantors of positions. First the clearing members and then the CCP. Currently international standards recommend that the initial margin must be quantified to cover losses up until at least the 99.0 percentile (BIS, 2012b). Many CCPs have simply adopted this as the percentile of their initial margin quantification (CME Base, Eurex non-interest rate swaps, ICE EU Futures, JSCC Futures & Options) while others have gone further into the tail to 99.5% and 99.7% (LCH, JSE Clear, CME, Eurex and JSCC interest rate swaps). Naturally, this has an impact on the size of the default fund (CME, 2021, Eurex, 2021, ICE EU 2021, JSCC, 2021, JSE Clear, 2021 and LCH, 2021).

In reality the exact amount of financial resources required is very difficult to quantify; it requires a level of expert judgement yet must be rules based to provide guidance to market practitioners. Questions arise regarding black swans, short volatility positions, market liquidity in periods of stress and similar issues. These questions are important and interesting in the light of markets changing due to economic conditions, technological advancements and policy changes. This is beyond the scope of the current paper and we will assume that the amount of financial resources required can be, and has been, established with certainty.

It is important that a CCP cannot, even in default of a clearing member, take on positions in the market. The CCP is entrusted with monitoring risk positions, setting margin and valuing positions; none of which can be done objectively while it has a position in which it has a financial interest.

Initial margin is required from each participant to sustain a risky position being cleared through the CCP. Risks being brought to the CCP by a portfolio are to be covered by initial margin to a desired confidence level. This is the foundation of a "defaulter pays" model. These risks include market liquidity risks due to the size of the individual position, model risks for pricing and of course, price risk. Risks that only exist on the default of a clearing member default normally be borne by the DF and hence only by the CCP and clearing members. These include the cost of a forced sale, potential PTU cost and the potential increase in size of the defaulted portfolio due to closing out non-defaulting clients who are not accepted for porting.

CCPs, therefore, concentrate risk but decrease inefficiencies in derivatives operational risk management across the market. While multilateral netting is increased, this comes at the cost of reduced bilateral netting (Cont & Kokholm, 2012).

3.3. A CCP IS A CCP

A CCP is a unique type of financial institution. There is no other application for the purpose and the economic business model employed by a CCP. Albeit that the risks it manages, the risks to which it is exposed and the risks to which it exposes other financial institutions have the same names as in other organisations. CCPs are different in several ways to banks with important consequences for their management, capital requirements and governance. Risk taking positions are not initiated by the CCP. A CCP does not take on market risk through derivative positions but is still exposed to the default of its clearing members by novating trades between them. To protect themselves and to provide an efficient service they have developed various default resources, like entry requirements, initial margin and a default fund, to absorb these losses (Cont, 2015).

CCPs by their nature serve a market, it is seldom observed or efficient to have multiple CCPs serving the same market. Not considering the differences between banks and CCPs can lead to disastrous results, not the least in the arenas of regulation (including recovery planning) and resolution. As mentioned above, it is indisputable that banks and CCPs face significant similar risks; e.g., credit, liquidity, systemic, and operational risks. That said, their risks are not the same due to very different revenue sources, business models and balance sheets. Above these apparent differences a CCP, a neutral party, plays the role of a quasi-referee establishing and enforcing rules and procedures to govern the contractual obligations of both market participants and the CCP, making that which is opaque in the bilateral market transparent in a centrally cleared setting. In terms of resolution, the biggest difference between a CCP and systemically important banks is that typically another bank can take over the business activities of a failed bank (investment services, lending, market making, etc.), while this is not the case for a CCP (Henkel, 2019).

Cox & Steigerwald (2017) point to further important differences in the way CCPs are viewed by regulators and policy makers. CCPs bear little resemblance in terms of their function, capital structure, business model and risk profile to that of banks. Neither are CCPs like other market infrastructures although they have some features that bear some resemblance to insurers. Importantly Cox & Steigerwald (2017) draw important conclusions for the effective regulation of CCPs. The CCP cannot contribute a significant portion of its capital to the default waterfall without altering the incentive structure that makes the CCP system an effective risk management framework. Capital analysis alone tells little for the strength of the CCP's resilience. The risk management framework, including stress testing, must focus on features that are unique to the viability of the CCP.

Ewing & Schreuer (2019) quote Duffie in an interview saying that CCPs should not fail: "Like a nuclear power reactor. You don't design them to survive in all but the most extreme circumstances." This is a very different expectation to that of banks which have a non-immaterial probability of default.

CHAPTER 4 A CLOSER LOOK AT CENTRAL COUNTERPARTY CLEARING

The primary function of derivatives markets is to facilitate risk transfer among economic agents by providing mechanisms to access liquidity and facilitate price discovery (Tsetsekos & Varangis, 1998) This is true in markets that are traded on exchange and over the counter, markets that are centrally cleared and bilaterally cleared. Gregory (2014) provides a broad background on CCPs and

Hills, et al., (1999) mentions that "there are signs that the central counterparty services that clearing houses provide could be an increasingly important part of the modern financial landscape". Recognition of the importance of CCPs slowly grew with their use in the early 2000s. During the default of Lehman brothers in 2008, CCPs were flung into centre-stage of risk management of financial markets as the event was successfully managed by CCPs around the world and counterparties contemplated the losses and consequences that would have been had the CCPs been absent. After the global financial crisis academics, practitioners, politicians, policy makers and regulators alike have weighed in on how these vital nodes in the financial market network operate, manage risk and allocate risk. This chapter aims to review the functions, benefits and incentives that are created using these unique financial institutions. The following chapter will focus on the risk management framework of CCPs.

.The body of literature covering CCPs has grown substantially in the last 10 years in depth and breadth. In this chapter however, only the most important and relevant themes are highlighted. The issues and risks pertaining to CCPs are all closely linked and interrelated and so topics of discussion inevitably overlap.

CCPs perform an important role within the financial markets and the wider financial system. Ripatti (2004) recognises the need for a CCP to therefore have a sound risk management framework and studies the various aspects thereof. Ripatti (2004) considers various frameworks for the evaluation of the risks and benefits within a CCP and specifically of introducing a CCP into a local market. Various standards regarding CCP management and operations have guided the industry; these include recommendations from BIS (2012b), ECB-CESR standards (Giovannini Group, 2001, 2003 and European System of Central Banks and the Committee of European Securities Regulators, 2009) dealing with cross border settlements, Group of Thirty recommendations (Group of Thirty, 2003) and various standards published by EACH (European Association of Clearing Houses) standards.

The benefits of a CCP are numerous and include multilateral netting of exposures resulting in a reduction of counterparty credit risk and also leads to a decrease in operational burden and risk of servicing portfolios of derivatives (Cecchetti, Gyntelberg & Hollanders, 2009, Duffie & Zhu, 2011, Pirrong, 2011, Berner, Cecchetti & Schoenholtz, 2019). CCPs ensure consistent valuation of positions and standardise collateral requirements leading to efficiencies. Risk management is standardised, on aggregate making assessment less costly. Transparency is enhanced for participants and regulators, allowing for improved oversight while trade anonymity is retained. From a "moral hazard perspective it is less problematic to bail out a CCP compared to bailing out individual banks" (Cont & Kokholm, 2012, p2). CCPs also mutualise extreme risks, thereby reducing the overall cost and increasing the coverage of protection.

Theoretical analysis of interbank liabilities adapted to the OTC derivative market by Amini, Filipovic & Minca (2016) shows that a CCP reduces banks' liquidation and shortfall losses compared to bilateral clearing, however they find that a CCP does not always reduce systemic risk.

The organisation of derivative markets is categorised by execution and settlement. There are three clearing organisations commonly seen in the market (Cecchetti, Gyntelberg & Hollanders, 2009). First, the bilateral OTC market, where trading and clearing (including risk mitigation) occurs between the two counterparties to the transaction alone. The second is where the trade is negotiated and executed bilaterally between two counterparts and thereafter novated by a CCP for centralised clearing and risk management. A hybrid of this arrangement, which is less common, is ring-clearing where net amounts are calculated between counterparties and each counterparty settles against one or two counterparties only. Lastly, trading is executed through an exchange where it is not uncommon that counterparties do not know with whom they have traded. The trades are then novated by a CCP.

4.1. FUNCTIONS OF A CCP

While counterparty credit risk management through margining is the focus of the study, Baer, France & Moser (2001) note some of the other important economies of scale that are achieved when a market is organised through a CCP. They include recordkeeping, simplification due to multilateral netting, credit assessment occurring once by the CCP and not by each counterparty and arbitration is simplified as members pre-commit to terms which would be bilaterally negotiated in a bilaterally cleared setting.

Cecchetti, Gyntelberg & Hollanders (2009) argue that CCPs can provide improvements on bilateral OTC markets by reducing counterparty credit risk through multilateral netting, Cont & Kokholm (2012) point out that this comes at the expense of reduced bilateral netting. Multilateral netting introduces significant operational efficiency, improves market transparency, increases the amount of financial resources available to absorb counterparty losses through mutualisation (assuming high risk management standards are employed by the CCP) and reducing the contribution made by derivatives to the procyclicality of the financial system. Cecchetti, Gyntelberg & Hollanders (2009) recognises that CCPs are not a panacea to derivative market losses and that CCPs alone are not sufficient to ensure the efficiency and resilience of the OTC derivative markets.

Bliss & Steigerwald (2006) highlight that CCPs bring several interrelated services to the market. These services include credit risk management, liquidity management, default management, delegated monitoring, centralised bookkeeping and the establishment of a risk and legal framework for exposure management. Importantly they compare a CCP's loss mutualisation through its default waterfall to that of other loss sharing arrangements where customers pay a non-refundable premium up front in exchange for coverage of losses. Expected losses are paid ex ante whereas in a CCP's loss sharing arrangement losses are assessed ex post and recovered through the attachment of member funds and additional assessments. This comparison is pertinent as it highlights the necessity for enough members (in a CCP setting) or premium paying insured clients (in the insurance model or a bank's lending book). Further, the identification of individual functions a CCP performs aids to distinguish between the credit insurance it has arranged which relies in part on the capital of its member base and the services that are necessary and separate. This is important because these services have a real cost which is often challenged while the benefit to clearing members and market participants is often overlooked or ignored altogether.

CCPs are a mechanism to create operational and risk efficiencies and in doing so transform and reallocate risks in financial markets. As mentioned above, managing risks through a CCP changes how risks are managed, how they eventuate and who bears the cost. Importantly risks do not disappear; losses, while they are managed differently, are not reduced to zero. In any financial ecosystem the cost of managing risks is lowest when they are managed by those who are most qualified to do so.

CCPs have a broad and deep influence on the functioning and particularly the efficiency of financial markets. That has become more accentuated as CCPs have become more popular in Europe and across the globe. Figure 4.1 shows the value of derivatives submitted to CCPs in Europe's main derivative CCPs based in the United Kingdom, Germany and France. The growth in the United Kingdom is mainly attributable to the increase in clearing of OTC swaps at LCH.

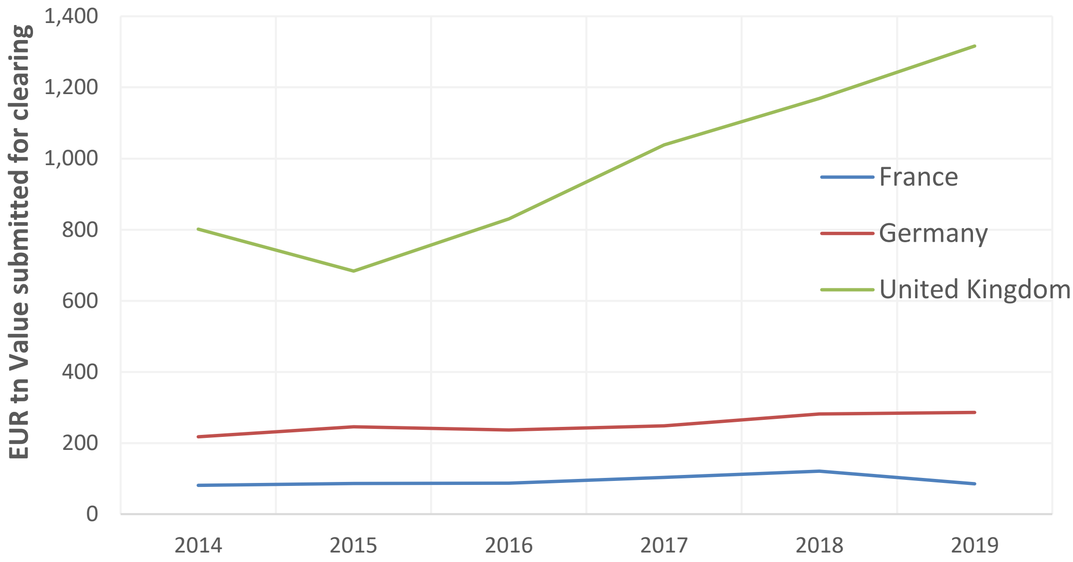

Figure 4.1: Value of derivatives submitted for clearing to CCPs in France, Germany and the United Kingdom in EUR tn.
Source: BIS (2021b).

Having concentrated risk in the clearing house, it must be redistributed back to market participants in ways that are clear and which incentivise market discipline (Tucker, 2013). Tucker notes that otherwise, CCPs would be too big or too important to fail. That is not hypothetical. Markets typically cease to function if a CCP fails or closes abruptly.

4.2. CCP CAPITAL

CCPs are like insurance firms in that they guarantee losses however the "excess" is so large, the probability of exercising extremely small. Management information and tools at the disposal of CCPs are not comparable to insurance. With CCPs it is not a statistical or actuarial problem of computation and capital, it is about risk transformation and distribution. Further, the CCP does not originate trades and market risk, it simply novates and streamlines operations and to do so it guarantees performance. Therefore, the CCP's balance sheet does not look like that of an organisation that does take on market, credit and insurance risks.

Whereas other financial institutions, banks in particular, make money from leveraging their balance sheet. It is clear that leveraging its balance sheet is not the manner in which a CCP generates returns. This has an implication on regulation and capital requirements of a CCP (Cox & Steigerwald, 2017).

CCPs normally maintain capital for three purposes, namely: infrastructure investment, on-going operations in times of low revenue and risk coverage which includes guaranteeing participant's positions. On the revenue side of its income statement the CCP receives fees for clearing contracts and for maintenance of outstanding derivative positions. In short, it has a largely fixed expense base which is covered by a variable income stream which is influenced chiefly by factors outside its control.

A risk sensitive approach to quantifying CCP risk capital was developed by Ghamami (2015) who used this model to allocate default fund contributions among clearing members. While the approach has not been adopted by standard setters, possibly due to its complexity, it may be used to assess approaches that are more straightforward and intuitive for practitioners.

4.3. PARTICIPANTS IN A CLEARED MARKET

In the financial markets there are several categories of players. Each of these players performs and important function in the efficacy and efficiency of the derivatives market. Each of these players bring risks to other participants. It is important to understand these players, their incentives and function as it related to the cleared derivatives market. BIS (2012b) identifies three groups of interested parties which are discussed here; participants are split into clearing members, non-clearing member dealers and end-users.

4.3.1. The central counterparty

The CCP sets entry requirements (for the clearing members and products), implements robust systems to give effect to the risk management framework, sets and maintains a risk framework, manages any default of a clearing member and puts in place a collateral management framework.

The CCP is not a credit granting organisation and does not build a core competency in general credit assessment as a bank does. While the CCP can and does assess the credit quality of the clearing members this is not for the purpose of lending and is not their core, day-to-day function. Many CCP's rely in part on third party credit rating agencies and on annual or semi-annual credit reviews of their clearing members. The risk management framework is based on all clearing members meeting the minimum credit requirements. Should a clearing member have a credit quality significantly greater than the CCP's standard, they do not get any leeway or special benefit for doing so. Conversely if a clearing member does not meet the requirements the CCP will have the ability to limit their risk-taking capacity or require greater levels of collateral and eventually, should the clearing member's credit quality deteriorate sufficiently, remove their membership of the CCP.

Likewise, the CCP is not a liquidity providing institution but does ensure that it has access to sufficient liquid resources as and when needed. A CCP is designed to be liquidity neutral. CCPs are not designed to provide liquidity should their CMs have trouble (operational or liquidity related) in meeting their liquidity needs.

4.3.2. Clearing members

Clearing members are normally required to be active in the market they clear, have sophisticated market risk management, be in the business of credit provision, and have ready access to liquidity. They settle obligations daily with the CCP and guarantee performance for the firms for which they clear. Banks are a natural fit for the role a clearing member is expected and required to fill. Some CCPs allow non-banks to become clearing members but they must appoint a settlement bank with sufficient capability (in terms of operations and credit) to fulfil the settlement requirements of a clearing member. Some cleared markets are structured such that there are incentives to become a clearing member.

Commonly, clearing memberships are either given for own trades (self-clearing) or including those of the clearer's clients (general clearing membership).

It is important for the strength of the market as a whole that the clearing membership be broad and diverse. A clearing membership that is not sufficiently broad is by consequence concentrated which is a risk for the clearing house and all participants in the market. Mitigating actions will necessitate higher levels of collateralisation of exposures and hence higher usage of capital.

Dion, Lane & Slive (2013) provides a brief overview of some of the important issues relating to clearing membership and the impact on financial stability.

4.3.3. Non-clearing member dealers

Trading members: in an exchange traded market only members of the exchange enter trades on the exchange's system. In the South African exchange traded derivative market, trading members enter into a clearing arrangement with a clearing member and clear their clients' trades providing a guarantee to the clearing member with whom they have a clearing relationship. It is not uncommon for CCP rules to make provision for this type of indirect clearing, where a clearing member's client clears for its own clients albeit through its clearing member.

4.3.4. Other counterparties

End users are either enterprises, investment forms or individuals. They are looking to either hedge an existing exposure arising from the nature of their business interests or take leveraged exposure through cleared instruments. These counterparties must establish a clearing relationship with a direct or indirect clearing member to clear their positions.

4.3.5. Policy makers and regulators

In each market there is one or more regulators that oversees the CCP and firms that participate. These regulators give effect to the policy as determined by the policy makers who are normally independent of those that regulate. The regulators monitor the performance of the CCP against the regulations that have been set to ensure the standards of risk management and solvency are adhered to so that the market continues to function smoothly.

4.4. INCENTIVES AND CENTRAL CLEARING

4.4.1. Incentives to clear

Prior to the financial crisis of 2008-2009 central counterparties were formed to streamline back-office operations and to make settlement more efficient (Norman, 2011). This has the added benefit of reducing exposures through netting. As portfolio sizes increased so this benefit became more and more important. The incentive then to bilaterally clear any new exposure that could be cleared by the CCP diminished. The efficiencies created by increased and different netting sets will be the main subject of this study.

Another incentive to clear through the CCP soon became clear as new entrants to the market with varying credit standings appeared(Norman, 2011). Only a new entrant's clearing member, not every counterparty, needs to determine their credit quality and continually manage that exposure. Firms could trade with these new entrants without having to credit assess each one individually and these firms could access the same prices on trades as the rest of the market. Essentially every counterparty received a credit wash through the CCP.

Conduct regulation has increased for several reasons over the last decade. The on-boarding of new clients is time consuming involves an administrative burden which increases the cost of trading. For banks, a new bilaterally cleared client relationship would need an ISDA signed and a CSA agreed, each of these can take much time to negotiate and agree between legal teams. Some trading opportunity will be no longer be present as this administrative process is completed due to the market moving away from where the trade makes economic sense for all parties.

For clients and trading firms alike, CCPs lower the cost of trading through reduced settlement costs due to netting. This is shown in Figure 1.2. As mentioned above, the simplification of settlement through netting lead to a decrease in costs as a counterparty only needs to establish one settlement relationship – with a clearing member – and can trade with multiple counterparties using the same settlement mechanism. In bilaterally cleared markets each counterparty pair would establish procedures for making and receiving settlement on whatever frequency basis was agreed. This may or may not coincide with settlement frequencies of other similar agreements leaving liquidity mismatches.

CCPs have a standardised risk management framework which is determined through a robust governance structure. This risk management framework is transparent and publicly disclosed so that existing and potential counterparties can continuously assess the CCP's credit worthiness.

4.4.2. Incentives not to clear

For certain market players, the price it may obtain in the market may be more favourable should they choose to bilaterally clear due to their own credit, acceptable collateral under a bespoke CSA or netting with a different set of exposures than those already cleared centrally. This will increase the cost of collateral if factored into the price of the trade and determines how much profit will be made over the life a trade. It may be that under bespoke CSAs, collateral is acceptable that is cheaper for a client to deliver or is, in absolute terms, less for dealers due to their credit worthiness and negotiating power in the relationship.

To centrally clear, technical infrastructure is required to connect to the CCP, and a clearing member charges for the services it provides to the clients. These services include liquidity provision, credit enhancement, operational assistance and analytics.

Due to the amount of netting and the aggregation of positions across so many participants, CCPs can pose a systemic risk to the market. Too many (if not all) large players pose a concentrated risk. This has been one of the reasons there has been such focus on CCPs' resilience, recovery and resolution over the years since the financial crisis. More detailed discussions are to be found in BIS (2017), CPMI-IOSCO (2014), Singh & Turing (2018) and Faruqui, Huang & Shirakami, (2018). Nevertheless, a dealer's concentration of exposure to a CCP is a risk that may discourage a dealer from adding a trade to their existing exposure to a CCP.

Another reason that a client or dealer may not want to centrally clear a trade is that it may benefit existing non-centrally cleared exposures with that counterpart. Hence it may receive better pricing not to centrally clear and will be cheaper from a counterparty credit risk and collateral perspective not to clear the exposure.

Central counterparties have a standardised and transparent risk management framework that is applicable to all counterparties. The framework may differentiate between counterparties but even the basis for such differentiation will be transparent and justified. The amount of collateral required for every position is transparent and the daily instrument price used for the exchange of variation margin is independently determined. Often it suits dealers to exploit the opacity of the OTC and bilaterally cleared market which may create an incentive not to clear.

Even for clearing members, for whom many of the expenses are sunk costs, the decision to centrally clear is not a clear-cut preference.

4.4.3. Fees in the CCP

How a CCP charges for its services can also create incentives for different behaviours and should be structured in a way that these incentives align the outcomes desired by different market participants.

Aminiy, Filipović & Minca (2015) show how fees affect banks' incentives and use that insight to inform CCP design to reduce system risk.

Biais, Heider & Hoerova (2013) discuss some of the CCPs' incentives influencing risk management. Ways in which moral hazard can arise are highlighted for attention by supervisors.

4.4.4. Ownership and structure

The ownership of the CCP also provides and drives incentives. Vuillemey (2020) studies the CLAM (mentioned in Chapter 2) and notes it resembled a member-owned institution on the context of non-mandatory clearing. It urges that caution is used when drawing comparisons to today's market for mandating clearing as the ownership has an impact on risk management incentives.

BIS (2010) discusses the risks and benefits of various market structures focusing on vertical and horizontal financial market infrastructures. Some CCPs are subsidiaries of an exchange group and are vertically structured (e.g. CME and Eurex) so that efficiencies are created along trading, risk management and settlement. Gregory (2014) notes that this model has developed out of futures exchanges. Horizontal CCPs potentially clear a number of products and are not affiliated to an exchange. These CCP's generally clear OTC trades and examples include LCH and OCC (Gregory, 2014).

4.5. GOVERNANCE

Ownership and governance of CCPs has a profound impact on the risk management framework and robustness of a CCP, especially in times of stress. Tsetsekos & Varangis (1998) study the organisation of market infrastructures and find that many, but not all, exchanges own CCPs. They find through a survey mechanism that the introduction of derivatives contracts in emerging markets take more time compared to developed markets except for equity index products. Irrespective of ownership, it should be clear who bears risk through the CCP's default risk sharing mechanisms (those with "skin-in-the-game"), and that those that bear that risk should have significant influence over the CCP's risk management arrangements (Bliss & Papathanassiou, 2006).

BIS (2010) analyses various market structures, focusing on vertical and horizontal financial market infrastructure groups, and consider the benefits and risks therein. While they note that different structures bring different risks and risk reduction benefits, they conclude that there is no evidence to suggest one structure is better than another.

Ripatti (2004) discusses governance arrangements including the shift from user owned CCPs to profit making institutions. The importance of adequate governance procedures in a CCP is highlighted by pointing out that the concentration of operational risk (given an adequate legal and financial risk framework) is higher in a CCP than in a decentralised market. The consequences of incompetent management are correspondingly greater for the institution and the market as a whole. the Principles for Financial Market Infrastructures (PFMIs) (BIS, 2012b) identify three groups with distinct interests in the operations and risk management of a CCP. Due to the systemically important nature of a CCP and concentration of risk, the first group is the public (and hence legislative and regulatory authorities) who is interested in safety. The owners are obviously interested in the efficiency and sustainability of the firm. Finally, the users are interested in the efficiency and safety of the CCP.

The efficiencies of different configurations of market infrastructures are discussed by Pirrong (2008), specifically, vertical vs. horizontal integration of market infrastructures is discussed and it is concluded that vertical integration can enhance total efficiency in exchange traded derivative markets by reducing operational risk and frictional costs.

4.6. BILATERAL VS. MULTILATERAL NETTING

In bilateral OTC markets counterparty credit risk is managed using collateral, bilateral netting and, importantly, through limiting counterparty exposures. When requiring collateral counterparties agree on the amount, frequency and triggers of top-up of collateral and in what form. Participants have also focused attention on the form of collateral, whether it can be rehypothecated and how the collateral is held to protect the collateral from the counterparty's default (BIS, 2013). Netting reduces the net exposure between counterparts significantly and hence the amount of collateral required.

Bilaterally cleared OTC markets provide important benefits to clients and dealers, namely heterogeneity of instruments traded, the ability of participants to tailor collateral arrangements, the facilitation financial instrument innovation and finally, opacity. Gregory (2014) provides a concise comparison of the broad principles involved in bilateral and central clearing. The commitments made by the Group of 20 Nations past the 2008-2009 focused in part on increasing transparency in OTC derivative markets (G20, 2009).

Multilateral netting provides an opportunity to optimise the margin collateral required by parties to derivative transactions to protect themselves against counterparty credit risk. Baer, France & Moser (1994) show that the creation of a clearing house allows counterparties to reduce default and economise on margin. Baer, France & Moser (1994) and Baer, France &

Moser (2001) show that multilateral netting systems that are the result of novation as used by central counterparties is superior to bilateral margining regimes.

Jackson & Manning (2007) quantify the benefits of moving from a bilateral arrangement to central clearing in terms of reduced exposure. They do not consider breaking up netting sets and assume that all instruments in the market are suitable for clearing. Further, they show that there are benefits when clearing multiple assets through the same clearing arrangement. The scale of the benefit of central clearing is dependent on the number of members. Alternatively stated, the benefit is dependent on the number of trading counterparties who clear through the CCP.

In a market served by a CCP, counterparties benefit from greater reduction in exposures through multilateral netting. Not only do exposures against each counterparty get netted (as in a bilateral market) but across counterparties. Based on multilateral netting, collateral is used in CCP markets to manage counterparty credit risk. After collateral is exhausted, losses are mutualised across members (Jackson & Manning, 2007). Note first that collateral arrangements in a CCP are standardised and updated frequently (at least daily). Mutualisation is used to align incentives and reduce the costs of defaults and collateral. Through mutualisation, members are incentivised to ensure the CCP performs risk monitoring of members and adequately enforces the agreed risk framework (Hills, et al., 1999 and Knott & Mills, 2002).

4.7. MANDATING CENTRAL CLEARING AND CLEARING INEFFICIENCIES

During the financial crisis of 2008-2009, clearing houses protected market participants from severe losses from the default of Lehman Brothers (Monnet, 2010). The G20 made several commitments in 2009 off the back of the financial crisis to put in place measures to improve the strength of the global financial system (Group of 20 Nations, 2009). One of these commitments was that standardised OTC trades should be cleared through CCPs. Subsequent to that decision there has been studies investigating the wisdom of widespread mandates of this nature.

Pirrong (2009) investigates the efficiency of clearing mandates and finds that in conditions of complete information CCPs can improve welfare by allocating losses more efficiently. More specifically Pirrong (2009) shows that in equilibrium the quantity of contracts traded is smaller in the bilateral market than the cleared market, the forward price is higher in the bilateral market than the cleared market and dealer profits are higher in the cleared market than the bilateral market. This is explained by the fact that defaults occur more frequently in a bilateral market.

Further it is noted that a CCP affects the distribution of losses among market participants, including ensuring effective transfer of the burden of counterparty losses from non-members to members of the CCP. Pirrong (2009) points out that trades cleared through a CCP, through netting, gain a senior position on the defaulter's balance sheet. It is important to remember that to be a member of a CCP a firm must satisfy stringent capital, risk management and access to liquidity requirements.

Risk transfer markets incur costs arising from asymmetric information and these costs are likely to be higher in a centrally cleared market than one in which transactions are bilaterally cleared (Pirrong, 2009). This information asymmetry is increased with the complexity of the counterparties and complexity of the instrument being cleared. CCPs distribute wealth from one group of counterparties to another and affects the magnitude of costs relating to asymmetric information, therefore it is not guaranteed that the formation of a CCP is efficient or produces positive net benefits for participants. Finally, Pirrong (2009) shows that due to the way clearing redistributes wealth and the concomitant effect on default risk pricing, it is not true that under all scenarios that the formation of a CCP reduces systemic risk. The conclusion re-enforces that not all instruments are suitable for clearing.

Kubitza, et al., (2019) show that CCPs do not always reduce counterparty credit risk particularly during extreme events for traders with directional portfolios.

Duffie & Zhu (2011) model the clearing of classes of derivatives to measure the effect on counterparty exposures. Their work forms the foundation on which a number of other subsequent studies are built that investigate various characteristics and impacts of central clearing on the derivative markets. Duffie & Zhu (2011) show that it is not necessarily the case that a CCP reduces counterparty credit risk across the system. For plausible market configuration scenarios, they show, using a general model of overall market credit exposure, that a CCP may not reduce counterparty credit risk. Their focus is on credit default swaps (CDSs) due to the policy pressure to clear CDS contracts at the time. Pertinent to this study, they prove the intuition that clearing different asset classes in separate CCPs always leads to greater overall counterparty credit risk than clearing them in a single CCP. Duffie & Zhu's (2011) work has become influential among OTC participants in debates regarding the scope of clearing mandates.

CDS contracts that require arbitration as to whether the reference entity has defaulted provide uncertainty to counterparties. This is simply the nature of bilateral contracting in credit markets, that there can be ambiguity as to what constitutes a default event, or rather whether what transpired constituted a default event. CCPs have an advantage over bilateral markets in that they have broader discretion over declaring a default under a CDS contract as compared to bilateral counterparties and a formal arbitration body, like the ISDA Determinations Committee (Henkel, 2019).

Acharya & Bisin (2011) show that organising a market through a CCP would induce efficient risk-sharing among participants. They achieve this by considering the opacity of the OTC bilateral market, in particular that defaults on contracts are not mutually observable. However, this would come at the cost of restricting trades to those that are suitable for central clearing and for clearing to occur through a single CCP.

The impact of central clearing on counterparty exposures is investigated by Cont & Kokholm (2012). Starting with the framework established by Duffie & Zhu (2011), Cont & Kokholm (2012) show that the impact of the introduction of a CCP for a given asset class is sensitive to the heterogeneity of asset class returns and the correlation between them. Under assumptions of normality Duffie & Zhu (2011) show that for four asset classes, at least 15 clearing members are needed for a CCP for one asset class to improve netting. In contrast, Cont & Kokholm (2012) show that for plausible model assumptions regarding correlation and non-equal asset class risk, CCPs are efficient at reducing counterparty credit risk for the same number of asset classes.

The framework developed by Duffie & Zhu (2011) is extended by Garratt & Zimmerman (2015) focusing on scale-free and core-periphery structures, which are more accurate models of real-world financial networks. They investigate the mean and variance of net exposures and derive conclusions regarding the efficiency of CCP netting in financial networks that rely on a few key nodes and in large scale-free networks.

Koeppl & Monnet (2010) present a framework explaining why CCP clearing is an efficient part of exchange traded market structures. Whether it should also be introduced for OTC markets is considered. It is asserted that the scope of insurance against counterparty default is limited when clearing OTC transactions due to the lack of fungibility of transactions in the OTC market and that the gains from customisation introduces the inefficiency that some counterparts take on too much risk. While Koeppl & Monnet (2010) consider novation and mutualisation of losses through a CCP, the benefits of multilateral netting which comes a result of novation is not included in their study.

In the light of the increased use of CCPs, Roe (2013) emphasises that CCPs do not eliminate all risks and that CCPs are mechanisms that transfer, allocate and manage risk already in the system. It appears from the debates between clearing members and CCPs that post the crisis members expect CCPs to bear more risk and absorb all risk that is initiated by market participants. The benefits of netting against many counterparties are ignored when looking only at the principles and consequences of offset between only two counterparts. The effective juniorisation of claims not part of the clearing house is highlighted by Roe (2013) and it is asserted that, because of this juniorisation, the financial instability could spread across economy.

Various loss allocation arrangements are studied by Antinol, Carapella & Carli (2019) and clearing arrangements are characterised based on the uncertainty of performance of counterparties. The problem arises from the heterogeneity of counterparties and the information asymmetry regarding their ability to perform. The study identifies a trade-off between central clearing, with the concomitant collateral optimisation and operational benefits for the counterparties involved, and bilateral clearing with appropriate counterparty monitoring incentives. The result highlights some of the limits inherent in loss allocation mechanisms and the importance of CCP risk management.

Berner, Cecchetti & Schoenholtz (2019) investigate financial networks and the system's interconnectedness. Linkages in financial networks serve to diversify risk and dampen stress and provide clear benefits of efficiency; while simultaneously act as transmission mechanisms for stress, especially if the network operates across jurisdictions with different regulatory and legal frameworks. Berner, Cecchetti & Schoenholtz's (2019) main contribution is the proposal of a metric to measure the extent to that a CCP is likely to transmit and amplify shocks through the system.

Briukhova, D'Errico & Battiston (2019) highlights another externality of central clearing, that of the creation of basis between clearing venues. Briukhova, et al., (2019) assert that value is redistributed through valuation differentiation of derivatives contracts that are bilaterally cleared and those that are centrally cleared. Looking at credit quality alone, the transition from a bilateral to a CCP is beneficial for counterparties whose credit quality is higher than the average of the counterparties with whom it trades and who clear through the CCP. The converse is true for counterparties whose credit quality is lower than the average although a counterparty with below credit quality receives a credit enhancement when clearing through a CCP.

Over recent times there has been an exponential growth in the funds invested in Exchange Traded Funds (ETFs). Many of these funds use derivatives that are cleared to achieve the performance advertised. This directional, not-actively-traded investing activity and use of CCPs may transfer even more systemic risk to CCPs (Henkel, 2019).

4.8. AGENCY AND PRINCIPAL CLEARING

The model of the CCP makes a large difference in terms of legal recourse when there is a default as to who pays and what can be done with collateral. An Agency Model is one where the clearing member simply acts as a payment agent and guarantor. The position and original obligation belong to the end client. The CCP requires each position holder to post margin to the CCP. In a Principal Model positions with the CCP are owned by the clearing member who has a back-to-back trade with their client. The CCP places the principal obligation on the clearing members to perform and post initial margin. Omnibus accounts, in either model, are unlikely to be able to be ported; depending on the availability of records and nature of collateral.

A Principal Model may allow a clearer to take on more risk and manage the risk differently to how the CCP would manage the same risk. In a Principal Model the ability to re-hypothecate position holder's assets is vital to clearers as the clearer interposes itself between the CCP and the position holder.

It will be shown that the number of participants in the market that trade with each other and potentially clear through a CCP makes a material difference to the netting efficiencies to be achieved. For a bank to join a CCP there is much due diligence required from the bank and the CCP alike. Payment links need to be established on both sides and the clearing member needs to establish the required infrastructure to ensure accurate daily reconciliations daily. This investment is not trivial for a clearing member. Figure 4.2 shows the aggregate number of clearing members for all clearing services at selected CCPs since the end of 2015. Even though initial margin has more than doubled over the same period there has only been a modest 6% increase in the number of clearing members. The average number of clearing members in a clearing members per clearing service is 55. Many of the selected CCPs operate more than one clearing service.

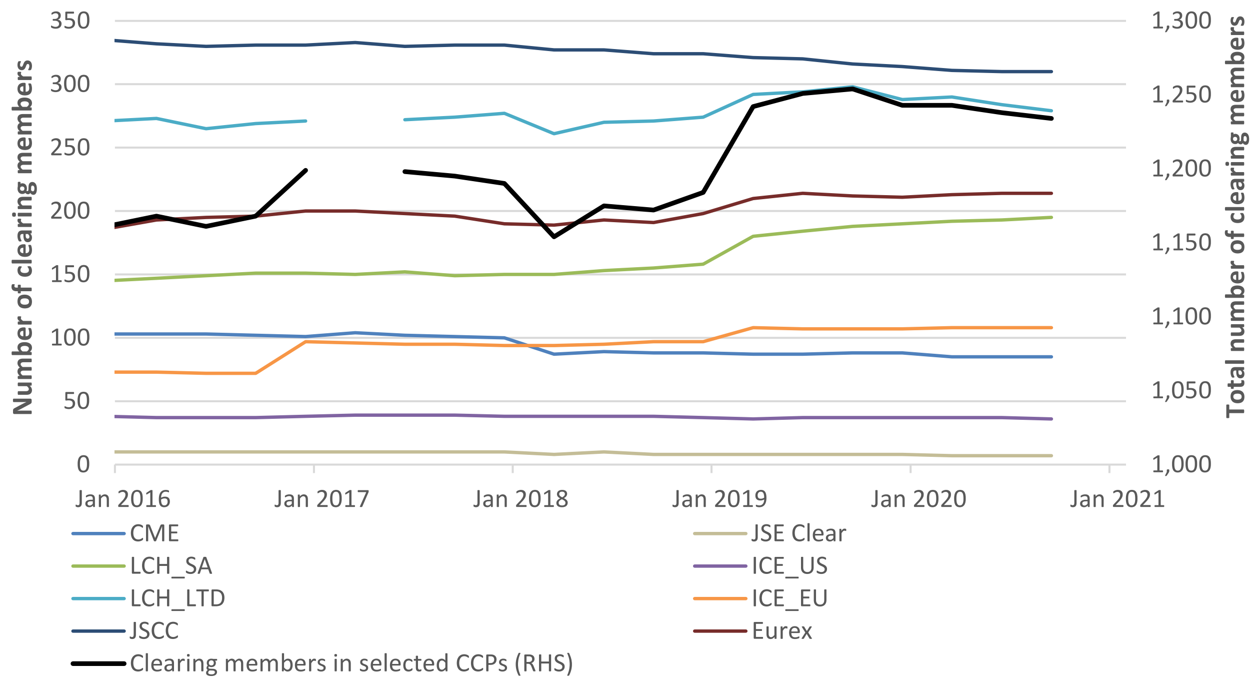

Figure 4.2: Number of clearing members at selected CCPs
Note: LCH Ltd did not publish data for March 2017.
Source: Chicago Mercantile Exchange Group (2021), Japan Securities Clearing Corporation (2021), Eurex (2021), ICE Clear Europe (2021), ICE Clear US (2021), JSE Clear (2021), LCH Ltd (2021), LCH SA (2021). In the interests of brevity these sources pertain to Figures 4.2, 5.1, 5.2, 5.3, 5.4, 5.5 and 5.6

CHAPTER 5 RISK MANAGEMENT IN A CCP

CCPs all differ in terms of approach to risk management and implementation of the PFMIs. This is in no small part due to differences in legal frameworks, market conventions, market evolution, market structure and products cleared.

Clearing members (some more than others) have become aware of their responsibility and influence on the risk management regimes of clearing houses. Market engagement from clearing members has increased over the years since the crisis. There are frequent and vigorous debates on the appropriate risk management techniques between market participants, clearers and CCPs. This is only good for the markets served by CCPs.

In 2012 the BIS Committee on Payment and Settlement Systems (CPSS, which later became the Committee on Payments and Market Infrastructures) with the Board of the International Organization of Securities Commissions (IOSCO) published the PFMIs (BIS, 2012b). These principles covered all aspects for market infrastructures risk management framework and gave guidance for the required standards to ensure a stable payment system and financial market infrastructure. Further, the BIS recommended that banks' exposures to CCPs that met these standards were to receive preferential capital treatment (BIS, 2012a). The intention is that this will incentivise CCPs to meet the stability standards and incentivise banks to clear through qualifying CCPs. The PFMIs covers 24 principles, two of which do not apply to CCPs. Risks are discussed in general as they apply to and manifest in financial market infrastructures. The PFMIs and the subsequent guidance documents on implementation thereof published by CPMI-IOSCO is a culmination of a number of standards, recommendations and principle documents published by standard setting bodies starting as far back as with the Lamfalussy Report (BIS, 1990) in 1990 that dealt with netting schemes.

Before central clearing of OTC derivative market trades was mandated in any jurisdiction, Bliss & Papathanassiou (2006) noted that both centrally cleared arrangements and bilaterally cleared arrangements existed side by side. They focus their study on competition among CCPs and the impact of legislation being considered at the time of their study, particularly in Europe. Market participants and CCP users were afraid of the price implications of the natural monopoly that is inherent in the CCP's function. With some foresight, Bliss & Papathanassiou (2006) addressed the reluctance up until that time of dominant market participants to centrally clear: "…it will require a crisis or series of crises (one LTCM is not enough) to convince the dominant market participants that it is in their own interest to trade-off the risk of increased competition for the benefit of mutualised credit risk management". Zhu (2011) studies the impact of competition among CCPs and shows that risk management frameworks of CCPs are not weakened by competing for business.

Much of the focus on CCPs and their risk management is ensuring that they have adequate (prefunded) resources in the case of a clearing member default. Related issues include the CCP's legal framework, variation and initial margin methodologies, default fund size and form, governance pertaining to the risk management framework including the products it clears and clearing member criteria and monitoring. Cont (2017) argues that while these are important risks to monitor, CCPs transform counterparty risk into liquidity risk which should be the main focus of the stability assessment of a CCP's members. CCPs "crystallise" accounting losses through the transfer of variation margin daily and affect a clearing member's liquidity buffers.

Moser (1992) and Kupiec (1998) consider futures margin levels and their use to control volatility in the market. Moser (1992) provides evidence that higher margins do not control speculation resulting from excessive volatility in the market. Kupiec (1998) similarly finds that margins cannot be systemically altered to manage volatility in the market.

5.1. CLEARABLE PRODUCTS

A suggestion regarding clearing mandates is made by Hull (2010a) in which all OTC derivatives (standardised and non-standardised) are to be cleared. An important reason for mandating clearing, Hull argues, is the increase in transparency which a cleared market brings for participants and regulators alike. Hull (2010a) points out that large losses often arise out of non-standard OTC derivative positions. He divides all OTC derivatives into four groups according to valuation complexity, namely vanilla derivatives with standard maturities, vanilla derivatives with non-standard maturities, non-standard derivatives where there is a well-established pricing model, and highly structured deals. In structured deals that are marked-to-market at mid prices there is often a large up-front profit made by the market maker which is justified by the work done to structure the trade and the costs to be incurred in hedging the exposure. Hull proposes that mechanisms are built to amortise these profits as is done in many banks' provisions to account for the reality of earning the profit over the life of the trade as costs are incurred. Finally, Hull (2010a) suggests methods of managing each category within a CCP setting. Consideration is limited to individual deal risk management, the issues regarding risk mutualisation; member exposure to bespoke transactions between other counterparts through the default waterfall.

In investigating information asymmetries for bespoke structured deals and complex instruments, Pirrong (2009) shows that the costs of clearing certain instruments may exceed the benefits. Pirrong (2011) defines the main attributes that determine an instrument's suitability for clearing. These are standardisation, complexity, liquidity, and risk characteristics. A CCP must consider each instrument and determine its ability to find a buyer or seller in case one of them defaults. It is imperative that a CCP remains risk neutral at all times for every instrument it clears. A CCP is not in the business of holding an exposure to maturity. The risk characteristics considered are the instrument's continuous volatility, tail/gap risk and dependencies between other products cleared and members' credit quality. Pirrong (2011) urges CCPs, participants and regulators to be realistic about the suitability of many OTC derivative products for clearing, especially in the light of CCPs being systemically important institutions and their financial strength being of critical importance.

Further Cecchetti, Gyntelberg & Hollanders (2009) assert that it may not be feasible or desirable to introduce a CCP for non-standard, custom-made OTC derivatives, or include these types of transactions in an existing CCP. Bilaterally cleared OTC markets are recognised as having advantages over centrally cleared markets that enable them to create and innovate cost-effective and well-tailored risk reducing products for a broad range of counterparts.

In South Africa, while all locally cleared derivative products are listed on the JSE derivative markets, there is only a central order book for a few instruments. This means that while transactions are reported to the exchange and are cleared through the CCP, the vast majority of the products listed trade over-the-counter. Most of the open interest though, by value or size of exposure is in those contracts that have an active order book. Although many instruments' trades are executed over-the-counter, they are sufficiently standardised to be listed. Even though these products are executed over-the-counter and only reported to the exchange, they are cleared by the clearing house and use the same default waterfall (including the same default fund) as other more liquid products.

5.2. MARGINS

Margin collateral is a CCP's first and most important line of defence against the default of a member (Arnsdorf, 2012). Margin is used to constrain risk taking activities and is considered optimal when the incremental opportunity cost of extra margin is proportional to the incremental protection obtained from that additional margin. Baer, France & Moser (2001) highlight the economic opportunities and reputational credibility presented by clearing membership. The potential expulsion from the clearing house is an incentive for clearing members to maintain their own creditworthiness and causes potential defaulters to perform when the amount owed exceeds the margin held by the clearing house.

Baer, France & Moser (2001) measure the coverage of margin by using option implied volatilities (estimations of forward-looking volatility) and comparing that with required margin. They find that when volatility increases, coverage ratios decrease, meaning that margin covers a smaller change in the futures price (in terms of standard deviations). This is indicative of how the CCPs studied set and update the level of initial margin and how sensitive the margins are to price changes.

Bates & Craine (1998) study the margins, stock price changes and tail distributions of futures prices in relation to the Chicago Mercantile Exchange's clearing house during the crash of 1987. They point to the danger in only considering the probability that margins will be insufficient without contemplating the amount by which margins can be exceeded.

5.2.1. Variation margin

Variation margin is money exchanged to settle mark to market differences usually at least daily. Variation margin is normally paid in the currency of the contract.

Variation margin is a key difference between the non-cleared market and the cleared market. The exchange of variation margin (whether it is initial margin exchange or settlement of profit and loss) reduces the length of the outstanding exposure from maturity, which could be years, to the time of the next exchange of variation margin.

Counterparties take a credit view on their counterparty and require commensurate collateral. In most cases the level of collateral is regularly maintained. Each OTC relationship (and potentially each trade) can have different terms of collateral and variation margin payment. In a CCP these terms are standardised and fixed. The requirement to post margin daily can create mismatches in liquidity; the exposure being hedged often produces a cashflow at a different (often later) time than the derivative contract where margin is required. This can pose a strain on firms wanting to hedge their market exposure and an opportunity for liquidity transformation firms (banks) to meet this need. This is also a fundamental reason why banks are well placed to provide credit for this purpose and act as clearing members.

Timing of variation margin settlement has a far-reaching impact on the risk management framework of the CCP. If a CCP requires variation margin payments at end of day on the same day as trade and mark-to-market, then a CCP only needs initial margin to cover the market movement of one day to close out the positions. If payment happens the following day before the market opens, the CCP will need initial margin to cover at least one and a half days of market moves to close the outstanding positions. Should payment be required the following day at mid-day, two days of market moves will be required to cover potential losses.

The extent to which variation margin is based on prices that are different to where an instrument can be traded in the market is the extent to which the CCP's models compromise the protection offered by the CCP. Where the instrument's end of day price cannot be determined due to a lack of updated trading data the CCP has to question whether the product itself is still clearable. In such circumstances the exact instrument may not have been traded but the inputs to the generally accepted valuation model may be updated and variation margin be called on the new calculated value. This is discussed by Hull (2010a) in more depth. If an instrument becomes illiquid and difficult to value post the novation of a trade therein, the CCP must compensate for the uncertainty in its valuation and initial margin models by including in its initial margin an amount for model risk.

5.2.2. Initial margin

BIS (2012b) recommend that all CCPs should ensure that initial margin should cover 99% of losses over a two-day period (for exchange traded derivatives) this assumes that the instrument/position can be liquidated in one day (as generally one day has already passed since the last time VM has been collected). OTC derivatives must have a margin period of risk of greater than five days (South Africa, 2018). These periods are arbitrary in the sense that some OTC markets are more liquid than some exchange traded markets.

Initial margin is intended to be a VaR type measure however in practice due to the high percentile of the measure the tail and data have significant impact on the number. Further conservativism is built in when considering correlations between products with a portfolio and different risk factors impacting the portfolio's value.

Figure 5.1 shows the initial margin for selected CCPs from September 2015 to September 2020. From December 2015 to June 2020 there is an increase of 118% in USD terms. Most of the increase is attributable to LCH Ltd and CME. As initial margin is a VaR metric it is an indication that the risk cleared through CCPs increased at an annually compounded rate of 15% over the five-year period. JSE Clear is a relatively small player compared to the CCPs selected, requiring USD2.9bn; LCH Ltd is the largest with required initial margin of USD219bn with CME being the second largest. LCH Ltd's main business is clearing OTC interest rate swaps whereas CME's main business is clearing listed derivatives.

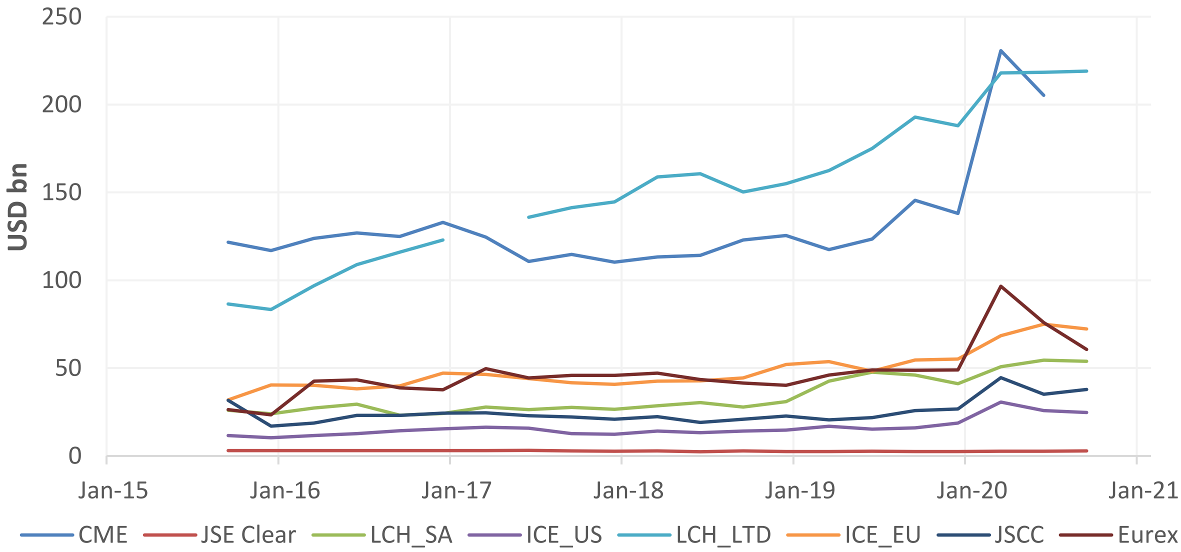

Figure 5.1: Initial margin requirement for selected CCPs from September 2015 to September 2020.
Note: LCH Ltd did not publish data for March 2017; CME did not publish data for September 2020.
Source: As for Figure 4.2

It is clear that LCH represents a significant portion of the market. The CCP market is not one that lends itself to competition as a participant that is already linked to a CCP only has an incentive to send its new trades to that CCP. Sending trades to a new CCP will not reduce its counterparty exposure whereas sending it to an existing CCP may do so. Any new counterparty is in all likelihood going to trade with an existing counterparty that already has the aforementioned incentive and hence prefer to clear through an existing CCP. Most USD interest rate swaps are cleared by LCH. Bo, Liu & Zhang (2021) study netting efficiencies and find that it is possible for a CCP to lose its superiority to bilateral clearing and multiple CCPs. This has particular relevance for the concentration of OTC exposures at LCH.

Internationalstandard setters have required that initial margin remain anti-cyclical by forcing a period of stress into the data used to calibrate the models (BIS, 2012b). This means that too much initial margin is required during periods of market calm but when the market turns more volatile there is not a significant increase in the level of leverage allowed. This is a form of leverage control imposed by regulators on the cleared derivative markets.

Initial margin is to be posted by the position holder to cover the risk of the positions held. This supports the capital used by the clearer to guarantee the position. Should the position holder be required to post more than that, she is being charged too much or her credit quality is materially lower and requires support. Collateral posted as initial margin should not be exposed to market risk (BIS, 2012b).

In SA, JSE Clear employs the concepts of initial margin (set by the clearing house), maintenance margin, additional margin, retained margin and variation margin (JSE, 2019). Other CCPs have the concept of initial margin and maintenance margin. Not all types or margin are synonymous across CCPs. In SA maintenance margin is to top up additional margin in the case that additional margin is used to pay variation margin. In other markets maintenance margin is required for future variation and initial margin calls and is often set by the CCP, not the clearing member.

In a CCP it is important that the margining methodology, frequency of calculation and calibration is transparent. It is also important that it is consistently applied. Market participants need to understand their future obligations to be able to plan for future liquidity requirements and price in the true value of a cleared position which means considering future cashflows.

5.2.2.1. Margin methodologies

Margin methodologies have grown up from a simple, per contract, margin amount to a framework that views the portfolio as a whole (all the contracts therein simultaneously) and the risks therein together against a counterparty. These changes have happened gradually and with much debate requiring changes to systems, methodologies and calibration.

Starting with a per contract margin is fairly simple and provides the user with an easy way to budget for the margin required for each new transaction, however when taking offsetting positions, it leads to unnecessary consumption of collateral. The next step of advancement is a framework wherein offset is provided either by adding on an amount to account for non-perfect correlations or by subtracting an amount from the base aggregate margin.

For margin models to be effective in a CCP setting they should be intuitive and reward good risk management by all parties. As initial margin is required to protect against the position holder's default, intuition states that the margin should increase as the overall risk of the position increases. A margin model that is too simplistic, one that favours rough estimates of margin requirements in even complex offsetting portfolios, generally will either under-estimate some risks or overcompensate and call for too much collateral. A CCP with a good margin framework will be rewarded by more business due to margin efficiencies and a broader range of risks covered to margin completeness and accuracy. A market participant will be rewarded for good risk management of their portfolio by lower margin requirement for less risk taken and potentially higher quality collateral placed.

5.2.2.1. Confidence intervals

Clearing members have a big influence over the risk framework and confidence interval. To the extent that clearing members rely on the CCPs margins to ensure that their clients are sufficiently collateralised (and effectively outsource their risk management and monitoring to the CCP) they will advocate for a higher CI. A consequence of this is that Clearing members can avoid creating competition among clearing by setting the margin level sufficiently high so that Clearing members with a more aggressive risk appetite are more protected than they would have been if they were determining the collateral themselves. This means that there is no expression of risk appetite among clearing members when providing clients and clearing members with a greater risk capacity or more efficient way of managing client clearing accounts.

The risk appetite of a CCP is not measured in the confidence interval it uses to set initial margin as all counterparty credit risk should be covered by prefunded resources. Furthermore, a CCP's first exposure to the materialisation of counterparty credit risk above the initial margin threshold is only after a clearing member has not met their obligations to guarantee their own and clients' obligations (has defaulted) AND that clearing member's contribution to the default fund has been utilised. In such a manner its exposure is limited to its own contribution to the default fund until the remaining clearing members' contributions are used.

Effectively a CCP has little or no appetite for financial risk. This is because it does not make money from taking financial risk, but rather it manages risk that belongs primarily to other people. The CCP puts capital up only to align incentives, that is, only to ensure that it shares in any down-side in inappropriate management of the clearing member counterparty credit risks. The mount of its capital it puts up in the waterfall does not determine how much money it will make from its clearing services. A significant risk of the CCP that it manages is operational risk in its various forms (legal, people, processes, systems).

5.2.2.2. Holding periods

Exchange traded derivatives are normally margined using a one- or two-day margin period of risk while for OTC derivatives a five-day margin period of risk is typically used. In South Africa, many exchange traded derivatives are traded OTC and reported to an exchange for clearing. In many cases this does not detract from the risk characteristics as there is a deep and liquid in the market for the underlying which is also the market used to hedge the derivative (e,g, single stock futures).

5.2.2.3. Look back period for margins

Due to the level at which margin is measured, at a confidence interval of 99% or greater, the data period which is used to calibrate the margin at that confidence interval has a large impact, the measure of risk is data sensitive. It is important that margin requirements do not drain liquidity from the market during times of stress and hence potentially force market participants to close positions to meet increased margin calls. BIS (2012b) and South African regulation (2018) require margins to be anti-cyclical. This means that margin levels should not decrease too much during times of low volatility and not increase too much during times of high volatility. A natural implication is that too much margin may be required during times of low volatility; this is weighed against the potential disruption of market players having to close positions during stressed market conditions to fund margin calls. To avoid the very negative impact of forced close-out and to ensure that positions remain sufficiently collateralised, regulators stipulate that margins should not be procyclical in nature (BIS, 2012b and South Africa, 2018). To achieve this, it is not unusual for a CCP to force a period of stress into their look back period for calibrating initial margin parameters. This period of stress may be the global financial crisis or some other period relevant to a specific asset class or instrument set, examples are a drought in an agricultural market or a country's rating downgrade for its bond and forex markets.

5.2.2.4. Margin Offsets

Offsets are normally provided for opposite positions in instruments with an economic relationship and historically observed strong correlation. More and more margin methodologies are moving away from single instrument margining to portfolio margining recognising the diversification benefits inherent in even a portfolio of long only positions in a wide variety of instruments. This is justified by the assertion that not all instruments will experience extreme losses simultaneously. Because CCPs measure risk at a very high confidence level, extreme value theory is of particular importance when choosing margining models that allow for diversification benefits in the initial margin called.

5.2.2.5. Concentration margins

CCPs increasingly are recognising the effect that concentrated portfolios have on their ability to liquidate the open positions give a specific default scenario. A concentrated position in a single security would attract a larger bid/offer spread when seeking an off-taker than a small position in that same instrument, all things being equal. This larger bid/offer spread is then used to margin the larger net positions to ensure this risk is collateralised.

Huang, Menkveld & Yu (2021) investigated real-time exposure quantification at a CCP using European high-frequency equity data. They found that a CCP's exposure is almost entirely driven by changes in positions of clearing members to trading and not asset volatility. They also noted that position concentration increased during increases in exposure. Due to the large differences in trading and clearing of OTC and exchange traded derivatives, these results are not relevant to the present study.

5.2.2.6. Back-testing

Initial margins in their entirety are tested daily against the moves observed in the market at an instrument level but also at a portfolio level. Not only are initial margin parameters tested but also the sufficiency of initial margin post offsets being granted on portfolios that are cleared. It is impossible for a CCP however to back-test all possible hypothetical combinations of market instruments with the initial margin that would have been held against that portfolio to ensure the integrity of its initial margin model.

5.2.3. Collateral

CCPs must manage the resources given to them by market participants. This involves daily valuation, calling of more collateral in the case of a shortfall, returning collateral in the case of an excess and selling securities when a participant defaults (Henkel, 2019). The PFMIs (BIS, 2012b) require that qualifying CCPs accept only high credit quality, liquid assets with low market risk as collateral to satisfy initial margin requirements. This increases the demand for high quality liquid assets. Holding high quality liquid assets is an inefficient use of capital for dealers who can put that capital to use elsewhere and earn a higher return for shareholders. In practice this means that the CCP will only accept cash in the currency of settlement (and possibly G7 currencies) and government bonds.

BIS (2012b) also requires prudent valuation of collateral securities and the establishment of conservative, anti-cyclical haircuts. This is important as it increases the likelihood that sufficient collateral will be available when its needed, on the default of a counterparty.

Collateral remains on the balance sheet of the market participant and continues to earn a return on the asset (Cont, 2017). Solvency of dealers is therefore not impacted but liquidity resources are.

In South Africa, because legislation regarding securities collateral is incomplete, only ZAR cash is accepted as collateral by JSE Clear. Only registered banks can deposit funds with the central bank while JSE Clear may not. The cash posted to the clearing house therefore must be deposited with local commercial banks of high credit quality. South Africa's banking system is very concentrated and most of the qualifying banks are clearing members of JSE Clear. Because of the fungibility of cash, a circular risk problem is created in that there is a high probability that the protection against an institution's default is being held by that institution.

Figure 5.2 shows the breakdown of the collateral provided to cover initial margin requirements as at June 2020. Government bonds, secured cash deposits and central bank deposits make up the vast majority of assets. JSE Clear is clearly an outlier.

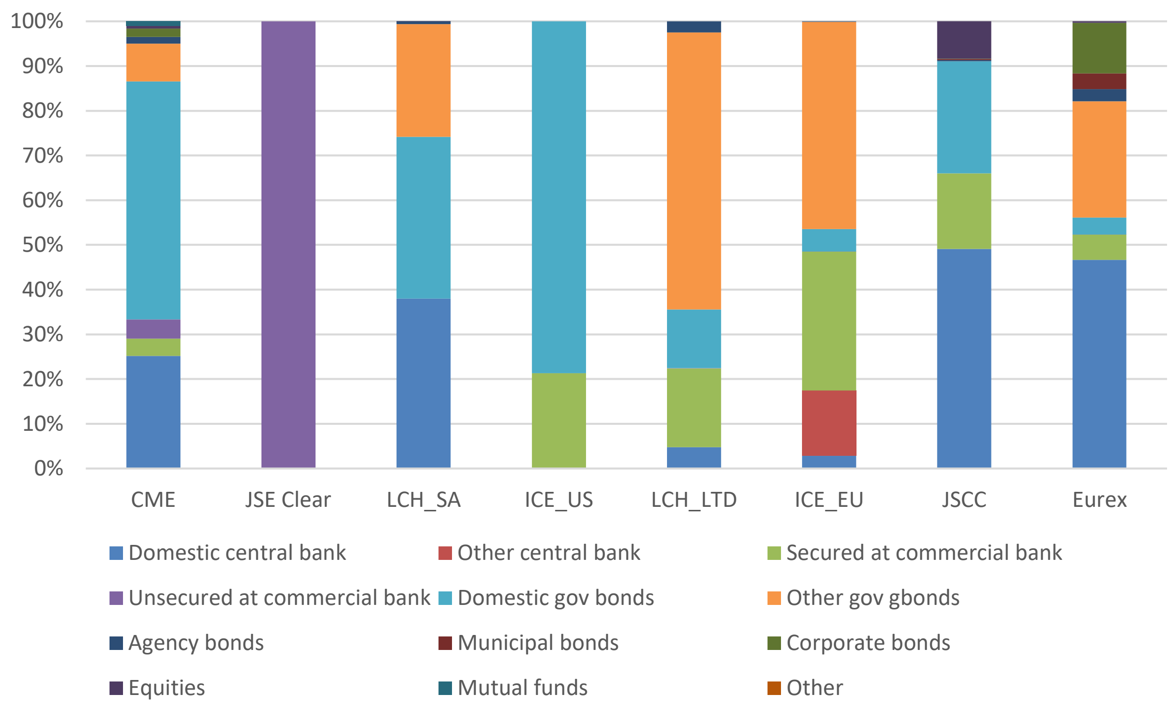

Figure 5.2: Composition of assets backing initial margin obligation at selected CCPs as at June 2020.
Source: As for Figure 4.2

5.3. DEFAULT FUND

Current standards require the establishment of a loss-mutualising mechanism (often termed the default fund) to which the CCP and clearing members contribute. This fund is required to be sized to cover extreme but plausible market events (BIS, 2012b and South Africa, 2018) It is important to note that this definition does not include any consideration for the likelihood of such an event happening. Also, it explicitly excludes events that are conceivable but not plausible. This means that prefunded resources could be insufficient in a black swan type event due to a black swan event not being plausible *ex ante*. This is an important mechanism that is designed to align incentives to manage risk. The amount the CCP and each clearing member contribute to the default fund is important as this drives behaviour and risk-taking activities. Clearing members contribute in direct proportion to the risk they bring to the market. The CCP manages all risk without taking a position in the market. The amount that CCPs contribute to the default fund varies widely and for many reasons. The amount the CCP contributes to the default fund has been the source of much debate for some time.

Knott & Mills (2002) show that Extreme Value Theory performs well in assessing a CCP's required level of total default resources above initial margin. However, they are quick to point out the difficulties of using this method in practice and suggest scenario-based stress-testing procedures which is what is common today. The CCP market is transparent in terms of the prices used to mark-to-market daily, collateral requirements and default management procedures which generally include organised auctions.

Kotzé (2012) quantifies how large the default fund of a clearing house should be. Some bold netting assumptions are used which imply that netting is allowed between segregated accounts within a clearing member. This is not legally the case. Three calculation methods are used to derive three very divergent indications of the size of the default fund. He uses actual initial and variation margin from JSE Clear (the JSE derivative markets' clearing house) over a period including dates where there were large variation margin flows. While large variation margin flows are indicative of market stress, there could be stressed market moves where there were no large variation margin flows because of the nature of the positions at the time due to clearing member flows to and from the clearing house being netted.

Daily initial margin and variation margin data are used from JSE Clear. At that time JSE Clear used a 99.95% confidence interval which, because it is so far in the tail is very difficult to accurately measure. Kotzé (2012) uses three methods for estimating the required size of the default fund. First, he uses Basel's current exposure method (CEM) and clearing member variation margin payments observed to and from the clearing house on certain dates. The second method used is an expected shortfall. He uses observed initial margin data and the assumption of log-normality to calculate an expected shortfall metric for all position accounts where the difference between the expected shortfall and initial margin is the size of the default fund. The third methodology used is a VaR methodology whereby gross variation margin is used to extrapolate a parametrised normal distribution of losses, after which a risk weight is applied. None of the methods employed use individual position data and individual stress scenarios. The methods employed do not explicitly provide for the coverage of the default of the largest clearing member and its affiliates as required by the BIS's Committee for Payment Infrastructures and the International Organisation of Securities Commissions (BIS, 2012b).

Haene and Sturm (2009) investigate the optimal balance between margin and mutualised default fund resources. They find that a CCP can enhance resilience without imposing increased collateral costs on participants.

Comparing the size of the default fund to initial margin is not straight forward. Although Figure 5.3 shows the size of the default fund as a percent of initial margin for selected CCPs, this metric neglects the impact of the confidence interval, the products cleared and the number of clearing members; it also ignores whether a CCP aims to cover with prefunded resources the default of the single largest ("Cover 1") or two largest ("Cover 2") clearing members. JSE Clear has a high confidence interval (99.7%) as does LCH Ltd, however JSE Clear is Cover 1 and clears only exchange traded derivatives (JSE Clear, 2021), which have a lower margin period of risk. Japan Securities Clearing Corporation (JSCC) has a confidence interval of 99%, clears a mix of OTC and exchange traded derivatives and for some services is Cover 1 (futures and options) and for the remaining services is Cover 2 (JSCC, 2021).

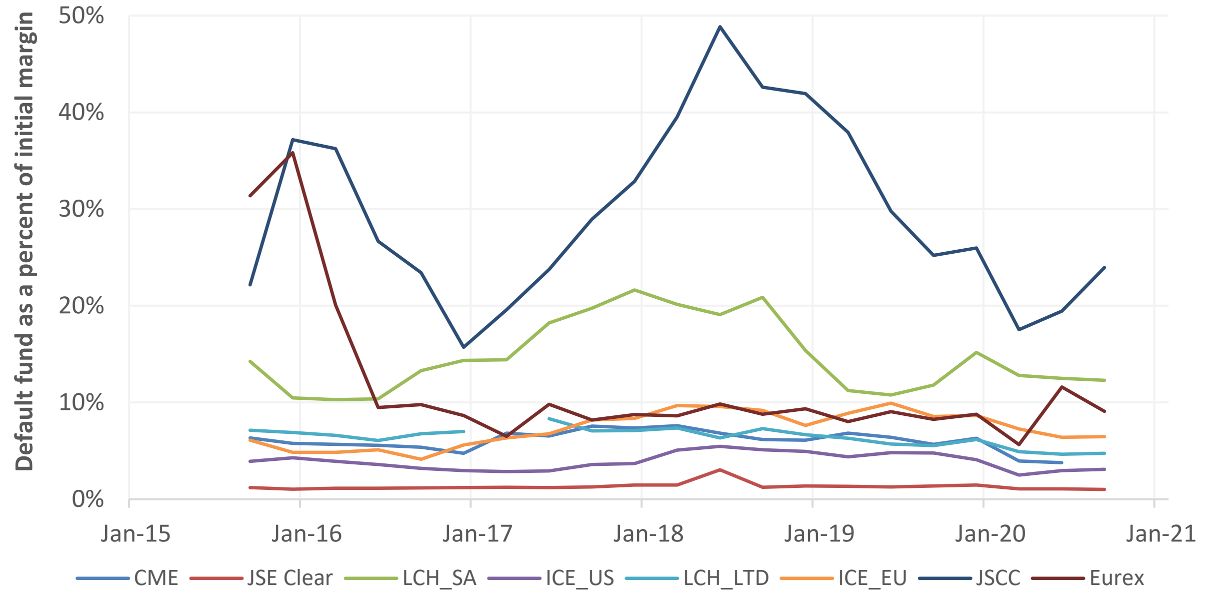

Figure 5.3: Default Fund as a percent of initial margin for selected CCPs
Note: LCH Ltd did not publish data for March 2017; CME did not publish data for September 2020
Source: As for Figure 4.2

Like Roe (2013), Arnsdorf (2012) joins the chorus pointing out that a CCP does not eliminate all risk in the market. In fact, the risk faced by a member to the CCP can increase while his position and market conditions remain unchanged. The risk faced by the CCP to each of its members can be hedged by purchasing (and daily adjusting) credit default swaps on each of its members. Arnsdorf (2012) asserts that the value of the CCP risk is the total cost of the protection purchased. However, in a CCP there is a buyer for every seller and hence when some members are in a losing position (and pose a risk to the CCP) others are in a winning position (and pose no risk to the CCP) which means that on average half of the protection bought is superfluous.

Arnsdorf (2012) states that, to accurately measure the risk to which a member is exposed, he needs the portfolio composition of all other clearing members as well as their posted collateral, which is true albeit idealistic. Recognising the limitations of the available information Arnsdorf goes on to develop a specific model to assess a member's risk to suffering losses through the CCP's default fund, i.e., the risk to other clearing members defaulting and their loss exceeding their initial margin plus their default fund contribution plus the contribution of the CCP.

Like Arnsdorf (2012), Cumming & Noss (2013) build a model for quantifying the risk to which a clearing member is exposed through the CCP's default fund. However, unlike Arnsdorf

(2012) who takes a “bottom up” approach, Cumming & Noss (2013) take a “top-down” approach. The risk of a clearing member’s contribution to the default fund can be assessed by measuring the size of clearing member positions and the probability of default of the other clearing members (and correlation of those probabilities). This is achieved by using a joint probability distribution function on changes in member positions and observing data from the iTraxx index, an index of structured credit instruments which is based on CDSs of European firms. The method requires an active credit default swap market and a CCP’s member exposure. The method presented is pertinent to regulators and CCPs as the data required are not available to clearing members, whereas the method developed by Arnsdorf (2012) is specifically aimed at use by clearing members.

The merits of requiring a default fund for the CCP serving the South African exchange traded derivative market are questioned by Kotzé & Labuschagne (2014). Claims are made that the default fund should be between zero and R150 million. JSE Clear’s default fund size has been R500 million since inception in 2013 (see Figure 5.5). However, they argue that “if one of the major clearing banks should default, the South African Reserve Bank will be forced to intervene to prevent the knock-on effects of systemic risk and the possible meltdown of the economy. This intervention is independent of the existence or the non-existence of a default fund of JSE Clear.” It is further argued that, on the basis of the conservative margins and likelihood of a central bank bail-out, a default fund is not necessary, that banks’ CCP exposures should receive preferential capital treatment in despite the absence of a default fund and imply that derivative positions of banks be underwritten by the reserve bank or potentially by private insurance.

Kotzé & Labuschagne (2014) go on to note that many of the recent clearing member failures (up until that time) did not need the support of the default fund to ensure that counterparties were protected. Counterparties were protected rather by other parts of the holistic and strong risk management framework of the CCP affected.

The amounts that selected CCPs contribute to the default fund, where their contribution is junior to that of clearing members, is shown in Figure 5.4. While most CCPs contribute less than 5% of the size of the default fund, JSE Clear contributes 20%. Figure 5.5 shows the size of the default fund in USD terms for selected CCPs.

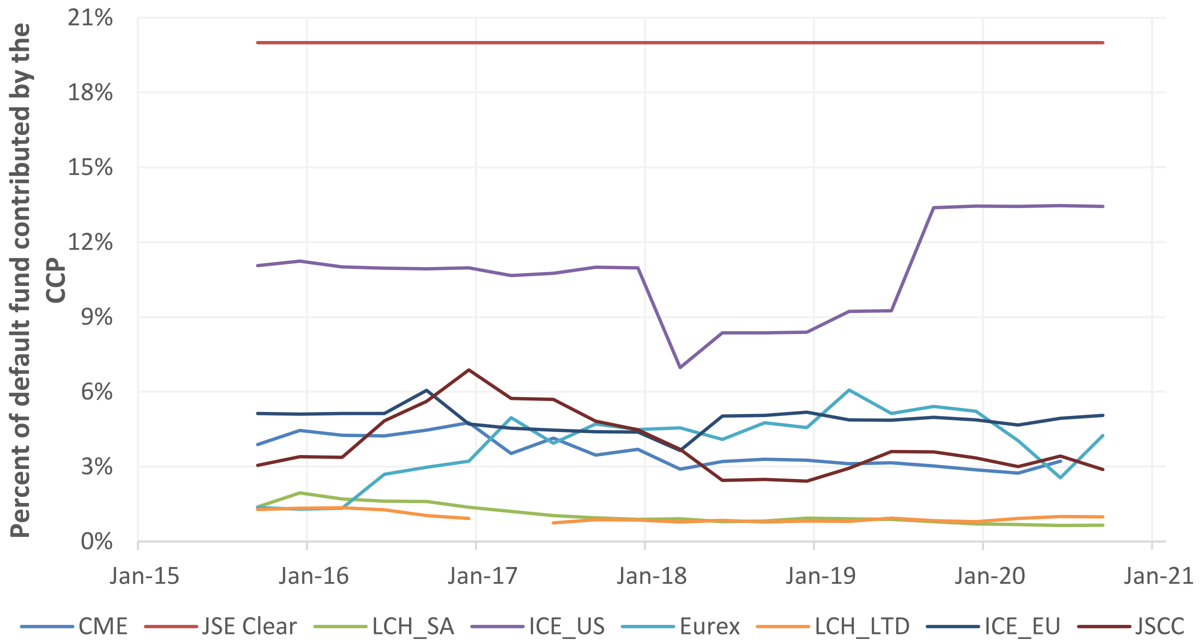

Figure 5.4: Percent of the default fund contributed by the CCP for selected CCPs. ***Note:*** LCH Ltd did not publish data in March 2017; CME did not publish data in September 2020. . *Source: As for Figure 4.2*

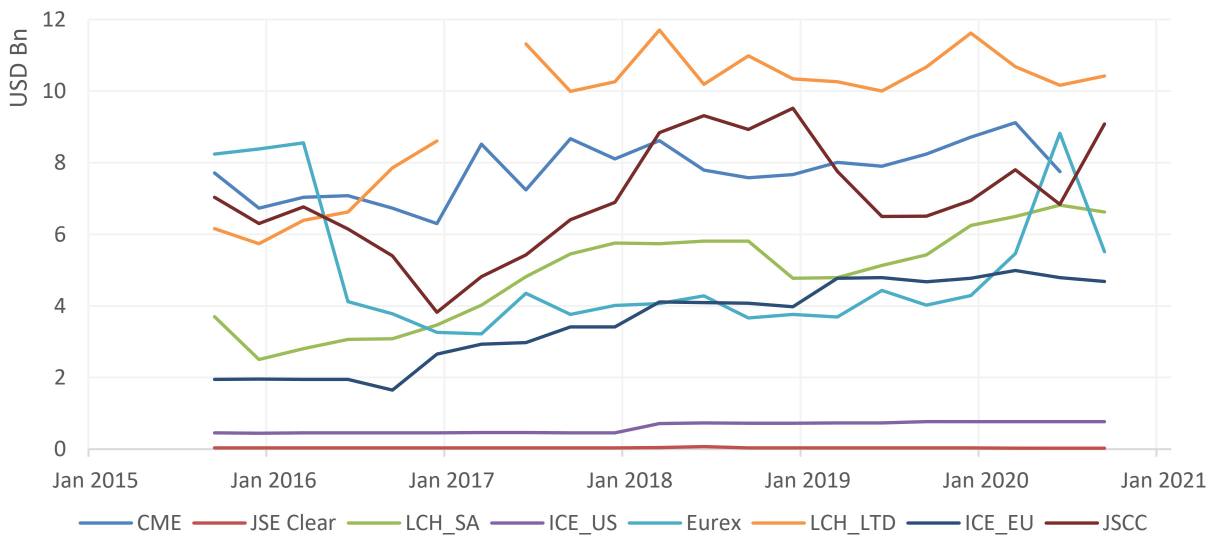

Figure 5.5: Size of selected CCPs' default funds in USD terms from September 2015 to September 2020.
Note: LCH Ltd did not publish data in March 2017; CME did not publish data in September 2020.
Source: As for Figure 4.2

The default fund is a pre-agreed loss sharing mechanism. It is, in fact, a type of insurance mechanism paid for *ex post*. In this insurance scheme the defaulter pays at least the initial margin percentage (99% is the minimum IM percentage) of the exposure plus their default fund contribution, after which the CCP has put up dedicated capital for this purpose. Only after those resources have been used does the non-defaulter pay anything and only in proportion to the risk they have brought to the market. Should losses exceed the funds available the CCP's other capital is used and potentially defaults itself with extreme consequences for the market it serves. While the likelihood of this event is extremely small it is a possibility that must be considered and for which participants must be prepared. This consideration has led to the recent focus on CCP recovery (BIS, 2017) and resolution. Clearing members acknowledge that this mechanism reduces the cost of counterparty credit risk, is necessary for the correct incentivisation and reduces systemic risk.

CCPs set a specific order of juniorisation of the fund's contributions. This generally follows the following order: the contribution of the defaulting clearing member is used first where after the contribution of the CCP is used and this is followed by the use of contributions of non-defaulting clearing members. Non defaulting clearing members' contributions are also sometimes ordered according to their participation in the default management process; that is their participation in any auction or sale of the defaulting portfolio. The DF contributions of non-defaulting clearing members who bid most competitively are the last to be used.

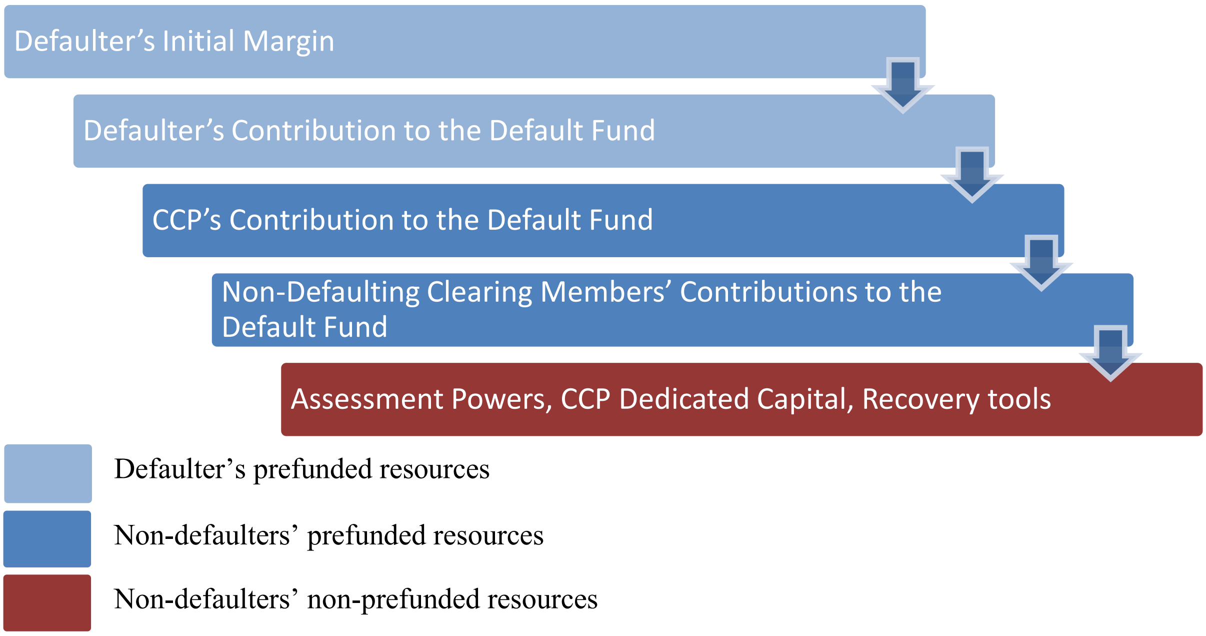

Figure 5.6: Typical default water of a CCP

Default funds are used to fund losses in the case of a clearing member default after all available resources of that clearing member are used. It is a core function of the CCP to establish fair and transparent mechanisms for dealing with a clearing member default.

In theory the percentage of the required resources which is made up by the default fund can range between 0% and 100%. This can easily be interpreted. Where the default fund's percentage of required resources is 0%, each position holder effectively fully funds all their potential losses in the rom of initial margin. This is an extreme example of a defaulter pays model and is a situation where there is little or no leverage provided. Clearing members effectively take on no guaranteeing function. Here there is no incentive to take on risk through the CCP, to clear their exposure through the CCP. It is a perfectly guaranteed environment which is extremely expensive and consumes a very large amount of capital. Where the default fund is, hypothetically, 100% of required resources, there is no amount of initial margin required by position holders and all losses are mutualised. The clearing members underwrite all the risk of every position and portfolio; the losses then are ALL mutualised and everyone bears everyone else's risk. There is no incentive for anyone not to default or to maintain and manage their position. This is obviously also a very capital-intensive proposition as significant capital will be required from each clearing member for the position of everyone else in the cleared environment. While the size of the default fund will be smaller than the sum of the initial margin the percentage is 0, perverse incentives will be created. The CCP will be incentivised to be overly conservative wherever it can within its framework. Clearing members will be encouraged to engage in a race to the bottom; to be aggressively risk seeking as they will only bear a portion of any loss they incur and to default before any other clearing member does so.

Because the default fund is mutualised and only used after all the defaulters' resources are used, there are several people who are interested in the balance between the size of the default fund relative to initial margin. Those who are interested in this balance fall primarily into four categories.

First is the CCP itself whose capital is at risk but who is directly responsible for establishing and operating the risk management framework. For the CCP, the greater their contribution to the default fund, the more expensive it is for them however the greater the size of the default fund in proportion to total resources required, the more leverage end-participants can take as there is more loss mutualisation and hence greater use of the CCP; greater use of the CCP means greater revenue for the CCP. The lower the percentage of DF to total resources required, the less chance their contribution to the default fund will be used and greater the incentive for end participants to manage their own risk. This decreases the probability of the DF actually being used.

Naturally, the clearing members have a keen interest in the size of the default fund. The clearing members contribution is effectively dependent on two things, their proportion of risk within the cleared environment and the proportion of the DF to the amount of financial resources required. The amount of clearing member capital consumed is a function of the amount of risk from their clients that they guarantee and the amount of risk to which their contribution to the default fund is exposed. It is also easy for a clearing member to require higher collateral from its clients for whom it clears if it is the CCP requiring that amount of collateral as it absolves the clearing member firm from the decision on the quantum. This has an important impact on the competition between clearing members.

Market participants would prefer to pay lower margin and are leverage seeking. They are interested in the size of the default fund and the confidence interval set by the CCP. The higher the default fund is, the less initial margin is charged for end users which lowers the cost of trading including capital cost.

Fourth, regulators are interested in effective derivative markets for the efficient management of exposure and effective price discovery. Regulators, however, also recognise the systemic risk of a CCP failing in a market and sometimes that of a clearing member. This is exacerbated by the decision by some policy makers to mandate the use of CCPs for standardised OTC derivatives in some jurisdictions. Hence the number of prefunded resources a CCP requires and the form thereof (IM or default fund) are of concern to the CCP's regulator.

The default fund should cover risks faced on the default of a clearing member; i.e. all costs to liquidate a clearing member's portfolio and restoring matched book. The careful and accurate articulation of these risks is important as this will then inform how the minimum size of the default fund is to be calculated. There are several types of risk faced by the waterfall when a clearing member defaults. First is that the initial margin of the defaulter will be insufficient to cover losses of the defaulter's portfolio. Extreme moves in market prices (stress-testing) are used to provide a guide as to how large the prefunded resources should be to cover a clearing member default. The second is that there may be one or more clearing members defaulting simultaneously and the default fund will be required to fund more than one clearing member default prior to the default fund being replenished. Assumptions regarding portability of a clearing member's clients are to be explicit and tested when calculated the default fund size. If large clients are assumed to be able to be ported, then the size of the required default is smaller than otherwise. The final portfolio being liquidated in a clearing member default may have liquidation costs not seen when looking at individual portfolios' risk. Initial margin is normally calculated using price changes over a two-day period for exchange traded derivatives and over a five-day period for OTC derivatives. When liquidating a whole clearing member's portfolio and those clients of the clearing member that cannot be ported, the extra time it may take to arrange an auction, hedge the portfolio if necessary and liquidate a larger portfolio should be calculated and any extra resources should be part of the default fund. Finally, the change in position should be estimated for the time between the time of the last receipt of VM and IM and the time when trading is terminated for that defaulting portfolio (that clearing member and non-ported clients). Resources are required for this known risk and a portfolio slightly larger than that recorded as the end of day position be required to calculate the default fund size.

5.4. DEFAULT MANAGEMENT

The default of a clearing member is not common and is an unlikely event. It is also not common that on any given day a clearing member will be required to pay more variation margin than initial margin and default fund posted (as initial margin is set at a very high confidence interval). These two events are separate and yet can overlap. The probability, therefore, that these two events happen simultaneously is smaller than either single one. That said, it should be noted that the consequences of such an event will have a very large impact on the market.

One of a CCP's key functions is to manage the default of one of its clearing members. This is a complex and very time sensitive operation as Nasdaq discovered in 2018 (see Section 2.1.1). CCPs are expected to test these procedures at least annually (BIS, 2012b). These tests are known as "fire drills" and take the form of simulating a portion of a clearing member default, testing a portion of the processes and systems involved in managing a default or simulating a full default of a clearing member. In most CCPs, participation in fire drills is mandatory. The fire drills vary in scope depending on the purpose from system testing, to auction testing, to full process and systems simulations.

5.4.1. Auctions

The determination of the price at which the defaulting portfolio is sold is normally done using an auction. The establishment and running of a default auction have been the subject of much debate recently between policy makers, CCPs and clearing members. Of concern has been the governance around the process and who is responsible for making key decisions in the process. Because the clearing members have resources at risk in the form of default contributions, they have a vested interest to ensure that the auction is successful and results in the best price, requiring the least amount of funding from the mutualised default fund.

5.4.2. Hedging

A CCP must maintain a market neutral position. All OTC derivative CCPs and some exchange traded derivative CCPs have the ability to hedge the risk of the defaulter's portfolio in the name of the defaulter. It is important that the hedge be placed in the portfolio of the defaulter and for their account as profits and losses from the defaulting portfolio and hedge must be able to be offset and be protected under any insolvency proceeding. Hedging the risk is done in several stages and the policy regarding hedging should be approved by the CCP's risk management committee with input from clearing members. Fist "macro hedges" are put in place, that is to hedge general asset class risk using equity indices, average weighted duration swaps or bonds and the largest exposures in commodities and forex. Thereafter hedges are placed on more specific price risks. Finally, all the exact instruments and positions of a defaulters' portfolio, including any hedges executed to protect it from immediate price moves, will be sold to ensure that the CCP has a matched book (has a buyer and seller for every outstanding position being cleared).

5.5. NON-DEFAULT LOSSES

Losses apportioned to the CCP not stemming from counterparty credit risk is simply termed in the market as non-default losses (NDLs). A major potential of NDLs is where a CCP takes on the risk of guaranteeing the collateral deposited with the CCP from fraud or default of the deposit taking institution. Most CCPs take title transfer on securities collateral and some CCPs accept a secure pledge over the asset.

5.5.1. Operational risk and losses

The practical mechanics of CCPs and the settlement procedures make a big difference to strength of liquidity ability and sufficiency of prefunded resources. Close attention must be paid to the frequency and timing of variation margin exchange and initial margin collection. While all CCPs exchange VM at least daily, the time at which VM is exchanged is often the following day. If VM is only exchanged and margin is only collected at mid-day the following day, a clearing member or client who cannot pay their CCP obligations can trade for one and a half days before the CCP realises it and stops them from trading. This means that the basis for

IM calculation is a portfolio that is one and a half days old and could be significantly under collateralised.

An in-depth discussion of the operational risks involved in running and maintaining a CCP is beyond the scope of this work. The complexity of the myriad of synchronised tasks that must be completed in specific order and at specific times to ensure orderly payments and receipts within payment and securities systems cannot easily be overstated. The continued accuracy of calculations and data is paramount to ensure the market infrastructure is safe and reliable.

5.6. LIQUIDITY MANAGEMENT

Due to the design of central clearing, a CCP should have enough liquid resources to fulfil all its obligations as and when they become due. This includes having committed lines of credit where appropriate or, due to their systemic importance, access to central bank money. The Bank of England (2012) acknowledges the importance of adequate access to liquidity by a CCP by expressing its policy: "in respect of liquidity, the Bank will, without committing to lend, seek to ensure that there are no technical obstacles to timely provision of central bank liquidity where the CCP is solvent and such provision will help safeguard financial stability."

Chamorro-Courtland (2011) reviews the law and regulatory reforms relevant to CCPs in various jurisdictions and analyses the legal nature of central bank liquidity assistance to CCPs. CDS clearing and analyses issues specific to central bank assistance for CDS CCPs are explored.

There should only be one instance in which a CCP should require liquidity, that is when a clearing member has defaulted, and security has been sold to satisfy variation margin requirements. There will then be a difference in the time that cash is available from the sale of securities to receiving the funds from the sale (normally two to three days) and the time that variation margin is due (immediately).

5.7. LOSS ALLOCATION, RECOVERY AND RESOLUTION

In 2017 the Committee for Payments and Market Infrastructures and the International Organisation for Securities Commission (BIS, 2017) published further guidance on the PFMIs (BIS, 2012b) relating to recovery of financial market infrastructures. The guidance covers governance arrangements, loss allocations and the role of authorities when a CCP is in recovery. Specifically, for CCPs, scenarios of recovery cover events caused by default losses exceeding available resources and as a result of non-default losses. The latter are losses because of the management of the CCP business, often this includes investment losses on collateral where the collateral sits on the balance sheet of the CCP.

After a defaulting clearing member's initial margin is used and the default fund is used in its entirety there is not only one single method to deal with remaining losses but a number of methods are common among CCPs. Generally, a CCP contributes more of their own capital and requires the surviving clearing members to contribute to the default. The latter is known as clearing member assessments. Figure 5.6 shows selected CCPs' assessment powers over clearing members as a percentage of the clearing members' default fund contribution. Note that Eurex and JSE Clear do not have assessment powers. The range of additional resources, above its contribution to the default fund, that a clearing member may be required to pay to mutualise another clearing member's default currently ranges from 50% to 200% of their default fund contribution. Other methods of extinguishing outstanding losses are to implement a period of variation margin gains haircutting (VMGH) during which variation margin is still collected from losing positions but only a portion paid out to winning position holders; partial tear-ups (PTUs) are used to re-establish a matched book; and discussions have been initiated but not progressed on initial margin haircuts whereby a CCP uses a portion of non-defaulting members' initial margin to fund losses which much then be topped up by members (Cont 2015).

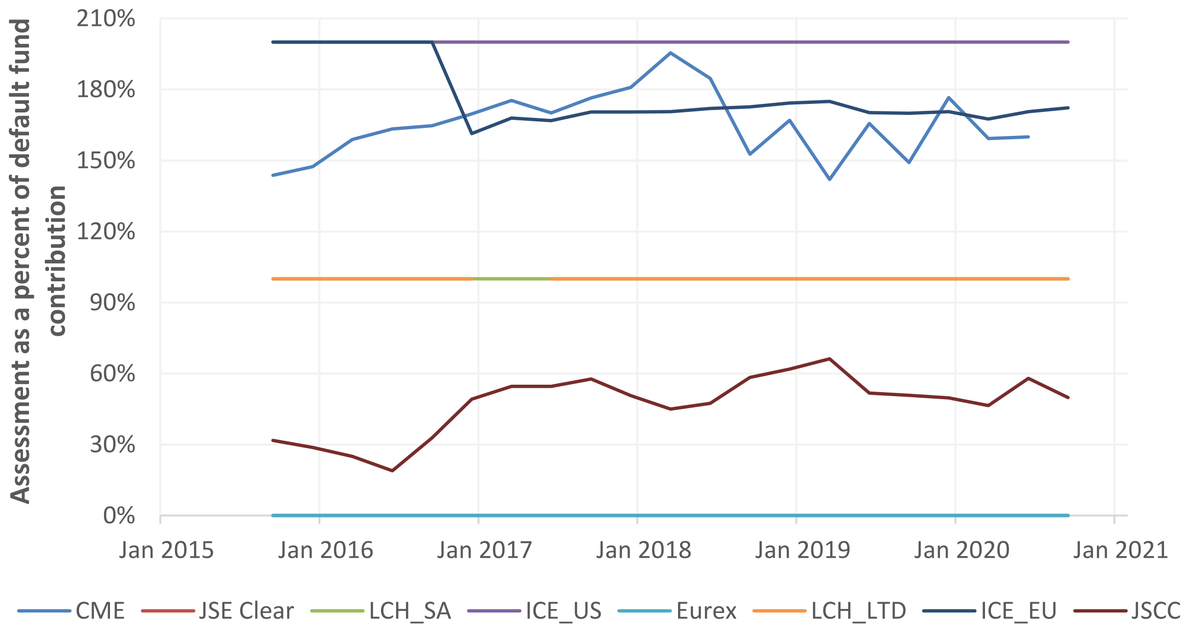

Figure 5.7: Assessment powers of selected CCPs as a percent of clearing members' default fund contributions.

Note: LCH Ltd and LCH SA have assessment powers of 100%, LCH Ltd did not publish data for March 2017.
Source: As for Figure 4.2

There is some consensus that after the default fund is utilised in its entirety and the clearing member assessments are used and that the powers, the CCP enters its “recovery plan” and that elements of the plan are written into the CCP’s rulebook (Tucker, 2013 and BIS, 2017). The recovery plan has stricter governance and oversight from members and the applicable regulator. When all avenues of addressing default-losses are exhausted (or when the resolution authority so decides if they have the power so to do) the CCP is then in resolution. The management of the CCP is normally replaced and the authorities take over running the CCP until a suiter is found to purchase the business or it is wound down in an orderly fashion. A CCP failure is a catastrophic potential which highlights the importance of the success of the risk management framework and active participation by all parties (BIS, 2017).

In the study of Antinol, Carapella & Carli (2019), institutional features of various loss allocation methods commonly adopted by modern CCPs are modelled. They conclude that crucial information gained on counterparties from contracts that are not cleared is lost when moving from a bilateral arrangement to central clearing. Antinol, Carpapella & Carli (2019) consider clearing member assessments; the contentious method of variation margin gains haircutting is not investigated in the model put forward by Antinol, Carapella & Carli (2019).

Much focus has recently been placed on the recovery and resolution of CCPs as well as ensuring the resilience thereof. Arnsdorf (2012) notes that the probability of losses exceeding all prefunded resources, default fund and initial margin, is extremely remote. Jones & Perignon (2013) recognise the catastrophic nature of a CCP default and consider the likelihood of such an event. They find that a CCPs exposure to clearing members is greater to the members’ proprietary risk-taking activities rather than through guaranteeing their clients. They raise concerns regarding systemic risk by showing that extreme losses suffered by important clearing members are clustered. Extreme value theory is used to quantify the tail risk of the clearing house.

The analysis done by Jones & Perignon (2013) uses the ratio of margin available to cover default losses with the variation margin called daily (profit or loss) for a participant. Clearing member house accounts are analysed separately from those of clients of clearing members. They find that house accounts are underwater more frequently than client accounts.

Methods of resolving unfunded losses must be agreed upon by clearing members, CCPs, participants and regulators alike before they are needed. Irrespective of the extreme unlikeliness of being used, the market cannot wait in fear of catastrophe, hoping it does not happen because it is unlikely and beyond the scope of protection. Below are mentioned the most common methods used to address unfunded losses. This is an area of debate as no-one wishes to pay for others' mismanagement.

The methods described below must continue the incentives created for sound risk management. Using these tools should be punitive for the CCP and those that do not support the process set forward to ensure sound risk management.

5.7.1. Variation margin gains haircutting

Variation margin gains haircutting is a method put forward where the full amount of VM is collected from losers but only a portion thereof is passed on to the winners (Singh & Turing, 2018). This changes the incentives for risk taking in the first place, and for driving the market price in the event of a clearing member default. If a participant knows that, when a clearing member defaults, they will not get all their winnings if they push the price far away from the defaulter's position, they will think twice before considering the exuberance with which they willing to take advantage of the CCP's obligation to close out the defaulter's positions.

Implementation of VMGH can vary and be specific to an intended outcome. The wider the implementation is, the lower the impact on each particular instrument and user will be. However, this may not create the desired incentives of calming the market in a time of stress. VMGH could be implemented across the CCP, across the markets used by the defaulting clearing member or only the exact instruments and product sets within the defaulting clearing member's portfolio (Gull, 2018).

5.7.2. Partial tear ups

The practice of partial tear ups (PTUs) is the closure of positions at a price determined by the CCP. That is, if a CCP cannot find a buyer for a defaulted position they will terminate the position and the person on the other side will be compensated and must re-transact to regain the exposure that has been closed out by the CCP.

PTUs can be partial and pertaining to the defaulting clearing member's open contracts only. This is generally considered when options to return to a matched book are exhausted. A full tear up involves all open contracts of the CCP or of the affected service; this to possibly be used in the extreme scenarios subject to financial stability not being jeopardised (Gullo, 2018).

CHAPTER 6 THE GLOBAL FINANCIAL CRISIS AND REGULATORY REFORMS

6.1. AN OVERVIEW OF THE GLOBAL FINANCIAL CRISIS

In the first five years of the twenty first century, US house prices increased much faster than they had in the previous decade. This was fuelled by low interest rates and lending practices. The period 2000-2006 saw an increase in subprime mortgage lending, allowing many people that were previously excluded from the housing market to buy houses and others to purchase second houses. In the US many mortgages have a non-recourse feature, meaning that on default the lender only has recourse to the asset but cannot touch other assets owned by the borrower. This effectively gives the borrower an American-style call option on the property. Should prices drop below what they have paid to that time, the borrower can simply walk away and buy another similar house but for a lower value (Hull, 2010b).

Lenders securitised portfolios of loans and sold these off to investors seeking yield in a low interest rate environment. It was not uncommon that the security was opaque and terms complex making accurate valuations very difficult for investors. The market relied heavily on rating agencies, whose traditional business was rating bonds, to determine the value of mortgage securitisations. Many of the models used by rating agencies were not studied or not understood by traders who relied on the outcome (Hull, 2010b).

Mortgage originators used lax lending standards; risk was easily transferred to investors in complex products. Rating agencies assigned high ratings to securities which relied on the structure of correlation between asset classes (Hull, 2010b).

The three largest defaults during the crisis were that of Bear Stearns, Lehman Brothers and AIG; while troubled mortgage exposures were at the core of each, derivatives played a varying degree in all of the failures. Post the crisis the focus of reform was on transparency, counterparty risk and leverage implicit in the OTC derivatives market (G20, 2009 and Rosenberg, 2010).

In the aftermath of particularly the Lehman's default, central counterparty clearing emerged as the hero preventing an even darker and deeper crisis (Norman, 2012). What was previously relegated to the backstage and considered an unattractive, at times pedantic and always unglamorous part of any financial market business was suddenly flung into the spotlight as businesses counted their losses. Banks and financial market participants quickly became acutely aware of how much bigger those losses could have been and how big similar potential losses can be.

6.2. A NOTE ON THE EVOLVING REGULATORY ENVIRONMENT

The financial market reforms initiated post the Global Financial Crisis (GFC) focused on CCPs as CCPs prevented some serious losses and contagion. It became apparent to banks and regulators that the amount of risk being transferred and mitigated through CCPs was significant, systemically significant. But in its very nature a CCP is systemically important for the market it clears. The magnitude of its greater systemic importance is proportional not to its size or the number of transactions or value it clears but rather the systemic importance of the market its clears. A CCP that clears agricultural products for a country (that country's staple food produce) could be as important to that jurisdiction as the financial market which could be multiples the size of the former in nominal terms.

Aigrain, (2013, p154) notes that in Lehman Brothers' collapse, "LCH.Clearnet's successful management of the default, for which it only needed to resort to a small portion of the initial margin held, gave global policymakers a clear demonstration that greater use of CCP clearing should form a major part of their agenda to bring greater stability to the world's markets and, in particular, to the use of derivatives."

The 2009 Group of 20 nations (G20) Pittsburgh Summit was a watershed in the regulation and oversight of the world's financial markets. It was the third meeting of the G20 leaders to discuss financial markets and from it the G20 Framework for Strong, Sustainable and Balanced Growth was launched. The G20 officially became "the premier forum for international economic cooperation". The G20 committed to reform the global financial architecture a component of which was to have standardised OTC derivative contracts traded on exchanges or electronic platforms and, where appropriate, cleared through central counterparties by the end of 2012 (G20, 2009).

A review of the regulatory reform by Duffie (2018) provides a summary of some of the most important changes in the financial system brought about as a result of the financial crisis. He comments on the debate regarding CCPs' efficiency of reducing exposures and noted the impact of trade compression on reducing swap exposures. This risk of a CCP failure and resolution of financial institutions is also discussed, along with associated regulatory reforms.

Regulators and market participants then turned their attention to what would happen if a CCP itself was went into liquidation or its waterfall could not manage the default of a clearing member. Guidance on the recovery of CCPs has been issued by CPMI-IOSCO, which is still being implemented in many CCPs and jurisdictions (BIS, 2017). The default of a bank is a rare event and the default of a systemically important bank even rarer. There are only a handful of examples of a CCP defaulting/being placed into liquidation or recovery in the history of clearing. Norman (2011) provides an exposition of CCP defaults. For a CCP to be in a position that it cannot fulfil its obligations there must have been losses emanating from a failure at a clearing member (normally a bank) or another source.

Recent policy and regulatory focus have turned to the resolution of CCPs including the transparency and legal framework thereof. A cause for this emphasis has been the increasing systemic importance and concentration of risks in CCPs. This has been caused in part by the commitments of the G20 mentioned above. Also, the decision to clear one more trade is influenced by whether that trade will increase a bank's exposure to a counterparty and how much it will cost in extra (or save in reduced) initial margin. The events at Nasdaq in 2018 (Ewing & Schreuer, 2019) also helped sharpen the minds of clearing members and policymakers as it was not unimaginable that a CCP's safeguards and risk framework could fail when the market needed them most.

For a more complete discussion on resolution of CCPs see Tucker (2013), Duffie (2014), Sungh & Turing, (2018), Faruqui, Huang & Shirakami (2018) and Gullo (2020).

6.2.1. South African CCP regulation

The Securities Services Act (2004) (SSA) took effect on 1 February 2005. It governed the regulation of securities services in South Africa to include securities exchanges, central securities depositories (CSD), clearing houses, and their respective members. It consolidated the South African regulatory framework for capital markets and aligned the regulation and supervision of South African financial markets with the prevailing international developments and regulatory standards (South Africa, 2011).

The SSA did not allow for a clearing house to be a self-regulatory organisation. This meant *inter alia* that it could not publish rules and approve or regulate its own clearing members. The clearing house under the SSA operated under the rules of the exchange for which it cleared and could simply calculate the net settlements for market participants or could do so and underwrite the performance of the transactions. Importantly a clearing house could not operate in the absence of an exchange. South Africa's legal framework did not allow for a payment clearing house or a clearing house that cleared transactions not under the rules of an exchange (over-the-counter trades). The SSA was repealed by the Financial Markets Act (2012) (FMA).

The FMA was promulgated in 2012 (South Africa, 2012) and distinguished two types of clearing house; a clearing house could either be an "associated clearing house" or "independent clearing house". An associated clearing house operates under the rules of the exchange for which it clears. The latter authorises and supervised its own clearing members in accordance with its own rules. The introduction of an independent clearing house allowed for a clearing house to be established that did not depend on an exchange infrastructure for its infrastructure and resources, but more importantly could clear trades that were concluded bilaterally and not reported to any exchange, i.e., over-the-counter trades. Prior to the new definition of clearing (which was previously limited to transactions in listed securities) in the FMA and the introduction of an independent clearing house licence in 2012, South Africa did not have a legal framework for the clearing of OTC transactions.

Neither the SSA nor the FMA initially defined a central counterparty. Rather the FMA was amended by the Financial Services Regulation Act (FSRA or Twin Peaks) in August 2017 (South Africa, 2017) with the introduction of a type of clearing house called a central counterparty "that interposes itself between counterparties to transactions in securities, becoming the buyer to every seller and the seller to every buyer and thereby ensuring the performance of open contracts; and becomes a counterparty to trades with market participants through novation, an open offer system or through a legally binding agreement" (South Africa, 2017). This is also the first time that the term novation has been used in South African legislation as it pertains to the financial market. Novation, the act generally by a CCP, is the interposition between counterparties and becoming a counterparty itself is the cornerstone of central counterparty clearing and the basis on which a CCP's risk management arrangements hinge. Up until the promulgation of the FSRA, this was only described in the rules of the JSE's derivative exchange as it related to the activity of the clearing house. The FSRA introduced a financial market infrastructure that is a CCP and defined it in terms of the function of novation it performs.

Before the release of the FMA regulations in February 2018 there were no detailed requirements for clearing houses and before CCPs. Most of the regulations detailed in the FMA regulations (South Africa, 2018) focus on the requirements for CCPs.

The term "clear" was defined in the SSA and has a similar definition in the FMA. This definition is very broad and describes the process of calculating aggregated and netted settlements. The JSE's derivative rules defines clearing differently as the act of interposition between counterparties. It does not explicitly state who fulfils the action of clearing as defined in the act but this is inferred from the function each party undertakes. The FMA, as amended by the FSRA, confers power on the Registrar of Securities Services to authorise or exempt from authorisation a foreign company to perform the functions of a clearing house in South Africa. Details of the application process for a CCP, have not been published. No local or foreign entity has applied for a CCP licence or independent clearing house license in South Africa. This means that a local market participant cannot currently clear their OTC trades in South Africa.

CHAPTER 7 CENTRAL CLEARING NETTING EFFICIENCIES

It is well established that there is a real economic cost of breaking and splitting netting sets within a market (Benos et al, 2019, Duffie & Zhu, 2011, and Pirrong, 2010).

As has been discussed, a CCP must have a well-defined set of instruments that they are willing to accept for clearing. This means that by necessity there are derivatives which participants have to bilaterally manage and settle should they wish to trade them even if both counterparties have access to the same CCP. In South Africa, the local CCP only clears listed derivatives. These derivatives are equity futures and options, forex futures and options, commodity futures and options and SA bond futures. There are derivatives listed and cleared that do not fit these strict definitions, but the open interest and risk associated with the products not mentioned above are not significant in proportion to those noted above as shown in Chapter 8. The most common instruments traded by SA counterparts are done over-the-counter and are not cleared by the domestic CCP. They are interest rate derivatives; forward rate agreements (FRAs), interest rate swaps and swaptions that are standard or standardisable, all valued using the interbank swap curve and collectively referred to as interest rate derivatives. The exposure inherent in interest rate derivatives is different to that of a bond future in several ways. The main way it is different is that the underlying risk factor is the interbank curve whereas the bond future's value is determined mainly by the bond price or SA sovereign risk. The risk that the difference between these curves changes is called basis risk. While there is a high correlation between assets based on the swap curve and assets based on the bond curve they do not move in sync. South African counterparties do indeed have a clearing alternative for interest rate swap exposures, however that alternative is based offshore (LCH), requires foreign currency collateral and a relationship with a foreign clearing member. The fact that ZAR cash and ZAR government bonds cannot be placed as collateral with LCH complicates the clearing of trades at LCH for local participants whose balance sheets are ZAR denominated. The forex risk inherent in placing foreign denominated collateral must be dynamically hedged which creates friction and increases costs. Only one SA bank, through its offshore subsidiary, has a direct clearing membership at LCH and can only clear for itself.

Adding an extra asset class to an existing CCP will always decrease the overall counterparty credit risk of the products asset classes under consideration (Duffie & Zhu, 2011). However, Pirrong, (2010) shows that it is not necessarily the case that the formation of a CCP reduces systemic risk when one considers the netting sets that are broken to form the CCP.

Considering that the value of OTC trades far exceeds that of listed derivatives in SA (see Chapter 8 providing data from the SARB's BA350 returns), the question of whether a CCP that clears interbank interest rate derivatives reduces counterparty credit risk in SA is of relevance. We will also study whether including interest rate derivatives in the existing derivative CCP's list of acceptable instruments for clearing will positively or negatively impact overall counterparty credit risk. Trades with offshore counterparts will likely continue to be cleared offshore and hence will not enjoy full offset benefits, this is known as bifurcation. While it is currently the case that banks' interest rate derivative portfolios are bifurcated between those trades transacted with offshore counterparts that are cleared and those transacted with local counterparts that are bilaterally cleared. The ISDA agreements signed between dealers and their counterparts and the accompanying Credit Support Annexes (CSAs) generally favour banks and often do not require banks to post collateral for the exposure they pose to their counterparts. Part of the G20 Pittsburgh commitments (G20, 2009) stated that bilaterally cleared trades will be appropriately margined however South Africa only imposed final requirements in 2020 which will only become fully effective in 2024 (South Africa, 2020a). Only the large banks and a few of the very largest counterparts will be impacted (South Africa, 2020b). It is possibly because their counterparts do not require collateral for their exposure to SA banks and the reliance on the strong oversight of banks by the SARB that local banks have not naturally formed a CCP for OTC interest rate derivatives.

7.1. DERIVATIVES IN SOUTH AFRICA

For the purposes of this study, we will split the traded derivatives in South Africa into distinct groups and provide the necessary characteristics for the study of netting efficiencies.

The first group of derivatives are cleared OTC interest rate derivatives. The LCH clears ZAR interest rate swaps but not ZAR forward rate agreements (FRA) as the settlement characteristics are different to their international equivalents. The prices discovered in the FRA market are used to determine the near end of the ZAR interbank curve. Most swaps and FRAs reference and reset against the Johannesburg Interbank Agreed Rate (JIBAR). All major banks in SA have an agreement with a clearing member of the LCH and clear their standardised interest rate swaps traded with offshore counterparts there.

The second group of derivatives are OTC interest rates but are uncleared and have an SA bank as a counterparty and an SA bank, a corporate or non-bank financial institution as a counterpart. These are not cleared and are netted under an ISDA agreement with an accompanying CSA to manage counterparty credit risk. These CSAs generally require collateral from the non-bank counterpart while the bank seldom posts collateral; this will change by 2024 when the SARB's requirement to collateralise bilateral OTC derivatives positions has been finally phased-in (Financial Sector Conduct Authority and Prudential Authority, 2020). Thresholds are applicable which will make the margining requirement irrelevant for many counterparts.

Standardised non-cleared non-interest rate OTC derivatives make up the third group. These are mostly equity derivatives and forex derivatives. The counterparties to these trades are local banks, local corporates and local non-banking financial institutions along with international counterparts (banking and non-banking financial institutions mainly).

The JSE operates a derivative market. All the transactions executed on or reported to the exchange in terms of the exchange rules are novated and cleared by JSE Clear, which is a 100% owned subsidiary of the JSE. The derivatives listed for clearing are grouped into four asset classes, namely equity derivatives which make up the largest portion, ZAR government bond derivatives, forex derivatives and commodity derivatives which are dominated by contracts in white and yellow maize. There are seven clearing members which contribute to a default fund and who clear for all.

The last group of derivatives are OTC non-standardised derivatives which are traded between banks and buy-side financial institutions.

7.2. MARKET PARTICIPANTS IN SOUTH AFRICA

In the South African context and for the purposes of this study the derivatives, there are four main distinct groups of derivative users two of which have some degree of overlap. Each of these users have distinct characteristics which drive their appetite for derivative instruments and methods of settlement. While there are other players in the interest rate derivative market, they are much smaller in size and volume of activity than the four described below.

Local banks make up the largest portion of derivative users in South Africa (South Africa 2020b). They have exposures to cleared OTC interest rate derivatives, OTC interest rate derivatives which are uncleared, non-interest rate OTC derivatives and cleared non-IR derivatives. There are offshore interest rate derivative participants for whom their exposures relating to

ZAR interest rate derivatives are mostly already cleared by a CCP. The margin requirements for bilaterally cleared OTC derivatives (South Africa, 2020a) will require variation margin to be posted by numerous counterparts. The thresholds pertaining to initial margin however, are sufficiently high that only a very few participants in South Africa will be required to post initial margin on their uncleared OTC derivative exposures (South Africa, 2020b).

Some large international banks actively trade ZAR interest rate derivative products and offer their clients exposure to the South African markets. Not all of these banks have a branch in South Africa and rely on local banks for local currency settlement services. Notably for this study, these banks commonly have a general clearing membership at LCH. It is common that these banks are active across asset classes.

The last two groups of derivative users are international and domestic non-bank financial institutions and corporates. Due to size and clearing mandate carve-outs, it is unlikely that these two groups will be required to post initial margin under margining rules (South Africa, 2020b). A consequence of clearing is that some portion of counterparty credit risk is transformed into liquidity risk as the nature of settlement and risk mitigation changes (Cont, 2017). This materially impacts the attractiveness of clearing for corporates and non-bank financial firms who are hedging non-daily payment cashflows or taking a view on asset prices. Further, as the main activities of these firms is not trading in derivatives, the amount of counterparty risk that these instruments pose is seldom sufficient for them to invest resources in establishing a clearing relationship and liquidity facilities. It is unlikely that trades with these firms will be cleared.

CHAPTER 8 DATA

Initially we will use international data to test our model and compare to results achieved by Duffie & Zhu (2011) whose investigation (and that conducted by Cont & Kokholm, 2012) investigated the efficiency of introducing a CCP for credit default swaps (CDS).

8.1. INTERNATIONAL DATA

The Office of the Comptroller of the Currency (OCC) in the United States publishes a quarterly bulletin on the trading and derivatives activities reported in the US. Included is the nominal amount of derivative contracts held by the 25 largest dealers (by total derivatives). Data for the third quarter from various years is used. Duffie & Zhu (2011) and Cont & Kokholm (2012) use Q3 2009. Table 8.1 shows the outstanding notional amounts by derivative type for OTCs held by the largest six dealers for Q3 2009; the top six comprise 97% of the top 25 by nominal amount.

Table 8.1: Notional amounts of OTC derivative contracts for the six largest banks in the US as at September 2009

Source: United States of America (2021)

	Forwards	Swaps	Options	Credit	Total
Bank 1	8,177	51,203	10,059	6,376	75,815
Bank 2	8,984	49,478	5,918	5,590	69,970
Bank 3	1,651	31,521	6,980	5,762	45,914
Bank 4	5,718	24,367	4,064	5,482	39,631
Bank 5	5,536	16,375	6,384	2,764	31,059
Bank 6	1,198	2,192	477	268	4,135
Total	31,264	175,136	33,882	26,242	266,524

Figure 8.1 shows the distribution of the largest 25 US dealers. Bank 1 is always depicted as the bank with the largest overall derivative notional, OTC plus exchange traded derivatives. The Bank 1 of one year may be different to Bank 1 of another year. It is clear that the top six banks continuously make up the majority of derivative positions.

The OCC's quarterly bulletin provides the data for other quarters. For a comparison over time, data for quarter three for 2007, 2009, 2012, 2014, 2016, 2018 and 2020 are used.

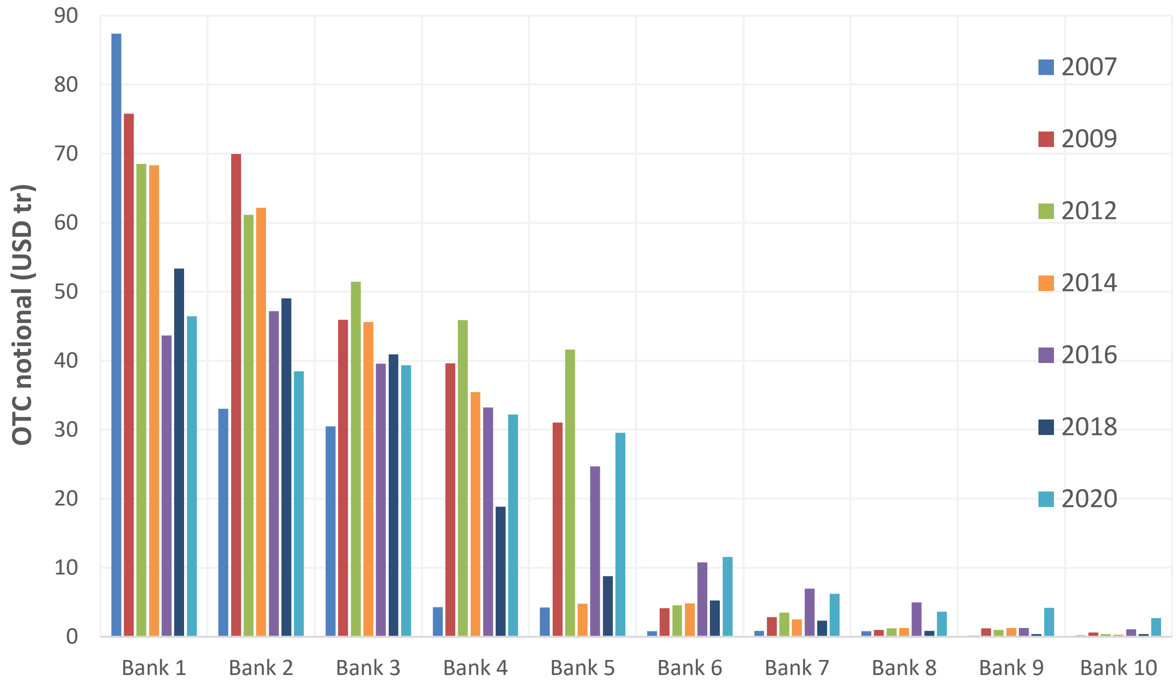

Figure 8.1: OTC notional for the top 10 US dealers for Q3 of selected years

Source: United States of America (2021)

The amount of notional outstanding varies from year to year as is seen in Figure 8.2. There was a dramatic increase in derivatives notional coming out of the global financial crisis of 2008-2009. Thereafter, notional outstanding held by US dealers has decreased to Q3 2018. Post the initial shock of COVID-19 on the world markets derivatives usage has increased.

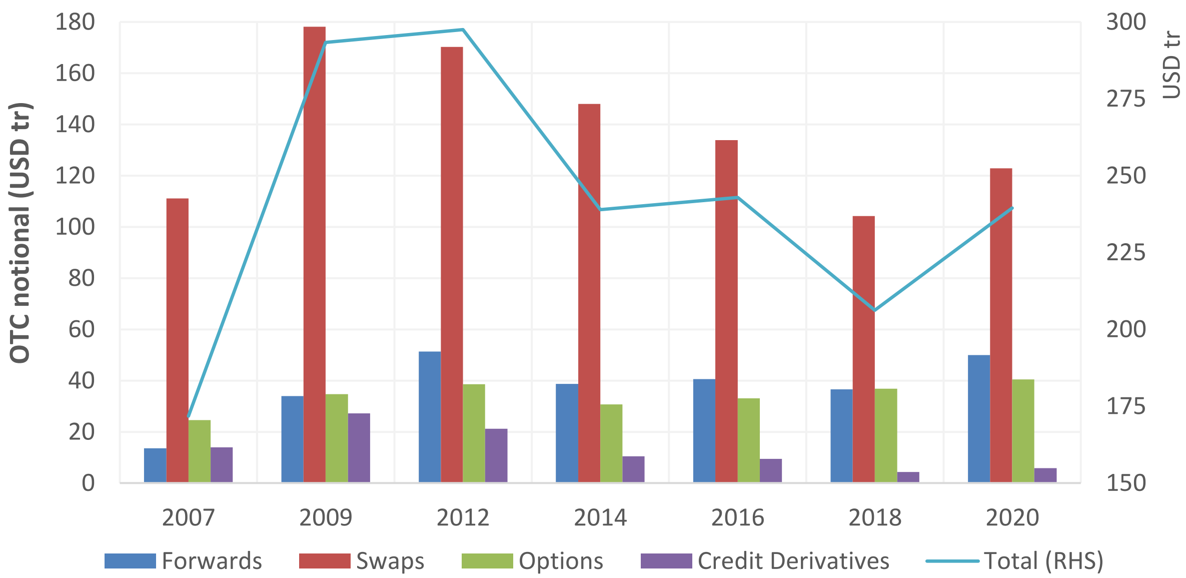

Figure 8.2: Derivatives notional outstanding by instrument type for selected years

Source: United States of America (2021)

The OTC derivative market is international by nature. It will be assumed, as in Duffie & Zhu (2011) and Cont & Kokholm (2012), that there are a further six international banks with whom the US banks trade in the same manner as local USD banks. These banks will have the same distribution of exposure as the six largest US banks. This simplification means that the exposures for the international banks will be the same as for the US banks.

The OCC does not provide data by underlying asset class as defined in the methodology below. The model, however, allows for an alternative definition of asset class. What is important is that the correct average standard deviation of the whole group of derivatives allocated to each asset class is used. Almost all swaps are interest rate swaps and all derivatives labelled credit are credit default swaps.

Figure 8.3 shows that in Q3 2009 CDSs make up 10% of the notional amount of OTC derivatives for the top six banks and that swaps make up 65% of the total notional.

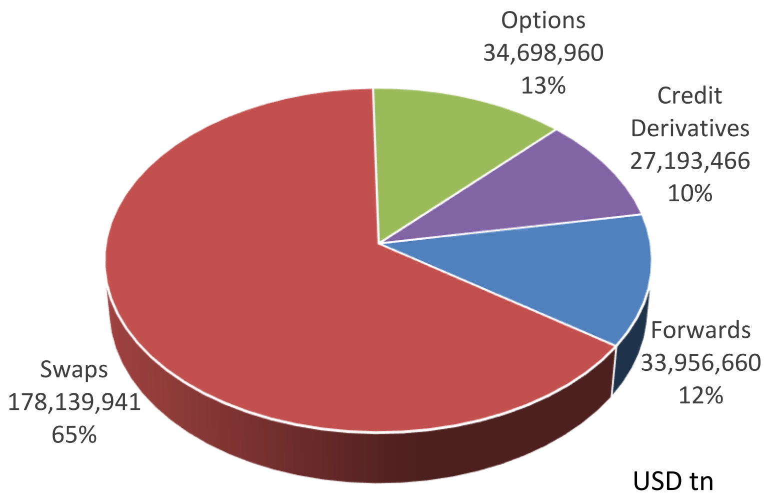

Figure 8.3**:** Outstanding notional in OTC derivatives for the largest 25 US dealers in 2009
Source: United States of America (2021)

There are no equivalent data for European banks. The OTC derivative are no longer national but international and banks in the US trade not only with each other but with their international counterparts. We will assume that there are a further six banks with similar sized exposures based offshore that also participate in the OTC market and are potentially clearing members.

Duffie & Zhu (2011) use a scaling factor, β_k, for interest rate swaps of 3.5% and three times that for all other asset classes. This is based on BIS's data as of June 2009 stating that the market value of swaps is roughly 3.5% of the notional amounts; for other asset classes the factor is 5.6%. this implies that other asset classes should be scaled 1.67 times more than interest rate swaps. They then arbitrarily increase this from 1.67 to 3.00 to allow for changes in market value between the time of valuation and the time additional collateral is received before a potential default.

8.2. SOUTH AFRICAN DATA

8.2.1. Risk weighted assets

Under Pillar III of the Basel accord banks are required to make quarterly public disclosures regarding *inter alia* risk weighted assets (RWA) that are exposed to market risk. This is published for the larger banking group, and not just each bank's South African operations. Banks use either an internal models approach to measure the capital requirement for market risks, subject to approval by the local regulator, or the standardised approach which is intended to be more punitive. According to their disclosures, most banks use internal model for their South African operations and the standardised approach for their non-SA trading activities.

As at the end of 31 December 2019 the five major banks in SA had risk weighted assets attributed to market risk as shown in Table 8.2. This has been gathered from each bank's public risk disclosures. The only south African banks that are clearing members of a central counterparty are the banks listed in Table 8.2.

***Table 8.2*:** Market Risk RWA (ZAR'm) as at December 2019

	Standardised	Internal Model	Internal Model %
ABSA	18,540	20,691	27%
FirstRand	10,274	18,891	24%
Investec	2,026	2,791	4%
Nedbank	1,487	20,712	27%
Standard Bank	60,795	14,588	19%

Source: ABSA Ltd (2020), Firstrand Ltd (2020), Investec Ltd (2020), Nedbank Ltd (2020) and Standard Bank Ltd (2020)

The data in Table 8.2 will be used to allocate the correct proportions of derivatives between the banks. As no other banks have clearing operations of their own, it will be assumed that the five banks listed in Table 8.2 are the only SA banks with material trading activity in derivatives.

8.2.2. Derivative instruments

The SARB monitors the banks' positions and activity in derivative instruments on an on-going basis through the banks' BA350 regulatory return. Aggregate monthly information is published (SARB, 2020) pertaining to the monthly activity in derivative instruments and the outstanding notional amounts of derivatives held by banks. Table 8.3 shows the notional amount held by all South African banks by execution type and asset class. Table 8.4 summarises the data by asset class only. Interest rate derivatives make up more than 85% of derivatives by asset class. Almost the entire derivatives market according to the BA 350 returns is executed over-the-counter (97%). Not all OTC derivatives are cleared bilaterally but all exchange traded derivatives are cleared through a central counterparty.

South Africa only has one derivatives exchange and all five major South African banks are active thereon and are clearing members of its CCP. Swaps are no longer listed on the exchange and JIBAR futures, which have similar risk characteristics to FRAs, have very little open interest as they are seldom traded. The bond futures market is the only active exchange traded interest rate market in South Africa. Only ZAR government bonds are actively traded and have material open interest.

Table 8.3: Derivative notional amounts outstanding for South African banks' derivative positions as at 31 December 2019 by asset class and execution type.

Execution type	Model Classification	BA350 Asset Class	Instrument	ZAR Trillion
OTC Derivatives	Interest Swap	03_IntRate_Trading	Forwards and FRAs	17.94
	Interest FRAs	03_IntRate_Trading	Swaps	15.07
	Forex	05_Forex_Trading	OTC contracts	4.38
	Equities	07_Equity_Trading	OTC contracts	1.00
	Commodities	09_Commod_Trading	OTC contracts	0.01
Exchange Traded Derivatives	Bond Futures	03_IntRate_Trading	Exchange traded	0.86
	Forex	05_Forex_Trading	Exchange traded	0.12
	Equities	07_Equity_Trading	Exchange traded	0.31
	Commodities	09_Commod_Trading	Exchange traded	0.01

Source: South African Reserve Bank (2021)

Table 8.4: Derivative notional amounts outstanding for South African banks' derivative positions as at 31 December 2019 by asset class

Model Classification	ZAR Trillion	ZAR Trillion
Interest Swap	45%	17.94
Interest FRAs	38%	15.07
Bond Futures	2%	0.86
Forex	11%	4.49
Equities	3%	1.31
Commodities	0%	0.03

Source: South African Reserve Bank (2021)

There are no data on the value of individual SA banks' derivative books as the OCC publishes for US banks. The banks' market risk RWA will be used to proportion the aggregate of the value of derivatives outstanding, as published by the SARB, between the banks.

BA350 data are available from January 2008 (SARB, 2020) with the latest being October 2020. Figure 8.4 shows the proportional breakdown of the asset classes and execution types as published by the SARB for December 2013 and December 2019. While the OTC interest rate swaps, FRAs and Forex remain the greatest three derivative asset classes, their relative proportions change significantly over time.

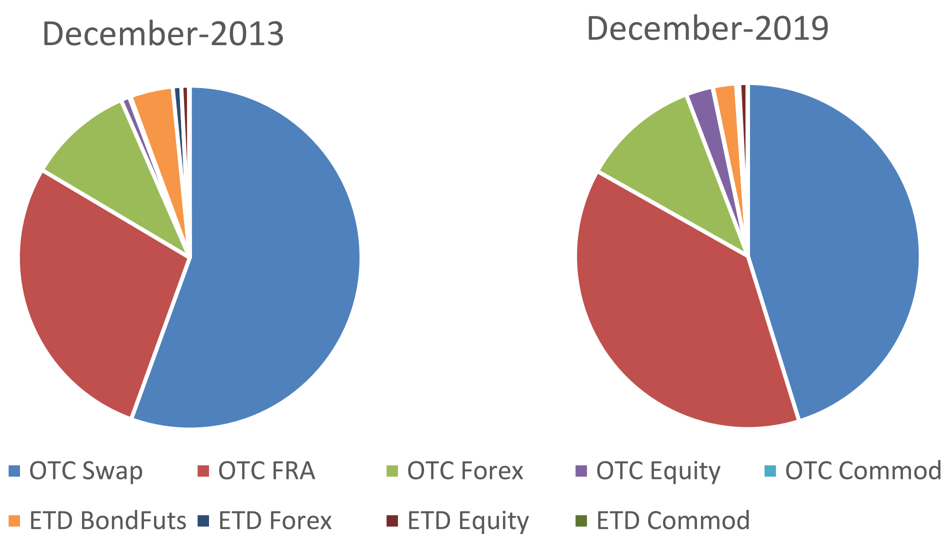

Figure 8.4: Relative sizes of derivatives outstanding for SA banks by asset class in 2013 and 2019.
Source: South African Reserve Bank (2021)

The derivative market in SA has grown by approximately 9% compounded annually since the beginning of 2008 (SARB, 2021). Derivatives outstanding held by SA banks reached a peak of R52.4tn at the end of April 2020. Figure 8.5 shows the growth in derivatives split by execution type. ETDs started 2008 at R438m and in October 2020 was R681m with a peak in February 2014 of R2.6tn. there was a significant drop in ETD open positions after the September futures expiry, from R1.2tn at the end of August to R685m at the end of September, the most significant drop came from bond futures which decreased by 51% to R394bn.

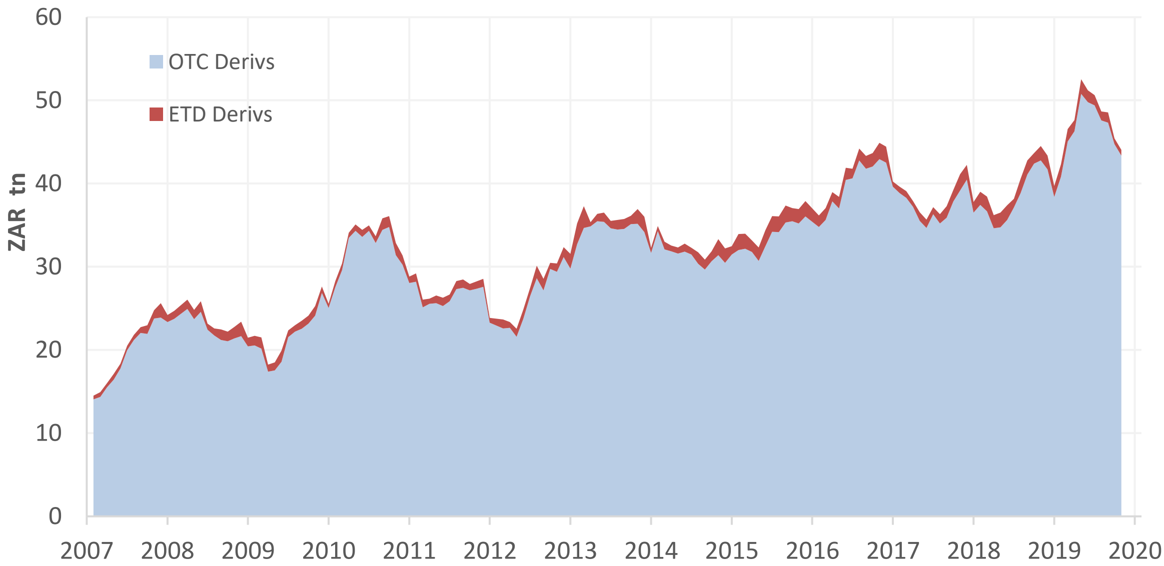

Figure 8.5: Derivatives outstanding held SA banks for 2007 through to 2020

Source: South African Reserve Bank (2021).

For the purposes of this study, we will use the derivatives outstanding as at end of 2019, 2018 and 2017 as the ratios of derivatives outstanding between the asset classes are not static. Figure 8.6 shows the proportional breakdown of derivatives outstanding by asset class.

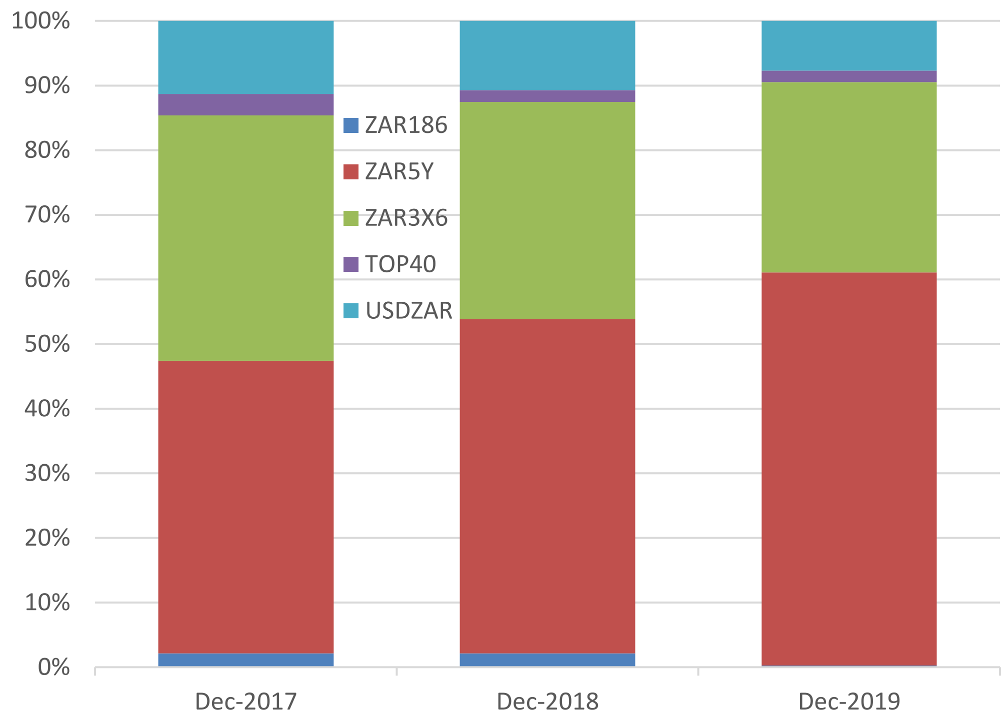

Figure 8.6: Outstanding notional of derivatives held by banks in South Africa by asset class *Source: South African Reserve Bank (2021).*

8.2.3. Asset class volatilities

The asset classes that comprise most SA derivatives and which will be included in this study are inter-bank interest rates, government bonds, foreign exchange and equities. As seen above, commodity derivatives make up a negligible portion of the derivatives outstanding at any point in time over the last 10 years.

Inter-bank interest rates will be split up further into FRAs and swaps. In South Africa, the FRA market is very active. In terms of daily average turnover Rand FRAs are the 6th most actively traded FRA globally after USD, EUR, GBP, SEK and CHF. If the average daily turnover in USD is taken as a ratio of gross domestic product (GDP) in USD per capita, it is only surpassed by USD, EUR and GBP FRA turnover (OECD, 2020 and BIS, 2021a).

To determine the volatilities of the South African asset classes, yield data from Bloomberg was used for the 3x6 FRA, 5-year swap and R186 bond; and price data from Investing.com for USD/ZAR currency and the FTSE/JSE Top40 equity index was gathered (Bloomberg (2021), Investing.com (2021a & b).

The five-day standard deviations were measured on each asset class and a correlation matrix computed over that holding period. We use an observation period of five years from July 2015 to June 2020 which includes periods of market stress and subdued market conditions. The same statistics were calculated for the year from July 2019 to June 2020 which includes a much higher proportion of market stress as COVID-19 unfolded on the South African market in the first half of 2020.

Table 8.5 shows the standard deviation of five-day returns in each asset class calculated over the two periods. In each asset class, the VaR over the five-year observation period is less than the VaR over the shorter period with a higher concentration of stressed observations. Unlike the other asset classes, the currency's standard deviation is slightly lower for the shorter period with greater stressed market conditions.

Table 8.5: VaR and standard deviations of five-day returns per SA asset class for one- and five-year look-back periods

		ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR
July 2015 to June 2020	95th pctile	1.42%	1.00%	0.03%	4.12%	4.41%
	Std Dev	1.06%	0.71%	0.02%	2.83%	2.44%
July 2019 to June 2020	95th pctile	2.62%	1.68%	0.09%	6.61%	4.95%
	Std Dev	1.55%	0.95%	0.04%	4.36%	2.31%

The currency is negatively correlated to the other asset classes as is shown in Table 8.6 which displays the correlation matrix for the period July 2015 to June 2020. FRAs appear to have the least correlation to the other asset classes. As expected, there is a strong but not perfect correlation between the bonds and swaps.

Table 8.6: Asset class correlation matrix of five-day returns for the period July 2015 to June 2020 and July 2019 to June 2020 look-back periods

		ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR
July 2015 to June 2020	ZAR186	1	0.875	0.255	0.337	-0.570
	ZAR5Y	0.875	1	0.486	0.317	-0.566
	ZAR3X6	0.255	0.486	1	0.090	-0.180
	TOP40	0.337	0.317	0.090	1	-0.243
	USDZAR	-0.570	-0.566	-0.180	-0.243	1
July 2019 to June 2020	ZAR186	1	0.816	-0.111	0.563	-0.350
	ZAR5Y	0.816	1	0.230	0.556	-0.237
	ZAR3X6	-0.111	0.230	1	0.041	0.258
	TOP40	0.563	0.556	0.041	1	-0.413
	USDZAR	-0.350	-0.237	0.258	-0.413	1

Using the one-year period all asset class return correlations changed materially from when a longer five-year period was used. Over the one-year period that included the market turmoil as a result of COVID-19, swap returns became less correlated with other asset class returns than when measuring using a five-year lookback ending at the same time.

CHAPTER 9 METHODOLOGY: MODELLING CLEARING EFFICIENCY

This chapter continues to lay the notational groundwork introduces in Section 3.1 for the model that will be used to compare various market clearing configurations. The aim is to measure and compare overall exposure or netting efficiency of clearing configurations. This measure is appropriate because collateral requirements, capital consumption and implied trading costs are directly linked to outstanding exposure and the efficiency of netting.

The methodology established by Duffie & Zhu (2011) will be explored and generalisations thereof will be made before variations of the model are used to describe the South African context more accurately.

A CCP alters the allocation of risk within a market (Pirrong, 2011 and Cont, 2017). Multilateral netting dramatically affects the aggregate expected counterparty exposure of each firm and the market in total. We will compare various configurations of clearing of derivative markets first in the international derivatives market and thereafter in the South African setting. We will use the methodology described by Duffie & Zhu (2011). Cont & Kokholm (2012) made extensions which will be considered after the base model has been established.

Heath, Kelly & Manning (2013) present a framework for counterparty exposure that includes clients who only trade with banks- not with other clients. This is different from the framework presented here and by Duffie & Zhu (2011) where all counterparties trade with all others. The work by Heath, Kelly & Manning (2013) does not account for banks' exposure to their clients in a cleared setting and hence was not adopted here.

The work of Garratt & Zimmerman (2017) differs in that it is a study of a network of counterparties where not all participants trade with each other. A core periphery model and a scale-free model are used to measure counterparty risk in which a small number of counterparts trade with each other and others who trade only with a few counterparts.

We consider a market with N counterparties which trade derivatives in K asset classes which are labelled $k = 1, \dots, K$. The definition of an asset class is important as it determines the size of K. It will be evident that this has an impact on the netting efficiencies. We will define an asset class as all derivatives with a singular type of underlying asset, i.e., equities, foreign exchange rates, interest rates or commodities.

We denote by X_{ij}^k the amount that firm j will owe firm i in asset class k. When X_{ij}^k is less than zero (when firm i owes firm j), firm i has no exposure to j. Therefore, the exposure of firm i to firm j in asset class k is $\max\{X_{ij}^k, 0\}$. This implies that the exposure of firm j to firm i is $\max\{X_{ij}^k, 0\}$ because $X_{ij}^k = -X_{ji}^k$.

Before deciding to establish a CCP, the size of any firm's positions is not known for a future date of the CCP's existence. The level of market prices, volatility of those prices and correlation between prices are also not known *ex ante*. Furthermore, it is not known with whom trades will be executed and hence the netting that is to be achieved bilaterally is also not known. X_{ij}^k is therefore a stochastic variable with a number of different sources of uncertainty.

With this notation we will first depict the case where all trades are cleared bilaterally. Entity i's exposure to all other counterparts and asset classes is then

$$e_i^0 = \sum_{j \neq i}^{N} \max\left\{\sum_{k=1}^{K} X_{ij}^k , 0\right\} \quad . \tag{1}$$

In the presence of a CCP the exposure of entity i to a multi asset class CCP is:

$$e_i^{CCP} = \max\left\{\sum_{j \neq i}^{N} \sum_{k=1}^{K} \omega^k X_{ij}^k , 0\right\}, \tag{2}$$

where all ω^k is the proportion of the market in asset class k that is cleared through the CCP.

In the general case where there exists more than one CCP the exposure of firm i across the market is,

$$e_i^1 = \sum_{j \neq i}^{N} \max\left\{\left(1 - \left(\sum_{l=1}^{L} \omega_l^k\right)\right) \sum_{k=1}^{K} X_{ij}^k , 0\right\} + \sum_{l=1}^{L} \max\left\{\sum_{j \neq i}^{N} \sum_{k=1}^{K} \omega_l^k X_{ij}^k , 0\right\}.$$

where ω_l^k is the proportion of trades in asset class k that are cleared by CCP l, subject to $0 \leq \sum_{l=1}^{L} \omega_l^k \leq 1 \; \forall \; k \leq K$ and $0 \leq \omega_l^k \; \forall \; k \leq K$ and $l \leq L$.

This definition of exposure is useful as it is independent of the definition of asset class and entity. We assume that X_{ij}^k is normally distributed. Further, initially we will assume that all X_{ij}^k

are independent and identically distributed, that is, all X_{ij}^{k} have the same variance and are independent from each other. For simplicity, we will also assume symmetry in the distributions of exposures across all entities in all asset classes (all X_{ij}^{k}). This means that no entity expects to have an exposure to any particular counterparty, alternatively $E\left(X_{ij}^{k}\right) = 0$. This is not an unreasonable assumption when positions are marked-to-market and collateral is exchanged regularly (Duffie & Zhu, 2011). Therefore, under current assumptions $X_{ij}^{k} \sim N(0, \sigma^2)\ i.i.d. \forall\ i, j$ and k. These assumptions are reviewed and relaxed below.

9.1. MEASURE OF NETTING EFFICIENCY

Counterparty credit risk across the system is simply the sum of each participant's counterparty credit risk. This exposure is then the maximum of zero and the value of the position.

Of interest to market participants is the expected exposure given different market configurations. However, it is also important, not only for market participants but for market infrastructures, regulators and policy setters, to understand the variance and tails of the distribution of exposure. For this reason, we will look also at the value-at-risk and expected-tail-loss of the exposures. Differences in these metrics from the no-clearing case will determine the netting efficiency of any clearing configuration that is considered. Under the current assumptions we can derive the expectation of the joint distribution of exposures.

9.1.1. Bilateral trades

Bilaterally, it is common for counterparts to agree that obligations are netted on the various derivative contracts that may be struck between them, including across asset classes. This significantly reduces the counterparty credit risk between two counterparts. In a portfolio of positions against a single counterpart, the counterparty credit risk then becomes the maximum of zero and the sum of the values of the outstanding derivative positions.

Let $\phi_{N,K}$ denote firm $i's$ expected exposure to all counterparties where all trades are bilaterally netted across all K derivative asset classes. In this case exposures are netted across asset classes but not across counterparties. Naturally, if Bank B does not pay Bank A (positive amount owed), Bank A is still obliged perform to Bank C (negative amount owed) and hence these values cannot offset each other. Therefore, before introducing a CCP, the total netting efficiency is the expectation of (1), $\phi_{N,K} = E[e_i^0]$.

Due to independence and the identical distributions of $X_{ij}^{k} \sim N(0, \sigma^2)$, we obtain

$$\begin{aligned}\phi_{N,K} &= \sum_{j\neq i}^{N} E\left[\max\left\{\sum_{k=1}^{K} X_{ij}^{k}, 0\right\}\right] \\ &= (N-1)E\left[\max\left\{\sum_{k=1}^{K} X_{ij}^{k}, 0\right\}\right].\end{aligned} \tag{3}$$

The expectation of $X \sim N(0, \sigma^2)$ is

$$\begin{aligned}E(X) &= \int_{-\infty}^{\infty} \frac{x}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}\, dx \\ E(\max(X,0)) &= \int_{0}^{\infty} \frac{x}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}\, dx.\end{aligned} \tag{4}$$

Now let

$$\chi = e^{\frac{-x^2}{2K\sigma^2}}$$

Then differentiating χ gives:

$$\begin{aligned}\frac{d\chi}{dx} &= \frac{-x}{\sigma^2 K} e^{\frac{-x^2}{2K\sigma^2}} \\ -\frac{\sigma^2 K}{\sqrt{K2\pi}} d\chi &= \frac{1}{\sqrt{K2\pi}} x e^{\frac{-x^2}{2K\sigma^2}} dx \\ -\sigma\sqrt{\frac{K}{2\pi}}\, d\chi &= \frac{x}{\sigma\sqrt{K2\pi}} e^{\frac{-x^2}{2K\sigma^2}} dx.\end{aligned} \tag{5}$$

Then combining (3), (4) and (5) gives the expected exposure of i to j across K derivative asset classes:

$$\begin{aligned}E\left[\max\left\{\sum_{k=1}^{K} X_{ij}^{k}, 0\right\}\right] &= \int_{0}^{\infty} \frac{x}{\sigma\sqrt{2K\pi}} e^{\frac{-x^2}{2K\sigma^2}} dx \\ \int_{0}^{\infty} \frac{x}{\sigma\sqrt{2K\pi}} e^{\frac{-x^2}{2K\sigma^2}} dx &= \int_{0}^{\infty} \frac{-\sigma}{\sqrt{2\pi}} d\chi \\ = \frac{-\sigma}{\sqrt{2\pi}} \int_{0}^{\infty} d\chi &= \frac{-\sigma}{\sqrt{2\pi}} \left[e^{\frac{-x^2}{2K\sigma^2}}\right]_{0}^{\infty} \\ &= \frac{-\sigma}{\sqrt{2\pi}} (0-1) \\ &= \sigma\sqrt{\frac{K}{2\pi}}.\end{aligned} \tag{6}$$

The expected exposure of entity i across all counterparts in a market with multiple asset classes and only bilaterally cleared trades is therefore:

$$\phi_{N,K} = (N-1)\sigma\sqrt{\frac{K}{2\pi}}. \tag{7}$$

9.1.2. Single asset CCP

Let us consider the case where a CCP clears all trades in a single asset class. Trades executed with all counterparts are novated to the CCP and are netted for that asset class. The expected exposure of entity i that trades in asset class K with N counterparts to that CCP is then:

$$\gamma_N = E\left[\max\left\{\sum_{j\neq i}^{N} X_{ij}^{K}, 0\right\}\right].$$

Again, as above, due to independence and identical distributions of $X_{ij}^{k} \sim N(0,\sigma^2)$

$$\begin{aligned}\gamma_N &= \int_0^\infty \frac{x}{\sigma\sqrt{2(N-1)\pi}} e^{\frac{-x^2}{2(N-1)\sigma^2}} dx \\ &= \sigma\sqrt{\frac{N-1}{2\pi}}.\end{aligned} \tag{8}$$

9.1.3. Multi-asset CCP

To generalise, we have one CCP that clears all trades in K asset classes. From (2) and (8) we get the exposure of firm i to this CCP:

$$\begin{aligned}\gamma_{N,K} &= E\left[\max\left\{\sum_{k=1}^{K}\sum_{j\neq i}^{N} X_{ij}^{k}, 0\right\}\right] \\ &= \sigma\sqrt{\frac{K(N-1)}{2\pi}}.\end{aligned}$$

9.1.4. Multiple multi-asset class CCPs

There are scenarios where there is a choice of CCP for a particular asset class. Depending on the parties' exposures and netting sets at the time it will be more beneficial to clear an incremental trade through a specific CCP where a choice exists. That leaves us with the following expected exposure for firm i to all the CCPs

$$\gamma_{N,K,L} = E\left[\sum_{l=1}^{L} \max\left\{\sum_{k=1}^{K}\sum_{j\neq i}^{N} X_{ij}^{k}\,, 0\right\}\right]$$

$$= \sum_{l=1}^{L} E\left[\max\left\{\sum_{k=1}^{K}\sum_{j\neq i}^{N} \omega_l^k X_{ij}^{k}\,, 0\right\}\right].$$

Now, note that since X_{ij}^{k} are independent and identically distributed across $i, j\ and\ k$

$$Var\left(\sum_{k=1}^{K}\sum_{j\neq i}^{N} \omega_l^k X_{ij}^{k}\right) = (N-1)Var(X_{ij}^{k})\sum_{k=1}^{K}\omega_l^k$$

$$= (N-1)\sigma^2\sum_{k=1}^{K}\omega_l^k\,.$$

Now, we know from (4) and (6) where $X{\sim}N(0,\sigma^2)$ that

$$E(\max(X,0)) = \int_0^\infty \frac{x}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}\,dx$$

$$= \sqrt{\frac{\sigma^2}{2\pi}}.$$

Therefore, through substitution we obtain

$$\sum_{l=1}^{L} E\left[\max\left\{\sum_{k=1}^{K}\sum_{j\neq i}^{N} \omega_l^k X_{ij}^{k}\,, 0\right\}\right] = \sum_{l=1}^{L}\sqrt{\frac{\sum_{k=1}^{K}\sum_{j\neq i}^{N}\left(\sigma\omega_l^k\right)^2}{\sqrt{2\pi}}}$$

$$= \frac{1}{\sqrt{2\pi}}\sum_{l=1}^{L}\sqrt{\sigma^2\sum_{k=1}^{K}\sum_{j\neq i}^{N}\left(\omega_l^k\right)^2}$$

$$\gamma_{N,K,L} = \frac{\sigma}{\sqrt{2\pi}}\sum_{l=1}^{L}\sqrt{(N-1)\sum_{k=1}^{K}(\omega_l^k)^2}\,,$$

where ω_l^k is the proportion of asset class k that is cleared through CCP l.

9.1.5. Total exposure of an entity

The expected exposure of an entity is not only bilateral trades and not only trades through a single CCP. It is not even the expected exposure to all the multi-asset class CCPs. Rather, the expected exposure of entity i is the sum of its bilateral exposure to all $N-1$ counterparts plus the sum of its exposures to all CCPs. Entity $i's$ total expected exposure is$\phi_{N,K}+\gamma_{N,K,L}$.

9.2. WHEN IS A CCP NOT EFFICIENT?

With our current methodology we can now consider when will the introduction of a CCP for an asset class lead to netting efficiencies. Consider the case where there is a single CCP clearing a single asset class, asset class K, and the remaining $K-1$ asset classes are bilaterally cleared. Entity i will only prefer this configuration when their expected exposure is less than before the introduction of the CCP. That is, the central clearing of K is preferred if and only if:

$$\phi_{N,K-1}+\gamma_N<\phi_{N,K}. \tag{10}$$

Let us pause and review our current assumptions. We have stated that all X_{ij}^k are

- normally distributed,
- identically distributed,
- independent,
- have zero mean, and for this case
- the CCP clears all trades in asset class K.

These assumptions are not all realistic; we will investigate relaxing these assumptions. Presently, these assumptions are useful in enabling us to build an appropriate investigation methodology.

From (10), (8) and (3) we obtain:

$$(N-1)\sigma\sqrt{\frac{K-1}{2\pi}}+\sigma\sqrt{\frac{N-1}{2\pi}}<(N-1)\sigma\sqrt{\frac{K}{2\pi}}.$$

Dividing both sides by $\sigma\sqrt{\frac{1}{2\pi}}$ gives:

$$(N-1)\sqrt{K-1}+\sqrt{N-1}<(N-1)\sqrt{K}.$$

Dividing by $\sqrt{N-1}$ and then squaring both sides we are left with:

$$(N-1)(K-1)+2\sqrt{N-1}\sqrt{K-1}+1<(N-1)K.$$

Which simplifies to:

$$2\sqrt{N-1}\sqrt{K-1} < N-2.$$

Squaring both sides again to remove square roots gives:

$$4(N-1)K - 4(N-1) < N^2 - 4N + 4.$$

Solving for K gives:

$$K < \frac{N^2}{4(N-1)}. \tag{11}$$

Naturally, if there is only one asset class, and if, as is expected, there are more than two counterparties, a CCP is always preferred. However, the number of counterparties to satisfy two asset classes where $K = 2$ is seven. Based on (11), if there are four asset classes, the introduction of a CCP only provides efficiencies when there are at least 15 clearing members. This result relies on the assumptions stated above. In particular, the assumption regarding the equal size of counterparts and equal standard deviations of asset classes (identical distribution of X_{ij}^k) facilitates this simplification of (10).

Table 9.1 shows the required number of clearing members to provide netting benefit when a single CCP clearing 100% of a single asset class is formed in a market made of K asset classes.

Table 9.1**:** Required number of clearing members when forming a single asset class CCP

K	2	3	4	5	6	7	8
N	7	11	15	19	23	27	31

9.3. DIFFERENT SIZE EXPOSURES

Suppose now we generalise our model to allow for exposures of different sizes. In particular we allow for the asset class that is being considered for clearing to have a different size exposure. This means that if we are considering asset class K for clearing, we have $E\left[\max\left(X_{ij}^K, 0\right)\right]$ that is different from the that of another asset class. The expected exposure of entity i to any counterparty in a specific asset class, K as a ratio of the remaining asset classes is given by

$$R = \frac{E\left[\max\left(X_{ij}^K, 0\right)\right]}{E\left[\max\left(\sum_{k=1}^{K-1} X_{ij}^k, 0\right)\right]}. \tag{12}$$

We have noted previously in (6) that

$$R = \frac{\sigma_k\sqrt{\frac{1}{2\pi}}}{\sigma\sqrt{\frac{K-1}{2\pi}}}$$

$$= \frac{\sigma_k}{\sigma\sqrt{K-1}}. \tag{13}$$

This Duffie & Zhu (2011) propose that the introduction of a CCP for a single asset class leads to a reduction in average expected exposures if and only if

$$R > \frac{2\sqrt{N-1}}{N-2}. \tag{14}$$

where R is defined as in (12).

This is shown to be true in a similar fashion to the previous inequality (11). We assume that exposures in asset class K have a variance σ_K^2, all remaining asset classes have variance σ^2. The assumptions regarding normality and independence remain. From basic statistics we know that if $Y \sim N(0, \sigma^2)$ then $Y = \sigma X$ where $X \sim N(0,1)$ From (3) we obtain

$$\tilde{\phi}_{N,K} = \sum_{j \neq i}^{N} E\left[\max\left\{\sum_{k=1}^{K} X_{ij}^k, 0\right\}\right],$$

$$E\left[\max\left\{\sum_{k=1}^{K} X_{ij}^k, 0\right\}\right] = E\left[\max\left\{\sqrt{\sigma^2(K-1) + \sigma_K^2}\, X, 0\right\}\right].$$

where $X \sim N(0,1)$. Then

$$E\left[\max\left\{\sum_{k=1}^{K} X_{ij}^k, 0\right\}\right] = \sqrt{\sigma^2(K-1) + \sigma_K^2}\, E[\max\{X, 0\}]$$

$$= \sqrt{\sigma^2(K-1) + \sigma_K^2}\, \frac{1}{\sqrt{2\pi}}.$$

Hence the expected exposure before the introduction of a CCP is

$$\tilde{\phi}_{N,K} = (N-1)\sqrt{\sigma^2(K-1) + \sigma_K^2}\, \frac{1}{\sqrt{2\pi}}. \tag{15}$$

The expected exposure to the CCP remains unchanged in form from (8) however the variance changes,

$$\tilde{\gamma}_N = \sigma_K \sqrt{\frac{N-1}{2\pi}}.$$

Hence, as in (10), the introduction of a CCP only reduces exposure when

$$\phi_{N,K-1} + \tilde{\gamma}_N < \tilde{\phi}_{N,K}$$

$$(N-1)\sigma \sqrt{\frac{K-1}{2\pi}} + \sigma_K \sqrt{\frac{N-1}{2\pi}} < \frac{N-1}{\sqrt{2\pi}} \sqrt{\sigma^2(K-1) + \sigma_K^2}\,.$$

Dividing both sides by $\sqrt{\frac{N-1}{2\pi}}$ we obtain:

$$\sqrt{(N-1)}\sigma\sqrt{K-1} + \sigma_K < \sqrt{N-1}\sqrt{\sigma^2(K-1) + \sigma_K^2}\,.$$

Square both sides

$$2\sigma_K\sqrt{(N-1)}\sqrt{K-1}\sigma + \sigma_K^2 + (N-1)(K-1)\sigma^2$$
$$< (N-1)(K-1)\sigma^2 + (N-1)\sigma_K^2).$$

Cancelling out $(N-1)(K-1)\sigma^2$ on both sides gives

$$2\sigma_K\sqrt{(N-1)}\sqrt{K-1}\sigma + \sigma_K^2 < (N-1)\sigma_K^2.$$

We then rearrange to solve for (14)

$$2\sigma_K\sqrt{(N-1)}\sqrt{K-1}\sigma < (N-2)\sigma_K^2$$

$$\frac{2\sigma_K\sqrt{(N-1)}\sqrt{K-1}\sigma}{N-2} < \sigma_K^2$$

$$\frac{2\sqrt{(N-1)}}{N-2} < \frac{\sigma_K}{\sigma\sqrt{K-1}}\,.$$

Now the right-hand side is (13) which is R

$$\frac{\sigma_K}{\sigma\sqrt{K-1}} > \frac{2\sqrt{(N-1)}}{N-2}$$

$$R > \frac{2\sqrt{(N-1)}}{N-2}.$$

Therefore, a necessary condition for decreased expected exposure when introducing a CCP for a single asset class with different variance is that the ratio of expected exposures in that asset class to remaining expected exposures is greater than a specific function of the number of clearing members.

9.4. USE OF THE METHODOLOGY

The model set out is useful because relaxing the initial assumptions to approximate a real-world environment more closely is straightforward with this starting point. The variance of X_{ij}^{k} can be set in such a way that it is a function of position size and asset class variance.

The methodology set out can be used to determine clearing efficiency based on the expected exposures metric via the closed form solutions that have been derived above when the assumptions are maintained; and Monte Carlo simulations can be used to determine the other risk metrics being studied. The solutions can all be expanded as in (15) to relax the homoscedastic assumption of X_{ij}^{k}.

When the correlation assumption is relaxed the same methodology can be used, however, Monte Carlo simulations must be used to determine results as the closed form solutions no longer hold.

Further, when using Monte Carlo simulation, the assumption of normality can be changed. Cont & Kokholm (2012) used a t-distribution instead of assuming normal exposures and tested whether a CCP reduces exposure when asset class variances are not uniform and when asset class exposures have a non-zero correlation. They find that the conclusions regarding the exposure reducing effect of the introduction of a CCP remain unchanged with a fatter-tailed distribution of cleared derivative class.

The inequality (14) determining clearing efficiency for different exposure variances is a convenient result, as it reduces the determination of clearing efficiency to a function of the number of proposed clearing members and the ratio of to-be-cleared exposure to non-cleared exposures. K can be set to 2, where the two asset classes are simply derivatives to be cleared and derivatives to remain bilateral.

In practice, the size of every counterpart's trading activity with every other counterpart is not known. The size of exposures can however be estimated with reasonable assumptions based on available data. As in Duffie & Zhu (2011) and Cont & Kokholm (2012) we let Z_{i}^{k} be the notional size of exposure entity i has traded across all counterparties in asset class k.

We will also assume that the exposure of entity i to entity j in asset class k (X_{ij}^k) is also proportional to the ratio of Z_j^k to all $Z_h^k \ where\ h \neq j$.

We will assume that the standard deviation of the exposure of all trades for any counterparty in asset class k are scaled by a factor of β_k which represents the riskiness of asset class k.

We can now state the exposure of entity i to entity j in asset class k as

$$X_{ij}^k = \beta^k Z_i^k \frac{Z_j^k}{\sum_{h \neq j} Z_h^k} Y_{ij}^k, \tag{16}$$

where $Y_{ij}^k \sim N(0,1)$.

9.5. MODEL IMPLEMENTATION AND TESTING

The model above was implemented in MS Excel and separately in Python script. Using the 2009 data described in Duffie & Zhu (2011) and which were also used by Cont & Kokholm (2012) we replicated the results published in both papers.

When considering whether to establish or join a CCP, infrastructure and counterparties must make estimations regarding their future potential exposures over a time horizon. The use of the current book of positions and counterparty exposures will only paint a point-in-time picture of the potential outcome. It would be wiser to examine the results of several such calculations using several points in time, and potentially using budgets, as exposures change over time. Joining a CCP has a long-term horizon for its return on investment and hence should be considered carefully. The exposures of a firm in two years' time are not known however the decision to join the CCP should hold over a time. This model provides a framework with which, given realistic data, results can be derived to provide quantitative benefits of various clearing arrangements.

CHAPTER 10 RESULTS

Of interest is the netting benefit to be achieved in any potential clearing scenario. We will depict the results as a proportion of the case where only bilateral netting takes place, the absence of any central clearing.

10.1. INTERNATIONAL DERIVATIVES MARKET

Table 10.1 depicts the dealers' expected counterparty OTC exposures under various clearing scenarios relative to the scenario where no CCP exists. Each scenario is described showing the proportion of that asset class that is to be cleared at a CCP. Scenarios with all cleared asset classes novated through a single CCP are labelled "Single" and where each asset class is cleared through its own dedicated single asset class CCP are labelled "Mult." As there will be multiple CCPs. Results are shown for the closed-form solution using the formulas derived in Chapter 10 (labelled "Form") and using 10,000 simulations (labelled "Sim"). The scenario name (e.g. Base1, Scen2, Sen4) corresponds to the scenarios given in Duffie & Zhu (2011).

Using the data described in Chapter 9 and the formulas derived in Chapter 10, $N = 12, K = 4, L = 0, 1\ or\ 2$ (depending on the scenario). Only results for the six US clearers are shown.

The scenarios where only the CDS market is cleared actually increases expected exposure. In fact, the more that is cleared, the greater existing netting sets are disturbed and exposures increased as is seen in Scenarios 2 and 3. However when σ^k is increased, in this case, not through market volatility, β^k, but through the larger position sizes of swaps, a benefit of clearing is derived (as seen in scenario 4).

As is expected, a scenario where there is a single CCP for swaps and CDSs is preferred to a single asset class CCP clearing only swaps and the scenario where each asset class is cleared separately through its own CCP. Expected exposure is significantly reduced when introducing a CCP that clears all asset classes.

It is interesting to note that the scenarios depicting clearing 75% of a single asset class leads to different expected netting offsets. Where only CDSs are cleared leads to an increase in expected exposure, whereas clearing 75% of swaps decreases exposure. As is noted above the size of σ_k^2 is the reason for this difference. The size of the 75% of swaps is much larger than 75% of CDSs even though the standard deviation of CDSs used is three times greater for CDSs than for swaps. In 2009 swaps made up 65% of OTC notional.

Table 10.1: Expected exposures under various clearing configurations

	1 Base1	2 Scen2	3 Scen4	4 Scen5	5 Scen6	6 Scen7	7 Scen8	8 Scen9
	Fraction of the OTC market cleared on CCP(s)							
Forwards	0	0	0	0	0	0	0.4	0.4
Swaps	0	0	0	0.75	0.75	0.75	0.75	0.75
Options	0	0	0	0	0	0	0.4	0.4
Credit	0	1	0.75	0	0.75	0.75	0.75	0.75
Number of CCPs		Single	Single	Single	Mult.	Single	Mult.	Single

	Total exposure as a fraction of all bilateral exposures														
	Base	Form	Sim	Form	Sim	Form	Sim	Form	Sim	Form	Sim	Form	Sim	Form	Sim
Bank1	1.0000	1.0522	1.0527	1.0313	1.0316	0.8788	0.8803	0.8895	0.8922	0.8310	0.8317	0.7851	0.7875	0.6310	0.6319
Bank2	1.0000	1.0520	1.0517	1.0318	1.0314	0.8440	0.8418	0.8508	0.8486	0.7935	0.7921	0.7608	0.7579	0.6162	0.6148
Bank3	1.0000	1.0467	1.0453	1.0183	1.0175	0.8831	0.8811	0.8541	0.8518	0.7762	0.7730	0.7593	0.7576	0.6086	0.6069
Bank4	1.0000	1.0408	1.0402	1.0106	1.0104	0.9381	0.9386	0.9079	0.9083	0.8285	0.8300	0.8033	0.8030	0.6290	0.6306
Bank5	1.0000	1.0502	1.0504	1.0309	1.0311	0.9989	0.9992	1.0243	1.0248	0.9745	0.9752	0.8608	0.8608	0.6931	0.6934
Bank6	1.0000	1.0388	1.0383	1.0259	1.0255	0.9988	1.0016	1.0211	1.0236	0.9863	0.9894	0.8327	0.8340	0.6957	0.6951
Total	1.0000	1.0490	1.0487	1.0260	1.0257	0.8975	0.8973	0.8963	0.8964	0.8333	0.8330	0.7880	0.7877	0.6324	0.6323

When considering the VaR and expected shortfall (ES) with a 95 percent confidence interval the various clearing configurations perform similarly. The results are consistent over different measures of risk as noted by Cont & Kokholm (2012). Figure 10.1 shows the exposure increase or decrease using as measured by a 95% VaR and ES over the same clearing configurations as above for notional sizes measured in 2009.

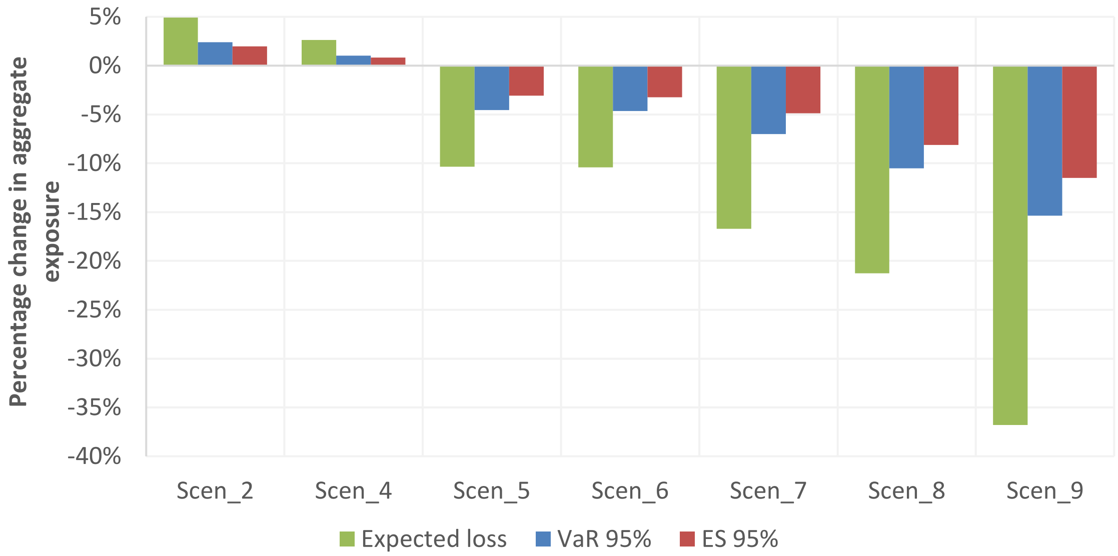

Figure 10.1: Percentage change in aggregate exposure of the six largest US dealers under various clearing configuration scenarios relative to aggregate exposure in the absence of clearing using 95% VaR and ES for 2009

The results show that the difference in the expected losses is greater than for expected tail events for changes in the CCP clearing configuration. The apparent improvement in expected exposure is greater than the improvement in VaR for the scenarios that show decrease in exposures. The same effect is seen in Figure 10.1; ES is deeper in the tail than VaR.

Gathering data from the same source for Q3 of multiple years (2007, 2009, 2012, 2014, 2016, 2018 and 2020) allows the same analysis to be performed using different market conditions. This is useful as forming a CCP and becoming a clearing member is a long-term investment and commitment. Figure 10.2 shows how the expected exposure of the six largest US dealers could be affected by the introduction of a CCP that clears both CDS and swaps over those years. In 2018 swaps notional outstanding was a lower percentage of derivatives outstanding than the other years; CDS notional outstanding was also relatively lower. This led to lower benefit of the scenarios that introduced a CCP for these asset classes. This is congruent with the findings of Duffie & Zhu (2011).

Introducing a CCP for CDSs, swaps, both separately or together provides marginal benefit. Comparing the results of the study for scenarios two, four, five, six and seven over different years' positions it is clear that the benefit of a CCP for a single asset class or a single CCP for only swaps and CDSs is small, varies and is potentially a cost depending on the positions of the dealers at the time. The benefit of introducing a CCP is dependent on the position sizes and spread between asset classes which is instructive to policy makers and those potentially investing in a clearing service.

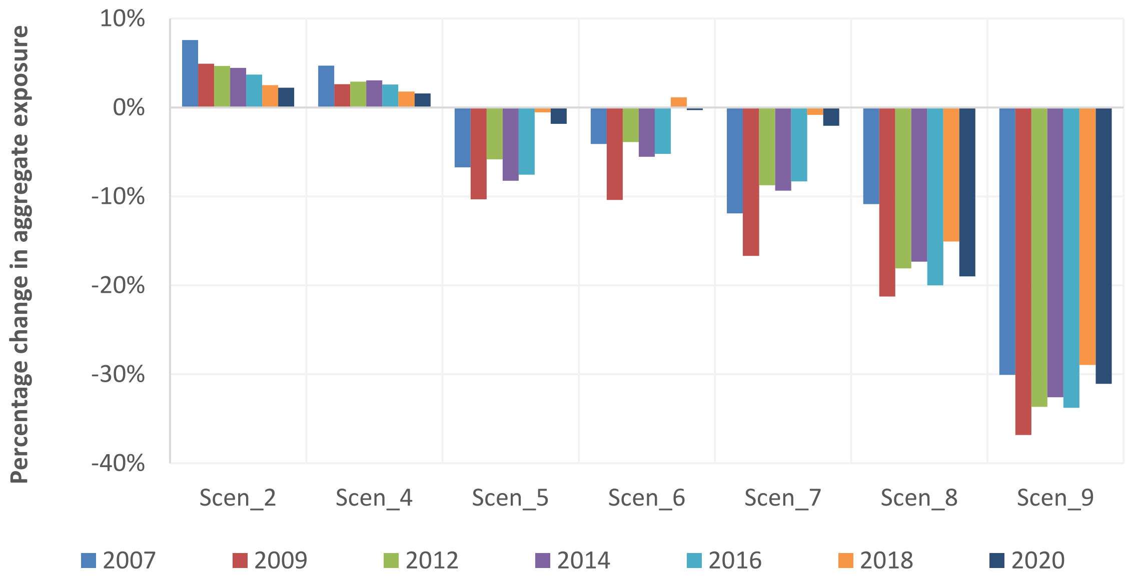

Figure 10.2: Expected exposure of the largest six US dealers for various clearing configurations in various years.

Figure 10.2 confirms the expectation that a CCP for all asset classes produces the greatest benefit and that there is still a strong, albeit smaller, benefit even when each asset class is cleared through a separate CCP. Figure 10.3 shows the loss distribution under each scenario for the largest dealer, Bank 1, in 2020. The shape of the distribution is as expected and illustrates how little benefit is provided by the single and double asset class clearing scenarios.

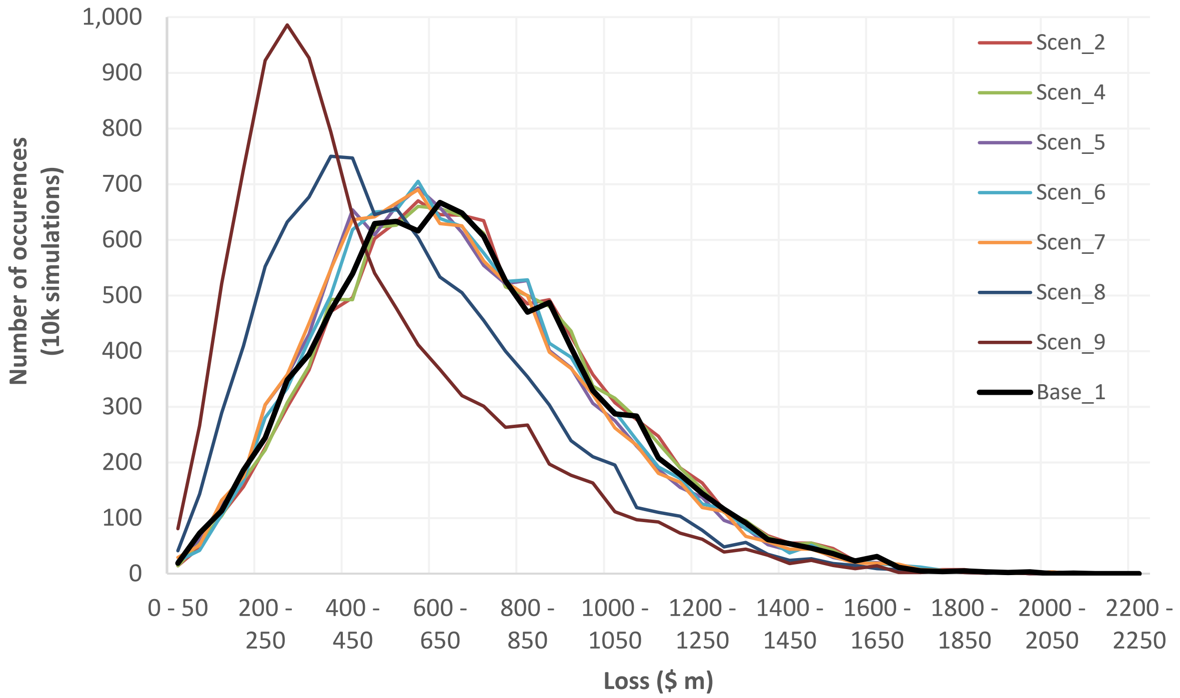

Figure 10.3: Loss distributions for Bank 1 in 2020 for various clearing configurations.

Further, Duffie & Zhu (2011) show that the relaxation of the independence assumption increases the attractiveness of a CCP. When correlation is allowed between asset classes, as is the case in real markets, the benefit of introducing a CCP increases compared to when the distributions of X_{ij}^{k} are not correlated. Figure 10.4 shows the difference in expected exposure for various clearing configurations compared to the scenario where no OTC derivatives are cleared. This is shown where it is assumed that asset classes are not correlated and where asset classes have a correlation of 0.1 and a correlation of 0.2.

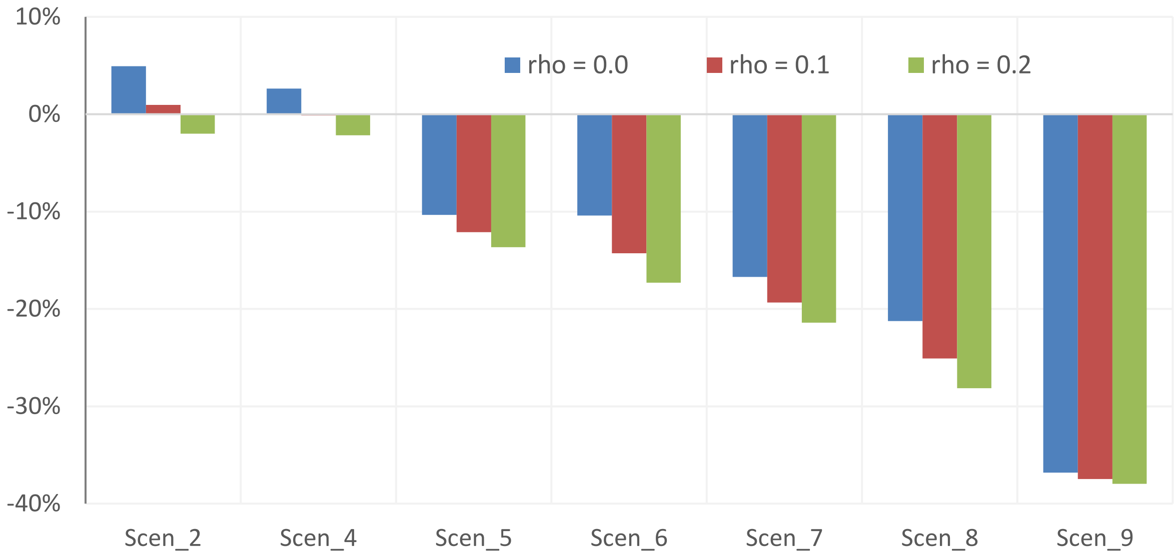

Figure 10.4: The expected exposures of the six largest US dealers under various clearing configurations using zero correlation and a correlation of 0.1 and 0.2 between asset classes.

It is clear from Figure 10.4 that the increased correlation leads to an increased benefit for clearing even one asset class. The increased benefit of clearing all asset classes through one CCP is only marginally improved where correlation increases to 0.2.

10.2. SOUTH AFRICAN DERIVATIVES MARKET.

10.2.1. Potential clearing configurations for South African derivatives

As mentioned above, there is currently only one licensed clearing house in South Africa. The only potential clearing venue currently for ZAR denominated OTC interest rate swaps is the LCH. Potentially local participants may want to establish a local OTC CCP. We will investigate various clearing configuration scenarios and the impact on expected exposures.

Table 10.2 shows the proportion of each asset class that is to be cleared at each CCP. These asset classes include OTC and exchange traded derivatives. Scenario 1 is the base case against which all other scenarios are compared, it is where there is no central clearing of any derivatives. Scenario 2 is the case where only exchange traded derivatives are cleared through JSE Clear.

All of the Scenarios 3 through 22 are combinations of portions of the market where all counterparts have proportionate access to all the CCPs. This is not realistic. Further investigation into scenarios where not all counterparties are members of all CCPs will provide more insight. Dion, Lane & Slive (2013) discuss the issues relating to access to CCPs and the issues that domestic banks in particular face when considering membership at an international CCP.

Table 10.2: Potential clearing configuration scenarios for the South African derivatives market

Scen	CCP	ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR	Description
1	CCP_JSE	0.00	0.00	0.00	0.00	0.00	Base case with all OTC
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.00	0.00	0.00	0.00	
2	CCP_JSE	1.00	0.00	0.00	0.23	0.03	Base Case with Clearing all ETD and assuming that all ETD interest rate derivatives held are bond futures and that all OTC interest rate derivatives are Swaps or FRAs
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.00	0.00	0.00	0.00	
3	CCP_JSE	1.00	0.00	0.00	0.23	0.15	Forex forwards over a tenor are mandated for clearing. Some business stays on-shore, more goes offshore as counterparts are foreign.
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.00	0.00	0.00	0.20	
4	CCP_JSE	1.00	0.00	0.00	0.23	0.15	Forex forwards over a tenor are mandated for clearing. Some business stays at existing exchange CCP, more goes offshore as counterparts are foreign and local counterparts form local FX CCP (35%).
	CCP_Local	0.00	0.00	0.00	0.00	0.35	
	CCP_Intl	0.00	0.00	0.00	0.00	0.20	
5	CCP_JSE	1.00	0.00	0.00	0.23	0.03	10% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.10	0.00	0.00	0.00	
6	CCP_JSE	1.00	0.00	0.00	0.23	0.03	20% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.20	0.00	0.00	0.00	
7	CCP_JSE	1.00	0.00	0.00	0.23	0.03	30% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.30	0.00	0.00	0.00	

Scen	CCP	ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR	Description
8	CCP_JSE	1.00	0.00	0.00	0.23	0.03	40% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	
9	CCP_JSE	1.00	0.00	0.00	0.23	0.03	50% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.50	0.00	0.00	0.00	
10	CCP_JSE	1.00	0.00	0.00	0.23	0.03	50% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.60	0.00	0.00	0.00	
11	CCP_JSE	1.00	0.00	0.00	0.23	0.03	70% of Swaps are cleared by LCH, JSE clears all ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.70	0.00	0.00	0.00	
12	CCP_JSE	1.00	0.40	0.00	0.23	0.03	JSE clears 40% of swaps
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.00	0.00	0.00	0.00	
13	CCP_JSE	1.00	0.00	0.00	0.23	0.03	40% of Swaps are cleared by LCH, Local CCP clears 30% of swaps, JSE ETD only
	CCP_Local	0.00	0.30	0.00	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	
14	CCP_JSE	1.00	0.30	0.00	0.23	0.03	40% of Swaps are cleared by LCH, JSE clears 30% of swaps + ETD only
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	
15	CCP_JSE	1.00	0.30	0.75	0.23	0.03	40% of Swaps are cleared by LCH, JSE clears 30% of swaps and 75% FRAs + ETD
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	
16	CCP_JSE	1.00	0.00	0.00	0.23	0.03	40% of Swaps are cleared by LCH, Local CCP clears 30% of swaps and 75% FRAs, JSE ETD only
	CCP_Local	0.00	0.30	0.75	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	

Scen	CCP	ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR	Description
17	CCP_JSE	1.00	0.00	0.00	0.73	0.03	JSE adds another 50% of Equity market (CFDs and fwds are cleared)
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.00	0.00	0.00	0.00	
18	CCP_JSE	0.75	0.00	0.00	0.73	0.32	40% of Swaps and 20% FX cleared by LCH, Local CCP clears 30% of swaps and 75% FRAs and takes 25% of bonds from JSE, JSE ETD increases to 73% and takes 21.6% of FX
	CCP_Local	0.25	0.30	0.75	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.20	
19	CCP_JSE	0.75	0.00	0.00	0.73	0.02	40% of Swaps are cleared by LCH, Local CCP clears 30% of swaps and 75% FRAs and takes 25% of bonds from JSE, JSE ETD only
	CCP_Local	0.25	0.30	0.75	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	
20	CCP_JSE	0.75	0.00	0.00	0.73	0.03	40% of Swaps and 20% FX are cleared by LCH, Local CCP clears 30% of swaps and 75% FRAs and clears 30% FX, JSE ETD only
	CCP_Local	0.25	0.30	0.75	0.00	0.30	
	CCP_Intl	0.00	0.40	0.00	0.00	0.20	
21	CCP_JSE	1.00	0.30	0.75	0.73	0.33	40% of Swaps and 20% FX are cleared by LCH, JSE ETD + 30% swaps, 75% FRA, 73% EQD, 33% FX
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.20	
22	CCP_JSE	1.00	0.30	0.00	0.23	0.35	40% of Swaps are cleared by LCH, JSE clears 30% of swaps + 35% FX+ETD + ETD
	CCP_Local	0.00	0.00	0.00	0.00	0.00	
	CCP_Intl	0.00	0.40	0.00	0.00	0.00	

We have included potential clearing configurations that provide insight that can be used in policy or clearing business decisions. We have not included scenarios where LCH clears FRAs as it is unlikely that LCH will clear South African style FRAs due to the different settlement and valuation characteristics to that of FRAs already cleared by the CCP. As explained above, exchange traded interest rate derivatives are cleared and assumed to be bond derivatives. Other than bond derivatives, it is unlikely that 100% of any asset class market will be cleared as not all OTC derivative instruments are clearable. This is clear from the discussion above on the characteristics of clearable instruments.

10.2.2. Results

The results of simulating exposures according to the methodology described above are presented in Table 10.3. The expected exposure is used to compare clearing arrangements. Results for different clearing configurations are compared to the base case where all derivatives are cleared bilaterally.

Table 10.3: Expected exposure under various clearing configurations using derivatives outstanding at end 2019, 2018 and 2017 using a five-year lookback period and a one-year lookback period. Scenario 1 is in ZAR millions; for scenarios 2-22 the relative difference against Scenario 1 is shown.

Scenario	5yr lookback 2019 positions	5yr lookback 2018 positions	5yr lookback 2017 positions	1yr lookback 2019 positions	1yr lookback 2018 positions	1yr lookback 2017 positions
1	10,260	10,166	12,272	17,005	16,691	19,438
2	0.968	0.973	0.998	0.961	0.970	0.991
3	1.016	1.044	1.090	0.974	0.986	1.018
4	1.194	1.220	1.224	1.043	1.049	1.069
5	0.943	0.935	0.936	0.922	0.924	0.934
6	0.925	0.903	0.878	0.884	0.879	0.879
7	0.917	0.880	0.825	0.848	0.837	0.824
8	0.918	0.870	0.777	0.816	0.799	0.772
9	0.933	0.873	0.740	0.789	0.766	0.722
10	0.960	0.894	0.717	0.767	0.740	0.677
11	1.002	0.933	0.715	0.753	0.723	0.639
12	0.909	0.864	0.769	0.810	0.795	0.768
13	1.002	0.933	0.715	0.753	0.723	0.639
14	0.993	0.928	0.707	0.747	0.718	0.635
15	0.996	0.930	0.706	0.739	0.712	0.630
16	1.005	0.935	0.714	0.746	0.716	0.634
17	0.976	0.977	1.000	0.950	0.963	0.982
18	0.703	0.681	0.626	0.602	0.593	0.580
19	1.056	0.967	0.731	0.776	0.737	0.640
20	0.658	0.620	0.581	0.607	0.587	0.574
21	0.621	0.599	0.561	0.578	0.570	0.559
22	0.760	0.711	0.611	0.655	0.627	0.596

It is clear that using different assumptions on the standard deviation of asset classes and their correlation between each other makes a difference to expected exposures for each clearing configuration. Likewise, changing the proportion of asset class holdings influences the benefit of clearing or not clearing certain asset classes. Mostly, netting benefits appear larger in 2017 in general. This is due to the lower concentration of a single asset class in 2007 as seen in Figure 8.2.

10.2.3. The existing exchange traded derivatives CCP

An exchange traded derivative CCP already exists in South Africa; Scenario 2 quantifies the netting benefit provided by JSE Clear. Scenario 2 shows that there is a benefit, however we will see that this benefit is smaller than other scenarios due to the small size of exchange traded derivatives in relation to bilaterally cleared OTC trades. This result does not quantify other benefits of the derivatives exchange CCP which includes price discovery, standardisation, access to hedging opportunities, simplified access to multiple market makers and liquidity. The existence of a local exchange traded derivatives CCP provides the opportunity for local financial firms to offer trading and clearing services and leverage expertise and infrastructure investment to gain revenue streams.

10.2.4. Foreign exchange derivatives clearing

Scenarios 3 and 4 explore the potential benefit of forex clearing. In Scenario 3, local forex derivatives clearing is increased through JSE Clear to 15% of outstanding forex derivatives and 20% is cleared offshore, potentially with LCH, as many of the forex counterparts are not domestic. This leads to a deterioration in netting arrangements when lower, five-year asset standard deviations and correlations are used. For stressed standard deviations and correlations, a benefit is seen for 2019 and 2018 positions, however a deterioration is noted for 2017 positions where forex makes up only 8% of derivatives outstanding. Scenario 4 is interesting as a third CCP is introduced and an additional 35% of forex is cleared through that venue. This fragmentation of the market leads to an increase in expected exposure using all volatilities and correlations as netting sets are broken.

10.2.5. Interest rate swap clearing

Scenarios 5 to 11 explore clearing different proportions of interest rate swaps through LCH. For the scenarios using standard deviations and correlations from the stressed period, exposure is monotone decreasing to 70% of swaps being cleared as the proportion of swaps cleared increases. This is the case too, for five-year standard deviations using 2017 positions. However, for 2018 and 2019, where swaps are a larger portion of the market, there is an optimal clearing proportion of swaps. Figure 10.5 shows expected exposure in proportion to the base case for various percentages of cleared swaps. The non-linear nature of the relationship between proportion of the market cleared and expected exposure is especially clear when five-year market data are used. When standard deviations are higher, the non-linearity is dampened.

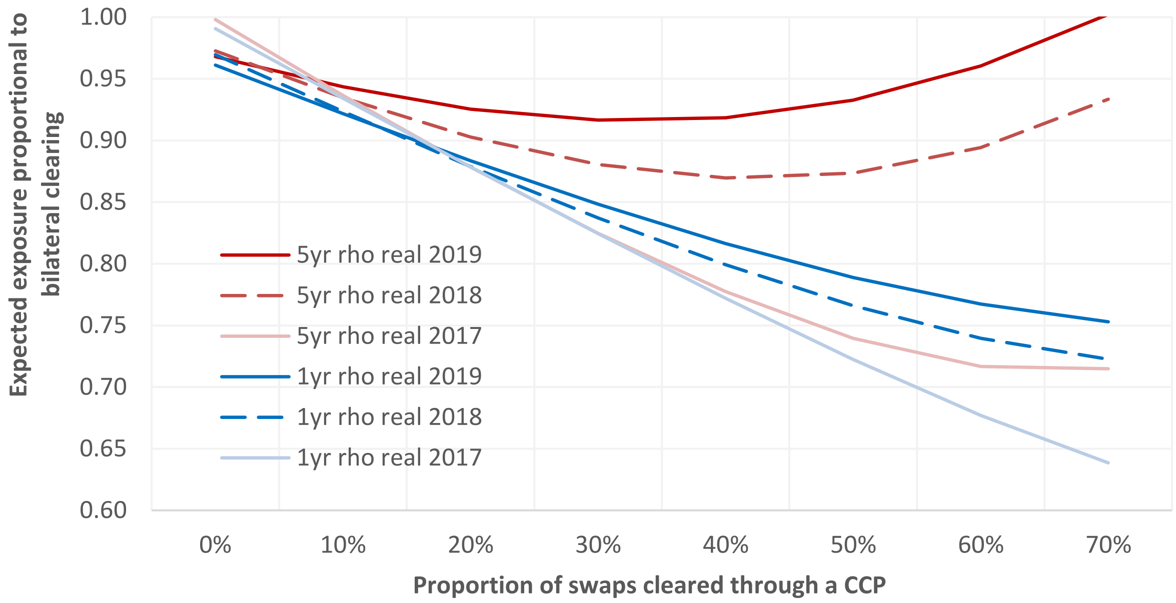

Figure 10.5: Expected exposure for various proportions of swaps cleared through a CCP using positions as at end of 2017, 2018 and 2019, and market data for one year and five years. For all simulations observed market correlations between asset classes was used ("rho real").

Comparing Scenario 12 to Scenario 8 shows the effect of clearing 40% of the swaps market in a separate CCP or in the same CCP as exchange traded derivatives. In each asset class and market configuration clearing exchange traded derivatives with swaps leads to lower expected exposure than clearing them separately.

10.2.6. Clearing location

Scenario 13 maintains that 40% of swaps are cleared by LCH and the Local CCP clears 30% of the remaining swaps. This leads to a deterioration in expected exposure for 2019 and 2018 positions when five-year asset data are used. In all other cases there is a decrease in expected exposure. The results of Scenario 13 are like that of Scenario 11, where 70% of swaps are cleared through LCH. It appears that if 70% of swaps are cleared through LCH or 40% through LCH and 30% through a local CCP, there is no material difference in expected exposure. If the Local CCP clears nothing and 30% of swaps are novated through JSE Clear (Scenario14), expected exposure is reduced from Scenarios 11 and 13.

When the Local CCP clears 75% of FRAs in addition to 30% of the swaps there is a small decrease in expected exposure seen in Scenario 16. This is slightly improved in Scenario 15 when JSE Clear clears the 75% of FRAs and 30% swaps rather than the Local CCP. It is clear from these results and from (16) above that expected exposure is not only a function of relative exposures of asset classes but also asset class riskiness as measured by standard deviation of returns. The standard deviation of FRAs is between 3% and 4.5% of that of swaps. Even though the notional outstanding for FRAs is large, the low standard deviation dampens the impact of including FRAs in a CCP's netting set.

Scenario 17 simply investigates increasing the proportion of equity derivatives cleared. Should JSE Clear broaden its offering to include equity forwards, contracts for difference and equity swaps in a manner that mimics the economics of OTC clearing this scenario is plausible. Expected exposure is improved slightly for five-year market data but for higher standard deviations, expected exposure increases slightly.

If forex clearing is included at LCH and JSE Clear (20% and 32% respectively) with swaps clearing still bifurcated between the Local CCP and LCH (Scenario 18), there is a dramatic decrease in expected exposure to between 70% and 58% of the base case. Scenario 19 replicates that scenario without the forex clearing and using 2019 positions and normal market conditions, there is an increase in expected exposure from Scenario 18. Expected exposures, however, vary significantly when positions are more concentrated (2019 positions compared with 2017 positions).

Replicating Scenario 18 but including 30% of the forex market cleared at the Local CCP and 20% at LCH (Scenario 20) only slightly decreases exposure from Scenario 18. When the Local CCP is eliminated and the exposures cleared by the Local CCP in Scenario 20 are cleared by JSE Clear, Exposure decreased to below a ratio of 0.60 of the base case for all but one combination of positions and market conditions.

Scenario 22 explores the scenario where LCH clears 40% of swaps and JSE Clear clears 30% of swaps, 32% of OTC forex and all exchange traded derivatives. This significantly reduces expected exposure under all position and market condition combinations from even the case where JSE Clear clears only exchange traded derivatives and LCH clears any proportion of the sap market up to 70%.

10.2.7. Concentration and market volatility

We have assumed that the exposures of the domestic banks are proportional to their market risk exposures as disclosed in their annual financial statements. We have further simulated five international banks with the same size exposures as the domestic banks. We now relax these assumptions.

Huang, Menkveld & Yu (2019) investigate CCP exposures at extreme levels and find that crowding is common. While their investigation uses European three-day settlement equity CCP data, the insights for central clearing are informative. We increase the concentration of the two largest banks' 2019 positions relative to the other three domestic banks by 5% each and also decrease the sum of the exposure of the international banks from 50% to 60% to simulate an increase in concentration as observed by Huang, Menkveld & Yu (2019). This leads to an overall increase of the two largest participants from 27% to 38%.

The results show a deterioration in the benefit of introducing a central counterparty in all configuration scenarios of approximately 1%. This means that despite the increase in concentration which is anticipated in periods of stress, there remains a benefit of introducing a CCP. This result is important for the South African market which is already concentrated and the reduction of international participation due to country risk factors is a concern.

We further relax the assumption of the time period used to measure volatility and correlation, and only use the first six months of 2020. We now combine the introduction of concentrated positions with elevated standard deviations and associated "stressed" correlations. We notice that the benefit of central clearing is increased. The greatest increase in the clearing benefit is for scenarios involving the clearing of interest rate swaps and FRAs.

We repeat the exercise of increasing concentrations and market stress but begin with 2017 positions. The different asset compositions result in a marked increase in the benefit of central clearing in most configuration scenarios, this is due to the higher concentration of interest rate exposures in 2017. Table 10.4 shows the results of relaxing the assumptions according to the description above.

Table 10.4: Expected exposure under varying assumptions of concentration and heightened stressed market conditions.

Scenario	1yr lookback 2019 concentrated positions	6 mth lookback 2019 concentrated positions	6 mth lookback 2017 concentrated positions
1	17,002	22,933	26,457
2	0.96	0.96	0.99
3	0.98	0.98	1.02
4	1.05	1.05	1.07
5	0.93	0.92	0.93
6	0.89	0.88	0.88
7	0.86	0.84	0.83
8	0.83	0.81	0.78
9	0.80	0.77	0.73
10	0.78	0.75	0.68
11	0.77	0.73	0.64
12	0.82	0.80	0.77
13	0.77	0.73	0.64
14	0.76	0.73	0.64
15	0.75	0.72	0.63
16	0.76	0.72	0.64
17	0.96	0.94	0.98
18	0.62	0.60	0.59
19	0.79	0.74	0.64
20	0.62	0.61	0.59
21	0.59	0.58	0.58
22	0.67	0.66	0.61

10.2.8. General observations

The results for similar assumptions using different starting positions highlight the importance of making decisions of this nature using information from more than one point in time. South African banks' positions are not static and hence the introduction of a CCP should provide benefit in multiple scenarios.

For selected scenarios we empirically tested whether the number of clearing participants influenced the outcome. Using five-year market data and positions from 2019, we excluded three international counterparts and found that expected exposure increased against the base case for every scenario tested.

The above shown in Table 10.3 and Table 10.4 confirm the assertion of Pirrong (2009) and Duffie & Zhu (2011) that the introduction of a CCP does not always lead to a decrease in expected exposure. However, the results also indicate that increasing central clearing of South African OTC derivatives will, in most plausible scenarios, lead to a decrease in expected exposure.

The results of the study indicate that the biggest impact of clearing efforts in practice and in developing policy frameworks in South Africa will be on interest rate swaps. However, other asset classes will impact the end result either by their inclusion or exclusion. South African financial markets stand to benefit from increased clearing through a multi-asset class CCP.

Importantly for South African policy makers (when considering whether to mandate central clearing) the present study shows that the inclusion of equity derivatives will not reduce counterparty risk as much as mandating the clearing of interest rate derivatives. The benefits associated with clearing of interest rate derivatives hold across various permutations of positions, market volatility and counterparty concentration. Mandating the location of clearing of local currency interest rate swaps will not materially influence the magnitude of counterparty exposure reduction.

Focussing on New Zealand, Budding & Murphy (2014) consider design choices for CCPs for small developed economies. New Zealand is not a member of the G20 ad has a small, albeit developed, financial market. Consideration is given to the derivatives global reform agenda which is relevant to South Africa's regulatory journey.

10.3. FURTHER INSIGHTS

10.3.1. Location of clearing

South Africa does not have a CCP that clears OTC derivatives. Despite the IMF's (2015) recommendation that South Africa institute the mandatory clearing of standardised OTC derivatives, domestic regulators have chosen not to do so. The SARB and FSCA have issued a joint standard on margining of OTC transactions that will only affect the largest participants after the finalisation of the phasing-in period (South Africa, 2020a). LCH is the only CCP that currently clears ZAR OTC swaps.

It is unlikely that the margining requirement will be a sufficient incentive for local counterparts to clear their OTC trades which do not face foreign counterparts and that fall under the margining requirement. There are several reasons for this.

When clearing through LCH, most South African banks will use their third party clearer who charges fees for their clearing services and the guarantee they provide is related to the South

African (sovereign) risk level. This is a cost that must be negated by a significant decrease in exposure. Ideally South African banks would want to be direct a clearing member themselves to eliminate a cost layer.

LCH accepts neither ZAR cash nor bonds as collateral. South African banks will have to raise foreign collateral to place with LCH or incur the cost of collateral transformation with their clearing member. In these transactions further counterparty risk is incurred. Thereafter, the foreign exchange exposure needs to be hedged; incurring transactional friction and additional cost.

Should a significant portion of South African interest rate swaps be cleared through LCH due to a mandate, this will lead to a material indirect risk to foreign banks through LCH. South African banks will be materially exposed to their clearing members, LCH has a principal model whereby clients of clearing members take on the credit risk of the clearing member. Should this clearing member fail, there is a risk that a South African bank's collateral may be comingled with the assets of the failing clearing member making full recovery of those assets doubtful. Further, South African banks will need to port to another clearing member in haste. Another clearing member will have to assess the credit quality of the South African bank and portfolio exposures under, what will certainly be, stressed market conditions. South African banks will not be the only ones seeking new clearers: clearers will seek counterparties with the strongest capital, largest collateral and most stable currency.

In the case of a clearing member failure at LCH, the world's largest OTC CCP (see Figures 4.2 and 5.1), it is likely there will be a flight to safety. When LCH last had a clearing member default, Lehman Brothers in September 2008, the data in described in Section 8.2.3 show that the ZAR devalued 43% between 24 August 2008 and 24 October 2008. It is plausible that if South African banks had a significant portion of their OTC derivatives portfolios cleared through LCH this devaluation may be greater, particularly if the defaulting bank were a clearing member for a large South African bank.

If the defaulting bank held a portfolio of ZAR swaps it is unlikely that it would be its only (or largest) swap currency. LCH would be obliged to neutralise and auction the portfolio as quickly as possible. The manner and timing of this action will be determined by the offshore clearing house when it assesses, among other factors, the risk factors involved (including currencies, tenors and instruments), the complexity and liquidity of the portfolio and the collateral available. The SARB has no jurisdiction over LCH. Furthermore, should the SARB call LCH or its regulator (Bank of England) to influence actions that affect South African currency, it is unlikely that the call will be the first answered on the day or possibly at all. The SARB would have little say as to how or when the portfolio of ZAR swaps would be liquidated. It is probable that the auction will have a material impact on the swap rate and the rate at which the South African government can raise funds.

A potential alternative, measured in Section 10.2, is that JSE Clear, the local dealers or a third party establish a separate CCP for OTC derivatives. Many of the issues mentioned above would be solved, however different considerations will come to the fore.

To this date JSE Clear has not cleared OTC derivatives. The fundamental differences between OTC derivatives and exchange traded derivatives permeate to every aspect of a CCP and must be understood to launch a successful clearing service. There are differences between OTC clearing and exchange traded derivatives clearing in important details in the rules, contracting, initial margining, variation margining, default management and even system architecture. It is not clear that the local banks will trust a novice to provide this service.

If a third party or the banks came together to establish a CCP, there would be no potential opportunity for market participants to offset their OTC exposures with their exchange traded derivatives. Further, the banks' exposure to the CCP would be even more concentrated since they would be investors as well as clearing members.

The first considerations for local banks when clearing OTC trades not at LCH would be cost and collateral. It would be expected that a local CCP would be significantly cheaper as its costs would be denominated in ZAR and not in foreign currency. It is also plausible that technology be developed locally further reducing the cost of the service. The domestic OTC CCP would need to overcome the hurdles preventing the accepting of securities collateral by a CCP.

If a local OTC clearing venue were established, irrespective of who owned or operated it, it is highly unlikely that international banks would clear through the local CCP as they have established exposures at another CCP that clears ZAR swaps (LCH). An implication for domestic banks clearing locally is that they would have bifurcated portfolios. The results discussed in Section 10.2.6 are relevant here and noteworthy to regulators and banks alike.

10.3.2. Client clearing

This model can be extended to include clients of clearing members. It was mentioned earlier in Chapter 9 that Heath, Kelly & Manning (2013) developed the model of Duffie & Zhu (2011) to incorporate clients. The guarantee that clearing members provide was not modelled as it materialises in the South African setting. Heath, Kelly & Manning (2013) show that the benefit of central clearing is larger for banks than for clients; whether this is the case in the South African environment remains unexplored. Garrat & Zimmerman (2017) include a core periphery model, study expected exposure and make important observations on the variance of netted exposures in a cleared setting. More work is required on this topic.

Murphy (2020) notes that the OTC markets have changed since the clearing mandates have been implemented in certain jurisdictions such that the benefit to end clients has reduced. The study advocates innovations that increase the likelihood of porting and direct access for large clients thus reducing clients' dependence on a single clearer and hence improving resilience of the system.

Section 5.2 points out that the required size of the default fund is smaller if ambitious porting assumptions are used. While this reduces the day-to-day cost of clearing for CCPs and clearing members alike, it potentially decreases the stability of the system that CCPs are designed to strengthen. Regulators would be wise to ensure the details of the default fund quantifications align to default scenarios and their plausible consequences.

In the South African setting, only the largest clients are multi-banked. This makes client porting considerations important in the CCP design. Establishing a derivatives capability with a new dealer due to the many conduct regulations and requirements is a non-trivial exercise. When clients are linked to a CCP these requirements are dramatically reduced. Clients are therefore limited to trade only those banks with whom they have an established trading relationship. Often, because the OTC is opaque and clients do not have many choices of counterparties, they do not receive the most efficient prices. Banks bundle services like collateral transformation, market risk transformation, liquidity provision and funding all together making prices difficult to compare.

10.3.3. To clear or not to clear

It is clear that for banks there is little incentive to establish or join a domestic OTC CCP. While a CCP may decrease overall exposure in the system, it is not evident that it will decrease a particular bank's exposure. Further, it will require investment into infrastructure to link to the CCP. While some profit opportunities with clients through the provision of clearing services will be created, an existing revenue stream will have to be sacrificed. In this case the adage of *a bird in the hand is worth two in the bush* is very relevant.

The decision to establish or join a clearing service is multifaceted. Each potential clearing member must analyse not only their own portfolio but their own portfolio at a number of time intervals and make assumptions about the exposures of their counterparties and the counterparties of their counterparties. This is the value of the model introduced by Duffie & Zhu (2011), investigated in this study. The quantification of exposure is only one aspect of the analysis, albeit a large one, and many assumptions must be made about the future landscape that includes clearing and ancillary services to make a decision. This work is not trivial and must be performed by each potential clearing member. Further, for the launch of the service to be successful, the analysis of the *last* bank must be completed within a relatively short period after the first one as the results will not hold forever.

It is unlikely that local OTC clearing services will gain traction in the absence of a regulatory clearing mandate. Similarly, without a clearing mandate there are few incentives for domestic banks to clear their local counterparty exposures at LCH. Should OTC clearing be an added service to an existing CCP, it is unlikely it will be a succuss without the CCP overcoming present hurdles regarding the acceptance of securities collateral, the risk management of the products cleared and offset provided across products.

CHAPTER 11 CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDY

CCPs have been an important part of the fabric of financial derivatives markets for some time. Netting exposures through a CCP, as opposed to bilaterally clearing derivative exposures, changes the way risk is managed and the nature of the risks themselves. The business of central clearing is conceptually simple but in practice CCPs are complex organisations with unique risks, business models and incentives driving their management and usage.

Market participants and CCPs have a keen interest in the solvency of each other. The traditional default waterfall where a CCP’s capital is used before non-defaulters’ resources aligns the incentives of the CCP and clearing members. CCPs vary in the proportion of risk that is covered by their own resources.

The financial crisis of 2008-2009 showed the resilience of CCPs, however they are not immune to failure. The probability of the failure of a CCP is remote, however, CCPs, market participants and regulators must understand the risks they take and prepare themselves appropriately. Scenarios involving a CCP’s recovery or resolution are extremely low probability events but the impact is of systemic consequence.

11.1. CONSIDERATIONS FOR CCPS IN THE SOUTH AFRICAN DERIVATIVE MARKET

We have investigated and highlighted risks relating to CCPs in the South African market. Many of the challenges are found to be common among CCPs. While participants enjoy the benefits of central clearing for exchange traded derivatives, access to clearing of South African OTC derivatives is limited. While some CCPs in other jurisdictions have access to central bank liquidity, we have seen that the framework for such a facility does not yet exist in South Africa. It was highlighted that South Africa is one of the only CCPs that does not accept securities as collateral but only accepts local currency cash.

As mentioned, the major benefit of a CCP is of exposure netting, however we have also discussed many other benefits of the introduction of a CCP. These other benefits and impacts, including concentration risk on default of a CCP, have yet to be modelled and quantified.

In a market as concentrated as South Africa, even if the losses are covered by the collateral secured by the CCP when looking at prices in bilateral markets, there may not be sufficient market depth among the CCP's remaining non-defaulting participants to neutralise its book. This is an important consideration when implementing a risk management framework, ensuring robust monitoring and deciding on what contracts are clearable.

Within CCPs there is a challenge to ensure that their risk management models retain sufficient prefunded resources but simultaneously do not consume too much collateral and waste potential investment opportunities. CCPs are to ensure that their systems remain efficient and effective while their legal framework remains relevant and certain.

Clearing members must ensure first that they manage their own businesses well and not pose a threat to CCPs of which they are a part. Thereafter clearing members are to challenge the CCP's actions and rules to ensure that incentives work to create a secure financial system. It will benefit clearing members to encourage and work with CCPs to continue to innovate systems and broaden the scope of clearable products.

As is seen by the commitments of the G20 (2009), policymakers see the benefits that CCPs can bring to the derivative markets. We have discussed some of the challenges that lie ahead for policymakers regarding resolution of FMIs and the potential too-big-to-fail nature of CCPs. The details of what makes up standardised derivatives, what exactly should be mandated for clearing, to strengthen the system is different in each asset class and each jurisdiction; therefore, regulators must make their own studies of the facts relevant to their market and cannot rely blindly on global standard-setters.

The regulation of CCPs and standards that govern their risk management frameworks have materially improved over the last decade to strengthen the financial systems they support. While CCPs have faithfully served financial markets for many decades, over just the last 10 years CCPs have gone from stage-hands to actors in the limelight on the stage of financial markets worldwide.

11.2. COUNTERPARTY EXPOSURE MEASUREMENT

While the benefits of CCPs are many, the main benefit is counterparty credit risk reduction through multilateral netting of exposures. This study investigated the model described in Duffie & Zhu (2011) as adapted by Cont & Kokholm (2012) and uses it to quantify counter party credit exposures in portfolios of derivative transactions.

11.2.1. Increased clearing of South African derivatives

Using South African data, we found that, for plausible clearing configurations, counterparty positions and market environments, increasing the level of clearing in derivatives markets will lead to a decrease in counterparty exposure.

11.2.2. Specific asset class clearing

It was noted that the size of positions in different asset classes and volatilities of those asset classes makes a material difference as to whether the inclusion of those exposures in a CCP is beneficial for the market as a whole or not. In the South African context, we found that increasing the clearing of interest rate swaps will lead to the greatest reduction in counterparty exposures.

11.2.3. Clearing location

In the South African financial market, there is currently no opportunity to locally clear OTC derivatives. Domestic-to-domestic trades are likely to remain uncleared for some time. The SARB (2020b) estimates that the new margining rules for bilaterally cleared OTC derivative exposures, when fully implemented, will only impact large banks. It is unclear how material that impact will be compared to the all-in costs involved in clearing offshore, or establishing a domestic CCP.

We have confirmed that the introduction of a CCP does not always reduce exposures. Further, in South Africa, whether swap exposures are bifurcated between a local and international CCP or consolidated through one CCP does not significantly change expected exposure. This has important implications for those investing in a CCP or regulating OTC markets. This indicates that the future decision to clear at a domestic CCP or international CCP could potentially be reduced to one of cost.

Should clearing of standardised OTC derivatives be mandated in South Africa, restricting the location of clearing to South Africa will not materially increase or decrease overall exposure compared to allowing participants to choose their clearing location. However, we have seen that in the South African context the choice of clearing location by participants will have other large consequences. Costs will be significantly different as domestic banks have to find an intermediary to clear they positions internationally whereas locally they would in all likelihood be direct clearing members of the CCP. The fees internationally are based in foreign currency. Locally, as the legal framework stands, only Rand cash will be able to be placed as collateral.

Internationally however South African government bonds are not accepted. These factors materially affect the cost of clearing.

11.2.4. Concentration and market volatility

We investigated some specific characteristics of exposure concentration and market volatility common to the South African market. We found that for plausible scenarios where our original assumptions were relaxed, the earlier findings regarding the benefits of introducing clearing still held.

11.2.5. Further observations

We noted that the size of positions was not static over time, what is sometimes understood as the structural make up of a portfolio due to economic trading flow changes over time. Due to the long term-to-maturity of some OTC derivatives, taking a single, point-in-time measurement of clearing efficiency to inform a decision to establish or not establish a CCP may be short-sighted.

We also saw that the number of participants influences whether a benefit is to be achieved by establishing a single asset class CCP. This study and the model used, investigates only dealer-to-dealer flow and ignores client trades. All but the very largest clients are unlikely candidates for self-clearing membership offerings by CCPs. The SARB's (2020b) impact study shows that non-banks exposure is not as large as bank exposure but also not immaterial. Future study could investigate the impact on exposure of client clearing.

11.3. SUGGESTIONS FOR FURTHER RESEARCH

Further investigation is required to determine whether an optimal CCP contribution can be determined considering all costs. Specific attention should be given to the way incentives are changed by the changing weight of a CCP's default fund contribution.

Opportunity exists for quantifying the impact of the recovery measures discussed in Chapter 5 on exposures. Effectively these are different ways of distributing losses. The cost of such distribution is still to be investigated.

In South Africa, because collateral at the existing CCP for exchange traded derivatives is only taken in ZAR cash, there exists opportunity to quantify the impact of a default of a bank clearing member that also holds a portion of the initial margin. We have seen that South Africa does not have a framework for the CCP to deposit funds with the SARB like other CCPs.

Investigation is warranted to determine the impact on local bank liquidity if the initial margin deposited with the CCP, which is approximately ZAR 49bn as at September 2020 (JSE Clear, 2021), were to be taken out of direct circulation and deposited with the SARB. Alternatively, the cost of securing deposits with collateral could be investigated.

This model could be extended to include the largest clients of banks and investigate the impact of client clearing and self-clearing. This is important as large non-banks will likely be counterparties to more than a single bank in a bilaterally cleared setting. These exposures will be netted and guaranteed by a single clearing member bank in a cleared setting.

The difference in cost of bilateral clearing and central clearing in South Africa is unknown. Further research could consider the potential impact of the introduction of a domestic CCP for OTC derivatives.

Further research opportunities also exist to quantify the impact of a CCP that only serves domestic participants. While international banks continue to clear at LCH, domestic banks bifurcate their portfolios between two CCPs. The scenarios in this present study related only to various proportions of asset classes being cleared by different CCPs, where all counterparts split their clearing portfolios in similar manners among all CCPs. In reality, it is unlikely that an offshore non-bank counterpart will execute with a domestic bank; and when executing with an offshore bank, will unlikely clear at a domestic CCP. These refinements to the model will be informative to domestic banks and policy makers alike.

Non-netting benefits of a CCP were not modelled in the current investigation. Future investigation should include modelling the impact on capital requirements, collateral availability, operational costs, legal cost rationalisation and changes to liquidity profiles of derivative contract maintenance. There is the prospect of a further study to expand current quantification models to incorporate cost efficiencies that are gained from the use of CCPs.

In the South African context investigation is required as to how plausible it is to auction the portfolio of a defaulting clearing member if that clearing member is a major bank. Before a local CCP is considered for OTC instruments, investigation is required to determine if a defaulting portfolio can be absorbed by the remaining non-defaulting members of the CCP. We have noted that the CCP must stay market neutral at all times, it cannot have an open position in the market. When a clearing member defaults, the defaulter's positions must be sold in the market.

Further work is required to extend the model by Duffie & Zhu (2011) to incorporate constraints on balance sheets that participate in the CCP.

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APPENDIX A: PYTHON CODE

In Python commentary is prefixed by “#” in a line or with three consecutive quotation marks for multiple line comments.

Explanation of the code procedures are inserted in code text boxes below and must be omitted if copying into a Python script.

```
# -*- coding: utf-8 -*-
"""
Modeling central counterparty exposures
Terence Saayman
February 2021

Definitions:
    ~ K Asset classes:k
    ~ N Counterparties: i,j,h
    ~ G CCPs: g

Import:
    chooseY (var_chooseY.csv) = control file with choices on the number it-
erations, which randoms to use, output file name to use
    z_k_i (var_Z.csv) = notional amount invested in asset class k by coun-
terparty i (size: K x N)
    w_g_k (var_W.csv) = counterparty weights, how much of asset class k is
cleared through CCP g, sum w_g_k across g < 1 (size: G x K)
    b_k   (var_B.csv) = std deviation of 1-day returns on one unit of asset
in asset class k (size: K x 1)
    r_k_k (var_R.csv) = correlation matrix between 1-day returns of asset
classes (size: K x K with 1 on diagonal)
Generate:
    y_i_j_k = standard normal random variables, correlated across k (for
given i & j) (size: K x N x N, and y_i_j_k=0 where i=j )
     [either generate randoms or import from var_Y.csv]

Calculate
    l_k_k = cholesky decomposition of r_k_k (size: K x K)
    x_i_j_k = (10) in Cont & Kokholm =f(b_k, z_k_i, y_i_j_k)   (size: K x N
x N, and x_i_j_k=0 where i=j )

@author: tsaay
"""
```

```
Import required Python libraries.
```

```
import numpy as np
import pandas as pd
import scipy.linalg as linalg
import time as tm
import itertools as itls
start_time = tm.time()
start1_time = start_time
```

Import required input files and set initial variables – examples of csv files are provided in Appendix B

```
#--1---------Import Data Files--------
rootpath='C:/Users/tsaay/Documents/Saay.Terence/Study.Masters/Modelling/Model_Python/DuffieZhu/'
path = rootpath + 'Input_files_csv/'
outpath = rootpath + 'Results/'

B = pd.read_csv(path + 'var_B.csv') # std deviation of one day returns
R = pd.read_csv(path + 'var_R.csv') # correlation matrix of std deviation of one day returns
Z = pd.read_csv(path + 'var_Z.csv') # Size of positions for each counterparty
W = pd.read_csv(path + 'var_W.csv') # Scenario of CCP weights
chooseY = pd.read_csv(path + 'var_chooseY.csv') # Info for running

Y=pd.DataFrame()
rho = R.copy()

rho = rho.set_index("assetclass")

zed = Z.copy()
zed = zed.set_index("counterparty")
beta = B.copy()
beta = beta.set_index("assetclass")
beta = beta.T
fullw = W.copy()

#--2---------Cholesky decomposition----
```

Apply the Cholesky decomposition on the correlation matrix

```
def my_cholesky(corr_matrix):
```

```
    L = linalg.cholesky(corr_matrix, lower=True)
    L = pd.DataFrame(L)
    return L
#--2<<<<-------------------------------------

#--3-------Make sum of Z less Z_i   ------------------------
```

Make a dataframe with the X_{ij}^k values as in (16) before including Y_{ij}^k: $\beta^k Z_i^k \frac{Z_j^k}{\sum_{h \neq j} Z_h^k}$. size of dataframe = $N \times N \times K$

```
def make_static_zedfactor(beta):
    #global cpty_indices

    # # #--- make   Zi * Zj / Zh  --------
    Zi = Z.copy()
    Zi = Zi.rename(columns={'counterparty':'counterparty_i'})

    Zj=Z.copy()
    Zj = Zj.rename(columns={'counterparty':'counterparty_j'})

    Zh = Z.copy()
    Zh = Zh.rename(columns={'counterparty':'counterparty_i'})

    l1 ,l2 = Zi['counterparty_i'], Zj['counterparty_j']
    mycombin = pd.DataFrame(itls.product(l1,l2))
    mycombin.columns=['counterparty_i','counterparty_j']
    mycombin=mycombin.set_index(['counterparty_i','counterparty_j'])



    Zi=Zi.set_index(['counterparty_i'])
    Zj=Zj.set_index(['counterparty_j'])


    Zh = Zh.set_index("counterparty_i")
    Zh = Zh.sum(axis=0)-Zh
    Zh = 1/Zh


    newz_i = pd.merge(mycombin, Zi, how='outer', left_index=True, right_in-
dex=True)
    newz_j = pd.merge(mycombin, Zj, how='outer', left_index=True, right_in-
dex=True)
    newz_h = pd.merge(mycombin, Zh, how='outer', left_index=True, right_in-
dex=True)
```

```
    zedfull = newz_i  * newz_h
    zedfull = zedfull * newz_j

     # # #---finished making Zi * Zj / Zh  --------
    zedfullbeta = zedfull * beta.iloc[0]
    zedfullbeta=zedfullbeta.reset_index(drop = False)
    zedfullbeta.loc[zedfullbeta.counterparty_i==zedfullbeta.counter-
party_j,beta.columns]=0
    zedfullbeta.set_index(['counterparty_i','counterparty_j'],inplace=True)

    #------  Now we have Beta * Zi * Zj / Zh for each i, j & k with zed-
fullbeta = 0  for i=j
    return zedfullbeta

#-4---------Generate Random Vars--------
```

Generate dataframe with $N \times N \times K$ random variables using post-Cholesky decomposition correlations.

```
#-- Need to do this for each new correlation matrix or StdDev vector
def correlate_randoms(temp_var):
    cor_rand = temp_var.dot(L.T)
    return cor_rand

def make_new_Y():  #---use this code to generate correlated random varia-
bles in python

    Y_temp =pd.DataFrame()
    Y_rand_temp = pd.DataFrame(np.random.normal(size=(len(Z)**2,len(L))),
columns=rho.columns)
    my_dict = {}
    col_list = list(rho.columns)
    for z in range(len(Z)**2):
        val_list=list(correlate_randoms(np.array(Y_rand_temp.iloc[z,:])))
        my_dict[z] = dict(zip(col_list,val_list))
    Y_temp = pd.DataFrame.from_dict(my_dict,"index")
    return Y_temp
```

Use the random variables imported in the csv files, do not generate random variables as above (used for validation).

```
def use_excel_Y():  #--- use this code to get Random Variables from Excel
```

```
    Y_temp = pd.read_csv(path + 'var_Y.csv')
    return Y_temp
#-5--  CCP Aggregation ---------
```

Matrix multiplication of exposures in the presence of a CCP (netting across counterparties and proportions of cleared asset classes)).

```
def ccp_aggregation(xw_matrix):
    xw_matrix = xw_matrix.groupby(by=['counterparty_i']).sum()
    xw_matrix['total'] = xw_matrix.sum(axis=1)
    xw_matrix['zero'] = 0
    xw_matrix['CCPexpos']=np.maximum(xw_matrix['total'],xw_matrix['zero'])
    return xw_matrix['CCPexpos']


def ccp_iteration(x_matrix, w_one_scen):
    my_dict={}
    w_one_scen = w_one_scen.drop(['Scenario'], axis=1)
    one_scen = pd.DataFrame()
    for i in range(len(w_one_scen)):  #range(2):
#range(len(w_one_scen)):
        this_ccp = w_one_scen.iloc[i]['CCP']
        w_one_ccpscen = w_one_scen.drop(['CCP'], axis=1)
        w_one_ccpscen = w_one_ccpscen.iloc[i]
        working_matrix = x_matrix.copy()


        working_matrix = pd.DataFrame(x_matrix.values*w_one_ccpscen.val-
ues,columns=x_matrix.columns, index=x_matrix.index)
        working_matrix = ccp_aggregation(working_matrix)
        working_matrix['ccp'] = this_ccp
        my_dict[i] = dict(working_matrix)


    one_scen = pd.DataFrame.from_dict(my_dict,'index')
    return one_scen


#-6--  Bilat Aggregation
```

Matrix multiplication of exposures in a bilaterally cleared setting (netting across asset classes only).

```
def bilat_iteration(x_matrix, w_one_scen):


    w_one_scen = w_one_scen.drop(['Scenario','CCP'], axis=1)
```

```
    w_one_scen = w_one_scen.sum()
    w_one_scen = 1 - w_one_scen
    working_matrix = x_matrix.mul(w_one_scen)
    working_matrix['total'] = working_matrix.sum(axis=1)
    working_matrix = working_matrix.drop(beta.columns,axis=1)
    working_matrix['zero'] = 0
    working_matrix['CCPexpos']=np.maximum(working_matrix['total'],work-
ing_matrix['zero'])
    working_matrix = working_matrix.drop(['total','zero'],axis=1)
    working_matrix = working_matrix.groupby(by=['counterparty_i'] ).sum()

    return  working_matrix
#-6-<<<<<<<------------------------------------

#-7----  repeating Clearing configurations  ---------------------
```

Repeat through the clearing configurations as set out in dataframe W, input file: var_W.csv

```
def rept_thru_clear_configs(my_iter):
    global Y
    global X_t
    # repeatable part.....
    Y = make_new_Y()
    X_t = zedfact.copy()

    X_t = X_t.reset_index(drop=True) * Y
    X_t.set_index(zedfact.index, inplace=True)
    my_result_collected = pd.DataFrame()
    my_result_cols = pd.Series(['counterparty_i', 'ccp_scen', 'bilat'])
    my_result_cols = my_result_cols.append(pd.Series(W['CCP'].unique()))

    #record & remove the Scenario before passing W
    allscenarios  = W['Scenario'].unique()
    for scen in allscenarios:

        my_result = ccp_iteration(X_t,W[(W.Scenario==scen)])
        ccplist = my_result.loc[:,'ccp']
        my_result = my_result.drop('ccp', axis=1)
        my_result = my_result.T
        my_result.columns = pd.Series(ccplist)
        my_resultb = bilat_iteration(X_t,W[(W.Scenario==scen)])
```

```
        my_result['bilat'] = my_resultb
        my_result['ccp_scen'] = scen
        my_result.reset_index(inplace=True)
        my_result.rename(columns={'index':'counterparty_i'}, inplace=True)
        my_result = my_result.reindex(columns=my_result_cols)
        my_result_collected = my_result_collected.append(my_result, ig-
nore_index = True)

    return my_result_collected
#-7-<<<<<<<-----------------------------------
```

Repeat through the number of iterations as specified in the input file `var_chooseY.csv`

```
def repeat_iterations( the_results, start_time_t):
    printscens = 100
    for rpt in range(my_iterations):

        #--run the clearing configurations->
        one_result = rept_thru_clear_configs(rpt)
        one_result['ThisResult'] = 'simulation_' + str(rpt)
        the_results = the_results.append(one_result, ignore_index=True)

        if (((rpt+1) % printscens == 0) & (rpt > 0)) or rpt == 5:
            end_time  = tm.strftime("%d %b  %H:%M:%S", tm.strp-
time(tm.ctime((tm.time()-start_time)*my_iterations/(rpt+1) + start_time)))
            time_taken = tm.strftime("%d %b  %H:%M:%S", tm.strp-
time(tm.ctime((tm.time()-start_time)*my_iterations/(rpt+1) )))
            print('clearing scen: ',rpt+1, "Time to take:", time_taken,"
Est end time:", end_time)
            start_time_t = tm.time()

    return the_results,  start_time_t

#---10---------------------------------------------------------------------
#------->>>>>>>>>>>>>>>>>>>>>>>>--Main-Code-Starts-Here--------------------
```

Execute the code above.

Assign variables and run “`repeat_iterations`” which calls “`rept_thru_clear_configs`” which calls the previous procedures.

```
X = pd.DataFrame()
```

```
my_iterations = chooseY['TestCalc'][1]
my_iterations = int(my_iterations)
all_results = pd.DataFrame()

print('The time is: ', tm.strftime("%d %b  %H:%M:%S",  tm.strp-
time(tm.ctime(tm.time()))))
print('There are ', str(len(W['Scenario'].unique())), 'clearing configura-
tions')
print('There are ', str(my_iterations), 'simulations')
#------Calc Base ------
L = my_cholesky(rho)

zedfact = make_static_zedfactor(beta)

all_results, start1_time = repeat_iterations( all_results, start1_time)
all_results['scen_beta']='Base'
all_results['scen_rho']='Base'

if chooseY['TestCalc'][0] == 'Yes': print('Cant print in this version, use
version 7 of code.')

#---------------------------------------------
```

Reshape the results and calculate statistics meaningful statistics (mean, Max, VaR at 95% & 99% and Expected short-

```
all_results['total_expos'] = all_results.sum(axis=1)
# all_results.set_index(['counterparty_i'], inplace=True)

temp_results = all_results.drop("ThisResult", axis=1)
temp_mean = temp_results.groupby(by=['counterparty_i','ccp_scen','scen_be-
ta','scen_rho']).mean()
temp_quant95 = temp_results.groupby(by=['counter-
party_i','ccp_scen','scen_beta','scen_rho']).quantile(0.95)
temp_quant99 = temp_results.groupby(by=['counter-
party_i','ccp_scen','scen_beta','scen_rho']).quantile(0.99)
temp_max = temp_results.groupby(by=['counterparty_i','ccp_scen','scen_be-
ta','scen_rho']).max()

tempdf = all_results[['counterparty_i','ccp_scen','ThisResult','to-
tal_expos']].copy()
tempdf=tempdf.reset_index(drop = True)
tempdf = tempdf.set_index(['counterparty_i','ccp_scen'])
```

```
tempdf=tempdf.sort_index()
newdf95 = temp_quant95.copy()
newdf99 = temp_quant99.copy()
newdf95=newdf95.reset_index(drop = False)
newdf99=newdf99.reset_index(drop = False)
newdf95=newdf95.drop(['scen_beta','scen_rho'], axis=1)
newdf99=newdf99.drop(['scen_beta','scen_rho'], axis=1)
newdf95['ETL95'] =1.0
newdf99['ETL99'] =1.0

for i in range(len(newdf95)):
    newdf95.loc[i,'ETL95']=tempdf.loc[((newdf95.loc[i,'counter-
party_i'],newdf95.loc[i,'ccp_scen']),tempdf['to-
tal_expos']>newdf95.loc[i,'total_expos']),'total_expos'].mean()
    newdf99.loc[i,'ETL99']=tempdf.loc[((newdf99.loc[i,'counter-
party_i'],newdf99.loc[i,'ccp_scen']),tempdf['to-
tal_expos']>newdf99.loc[i,'total_expos']),'total_expos'].mean()

newdf95=newdf95.loc[:,('counterparty_i','ccp_scen','ETL95')]
newdf95.rename(columns={'ETL95':'total_expos'}, inplace=True)
newdf99=newdf99.loc[:,('counterparty_i','ccp_scen','ETL99')]
newdf99.rename(columns={'ETL99':'total_expos'}, inplace=True)

tempinfo = pd.DataFrame()
temp_results = [temp_mean, temp_max, temp_quant95,
temp_quant99,newdf95,newdf99]
tempinfo['plsjoin'] = temp_results
tempinfo['metricname'] = ['mean', 'max', 'quant95',
'quant99','etl95','etl99']

for x in tempinfo.index:
    makemetric = tempinfo.loc[x,'plsjoin']
    makemetric['metric'] = tempinfo.loc[x,'metricname']
    makemetric.reset_index(inplace=True)

result_stats = pd.concat(temp_results, ignore_index=True)
result_stats=result_stats.drop('index', axis=1)
```

Save the results required to csv

```
save_file =    'AllResults_'  + chooseY['TestCalc'][2] + '_' +
chooseY['TestCalc'][1] +'.csv'
all_results.to_csv(outpath + save_file, index = None, header = True)
```

```
save_file =    'AllResultsStats_'  + chooseY['TestCalc'][2] + '_' + chooseY['TestCalc'][1] +'.csv'

result_stats.to_csv(outpath + save_file, index = None, header = True)


tottime = tm.time()-start_time

print('Total time:', round(tottime/60,3),'minutes') #' &', round(((60*5)/tottime)/len(W['Scenario'].unique()),2), 'simulations per 5 minutes')
```

APPENDIX B

Table B.1: Standard deviations of the asset classes used (var_B.csv)

assetclass	stddev
ZAR186	0.021758
ZAR5Y	0.012866
ZAR3X6	0.000561
TOP40	0.058976
USDZAR	0.027065

Table B.2: Instruction file for controlling the code (var_chooseY.csv)

VariableDesc	TestCalc
ValidateResults	No
Number of iterations	10000
File Name for Results	SA 6mo2017__Concentrate
Run Many Python Scenarios	Python

Table B.3: Correlation matrix for the asset classes used (var_R.csv)

assetclass	ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR
ZAR186	1	0.817897	-0.18069	0.600763	-0.36312
ZAR5Y	0.817897	1	0.149047	0.627652	-0.25723
ZAR3X6	-0.18069	0.149047	1	0.027328	0.334755
TOP40	0.600763	0.627652	0.027328	1	-0.4228
USDZAR	-0.36312	-0.25723	0.334755	-0.4228	1

Table B.4: CCP configurations to be tested (var_W.csv)

Scenario	CCP	ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR
01_Base_1	CCP_JSE	0	0	0	0	0
01_Base_1	CCP_Local	0	0	0	0	0
01_Base_1	CCP_Intl	0	0	0	0	0
02_Base_2	CCP_JSE	1	0	0	0.23	0.03
02_Base_2	CCP_Local	0	0	0	0	0
02_Base_2	CCP_Intl	0	0	0	0	0

Table B.5: Standard normal random variables only used for validation (var_Y.csv)

Forwards	Swaps	Options	Credit
1.507174	-0.06536	1.511041	-0.02856
-1.37125	1.392541	0.314133	0.429207
…			
-0.6211	-1.19703	0.68686	-0.30071

Table B.6: Position sizes for each bank in each asset class (var_Z.csv)

counterparty	ZAR186	ZAR5Y	ZAR3X6	TOP40	USDZAR
Bank1	37774.52	9281187	4488718	273268.9	1175967
Bank2	22819.44	5606729	2711617	165080.7	710397
Bank3	3371.397	828351.1	400620.6	24389.4	104955.7