The impact of EMIR

The structure, dynamics, and challenges found in the Dutch interest rate swap market

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ABSTRACT

Recent developments in the technical standards of the European Market Infrastructure Regulation (EMIR) have opened the doors for systemic – albeit limited – use, to establish and explore structural changes in the interest rate swap market in response to proposed legislation. This thesis will attempt to establish these relations and continue on the work of Ascolese et al. (2017) to systematically review the data quality, aiming to provide a methodology which will allow regulators to comprehensively and systematically use EMIR in the implementation of their respective mandates. The thesis presents evidence that the clearing obligation has lowered the overall exposure, but has resulted in increased dependence on a limited number of counterparties. Moreover, the initial margin calculated based on the International Swaps and Derivatives Association's Standard Initial Margin Model (SIMM), exhibits procyclical effects in terms of substantial variation across time. However, the required levels to be posted appear to be limited relative to the gross notional.

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Contents

Introduction **2**

1 Literature **4**

1.1 EMIR . . . 4

1.2 The Transformed Landscape . . . 6

1.2.1 The IRS Market . . . 6

1.2.2 Regulatory Responses . . . 7

2 Data **12**

3 Methodology **14**

3.1 Processing Procedure . . . 14

3.1.1 Stage One . . . 15

3.1.2 Stage Two . . . 15

3.2 Transformed Landscape . . . 22

3.2.1 The Interest Rate Swaps Market . . . 22

3.2.2 Network analysis . . . 23

3.2.3 Regulatory Responses . . . 24

4 Results **28**

4.1 The Dutch Interest Rate Swaps Market . . . 28

4.1.1 Network Analysis . . . 35

4.2 Evolution of the Interest Rate Swap Market . . . 38

4.2.1 Clearing Obligation . . . 38

4.2.2 Margin Requirements . . . 42

5 Discussion **47**

6 Conclusion **47**

References **49**

A Data **52**

B Methodology **54**

B.1 SIMM calculation . . . 56

C Results **57**

The research data in this thesis is drawn from the European Market Infrastructure Regulation (EMIR). The regulation requires all institutions that fall into purview of regulators in the EU to report their derivatives trades. To date, limited research has explored the evolution of the interest rate swaps (IRS) market in relation to regulatory measures using EMIR. Recent developments in the technical standards of EMIR have, however, opened doors for systemic – albeit limited – use, to establish and explore these exact relations. Hence, this thesis reviews the data obtained through EMIR, aiming to provide a framework which allows thorough and standardized use of the data set in the implementation of financial authorities' mandates. Moreover, following this quality assessment, the thesis sets out to asses the effects of several mandates in relation to the changing nature and underlying structure of the IRS market. The mandates explored are the clearing obligation and the initial margin requirements.

The relative percentage of transactions cleared has increased substantially over time, and has mostly been attributed to the clearing obligation. In addition, the clearing obligation has led to separation of clearing activities between clients and central counterparties. The thesis aims to examine these effects, and tries to assess whether these have occurred are as a result of the clearing obligation Margin requirements for derivative contracts serve as a buffer against the transmission of losses through the financial system by protecting one party to a contract against default by the other party. However, due to the data constraints, most literature was forced to remain theoretical in nature. In contrast, this paper uses the data obtained through EMIR to assess whether or not the margin requirements are an actual risk to the liquidity of the market.

Thus, drawing upon two strands of research into the IRS market, this thesis attempts to investigate what behavioural responses are evident in the market in reaction to regulatory measures. Moreover, this thesis will continue on the work of Ascolese et al. (2017) and systematically review the data quality, aiming to provide a methodology which will allow regulators to comprehensively and systematically use EMIR in the implementation of their respective mandates.

Due to the granular nature and the subsequent limitations of the data, this thesis will focus on the IRS outstanding with at least one Dutch counterparty. Moreover, the analyses utilize multiple end of the month moments. The entire data set used in this thesis runs from the 31th of August 2016 until 31th of December 2018, where each moment contains all outstanding trades in the IRS market.

The thesis presents evidence that the clearing obligation has lowered the overall exposure, but has resulted in increased dependence on a handful of counterparties. Moreover, the interconnectedness of smaller parties has remained relatively stable over time, while the on average larger parties have increased in size substantially. These findings extend to the relationship types based on client-member and member-CCP clearing. Moreover, the initial margin calculated based on the International Swaps and Derivatives Association's Standard Initial Margin Model (SIMM), exhibits procyclical effects in terms of substantial variation across time. However, the levels required to be posted appear to be limited relative to the total gross notional per sector.

The remaining sections are structured as follows. Section 1 describes the literature on which the findings are based, this is followed by the description of the data in section 2. Then, section 3 lays out the methodology. Section 4 presents the finding of this thesis. The thesis is then concluded by the discussion and the conclusion – section 5 and 6, respectively.

1 Literature

The literature relevant to this thesis can be separated into two distinct strands of work. Namely, first, research based on granular, transaction-level data sets – specifically research based on EMIR data. Second, the literature connected to the systemic risk and the development of the market in response to proposed regulation. This distinction has several purposes, the most important being the prudential function of an overview of the (micro)structure of the IRS market. As the intricate nature of EMIR data forces the cleaning procedure to be subject to strong assumptions, a framework to compare the findings against ensures consistent and robust results. Moreover, the established framework will serve as a foundation for the subsequent analyses.

The other strand of literature explores the current research regarding behavioural responses found in the market as a result of regulatory changes. Despite the importance of understanding said mechanisms, there remains a paucity of practical evidence due to the intrinsically complex and fast-changing IRS market. However, the recent quality improvements seen in the EMIR data set means that established regulation can be tested and adapted in response.

1.1 EMIR

The European Market Infrastructure Regulation (EMIR) was adopted in 2012 in response to the 2008 financial crisis. During the financial crisis, the shadow banking system appeared to cast a much wider shadow than was previously estimated. Although it was widely accepted that derivatives played an important role in the economy, there were no regulatory systems in place to quantify their existence and the risks they imposed on the market. As a result, the financial crisis highlighted the significant impact unregulated markets could have on the economy. In response, regulators developed, and are still in the process of developing, a framework to ensure a more transparent and resilient functioning of the derivatives markets (European Parliament and of the Council 2009). The commitment, as described by Ascolese et al. (2017) as the Pittsburgh commitment, encompassed five elements: (1) reporting of all over-the-counter (OTC) derivatives contracts to trade repositories; (2) moving of all standardised OTC contracts on exchanges; (3) clearing obligation through central counterparties (CCPs); (4) introduction of margin requirements for non-cleared trades and (5) periodic assessment of the reforms' implementation. The elements aim to increase transparency in the derivatives market, mitigate credit risk, and reduce operational risk for all parties involved.

The clearing obligation was introduced as a key element for the mitigation of credit risks, as well as an overall improvement to the financial stability of the derivatives market. In essence, the clearing obligation imposes a CCP between OTC derivatives counterparties, this process insulates both parties from each others possible default. Duffie et al. (2011) established that effective clearing mitigates systemic risk by halting the propagation of defaults from counterparty to counterparty. Moreover, the CCP also performs a curbing function, in cases where market participants are be confronted with counterparties suddenly reneging their contracts, such as the recent response to the Deutsche Bank regarding their solvency. The CCP can in, such cases, prevent the exacerbation of the, possibly already present, solvency issues.

Another, closely related, main pillar introduced through EMIR are the margin requirements for non-cleared derivatives. As mentioned in the previous paragraph, an essential function of a CCP is to prevent the propagation of defaults. The collection of the margins, especially initial margins, allows a CCP to perform that function. The margin requirements serve as a buffer against the transmission of losses between counterparties, and are comprised of the variation and the initial margin. Both margins exist to shield each party from potential counterparty default risks, but differ in the underlying functionality. The variation margin exists to ensure both parties are compensated for changes in the market which could potentially influence the value of the contract. In other words, the variation margin equals the market to market changes over the entire lifetime of the contract. Initial margins, as opposed to the variation margin, exists to cover the costs of replacing the contract. Interesting to note, the legislation specifically targets non-cleared derivatives due to the already implicit margin requirements found in centrally cleared trades. It appears that one of the intentions behind the requirement is to make the bilateral collateral practices closer to the practices seen in the centrally cleared market (Gregory (2016)).

The growing body of literature regarding the market evolution as a results of the clearing obligation as well as the margin requirements is described in section 1.2.2. Lastly, all mandates regarding EMIR were introduced according to a phase-in structure. The time line for the legislation regarding the clearing obligation and the initial margin requirements can be found in table 1.

Category[1]	IRS in G4 currencies	IRS in additional currencies
Category 1	21/06/2016	09/02/2017
Category 2	21/12/2016	09/08/2017
Category 3	21/06/2019	21/06/2019
Category 4	21/12/2018	09/08/2019
Clearing threshold	EUR 3 billion*	

IM Notional Threshold	Implementation date
EUR 3 trillion*	04/02/2017
EUR 2.25 trillion*	01/09/2017
EUR 1.5 trillion*	01/09/2018
EUR 0.75 trillion*	01/09/2019
EUR 8 billion*	01/09/2020

Table 1: The implementing dates for the clearing obligations for each category and currency, and the dates for the initial margin notional thresholds. Adapted from Ascolese et al. (2017) and European Parliament and of the Council (2019).
* in gross notional value

1.2 The Transformed Landscape

1.2.1 The IRS Market

The topology of the interest rate swap (IRS) market is, currently, most commonly based on the EMIR data gathered at European level. Abad et al. (2016) were one of the first to shed light on this market using European EMIR data. Their analysis relied on the DTCC trade state report for 02-11-2015. Moreover, they focus on the 6 month EURIBOR plain-vanilla fixed-floating IRS, which accounts for roughly a fifth of the total notional value of the IRS. Moreover, the IRS accounts for the majority of the IRD, namely around 88%. These numbers are confirmed in more recent papers using the same data set on European level, e.g. Ascolese et al. (2017) analyze all trades from April 2015 until March 2017. Abad et al. (2016) and Ascolese et al. (2017) both find that the 6 month EURIBOR tenor is the most prevalent benchmark, relative to the notional share as well as the total number of observations. The remaining benchmarks account each for less than 10% of the gross notional. Yet, Ascolese et al. (2017) do show that the share of each underlying benchmark remains stable over time. Thus, they conclude that the market is decidedly heterogeneous, but stable.

Regarding the micro-structure of the OTC IRS market, Abad et al. (2016) report that the modal year found in the effective dates is 2015, which, in their opinion, reflects the market practice of compressing economically redundant trades into new contracts with a smaller gross notional as the reporting date they investigate is 02-11-2015. In addition, they find a maturity distribution, which has been replicated numerous times, with an initial spike at five years. Another more pronounced spike at ten years, followed by another slightly lower spike at thirty years. They narrow the scope of the maturities by analyzing the distribution across counterparties type[2]. All types except for the insurers and pension funds show similar distributions, where the insurers and pension funds appear to favour swaps with longer maturities. The preference for long-dated swaps reflects the duration of their liabilities, and the fact that there exists a mismatch whenever insurers and pension funds are unable to buy assets with similar duration. The mismatch can, however, be managed by taking long-dated pay-float position in IRD. This process, thus, explains the unique maturity profile of insurers and pension funds.

Moreover, the distribution of the fixed rate based on the execution date highlights the trajectory of the rates over time. As can be expected given the flat EURIBOR rates seen in the past years, contracts with more recent execution dates see lower fixed rates.

Interestingly, Ehlers et al. (2016)[3] found a substantial shift in the currency composition of the OTC derivatives market between 2013 and 2016. The authors attribute the shift, amongst other reasons, to the monetary policy in the US.

1.2.2 Regulatory Responses

A great deal of the literature regarding derivatives has investigated the consequences associated with central clearinghouses. Bliss et al. (2006) and Duffie et al. (2011) were one of the first studies to investigate the clearing and settlement systems found in the OTC derivatives market. Bliss et al. (2006) underline that clearing systems are critical to the stability of the financial system, a system which was and is becoming increasingly interconnected and global in scope. The authors explore the evolution of practices and institutional arrangements established to deal with the special characteristics of the derivatives market. The special characteristics refer to the much longer time horizon between effective and maturity dates, the greater uncertainty as to the value of the ultimate transfer obligations, and the unavoidable significant counterparty credit risk related to a derivative contract. As a result, at time of writing[4], the market evolved to comprise of two parallel systems for clearing derivatives: the bilateral clearing and the central counterparty clearing. At the time, most OTC derivatives were settled bilaterally, that is, by the counterparties to each contract. The implementation of the Dodd-Frank act of the United Stated Congress in July 2010 changed this structure immensely. The act stated that all sufficiently standard derivatives traded by large market participants were now obligated to be cleared with regulated CCPs. Cont et al. (2014) find, as a results of the mandatory central clearing, increased compression in the Credit Default Swaps (CDS) market. Moreover, the resulting compression

[2]These are based on the information from Orbis, and identify six groups: G16 dealers, banks, central counterparties, other financial insitutions, pension funds and insurance companies, and non-financial institutions.

[3]The paper uses BIS Triennial Central Bank Survey data from 2001 until 2016.

[4]The paper was published in Economic Perspectives in December 2006

of bilateral trades led to an overall decrease in dealer exposures. Ehlers et al. (2016)[5] find further evidence for increased compression, as more than 70% of the gross notional amounts of OTC IRD were centrally cleared for all major currencies as of June 2016. In addition, the total gross notional values for each counterparty has shrunk for all portfolios entered with a CCP from the start of 2015 until end 2016.

Ascolese et al. (2017) investigate the evolution of clearing rates in the European OTC derivatives market. They find an upwards trend in the clearing rates. Moreover, at the end of February 2017 they find 46% of the total outstanding trades cleared, which accounted for more than 60% of the total notional outstanding. The difference in percentages in relation to the figures presented by Ehlers et al. (2016) can be attributed to the latter using a data set based on global figures, as well as different cleaning procedures. Interesting to note is that Ascolese et al. (2017) find an existing number of trades (around 20%) already cleared in 2014, well before the clearing obligation went into force. They suggest that the practice of clearing was already somewhat common in the market, and this practice could explain the lack of sudden increases whenever the threshold went into force for new categories.

One possibly problematic, yet inevitable, consequence of the clearing obligation is the increased dependence on CCPs in the derivatives market. As mentioned in the previous paragraph, Duffie et al. (2011) examined the effect of central clearing to the derivatives market. They underlined the necessity of balancing bilateral netting against centrally cleared efficiencies. Their comments were highly influential in the regulation that followed, and the subsequent stringent CCP authorization has now led to a, possibly, greater level of concentration in the market. Indeed, Ascolese et al. (2017) find the network of European IRS 6M EURIBOR contracts to increase in density – a proxy for the interconnectedness – with around 20% over January 2016 until March 2017. Moreover, the average strength, which refers to the average of the aggregate outstanding notional value of all trades a counterparty is involved in, increases with approximately 10% for the 6M EURIBOR market. The findings suggest that the influence of compression as well as the obligatory clearing procedures, led to an increased notional value aggregated across all outstanding contracts seen in existing nodes, as well as a more dense structure surrounding the counterparties.

In addition to the increased interconnectedness among all counterparties in the EURIBOR 6M market, Abad et al. (2016) underlined the inevitable consequence of the clearing obligation, and found the relative notional share of the CCPs to significantly outweigh the aggregates found in other sectors. Moreover, Fiedor et al. (2017) found interesting structural properties in the IRD market as a – probable – consequence of the clearing obligation. They focused on the direct (house) and client clearing segments of the central clearing system, as European Securities and Market Authority

[5] The paper uses BIS Triennial Central Bank Survey data from 2001 until 2016.

(2016) found that around 90% of counterparties in the IRS market in the EU had not yet been directly linked to a CCP. Therefore, it is extremely valuable to monitor the structure of the client clearing segment within the overall IRS market. They presented evidence that the client clearing side dominates the IRD market in terms of number of relations between counterparties, as well as the level of interconnectedness. Moreover, the increasingly complex nature of CCPs as a result of their systemic importance has meant that most CCPs provide client clearing services only exclusively via their clearing members. As a result, the network of positions beyond immediate counterparties makes a significant difference to the rank ordering of the systemic importance of institutions. Furthermore, the emergence of client clearing could dilute one of the main advantages of central clearing, namely: the homogenization of credit risk (Bliss et al. (2006)). All clearing members have to meet identical credit requirements, and are subject to the same oversight. This not only reduces the informational costs greatly, it also harmonizes the underlying contracts in the market. A potential consequence of the increased dependence on clearing members is the re-placement of the credit risk from the CCPs to the clearing members. Moreover, as clearing members face more lenient requirements, in comparison with mandates for CCPs, their enlarged involvement in the market as a consequence of the clearing regulation requires thorough investigation.

The clearing obligation was introduced to control and mitigate the credit risks, as well as to improve the overall financial stability of the derivatives market. In response, the market has lowered its exposure to counterparty credit risk by entering into contracts with CCPs. However, as a consequence, the market shows signs of elevated interconnectedness as well as increased dependence on a limited number of parties. As mentioned in the previous paragraph, margin requirements were introduced to stabilize the effects of the increased dependence. Specifically, initial margins were introduced to cover the potential counterparty credit risk of default. A considerable amount of the literature on margin requirements focuses on the liquidity impact of the initial margin. As explained by Murphy et al. (2016), whenever a party has to post margin, it has to find and fund that margin, often in high-quality or liquid assets. In addition, the margin has to be posted within a short time-frame, at times this can be as little as two hours. Failure to meet the margin call can, and usually is, seen as an event of default. Thus, margin obligation can be extremely demanding, and the consequences rather drastic. Moreover, the initial margin requirements are risk-sensitive by nature. The requirements are, more often than not, designed to cover potential price changes over a period of 5-10 days with a probability of 99 percent or higher. In other words, if one counterparty were to default, the initial margin is intended to cover losses incurred by the other counterparty as they try to replace or unwind the contract (Glasserman and Wu (2018)). Since the mechanism guiding the initial margin is, thus, determined by the market volatility, the dynamic can have a destabilizing effect. For example, a spike in the market volatility leads to a margin call to all firms trading through a CCP or bilaterally. However, a spike in volatility is often accompanied by limited available liquidity, forcing firms to find other sources of cash, e.g. forced to sell assets. This, in turn, could push the market volatility further down, forcing the market to enter into a downward spiral. The process described here is referred to as procyclical in nature, i.e. the requirement exacerbates the shocks influencing the market.

The balance between procyclicality and greater risk-sensitive measures has been greatly debated in the literature in reference to the initial margins. In the discussion, the methodology to determine the initial margins required is important. The margin must be dynamic in nature and should, thus, be able to move in tandem to the portfolio compositions as well as the market conditions. Value-at-risk (VAR) approaches have become relatively common to tackle this dynamic complexity (Gregory 2016). However, such approaches are forced to employ high confidence levels and are usually calibrated using historical data. This could lead to an increased margin call in non-volatile market conditions, and vice versa. For example, the margin calculated based on the extremities in non-volatile times will be significantly different from the margins calculated in volatile moments.

Gregory (2016) and Glasserman and Wu (2018) replicate the potential procyclical effects using structural models, which are calibrated to reflect the relevant features. Glasserman and Wu (2018) examine the role of the procycality through a GARCH model which captures the volatility clustering and persistence in volatility, and find indeed that risk-senstitive margin requirements are procyclical. In addition, they find alternative strategies to dissuade the amplification of the liquidity problems associated with the initial margin. The alternative presented is to set the margin level "through the cycle", which are less sensitive to current conditions but are dependent on unconditional distributions. Gregory (2016) examines the impact of initial margin on the wealth transfer associated with the margins, and claims that the segregated initial margins posted will adapt the underlying relations between creditors. Notably, creditors holding initial margin will effectively recover more in a default situation than existing creditors. Hence, the margin makes derivatives creditors structurally senior to other creditors. The implication of this transformed relation can result in increased rates for lending money, in the expectation that the funds might be used in order to finance initial margin posting.

In response to the literature regarding the liquidity problems associated with the initial margins, regulators acknowledged the procyclical mechanism found in margins requirements. Murphy et al. (2016) illustrate the predicament regulators are faced with regarding the trade-off between risk sensitivity and procycality. Notably, whenever the market exhibits more volatile characteristics, risk is higher, thus margins *should* in fact be higher. However, it is undesirable for margin to over-react to the market conditions. In order to curb the potential over-reactions, EMIR prescribed several tools for procyclical mitigation, of which at least one has to be incorporated by CCPs. The tools interweave margin requirements with weighted market conditions. Murphy et al. (2016) find that the new tools indeed help to mitigate procyclicality, but that the optimal calibration of the tools is extremely dependent on the relative weights used. Hence, they suggest to consider moving from tool-based procyclicality regulation to one based on the desired outcomes.

However, what is not yet clear is the relation between the presented limitations found in the literature and those found in the markets. Moreover, there is a limited understanding of how the clearing obligation has *directly* influenced the evolution of the IRS market. Moreover, there have been few empirical studies investigating the practical effects of the initial margin requirements and their potential procyclical nature. In addition, due to the nature of margins, the gross notional thresholds are set out to only apply to parties that could have a significant impact on the market. As mentioned in the previous paragraph, the process of margin requirements can be extremely demanding. Thus, the threshold create an incentive for counterparties to respond to the threshold by adjusting their gross notional values to lie below the thresholds. To date, it is unclear whether the nature of the requirements as well as the mandates incorporated in the regulation have seen the responses regulators expected.

2 Data

EMIR requires all counterparties located in the EU to both report the details of their derivative contract to a trade repository (TRs) authorised by the European Securities and Markets Authority (ESMA). The reporting obligation covers all derivatives classes. The most represented derivative class in terms of gross notional is the interest rate derivative (IRD) class with a representation of 80% end-2016 (Ascolese et al. 2017)[6]. Due to the predominance of the interest rate derivative market and technical limitations, all subsequent analyses focus on this class.

As of writing, there are six registered TRs authorised by ESMA[7]. In this thesis, the data is only gathered from DTCC. The reason for this is two-fold. Firstly, the coverage of DTCC extends to the majority of the IRD market (Ascolese et al. 2017), thus the information gathered from this specific TR should be sufficient to attempt to explain the IRD market. Secondly, due to the intricate nature of EMIR data, the initial provisions included in the technical standards did not prove to be effective in guaranteeing a sufficient level of standardisation across different TRs. Furthermore, the validation procedures were found to be inadequate which has resulted in a significant volume of misreported information especially in the early stages of the reporting obligation.

Each TR, in turn, provides the information to their respective National Competent Authorities (NCAs), in the Netherlands these are The Dutch Authority for the Financial Markets (AFM) and the Dutch Central Bank (DNB). The data flowing from these supervisory bodies is on *Trade Activity* (also referred to as the trade flows) and *Trade State*. Trade state gives a snapshot of all outstanding transactions at a given moment – usually this will be the end of the day. While, trade activity records all new transactions as well as adaptions to existing contracts – for example early termination. As the objective of this thesis is to explore the underlying mechanisms of the IRS market, trade state data is more suited due to their nature of representing the entire market at that specific point in time. Thus, all subsequent analyses will use trade state data.

Furthermore, due to a significant share of the data missing or misreporting relevant sector information, the information is extended with information from ORBIS. Moreover, the sector information is extended by the GLEIF Relationship Records for specific companies. The specific companies are also referred to as G16 dealers. Entities within this group are the largest domestic and international financial institutions dealing in derivatives[8]. The Relationship Records allow for all child entities to

[6]Other derivatives classes are credit, commodity, equity and foreign exchange, with a residual classified as others.

[7]DTCC Derivatives Repository Ltd. (DDRL/DTCC), Regis-TR S.A., ICE Trade Vault Europe Ltd (ICE TVEL), UnaVista Ltd, CME Trade Repository Ltd (CME TR), and Krajowy Depozyt Papierów Wartosciowych S.A. (KDPW)

[8]The group of G16 dealers includes Bank of America, Barclays, BNP Paribas, Citigroup, Credit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JPMorgan Chase, Morgan Stanley, Nomura, Royal Bank of Scotland, Societe Generale, UBS, and Wells Fargo.

Counterparty Data	
Parties to the contract	Counterparty LEI – both for the reporting entity, and for the counterparty of the reporting entity, reporting timestamp, clearing member ID, trading capacity, counterparty side, initial margin information, variation margin information
Common data and contract variables	
Contract type	Product and underlying IDs, notional/deliverable currencies, asset class and type
Details on the transactions	Trade ID, notional amount, execution timestamp, effective date, maturity date
Clearing	Clearing obligation, cleared, CCP, intragroup, clearing threshold
Interest rates	Fixed rate and floating rate information, reset frequency, payment frequency, reference period[10]

Table 2: Overview of the selected variables reported under EMIR

appear under the same distinction as their respective G16 parent.

A summary of the elements used in the analyses can be found in table 2[9]. Moreover, the time span of the data is from 31-08-2016 to 31-12-2018, where each end-month date is used for the analysis. Although this limits the conclusion drawn from the time-series analyses, as all portfolios with time to maturities of less than a month which were concluded in between two dates are not taken into account, there are several reasons why this loss of information is justified – in this thesis. First, technical limitations force the limited time-span. Secondly, as the goal of this thesis is to explore the mechanisms of the IRS market and the responses of the market, long-term contracts better capture the changes in attitudes as a result of regulatory measures.

Finally, all notional values are converted to euro based on the exchange rates in 12-02-2017.

[9] Detailed information regarding the variable definitions can be found in Appendix A

3 Methodology

This section describes the processing procedure adopted. The process follows existing cleaning rules, specifically the procedures described by Abad et al. (2016), Ascolese et al. (2017), and Fiedor et al. (2017). In addition to the processing procedures, this section sets out to explain the main insights to be gained from the previously mentioned analyses. Moreover, the methods adopted to conduct the studies are described.

3.1 Processing Procedure

The rules applied in current literature focus on two stages, namely a general cleaning stage applied to all derivatives classes and a more distinct cleaning process reserved for individual classes. In this thesis, these processes are referred to as stage one and stage two processing.

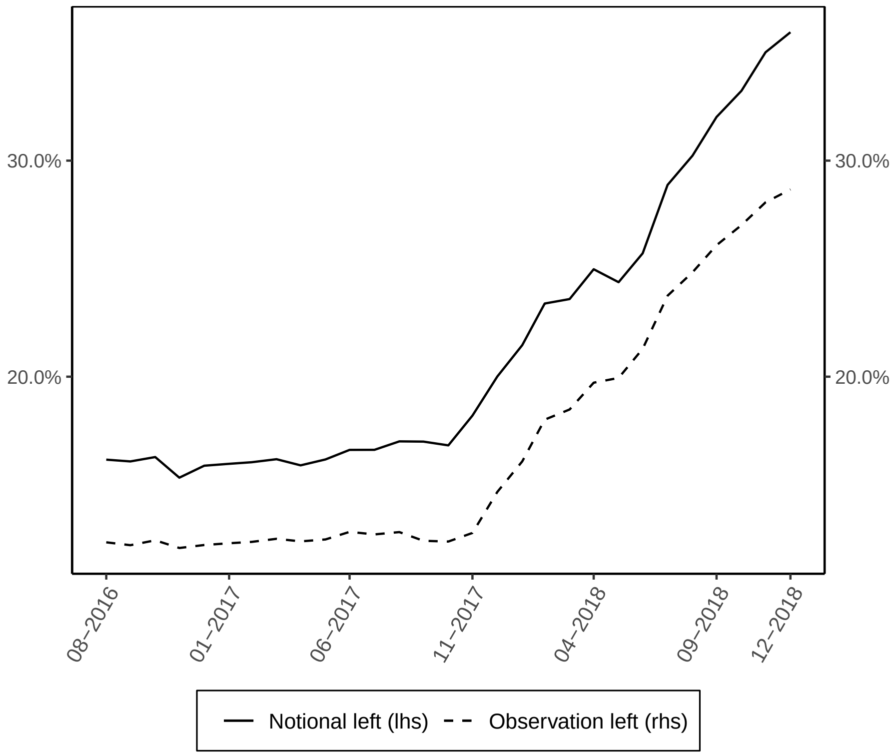


Figure 1: The graph shows the final cleaning procedure across the entire data-set. Presented are the final cleaned figures, where the notional value (number of observations) is relative to the initial notional value (number of observations) at the start of the cleaning procedure.
Source: DTCC OTC interest rate swaps data set (based on the 31-08-2016 until 31-12-2018 trade state reports)

The final share in terms of observations as well as notional values in the processing procedure across the entire time span is shown in figure 1. The improvements in quality from November 2017 are due to the adoption of the revised delegated and implementing acts[11]. The measures ensured that

[11] Regulation (EU) No 104/2017 and Regulation (EU) No 105/2017

the EU reporting regime incorporates global standards (such as LEI or ISIN codes) to the maximum extent practicable and as timely as possible. In addition, multiple new fields were added to improve the readability of the data as well as the applicability. A summary and the impact of the measures on the data quality can be found in Ascolese et al. (2017).

3.1.1 Stage One

Stage one processing consists of the detection of abnormal notional values, removal of duplicate transactions, illogical time-stamps, inconsistency of reference contracts, and other steps. Initially, all counterparty identification codes are matched to contain a valid Legal Entity Identifier (LEI). Moreover, all duplicated transactions are removed. The most appropriate and identifiable field for this process is the Trade ID, especially in later dates the field becomes more reliable. Following this, the two time-related fields used in this paper are evaluated, namely the maturity date and effective date. During the first stage, all observations missing either date are dropped. The first stage is concluded by the de-duplication of contracts. The double reporting within EMIR created the opportunity to not only ensure contracts are reported in the first place, but has also given way to 'fill-the-gaps' within contracts thus improve the overall quality. The de-duplication process drops inconsistencies across identical observations (based on the Trade ID) within the following fields: notional, reporting Counterparty ID, ID of the other Counterparty , counterparty side, maturity date, reference rate, and intragroup.

3.1.2 Stage Two

The processing procedure for stage 2 is described in the tables 3 and 4[12]. The tables describe the dropped observations at different points in time, where 3 shows the procedure at 31-08-2016 , while 4 gives the procedure for 31-12-2018 . The second column shows the observations which are discarded at each step, which is in turn described in the first column. The third column shows the observations remaining, followed by the percentage of observation remaining compared to the initial values. The fourth and fifth column give the total notional values of the remaining observations, where the percentage is again dependent on the initial values as base value, in the data-set.

Initially, all portfolios without EURIBOR as floating leg are dropped[13]. A major advantage of early identification of the benchmarks is the improvement in the technical handling of the subsequent steps. As can be seen from the tables, the improvement in quality in later dates is rather substantial. In addition to the non-EURIBOR trades observations which did not report a reference rate or reported a reference rate other than 1M, 3M, 6M and 12M are also included in the discarded observations. In

[12]Moreover, the procedure for 31-12-2017 can be found in appendix B (table 13)

[13]The regular expression used to capture all variants is "EURI(BOR)?", where capitalization is disregarded

section 4, more information will be provided regarding the shares of all reference rates. Another source included in the observations discarded were trades which included numeric values, e.g. "EURIBOR 6M +0.231".

Following the benchmark identification, all missing buy/sell indicators are discarded from the data set. The field explains which party pays and receives either leg, thus any analysis regarding the structure of the market is heavily dependent on this field. Then, all duplicated tradeIDs are removed. Current standards (e.g. Abad et al. 2016) only remove one of the duplicated trades. However, this requires an arbitrary decision regarding the duplicated trade and the *actual* trade. This decision would require an analysis based on the action type given, which in turn depends on the quality of the action type provided. As can be seen in the tables, the process of discarding all duplicated trades has only a limited impact on the actual amount of observations remaining, thus it is, arguably, acceptable to remove all trades duplicated in terms of trade IDs to ensure the data maintains a certain level of quality.

The effective and maturity dates are discarded based on three arguments. First, all trades with missing dates are discarded. Secondly, a threshold of 01-01-2080 discards either trades. The threshold works as follows, whenever a maturity date lies beyond the threshold the entire trade is dropped, due to the debatable quality of the trade. For the effective date, the threshold works mirrored. Whenever a trade specifies the effective date to lie beyond 01-01-2080, the trade is discarded. Thirdly, all trades where the effective date lies beyond the date of maturity are also discarded.

As underlined by Ascolese et al. (2017), the presence of uncommon and extreme notional values had a substantial effect on the subsequent analysis. Therefore, all contracts with a notional beyond EUR 10 billion and below EUR 1,000 are removed, these include negative as well as zero-valued contracts. As can be seen from the tables, the relative number of trades discarded at this step remains equal as a percentage of the notional remaining. Thus, most trades discarded had in fact zero or close to zero notional values.

The following steps are all based on discarding missing values which are relevant to the analyses performed in this thesis. Although a selected number of the fields will be necessary in all analyses performed on the IRS market, some are specific to this thesis alone. First, the data-set is extended with the sector information obtained from ORBIS and GLEIF. This step discards all trades where the LEI is either not present in the ORBIS database, or the ID is non-LEI in the first place. The difference in relative notional value dropped between 31-08-2016 and 31-12-2018 highlights the effectiveness from the adoption of the revised acts in November 2017. Second, all trades with missing intragroup identification are dropped from the data-set. The inclusion of intragroup identification is due to the exclusion of intragroup trades on several regulatory measures. For example, intragroup trades are exempt from the

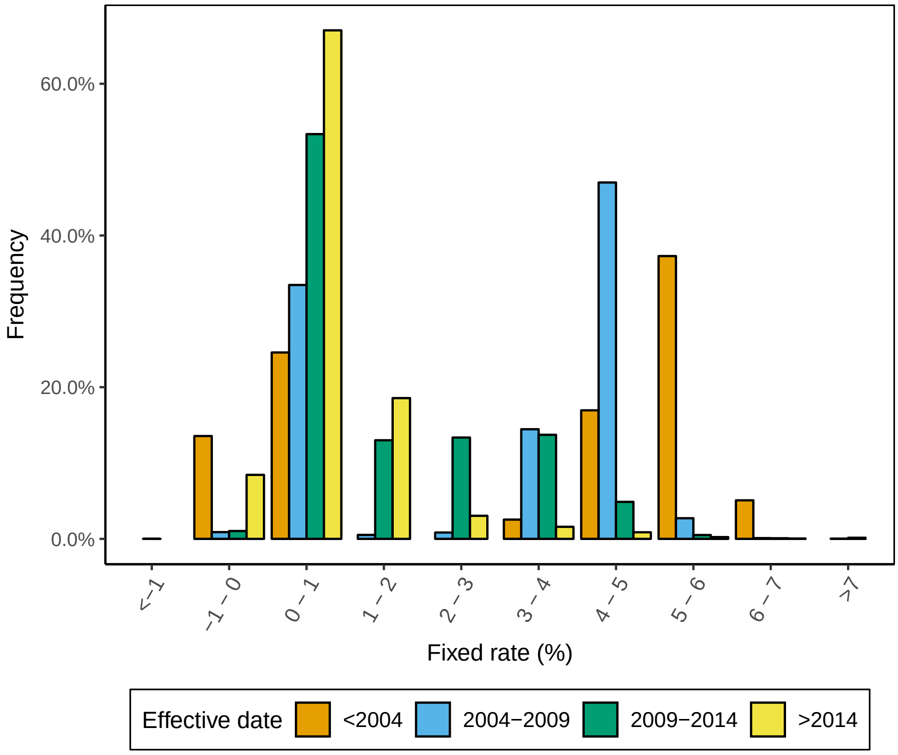


Figure 2: The fixed rate ranges in relation to the underlying effective date of the respective trade.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

clearing obligation depending on the nature of the relationship. Thus, their identification is essential to determine the structure of the underlying market. In addition, the structure of a contract between two parties defined as an intragroup transaction can be significantly different from *regular* trades. Therefore, their inclusion might alter underlying structures. Third, all trades where the clearing indication is missing are discarded. Fourth, all trades where the fixed and floating rates are missing are discarded. The amount of observations discarded during this step seems to have increased over time, however, the amount discarded is relative to the observations remaining more or less equal. Interestingly, multiple trades are reported where three or more rates contain values. Whenever such cases occurred, the fixed-floating structure was preferred over other represented structures due to the more common occurrence of the fixed-floating IRS. In addition, all trades with a reported fixed rate beyond 10% and/or below -10% are discarded. However, as can be seen, no trades for the presented reporting dates are actually discarded. In fact, only a handful of trades are actually discarded due to the threshold. Thus, implausible fixed rates are a rare occurrence. An identified issue relating to the fixed rates actually lies on a different plane. Figure 2 presents the fixed rates in relation to their respective effective date, based on the cleaned data from 31-12-2018. The range for the fixed rate relative to effective date before 2004 finds a rather substantial range of values, namely, between -1% and 7%. Abad et al. (2016), however, report a range of fixed rates on similar effective dates, albeit between

1996 to 2007, from 2% to around 8%. One explanation for this substantial difference between ranges might be attributed to *percentage points* and *percentages as decimals*. For example, the percentage point 3% is actually reported as a decimal percentage, namely as 0.03. The figure shows that there is a gap in reported rates between 0%-1% and 3%-4%, thus there is a strong possibility that rates are improperly defined by the reporting counterparty. However, given the current available information, there is no definitive testing possible. A — rather crude, yet – potential solution to the problem could be to transform the rates based on their relation to the 'effective dates'-buckets. Figure 22 presented in Appendix B shows the effects of transforming the rates whenever the fixed rate fell below the first quantile found in the respective effective date-bucket. Overall, the rates seem to be unaffected by the transformation. The range of trade with effective dates beyond 2014 has increased, but a clear benefit of the transformation could not be identified. Another solution would be to discard all potentially ambiguous trades. However, the total density of trades within the range highlights the necessity to retain the information provided by the range. Thus, taken together, the trades themselves provide important insights into the market, but studies regarding the fixed rates must be evaluated with the previous results in mind. Finally, all trades with missing as well as implausible payment frequencies are discarded, where all frequencies beyond 40 months ($\sim$3.3 years) were discarded. Several anomalies were found in the reported payment frequencies. First, a large fraction of the payment frequencies reported corresponded to the total number of payments made throughout the contract. To illustrate, say the lifetime of a contract is 15 years, and the payment frequency written is 15Y, then it can be assumed that parties exchanged payments once a year. Thus, all frequencies equal to the relative total payments made were converted to the respective frequencies[14]. Second, there seemed to be a lack of consistency regarding the information pertinent to the legs of the trade. For example, the reporting counterparty reported values for the fixed rate of leg 1 and the floating rate of leg 2, but reported payment frequencies for both fixed rate leg 1 and floating rate leg 1. As determinant for the underlying structure of the swap are the fixed and floating rate fields, all available information irrelevant of the leg was used in reference to the payment frequency.

The final phase in stage two relates to the exclusion of specific trades which fit certain criteria. The first criteria removes all intragroup trades. As mentioned in the paragraph before, intragroup trades are excluded from several regulatory measures and their nature can substantially alter the structure found. An example of unjustified inclusion would be to investigate the relative number of relations per counterparty without accounting for intragroup trading. The relative degree would be inflated due to the underlying relations between counterparties, and the results would therefore be biased. Once

[14]The threshold for the respective conversion also included a minimum of 36 months (3 years). This prevents infrequent payments to be converted.

these trades were discarded, all trades with payment frequencies of zero are removed. The valuation as well as the handling of zero coupon IRS is significantly different from non-zero IRS, thus for the sake of clarity and validity, all zero coupon IRS are dropped. Finaly, all closed and forward contracts are discarded. As this thesis sets out to investigate the current structure of the IRS market, all closed and forward contracts could alter the interpretation of time-dependent information.

Reason	# Obs. discarded	# Obs. remaining	# Obs. rem. (%)	Notional rem. (bn)	Notional rem. (%)
Initial values	0	185090	100.00	8540.15	100.00
non-EURIBOR	158610	26480	14.31	1555.94	18.22
Missing buy/sell indicator	1	26479	14.31	1555.92	18.22
Duplicate tradeID	25	26454	14.29	1550.55	18.16
Effective date missing or outlier	309	26145	14.13	1537.30	18.00
Maturity date missing or outlier	0	26145	14.13	1537.30	18.00
Outliers notional	6	26139	14.12	1537.30	18.00
Missing sector information or non-LEI	938	25201	13.62	1485.09	17.39
Missing intragroup identification	0	25201	13.62	1485.09	17.39
Missing cleared identification	0	25201	13.62	1485.09	17.39
Missing fixed and floating rates	1686	23515	12.70	1451.99	17.00
Implausible fixed rates	0	23515	12.70	1451.99	17.00
Missing and implausible frequency multipliers	32	23483	12.69	1451.81	17.00
Intragroup	372	23111	12.49	1400.94	16.40
Zero Coupon IRS (floating frequencies null)	0	23111	12.49	1400.94	16.40
Closed contract	2	23109	12.49	1400.87	16.40
Forward starting	281	22828	12.33	1380.12	16.16

Table 3: The cleaning procedure for the EMIR data set. The notional values are all reported in EUR, and the percentages are all calculated after the respective observations are dropped and are in relation to the initial values.
Source: DTCC OTC interest rate swaps data set (based on the 31-08-2016 trade state report)

Reason	# Obs. discarded	# Obs. remaining	# Obs. rem. (%)	Notional rem. (bn)	Notional rem. (%)
Initial values	0	194232	100.00	8810.15	100.00
non-EURIBOR	120292	73940	38.07	4241.06	48.14
Missing buy/sell indicator	8	73932	38.06	4240.87	48.14
Duplicate tradeID	71	73861	38.03	4235.25	48.07
Effective date missing or outlier	2853	71008	36.56	3802.79	43.16
Maturity date missing or outlier	0	71008	36.56	3802.79	43.16
Outliers notional	403	70605	36.35	3802.79	43.16
Missing sector information or non-LEI	637	69968	36.02	3797.02	43.10
Missing intragroup identification	0	69968	36.02	3797.02	43.10
Missing cleared identification	0	69968	36.02	3797.02	43.10
Missing fixed and floating rates	4888	65080	33.51	3551.51	40.31
Implausible fixed rates	0	65080	33.51	3551.51	40.31
Missing and implausible frequency multipliers	978	64102	33.00	3481.36	39.52
Intragroup	6911	57191	29.44	3249.35	36.88
Zero Coupon IRS (floating frequencies null)	3	57188	29.44	3249.34	36.88
Closed contract	29	57159	29.43	3248.73	36.87
Forward starting	1480	55679	28.67	3166.59	35.94

Table 4: The cleaning procedure for the EMIR data set. The notional values are all reported in EUR, and the percentages are all calculated after the respective observations are dropped and are in relation to the initial values.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

3.2 Transformed Landscape

3.2.1 The Interest Rate Swaps Market

A detailed topology of the Dutch IRS market has, as mentioned in section 1, a prudential function. However, the main insights of a detailed topology that can be drawn upon relates to the exploratory nature of the descriptive statistics. Due to the intricate structure of EMIR, early identification of potential problems or threats can greatly improve the subsequent studies. However, any process of particularizing requires an initial comprehensive overview of the market. Naturally, the comparability of the Dutch IRS market with the topology of the European market is determined. In general, as can be expected, the values presented should match as much as possible. Furthermore, the underlying structure of the IRS market are essentially the contracts themselves. The payments made as required provide essential information to the entire position of the counterparty. Moreover, the level of payments give weight to the relations found in the market unique to the notionals provided.

Moreover three specific dates are used to identify the underlying structure, whenever a full time series analysis isn't viable. The dates are 31-08-2016 , 31-12-2017 , and 31-12-2018 . The significance behind the dates is due to the phase-in structure of EMIR regulation. The clearing obligation for category 1 counterparties for OTC Interest Rate Swaps in G4 currencies went in force on the 21st of June of 2016[15]. Thus, August allows for tolerance regarding the quality of the data reported. In 2017, multiple important regulatory measures went into force, e.g. variation margin went into full force and improved technical standards were published, thus to capture all relative changes as well as provide an allowance for adoption, December is investigate. Finally, in December 2018 the clearing obligation went into force for category 4 in G4 currencies. Due to technical limitations, there was no possibility to add several months as allowance.

Moreover, several elements within EMIR require special attention due to the potential effects on the results. For example, the floating rate reset frequency can be approached from different angles. The reset frequency determines the usage and timing of the floating rate described, and is dependent on the exact date of reporting and the execution date. For example, a trade is reported with a floating rate of EURIBOR 1 month, a frequency rate of 3 months, the execution date is 01/01/2001, and the reporting date is 01/05/2005. The actual floating rate used in this trade is the EURIBOR 1 month reported on 01/04/2005. This is due to the fact that the floating rate is reset every 3 months, i.e. on 1/1, 1/4, 1/7, 1/10 of each respective year. However, due to the irregular occurrence of the reset frequency field, it is not possible to follow this procedure for each transaction. Thus, multiple assumptions are tested. For illustrative purposes, the following assumptions are explored regarding

[15] These are the currencies EUR, USD, JPY and GBP

the reset frequency for, for example a trade with a floating rate of EURIBOR 1M:

1. The EURIBOR 1M on the reporting date is assumed to be the rate paid and received for the trade. In other words, there is no reference to the reset frequency.
2. Take the average of the reference period's EURIBOR rates, and assume that the average of these rates proxies correctly for the actual rate used. Thus, in this case the average of the past month of EURIBOR 1M is the proxy used.
3. Similar to 2, but for each reference period take the average of previous α months ($\alpha \in [1 : \infty]$) instead of the specific reference period. In this case and $\alpha = 2$, the average of the EURIBOR 1M from the past 2 months is used as the proxy.

3.2.2 Network analysis

Following the descriptive statistics of the market and the exploration of certain assumptions, a network analysis is performed using similar methods as detailed by Ascolese et al. (2017). The network analysis is used as a tool to measure the interconnectedness, and quantifies the possible contagion risks in inter-banking markets. Following this, the network analysis is extended with the evolution of network measures over time. The measures and definition are described in table 5.

Measures	Definition
Network size	The total number of nodes (i.e. counterparties) in the network.
Network volume	The total number of links (i.e. outstanding trades) between nodes in the network.
Network degree	The number of links connected to a node, i.e. the number of counterparty each node trades with. The maximum degree is normalized by dividing it with the average degree.
Network strength	The sum of weights of all links connected to a node, i.e. the aggregate outstanding notional value of all trade a counterparty is involved in. The maximum degree is normalized by dividing it with the average degree.
Network density	The portion of the potential connections in a network that are actual connections. In a directed network this is calculated as $\frac{2 \times Network\ volume}{Network\ size \times (Network\ size - 1)}$

Table 5: The list of network measures and their respective definitions. Adapted from Ascolese et al. (2017)

The measures and networks described have mostly been restricted to limited comparisons of EURIBOR 6M trades, across a relative narrow range of dates. In contrast, this thesis includes the most frequently used EURIBOR reference periods, and explores the evolution over a substantially wider range.

3.2.3 Regulatory Responses

Finally, the behavioural responses evident in the market in reaction to regulatory measures are investigated. The specific elements within the published mandates have been phased-in since EMIR was adopted. The phase-in structure has created a unique opportunity to compare developments within the data set to the introduced mandates. As of writing the clearing obligation for all categories are almost completely into force[16], and the notional amount threshold for the margin requirements is enforced at EUR 1.5 trillion.

Initially, studies concerning the effects of the clearing obligation found in the literature are replicated, and are then subjected to new comparative measures. The reasoning for this is two-fold. First, the Dutch IRS market can be distinct from the European IRS market. Second, the replication of studies based on similar, yet unique, data sets ensures the conclusions drawn from all related studies are reliable and significant. The increased density is measured by relating the increased concentration with the previously mentioned network measures based on the entire IRS market. Moreover, the structural properties in relation to the client clearing services are addressed. First, the number of institutions are presented based on their relationship type. This study is then extended by an investigation of the average degree and strength of each sector dis-aggregated on their relationship type. Finally, the Jaccard index for the relationships found in the data is provided. The index compares the data on 31-12-2018 with the relations found on 31-12-2017 , as well as the 31-12-2017 with the relations found on the 31-08-2016 .

Lastly, the market response to the margin requirements is investigated. The initial margins provided by the data set are extremely rare in occurrence, thus any conclusions based on the values posted are not able to be extended to the entire market.

In order to obtain margins, the initial margins are calculated by the International Swaps and Derivatives Association's (ISDA) Standard Initial Margin Model (SIMM, ISDA 2018). The SIMM was created in response to the Basel Committee on Banking Supervision et al. (2015) as a tool to be used by all market participants. A common methodology accessible to the entire market has several key benefits. First, the disputes surrounding the posting of margins in non-cleared contracts can be alleviated. As regulation requires both parties to post the same levels of margin, the best option for each counterparty would be to duplicate the models used by the opposite party. For most firms, replicating the margin model presented by the opposite party for each distinct portfolio is not only highly time-consuming, but also unfeasible due to the heterogeneity of the data. Consequently, ISDA

[16]The categories depend on the classification and the trade volume of the counterparty. Category 1 are clearing members of at least one CCP in respect to at least one of the clearing classes, category 2 are financial institutions with large trade volumes but aren't member of a CCP, and so on.

has developed a standard initial margin model which can be used, as a satisfactory minimum, by industry participants to call each other for initial margin. Second, the margins calculated serve as a minimum buffer for counterparties to rely on. Currently, CCPs are not required to publish their margin models to the public. As a result, market participants are limited in their expectations of the potential buffer present in the market. The SIMM presents a rough minimum level of liquidity buffer present in the market, and thus delivers information previously unavailable.

The margin calculations can be generalized into two steps. First, a market scenario is defined which significantly impacts the market conditions for each risk factor and is then applied to the portfolio. The risk factors refer, in the case of the interest rate risk class[17], to the relevant yield curves of the currency in which the contract is denominated. The interest rate risk factors are, at time of writing, 12 yield curves for each currency: two weeks, 1 month, 3 months, 6 months, 1 year, 2 years, 3 years, 5 years, 10 years, 15 years, 20 years, and 30 years (ISDA 2018). The yield curve can be based on a selection of sub yield curves[18], however, any sub curve can be used as long as it is mapped to the closest equivalent. The changes in the portfolio values, i.e. the effect of the losses, are all recorded, and are then aggregated. The aggregation is finalized by sorting the gains and losses in order from the greatest gain to the worst loss, and selecting the observation corresponding to the confidence level sought, e.g. the 99^{th} percentile.

Mathematically, the initial margin exists of the sum of the Delta margin, Vega margin, and the Curvature margin[19] for the respective risk class. This is presented mathematically in the top equation (1), where X refers to each risk class. Moreover, there are four product classes, and every trade should be assigned to an individual product class and SIMM is then considered separately for each product class. However, in this thesis the only product class considered is the interest rates and foreign exchange class. The reason for this is related to the early specification of the asset classes investigated. Namely, the advantage of focusing on just the interest rate swaps is that it allows for the simplification of the classification per trade. The risk underlying most, if not all, interest rate swaps comes from the interest rate risk class, thus other product classes can be ignored without this procedure affecting the results. Moreover, the Vega risk and the Curvature risk measure the sensitivity to the volatility in relation to the inclusion of an option underlying the contract. The explanation for the exclusion of the product class assessment also explains the exclusion of the Vega and the Curvature margin. The only instruments which are subject to the additional margin requirements are instruments that include an

[17] In total, there are six risk classes: interest rate, credit (qualifying), credit (non-qualifying), equity, commodity, and FX.

[18] These are the OIS, LIBOR 1M, LIBOR 3M, LIBOR 6M, LIBOR 12M and, for USED only, Prime and Municipal.

[19] For the credit (qualifying) risk class the Base Corr margin is also present.

option. The resulting formula for the initial margin is presented in the second line in equation (1).

$$
\begin{aligned}
IM_X &= DeltaMargin_X + VegaMargin_X + CurvatureMargin_X \\
IM_X &= DeltaMargin_X
\end{aligned}
\tag{1}
$$

The following description of the SIMM is specific to the interest rate risk class only. The Delta Margin risk is calculated by finding the net sensitivity of the interest rate swap to each risk factor (k, i), where k is the rate tenor and i is the name of the sub yield curve. The sensitivity s is specified in the first part in equation (2), where $V(x)$ is the value of the instrument, given the value of the risk factor x. Moreover, for interest rate risk factors, the sensitivity is defined as the PV01. The calculation slightly differs in terms of the valuation base, and is presented in the second part of equation (2).

$$
s = V(x + 1bp) - V(x) \tag{2}
$$

$$
s(i, r_t) = V_i(r_t + 1bp, cs_t) - V_i(r_t, cs_t)
$$

The valuation of the instrument is now determined as a function of the risk-free interest rate at tenor t (r_t) and the credit spread at tenor t (cs_t). The risk-free interest rates used are the rates determined by the euro area yield curves from 05-09-2004 until 12-02-2019 (European Central Bank 2019). Moreover, the valuation of the swap is calculated based on the valuation presented in Hull (2014).

Following the sensitivity, the sensitivity is weighted against the corresponding risk weights (RW_k) and the concentration risk factor (CR_b) as shown in the equation below. The currency threshold (T_b) used is $210e6$, as the EUR has regular volatility and is well-traded, and is converted to EUR based on the FX rates on 12-02-2017.

$$
\begin{aligned}
WS_{k,i} &= RW_k s_{k,i} CR_b \\
\text{where,} \quad CR_b &= \max(1, (\frac{\Sigma_{k,i} s_{k,i}|}{T_b})^{\frac{1}{2}})
\end{aligned}
\tag{3}
$$

The weighted sensitivities are then aggregated within the currency used, in this case all tenors used in the sub yield curves are aggregated for EUR. This process is shown in equation (4), where the sub-curve correlations ($\phi_{i,j}$) and the tenor correlation parameters ($\rho_{k,l}$) are found in section B.1 in table 14. The table for the tenor correlation parameters can be found in ISDA 2018 in D.2.

$$
K = \sqrt{\sum_{i,k} WS_{k,i}^2 + \sum_{i,k} \sum_{(j,l) \neq (i,k)} \phi_(i,j) \rho_{k,l} WS_{k,i} WS_{l,j}} \tag{4}
$$

As there exists only one currency, the calculated K is equal to the $DeltaMargin$, and subsequently the intial margin. For those interested, the calculation for the aggregation of K across currencies is shown in section B.1 in appendix B. Finally, the data used for the SIMM to ease calculations as well as computing power is subject to several filters. First, only swap rates between 0% and 0.05% are used, however this captures the largest share of portfolios. Second, only fixed-floating swaps are used.

The margin calculated will be used in the following investigations. First, levels of the margins called are provided, they will be presented as absolute figures as well as relative to the notional values of the contracts. In addition, the initial margins posted and received provided through the EMIR data set are used to compare the figures presented by the SIMM calculations.

As explained by Murphy et al. (2016), the procyclical nature of initial margins consist of two key aspects. First, over the economic cycle, how much do margin requirements vary? Second, in the short term, if markets suddenly become stressed, how large could the increase in margin be? The first aspect will be explored as the deviation of the initial margin as a function of the volatility index (VIX). The average of the opening and closing value of the volatility index is taken as proxy for the average risk in the market at the reporting date investigated. Moreover, the initial margin is averaged across sectors as well as across the entire market. As the initial margin posted in dependent on the gross notional of each party involved, it can be expected that more present in terms of gross notional sectors are required to post more collateral. In addition, the segregation based on the sectors extends to the increased density discussion, and investigates whether the same structural changes are seen in the initial margin posted. Regarding the short term shocks, the SIMM is adapted to incorporate a relatively basic sensitivity measure. Notably, the shock affecting the net present value of the portfolio is performed on 1, 3, and 5 basis points. This translates to a sudden increased risk free rate of, in the case of three basis points, 0.03%, and changes the underlying risk structure of the interest rate swap. Finally, the reaction to the enforced threshold is investigated by presenting the gross notional of distinct parties as a function of time.

4 Results

The first set of analyses examines the structure of the Dutch IRS market, dis-aggregated on the general descriptive statistics of the market and the network underlying the structure. Following the topology, the IRS market is investigated in light of the G20 OTC derivatives market reform agenda in recent years.

4.1 The Dutch Interest Rate Swaps Market

Figure 3 shows the distribution of the fixed rates in percentage points. The magnitude of the rates lie between 0% and 1% for all the inspected dates, these numbers are in line with the rates found in other papers.

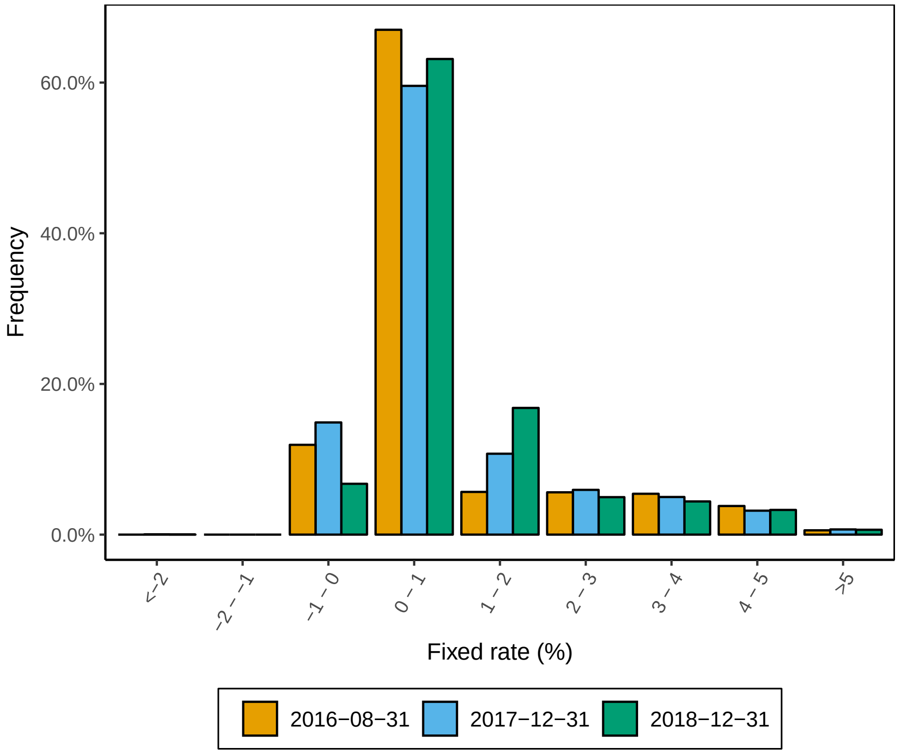


Figure 3: The distribution of the fixed rates in percentage points relative to the reporting date.
Source: DTCC OTC interest rate swaps data set (based on the presented reporting datestrade state reports)

For example, Abad et al. (2016) find around 50% of the rates to lie between 0 and 1 for the DTCC interest rate derivatives data set based on the 2015-11-02 reporting data set. Interestingly, the distribution appears to remain relatively similar across the reporting dates. There are, arguably, several explanations for this. First, the fixed rates contain some noise, as explained in section 3, thus – especially in the earlier reporting dates – the distribution might be more skewed to the right than portrayed in the figure. Second, contracts in the earlier reporting date are still represented in the later reporting date. To account for this, figure 4 portrays the fixed rates according to the underlying effective date. The figure present the fixed rates reported on 31-12-2018 , and identifies four effective dates buckets. The figures describe the clear distinction between the rates used within earlier contracts, as opposed to the significantly lower rates used in more recent contracts.

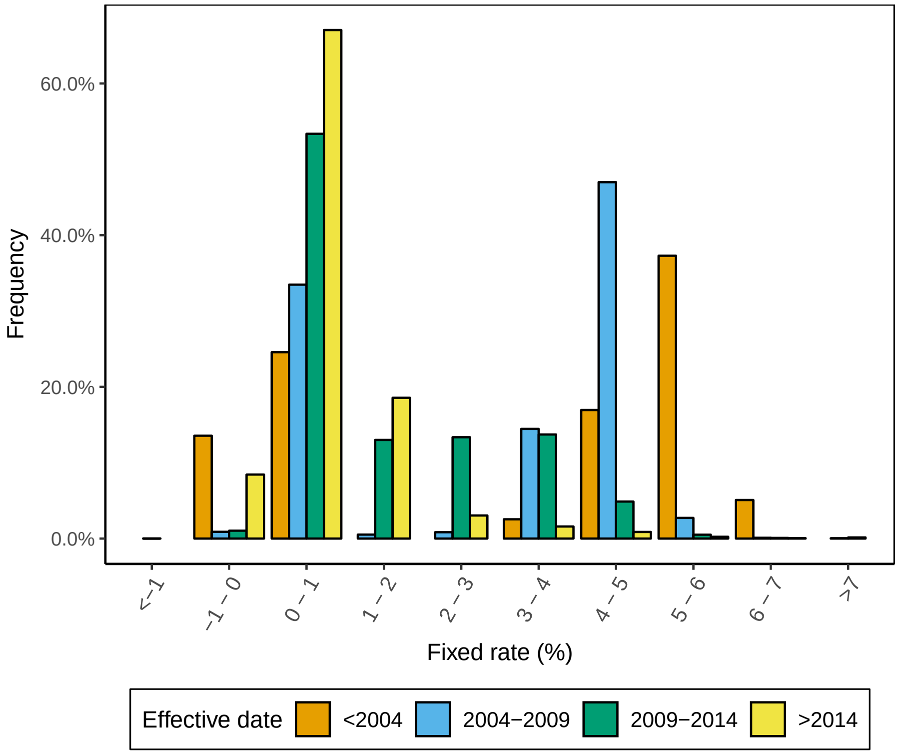
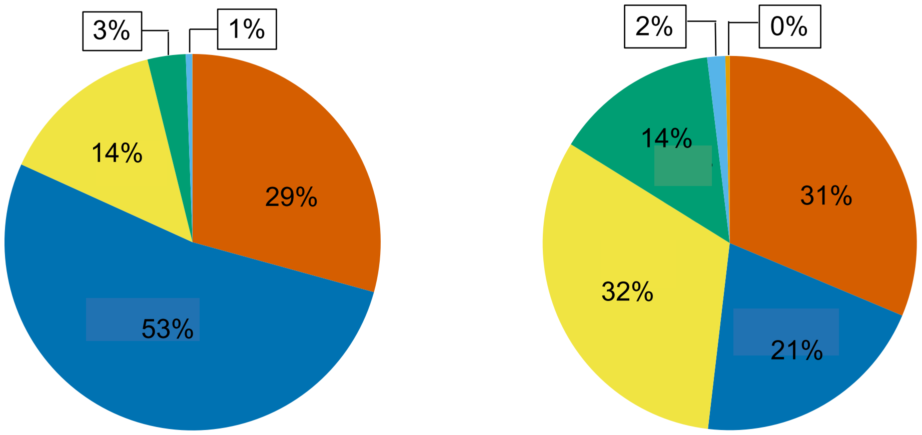


Figure 4: The fixed rate ranges in relation to the underlying effective date of the respective trade.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

Following the distribution of the fixed rates, figure 5 depicts the breakdown of the underlying benchmark found as floating rates. For illustrative purposes only the 31-08-2016 and 31-12-2018 are depicted in the graph. The breakdown for 31-12-2017 can be found in figure 23 in Appendix C[20]. Over two-thirds of the reported rates in 31-08-2016 reference EURIBOR, however, a significant fraction of the contracts are discarded due to the contracts missing the reference rate[21]. Interestingly, the share of EURIBOR reference rate remains more or less steady across the years, namely 71% in 31-08-2016 and 69% in 31-12-2018 . In relation to the European summary statistics of the IRD market, the share of EURIBOR regardless of the tenor is substantially lower. One reason for this difference can be attributed to the thesis' focus on the IRS market, instead of the IRD market. However, when figures are transmuted to be made comparable, there still exists a substantial difference. Thus, the Dutch IRS market sees a higher occurrence of the EURIBOR rates as floating rate benchmark, relative to the usage found in the European IRS market.

[20]The figures for 31-12-2017 will be the presentation for each of the following analyses unless stated otherwise to improve readability.

[21]Another option as stated in the caption of figure 5 is an EURIBOR tenor outside of the shown cases. However,



(a) Source: DTCC OTC interest rate swaps data set (based on the 31-08-2016 trade state report)

(b) Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

Figure 5: The share of trades in terms of the underlying benchmark rate. Other refers to all non-EURIBOR floating rates found in the data set, as well as missing rates. The missing reference rate EURIBOR field refers to all floating rates which present EURIBOR as their floating leg benchmark, but have no reference rate (i.e. tenor on which the rate is based) provided or provide a reference rate other than 1M, 3M, 6M or 12M.

Figure 6 shows the occurrence of the frequency rate according to the respective leg per presented reporting date. The chart shows the trend towards infrequent payments amongst fixed payments frequencies, while the floating payments show the opposite. The relation with the lower floating rate found in the market, might explain the tendency for parties to counter this by limiting the amount of fixed payments made. In other words, instead of dramatically lowering the fixed rate, parties choose to counter the lower rates by extending the frequency. However, in comparison with figure 2, it is also possible that the fixed rates are unable to be set any lower, thus this dynamic forces parties to extend their payment frequency instead.

Figure 7 displays the frequency distribution of the gross notionals for the three investigated dates. The graph displays exceptionally comparable densities amongst the dates. Moreover, the gross notionals of most contracts are between the order of ten and fifty million EUR, which is slightly lower than the notionals reported by Fiedor et al. (2017). However, Abad et al. (2016) also find at leat 40% of the notionals to lie between 10 and 50 million. The data set used by Fiedor et al. (2017) includes all the TRs, while Abad et al. (2016) and the data set used here only use the DTCC data set. This might give an indication that the other TRs report on trades with higher notional values.

The density of the years to maturity are shown in figure 8. The chart follows similar distributions presented by Abad et al. (2016) and Fiedor et al. (2017).

preliminary analysis finds this share negligible.

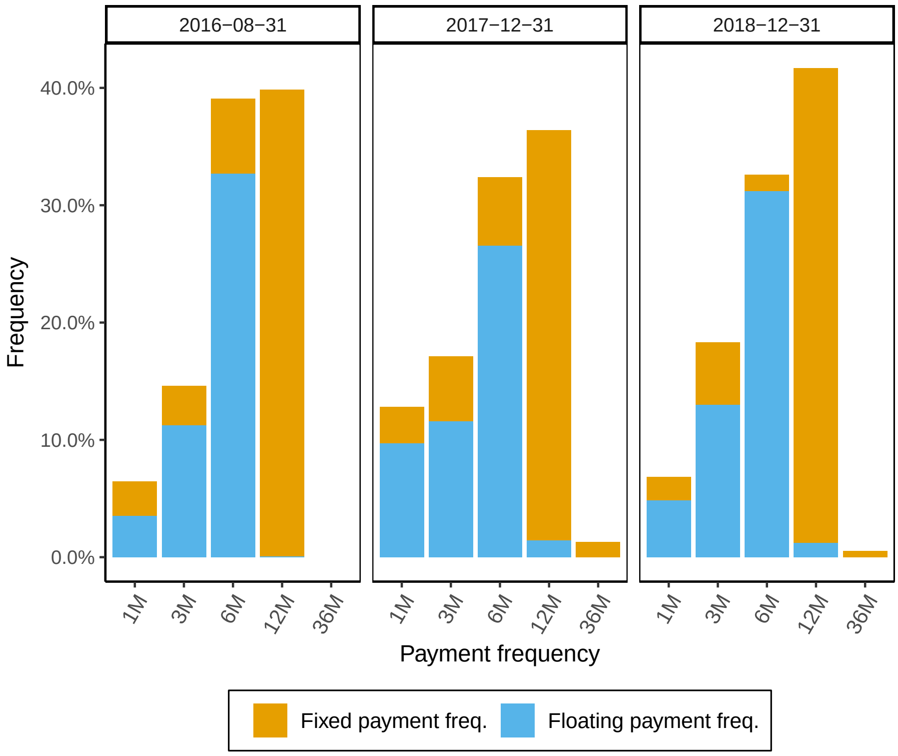


Figure 6: The occurrence of the payment frequency according to the respective leg per reporting date.
Source: DTCC OTC interest rate swaps data set (based on the presented trade state reports)

Namely, the largest occurrence is at ten years, another less pronounced, spike is seen at thirty and five years. In addition, small yet defined hikes are found in between ten and thirty years. Moreover, the densities displayed, similar to the density of gross notionals, remain comparable over time. The later reporting dates however, especially the report on 31-12-2018 , display a slight movement towards shorter time horizons. This is remarkably visible in the ten years to maturity contracts, where the density is cascading across the three displayed dates. One reason for the movement towards the shorter time horizons might be that a fraction of the portfolios found in the earlier reporting dates are starting to unwind, and are replaced in the later dates. This, however, still portrays the movement to shorter time horizons. Finally, the years to maturity are also showing a slight movement away from the definitive spikes at specific years to maturity. Most dates find exact spikes at e.g. twenty years and thirty years. In the later reporting dates, the contracts with shorter time horizons are less homogeneous with the horizon. In other words, the contracts with less than ten years to maturity find wider spikes in later dates.

Figure 9 displays the amount each sector receives and pays to each sector relevant to their respective legs . The colours are shaded based on the extremities of the values. As the underlying principle for the interest rate swaps is that each party essential nets their exposure completely, the sector perfectly offset each other (a perfect example is the total traded between the same sector, notably – exactly

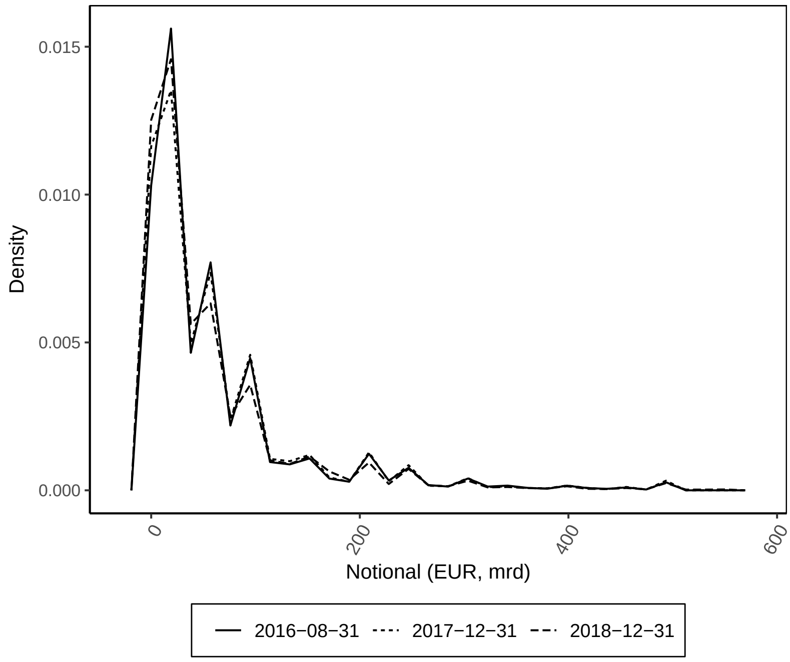


Figure 7: The frequency graphs explores the distribution of the gross notionals reported across the reporting dates displayed.
Source: DTCC OTC interest rate swaps data set (based on the presented trade state reports)

– zero). However, the actual levels of the difference between the amount received and paid gives interesting insights into the structure found in the market. The figure shows that firms and central parties in the CCP and Banking sector exchange, relative to the market, the highest amounts amongst each other. Second to their levels, the exchanges made by G16 firms in relation to the insurance & pension firms, the non-financial firms, and the banks see increased amounts of activity.

Moreover, the figure 10 highlights the relative share of the payments with regards of the gross notional levels of the respective sector. Interestingly, the figure presents distinct conclusions to the previous graph. Notably, the sectors which exchange limited, relative to the market, payments and receivables, find the share of the exchanges higher in relation to the gross notional in the sector. It must be noted, that the gross notional in the respective sector is different. Thus, the relation between the figures is limited. However, based on the figures presented in figure 10, do highlight that the gross notionals in the smaller sectors (e.g. public authority), do not off set the rates used to determine the payments/receive structure.

Finally, the different levels of amount exchanged in relation to the different options to calculate the reset frequencies are presented in Appendix 24. Due to the limited changes in the floating rates in the past years, there appears to be limited to no difference between the approaches used. The slightest difference is found between option 1 and 3, where 3 calculates lower levels exchanged. However, these differences are negligible in relation to the amounts they influence. Thus, to ease the data

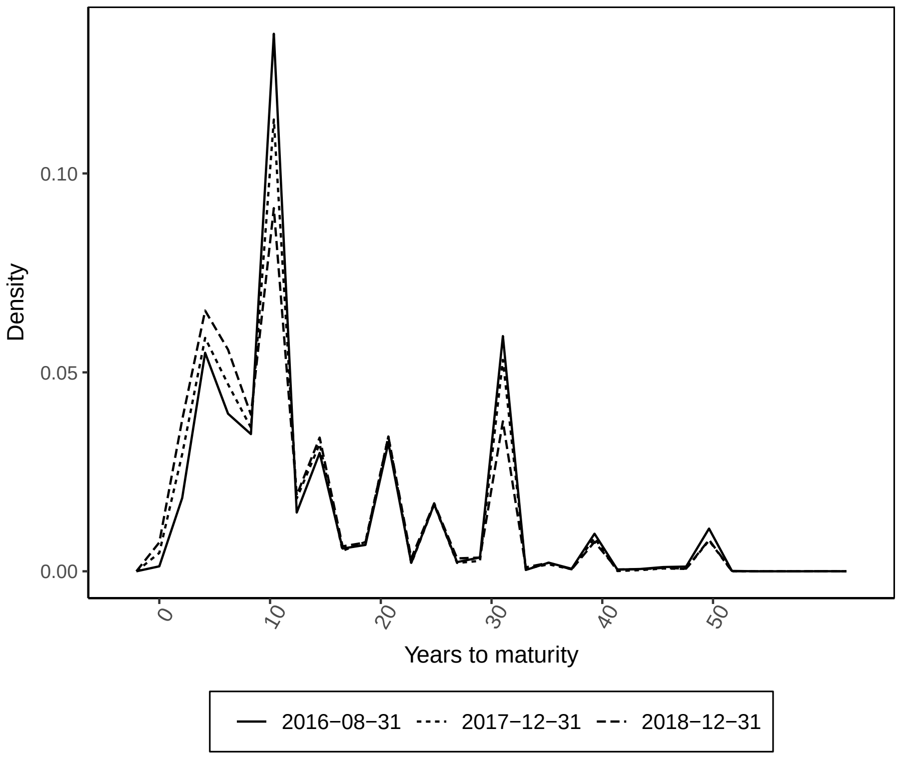


Figure 8: The density of the maturities in years based on the lifetime of each contract according to the relevant reporting date.
Source: DTCC OTC interest rate swaps data set (based on the presented trade state reports)

handling in reference to the EMIR data set, the reset frequency can be disregarded, and the reference rate associated with the floating rate benchmark can substitute rather perfectly for the actual reset frequency.

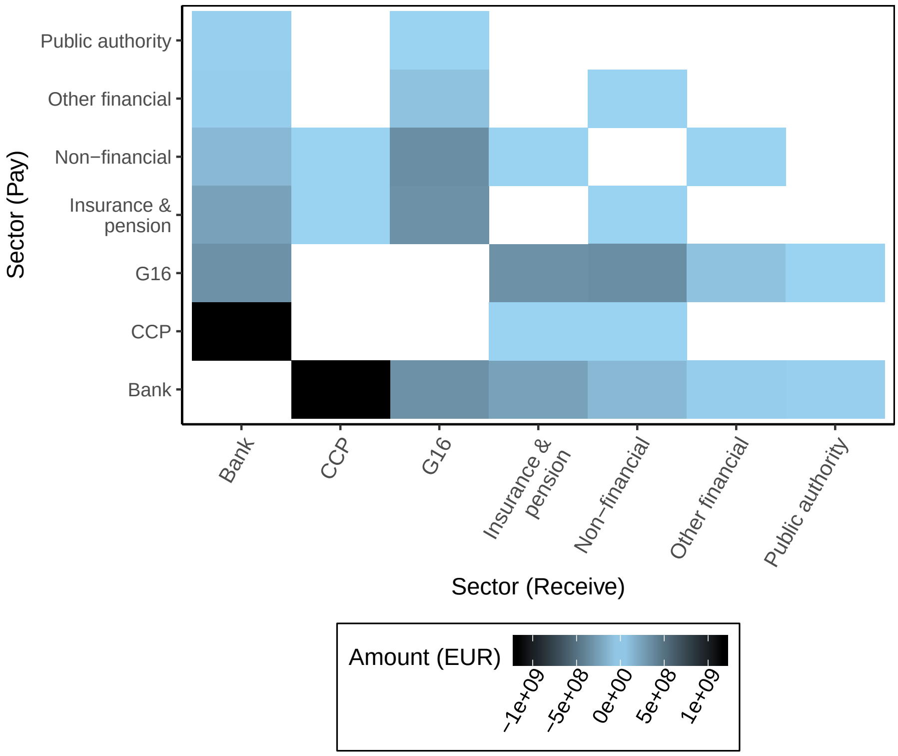


Figure 9: The absolute amounts exchanged according to the respective legs based on the reference rate on 31-12-2018 for each respective tenor. The colours reflect absolute figures, e.g. $1e^9$ has the same shade as $-1e^9$.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

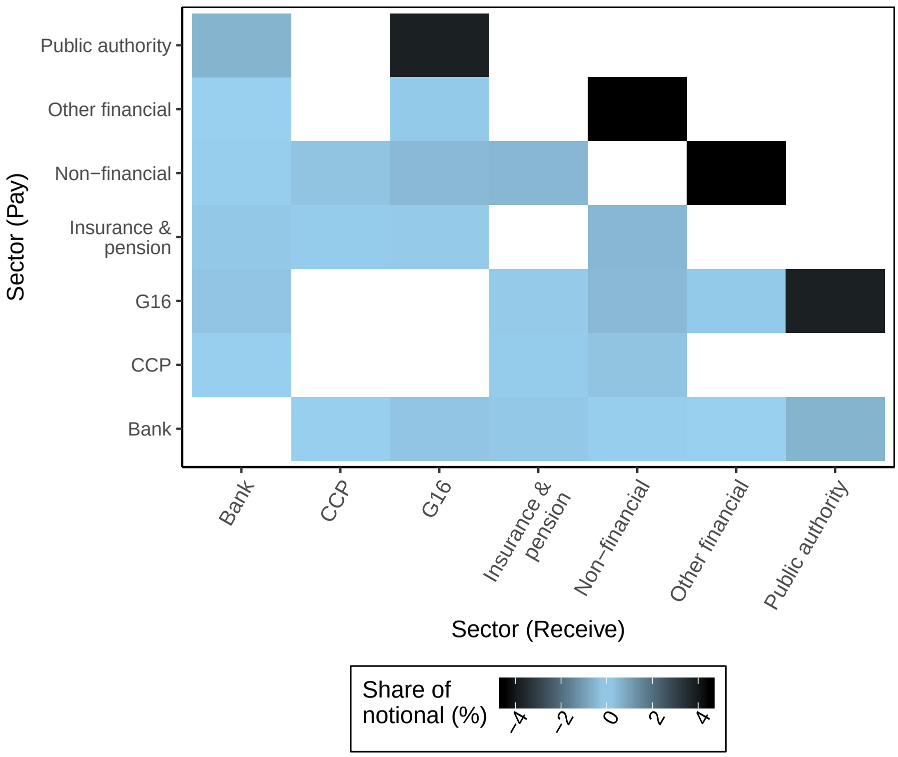


Figure 10: The relative amounts exchanged according to the respective legs based on the reference rate on 31-12-2018 for each respective tenor relative to the gross notionals of the respective sector. The colours reflect absolute figures, e.g. 1 has the same shade as −1.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

4.1.1 Network Analysis

Figure 11 shows the full network of counterparty relationships of the Dutch IRS market with EURIBOR as reference rate. The figure presents the core-periphery structure found in the market. Moreover, the initial findings based on the network are different than would be expected given the previously presented findings. For example, the aggregated degree between banks and non-CCP parties is rather substantial, while the amounts exchanged (as displayed in figure 9 and 10) would suggest a substantially lower degree. The network is analysed in detail below.

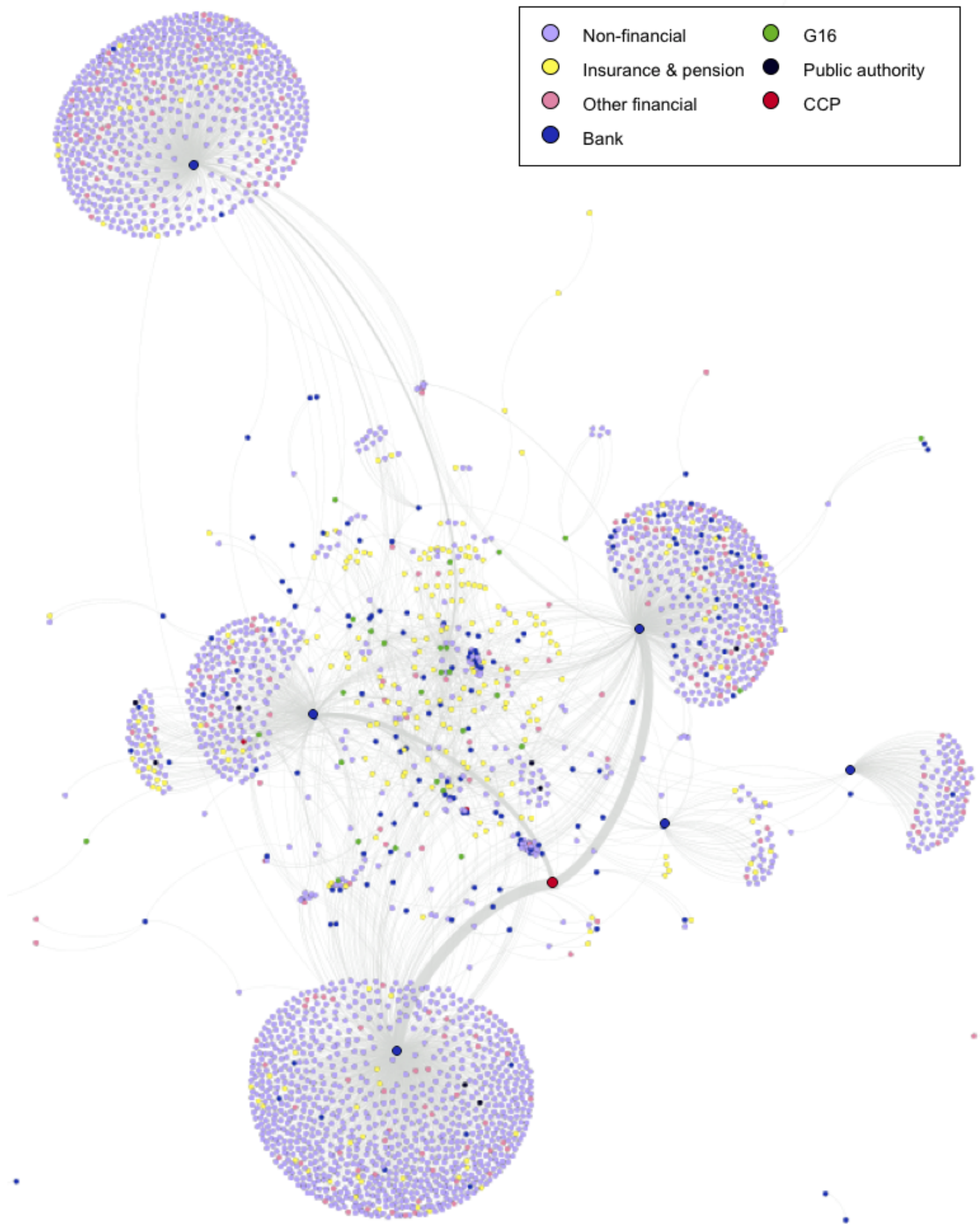
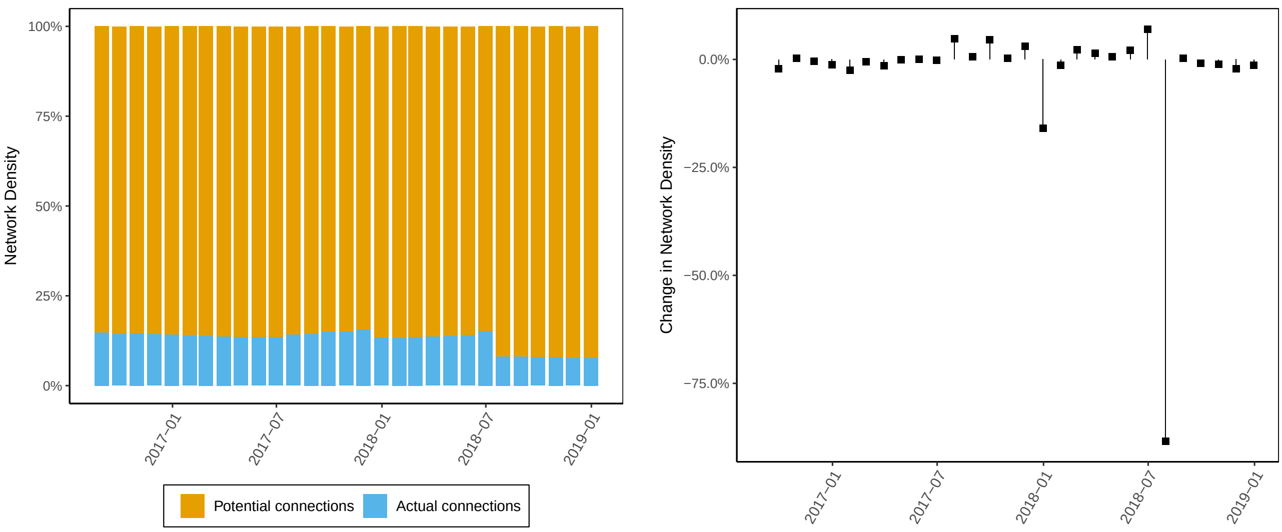


Figure 11: Full network of counterparty relationships of all EURIBOR IRS. The weight of the edges is relative to their degree (number of counterparty relations). The counterparty are coloured according to their respective sector, while the gross notional is excluded due to confidentiality issues.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

Figure 13a shows that the size, the total number of counterparties, and the volume, the total number of outstanding trades, has increased over time. However, the relative data quality might have had an influence on these results. Regardless, the number of trades relative to each counterparty is rather limited. This is also highlighted in figure 13c, which shows that the average number of counterparties for each node lies around 2.5. Ascolese et al. (2017) also find an average degree of around 3, although they find a declining trend in the size and volume of the European IRD market. Interestingly, the normalized maximum degree is higher in the Dutch market than found in the European market. On the last day reported by Ascolese et al. (2017), they find a maximum degree of 300, while this is around 600 in figure 13c. The degree does drop from 03-2017 onward, but still remains well above 300 connections. Thus, the dependence on a few distinct counterparties is more relevant in the Dutch market, than in the European market. Finally, figure 13b describes the average outstanding notional value of the counterparties in the market. Similar to the results found by Ascolese et al. (2017), the trend for the average strength is positive, while negative for the maximum strength.

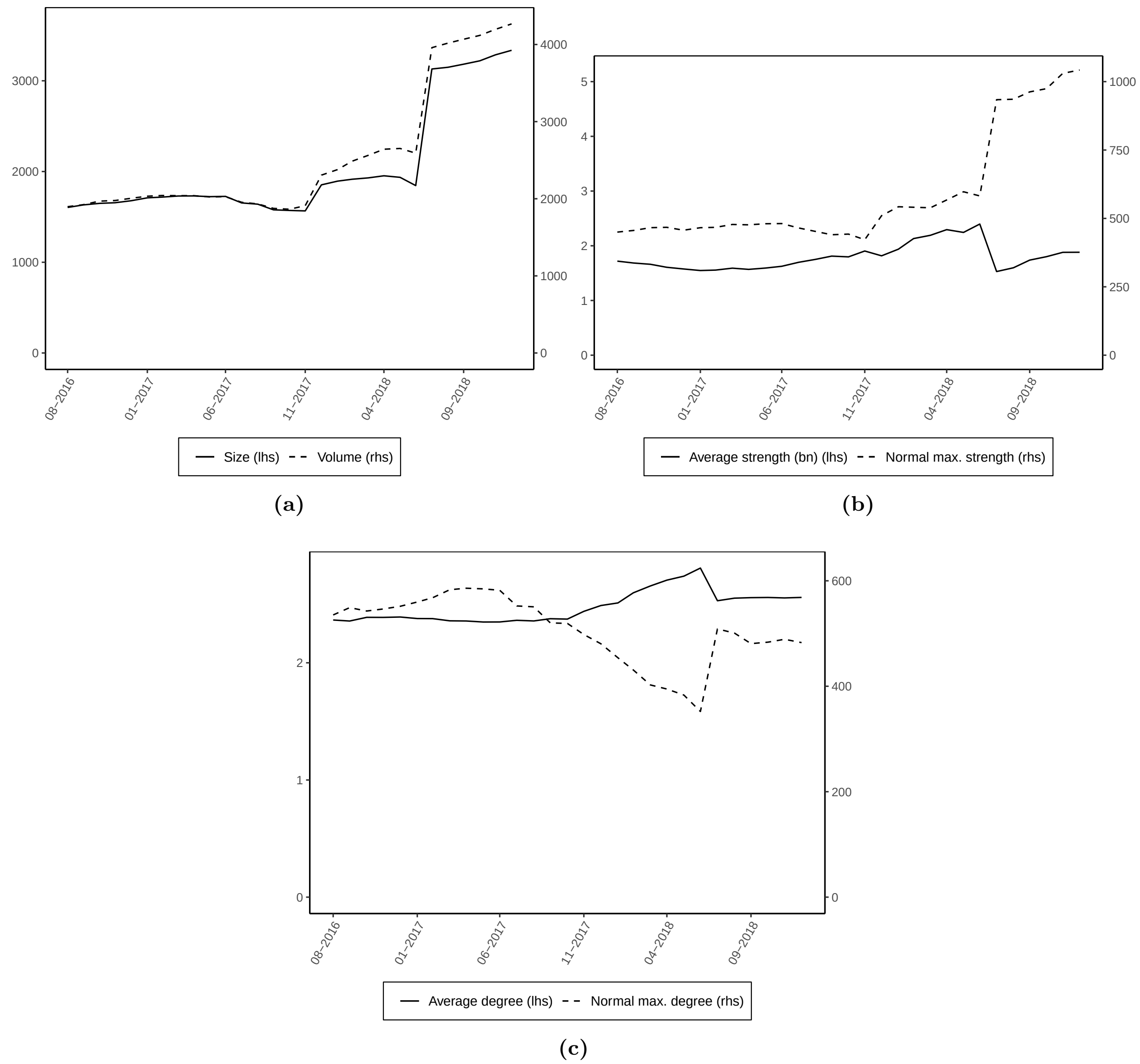


(a) Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

(b) Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

Figure 12: (a) displays the network density as described by table 5. (b) shows the change in the network density relative to the previous month, based on the data in (a).

Finally, the network density is described in figure 12a and 12b. The network density remains stable, until 07-2018, when there is a sudden drop in the actual connections. The drop can have several explanation, for example a counterparty could have defaulted and all contracts were terminated, or the contracts for a large fraction of counterparties ended. The latter explanation is just as likely as the former due to the similar years to maturities found in the previous literature. However, what is then interesting is the lack of rollover as a results of the contracts unwinding. Moreover, the density – and thus the interconnectedness – seems to be rather limited in terms of connections on the overall scale of the market. However, the as was shown in figure 11 there appear to be many smaller counterparties in relations with only two or three parties, as underlined by the average degree, while only a handful connect these parties to each other based on a tiered-structure.



(a) **(b)** **(c)**

Figure 13: The network measures – strength, degree, size, and volume – as described in table 5.
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

4.2 Evolution of the Interest Rate Swap Market

4.2.1 Clearing Obligation

Figure 14 presents the amount of transactions cleared in terms of gross notional as well as relative frequency. The bars indicate whenever the clearing obligation for the G4 currency relative to each category had gone in force. As already found by Ascolese et al. (2017), there appears to be no immediate reaction to the enforcement of the mandatory clearing. Moreover, the percentage of trades cleared is already near 50% when the first clearing obligation went into force. One explanation for the lack of spikes in reference to the introduced mandates, is the fact that most firms were aware of the upcoming legislation and prepared by adopting the central clearing mandate early on. However, earlier investigations of the level of transactions cleared find limited surges, even at time of the introduction of EMIR (Ascolese et al. 2017). In tandem, it is also reasonable that the market was already gravitating towards central clearing, regardless of the legislation. As mentioned in section 1, there are many advantages to central clearing also for the parties involved as it limits the information asymmetry and thus the resulting counterparty credit exposure.

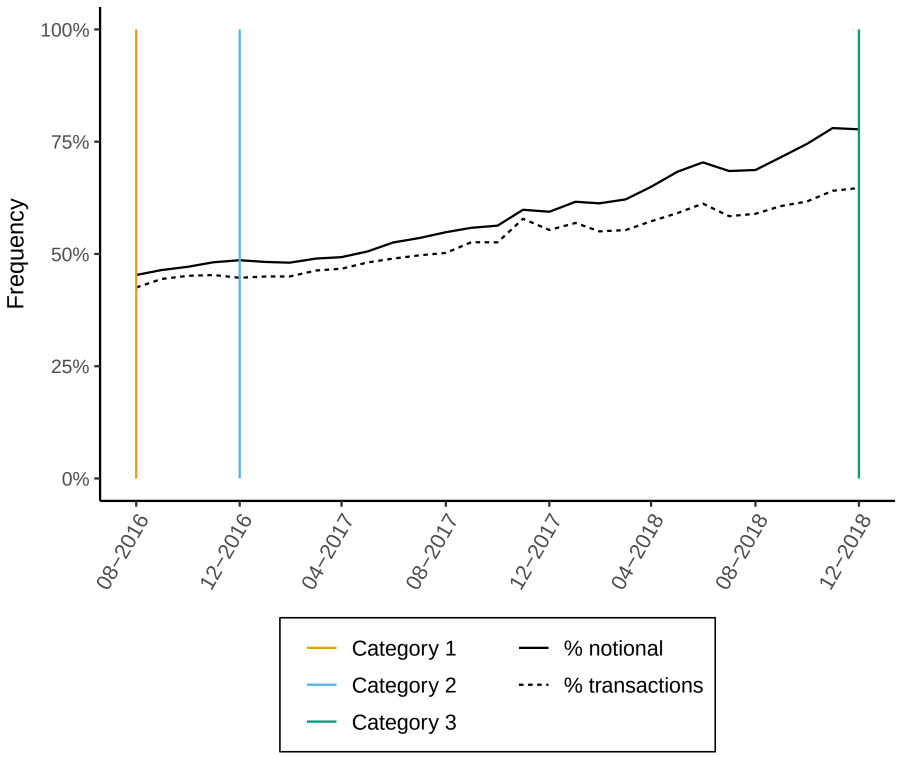
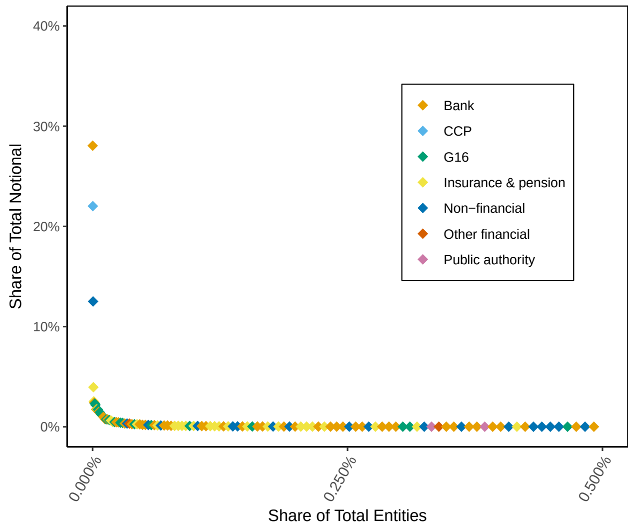
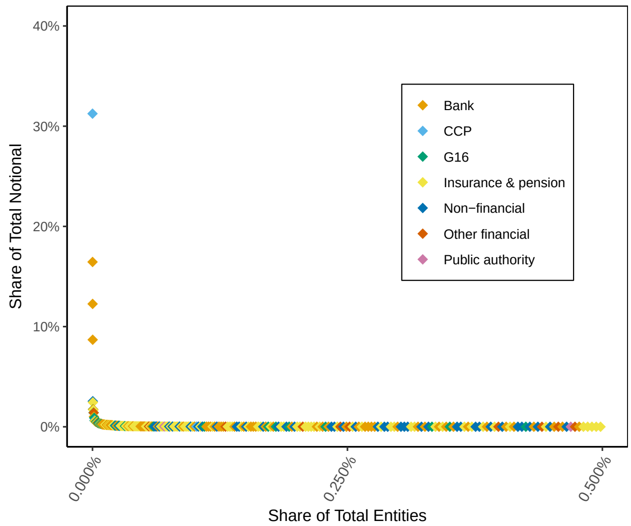


Figure 14: The percentages of the share of transactions cleared as a function of time. In addition, the implementation dates for the clearing obligation for the G4 currencies relative to each category is presented.
Source: DTCC OTC interest rate swaps data set (based on the presented trade state reports)

Figure 15a and 15b present the concentration in the market. The figures indicate that the market has a remarkable structure, where only one to four counterparties control a considerable amount of



(a) Source: DTCC OTC interest rate swaps data set (based on the 31-08-2016 trade state report)



(b) Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

Figure 15: The concentration in the Dutch IRS market across time, where the gross notional is summarized across each counterparty and compared to the total notional and number of counterparties found in the market.

the notional found in the market. Moreover, the differences between the figures clearly highlight the role of CCPs as a result of the obligations introduced. The share of the CCP has increased, while the share of other parties has decreased relative to the market.

In relation to the previously presented network measures, as well as the entire network, it appears that the overall interconnectedness has moderately decreased. But, the interconnectedness within the inner core network has increased substantially. Moreover, the relative size of the smaller counterparties based on the gross notional has remained relatively stable, while the on average bigger counterparties see their relative notional size increase substantially.

The shift towards a more exponentially structured market can, to an extent, be attributed to the existence of clearing members and non-clearing members. Table 6 represents the number of institutions (nodes) in the analysed networks by their type. The second column represents the full network (House and client clearing), while the third column shows the CCP to client member relations, referred to as House relations. Finally, the fourth column represents the client nodes (clearing member to client). Moreover, the Full column is not equal to the sum of the other columns due to the fact that clearing members can also act as a client and are, thus, represented in both types. The tables present the heavy reliance on the limited available clearing members, and highlights the action on the market relative to the type of relation. Moreover, the tables explain why several parties make up the largest share in notional value, as the parties are obligated to trade through the clearing members. The market has nearly doubled in amount of institutions present from 31-08-2016 to 31-12-2018 . Furthermore, the non-financial institutions has dominated the client clearing market, and thus appear to have limited

Type of institutions	Full	House	Client
Bank	76	1	75
CCP	1	1	0
G16	27	0	27
Insurance & pension	98	0	98
Non-financial	1025	0	1025
Other financial	101	0	101
Public authority	2	0	2
Total	1330	2	1328

Table 6: The number of institutions (nodes) in the analysed networks by their type.
Source: DTCC OTC interest rate swaps data set (based on the 31-08-2016 trade state report)

Type of institutions	Full	House	Client
Bank	153	4	149
CCP	3	3	0
G16	33	0	33
Insurance & pension	235	1	234
Non-financial	1669	1	1668
Other financial	162	0	162
Public authority	6	0	6
Total	2261	9	2252

Table 7: The number of institutions (nodes) in the analysed networks by their type.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

direct access to a CCP. The amount of clearing members has also increased, which could explain the substantial increased client-type institutions as the process of clearing has become more accessible.

The degree and the strength of the market relative to the relationship type underline this conclusion (figure 16 and 17). The amount of counterparties on average in the client market is more dispersed than found in the house market. Moreover, the banking sector remains visible in both the client as well as the house market, where the average degree exactly coincides with the degree of the institutions in the CCP sector. Thus, most clearing members active in the Dutch IRS market are in fact active in the banking sector. Figure 17 shows the relative out-of-balance strength amongst institutions within the house segment of the market and the client segment. Furthermore, the average notional per counterparty is substantially higher for institutions in the banking as well as the CCP sector.

Finally, the Jaccard index shown in figure 26 presents the percentage of counterparty relations (i.e. portfolios) present in common periods. Interestingly, the percentages found, most near 50%, are lower than those found by Fiedor et al. (2017). They find around 75% of the EUR dominated counterparty relations common in the European IRD market in the end of Q3 and the end of Q4 of 2016. An explanation could be that the Dutch IRS market sees a quicker turnover of contracts than found in the European IRD market.

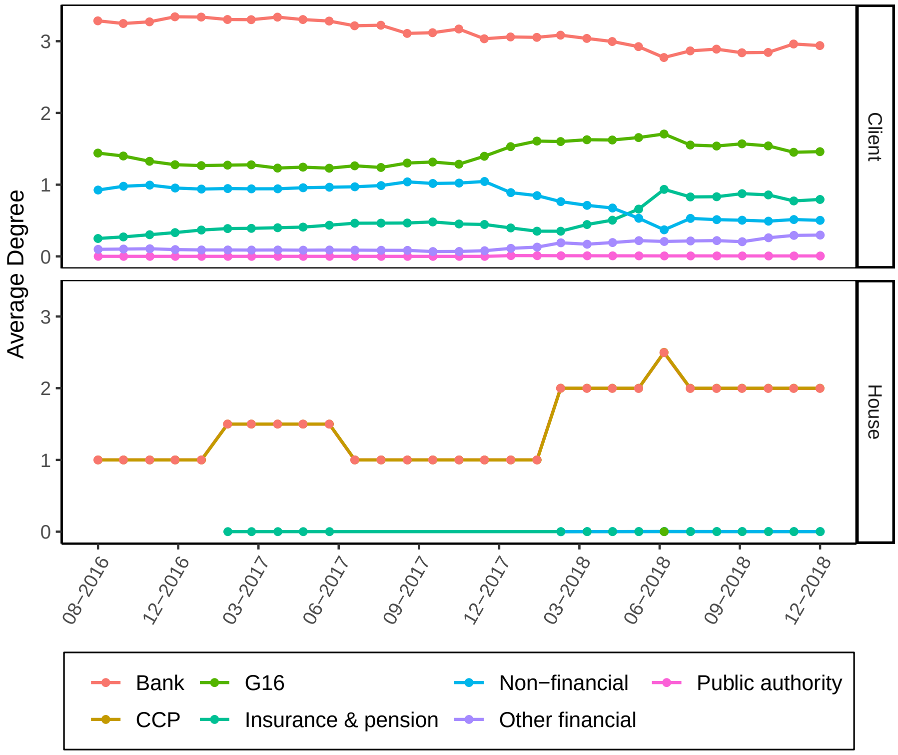


Figure 16: The average number of counterparties each sector trades with according to their type of relation and sector.
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

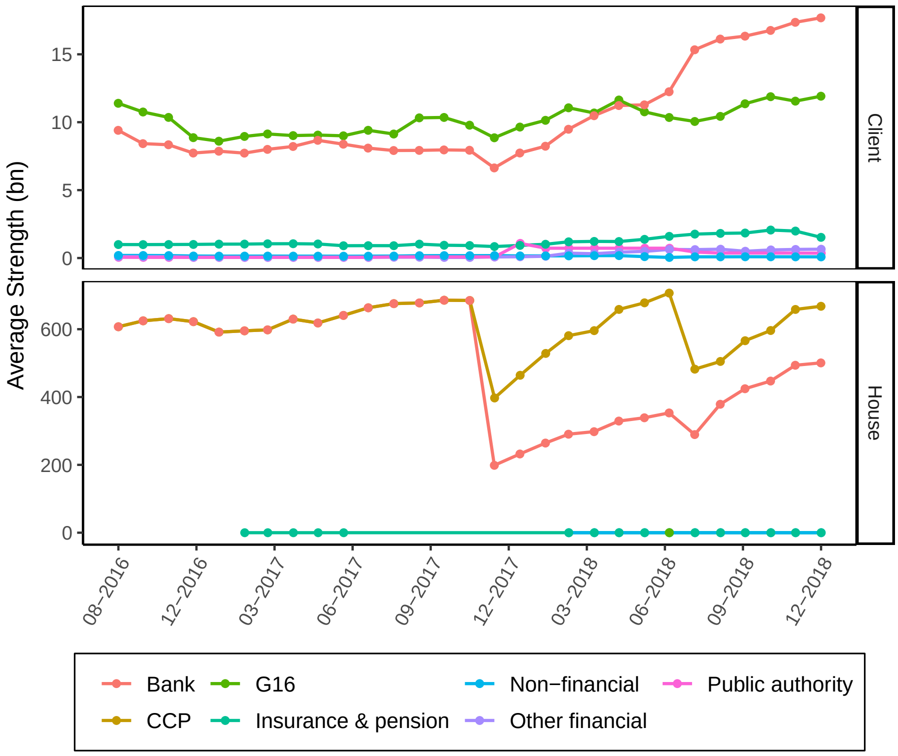


Figure 17: The average strength, the average notional per counterparty, according to their type of relation and sector.
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

4.2.2 Margin Requirements

The table below present the average initial margin requested relative to the gross notional according to each sector. In addition, table 9 presents the absolute figures posted and received based on the trade state report on 31-12-2018 . The amount of initial margin appears to be around 1% for most institutions, with a maximum of 1.72% for the institutions in the G16 sector and the other financial firms.

	Bank	CCP	G16	Insurance & pension	Non-financial	Other financial	Public authority
Bank	0.72%	0.75%	0.76%	0.94%	0.83%	0.28%	0.37%
G16			1.1%	0.7%	1.07%	1.72%	
Insurance & pension				0.06%	0.41%		

Table 8: The average IM and average notional per sector.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

	Bank	CCP	G16	Insurance & pension	Non-financial	Other financial	Public authority
Bank	2609309	1140328102	7245714	2479799	837240	903391	308467
G16			183687	4437961	2210270	9542712	
Insurance & pension				15038653	79232		

Table 9: The average IM posted by each sector according to the SIMM model calculated IM calls.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

The initial margins found in the data set are presented in figure 18. Important to note is the limited reliance on the margins provided, figure 27 highlights this necessity and the scarcity of the data. The percentage presented are the filters used to initially exclude unrealistic margins posted. The initial margin relative to the gross notional where all portfolios with a relative value higher than 20% are discarded is presented in figure 18. The margins are relative to the entire sector, and showcases the different margin received and posted for each sector.

To examine the trajectory of the margins called, the initial margin is compared to the volatility in the market. The figures below shows the average initial margin requested per sector based on the SIM model, in relation to the average VIX[22] of the market on the respective reporting date. Figure 21a and 21b both show how the initial margins follow a moderately similar trajectory as the VIX. Moreover, it appears that the initial margin is delayed in its response. This can be expected as the calculations respond to historical figures instead of forecasted levels. The initial margin posted by banks (figure 21c) appears initially to follow a different path than the VIX, however if the levels of

[22]The average VIX refers to the average of the opening and closing values.

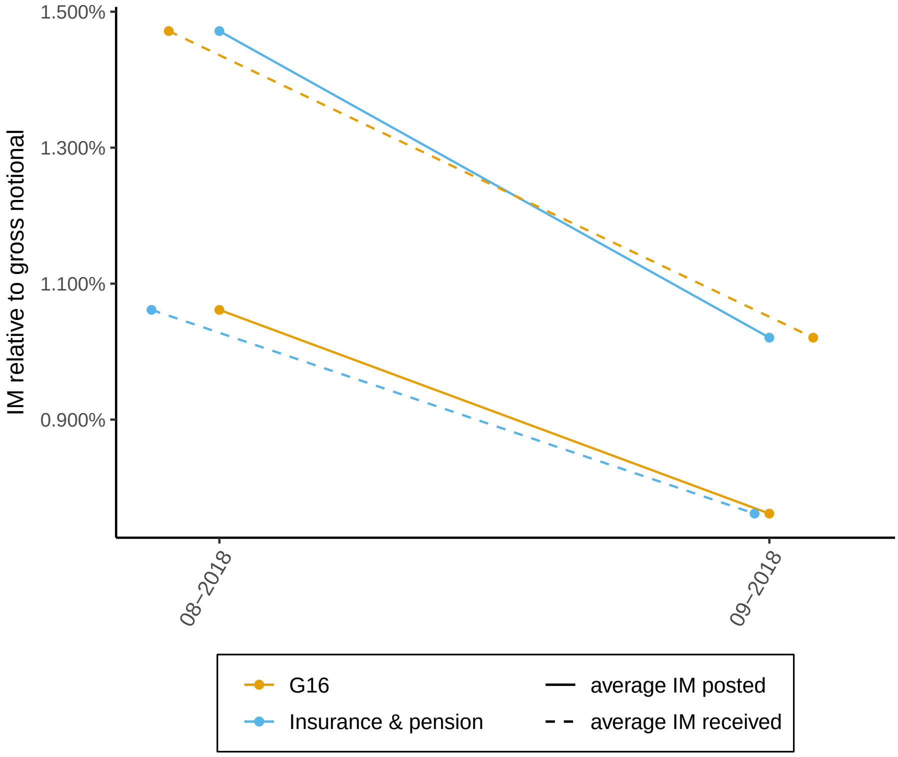


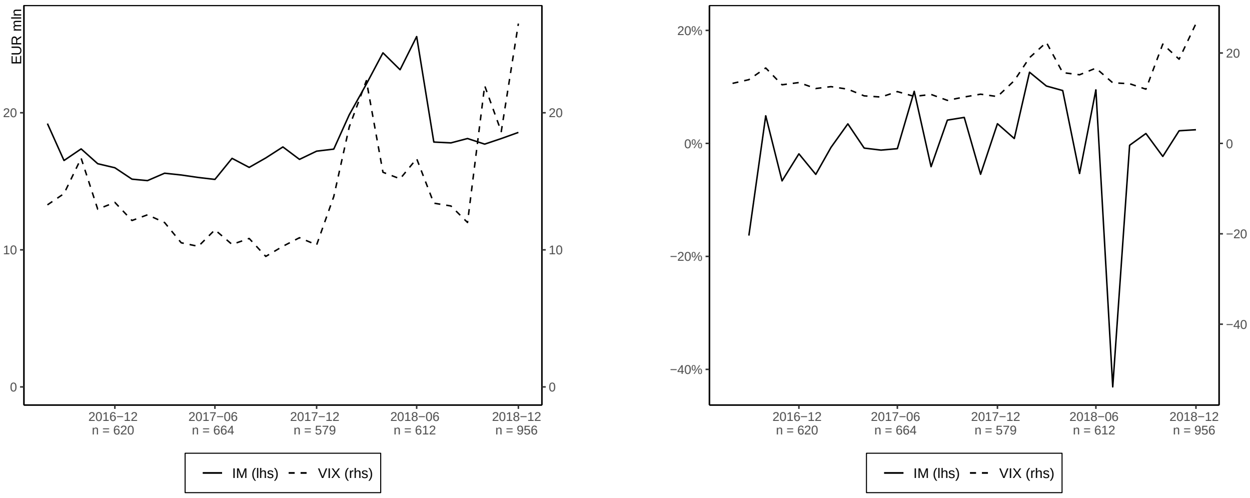
Figure 18: The initial margin posted and received relative to the gross notionals. Beforehand, the average of the portfolios is filtered to exclude all distinct portfolios with an IM relative to their notional values higher than 20%.
Source: DTCC OTC interest rate swaps data set (based on the 31-08-2018 and 30-09-2018 trade state reports)

the initial margin are taken into account, the initial margin actually reverts back to more realistic levels. The change in levels can, thus, probably be attributed to a counterparty winding down a large contract. Finally, the non-financial firms are in quantity most present, but appear to have the lowest average initial margin. In relation to the increased connected position of banks, it should come as no surprise that banks also pay, in absolute amounts, the highest average initial margin. In relation to the gross notional the relative amount of initial margin required is around 0.72%, thus their position does not appear to lead to on average higher initial margins.

The delayed response seen in the initial margin calculated by SIMM is especially visible in figure 19a. Which shows the average initial margin posted as an average of the entire market. In addition, the variation of the margins requested can be rather substantial as seen in figure 19b. This could potentially be harmful as pointed out by Glasserman and Wu (2018), as this is a sign of the procyclical nature of the requirements.

The tables below, tables 10 and 11, present the effects of the increased sensitivity measures based on a three and five basis points shift[23]. Moreover, the tables attempt to investigate the response of the initial margin to sudden increases of stress in the market.

[23]All the figures presented in the previous paragraph related to the normal one basis point shift are presented in Appendix C for the respective basis point shifts.



(a) Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

(b) Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

Figure 19: (a) The average IM across the entire market. (b) The difference in IM required compared to the IM requested in the previous time period. Each n represents all the distinct counterparties in each sector over which the mean IM is taken.

The basis point shocks affect the sectors heterogeneously, as is visible by the different increase for banks and institutions in the insurance & pension sector. The firms within the G16 sector and other financial firms see the highest initial margin call as a result of the increased basis point shock. Interestingly, the largest sector in notional value – Banks – is required to post moderately similar percentages across the board, while the firms in the G16 sectors see a wider range of margins.

	Bank	CCP	G16	Insurance & pension	Non-financial	Other financial	Public authority
Bank	2.15%	2.26%	2.27%	2.82%	2.48%	0.85%	1.1%
G16			3.31%	2.09%	3.2%	5.15%	
Insurance & pension				0.17%	1.23%		

Table 10: The average IM and average notional per sector based on the 3 basis point sensitivity measure. Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

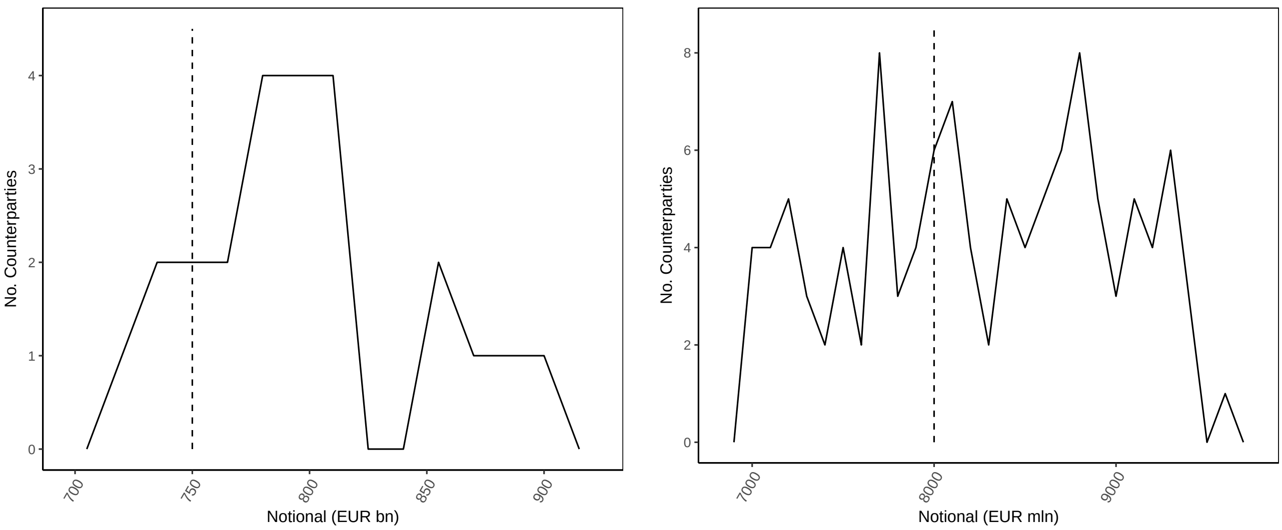
	Bank	CCP	G16	Insurance & pension	Non-financial	Other financial	Public authority
Bank	3.59%	3.77%	3.78%	4.7%	4.14%	1.42%	1.83%
G16			5.52%	3.49%	5.33%	8.58%	
Insurance & pension				0.28%	2.06%		

Table 11: The average IM and average notional per sector based on the 5 basis point sensitivity measure. Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

Moreover, the effect relative to the initial margin posted at 3 basis points and the normal 1 basis points is similarly translated to 5 basis points. In other words, the increase relative from 1 basis point to 3 basis points is equal to the increase from 3 basis points to 5 basis points. This is to be expected given the linear relation underlying the net present value changes.

Finally, the notional thresholds used to determine whether non-centrally cleared are obligated to post initial margins is investigated in figure 20. The counterparties and notional values are determined irrespective of their intragroup involvement as well as whether the contracts are forwards starting or not. In other words, no distinction is made regarding specific regulatory exclusions or inclusions, the investigation shown is purely used as an exploration of the current state of the market.

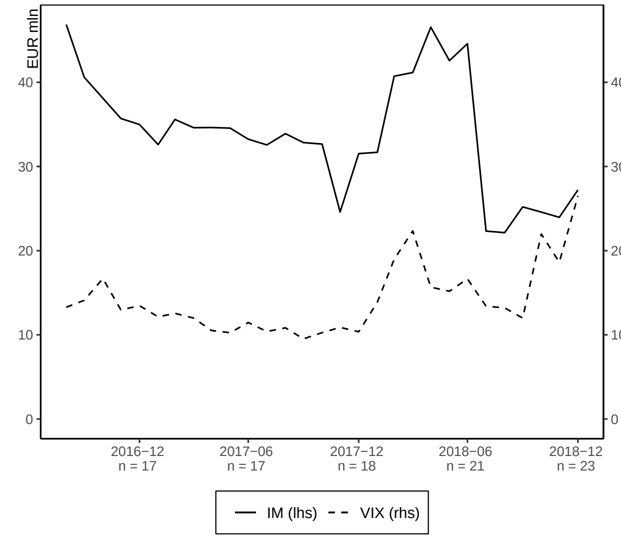
The most apparent from the graphs is the relative limited number of counterparties affected by the thresholds. The amount of parties affected by the first threshold, which will be implemented in 01-09-2019 only affects a handful of Dutch counterparties. The total number of counterparties affected is around 30 distinct counterparties. Moreover, The lower threshold ($8bn$) does affect more companies, a rough estimate shows the total to lie around 980 parties, but relative to the total number of counterparties ($\sim$ 3500) in the market, the fraction affected seems extremely limited. Especially, regarding the fact that no exclusions based on the intragroup transactions are made on the presented data.



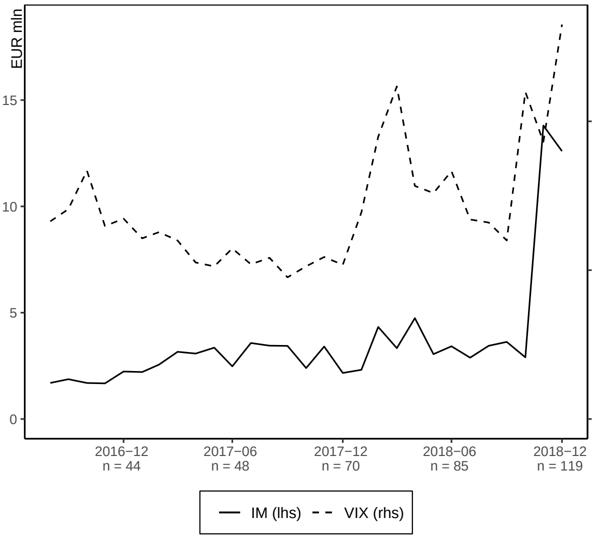
(a) Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

(b) Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

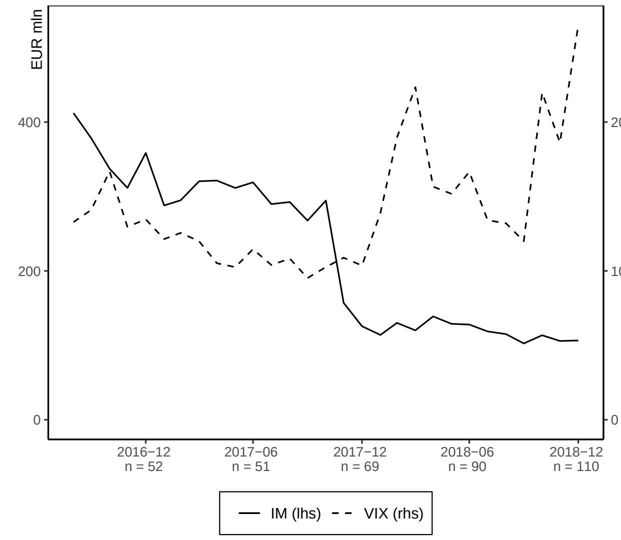
Figure 20: (a) The number of counterparties and their respective gross notional values in billions, the bar represents the notional threshold of 0.75 trillion which will be implemented on 01-09-2019. (b) The number of counterparties and their respective gross notional values in millions, the bar represents the notional threshold of 8 billion which will be implemented on 01-09-2020.



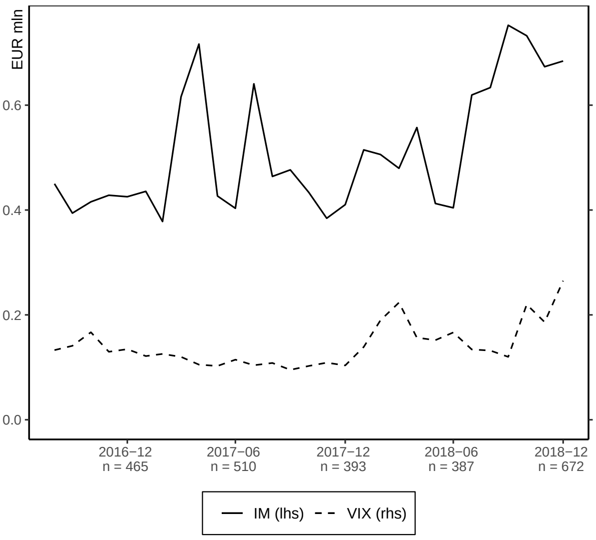
(a) The sector represented is G16.



(b) The sector represented is insurance & pension.



(c) The sector represented is banks.



(d) The sector represented is non-financial firms.

Figure 21: Each n represents all the distinct counterparties in each sector over which the average IM is taken. Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

5 Discussion

In all studies using EMIR data set, there is a significant potential for biases. As mentioned in section 3, the data requires strong assumptions to make the data worthwhile to study. Moreover, in this thesis the initial assumption has been to discard trades when the quality isn't guaranteed, which has led to a significant loss in quantity. However, the inclusion of iffy trades might have led to a loss in quality. In summary, the process requires a constant vigilance of quantity against quality in assessing the procedure used.

Several issues do require some special attention. Foremost, the end of the month focus limits the extend of the conclusions drawn. The choice to focus on the end of the month moments allowed for a time-series approach, but forced all the short term contracts to be completely excluded from the analysis which automatically skewed the results. Second, trade state data is used to explore the market due to the focus on the market as a whole. Trade activity data might present different results, especially regarding the short term contracts.

Third, the initial margin is calculated under the ISDA SIMM, as this is the approved method to calculate the initial margin for non-cleared OTC derivatives. One of the shortcomings of the SIMM is that CCPs use other models internally to calculate the initial margin requested. As a consequence, the calculated initial margins through SIMM are only an approximation of the actual margins used.

6 Conclusion

The thesis set out with the aim of providing a thorough framework to study subsequent analysis of the Dutch IRS market against. The findings are generally in line with the results published on European IRD data sets. Moreover, the amounts paid and received relative to each sector is explored and presents novel findings. Notably, there is an imbalance between the amount paid and received in absolute terms and the same figure against the gross notional of the respective sector. Moreover, the Dutch IRS market is structured around CCPs and client members, which represent around 80% of the gross total notional value in the market. In line with the literature on the European IRD market, the peripheral counterparties in the Dutch IRS see a substantially lower level of average connections as well as average notional value.

The second objective of the thesis was to identify the structural changes in the market in response to the legislation introduced. The clearing obligation has resulted in the previously mentioned dependence on a limited number of counterparties, but has lowered the overall exposure of the peripheral counterparties. Moreover, there appears to be little response to introductions of the clearing obligation, which implies that the market was already moving towards central clearing. Furthermore, the calculated margins appear to vary substantially over time, and are highly responsive to the market conditions. These findings suggest that the SIMM is inherently procyclical. Moreover, the shocks calculated by sudden increased risk-free rates, affect the counterparties heterogeneously, but remain rather limited on average (around 3% of the average gross notional).

Finally, and rather surprisingly, the initial margin notional threshold, which has been greatly debated, appears to have a narrow effect on the market due to the limited number of counterparties affected.

The overall aim of the thesis is to highlight the possibilities of the EMIR data set. In addition, the thesis sets out to establish a starting point from which subsequent research questions can emerge. For example, as a result of the structure of the market an investigation into the contagion risks associated with the smaller counterparties can provide interesting insights. Moreover, an examination of the risks associated with clearing members relative to their position to CCPs as well as non-CCPs could answer the possible changing risk structure of the entire market.

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A Data

Field	Details
Notional	The reference amount from which contractual payments are determined.
Trading capacity	Principal (P) is trading for yourself/own firm, while Agency (A) trading is done on behalf of a client.
Counterparty side	Buyer (B) or Seller (S), for the interest rate class the entity with counterparty side B is the payer of leg 1, and thus the receiver of leg 2. The opposite holds for the counterparty identifying as S.
Clearing threshold	If you exceed the threshold, you need to centrally clear those of your OTC derivative contract that are subject to the clearing obligation. The value of the thresholds depends on the class, for interest rate derivatives contracts this is EUR 3 billion in gross notional value. (Above (Y)/Below (N)).
Collateralisation	Whether the collateralisation was performed on a portfolio basis (Yes (Y)/No (N)). Portfolio means the collateral caclulated on the basis of net positions resulting from a set of contracts, rather than per trade. One-way collateralised (OC): only reporting party posts IM or VM. Parially (PC): one or both post VM, either none exchange IM or only reporting party does. Fully (FC): both parties post VM and IM.
Action type	New (N), Modify (M), Error (E), Cancel/Early termination (C), Compression (Z), Valuation update (V), Other (O), Correction (R), Position component (P). V: Refers to any change in MTM or collateral. P/N: first report received.
Execution time stamp	Date and time when the contract was executed (should be the lowest date).
Effective date	Date when obligation under the contract come into effect (equal to execution time stamp).
Maturity date	Original date of expiry of the reported contract. An early termination shall not be reported in this field (greater than or equal to effective).
Termination date	Termination date in the case of an early termination of the reported contract (greater than or equal effective, smaller than or equal to maturity).
Settlement date	Date of settlement of the underlying (greater than or equal effective).
Clearing time stamp	greater than or equal to effective
CCP	Unique code for the CCP that has cleared the contract.

Clearing member ID	in the case where the contract is cleared and the reporting party is not a clearing member itself, the clearing member through which the contract is cleared shall be identified by their LEI.
Intragroup	An intragroup transaction is a transaction between two undertakings which are included in the same consolidation on a full basis and are subject to appropriate centralised risk evaluation, measurement and control procedures (both conditions must be fulfilled cumulatively).
Fixed and floating rate payment frequency	The time period as well as the multiplier describing how often the counterparties exchange payments.

Table 12: All details are based on the Technical Standards, Question and answers, and validitation rules posted by ESMA and the EU.

B Methodology

Reason	# Obs. discarded	# Obs. remaining	# Obs. rem. (%)	Notional rem. (bn)	Notional rem. (%)
Initial values	0	196592	100.00	8941.32	100.00
non-EURIBOR	153715	42877	21.81	2354.87	26.34
Missing buy/sell indicator	8	42869	21.81	2354.68	26.33
Duplicate tradeID	49	42820	21.78	2351.43	26.30
Effective date missing or outlier	157	42663	21.70	2344.24	26.22
Maturity date missing or outlier	0	42663	21.70	2344.24	26.22
Outliers notional	249	42414	21.57	2344.24	26.22
Missing sector information or non-LEI	3154	39260	19.97	2181.48	24.40
Missing intragroup identification	0	39260	19.97	2181.48	24.40
Missing cleared identification	0	39260	19.97	2181.48	24.40
Missing fixed and floating rates	2815	36445	18.54	2093.21	23.41
Implausible fixed rates	0	36445	18.54	2093.21	23.41
Missing and implausible frequency multipliers	3731	32714	16.64	1918.29	21.45
Intragroup	3126	29588	15.05	1833.53	20.51
Zero Coupon IRS (floating frequencies null)	4	29584	15.05	1833.47	20.51
Closed contract	46	29538	15.03	1832.18	20.49
Forward starting	705	28833	14.67	1789.07	20.01

Table 13: The cleaning procedure for the EMIR data set. The notional values are all reported in EUR, and the percentages are all calculated after the respective observations are dropped and are in relation to the initial values.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2017 trade state report)

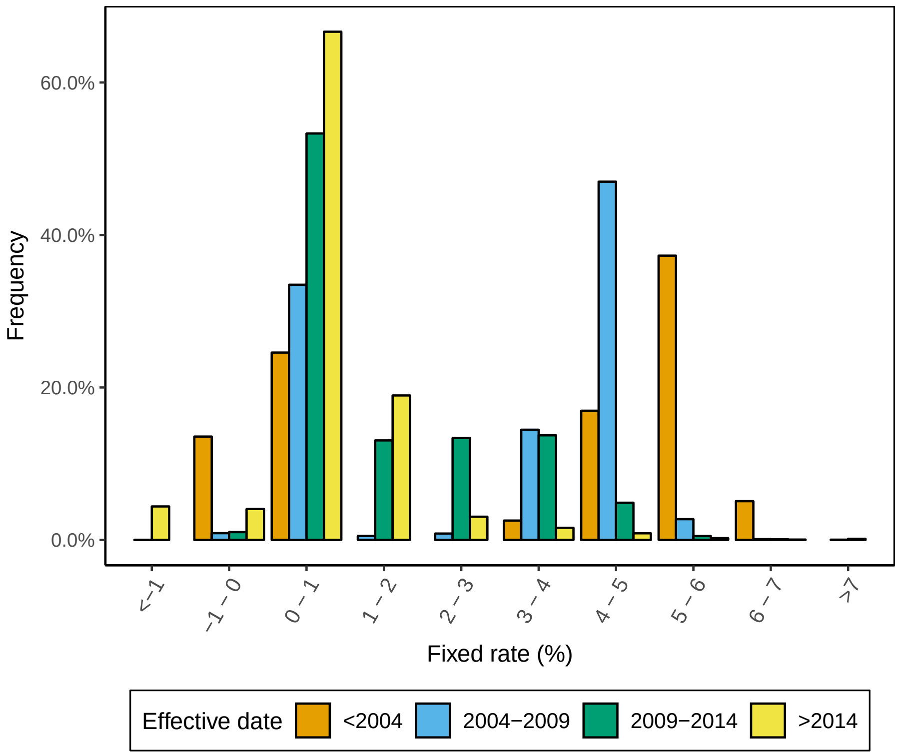


Figure 22: The fixed rate ranges in relation to the underlying effective date of the respective trade where the rates are adjusted based on the respective mean.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

B.1 SIMM calculation

vertex (tenor)	$\phi_{i,j}$
2W	114
1M	115
3M	102
6M	71
1Y	61
2Y	52
3Y	50
5Y	51
10Y	51
15Y	51
20Y	54
30Y	62

Table 14: The sub-curve correlations ($\phi_{i,j}$) as provided by ISDA 2018 in D.1 for the interest rate class.

The delta margin amounts is calculated as shown in (B.1). The correlation parameter (γ_{bc}) for EUR is 0.21.

$$DeltaMargin = \sqrt{\sum_b K_b^2 + \sum_b \sum_c \gamma_{bc} g_{bc} S_b S_c}$$
$$\text{where,} \tag{5}$$
$$S_b = \max(\min(\sum_{i,k} WS_{k,i}, K_b), -K_b) \quad \text{and} \quad g_{bc} = \frac{\min(CR_b, CR_c)}{\max(CR_b, CR_c)}$$

C Results

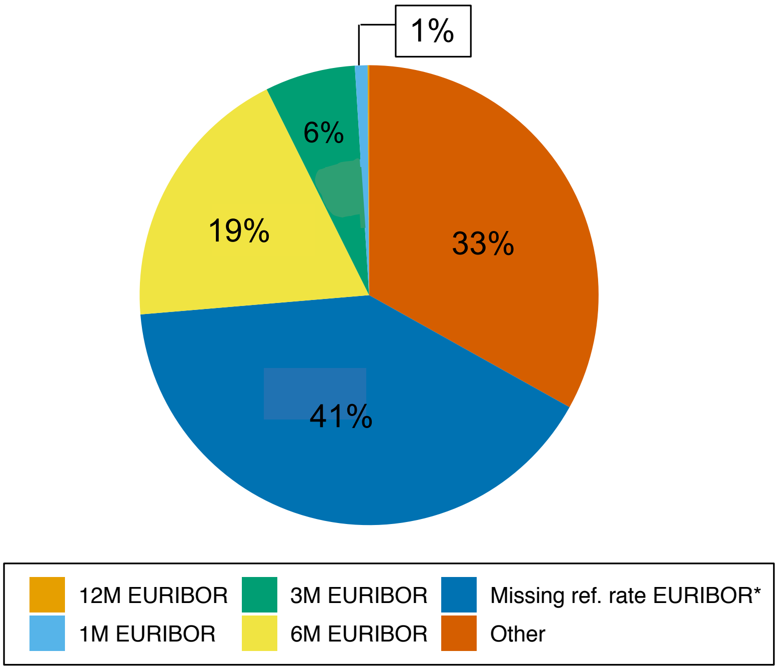
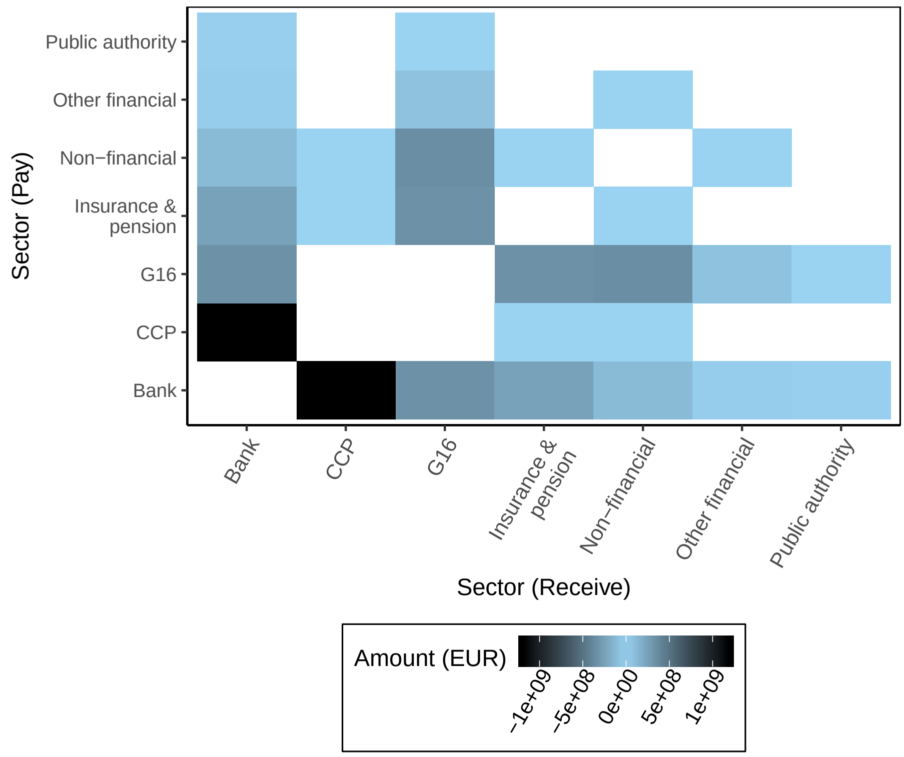
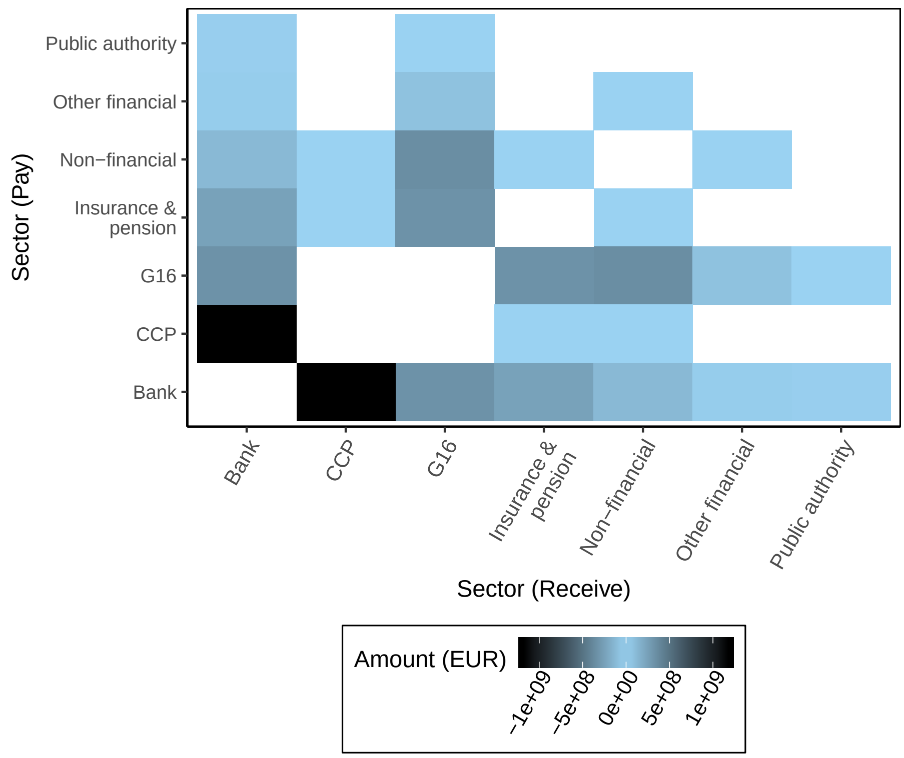


Figure 23: The share of trades in terms of the underlying benchmark rate. Other refers to all non-EURIBOR floating rates found in the data set, as well as missing rates. The missing reference rate EURIBOR field refers to all floating rates which present EURIBOR as their floating leg benchmark, but have no reference rate (i.e. tenor on which the rate is based) provided or provide a reference rate other than 1M, 3M, 6M or 12M.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2017 trade state report)



(a) The amounts are based on the reference rate option 2



(b) The amounts are based on the reference rate option 3

Figure 24: The absolute amounts exchanged according to the respective legs based on the reference rate on 31-12-2018 for each respective tenor, relative to the reference rate approaches. The colours reflect absolute figures, e.g. $1e^9$ has the same shade as $-1e^9$.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2018 trade state report)

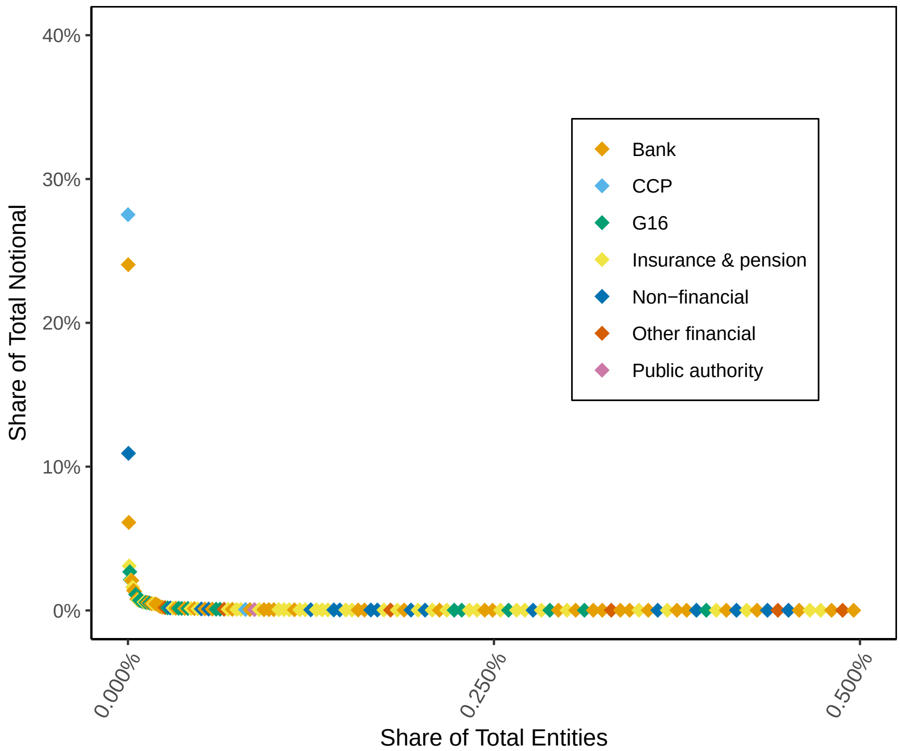


Figure 25: The concentration in the Dutch IRS market across time, where the gross notional is summarized across each counterparty and compared to the total notional and number of counterparties found in the market. Source: DTCC OTC interest rate swaps data set (based on the 31-12-2017 trade state report)

Type of institutions	Full	House	Client
Bank	117	4	113
CCP	2	2	0
G16	30	0	30
Insurance & pension	164	0	164
Non-financial	1233	0	1233
Other financial	129	0	129
Public authority	2	0	2
Total	1677	6	1671

Table 15: The number of institutions (nodes) in the analysed networks by their type.
Source: DTCC OTC interest rate swaps data set (based on the 31-12-2017 trade state report)

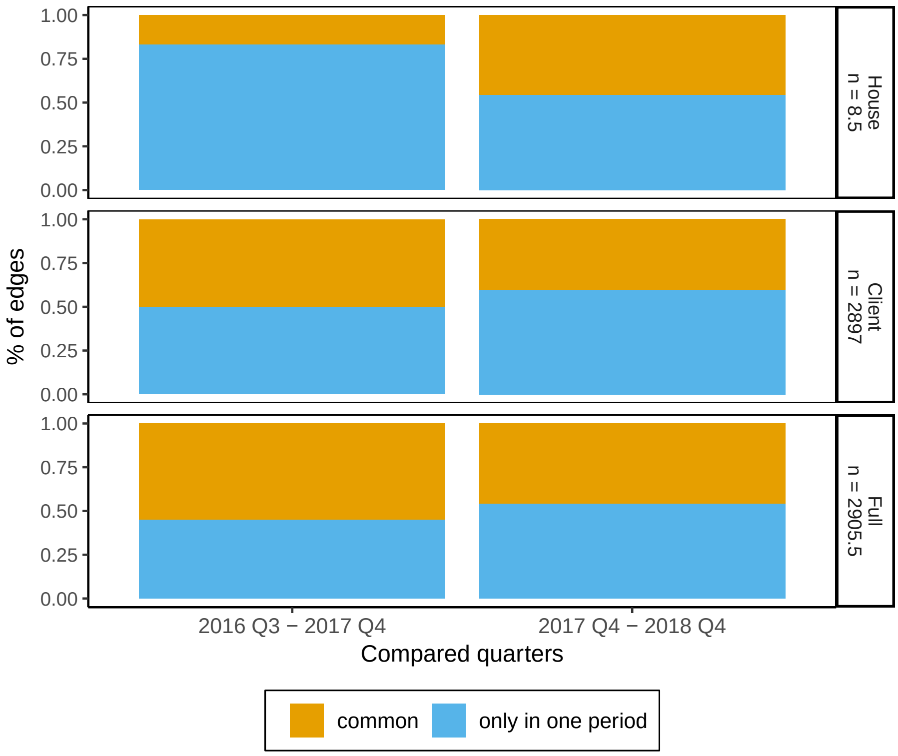


Figure 26: The jaccard index for the edges across selected quarters subsetted by their relationship type. In addition, the average total sample size is presented to indicate the relative strength of the output.
Source: DTCC OTC interest rate swaps data set (based on the 31-08-2016 , 31-12-2017 , and 31-12-2018 trade state reports)

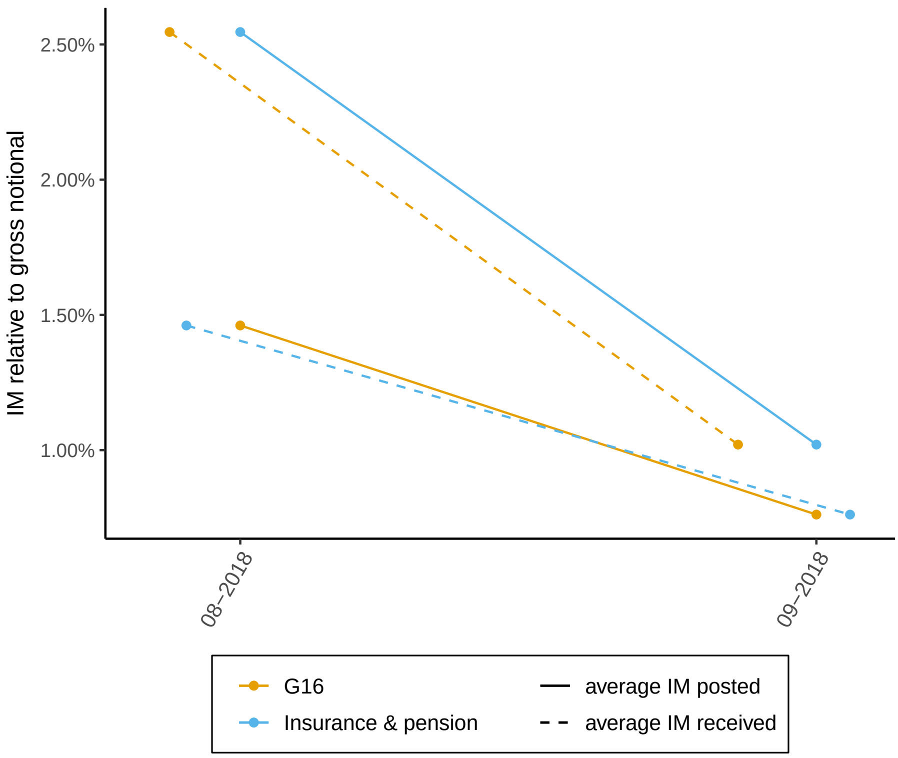
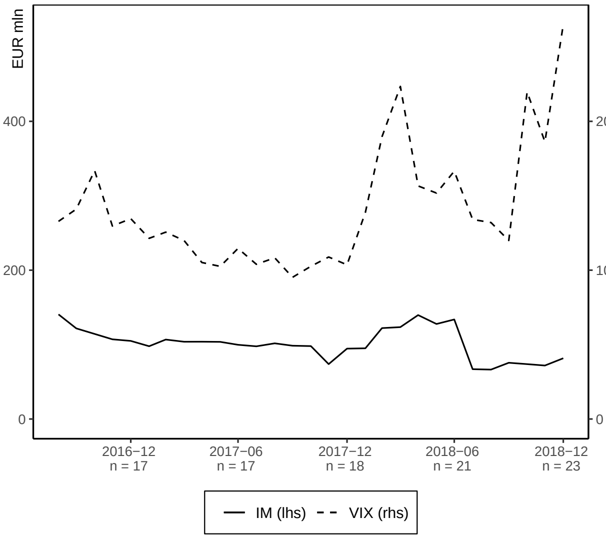
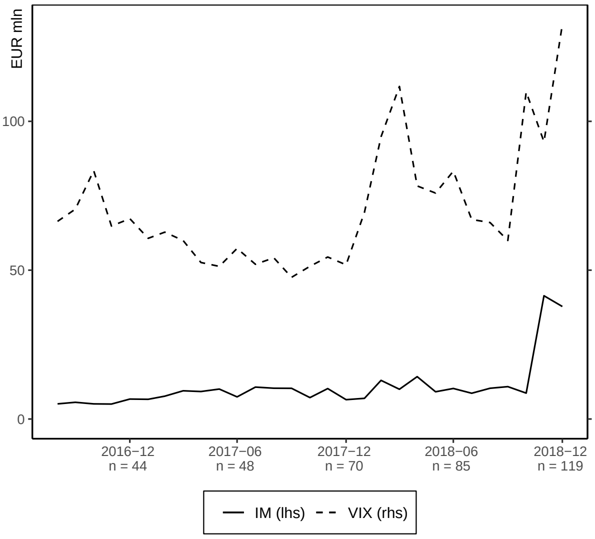


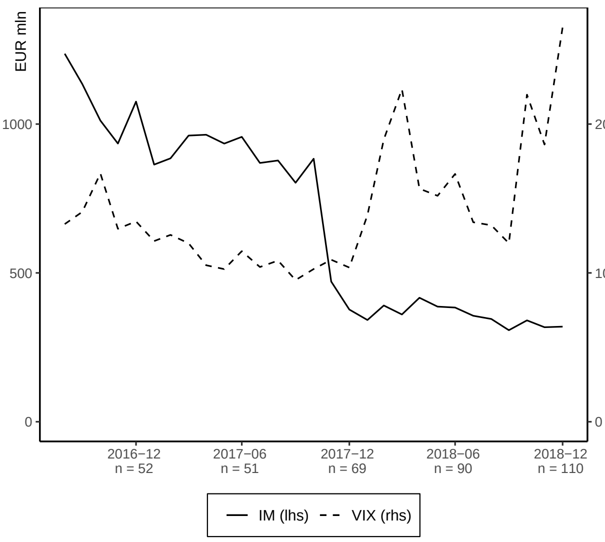
Figure 27: The initial margin posted and received relative to the gross notionals according to different filters applied to the percentages. The labels refer to the filters used to drop all distinct portfolios found with an IM relative to gross notional higher than e.g. 50%.



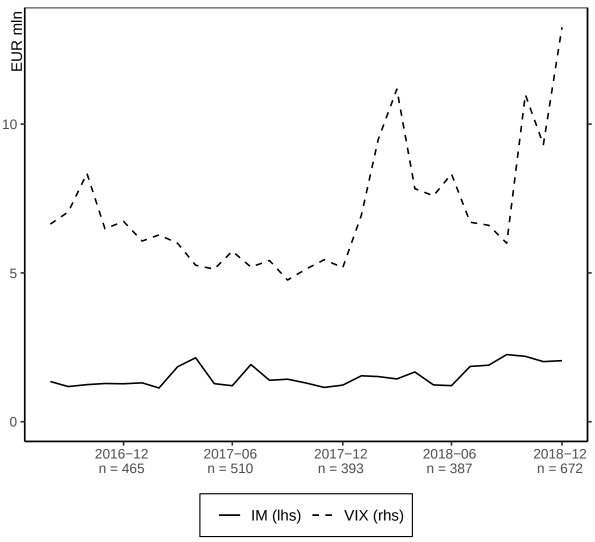
(a) The sector represented is G16.



(b) The sector represented is insurance & pension.

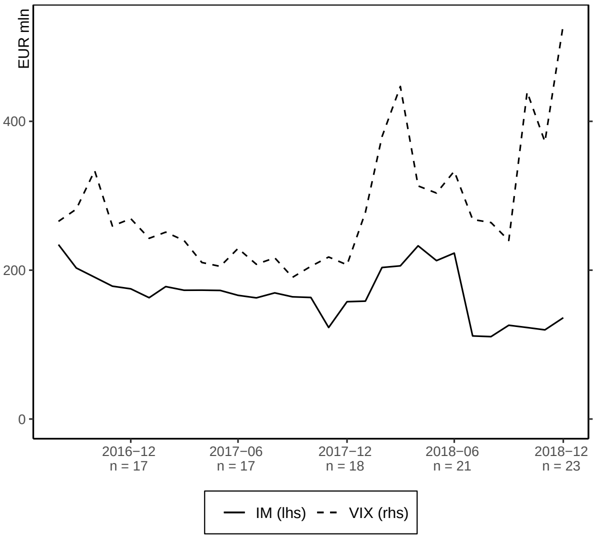


(c) The sector represented is banks.

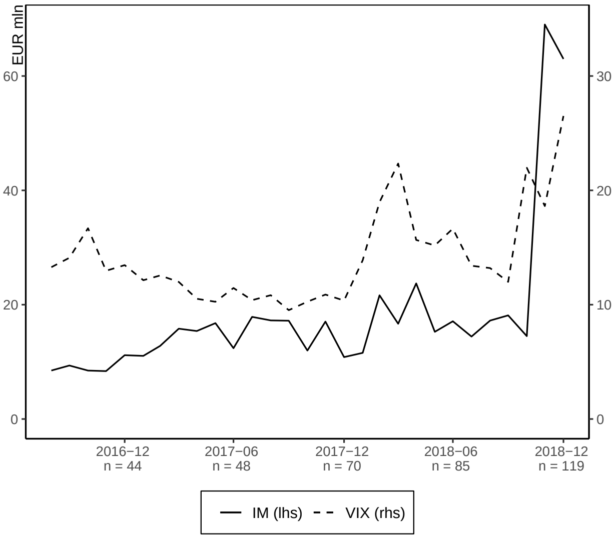


(d) The sector represented is non-financial firms.

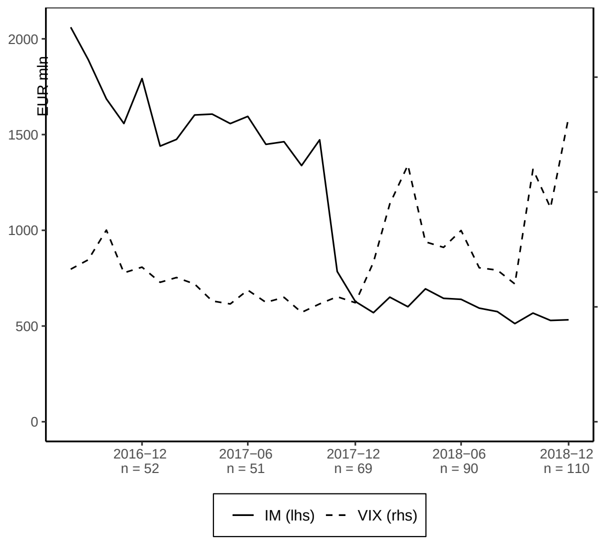
Figure 28: The IM in relation to the average VIX across time, for the IM based on the sensitivity measure of 3 basispoints.
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)



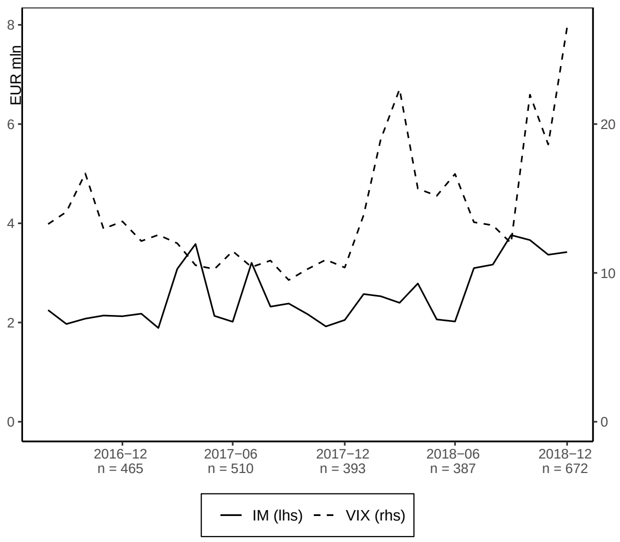
(a) The sector represented is G16.



(b) The sector represented is insurance & pension.

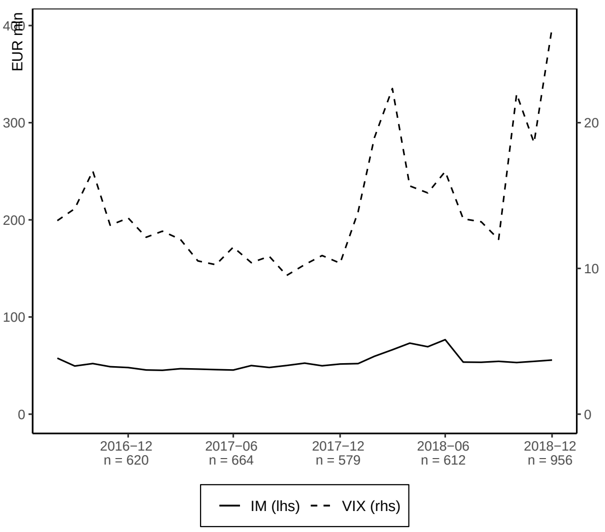


(c) The sector represented is banks.

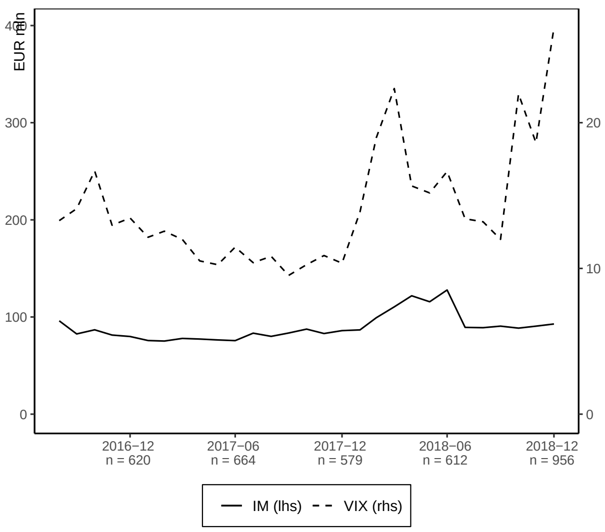


(d) The sector represented is non-financial firms.

Figure 29: The IM in relation to the average VIX across time, for the IM based on the sensitivity measure of 5 basispoints.
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)



(a) 3 basispoint shift
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)



(b) 5 basispoint shift
Source: DTCC OTC interest rate swaps data set (based on the reported trade state reports)

Figure 30: The average IM across the entire market. Each n represents all the distinct counterparties in each sector over which the mean IM is taken.