WORKING paper

BANQUE DE FRANCE
EUROSYSTÈME

On the Choice of Central Counterparties in the EU

Gabrielle Demange[1] & Thibaut Piquard[2]

March 2022, WP #868

ABSTRACT

New regulations promote the role of Central Counter-Parties (CCPs) as insurers of counterparty risk to stabilize derivative markets. Focusing on the demand side, we investigate how pairs of dealers choose the CCP on which they clear a given transaction. We use transaction data on three main CDS indices and focus on major dealers who are members of the two EU CCPs. Descriptive analysis shows that dealers do not optimize their positions across CCPs. Then, we build and test a reduced form model of CCP's choice. Differences in transaction size, two indicators of CCP's robustness and activities, squared positions to account for dealers' risk aversion, and market volatility affect this choice, but not the collateral costs, proxied by the dealers' positions.

Keywords: Central Counter-Party, Central Clearing, Dealers, Collateral.

JEL classification: G20, G23, G18, G33

[1] Paris School of Economics-EHESS, 48 Boulevard Jourdan 75014 Paris, France, demange@pse.ens.fr;
[2] Financial Stability Directorate Banque de France, thibaut.piquard@banque-france.fr;

We are grateful to Martin Oehmke, Loriana Pelizzon, and Guillaume Vuillemey for many helpful comments, as well as the participants in the research seminar of Banque de France. Funding: This work was supported by the grant Firr of Agence Nationale de la Recherche, ANR-18-CE26-0015-01 and the EUR grant, ANR-17-EURE-0001. The views expressed in this paper are those of the authors and do not represent those of the Banque de France or the Eurosystem.

NON-TECHNICAL SUMMARY

The 2009 G-20 Pittsburgh summit has been pushing for profound changes in the organization of markets for derivatives to limit the complexity and opacity of contracts between financial institutions and to better control contagion effects. For that purpose, regulators mandated the use of Central Counter-Parties (CCPs) for transactions on major standardized derivatives. The main economic function of a CCP is to insure each party in a transaction against the default of its counterparty -the counterparty risk- during the whole life of the derivative contract. CCPs are thus called to play a crucial role to safeguard financial stability. Leaving aside political concerns, there is an economic debate regarding the appropriate level of competition for central clearing. Central clearing generates network effects and presents features of natural monopoly calling for a single CCP clearing similar assets. Furthermore, competition between CCPs could lead to a race to the bottom regarding their risk management practices, potentially generating instabilities. The benefits of a single CCP, however, may be outweighed by monopoly rents. Weighing the benefits and costs of competition between CCPs is not easy explaining why there is no unanimous regulatory doctrine between the US and the EU.

To shed light on the effect of the multiplicity of CCPs, we investigate how major EU dealers effectively choose the CCPs on which they clear their transactions. These dealers are members of the two EU CCPs clearing three main CDS indices and use them alternatively for clearing their transactions. We test whether their choice is influenced by CCPs' fees, the cost of exposure to the CCP, and the cost of collateral. These factors depend on the CCPs' risk management policies, in particular the setting of margins and contributions to the default fund and their adjustment to the market conditions. According to our results, the major dealers in our sample are not so much concerned with collateral costs but rather care about the soundness of the CCPs. This suggests CCPs have no incentives to engage in race-to-the-bottom policies to attract major dealers.

Our analysis uses transaction data reported under EMIR to Banque de France. The 12 dealers from the study are members of the two EU CCPs, LCH SA and ICE-EU, and all of them except one are major systemic institutions. When a pair of such dealers enters into a transaction, it must choose a CCP to clear it. Descriptive statistics highlight that the choice of CCP is segmented since a substantial proportion of dealers' pairs, around 35%, always choose to clear at a single CCP. They also indicate that dealers do not seem to optimize the additional cost of collateral stemming from clearing at two CCPs. A simple test of dealers' choice of CCP based on the sign of their positions[3] shows that they do not seem to choose their CCP to decrease their position. Furthermore, as Figure 1 depicts, the current market structure with two CCPs generates up to €35bn more of dealers' positions in absolute value for the largest CDS index compared to a hypothetical market structure with a single CCP.

We build and estimate a reduced form model to investigate the determinants of the CCP's choice by dealers. The model assumes pairs' decisions result from an evaluation and comparison of the costs of clearing on each CCP. These costs fall into three categories: fees, the cost of exposure to the CCP, and the cost of collateral. Which CCP is chosen by a pair significantly depends on the size of the transaction being cleared, two indicators on the CCPs' robustness, the dealers' squared positions, and the volatility index. It does not relate to the buyer and seller's positions. The absence of significant relation between buyer or seller's positions[4] and the choice of CCP suggests that collateral costs do not drive this latter.

[3] A dealer's position at a CCP is the notional value of its whole cleared portfolio.

[4] We do not have access to the cost of collateral nor the margins and proxy it with the dealers' positions.

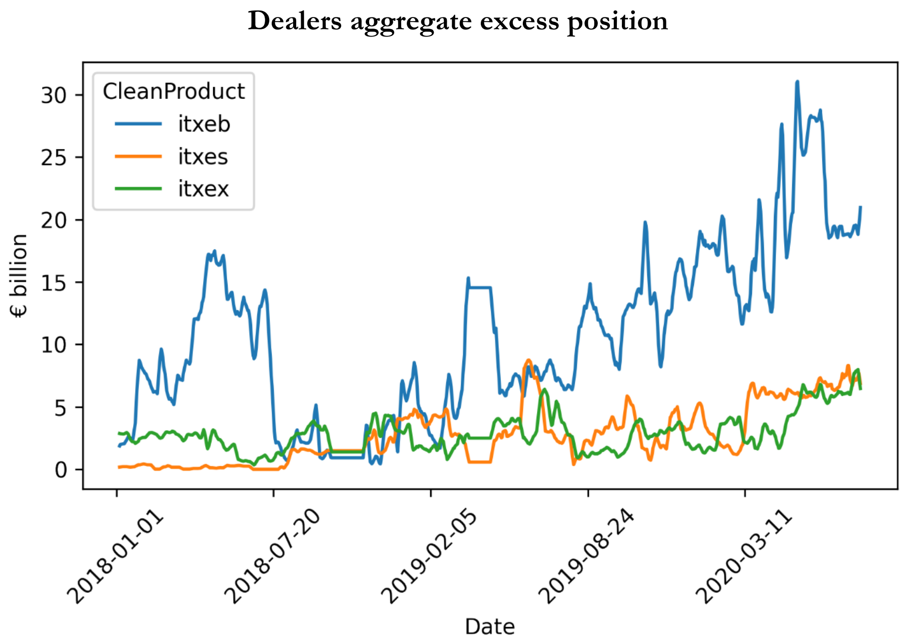

Figure 1: The figure presents the evolution of the excess position by product summed over dealers in the sample. The sample period runs from 2018Q3 to 2020Q3. The excess position provides a crude measure of fragmentation by computing the additional positions that arise from clearing at two CCPs instead of a hypothetical market structure with transactions cleared at a single CCP.

Sur le choix des contreparties centrales dans l'UE

RÉSUMÉ

De nouvelles réglementations promeuvent le rôle des contreparties centrales (CCP) en tant qu'assureurs du risque de contrepartie afin de stabiliser les marchés de produits dérivés. En nous concentrant sur la demande, nous étudions comment des paires de « dealers » choisissent la CCP sur laquelle ils compensent une transaction donnée. Nous utilisons des données de transaction sur trois principaux indices de CDS et nous nous concentrons sur les principaux « dealers » qui sont membres des deux CCP actives dans l'UE. L'analyse descriptive montre que les dealers n'optimisent pas leurs positions entre les CCPs. Dans un second temps, nous construisons et testons un modèle en forme réduite du choix de CCP. La différence de taille de transaction, deux indicateurs de robustesse et des activités de la CCP, les positions au carré pour tenir compte de l'aversion au risque des dealers et la volatilité du marché affectent ce choix, mais pas le coût du collatéral, approximé par les positions des dealers.

Mots-clés : contreparties centrales, compensation centrale, dealers, collatéral.

---

1 Introduction

The 2009 G-20 Pittsburgh has been pushing for profound changes in the organization of markets for derivatives to limit the complexity and opacity of contracts between financial institutions and to better control contagion effects. For that purpose, regulators mandated the use of Central Counter-Parties, hereafter CCP,[1] for transactions on major standardized derivatives. The main economic function of a CCP is to insure each party in a transaction against the default of its counterparty -the counterparty risk- during the whole life of the derivative contract.[2] CCPs are thus called to play a crucial role to safeguard financial stability.

Leaving aside political concerns, there is an economic debate regarding the appropriate level of competition for central clearing. Central clearing generates network effects and presents features of natural monopoly calling for a single CCP clearing similar assets. Furthermore, competition between CCPs could lead to a race to the bottom regarding their risk management practices, potentially generating instabilities. These benefits, however, may be outweighed by monopoly rents. Weighing the benefits and costs of (limited) competition between CCPs is not easy,[3] explaining why there is no unanimous regulatory doctrine between the US and the EU. In the US, the Department of Justice (2007) advocates for a single CCP clearing futures, or at least for a full "interchangeability", which would have similar effects. On the opposite, the European Market Infrastructure Regulation (EMIR 2012) only mandates central clearing for products that are cleared by at least two CCPs authorized in the EU.[4]

To shed light on the effect of the multiplicity of CCPs, we investigate how major EU dealers effectively choose the CCPs on which they clear their transactions. Specifically, these dealers are members of the two EU CCPs clearing three main CDS indices and use them alternatively for clearing their transactions. We test whether their choice is influenced by CCPs' fees, the cost of exposure to the CCP, and the cost of collateral.

[1]A glossary summarizes the definitions of terms highlighted in red.

[2]For a comprehensive description of central counterparties, see Pirrong (2011). CCPs are ancient institutions. Vuillemey (2019) analyzes the economic benefits due to the creation of the Caisse de Liquidation des Affaires en Marchandises in Le Havre (France) in 1882 by traders on coffee futures.

[3]The Committee on Payment and Settlement Systems (part of BIS) (2010) discusses the lessons to draw from the notions of horizontal and vertical differentiation used in industrial organization.

[4]However, Coeuré (2014), an EU regulator, voiced concerns that competition between CCPs could lead to a race to the bottom. In the US landscape, Wolkoff and Werner (2010) show how the respective histories of SEC and CFTC regulators have shaped the competition between CCPs on different asset classes, with a monopoly on options and oligopolies on commodities.

These factors depend on the CCPs' risk management policies, in particular the setting of margins and contributions to the default fund and their adjustment to the market conditions. According to our results, the major dealers in our sample are not so much concerned with collateral costs but rather care about the soundness of the CCPs. This suggests CCPs have no incentives to engage in race-to-the-bottom policies to attract major dealers.

Our analysis uses transaction data reported under EMIR to Banque de France. The 12 dealers from the study are members of the two EU CCPs, LCH SA and ICE-EU,[5] and all of them except one are major systemic institutions (G-SIB banks as defined by the Financial Stability Board). When a pair of such dealers enters into a transaction, it must choose a single CCP to clear it. Descriptive statistics highlight that the choice of CCP is segmented since a substantial proportion of dealers' pairs, around 35%, choose to clear at a single CCP. They also indicate that dealers do not seem to optimize the additional cost of collateral stemming from clearing at two CCPs. A simple test of dealers' choice of CCP based on the sign of their positions[6] shows that they do not seem to choose their CCP to decrease their position. Furthermore, according to our calculations, the current market structure with two CCPs generates up to €35bn more of dealers' positions in absolute value for the largest CDS index compared to a hypothetical market structure with a single CCP.

We build and estimate a reduced form model to investigate the determinants of the CCP's choice by dealers. The model assumes pairs' decisions result from an evaluation and comparison of the costs of clearing on each CCP. These costs fall into three categories: fees, cost of exposure to the CCP, and the cost of collateral. The main results of our estimations are as follows.

Which CCP is chosen by a pair significantly depends on the notional of the transaction being cleared, two indicators on the CCPs' robustness, the dealers' squared positions, the volatility index, and does not relate to the buyer and seller's positions. The interpretations are the following ones. The choice of CCP depends on the notional of the transaction due to differences in fee policies between the two CCPs. The first CCP's indicator is the Default Fund to Cover2 ratio, defined as the default fund over the largest stress loss (called the Cover2), which measures its resilience to members' defaults. The ratio is significant

[5] This eliminates ICE-US, which has a low market share in the EU and is only used by pairs involving a US dealer.

[6] A dealer's position at a CCP is the notional value of its whole cleared portfolio.

and positive in all our specifications: pairs choose relatively more a CCP whose ratio is higher relative to the other. The second CCP's indicator is the prefunded ratio, defined as prefunded resources (default fund and initial margins) over the CCP's open interest. This ratio is significant and negative, suggesting that dealers interpret an increase in prefunded resources relative to the CCPs' positions as an adverse change in the pool of the CCP's members or products and not as an increase in the robustness of the CCP stemming from a stricter policy. Dealers' squared positions at CCPs tend to negatively relate to the choice of CCP, which suggests dealers are averse to holding large positions at CCPs, mostly because they could lose their contribution to the default fund in case of failure from another member of the CCP. Finally, the absence of significant relation between buyer or seller's positions[7] and the choice of CCP suggests that collateral costs do not drive this latter. As the requested collateral due to the observed transaction at a given date is computed based on the whole portfolio, the variations of collateral costs for the buyer and seller due to a new transaction depend on their positions. Such effect holds whether CCPs have identical collateral policies or not: having different positions at the two CCPs should matter to a trader seeking to minimize the cost of collateral. Extensions with an alternative measure of the costs and positions aggregated across products corroborate the absence of relation between collateral costs and the choice of CCP. They also hold whether the decision is assumed to be made by the pair (by considering the total costs of the pair) or only by the buyer or seller.

Related literature The paper relates to studies on the cost of collateral, the comparison between central and bilateral clearing, and the robustness of financial infrastructures.

The advantages of central clearing over bilateral clearing are subject to debate. A large part of the literature focuses on collateral costs and on what is referred to as netting efficiency. In their theoretical contributions, Duffie and Zhu (2011), Cont and Kokholm (2014) compare the collateral costs under bilateral and central clearing. They show that the need for collateral is minimized when a single CCP clears all derivatives across all asset classes. The results, however, assume no frictions. In particular, they are based on a correct assessment of the portfolio risks. Due to the difficulties of assessing the risks of a portfolio composed of assets of different nature, regulation limits CCPs in using netting across such assets and compels them to segregate the margins requirements by asset class. Our analysis considers the CDS asset class. Anderson and Joeveer (2014)

[7] We do not have access to the cost of collateral nor the margins and proxy it with the dealers' positions.

compare bilateral clearing, central clearing per segment, and global central clearing in the presence of frictions due to geographic or asset class segmentation. A trade-off between local and global CCPs arises, as a global CCP requires less collateral than the local ones due to improved netting but accepts only high-quality collateral. In our analysis, the trade-off does not arise since the two CCPs are global and accept collateral of similar quality. These studies do not account for the impact of the clearing setting on investors behaviours (except indirectly for the last one). Central clearing may give traders incentives to increase their positions, hence potentially increasing aggregate risk (Biais, Heider, and Hoerova 2012). Two recent papers study the impact of these moral hazard effects on banking lending behaviour (Arnold 2017) or on how CCPs capital and allocation rule should be set to cope with moral hazard in the presence of correlated defaults (Cucic 2021).

Empirical studies on collateral costs and the impact of clearing obtain somewhat different results depending on the financial institutions considered. Using position data from the CDS market, Duffie, Scheicher, and Vuillemey (2015) show that central clearing lowers collateral demand for the main dealers who are mainly intermediaries. In an empirical study on the decision to clear CDS on sovereign bonds (French, German, and Italian) for which clearing is not mandatory, Bellia, Girardi, Panzica, Pelizzon, and Peltonen (2019) provide results suggesting the opposite for non-clearing members: the proportion of transactions they centrally clear is small, which indicates a larger cost for central rather than bilateral clearing. According to our results, the dealers in our sample significantly clear the index that is not subject to clearing obligation. Furthermore, equalizing their positions at the two CCPs to reduce collateral requirements does not seem to drive their choice between the two CCPs. Our results bear on dealers, who already take advantage of the most of netting within each CCP. Finally, Benos, Huang, Menkveld, and Vasios (2021) highlight a difference in the transacted prices between the US and EU CCPs, which they call the CCP basis. They interpret this basis as stemming from collateral costs. They arise because of the asymmetry in clients' demands between the two markets. This compels dealers to bear a long position on one CCP and a short one on the other. We also document substantial fragmentation of positions between ICE-EU and LCH SA on CDS indices. However, the fragmentation arises inside the same regulatory area (the EU), hence cannot be due to frictions between the two markets.

Finally, bilateral and central clearing also change the exposures to counterparties. Ghamami and Glasserman (2017) compare in detail central and bilateral clearing by taking into account not only the differences in collateral requirements but also capital charges. These charges arise from the exposures to counterparties, contracting institutions under bilateral clearing and CCPs under central clearing. Their simulations show that, in some cases, central clearing is more costly due to higher capital charges. In our model, the clearing costs at the two CCPs include measures of the costs of exposure at each of them. These measures turn out to be significant.

There is little empirical research on CCPs' policies, their safety, and the impact of competition. While Zhu (2011) documents stark competition in fees between European CCPs clearing equity, Abruzzo and Park (2014) study how expected changes in products volatility affect the initial margins set by CME, a major CCP on futures, and analyze competition in margins between CME and ICE. They show that margin requirements react to the margin difference between the two CCPs, suggesting competition in margins. Our analysis differs as we focus on the choice of CCP from major dealers, who are members of the two main CCPs on CDS, using detailed transaction data by pairs of dealers. Armakola and Laurent (2015) assess the soundness of the members of 8 European and 5 US CCPs. They show a strong heterogeneity in the distributions of the members' credit ratings, suggesting differences in screening and pricing policies generating sorting. Finally, two recent papers study the soundness of CCPs and the "breaches" that occur when a member cannot meet a margin call. Paddrik and Young (2021) introduce a novel method to assess CCP counterparty risk. Their model estimates the likelihood of breaches in prefunded resources based on the regulatory disclosure from IOSCO. We use the same data to assess CCP risk but do not model explicitly the likelihood of breaches. Finally, Grothe, Pancost, and Tompaidis (2021) provide a detailed empirical study of margins, their evolutions, and the occurrence of "breaches". One of their main results is that the occurrence of breaches differs across CCPs and that CCPs do not engage in race-to-the-bottom policies. All these papers relate to our results showing that indicators on CCPs robustness and activities differ across CCPs and partly explain dealers' choices between two CCPs.

The plan is as follows. Section 2 describes the costs related to clearing. Section 3 presents the data from the CDS interdealer market and analyzes the main characteristics of dealers' positions. Section 4 presents the reduced form model of clearing costs to guide the estimations while Section 5 estimates the determinants of choices by pairs of dealers who clear on several CCPs. Section 6 concludes. Appendix Section 7 provides a glossary describing technical terms and gathers the remaining tables and figures.

2 The central clearing process and its costs

The objective of the paper is to investigate how two institutions clearing a derivative contract on a CCP choose that CCP. The empirical analysis bears on interdealer transactions from the CDS market in the EU. Two EU CCPs are authorized to clear CDS in the EU, LCH SA and ICE Clear Europe (hereafter ICE-EU), while ICE Clear Credit (a US CCP) is recognized as a third-country CCP. We focus on traders who are Clearing member of at least two CCPs, hence can directly clear at them. In practice, such traders are major investment banks, called dealers, acting as intermediaries in OTC markets. In the derivative market, the literature commonly refers to the group of G16 dealers[8] although not all of them act as such on credit derivatives. The analysis builds on an assessment of the cost of clearing. These costs are crucial in determining whether institutions have incentives to clear (when they have the choice) and on which CCP they clear. The focus of this paper is on the latter decision. The costs for a particular dealer involved in a transaction at a particular date may differ across CCPs, hence may influence its preferences over which CCP to choose for clearing, and similarly for the counterparty involved in the transaction. These differences drive the model proposed in Section 4 and estimated in Section 5.

To understand the benefits and costs of clearing, let us briefly recall the main features of the clearing process. After two institutions have traded a derivative contract, either bilaterally or through an exchange, they can choose (or are mandated) to clear their contract through a CCP. The main purpose of a CCP is to provide insurance against counterparty risk. It stands as the counterparty of both the buyer and the seller: the initial contract between the two parties is canceled and replaced by two new contracts from each counterparty to the CCP. The institutions' exposures to their counterparties are thus transformed into an Exposure to the CCP. In addition, the current practice is to net the positions of a member on a given class of derivative thereby decreasing the exposure of a member who is both long and short. As a result of these operations, the CCP pools the idiosyncratic parts of members' risk but is subject to their failure. To manage this risk, it requires collateral from its members: initial margins (IM) at the onset of a contract to account for the cost of liquidation in case a counterparty defaults, daily cash variation margins that stick to the contract changes in value, and contributions to a default fund (DF). Unlike initial and variation margins, the default fund is a mutualized

[8] As Abbad et al. (2016) mention, G16 dealers are Bank of America, Barclays, BNP Paribas, Citigroup, Crédit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JPMorgan Chase, Morgan Stanley, Nomura, Royal Bank of Scotland, Société Générale, UBS, and Wells Fargo.

resource: CCPs can draw into it to replenish a member's losses in excess of initial margins.[9] The potential loss of the contributions to the default fund and the possibility of CCP's bankruptcy determine a member's exposure to the CCP. As we see from this description, the CCP's collateral policy affects its members in two ways, positively through the quality of the insurance provided by the CCP against counterparty risk and negatively through individual collateral costs. Netting decreases the requested collateral.

Let us describe more precisely the clearing costs for a particular dealer clearing a transaction at a given CCP. The costs fall into three categories: fees, the cost of exposure to CCPs, and the cost of collateral. The next section presents the sample of transactions and statistics on the variables that could influence these costs.

Exposure to the CCP The quality of the insurance depends on the total amount (and quality) of collateral received relative to the risks undertaken by the CCP. Members' exposures to CCPs mostly come from their contribution to the default fund which implies capital charges on it (for a dealer subject to Basel regulation) as well as the assessed CCP's counterparty risk and activity. Our estimation in Section 5 bears on two measures to assess the risk of a CCP. These measures are computed over all the products and members in a given asset class using the following variables: the default fund (DF) and initial margins (IM) already defined, the open interest (OI), and the Cover2 (or largest stress loss). Open interest is the notional of the cleared transactions at the CCP, also defined as the gross outstanding. Cover2 is defined as the maximum of the largest loss caused by the default of the first or the second and third largest members in excess of their initial margins. The measures are computed from CCPs quarterly variables available in the IOSCO quantitative disclosure for the three CCPs authorized to clear CDS in the EU.

The first measure is the Default Fund to Cover2 ratio, defined as the default fund over Cover2. The regulation requires the default fund should withstand extreme shortfalls from the Cover2 scenario. The ratio measures the soundness of CCPs but depends on their assessment of Cover2. Figure 1 presents the ratio for the three CCPs and shows a

[9] CCPs specify how members' losses exceeding their margins are allocated between participants, see Elliot (2013) on such loss-allocation rules (often referred to as waterfall). In addition, the regulation grants the right for CCPs to require additional collateral from their members if the former pre-funded resources are not sufficient to cover losses, as happened recently after the failure of a rogue trader on the Nasdaq OMX (see the Financial Times (2018) paper for more information), or after the failure of a securities firm on the Korea Exchange, e.g. Vaghela (2014).

large heterogeneity and variations except for LCH-SA. These might be due to differences and changes in the computation of the Cover2. In particular, the level of the Default Fund to Cover2 ratio for ICE-EU jumps over the period. It is likely due to a change in the risk model used to compute the Cover2 even though it looks temporary.

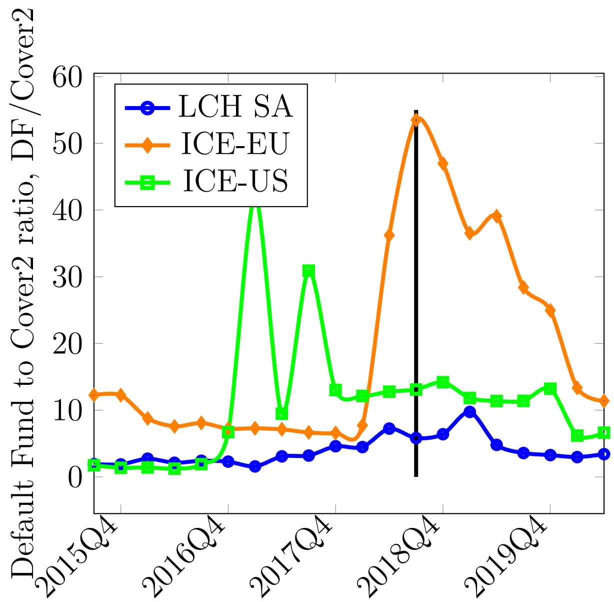

Figure 1 – CDS, evolution of the Default Fund to Cover2 ratio

The figure plots the quarterly evolution of LCH SA, ICE EU, ICE US Default Fund to Cover2 ratios, DF/Cover2. Source: CCPs IOSCO quantitative disclosure from 2015$Q3$ to 2020$Q2$. The sample used in the estimation starts at the right of the black line.

The second measure is the prefunded ratio, defined as prefunded resources (DF plus IM) over the open interest. Prefunded resources are mostly composed of the initial margins, which are less subject to the CCP's choice than the default fund and Cover2; furthermore, open interest is observed and very large. Both elements explain why the ratio varies much less than the Default Fund to Cover2 ratio. Prefunded resources depend on the mix of clients, members, and products of the CCP. The level of the ratio thus hinges on the risk policy (selection of clients, prudent behavior in the computation of margins). The variations of the ratio depend on the variations in the riskiness of the members and of the cleared trades, provided margins and default contributions are adjusted consistently by the CCP. Hence the ratio does not measure the CCP's soundness but rather assesses both its risk policy (a high ratio indicating a prudent policy) and the riskiness of the pool of its members and products (a high ratio indicating a high-risk level).

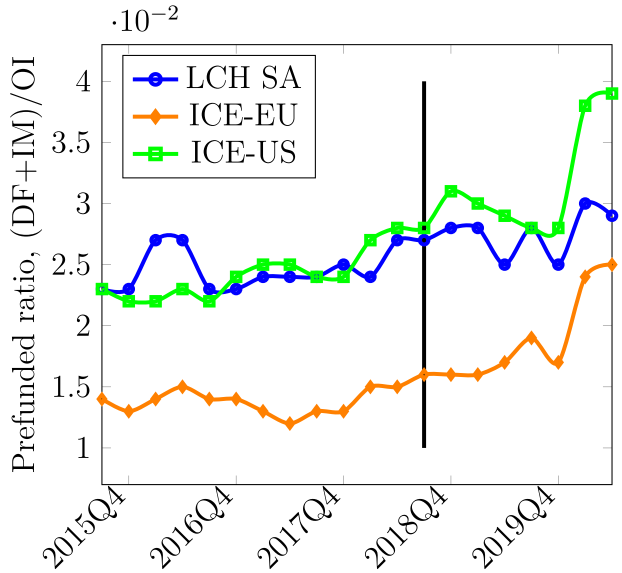

Figure 2 – CDS, evolution of the prefunded ratio

The figure plots the quarterly evolution of LCH SA, ICE EU, ICE US prefunded ratios, (DF+IM)/OI. The sample used in the estimation starts at the right of the black line. Source: CCPs IOSCO quantitative disclosure from 2015Q3 to 2020Q2.

We also add to these measures the dealers' squared positions at the CCP. Assuming dealers are risk-averse, this measure accounts for the (ex-post) possibility of losing default fund contributions caused by other members' default.

Individual collateral costs CCPs pay back the collateral pledged in initial margins or default fund to members when there is no default. Individual collateral costs include the liquidation costs of illiquid securities to purchase liquid collateral or the opportunity cost of frozen collateral at the CCP.[10] This cost depends on the transaction and position of each dealer. We assume the cost per unit of collateral to be constant and identical across CCPs.[11] Therefore, the members' cost of collateral is proportional to the required margins. In practice, CCPs compute margins on the whole portfolio cleared in the CDS asset class[12] since netting of positions between asset classes is prohibited for CDS (as Duffie

[10]According to Ghamami and Glasserman (2017), the BIS measures cost per unit of collateral $c_l = 0,7$ percent. In their simulations, Anderson and Joeveer (2014) evaluate the initial margins by 2.33 multiplied by the standard error of the absolute value of the notional.

[11]The two CCPs considered here are global and accept similar collateral baskets, each included in the ECB basket of securities eligible for refinancing.

[12]An asset class is composed of similar products, here CDS. CCPs use internal models for computing the margins, accounting for the payoffs' correlation (multi-netting). In the absence of information, using positions means that we abstract away from the impact of correlation on margins.

and Zhu (2011) raise). Therefore, the collateral cost on a single transaction depends on the inventory of outstanding transactions in the asset class. We have no access to this inventory and use the (net) position as a proxy. The dealer's daily Position by product at a given CCP is defined as the sum of all dealer's transactions, positive for buy and negative for sell, at the CCP with all other institutions including dealers. They are for the dealer's account, not for the account of its clients.[13] Clearing transactions affect positions as follows. Consider a dealer involved as a buyer in a transaction with notional x. Clearing the transaction on a CCP where the dealer's position is ν changes its position into $\nu + x$. As a result, the absolute position following the transaction may be increased (if ν is positive) or decreased (if ν is negative). Similar remarks apply to the seller in the transaction whose position is changed by $-x$. Therefore collateral requirements based on these positions may increase or decrease. We exploit this remark to develop a simple test of CCPs' choice (see the end of Section 3). Finally, to account for possible discrimination, we include the dealer's spread as a variable, as it represents the riskiness of the dealer. This riskiness is likely to affect the amount of collateral required by CCPs. Specifically, we work in Sections 4 and 5 with the deviation of the dealer's spread to the average dealers' spread, denoted by *Spread*.

Fees Members' fees are made of a fixed and a variable part, which is proportional to their total Notional cleared by the CCP. As regards the clearing of CDS, LCH SA offers three schedules. Two are piece-wise linear with a positive minimum and a (high) upper bound and the third is a fixed price schedule. ICE-EU offers a unique linear schedule, steeper than LCH SA ones but with a null minimum. As an example at end-2021, LCH SA clearing members' variable fees amount to €3.5 per million of notional for Index CDS and €10 per million for single-name CDS. ICE-EU fees for members respectively amount to €5 and €10 per million of notional. The fees are generally higher for clients than for members.

3 Description and statistics of the dealers' sample

The empirical analysis bears on interdealer transactions in the CDS market. The sample consists of EU dealers' transactions clearing three major CDS indices on EU CCPs: Itraxx

[13]When a member clears for a client, the client bears the collateral cost and may choose the CCP.

Europe, Itraxx Crossover, and Itraxx Senior Financials. The selected EU dealers are members of the two CCPs (LCH SA and ICE-EU), implying that they have the choice of the CCP on which they clear their transactions. This choice is not affected by regulatory motives since both dealers and CCPs are based in the EU. Finally, the choice is effective since no CCP has a clear monopoly on the three indices mentioned (in contrast with many other CDS contracts). This feature makes feasible the econometric analysis on the choice of CCP.

This section first presents the data and cleaning process then describes statistics on the positions in our sample, which are used as a proxy for collateral costs as explained in detail in the next section. Finally, preliminary evidence suggests that these collateral costs do not drive the choice of CCP.

3.1 Data collection and cleaning

We use transaction and position data provided by DTCC to Banque de France under EMIR regulation. Banque de France access covers all transactions entered by an EU legal entity if the underlying of the derivative contract is a French reference. This includes as well EU index CDS because at least one French reference falls in their composition. We retrieve from DTCC two daily reports, an *activity* report that accounts for every new transaction entered during the day, and a *state* report, that records the set of transactions active at the end of the day. The last report allows us to compute the daily position by product and dealer. We match it with the trade activity report. Our sample of transactions covers two years of trading, from 2018Q3 to 2020Q3. We describe precisely the cleaning procedure in Appendix 7.1.

In addition to the cleaning procedure, we apply a series of filters to generate the dataset used in the estimations. First, we keep interdealer transactions for their own account cleared at CCPs. Since we study the pairs' choices and not the choice of membership, dealer-to-clients transactions are not included. Furthermore, client clearing is anecdotal at LCH SA,[14] making the analysis on the choice of membership in the CDS asset class almost infeasible. Second, we restrict the analysis to three CDS indices, Itraxx Europe, Itraxx Crossover, and Itraxx Senior Financials since no CCP has a clear monopoly on them. The first two products are subject to the clearing obligation, but not the third

[14]Initial margins provided by the clients at LCH SA account for only 3% of its total. Source: IOSCO reporting 2019Q1.

one. Figure 4 in the Appendix presents the respective market shares at LCH and ICE (both EU and US) in open interest. While the three Itraxx above and the two major US indices are eligible for clearing at all CCPs, CCPs' market share split evenly for the three EU indices only. Third, we remove transactions entered on roll dates, March and September the 20th. These dates correspond to changes in the composition of CDS indices. Because investors often wish to hold a position on the most recent ("on the roll") index, a significant share of existing transactions is replaced with new transactions at these dates. We remove those transactions since the choice of CCP for these trades is persistent with the one at the inception of the original contract. Fourth, as explained in the model, we drop transactions that change the sign of the buyer or seller positions towards the CCP. Fifth, we exclude pairs that include a US dealer. Table 9 in the Appendix reports the active dealers' affiliated entities in the sample and their respective jurisdictions. Main jurisdictions include the Euro-area (EA), GB, and the US. However, we do not observe all transactions and positions from US dealers since they are not subject to the reporting obligation from EMIR regulation. Doing so, we discard the third CCP authorised to clear CDS in the EU, ICE-US, because almost all interdealer transactions it clears involve a US dealer. Sixth, we exclude pairs of dealers that always choose a single CCP since they are not informative on the choice in the estimations. Table 1 presents the number of CCPs chosen by dealers' pairs in percentage, and the total numbers of pairs clearing the product. A large percentage of pairs of dealers, from 25.5% to 45.5%, clear their trades at a single CCP.

Number of CCPs	1	2	3	Number of pairs
Itraxx Europe	25.5%	42.8%	31.7%	98
Itraxx Crossover	38.3%	38.3%	23.4%	107
Itraxx Senior Financials	45.5%	41.8%	12.7%	79

Table 1 – Number of CCPs chosen by pairs of dealers, percentage

EMIR dataset on inter-dealer transactions. For each product, the table presents the number of CCPs used by pairs of dealers in percentage, and the total number of pairs clearing the product. For example, 31.7% of pairs of dealers cleared Itraxx Europe at three CCPs during the period.

Therefore, the final sample restricts to transactions from pairs of EU dealers cleared at ICE-EU and LCH SA. These CCPs are the two main CCPs active in the European CDS market. The sample includes 12 dealers which are all members of these two CCPs and choose more than one CCP along the 2018$Q3$ to 2020$Q3$ period. It includes 54 different pairs of dealers.

3.2 Dealers' positions

As explained in the previous section, dealers' positions at each EU CCP are used as a proxy for collateral. Recall that a dealer's position for a product at a given CCP is defined as the sum of all the dealer's signed positions at the CCP (positive for buy and negative for sell), for its own account. Positions can be also computed over different products and counterparties. We present these positions aggregated over dealers in the cross-section.

Table 2 presents the distribution of dealers' positions at EU CCPs by product. They exhibit substantial heterogeneity between dealers for all indices. For example, the median position on the Itraxx Europe is €-137mn, while the first and third quartiles stand respectively at €-2050mn and €1362mn.

Itraxx	Europe	Senior Financials	Crossover
Mean	-1544.40	128.26	-174.47
St dev	9276.62	1188.59	1790.19
Min	-66834.03	-7654.24	-8403.42
q0.25	-2050.18	-428.63	-618.42
Median	-137.27	-2.45	-73.80
q0.25	1362.28	557.68	398.76
Max	23314.60	5555.65	11678.47

Table 2 – Distribution of dealers position in €mn at EU CCPs by product

The table presents the distribution of dealers' positions at EU CCPs by product. Positions are pooled between dealers, CCPs, and dates. The sample period runs from 2018Q3 to 2020Q3. Sample of EU dealers active at the two EU CCPs.

Table 3 reports the ratio of daily dealers' transactions over their position at CCPs. These statistics provide an order of magnitude on how daily transactions might change the dealers' positions, and ultimately their collateral costs. The table reports the distribution of dealers' daily net and gross notionals over their position in absolute value. The daily net notional is the absolute value of the summed transactions notional over the day, which are positive for buyers and negative for sellers. In contrast, the gross notional is the sum of transactions notionals in absolute value. By construction, the gross notional is larger than the net notional. Dealers' median ratio stands respectively at 4% for net and 7% for gross notionals. Therefore, the table shows that daily transactions significantly change dealers' positions at their CCPs, which can ultimately influence their choice of CCP provided the cost of collateral is one of its determinants.

	Daily Net transactions	Daily Gross transactions
	Over position	
Mean	0.24	0.42
St dev	4.71	5.25
Min	0.00	0.001
q0.25	0.01	0.03
Median	0.04	0.07
q0.75	0.12	0.22
Max	583.3	583.3

Table 3 – Daily dealers' transactions over positions at EU CCPs

The Table presents the distribution of dealers' transactions (notional values) cleared at a given CCP over the absolute value of their positions at this same CCP. Data are pooled between products, dates, and CCPs. Daily net transactions refer to the sum of transactions cleared during a day, positive for buy and negative for sell transactions. Daily gross transactions notional refer to the sum of transactions in absolute value cleared during a day.

3.3 Excess positions, collateral costs, and choice of CCP

We first measure how much positions would decrease in absolute value if dealers were clearing at a single CCP. The decrease is null for a dealer whose positions are of the same sign, so the measure indicates whether dealers tend to be either long at both CCPs or short at both of them. Furthermore, it provides a crude assessment of the cost of fragmentation in terms of collateral that arise from clearing at two CCPs.

Notation To define the measure formally, we use the following notation: the two CCPs are indexed by $i = 1, 2$ and $\nu_{d,i}$ denotes the position at CCP$_i$ of dealer d on a day, with $d = b$ for the buyer in a transaction and $d = s$ for the seller. This notation is used in the remaining of the paper.

Consider a dealer whose positions are of opposite sign at the two CCPs, say $\nu_{d,1} > 0$ and $\nu_{d,2} < 0$ with $\nu_{d,1} + \nu_{d,2} > 0$. Clearing on a single CCP, the dealer's position would be $\nu_{d,1} + \nu_{d,2}$. Assuming the collateral cost identical on the two CCPs and proportional to the absolute value of the position, the collateral would be computed on $\nu_{d,1} + \nu_{d,2}$ instead of $\nu_{d,1} + |\nu_{d,2}|$. The saving on collateral costs is thus proportional to $2|\nu_{d,2}|$. More generally, define the dealer's *position in excess* as the sum of the absolute value of the dealer's positions diminished by the absolute value of the sum of the positions. The position in excess writes for dealer d:

$$2 \times \mathbf{1}_{\nu_{d,1} \times \nu_{d,2} < 0} \min\left(|\nu_{d,1}|, |\nu_{d,2}|\right). \tag{1}$$

Figure 3 presents the evolution of the excess position summed across dealers by product. The excess position is large in amount, reaching €35bn for the Itraxx Europe, and €7.5bn for the two other indices. The relatively large magnitude of excess positions appears to be driven by a few individual dealers. Table 10 in the Appendix presents the distribution of dealers' excess positions as a proportion of their position in absolute value aggregated at the two EU CCPs. The majority of the distribution lies close to zero for every product. The third quartiles ratios respectively amount to 0.63, 0.46, and 0.43.

In Benos et al. (2021), the CCP basis arises because dealers gather positions of opposite signs on two CCPs. However, their fragmentation stems from clients' geographic fragmentation between EU and US CCPs. We highlight a similar fragmentation in terms of positions in our paper but this fragmentation does not arise from geographic segmentation since the two CCPs and dealers are subject to the same EU regulation.

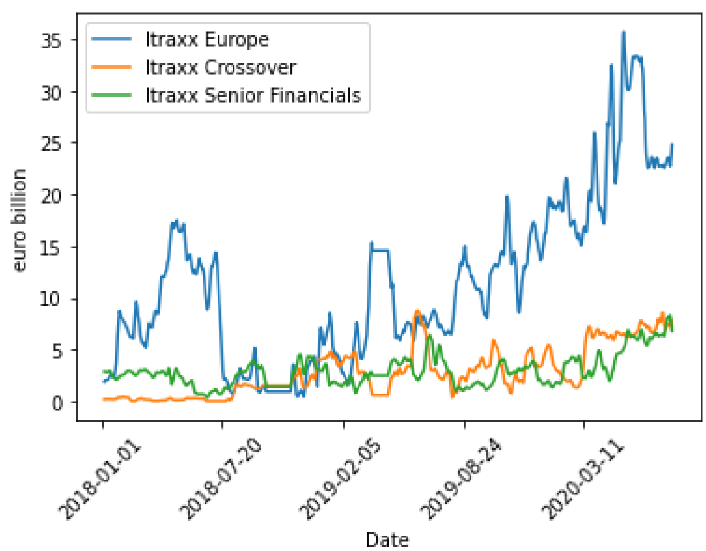

Figure 3 – Dealers aggregate excess position

The figure presents the evolution of the excess position by product summed over dealers in the sample at the two CCPs. The sample period runs from 2018Q3 to 2020Q3.

Finally, we present a simple test of pairs' choices based on the dealers' positions only. Transaction x changes the position of the buyer into $\nu_{b,i} + x$ and that of the seller into $\nu_{s,i} - x$. Observe that the buyer in the transaction (for which x is positive) may have a position of either sign. Therefore the absolute value of positions following the transaction may be increased (if $\nu_{b,i}$ is positive) or decreased (if $\nu_{b,i}$ is negative). If collateral requirements are based on these positions, they may increase or decrease. We exploit this remark to develop a simple test of CCPs' choice. Table 4 reports the proportion of times where pairs choose CCP_2 or CCP_1 depending on the sign of the buyer and seller's positions. Row 1 considers the case where clearing on CCP_2 diminishes the positions in absolute value for both dealers and clearing on CCP_1 increases them for both. Row 2 considers the opposite case. If dealers aim at decreasing their positions in absolute value to decrease the initial margins required by CCPs, one should observe different conditional frequencies, with larger values in row 1 than in row 2. Not only this is not the case but also the Fisher test rejects the null hypothesis that the two conditional distributions are identical, which may even indicate the result opposite to the one expected.

Conditional probability	By index	All indices	3 indices
$\mathbf{P}\left(2 \,\middle\vert\, \begin{cases} \nu_{s,2} > 0, \nu_{b,2} < 0 \\ \nu_{s,1} < 0, \nu_{b,1} > 0 \end{cases}\right)$	0.75	0.71	0.71
$\mathbf{P}\left(2 \,\middle\vert\, \begin{cases} \nu_{s,2} < 0, \nu_{b,2} > 0 \\ \nu_{s,1} > 0, \nu_{b,1} < 0 \end{cases}\right)$	0.81	0.78	0.78
Fisher test statistic	3.03	3.62	3.54

Table 4 – CCP choice conditional on the sign of net positions

The table reports the frequency of choosing CCP_2 or CCP_1 depending on the buyer and seller's positions in two cases. Row 1 (resp. Row 2) reports the proportion of transactions where the pair chooses CCP_2 when the signs of their positions could incite them to choose CCP_2 (resp. CCP_1). Positions are computed respectively at the product level for each transaction, for all indices, or on the three indices in the sample. For a Fisher test statistic larger than 1.96, we reject the null hypothesis that the two conditional probabilities have the same distribution. Reduced sample of EU inter-dealer transactions.

4 Modeling pairs' choices

This section models the costs of clearing introduced in Section 2. We derive from this section the specification used in the estimation. It is expressed as the difference in costs of clearing between the two CCPs.

Again, consider a pair of dealers who clears a given transaction after its negotiation. The involved buyer and seller must choose the same CCP while their interests may diverge. The benchmark model assumes that the pair chooses the CCP achieving the largest total benefits net of costs. Let us first consider each dealer in the pair separately.

Dealer's costs x denotes the positive notional of the transaction for the buyer. Specific benefits attached to a given CCP (e.g. geographical) are independent of the transaction x and are incorporated in pairs' fixed effects in the estimations. The costs are of three different types:[15] (1) fees, (2) the cost associated with the exposure to the chosen CCP, and (3) the opportunity cost to pledge collateral as initial margin and as contribution to the CCP default fund. The dealer's incremental cost due to clearing transaction x on CCP_i, with $i = 1, 2$, can be written as

$$\Delta F_i(x) + \Delta K_i(x) + \Delta C_i(x)$$

where $\Delta F_i(x)$ is the incremental fee, $\Delta K_i(x)$ is the incremental cost due to the exposure to CCP_i, and $\Delta C_i(x)$ is the incremental cost of collateral. Let us examine the three terms in turn.

(1) Fees. CCPs charge fees based on the yearly cleared transactions. For a linear schedule with fee f_i per unit, incremental fees associated with the transaction are given by:

$$\Delta F_i(x) = f_i x \tag{2}$$

for both the buyer and the seller. They do not depend on the yearly amount of dealers' transactions. We have no information on the schedules chosen by dealers. Therefore, we assume fees follow a linear schedule.

(2) Cost of exposure to the CCP. The cost of exposure (e.g. the capital charges and the cost of losing the contribution to the default fund) is computed on the yearly exposures so

[15] In practice, there are several other costs of clearing. We roughly follow the description in Ghamami and Glasserman (2017).

that the incremental cost $\Delta K_i(x)$ is unlikely to depend on the transaction x. The CCP's risk and activity are assessed through the Default Fund to Cover2 ratio, DF/Cover2, the prefunded ratio, (DF+IM)/OI, and the square of dealers' positions at each CPP introduced in Section 2. Furthermore, CCPs adjust their margins to the overall market conditions. In particular, they require higher margins in turbulent times. The ratios are thus affected by market volatility in a way that depends on the CCP's policy. To account for these adjustments, we include the volatility index Vstoxx as an explanatory variable. Overall, we assume the costs of exposure are identical across dealers.

This leads us to consider the following form for the cost of exposure to CCP$_i$:

$$\Delta K_i(x) = -\alpha \left(\frac{\text{DF}}{\text{Cover 2}}\right)_i - \beta \left(\frac{\text{DF+IM}}{\text{OI}}\right)_i + \zeta \nu_i^2 + \gamma_i \text{Vstoxx} \tag{3}$$

with ν_i the dealers' position at CCP$_i$. The buyer's and seller's incremental costs are identical.

As explained previously, the Default Fund to Cover2 ratio measures the robustness of the CCP. Hence we expect α to be positive. Consider now β. The prefunded ratio measures the level of prefunded resources per unit of CCP's open interest. A higher ratio may result from two effects. First, the CCP strengthens its policy and requires a higher level of collateral per unit, and, second, the pool of the CCP's members, clients, or products becomes riskier hence triggering an increase in the prefunded resources to cover the increase in risk. A larger ratio may thus indicate more robustness (safer policy), higher cost (higher margins), or more risk (riskier pool). The sign of β is thus ambiguous and will be interpreted according to the results. ζ is expected to be positive to reflect dealers' risk aversion. γ_i is expected to be positive and reflects the increase in the riskiness of CCP$_i$ in periods of higher volatility.

(3) Collateral costs. The dealer's collateral costs at CCP$_i$ are described by a function C_i of the positions. Recall that $\nu_{b,i}$ and $\nu_{s,i}$ denote the positions at CCP$_i$ respectively for the buyer and the seller on a day. Transaction x changes the position of the buyer into $\nu_{b,i} + x$ and that of the seller into $\nu_{s,i} - x$. So the incremental costs following transaction x are respectively equal to:

$$\Delta C_{b,i}(x) = C_i(\nu_{b,i} + x) - C_i(\nu_{b,i}) \text{ and } \Delta C_{s,i}(x) = C_i(\nu_{s,i} - x) - C_i(\nu_{s,i}).$$

A simple specification for C_i is a piece-wise linear function: $C_i^+(\nu) = c_i^+ \nu$ with $\nu \geq 0$

and $C_i^-(\nu) = -c_i^- \nu$ with $\nu < 0$. Due to the asymmetric distribution of CDS payoffs, CCPs are more exposed on dealers with negative positions than with positive ones, meaning that we expect c_i^- to be larger than c_i^+. We restrict to transactions x that do not modify the sign of the positions towards the CCP, i.e. $|x| \leq |\nu_i|$. In that case, the buyer's incremental cost is equal to $x(c_i^+ \mathbb{1}_{\nu_{b,i}>0} - c_i^- \mathbb{1}_{\nu_{b,i}<0})$ and similarly the seller's incremental cost is equal to $-x(c_i^+ \mathbb{1}_{\nu_{s,i}>0} - c_i^- \mathbb{1}_{\nu_{s,i}<0})$ for the seller. Using $\mathbf{1}_{\nu>0} + \mathbf{1}_{\nu<0} = 1$, we obtain

$$\Delta C_{b,i}(x) = -c_i x \mathbb{1}_{\nu_{b,i}<0} + c_i^+ x \text{ and } \Delta C_{s,i}(x) = c_i x \mathbb{1}_{\nu_{s,i}<0} - c_i^+ x, \tag{4}$$

where $c_i = c_i^+ + c_i^-$.

Consider dealers concerned with collateral costs only. With the linear specification of the collateral costs, the buyer whose positions at the two CCPs are of different sign prefers to clear on the CCP where its position is negative. Similarly, the seller prefers the CCP where its position is positive.

Different cost specifications for C_i lead to a different impact of the transaction on collateral costs. For example, if collateral costs are quadratic instead of linear in the positions, traders prefer to equalize their positions at the two CCPs by minimizing the 'gap' defined as the difference between a dealer's positions at the two CCPs.[16] Formally the *gap* for the buyer is defined by $\delta(\nu_b) = \nu_{b,2} - \nu_{b,1}$ and for the seller $\delta(\nu_s) = \nu_{s,2} - \nu_{s,1}$. A transaction increases or decreases a dealer's gap depending on its sign (assuming that the transaction does not affect the sign of the gap). For example, if $\delta(\nu_s) > 0$ and the pair chooses CCP_2 (resp. CCP_1), then the seller's gap decreases (resp. increases). Therefore, the seller's gap is expected to relate positively to the choice of CCP_2, and the buyer's gap negatively.

Finally, CCPs may discriminate between dealers according to their riskiness by requiring an additional margin specific to each dealer. The riskiness of a dealer is measured by the deviation of its spread to the average dealers' spread, denoted by *Spread*. Under discrimination, the add-on is increasing in the dealer's *Spread*. With a piece-wise linear specification for the add-on ($\alpha_i^+ \mathit{Spread}\, \nu_i$ if $\nu_i > 0$ and $\alpha_i^- \mathit{Spread}\, |\nu_i|$ if $\nu_i < 0$), following similar computations as for the collateral costs, we find that the incremental premia charged to the buyer and seller by CCP_i are equal to

$$-\alpha_i \mathit{Spread}_b \mathbf{1}_{\nu_{b,i}<0} x + \alpha_i^+ \mathit{Spread}_b x \text{ and } \alpha_i \mathit{Spread}_s \mathbf{1}_{\nu_{s,i}<0} x - \alpha_i^+ \mathit{Spread}_s x \tag{5}$$

[16] Under collateral requirements that are super-linear in the position, Glasserman, Moallemi, and Yuan (2016) indeed show that dealers equalize their positions at several CCPs.

where $\alpha_i = \alpha_i^+ + \alpha_i^-$ is positive under discrimination. As positive positions are less risky than negative ones for the CCP, we expect α_i^+ to be small relative to α_i^- and we will neglect it in the estimations.

Pairs' choice and baseline estimation Assume that pairs choose the CCP achieving the smallest total cost. The choice of CCP_2 instead of CCP_1 is increasing in the difference in the pair's incremental costs of choosing CCP_2 rather than CCP_1. Collecting terms in (2) (3), (4), and (5), the difference writes

$$2(f_1 - f_2)x \quad (6)$$

$$+2\alpha\delta\left(\frac{\text{DF}}{\text{Cover2}}\right) + 2\beta\delta\left(\frac{\text{DF+IM}}{\text{OI}}\right) - \zeta(\nu_{s,2}^2 - \nu_{s,1}^2) - \zeta(\nu_{b,2}^2 - \nu_{b,1}^2) - 2(\gamma_2 - \gamma_1)\text{Vstoxx} \quad (7)$$

$$+xc_1(\mathbf{1}_{\nu_{s,1}<0} - \mathbf{1}_{\nu_{b,1}<0}) - xc_2(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{b,2}<0}) \quad (8)$$

$$+x\alpha_1(\mathit{Spread}_s\mathbf{1}_{\nu_{s,1}<0} - \mathit{Spread}_b\mathbf{1}_{\nu_{b,1}<0}) - x\alpha_2(\mathit{Spread}_s\mathbf{1}_{\nu_{s,2}<0} - \mathit{Spread}_b\mathbf{1}_{\nu_{b,2}<0}) \quad (9)$$

where $\delta\,(\text{DF}/\text{Cover2})$ denotes the differences in the CCPs Default Fund to Cover2 ratios and $\delta\,((\text{DF+IM})/\text{OI})$ the differences in the prefunded ratios:

$$\delta\left(\frac{\text{DF}}{\text{Cover2}}\right) = \left(\frac{\text{DF}}{\text{Cover2}}\right)_2 - \left(\frac{\text{DF}}{\text{Cover2}}\right)_1, \;\delta\left(\frac{\text{DF+IM}}{\text{OI}}\right) = \left(\frac{\text{DF+IM}}{\text{OI}}\right)_2 - \left(\frac{\text{DF+IM}}{\text{OI}}\right)_1.$$

We estimate a discrete choice model (Logit) where the odds of choosing CCP_2 against CCP_1 by a pair (b, s) is the above difference plus fixed effects. From the above expressions, the explanatory variables are the notional of transaction x to control for the difference in fees, the difference in the Default Fund to Cover2 ratios, the difference in the prefunded ratios, the difference in squared positions, the volatility index, proxies reflecting the variation in pair's collateral costs at each CCP and the differences in the dealers' spread weighted by their positions at each CCP to account for discriminatory pricing.

The interpretation of the sign and significance of the coefficients is as follows:

(6): the coefficient on x is null if there are no significant differences in fees, positive (resp. negative) if CCP_1 charges higher (resp. lower) fees than CCP_2.

(7): the coefficient on the difference in Default Fund to Cover2 ratios is positive if dealers value CCP's robustness. The coefficient on the difference in prefunded ratios can be positive or negative. As discussed earlier, a positive β indicates a safer policy and a negative one a riskier pool of members, clients, or products. The coefficient on the risk aversion ζ is expected to be positive if dealers are averse to holding large positions on CCPs. The coefficient on the Vstoxx reflects different reactions of the CCPs to market conditions: a positive (resp. negative) value for $\gamma_2 - \gamma_1$ means that CCP_2 increases less (resp. more) than CCP_1 its collateral requirement in turbulent times. This effect is not captured by the ratios, since they are computed quarterly.

(8). To simplify, let us call $(\mathbf{1}_{\nu_{s,i}<0} - \mathbf{1}_{\nu_{b,i}<0})$ the *pair index* at CCP_i, with $i = 1, 2$. The pair index combines the positions of both members at CCP_i. It is equal to 1 when the seller's position is negative and the buyer's position is positive, in which case each position increases in absolute value if the transaction is cleared on CCP_i: the collateral of both traders is expected to increase. Similarly, the index is equal to -1 when the collateral of each is expected to decrease, and 0 when collaterals vary in opposite directions. The coefficient on the pair index on CCP_1 is expected to be positive and that on CCP_2 negative if incremental collateral costs influence pairs' choices.

(9): $\mathit{Spread}_s \mathbf{1}_{\nu_{s,i}<0} - \mathit{Spread}_b \mathbf{1}_{\nu_{b,i}<0}$ is a pair index weighted by the dealers' spreads. The coefficient is expected to be positive on CCP_1 if CCP_1 discriminates and negative on CCP_2 if CCP_2 discriminates.

5 Results

This section first presents descriptive statistics on the variables. Second, it presents the results from the baseline estimation with the coefficients on the measure of CCP robustness. Finally, it extends the analysis into several directions. In particular, additional estimations with fixed effects at a higher frequency allow us to better track dealer unobservable variables.

5.1 Descriptive statistics

Table 5 presents descriptive statistics for the explanatory variables, using the following units. Transactions notional is in million, the deviation of dealers' spreads (*Spread*) in basis point, Default Fund to Cover2 ratios in units, prefunded ratios in percentage (i.e. 100 times the amount of prefunded resources over total open interest), and dealers' positions in billions. Variables in difference are the differences between CCP_2 and CCP_1. Half of the transactions notional stands between €10mn and €25mn. The distribution of notional is skewed to large notional values. The dealers' spread in deviation ranges from -60.7 to 127.6 bps in the sample, with the majority being below ± 15 bp. Over all the period, CCP_2 has a larger prefunded ratio and a smaller Default Fund to Cover2 than CCP_1: The difference in prefunded ratios ranges from 0.48 to 1.26 pp and the difference in the Default Fund to Cover2 ratios ranges from -47.7 to -7.9. The pair indices reflecting the cost of collateral at each CCP have mean and median values close to zero and enough heterogeneity in between their 25% and 75% quantiles to potentially matter in the estimation. Finally, the Vstoxx on the period stands between 10.7 and 85.6 points.

	x	Spread	$\delta\left(\frac{\text{DF+IM}}{\text{OI}}\right)$	$\delta\left(\frac{\text{DF}}{\text{Cover2}}\right)$	$\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{b,2}<0}$	$\mathbf{1}_{\nu_{s,1}<0} - \mathbf{1}_{\nu_{b,1}<0}$	Vstoxx
Mean	31.1	2.7	0.91	-29.1	0.02	0.03	20.8
St dev	46.3	25.6	0.22	11.7	0.75	0.72	14.9
Min	0.005	-60.7	0.48	-47.7	-1	-1	10.7
q0.25	10.0	-14.4	0.74	-40.6	-1	-1	13.8
Median	25.0	-5.6	0.92	-26.8	0	0	16.4
q0.75	25.0	12.3	1.13	-21.7	1	0	22.0
Max	2000.0	127.6	1.26	-7.9	1	1	85.6

Table 5 – Explanatory variables, descriptive statistics

Descriptive statistics are calculated over the reduced sample of EU inter-dealer transactions. The difference in prefunded ratios is in percentage points and the difference in Default Fund to Cover2 ratios in units. Notional x is in €million, Spread is in basis points, and Vstoxx in points.

5.2 Baseline specification

Table 6 reports the baseline estimations. All specifications include a product fixed effect to account for differences in preference between products common across all dealers. They also include a pair of dealers-year[17] fixed effect to account for unobservables on every dealers' pair and year combination that could affect the choice of CCP. These include among others the geographic segmentation and the relations between the dealers and the CCPs that the dealers' spreads fail to capture. We report estimates with standard errors clustered at the pair-year level. Let us examine the coefficients in turn.

The coefficient on the notional x is negative, statistically significant in every specification: CCP_2's fees would be higher than CCP_1's at least for large notionals.

[17]Since Default Fund to Cover2 and prefunded ratios are available at a quarterly frequency, time fixed effects cannot have a higher frequency.

The coefficient on the difference in Default Fund to Cover2 ratios is significant and positive: dealers value CCP's robustness. The coefficient on the difference in prefunded ratios is significant and negative: an increase in the prefunded ratio of a CCP is interpreted as a deterioration of the pool of its members, clients, or products. The respective signs and magnitudes of these coefficients are similar in all specifications, whether only one ratio is included as in specifications (2) or both as in specifications (3) to (5). The coefficients on the risk-aversion, the difference in squared positions, is negative. That is, the probability to choose CCP_2 increases when dealers have higher positions in absolute value on CCP_1. However, it is only significant for buyers. The Vstoxx coefficient is significant and negative in every specification, meaning that dealers tend to choose CCP_2 less when volatility is higher: CCP_2 increases its collateral requirement more than CCP_1 in turbulent times.

The coefficients on the pair indices are not significant for both CCPs. Regressions with coefficients on the pair indices weighted by the spreads (9) fail to converge. This error might be due to co-linearity with the notional itself. So we choose to remove the notional from the term (9). The pair indices weighted by their spreads are only significant for buyers. Overall, we do not find evidence that positions, hence the requested collateral, affect the choice of CCP for clearing a transaction.

To gauge the economic effect of variables on the choice of CCP, we compute how a variable larger than the mean by one standard deviation changes the probability of choosing CCP_2 (in what follows "larger" means larger than the mean by one standard deviation).[18] A larger notional decreases the probability of choosing CCP_2 by 1.6%. The economic magnitude is larger for changes in the CCPs' ratios. A larger difference in the prefunded ratios decreases the probability of choosing CCP_2 by 3.9%, while a larger difference in the Default Fund to Cover2 ratios increases it by 8.2%. Finally, a larger Vstoxx decreases the probability of choosing CCP_2 by 5.7%.

[18]The reference probability of choosing CCP_2 is evaluated at the mean value of all variables and fixed effects.

	Dependent variable:				
	CCP_choice				
	(1)	(2)	(3)	(4)	(5)
x	-0.0021^{**}	-0.0021^{**}	-0.0021^{**}	-0.0021^{**}	-0.0021^{**}
	(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
$(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{b,2}<0})x$	-0.0007	-0.0006	-0.0006	-0.0007	-0.0007
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
$(\mathbf{1}_{\nu_{s,1}<0} - \mathbf{1}_{\nu_{b,1}<0})x$	-0.0013	-0.0014	-0.0014	-0.0013	-0.0013
	(0.0008)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
$\delta\left(\frac{\text{DF+IM}}{\text{OI}}\right)$		-1.4710^{***}	-0.8213^{**}	-0.8305^{**}	-0.8346^{**}
		(0.4639)	(0.3989)	(0.3951)	(0.3971)
$\delta\left(\frac{\text{DF}}{\text{Cover2}}\right)$			0.0420^{***}	0.0421^{***}	0.0418^{***}
			(0.0150)	(0.0149)	(0.0149)
$Spread_s(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{s,1}<0})$				0.0006	0.0003
				(0.0022)	(0.0021)
$Spread_b(\mathbf{1}_{\nu_{b,2}<0} - \mathbf{1}_{\nu_{b,1}<0})$				-0.0044^{*}	-0.0047^{*}
				(0.0027)	(0.0026)
$\nu_{s,2}^2 - \nu_{s,1}^2$					-0.0004
					(0.0002)
$\nu_{b,2}^2 - \nu_{b,1}^2$					-0.0002^{**}
					(0.0001)
Vstoxx	-0.0265^{***}	-0.0254^{***}	-0.0227^{***}	-0.0222^{***}	-0.0222^{***}
	(0.0086)	(0.0084)	(0.0079)	(0.0077)	(0.0077)
Pair x Year FE	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y
Observations	16791	16791	16791	16791	16791
Cluster SE	Pair x year				

Table 6 – CCP choice baseline results

The Logit estimation runs on the reduced sample of EU inter-dealer transactions. The sample period runs from 2018Q3 to 2020Q3. Standard errors are given in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

5.3 Additional specifications

The baseline results from Table 6 do not indicate that collateral costs drive the dealers' choice of CCP. This section extends the analysis in several directions. Departing from the baseline specification and still assuming linear collateral costs, we increase the frequency of fixed effects to track the dealers' unobservables with more precision. We also test the choice of CCP assuming the decision is made only by the buyer or the seller. Finally, we introduce an alternative measure of dealers' incentives to decrease their collateral costs: we replace the pair's index with a variable called *gap* and repeat the aforementioned robustness tests. The following results confirm the absence of significant relation between collateral costs and CCP's choices and tend to highlight a negative relation between dealers' squared positions and the choice of CCP.

First, we slightly change the baseline econometric specification to emphasize on the collateral cost. Because the dealers' variables related to the cost of collateral (pair index and gap) change on a daily frequency, a time fixed effect at a higher frequency suits better for accurate control of dealers' unobservables. As the estimations restrict to the cost of collateral, CCP related variables such as the Default Fund to Cover2 and prefunded ratios are now included in the fixed effects. To account for netting across products, we conduct additional estimations by considering dealers' positions summed across all index CDS. Every specification from Table 11 to 14 in Appendix 7 includes a product fixed effect and either an individual-time fixed effect or two separate fixed effects, one for individuals, and one for time. Individual means either a pair of dealers, the seller, or the buyer.[19] We report estimates with standard errors clustered either at the individual-time level or at the individual level for individual plus time fixed effects.

The relation between the choice of CCP and the pair indices is negative and significant at the 10% level in only two specifications from Table 11. While the model assumes the decision to choose a CCP is made by the pair, the decision might be always left to the seller or the buyer. Therefore, we restrict the pair index and the CDS spread to either the buyer or the seller in estimations (5 and (6) from Table 11. The pair index is still not significant for these estimations. To account for netting across products, Table 12 presents the same specifications with positions aggregated across all indices cleared by a dealer at each CCP. Likewise, there is no evidence that dealers' pair indices relate to the choice of CCP. In line with the benchmark results, the relation between the notional and the choice of CCP is negative across all specifications from both tables and significant in all specifications but one. Its magnitude is similar to the one from the baseline estimations. The coefficients related to the difference in squared positions are negative and significant

[19] As explained above, the individual-time fixed effect removes unobservables in the choice of CCP for all individuals at all periods. The separate individual plus time fixed effects remove unobservables for all individuals and all periods. They assume a common trend across time in the differences between dealers' unobservables.

in almost all specifications from Table 11. Their significance improved in comparison to Table 6. This may be due to the higher frequency of time fixed effects. Negative coefficients on this difference are also significant in Table 12. The Vstoxx is significant in two specifications with a similar magnitude than in the benchmark results.

Second, we consider the gap in positions as an alternative measure of dealers' incentives to decrease their collateral costs, as explained in Section 4. Recall that the gap is equal to $\delta(\nu_b) = \nu_{b,2} - \nu_{b,1}$ for the buyer and $\delta(\nu_s) = \nu_{s,2} - \nu_{s,1}$ for the seller. If traders prefer to equalize their positions at the two CCPs, the seller's gap is expected to relate positively to the choice of CCP_2, and the buyer's gap negatively. Table 15 in the Appendix presents the statistical properties of the gaps. It suggests that dealers do not seek to minimize their gap as the mean and median values respectively amount to €2.73bn and €0.28bn. There is no strong reversion to the mean in the time series of dealers' gaps as the regression coefficient from an AR(1) is 0.88 on average.

Table 13 presents the estimations with the gaps in positions instead of the pair indices. These estimations include as well individual-time or individual plus time fixed effects. Coefficients on both the buyer's and sellers' gap are not significant. This also holds when assuming the decision is made by the buyer or the seller. Table 14 presents the same specifications with positions aggregated across all index CDS. Buyer and seller's gaps in positions are also never significant for this set of estimations. The relation between the notional and the choice of CCP is still negative and significant in all specifications from both tables. The coefficient on the Vstoxx is significant in specification (2) from Tables 13 and 14, and it has a similar magnitude than in the benchmark results. Coefficients on the difference in squared positions are slightly less significant in those tables since they are likely to correlate with the gap in positions. Still, only the negative coefficients are significant.

Finally, dealers could adjust their position on a weekly or monthly basis instead of a daily one. In this respect, the choice of CCP would depend on the positions at the beginning of the reference period (week or month). We conduct the monthly estimations with the gap in positions at the beginning of the month. In these estimations, the dependent variable is the proportion of notional cleared at CCP_2 by pair and month. Again, the variables related to the gap in positions are not significant.

6 Concluding remarks

This paper studies the choice of CCP by major dealers clearing a CDS transaction in the EU. The dealers, who are members of multiple CCPs, do not balance their positions on the two main CCPs, which create additional collateral costs and suggest that dealers do not search to reduce these costs. Investigating the factors behind the choice of CCP, we build and estimate a reduced form model of pairs' choice. We show that fees, riskiness measures of CCPs, and the volatility of the market significantly affect this choice. In contrast, the collateral costs proxied by the net positions are not significant.

These findings have implications for financial stability. As said in the introduction, the EU favors the coexistence of several CCPs for the products that are subject to clearing obligation. This coexistence has been criticized on several grounds. First, central clearing presents features of natural monopoly stemming from enhanced netting and saving on collateral. As a result, a single CCP clearing a given asset class would be more efficient. However, as shown in this paper, major dealers are members of several CCPs, meaning that they derive benefits from multiple CCPs, and do not take full advantage of netting. Second, multiple CCPs may engage in competition and generate instability through race-to-the-bottom phenomena. But our results suggest that dealers care about the robustness of CCPs, which hampers harsh competition in price policies. Competition in quality favors stability, and, as in standard vertical differentiation models in the terminology of industrial organization, may result in CCPs of different qualities. Such multiplicity might provide easier access to traders smaller than the major ones we have analyzed.

Finally, let us mention that our results bear on a specific set of traders, namely major dealers whose net positions are small relative to their gross ones. As a result, their collateral costs are relatively small. Considering users with directional positions, as most clients, may show that collateral costs are an important driver for their choice to clear.[20] The difficulty for clients to clear their transactions has been recognised as a problem for implementing the EMIR regulation (Braithwaite and Murphy (2020)), possibly limiting its impact on financial stability. The nexus between CCP market structure and financial stability is left for further research.

[20]Clients are usually not members of any CCP and must clear through members. Thus we could not conduct the same type of analysis on clients as here on major dealers.

References

Abbruzo, N., & Park, Y.-H. (2016). An Empirical Analysis of Futures Margin Changes: Determinants and Policy Implications. *Journal of Financial Services Research, 49 (1)*, 65-100. https://doi.org/10.1007/s10693-014-0212-8.

Abad, J., Aldarosa, I., Aymanns, C., D'Errico, M., Rousova, L. F., Hoffmann, P., Langfield, S., Neychev, M., & Roukny, T. (2016). Shedding light on dark markets: First insights from the new EU-wide OTC derivatives dataset. *ESRB Occasional Paper Series No 11.*

Anderson, R. W., & Joeveer, K. (2014). The Economics of Collateral. *SSRN.* http://dx.doi.org/10.2139/ssrn.2427231.

Armakola, A., & Laurent, J.-P. (2017). CCP Resilience and Clearing Membership. *SSRN.* http://dx.doi.org/10.2139/ssrn.2625579.

Arnold, M. (2017). The impact of central clearing on banks lending discipline. *Journal of Financial Markets*, 36, 91-114.

Bellia, M., Girardi, G., Panzica, R., Pelizzon, L., & Peltonen, T. A. (2019). The Demand for Central Clearing: To Clear or Not to Clear, That Is the Question. *Safe W.P No. 193.* http://dx.doi.org/10.2139/ssrn.3116261.

Benos, E., Huang, W., Menkveld, A. J., & Vasios, M. (2021). The Cost of Clearing Fragmentation. *SSRN.* http://dx.doi.org/10.2139/ssrn.3397065.

Biais, B., Heider, F., & Hoerova, M. (2012). Clearing, counterparty risk, and aggregate risk. *IMF Economic Review*, 60(2), 193-222.

Braithwaite, J. P., & Murphy, D. (2020). Take on Me: OTC Derivatives Client Clearing in the European Union.

Coeuré, B. (2014). Central counterparty recovery and resolution. *Keynote speech at "Central clearing - guarantee of stability or new moral hazard?.*

Committee on Payment and Settlement Systems (2010) Market structure developments in the clearing industry: implications for financial stability.

Cont, R., & Kokholm, T. (2014). Central clearing of OTC derivatives: Bilateral vs multilateral netting. *Statistics and Risk Modeling, 31(1)*, 3-22. https://doi.org/10.1016/j.jfineco.2014.12.006.

Cucic, D. (2021). Central clearing and loss allocation rules. *Journal of Financial Markets*, 100662.

Duffie, D., Scheicher, M., & Vuillemey, G. (2015). Central clearing and collateral demand. *Journal of Financial Economics, 116(2)*, 237-256. https://doi.org/10.1016/j.jfineco.2014.12.006.

Duffie, D., & Zhu, H. (2011). Does a Central Clearing Counterparty Reduce Counterparty Risk? *Review of Asset Pricing Studies, 1(1)*, 74-95. https://doi.org/10.1093/rapstu/rar001.

EMIR (2012). Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories.

Elliott, D. (2013). Central Counterparties loss-allocation rules. Financial Stability Paper No. 20, Bank of England.

Financial Times (2018). Trader blows €100mn hole in Nasdaq's Nordic power market.

Ghamami, S., & Glasserman, P. (2017). Does OTC derivatives reform incentivize central clearing? *Journal of Financial Intermediation, 32*, 76-87. https://doi.org/10.1016/j.jfi.2017.05.007.

Glasserman, P., Moallemi, C. C., & Yuan, K. (2015). Hidden Illiquidity with Multiple Central Counterparties. *Operations Research, 64(5)*, 1143-1158. https://doi.org/10.1287/opre.2015.1420.

Grothe, M., Pancost, N. A., & Tompaidis, S. (2021). Empirical analysis of collateral at central counterparties.

Paddrik, M., & Youg, H. P. (2021). Assessing the Safety of Central Counterparties *OFR Working Paper.*

Pirrong C. (2011). The Economics of Central Clearing: Theory and Practice. *ISDA Discussion Paper Series*, 1.

United States Department of Justice (DOJ) (2007), Review of the Regulatory Structure Associated with Financial Institutions, in response to Department of the Treasury request TREAS-DO-2007-0018, http://www.usdoj.gov/atr/public/comments/229911.htm.

Vaghela, V. (2014). Korea clearing structure in question after HanMag trading error. *Risk Net.*

Vuillemey G. (2019). The Value of Central Clearing. *Journal of Finance, 75*, 2021-2053. https://doi.org/10.1111/jofi.12902.

Wolkoff, N. L., & Werner, J. B. (2010). The History of Regulation of Clearing in the Securities and Futures Markets, and Its Impact on Competition. *Rev. Banking & Fin. L., 30*, 313-381.

Zhu S. (2011). Is there a "race to the bottom" in central counterparties competition? *DNB Occasional Studies.*

7 Appendix

Glossary

CCP Central Counter-Party. 1

clearing member A member of a CCP clearing transactions for its own account and the account of its customers. 6

DF Default fund: collateral required by central counterparties to cover losses in excess of initial margin. 6, 7

exposure See position. 6

IM Initial margin: Collateral required to cover the losses from liquidating the portfolio in case the counterparty fails. 6, 7

notional In a CDS transaction, the notional is the amount of the underlying insured. A 100 notional CDS on firm AA insures the buyer against the default of AA for 100. 10

OI The CCP's open interest is equal to the gross notional outstanding as defined by the CPMI-IOSCO, except for some derivatives like commodities for which the open interest is the number of contracts. 7, 34

position The position of an institution to another is the sum of its transactions' notionals, positive for buy and negative for sell. 10

7.1 Data cleaning

As a French regulator, Banque de France has access to derivative transactions reported to Trade Repositories (TR) under EMIR.

We extract new transactions from trade activity reports and keep all existing transactions in the state report. It is important to retrieve new transactions from the trade activity report only since transactions in the state report often result from novation and compression, that aggregate together several existing transactions.

The following cleaning applies to both types of reports. EMIR regulation mandates both counterparties in a transaction to report. Therefore, a transaction appears twice in the data if it results from two EU counterparties (that are subject to reporting). To reconcile transactions, the two reporting counterparties share a common "Trade ID". We first remove transactions with non-LEI counterparties. Then, we clean the underlying identifier to retrieve either an ISIN (the underlying's security identifier or the index name), a LEI, or an index name. We drop transactions when the two counterparties differ on the following key criteria: underlying identification, notional, the currency of the transaction, execution, and maturity dates. Then, we match transactions with different identifiers (Trade ID) but with similar characteristics that correspond to the above criteria. We also match transactions subject to mandatory clearing but with no CCP reported with transactions sharing similar characteristics and taking place between a counterparty of the transaction and a CCP. Finally, we merge matched transactions and transactions with duplicate reporting in one-liner transactions. As in Abbad et al. (2016), we remove implausible notional, incorrect identifiers for underlying (either missing ISIN or wrong Index name), transactions without a maturity date. For the sake of the paper's analysis, we also remove intragroup transactions and keep on-the-run index CDS with a maturity of five years.

Even among products subject to the clearing obligation, no CCP is reported for a substantial proportion of transactions as Table 7 depicts. The proportion does not vary significantly across products, although clearing Itraxx Senior Financials is not mandatory. Removing those transactions, we lose 23% in number of transactions and around 19% in notional.

Product	Cleared	not cleared
Itraxx Europe	80.9%	19.1%
Itraxx crossover	81.0%	19.0%
Itraxx senior financials	82.3%	17.7%

Table 7 – Inter-dealer clearing rate by product, percentage of total notional on the period.

EMIR dataset on inter-dealer transactions.

7.2 Geographic segmentation

Table 8 reports the choice of dealers' pairs according to the geographic area of dealers. Dealers and CCPs locate in three different areas: the EA, GB, and the US. The first column reports the percentage of notional cleared by dealers from the same geographic area with a CCP from the same one. These are EA dealers clearing at LCH SA, GB dealers clearing at ICE-EU, and pairs with at least one US dealer clearing at ICE-US. The second column reports the percentage of notional cleared by dealers from the same geographic area at a CCP from another one. The last column reports the remaining percentage of notional, the one for which dealers are not from the same geographic area. The majority of transactions take place between dealers from different areas. Choice of CCPs exhibits a small geographic segmentation for transactions between dealers from the same area. As regards the Itraxx Europe, 26.5% of notional clears at a CCP from the same area, while 22.8% clears at a CCP from a different area. This result holds for the two other products.

Product	Same geographic area for dealers and CCP	Same geographic area for dealers, not for CCP	Remaining transactions	Notional
Itraxx Europe	26.5%	22.8%	50.7%	535.0
Itraxx crossover	23.4%	19.2%	57.4%	119.2
Itraxx senior financials	22.0%	19.0%	58.9%	95.1

Table 8 – Inter-dealer choice of CCP by geographic area, percentage of total notional on the period.

EMIR dataset on inter-dealer transactions. Geographic areas are EA, GB, and the US. Transactions between dealers from the same geographic area are between EA-EA, GB-GB, or with a US dealer. CCPs belong to either EA (LCH SA), GB (ICE-EU), or the US (ICE-US). The remaining transactions are between dealers from different geographic areas without a US counterparty. Notional is in €billion.

7.3 Figures and tables

Name	Country	LCH SA	ICE-EU	ICE-US
Bank of America, Na	US	X	X	X
Merrill Lynch International	GB	X	X	X
Barclays Bank Plc	GB	X	X	X
Bnp Paribas	FR	X	X	X
Citigroup Global Markets Limited	GB	X	X	
Citigroup Global Markets Inc	US		X	X
Citibank, National Association	US		X	X
Credit Suisse International	GB	X	X	X
Deutsche Bank Aktiengesellschaft	DE	X	X	X
Goldman Sachs International	GB	X	X	X
HSBC Bank Plc	GB	X	X	X
J.P. Morgan Secutities Plc	GB	X	X	
JPMorgan Chase Bank, Na	US		X	X
Morgan Stanley & CO. International Plc	GB	X	X	
Morgan Stanley Capital Services LLC	US		X	X
Nomura International Plc	GB		X	X
Societe Generale	FR	X	X	X
UBS AG	CH		X	X

Table 9 – Active dealers' membership

To account for different geographical areas, we do not aggregate active dealers affiliated entities at the group level. Sources: GLEIF, and CCPs websites.

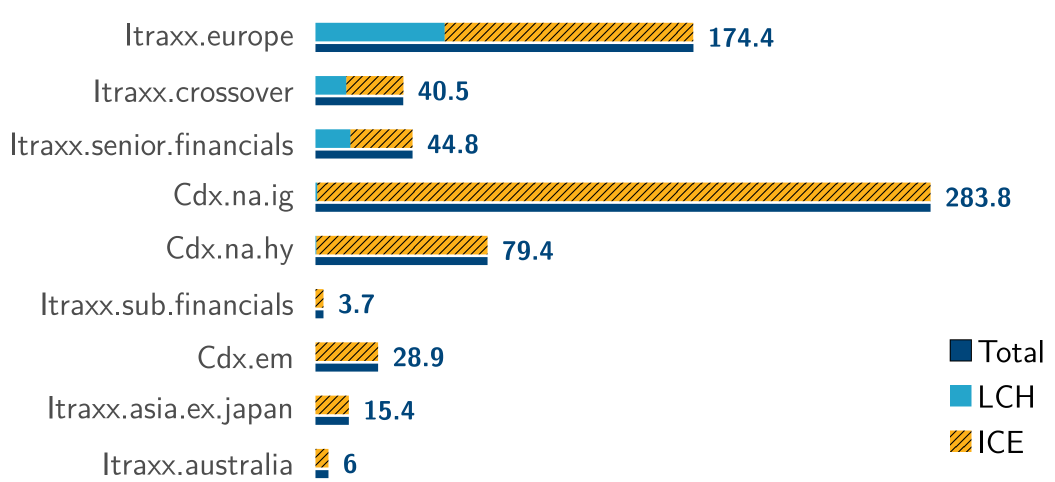

Figure 4 – Credit Default Swaps, Open Interest split by CCP and Index name

Open interest (OI) in €billion. Source: CCPs disclosure, as of April 2019. ICE OI is the sum of ICE Clear Credit and ICE Clear Europe OI.

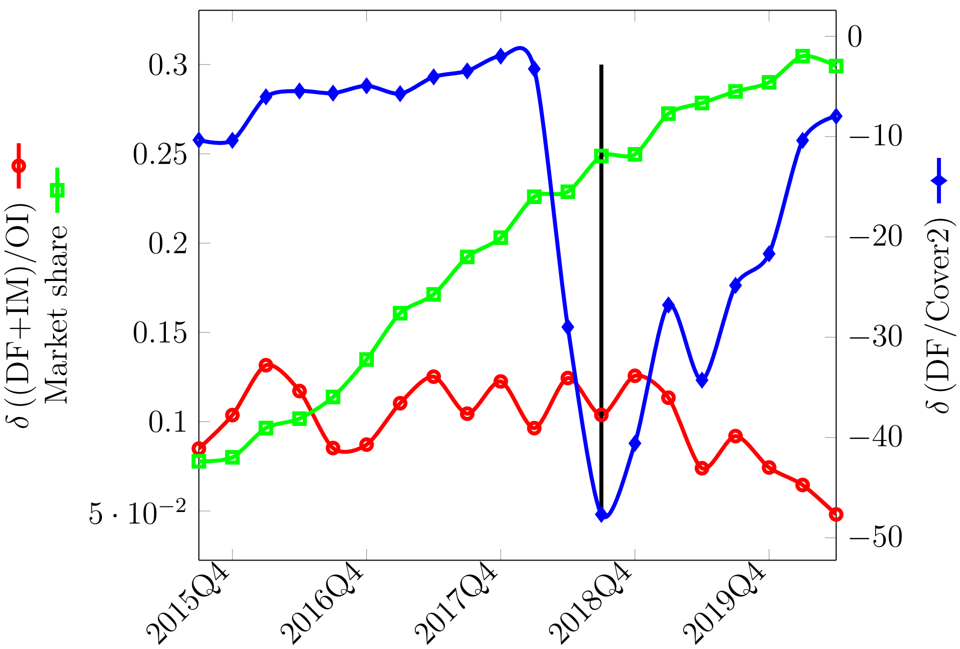

Figure 5 – LCH SA market share against ICE EU, differences in the Prefunded and Default Fund to Cover2 ratios

The figure plots the quarterly evolution of LCH SA market share against ICE EU, along with the difference in the Prefunded and Default Fund to Cover2 ratios between LCH SA and ICE EU. The sample used in the estimation starts at the right of the black line. Source: CCPs IOSCO quantitative disclosure from 2015$Q3$ to 2020$Q2$.

Itraxx	Europe	Senior Financials	Crossover
mean	2.736	13.523	2.707
std	35.767	1196.855	48.364
min	0.000	0.000	0.000
25%	0.000	0.000	0.000
50%	0.013	0.000	0.000
75%	0.628	0.462	0.432
max	1889.399	122212.693	2790.901

Table 10 – Distribution of excess position as a proportion of absolute position cleared by dealers at the CCPs

The table presents the distribution of dealers' excess positions over positions at EU CCPs by product. Excess positions are pooled between dealers and dates. The sample period runs from 2018Q3 to 2020Q3.

	Dependent variable:					
	CCP_choice					
	(1)	(2)	(3)	(4)	(5)	(6)
x	-0.0020^{**}	-0.0020^{**}	-0.0020^{**}	-0.0022^{*}	-0.0023^{*}	-0.0012
	(0.0009)	(0.0010)	(0.0010)	(0.0012)	(0.0012)	(0.0008)
$(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{b,2}<0})x$	-0.0007	-0.0008	-0.0009	-0.0009		
	(0.0008)	(0.0008)	(0.0008)	(0.0007)		
$(\mathbf{1}_{\nu_{s,1}<0} - \mathbf{1}_{\nu_{b,1}<0})x$	-0.0017^{*}	-0.0015	-0.0015	-0.0011^{*}		
	(0.0009)	(0.0010)	(0.0010)	(0.0007)		
$(\mathbf{1}_{\nu_{s,2}<0})x$						0.0003
						(0.0013)
$(\mathbf{1}_{\nu_{s,1}<0})x$						-0.0007
						(0.0012)
$(\mathbf{1}_{\nu_{b,2}<0})x$					0.0007	
					(0.0013)	
$(\mathbf{1}_{\nu_{b,1}<0})x$					0.0010	
					(0.0010)	
$Spread_s(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{s,1}<0})$			0.0042	-0.0013		0.0003
			(0.0029)	(0.0018)		(0.0011)
$Spread_b(\mathbf{1}_{\nu_{b,2}<0} - \mathbf{1}_{\nu_{b,1}<0})$			-0.0005	-0.0046	-0.0026	
			(0.0035)	(0.0029)	(0.0018)	
$\nu_{s,2}^2 - \nu_{s,1}^2$			-0.0005^{**}	-0.0006^{***}		-0.0003^{***}
			(0.0002)	(0.0002)		(0.0000)
$\nu_{b,2}^2 - \nu_{b,1}^2$			-0.0003	-0.0004^{**}	-0.0003^{***}	
			(0.0003)	(0.0002)	(0.0000)	
Vstoxx	-0.0247^{**}	-0.0263	-0.0275^{*}			
	(0.0120)	(0.0164)	(0.0163)			
Product FE	Y	Y	Y	Y	Y	Y
Pair x month FE	Y					
Pair x week FE		Y	Y			
Pair/Buyer/Seller FE				Y	Y	Y
Day FE				Y	Y	Y
Observations	12178	6735	6735	17761	18515	18515
Cluster SE	Pair x month	Pair x week	Pair x week	Pair	Buyer	Seller

Table 11 – CCP choice and changes in pair index

The Logit estimation runs on the reduced sample of EU inter-dealer transactions. We compute positions at the dealer product and day level. The sample period runs from 2018Q3 to 2020Q3. Standard errors are given in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

	Dependent variable:					
	CCP_choice					
	(1)	(2)	(3)	(4)	(5)	(6)
x	-0.0023^{**}	-0.0024^{**}	-0.0024^{**}	-0.0023^{*}	-0.0017	-0.0017^{**}
	(0.0009)	(0.0010)	(0.0009)	(0.0013)	(0.0015)	(0.0008)
$(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{b,2}<0})x$	-0.0003	-0.0007	-0.0007	-0.0001		
	(0.0010)	(0.0010)	(0.0010)	(0.0010)		
$(\mathbf{1}_{\nu_{s,1}<0} - \mathbf{1}_{\nu_{b,1}<0})x$	-0.0002	0.0001	0.0002	-0.0006		
	(0.0009)	(0.0009)	(0.0009)	(0.0006)		
$(\mathbf{1}_{\nu_{s,2}<0})x$						0.0011
						(0.0015)
$(\mathbf{1}_{\nu_{s,1}<0})x$						-0.0005
						(0.0013)
$(\mathbf{1}_{\nu_{b,2}<0})x$					0.0003	
					(0.0015)	
$(\mathbf{1}_{\nu_{b,1}<0})x$					0.0000	
					(0.0008)	
$Spread_s(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{s,1}<0})$			0.0046	-0.0006		0.0004
			(0.0029)	(0.0016)		(0.0011)
$Spread_b(\mathbf{1}_{\nu_{b,2}<0} - \mathbf{1}_{\nu_{b,1}<0})$			-0.0002	-0.0040	-0.0025	
			(0.0035)	(0.0026)	(0.0018)	
$\nu^2_{s,2} - \nu^2_{s,1}$			0.0013	-0.0004^{***}		-0.0002^{***}
			(0.0011)	(0.0001)		(0.0001)
$\nu^2_{b,2} - \nu^2_{b,1}$			0.0014	-0.0002	-0.0001^{*}	
			(0.0011)	(0.0001)	(0.0001)	
Vstoxx	-0.0245^{**}	-0.0259	-0.0283^{*}			
	(0.0122)	(0.0164)	(0.0162)			
Product FE	Y	Y	Y	Y	Y	Y
Pair x month FE	Y					
Pair x week FE		Y	Y			
Pair/Buyer/Seller FE				Y	Y	Y
Day FE				Y	Y	Y
Observations	12178	6735	6735	17761	18515	18515
Cluster SE	Pair x month	Pair x week	Pair	Pair	Buyer	Seller

Table 12 – Robustness check: CCP choice and changes in pair index, with positions on all index CDS

The Logit estimation runs on the reduced sample of EU inter-dealer transactions. We compute positions at the dealer and day level aggregated over across all CDS indices. The sample period runs from 2018Q3 to 2020Q3. Standard errors are given in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

	Dependent variable:					
	CCP_choice					
	(1)	(2)	(3)	(4)	(5)	(6)
x	-0.0021^{***}	-0.0015^{**}	-0.0013^{*}	-0.0021^{*}	-0.0015^{***}	-0.0014^{***}
	(0.0008)	(0.0006)	(0.0007)	(0.0011)	(0.0005)	(0.0005)
$\delta(\nu_s)$	-0.0047		0.0022	-0.0088		-0.0105
	(0.0170)		(0.0120)	(0.0138)		(0.0070)
$\delta(\nu_b)$	-0.0140	0.0093		-0.0014	-0.0050	
	(0.0148)	(0.0122)		(0.0114)	(0.0078)	
$Spread_s(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{s,1}<0})$	0.0043		-0.0002	-0.0014		0.0001
	(0.0029)		(0.0016)	(0.0017)		(0.0012)
$Spread_b(\mathbf{1}_{\nu_{b,2}<0} - \mathbf{1}_{\nu_{b,1}<0})$	-0.0005	-0.0002		-0.0045	-0.0028	
	(0.0035)	(0.0017)		(0.0029)	(0.0017)	
$\nu_{s,2}^2 - \nu_{s,1}^2$	-0.0006^{*}		-0.0002	-0.0007^{**}		-0.0004^{***}
	(0.0003)		(0.0002)	(0.0003)		(0.0001)
$\nu_{b,2}^2 - \nu_{b,1}^2$	-0.0005	-0.0001		-0.0004^{*}	-0.0004^{***}	
	(0.0004)	(0.0002)		(0.0002)	(0.0001)	
Vstoxx	-0.0270	-0.0238^{***}	-0.0054			
	(0.0165)	(0.0089)	(0.0082)			
Product FE	Y	Y	Y	Y	Y	Y
Pair x week FE	Y					
Buyer x week FE		Y				
Seller x week FE			Y			
Pair + day FE				Y		
Buyer + day FE					Y	
Seller + day FE						Y
Observations	6735	15589	15265	17761	18515	18515
Cluster SE	Pair x week	Buyer x week	Seller x week	Pair	Buyer	Seller

Table 13 – CCP choice and changes in differences in positions between CCP_2 and CCP_1

The Logit estimation runs on the reduced sample of EU inter-dealer transactions. We compute positions at the dealer product and day level. The sample period runs from 2018Q3 to 2020Q3. Standard errors are given in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

	Dependent variable:					
	CCP_choice					
	(1)	(2)	(3)	(4)	(5)	(6)
x	-0.0020^{***}	-0.0015^{**}	-0.0013^{*}	-0.0021^{*}	-0.0015^{***}	-0.0014^{***}
	(0.0008)	(0.0006)	(0.0007)	(0.0012)	(0.0005)	(0.0005)
$\delta(\nu_s)$	-0.0129		0.0062	-0.0119		-0.0078
	(0.0474)		(0.0380)	(0.0116)		(0.0058)
$\delta(\nu_b)$	-0.0058	0.0362		0.0020	-0.0000	
	(0.0445)	(0.0389)		(0.0126)	(0.0070)	
$Spread_s(\mathbf{1}_{\nu_{s,2}<0} - \mathbf{1}_{\nu_{s,1}<0})$	0.0044		-0.0001	-0.0011		0.0001
	(0.0029)		(0.0016)	(0.0016)		(0.0011)
$Spread_b(\mathbf{1}_{\nu_{b,2}<0} - \mathbf{1}_{\nu_{b,1}<0})$	0.0001	-0.0001		-0.0038^{*}	-0.0025	
	(0.0035)	(0.0017)		(0.0023)	(0.0018)	
$\nu_{s,2}^2 - \nu_{s,1}^2$	0.0010		0.0010	-0.0006^{**}		-0.0003^{***}
	(0.0016)		(0.0015)	(0.0002)		(0.0001)
$\nu_{b,2}^2 - \nu_{b,1}^2$	0.0012	0.0013		-0.0002	-0.0001	
	(0.0016)	(0.0019)		(0.0002)	(0.0001)	
Vstoxx	-0.0278^{*}	-0.0240^{**}	-0.0060			
	(0.0167)	(0.0095)	(0.0085)			
Product FE	Y	Y	Y	Y	Y	Y
Pair x week FE	Y					
Buyer x week FE		Y				
Seller x week FE			Y			
Pair + day FE				Y		
Buyer + day FE					Y	
Seller + day FE						Y
Observations	6735	15589	15265	17761	18515	18515
Cluster SE	Pair x week	Buyer x week	Seller x week	Pair	Buyer	Seller

Table 14 – Robustness check: CCP choice and changes in differences in positions between CCP_2 and CCP_1, with positions on all index CDS.

The Logit estimation runs on the reduced sample of EU inter-dealer transactions. We compute positions at the dealer summed across all index CDS and day level. The sample period runs from 2018Q3 to 2020Q3. Standard errors are given in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% level respectively.

	AR(1) Constant	ρ	Mean (€bn)
Mean	0.07	0.88	2.73
St dev	0.54	0.11	6.57
Min	-1.10	0.68	-5.89
q0.25	-0.09	0.82	-1.03
Median	0.09	0.94	0.28
q0.75	0.34	0.95	4.93
Max	0.87	1.01	16.71

Table 15 – Time series properties of dealers' gaps in positions at the two CCPs

Reduced sample of EU inter-dealer transactions. We compute the gap in positions between the two CCPs at the dealer and product level. The time series properties are computed across dealers and products. The sample period runs from 2018Q3 to 2020Q3.