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ALWAYS LOOK ON THE BRIGHT SIDE? CENTRAL COUNTERPARTIES AND INTERBANK MARKETS DURING THE FINANCIAL CRISIS

by Massimiliano Affinito* and Matteo Piazza*

Abstract

This paper joins the debate on the growing use of CCPs in interbank markets by analysing a scarcely explored source of risk. Namely, that central clearing may provide riskier banks that are cut off from the bilateral segment with another means of accessing the interbank market, thereby eluding market discipline and potentially increasing the risks borne by the financial system. We investigate this issue using monthly granular data on Italian banks from January 2004 to June 2013, and find that during the global financial crisis riskier banks increased the share of their interbank funding obtained via CCPs due to both the impact of general market uncertainty and heightened attention to counterparty risk in the bilateral segment of the market. More tellingly, we show that, for riskier banks only, this increase was accompanied by a decline in the duration of bilateral relationships, indicating that longer-standing counterparts, typically the most informed ones, withdrew from these relationships. This suggests that, compared with banks operating in the bilateral segment, on average banks working with CCPs may be riskier, confirming the importance of ongoing efforts to ensure that CCPs have a proper risk management framework.

JEL Classification: E58, G21.
Keywords: CCPs, central clearing, central counterparties, financial crisis, interbank markets, networks, interbank lending relationships.

Contents

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1 Introduction [1]

A well-known feature of the global financial crisis has been its impact on interbank markets and the repercussions on the transmission mechanism of monetary policy and the whole financial system (e.g. Brunnermeier, 2009; Taylor and Williams, 2009; Allen et al., 2009; Freixas et al., 2011; Garcia-de-Andoain et al., 2016). In some countries, however, overall interbank activity did not remarkably decline but rather changed its functioning with a significant surge in secured lending, notably via Central Clearing Counterparties (CCPs). CCPs are third parties that stand between two banks for the purpose of mitigating counterparty credit risk. In interbank transactions via a CCP all exposures are anonymous and secured, typically occurring through repos: lending and borrowing banks are no longer counterparties to each other, but both of them have the CCP as their counterparty, thereby transforming the interbank traditional *bilateral* relationship into two bilateral relationships of each bank with the CCP.[2] This may bring several benefits, reducing counterparty risk, saving collateral through greater netting efficiency and promoting transparency.[3]

Italy has been a point in case: domestic banks stepped up their recourse to CCPs for their interbank funding in a strikingly way since 2009, soon after the peak event of the global crisis (the Lehman Brothers collapse), with a sixfold increase of borrowed funds in less than four years, both as a share of total assets (Figure 1) and as a share of total

[1]The views expressed herein do not necessarily reflect the views of the Bank of Italy. We would like to thank for their comments two anonymous referees, Giorgio Albareto, Giuseppe Cappelletti, Riccardo De Bonis, Marc Deloof, Giovanni Guazzarotti, Gaetano Marseglia, Francesco Palazzo, Mario Pietrunti, Valerio Vacca, Barry Williams and participants at "Paris Financial Management Conference", "IFABS Barcelona Conference", "25th EFMA Conference", "Infinity Conference". Usual disclaimers apply. Corresponding author: massimiliano.affinito@bancaditalia.it.

[2]CCPs are active in several markets in addition to repo transactions, notably in derivatives markets. A CCP can be generally defined as an entity that interposes itself between (two or more) counterparties becoming the buyer to every seller and seller to every buyer. While in the bilateral transactions there is one contract, in the transactions involving a CCP there are two contracts: one between the buyer and the CCP and another one between the seller and the CCP. The CCP transforms the risk exposure among counterparties into a risk exposure of each counterparty with the CCP. The two parties become anonymous to each other. The reduction of counterparty risk occurs through loss mutualisation, high levels of collateralisation and multilateral netting. To manage the risk borne by the CCPs, members post initial margins and make contributions to the CCPs default fund. More institutional details are provided in Section 2.

[3]See for example, ECB (2007), FSF (2008, 2013, 2017), Cecchetti et al. (2009), Leitner (2012), Biais et al. (2012) and (2016), Loon and Zhong (2014), Acharya and Bisin (2014), Duffie et al. (2015); Baklanova et al. (2017). A review of the literature on benefits and risks of CCPs is provided in Section 3.

interbank exposures (Figure 2). The ratio between the number of banks operating via CCPs and the total number of banks operating in the interbank markets also increased significantly (Figure 3). This exponential increase mostly made up for the sharp decline in bilateral interbank funding with foreign banks (Figure 4), in turn due to the euro-area financial fragmentation (Banca d'Italia, 2013a and 2013b; IMF, 2013, Garcia-de-Andoain et al., 2016).

Overall, the Italian experience seems to lend support to the thesis that "[j]urisdictions that had CCPs for their repo markets in place before the crisis were relatively less affected than those that did not" (Chatterjee et al., 2012). A number of works (e.g. Cappelletti et al., 2011; Mancini et al., 2016, Heider et al., 2015) refers to the benefits that a CCP may bring to the functioning of interbank transactions in periods of turmoil. A stressed aspect is that the shift to centrally cleared transactions addressed the general increase in uncertainty and risk aversion of lending banks during the financial crisis, thereby allowing interbank activity to keep playing its crucial role for monetary policy transmission and financial system functioning.

Nevertheless, the shift may imply a possible drawback in terms of financial stability, which has been few explored at least from an empirical point of view. In fact, while the increased role of CCPs facilitates interbank activity, it may also increase the overall risk borne by the financial system, not only because it may contribute to a general trend toward concentration of risks in CCPs that may turn them into institutions of systemic importance, but also because the increased use of CCPs could be concentrated among a pool of borrowers that would have been otherwise cut off from the bilateral segment of the interbank market due to their riskiness.[4] In this case, the role played by the bilateral interbank market in assuring market discipline, which has been emphasised by both theoretical and empirical works (e.g. Calomiris and Kahn, 1991; Rochet and Tirole, 1996; Furfine, 2001; Huang and Ratnovski, 2008; King, 2008; Angelini et al., 2011; Distinguin et al, 2013) could be lost, with a potential impact on financial stability.

Investigating this aspect may be relevant for three different reasons: first, to analyze if the risk borne by the financial system may increase unintendedly, *ceteris paribus*, due to weakened market discipline. Second, as an increase in the risk taken by CCPs may be potentially dangerous in light of their growing systemic importance. Third, because the risk faced by a member of a CCP can increase, due to the mutualization of the losses, even if its own exposure does not change (Arnsdorf, 2012). Therefore, a riskier pool of borrowers may reduce the incentives to centrally clear and potentially encourage a

[4]Similar potential drawbacks of the use of CCPs may be found, for example, in Stephens and Thompson (2011); Pirrong (2011); Koeppl (2012); Thompson (2012); Biais et al. (2013) and (2016). See the review of the literature in Section 3.

return to bilateral trading, losing the benefits of centrally cleared transactions.

Our empirical analysis runs in two steps. First, we analyse empirically the determinants of the share of interbank transactions conducted via CCPs and we show that both general uncertainty and individual risk were relevant in determining the recourse to CCPs.[5] Taken alone, however, the fact that individual bank risk was positively influencing the recourse to CCPs is not sufficient to conclude that CCPs were taking up risks that were shunned by bilateral counterparties. This leads us to our second step where we take advantage of the granular nature of our data to infer, from the actual behaviour of bilateral interbank counterparts, whether the use of centrally cleared transactions for riskier banks was associated to a loss of their usual interbank bilateral counterparties, i.e. whether market discipline might have been somewhat relaxed by the availability of anonymous CCP transactions or not.

For our analysis, we rely on a very granular dataset containing monthly data on all banks operating in Italy since 2004, the actual start date of the CCP activity in the Italian repo market, up until 2013. The Italian case is interesting for two reasons: the relevant role played by CCPs in interbank transactions during the crisis period as well as the relevance of banks in Italy. In addition to standard balance sheet variables, our data contain information on the identity and duration of each interbank bilateral relationship, i.e. customer relationships in the interbank market (quite relevant in the Italian market as shown by Affinito, 2012). These data allows us: (a) to identify banks that use CCPs as well as when they started to do it; (b) to connect choices in terms of participation to CCPs and intensity of their use to a large number of bank specific characteristics and to bilateral interbank relationships, (c) to verify how the bilateral relationships were affected by the risk of borrowing banks and how this impacted on the use of CCPs.

Thanks to our granular data, the second step of our analysis examines the relation between variations in the use of CCPs and the weighted average duration of all bilateral interbank relationships of each borrowing bank. The hypothesis is that for riskier banks an increase in the share of CCPs transactions should be significantly associated to decreases in the duration of bilateral relationships, while for less risky banks the relationship should be positive or nil. The underlying idea is that, since older interbank relationships are affected more by bank-specific characteristics and risks (due to the informational advantages of long-term relationships compared to short term ones, a

[5]The *participation* of riskier banks to CCPs became instead less likely during the crisis, possibly due to the increased costs to use CCPs as a consequence of the stricter risk control frameworks gradually adopted. The increased use of CCPs all along our sample period is mostly explained, however, by the intensive margin.

well established result in the literature), long standing counterparts should tend to keep bilateral relationships with less risky banks, while they should be less inclined to lend to riskier banks. If this is the case, for riskier banks (e.g. those in the upper deciles of the distribution of our risk indicators) increases in the share of CCPs transactions and decreases in the duration of bilateral relationship would be a sign of the drying-up of interbank funding from longer standing (more informed) counterparts in the bilateral segment of the interbank market and of its replacement with transactions via CCPs. Instead, less risky banks may have no need at all to recur to CCPs, as they can keep existing relationships with long-standing counterparts: if any, they may be expected to recur to CCPs to replace newer counterparts that are less able to discriminate borrowing banks according to their risk, in particular in a period of uncertainty. This means that a positive relationship between increases in CCP use and duration could even be expected for less risky banks, although not necessarily sizeable and significant as these banks may be able to keep their bilateral funding largely unscathed and have no additional funding needs to be satisfied via CCPs.

In other words, the shift towards CCP-cleared anonymous contracts may be due to two alternative underlying causes, both related to asymmetric information: on the one hand, the risky bank may want to shift towards anonymous trades to elude market discipline; in this respect, the shift is welfare detrimental. On the other hand, one could also argue that the risky bank wants to avoid a stigma effect. In this case, having in place anonymous trades is welfare increasing, as it reduces the harmful effect of imperfect information. Our approach allows to disentangle these two possible causes: a shift to CCPs dictated by the desire to avoid a stigma would not impact primarily on *existing*, long-standing, relationships while, to the contrary, long-standing counterparts would be those better placed to first exercise market discipline.[6]

Our results show that indeed a significantly negative relationship exists for riskier banks between changes in the use of CCPs and the weighted average duration of bilateral interbank relationships (while this is not the case for less risky banks). The policy implication is a clear indication of the importance of the ongoing effort to ensure that CCPs put in place adequate risk control frameworks, started as an essential corollary to the growing importance of CCPs promoted by financial reforms (CPMI-IOSCO, 2012 and 2016; BCBS-CPMI-FSB-IOSCO, 2017).[7]

[6]We thank an anonymous referee to help us clarify the point.

[7]Recourse to central clearing has been strongly promoted, in the aftermath of the global financial crisis, for over-the-counter (OTC) derivatives, starting with the work of the Financial Stability Board (formerly Financial Stability Forum) in 2008 and the ensuing G20 commitments in Pittsburgh in 2009 (FSF, 2008 and 2013). As of mid-2017, 17 of 24 Financial Stability Board member jurisdictions have a

The rest of the paper illustrates in detail the features of our analysis, starting in Section 2 with a description of some institutional background on the development of CCPs. Section 3 summarizes the literature on benefits and risks of CCPs. Sections 4 to 6 describe respectively our empirical analysis, the data used and the main findings of the paper. Section 7 summarizes our robustness checks and section 8 concludes.

2 Institutional background

In the aftermath of the global financial crisis the use of CCPs has been actively promoted in the OTC derivative markets, with the aim of improving market transparency, mitigating systemic risk and preventing market abuse. The use of CCPs to clear interbank repurchase agreements has also strongly increased during the financial crisis and beyond (e.g., ECB, 2012).

While the traditional interbank bilateral transactions occur between pairs of banks, are nominative and may be secured or unsecured, interbank transactions via CCPs are anonymous, occur usually through repos and are thus typically secured (Figure 5). Their structure is as follows: i) the borrowing bank enters into a repurchase agreement with the CCP, borrowing the required amount and providing collateral; ii) the lending bank enters into a reverse repo with the CCP; iii) the CCP acts as the direct counterparty to the seller and the buyer, thus assuming the risk of borrower default, and manages the transaction and the collateral.[8] In addition, collateral management is highly standardised in terms of profiling and margining, which enhances transparency, and the administrative burden for borrower and lender is significantly lower than in a bilateral repo. In the Italian case, participants in this market were basically all banks, and this was broadly the case in other countries in the euro area.[9]

The use of CCPs may bring a number of benefits (e.g. Hardouvelis and Peristiani, 1992; Borio, 2004; ECB, 2007; Cecchetti et al., 2009; FSF, 2008 and FSB 2015 and the

legislative framework in force for mandatory central clearing requirements (FSB 2017).

[8]This scenario assumes that both the lending and the borrowing banks are members of the CCPs. If this is not the case, we have the so-called client-clearing models, where a counterparty is not itself a clearing member, but accesses a CCP via a third party who is a clearing member. It results in the creation of a distinct legal contract between the clearing member and its client (a back-to-back contract) in addition to the legal contract between the CCP and the clearing member. This is the most common client-clearing model in European CCPs. Four new trades result from the clearing of the original trade in the principal model, i.e. between each counterparty and its respective clearing member and mirror transactions between each clearing member and the CCP (ESMA 2017).

[9]For this reason, the ECB decided in 2012 to exclude, retroactively from June 2010, repos with CCPs from the reference monetary aggregate M3.

literature reviewed in the next Section). First, CCPs are supposed to reduce counterparty risk, making the entire financial system safer, by means of mutualization of credit risk (sharing it among all participants and insuring idiosyncratic risks) and the reduction of information asymmetries (allowing participants to trade with only one counterparty). Second, as counterparties of all trades, CCPs can net multilaterally, and, thanks to the multilateral netting, CCPs can increase the amount of available collateral. Third, by facilitating data collection, CCPs may improve market transparency and help a correct estimation of oustanding risks.

On the other hand, the rising importance of CCPs may be associated with a number of side effects, such as a concentration of risks that may assume systemic importance and potential contagion effects (in terms of losses and liquidity shortfalls). Significant efforts have been deployed to ensure an improved resilience of CCPs and, according to some views, they now employ "risk management methods that do not exist to the same extent in the bilateral world" (Coeure', 2014).

Typically CCPs adopt a multi-level system of safeguards to protect themselves and their members from losses caused by clearing member defaults. First, clearing members have to post an "initial margin", which is a form of collateral initially collected by the CCP and retained in the event of default. The initial margin is commensurate with the value and risk of contracts, is typically delivered either in cash or in the form of securities that have high credit quality and can easily be sold. Second, a "variation margin" is charged or credited daily to clearing members to cover any portfolio mark-to-market changes. This means that CCPs control daily the revaluation of open positions at current market prices and calculate any gains or losses that have to be paid or received each day. In periods with high volatility, positions may be marked to market intraday. Moreover, CCP risk control usually entails stricter rules on the posting of collateral than those used in bilateral markets.[10] Third, CCPs have an equity buffer provided by shareholders as well as their own assets. Fourth, every member contributes to the clearing house "default fund", which acts as a mutualised insurance for uncollateralised losses. Fifth, each clearing member is usually committed to providing further funds if necessary (recovery procedure). The so called "default waterfall" refers to the order in which these resources are used. Typically, the waterfall envisages first the use of the available resources of the defaulting member (initial margins and then its default fund contribution). Next, the CCPs' capital is used and then the default fund contributions of surviving members. Further down, other rules may be envisaged to face the situation,

[10]Rules establish what assets are allowed as collateral, how much of a haircut should be given to specific assets in determining their value as collateral, and how often margin calls should take place.

either as part of the waterfall or as a part of so-called end-of-the-waterfall situations, following the exhaustion of all the safeguards contemplated in the default waterfall (for further details, see CPSS-IOSCO, 2012; CPMI-IOSCO, 2014 and 2016).

In Italy only one central counterparty is authorized: Cassa di compensazione e garanzia S.p.A. (CC&G). Italian banks can however decide to (also) adhere to foreign CCPs, and symmetrically CC&G accepts foreign banks as clearing members. Moreover, thanks to interoperability arrangements, intermediaries can belong either to CC&G or to the French central counterparty LCH.Clearnet SA, as if the two partner institutions formed a single virtual central counterparty. At its outset CC&G dealt only with financial derivatives, but over time its activities expanded to include shares (on a compulsory basis), Italian Government securities (on an optional basis) and a broad range of trading platforms and financial instruments, including the collateralized interbank deposit market.

3 Related literature

Our work is related to a wide literature that explores benefits and risks of CCPs, usually in comparison to a situation where only the bilateral market exists. On benefits, Bernanke (1990) highlighted two positive roles of a clearinghouse: reducing transaction costs of consummating agreed-upon trades (analogous to a bank that clears checks) and standardizing contracts by setting terms and format and guaranteeing performance to both sides of trade (analogous to an insurance company). Koeppl and Monnet (2010) show that the benefit of centralized clearing is in the mutualization of counterparty default risk. Leitner (2012) argues that a clearing house mechanism, by allowing each party to declare its trades and inducing the revelation of hidden trades, can prevent agents from promising the same asset to multiple counterparties and then defaulting. Biais et al. (2012) find that an appropriately designed centralized clearing mechanism enables trading parties to benefit from the mutualization of (the idiosyncratic component of) risk. Loon and Zhong (2014) use data on voluntarily cleared CDS contracts to document a reduction of both counterparty and systemic risk. Acharya and Bisin (2014) show that the primary role of a centralized clearing mechanism (or of a centralized counterparty) is not necessarily to directly reduce or eliminate counterparty risk but to improve its price by aggregating information on trades. Another benefit pointed by the literature is the saving of collateral: a number of empirical works have assessed changes in collateral demand due to mandatory central clearing (Heller and Vause, 2012; Sidanius and Zikes, 2012; Duffie et al., 2015) and conclude that mandatory central clearing substantially

lowers system-wide collateral demand, unless there is significant proliferation of CCPs. Cont and Kokholm (2014) emphasize that the gains from multilateral netting are larger when more highly volatile assets are centrally cleared.

Another stream of the literature draws attention to the risks linked to the phenomenon of multiple CCPs (Cecchetti et al., 2009; Duffie and Zhu, 2011; Duffie et al. 2015). Multiple CCPs are deemed to entail a variety of costs. First, with multiple CCPs large market players would need to post several initial margins. Second, the existence of multiple CCPs makes regulatory consistency important in order to prevent regulatory arbitrage. Third, multilateral netting will be more difficult unless sufficient international coordination takes place across CCPs. So, while a single CCP is generally considered to reduce systemic risk relative to a bilateral segments, multiple CCPs may not. Moreover, given that multiple CCPs generate interconnectedness in the system, the literature also deals with the issue of networks between CCPs and between members of different CCPs.[11] As noted by Singh (2013), it is therefore uncertain whether multiple interconnected CCPs reduce or increase aggregate counterparty exposures and collateral requirements and empirical results are mixed.[12]

The part of the literature which is more closely related to our paper is the sizable work focusing on moral hazard issues. The central clearing mechanism may generate two types of moral hazards. The first one is the moral hazard of participants, which derives from

[11]In fact, multiple CCPs may decide to link each other to mitigate the costs of fragmentation of clearing activity across borders and markets. A way is the interoperability, where a participant in one CCP can clear its trades in a given product at any linked CCP. While CCP links allow for the netting of participant exposures in a way that approximates the outcome of using a single CCP, they create exposures between CCPs.

[12]On the one hand, several works conclude that risks are not likely to increase with multiple CCPs. Cox et al. (2013) find that CCP links can reduce overall system exposure in most plausible scenarios. Results tally with those of Anderson et al. (2013), who analyze CCP interoperability and the efficiency of multilateral netting with linked and unlinked CCP configurations. Barker et al. (2016) run different experimental simulations and find that interconnectedness through CCPs does not enlarge the transmission of contagion effects. Heath et al. (2013) and Heath et al. (2017) study the transmission of financial stress through a CCP network and confirm it tends not to be pejorative. On the other hand, Pirrong (2012) warns that systemic risk could increase, noting that fragmentation will increase the demand for CCP-eligible collateral, which in turn could result in significantly higher liquidity costs. Glasserman et al. (2014) also analyse systemic risks in markets cleared by multiple CCPs and find that the splitting of members among multiple CCPs causes the hiding of potential liquidation costs from each individual CCP and thus implies an underestimate of the costs. Yet another stream of the literature on CCPs concerns their organizational choices. For example, Haene and Sturm (2009) use a stylised model to analyse the extent to which CCPs should rely on initial margin versus their default fund. Koeppl et al. (2012) analyse the possible rules and organizations of CCPs across markets and study cross-subsidisation between centralised and non-centralised markets.

the mutualization of losses that compared to the bilateral market weakens participants' incentives to find and monitor solid counterparties. The second type of moral hazard is due to the CCPs themselves, which could fail to properly monitor counterparts counting on their systemic relevance, i.e. on being too big or too interconnected to fail (Stephens and Thompson, 2011; Jones and Perignon, 2013; Biais et al., 2016). Pirrong (2011) and Koeppl (2012) both conclude that use of CCPs is not welfare improving relative to bilateral transactions because it can lead to an inefficient increase in the risk of contracting with a bad protection seller and it can weaken market discipline. Jones and Perignon (2013) show that, in order to cope with the moral hazard problems in the clearing mechanism, an incentive compatible system must be put in place. Biais et al. (2013, 2016) point out that, in order to overcome both moral hazard issues, the CCP has to limit the amount of insurance it provides to clearing members so as to give them incentives to seek out sound counterparties that enhance the riskbearing capacity of the CCP. Hansen and Moore (2016) show that mandatory central clearing are welfare improving thanks to the mutualization of counterparty credit risk, but only if initial margin requirements are set optimally, due to the trade-off between the default insurance that a CCP provides and the incentive for market participants to trade too much when default losses are mutualised through the CCPs default fund.

4 Outline of the empirical analysis

Our analysis focuses on borrowing banks as a possible source of risk for CCPs. In Italy banks have typically been net borrowers on centrally cleared repo transactions (Figures 1 and 2).

First step: determinants of the use of CCPs

We start exploring the determinants of the share of centrally cleared transactions on total interbank transactions through the following Equation (1):

$$\mathrm{SH}_{jt} = \alpha_0 UNC_t + \beta_0 Risk_{jt} + \gamma_0 Bilateral_{jt} + \alpha_1 UNC_t * CR1_t + \alpha_2 UNC_t * CR2_t + \beta_1 Risk_{jt} * CR1_t + \beta_2 Risk_{jt} * CR2_t + \gamma_1 Bilateral_{jt} * CR1_t + \gamma_2 Bilateral_{jt} * CR2_t + \delta' KR_{jt} + \zeta' b_j + \eta' p_t + \epsilon_{jt} (1)$$

where SH_{jt} is the share of interbank borrowing via CCPs over total interbank borrowing (including bilateral transactions, secured and unsecured, domestic and abroad) of bank j at time t, in each month from June 2004 to June 2013. Explanatory variables can

be basically grouped in four sets (Table 1): a) general market uncertainty and risk aversion (UNC_t); b) individual risk of borrowing banks ($Risk_{jt}$); c) banks' relationships in the bilateral segment of interbank market ($Bilateral_{jt}$) and; d) control variables (KR_{jt}). Bank-specific dummies b_j are also included to account for unobservable structural bank characteristics. Crisis dummies (CR) are also included.

The variable UNC_t accounts for the role of general market uncertainty and risk aversion, and is measured by three measures used alternatively for robustness purposes. Our default measure is the ratio between the density estimated using historical data from the benchmark index for the Italian stock exchange and the risk-neutral density derived from the options on the index.[13] Results are equivalent using the alternative measures of UNC_t, such as VSTOXX and CISS (Figure 6), described in detail in Section 7 on robustness checks.

$Risk_{jt}$ includes our proxies for the individual risk of the borrowing banks. Our default measure is the *Bad Loans* ratio, which is a standard measure of banks' risk, available for each bank.[14] This variable, while available in the supervisory returns used in this analysis, is not known by counterparts on a continuous time basis (as it is usually published only in the financial statements) and it may be influenced by classification policies. However, it generally provides a reasonable approximation of the actual risk of each bank. Note that for Italian banks, credit risk typically represent by far the largest source of risk. As an alternative, we also use a pair of variables that capture the point of view of rating agencies and are described in Section 7 on robustness checks. Again, results are equivalent when using these alternative measures.

[13]The methodology underlying this proxy for risk aversion is described in Jackwerth (2000) and implemented by Tarashev, Tsatsaronis and Karampatos (2003). As we had this variable available only up to May 2012, we forecast it for the last months in our sample period by using the VSTOXX, the index based on EURO STOXX 50 options prices according to VIX methodology, which is closely correlated with the first indicator for the overlapping periods. Results do not change with respect to those obtained using data only until May 2012.

[14]According to the Italian regulation prevailing during our sample period, non-performing loans are broken down in four parts: a) Bad loans: exposures to an insolvent counterparty (even if insolvency is not legally ascertained) or in equivalent situations, regardless of any loss estimate made by the bank and irrespective of any possible collateral or guarantee; b) Substandard loans: exposures to counterparty facing temporary difficulties defined on the basis of objective factors - that is expected to be overcome within a reasonable period of time; c) Restructured loans: exposures in which a pool of banks or an individual bank, as a result of the deterioration of the borrowers financial situation, agree to change the original conditions (rescheduling deadlines; reduction of interest rate), giving rise to a loss; d) Past due: exposures other than those classified as bad loans, substandard or restructured exposure that are past due for more than 90 days on a continuous basis. Our variable, therefore, focus on the most impaired part of the loan portfolio of a bank and it is computed as the ratio of bad loans/total loans.

The third set of regressors $Bilateral_{jt}$ aims at verifying the impact of the bilateral interbank segment situation of each bank on the choice of recurring to CCPs. The set $Bilateral_{jt}$ includes two sub-sets of variables (Table 1).

The first sub-set, named *Bilateral Relationships*$_{jt}$, estimates the effect of interbank bilateral customer relationships on the use of CCPs. In turn, the sub-set *Bilateral Relationships*$_{jt}$ includes two alternative variables, which (taking advantage of available information on the identity of each counterpart, domestic and foreign, and the related gross bilateral positions) measure respectively the strength and length of relationships of each bank in the bilateral interbank market.[15] The first variable in the sub-set, Interbank Counterparties Concentration ICC_{jt}, measures the degree of concentration of bilateral interbank borrowing of a bank j in period t. It is computed applying the standard Herfindahl index, $\text{ICC}_{jt} = \sum_{i=1}^{N} s_{ijt}^2$, where s_{ijt} is the share of counterpart bank i as lending counterpart of bank j in time t, and N is the total number of banks lending to bank j in time t. This variable, which ranges between 0 and 1 by definition, provides a measure of the strength of interbank relationships of each bank j, with higher values suggesting that bank j tends to hold more exclusive relationships with few counterparts. The second variable, Interbank Relationship Duration IRD_{jt}, measures in each period the weighted average length of all interbank relationships of each bank. The variable IRD_{jt} is a weighted average to take into account the size of each exposure in addition to its length and it is defined as follows: $\text{IRD}_{jt} = \sum_{i=1}^{N} s_{ijt} * d_{ijt}$, where j, i, t, N, and s_{ijt} are defined as before and d_{ijt} counts in each period t the integer number of consecutive months elapsed since the start of an interbank relationship between bank j and each counterpart bank i. In order to minimize censoring, we collect data for this variable back to June 1998 (i.e. 72 monthly periods before the start of our sample period). The maximum value for the integer number d_{ijt} is accordingly equal to 181 in the last period of our sample if the pair *(j,i)* had a interbank relationship in any period, allowing for one month of interruption as a maximum.[16]

The second sub-set, named *Bilateral* $NetworkCentrality_{jt}$ is related but different. It measures the centrality of each bank in the network of bilateral links of the interbank

[15] We consider all *extra-group* secured and unsecured transactions executed both on regulated and over-the-counter markets. In order to eliminate the intra-group exposures, we used information on the identity of each counterpart and its group. For the banks that changed group during our sample period we traced the current group of affiliation in each period, and analysed their effective inter-group relationships in each period.

[16] As a robustness check, we allowed alternatively for zero, two and three months of interruption in order to consider a relationship as continuous. Results are robust. The average IRD amounts to 39 consecutive months on the lending side, and 27 months on the borrowing side (the one considered in the paper). See also Section 7 for our robustness checks.

market. We use three standard measures of centrality from the network literature, which is extensively used in the research on interbank markets mainly to analyse financial contagion. In the literature on interbank networks, banks are the units (or nodes) and the amounts of interbank exposures constitute the weighted links. The three centrality measures we use are: degree (i.e. the number of interbank connections of each bank); betweeness centrality (i.e. an index of interbank centrality of each bank that indicates the banks that each bank has to go through in order to reach another bank in the minimum number of hops); and closeness centrality (i.e. an index of interbank centrality of each bank that captures the length of shortest path to all others). The sub-set *Bilateral* $NetworkCentrality_{jt}$ is different from the previous *Bilateral Relationships*$_{jt}$ because, instead of measuring the strength and duration of bilateral relationships, it captures the possible central role of each bank in the web of the bilateral market, which could be possible even if the bank does not have concentrated and/or stable bilateral relationships. Indeed, a bank could establish a more ramified interbank network precisely because it lack strong bilateral relationships (e.g., by having multiple occasional counterparties): the outcome would be for such a bank a high centrality measure and low ICC_{jt} and IRD_{jt}.

Other important bank-specific covariates KR_{jt} are included as control variables. *Retail Fundraising* and *Central Bank Loans* describe funding sources alternative to the CCPs. *Tier1* and *RoE* describe respectively bank capitalization and profitability, while *Size*, *Loans to Private Sector* and *Portfolio of Government Bonds* approximate important aspects of a bank's business model. The last variable also provides a rough proxy for collateral availability.

In order to distinguish different phases of the financial crisis and to take into account that in some euro-area countries, including Italy, access to funding was more difficult during the sovereign debt crisis than in the previous phase of the financial crisis, we consider two crisis-related dummies. The dummy *CR1* covers the period from the Lehman Brothers bankruptcy in September 2008 to June 2011, when the sovereign crisis hit Italy. The dummy *CR2* covers the sovereign crisis and runs until the end of the sample period in June 2013. Monthly time dummies p_t are also typically included (whenever possible, see below) to take into account the impact of particular events (such as the impact of a change in haircuts in November 2011 or the launch of the Long-Term Refinancing Operations by the ECB) as well as other unobservable time-varying variables.

Our analysis focuses on demand side determinants (that is, banks' characteristics) of CCPs' use. Supply factors such as changes in the (unique) Italian CCP' standards

and conditions (e.g. fees, margins, risk management policies) or economic and financial situation may also be relevant. As our interest is on the determinants of the growing use of CCPs at bank level this limitation may not be so crucial. Supply side factors that apply indifferently to all banks may explain a generalized increasing recourse to CCPs but not the differential use. If they have a different impact on banks, our analysis is still valid as long as this heterogeneity depends on banks' characteristics, which is likely to be the case in our view. Moreover, from an econometric point of view, the time fixed effects may seize also supply factors as they capture part of all aggregate fluctuations of the dependent variable over time.

To estimate Equation (1) we run a zero inflated beta regression model. This model allows us to take into account that most banks do not use the CCPs for their funding (especially during the first part of the sample period) as well as the fact that our dependent variable is a ratio (the share of CCPs exposures over the total interbank exposures). In fact the zero inflated beta regression model is aimed to address the specification errors arising from modelling a ratio variable as a linear function of the explanatory variables and from ignoring that the conditional variance must be a function of the conditional mean since the former must change as the conditional mean approaches either 0 or 1 (e.g., Papke and Wooldridge, 1996; Cook et al., 2008). In addition, the zero inflated approach allows us to take into account that determinants of zero and positive observations (once an intermediary decides to use CCPs) may be different, avoiding the related selection bias. Indeed, while most of the increase in the use of CCPs is driven in each year by the intensive margin, as expected, the data shows that between 2009 and 2010 and again between 2011 and 2013 also the contribution of the extensive margin (i.e. the funding obtained by banks which were not operating via CCPs the year before) is not irrelevant (Table 2).

Second step: use of CCPs by riskier borrowers

Our second step aims at investigating whether recourse to CCPs allowed riskier banks to elude market discipline, potentially increasing the risk borne by the financial system as a whole. For such a conclusion, it is not enough to show that individual bank risk is positively associated to CCPs' share in the overall interbank transactions: a measure is needed that links the risk associated to each bank by its bilateral interbank counterparties to its recourse to CCPs. In fact, if the risk for CCPs is to fund a pool of borrowers that are reputed too risky by their, best informed, bilateral interbank counterparties, then we need an indicator that capture the judgement of these bilateral

interbank counterparties. The measure adoped to gauge this aspect is the *change* in the weighted average duration of each intermediary's interbank relationships ΔIRD_{jt}, where IRD_{jt} is the Interbank Relationship Duration for bank j at time t, defined above. In formal terms, we estimate the following Equation (2) by means of a fixed effect panel estimation model:

$$\Delta SH_{jt} = \alpha_0 UNC_t + \beta_0 Risk_{jt} + \gamma_0 \Delta IRD_{jt} + \gamma_1 \Delta IRD_{jt} * Risk_{jt} + \delta_{'} KR_{jt} + \zeta_{'} b_j + \eta_{'} p_t + \epsilon_{jt} (2)$$

where variables are defined as above and $\Delta variables$ are the changes over the previous month.

As the literature on relationship lending shows that long-lasting partnerships are characterized by better information, a positive ΔIRD_{jt} signals that on average better informed counterparts keep their relationship with the bank j while a negative change would signal a drying-up of interbank funding by longer-standing counterparts. Accordingly, the relationship between changes in CCPs share and change in the weighted average duration of bilateral interbank relationships should have, *ceteris paribus*, a negative sign for riskier banks. In fact, recourse to CCPs should compensate for the loss of older relationships (that shorthen the average duration of bilateral relationships). Using this measure not only addresses possible concerns about the precision and/or the observability by counterparties of the measures of risks used in our first step's regressions, but also it allows to tackle the issue of whether the CCPs are taking risks that are dogded by bilateral counterparts.

5 Data

Our sample period extends from June 2004, when centrally cleared repo transactions started in Italy, to June 2013. With the exception of measures of uncertainty and rating scores, our data are drawn from the Bank of Italy prudential supervisory reports, are available for each resident bank and include data on relationships with foreign banks. We excluded from our analysis cooperative banks because they are typically very small and tend to manage their liquidity needs and surpluses through a dedicated intermediary which acts as a liquidity hub. Data of intermediaries that are part of a banking group are consolidated at each point in time (considering the group as a single entity) as liquidity management is typically centralized at the group level and we are not considering infra-

group transactions.[17] This is done for all variables in our dataset and in the paper we refer to both banking groups and stand-alone banks in our sample as "banks".

Our final sample is a panel including about 200 banks on average in each of our 109 monthly periods. The banks in our sample represent on average about 90 per cent of the total assets of the Italian banking system along our sample period. Tables 1 - 3 describe our explanatory variables and provides summary statistics.

We use end-of-month outstanding amounts for all types of interbank exposures. Data on prices for over-the-counter transactions, which are very relevant in the interbank market, are not available. It is to remark that, even if interest rates were available, it would be very difficult to summarize all the different aspects directly or indirectly involved in the relative cost comparison between CCPs and bilateral transactions: haircuts, cost of collateral, contributions to CCPs default funds, etc. While this limitation, common to other contributions in the literature (e.g. Furfine, 2004 and 2009; King, 2008; Dinger and von Hagen, 2009; Cocco et al., 2009; Affinito, 2013), is clear, it may be observed that, according to the majority of the accounts of developments during the financial crisis, prices were basically moving in response to changes in quantities.[18] The use of end-of-month outstanding amounts is also explained by data availability. In fact, micro bank-by-bank data with the details of our dataset do not exist with an higher frequency. However, it is worth noticing that, although interbank activity is usually at very short maturities, the persistence of exposures and positions is very high, even towards specific counterparties (Affinito, 2012 and 2013; Affinito and Pozzolo, 2017).

6 Results

First step: determinants

The results of our first step are reported in Tables 4 and 5.

Table 4 shows the results on the determinants of *participation* to CCPs (the dependent variable is a dummy 0,1), while Table 5 shows those related to the *intensity* of the recourse to CCPs conditional to participation (the dependent variable is a ratio). Notice that in the estimation of participation reported in Table 4 (first stage of the zero inflated beta regression model), a positive sign indicates a lower participation (more zeros) and a negative sign a higher participation (less zeros).

[17] Intra-group transactions tend to fit into a group-specific scheme and are likely to be decided by the parent bank (e.g. Houston et al., 1997; de Haas and van Lelyveld, 2010).

[18] The typical example were transactions on the e-MID, the electronic platform for unsecured interbank activity in Italy, where exchanges dramatically dropped, making the quoted prices basically non informative.

Starting from the interbank bilateral factors underlying participation to CCPs transactions, we find that stronger interbank bilateral relationships (the variable ICC) are associated with a lower participation, supporting the idea that the two channels tend to be alternative in normal conditions (Table 4). During both phases of the crisis, however, this association tended to fade away, as also banks with established bilateral relationships had to tap all the available sources of funding, including the CCPs. Similar results hold when looking at the intensity of use (share of funding via CCPs), conditional to the participation to the market (Table 5). We again find that strong bilateral relationships reduce the intensity of CCPs use in normal conditions, but that this association disappeared during the crises. We also find that foreign extra-group interbank funding (as a ratio to total interbank funding) has a negative impact on CCPs participation (i.e. banks with higher bilateral funding from abroad were less likely to resort to CCPs, Table 4). As the financial crisis triggered a significant retrenchment of the foreign interbank bilateral funding (as shown above, Figure 4), we also use the change in funding from abroad as an explanatory variable and find that, as expected, a negative change in foreign funding is associated to a higher participation to CCPs transactions. Results on network indicators show that before the onset of the crisis, a higher centrality in interbank bilateral market favoured both recourse and intensity in the use of CCPs, while during the crisis banks more central in the bilateral interbank market present less needs to turn to and use CCPs.

Market uncertainty is not a significant factor in driving banks to CCPs until the start of the financial crisis. Then, for both the crisis periods, the coefficient associated to uncertainty becomes significant and associated with a larger participation and a larger share of CCPs transactions, reflecting the general move toward secured transactions at times of heightened risk aversion.[19]

The individual risk of a bank, proxied by its bad loans ratio, affects both the participation and the intensive use of CCPs but in opposite directions.[20] Participation of riskier banks to CCPs is more likely before the crisis and becomes instead less likely in both the crisis periods, possibly due to the costs associated to participation by CCPs in a context of tighter risk control frameworks. By contrast, for banks already using CCPs, individual bank risk becomes a significant positive determinant of the proportion

[19]To support this interpretation, we ran a similar regression for lenders that are likely the most affected by uncertainty if concerned about counterparty risk. We found that the participation to CCPs is indeed higher when our measure of general uncertainty is higher and when the degree of concentration of bilateral lending is lower.

[20]When banks' individual risk is proxied by the pair of variables on banks' credit rating, results are broadly similar to those of Table 4 and not reported.

of CCPs transactions during the crisis (coefficients are significant in both sub-periods, slightly larger during the sovereign debt crisis phase), in line with the finding of an increased market discipline on other segments of the interbank market.

In order to gain an insight into the estimated economic impact of the different determinants, Table 5 also reports the marginal effects of each regressor on the dependent variable other things being equal.[21] The total net impact of our measures of individual risk and general uncertainty are sizeable and very similar. Moving from the 25th percentile to the 75th percentile of the bad loans ratio, the intensity of the use of CCPs increases during the crisis with an impact ranging from 7 to 9 per cent in the two phases of the crisis, while the uncertainty increases the share of CCP transactions during the sovereign part of the crisis by around 15 per cent.

As for the other covariates, we find that larger banks tend to participate more to CCPs, consistently with the direct and indirect costs associated to the membership of CCPs, and that the share of centrally cleared transactions is higher for banks with a higher share of government bonds over total assets (broadly confirming the relevance of collateral availability for this type of funding).

Second step: CCPs and riskier borrowers

Results of the first step provide a broad view of the factors driving participation and recourse to CCPs transactions before and during the financial crisis, confirming that both uncertainty and risk play a significant role. As previously clarified, in the second step we focus on the change over time of the weighted average duration of the bilateral interbank relationships of each borrowing bank, ΔIRD_{jt}. If the shift to CCPs derives from bank-specific risk, older (i.e., better informed) counterparts should maintain relationships with safer borrowing banks and shut down those with riskier banks. The latter should then be forced to recur to CCPs to obtain their "interbank" funding. Accordingly, the relationship between ΔSH_{jt} and ΔIRD_{jt} should be negative for riskier banks (and positive and/or not significant for less risky intermediaries). To check if this is indeed the case, we separate banks according to their decile in the bad loans ratio distribution and we then check if the coefficients associated to the interaction terms ΔIRD_{jt} * *decile of* $risk_{jt}$ is negative and significant for the banks belonging to the upper deciles of the risk distribution while positive and/or non significant for the lower deciles.

[21] Marginal effects are computed only for the intensity of the recourse to CCPs measuring the percentage change of the dependent variable moving from the 25th to the 75th percentile of each regressor for the specification (6). Outcomes are very similar in the other specifications. Marginal effects on the participation to CCPs (first stage of the zero inflated beta regression model) are not reported because the dependent variable is a dummy 0,1.

Table 6 summarizes the results of Equation (2). It shows, first, that changes in the use of CCPs are negatively related to changes in the weighted average duration but only during the crisis (specifications 1-2). Moreover, in line with our hypothesis, the driver of this result is the level of individual risk, as indicated by the fact that only the interaction term is significant in specifications 3-4. Results are supportive of our interpretation of the weighted average duration variable since confirm that the relationship becomes negative as we move from the lowest to the highest levels of banks' risk. Interacting the changes in the weighted average duration with deciles of our risk indicator (bad loans ratio), we find that the effect is concentrated only in the highest deciles of the distribution by risk (the last two deciles in the first part of the crisis and the last one only in the sovereign debt crisis).

For the riskier borrowers, therefore, the negative and significant sign of the average duration suggests that a relevant determinat of the increased recourse to the CCPs is the loss of more established interbank customer relationships, a signal that there may be a specific issue with the risk associated to that bank.

7 Robustness checks

This section summarizes the main robustness checks carried out: for brevity some checks are not reported in additional tables but they are all available from the authors upon request.

Uncertainty and time fixed effects. The effect of market uncertainty and risk aversion on the use of CCPs was tested in two ways. First, as mentioned, we run our regression with different definitions of the variable UNC_t. A first alternative measure directly rely on VSTOXX, the index based on EURO STOXX 50 options prices computed according to VIX methodology. A second alternative measure is the Composite Indicator of Systemic Stress (CISS) index, which summarizes contemporaneous stress in the financial system (Holl et al., 2012).[22] The developments of the three alternative measures are very similar (Figure 6) and results are equivalent. In Table 7 (Specifications 1 and 2)

[22]CISS is computed by applying basic portfolio theory to the aggregation of five market-specific sub-indices created from a total of 15 individual financial stress measures. The aggregation accordingly takes into account the time-varying cross-correlations between the sub-indices. As a result, the CISS puts relatively more weight on situations in which stress prevails in several market segments at the same time, capturing the idea that financial stress is more systemic and thus more dangerous for the economy as a whole if financial instability spreads more widely across the whole financial system.

and Table 8 (Specification 1) we report results from regression analogous, respectively, to those in Tables 4 and 5 (Specifications 1 and 6) and Table 6 (Specification 1) this time using the CISS index instead of our default measure (the ratio between the densities). Results are unchanged.

Second, we verified the robustness of the variable UNC_t to either dropping or changing time fixed effects. In Tables 4-6 we reported results of Equations (1) and (2) that included time fixed effects to allow for supply side factors and all other macro unobservable time-varying variables. As time dummies could affect the estimation of the variable UNC_t absorbing some of its effect on the dependent variable we run the same regressions dropping time fixed effects and the coefficient associated to the variable UNC_t remains stable (Table 7, Specification 3 and 4, for the first step; and Table 8 Specifications 2, 3 and 4, for the second step).[23]

Sample time splitting to control for the impact of the crisis. Regarding the impact of the crisis, we have included in estimations an interaction term between the regressors and two period dummies *CR1* and *CR2*, which take the value of 1 during the corresponding phases of the crisis and 0 otherwise. As a check, instead of the two dummies and interactions, we have used a sample time splitting repeating the same estimations before and after the onset of each crisis (regressions were run on three sub-periods: up to 2008, from 2008 to 2011, and afterwards). Results remain equivalent to those obtained with the interaction terms.

Different starting dates of the two crises. In addition to time fixed effects, to test the sensitivity of results to different dates and periods, we employed two kinds of check. First, we experimented the beginning of the two crises with slightly different starting dates, bringing it forward and postponing it by one to four months. Second, instead of using time dummies, we used continuous variables accounting for major developments that could affect our variables, such as the total liquidity injected by the Eurosystem, GDP growth and inflation rates. Results remain stable.

Non-linear dynamics. Some of the relationships shown by our results could be affected by non-linear dynamics, in particular related to central bank liquidity provisions, which have been massively used by Italian banks during the crisis. We therefore added a higher order term to the variable *Central Bank Loans*. Both variables (*Central Bank*

[23]Results are also robust to the choice of the time dummy to be dropped to allow for the inclusion of the measure of market uncertainty.

Loans and its square) remain statistically non significant in the regression explaining participation to CCPs (first stage of the zero inflated beta regression model) while they are both significant in the regression on the intensity of the use of CCPs (second stage of the zero inflated beta regression model). *Central Bank Loans* is statistically positive and the squared term is significantly negative. All the other results remain unchanged in substance when the two variables are added in the estimations. Interacting *Central Bank Loans* with other covariates did not lead to significant findings.

Restricting estimation sample. In some of our estimations the sample varies from one specification to the other because of missing values in the variables or because the use of changes over time $\Delta variable$ implies the loss of initial observations of each bank. As a check, we restricted all estimations to the largest sample consistent across all specifications, and results remain the same.

Instrumental variable estimation. A concern regards the possible presence of reverse causality between our dependent variables in both models and the key bank-level regressors. This appears a possibility when we come to interbank bilateral characteristics (while we are not aware of channels through which the use of CCPs by a bank may determine its bad loans ratio). We tested the possible presence of reverse causality in two ways. First, through standard, although not necessarily very powerful, tests such as the Durbin and Wu and Hausman test. For both variables, regressors turned out not to be endogenous. Second, we re-estimated our regressions through an instrumental variable method alternating different instruments. We adopted as instruments alternatively either the respective lags of regressors or, for the $Bilateral_{jt}$ regressors, liquidity shocks correlation between interbank counterparties.[24] In all cases, results remain the same. As an example, we report (Table 8, Specifications 5 and 6) the same estimation of Specification 1 of Table 6 while using instrumental variable estimations.

Alternative definitions of variables. As a check we defined some variables in a different way. First, as mentioned, we tested different definitions of our crucial variable IRD, which counts in each period the integer number of months elapsed since the start of an interbank relationship between each pair of banks. Allowing a maximum of, respectively, zero, one, two or three months of continuous interruption as a precondition to

[24]Following Cocco et al. (2009) and Affinito (2011), liquidity shocks correlation between interbank counterparties measures the correlation between the liquidity shocks of each pair of banks and it is computed as a correlation between volatility of liquidity (i.e. coefficient variation) of balance sheet items measuring banking liquidity. Cocco et al. (2009) and Affinito (2011) show that this variable matters for the existence and persistence of interbank customer relationships.

consider a relationship as ongoing does not bring to differences in our results. Second, in alternative to the bad loans ratio, we measured the risk of each bank relying on the following pair of variables: *Rating*, which is coded so as to take values from 1 to 11, where 1 corresponds to the best rating class and 10 to the worst, with 11 assigned to banks with no rating; and the dummy *Banks without Rating*, which takes the value of 1 for banks with no rating and 0 otherwise.[25] Third, just for the pair of variables *Rating* and *Banks without Rating* we used an alternative approach avoiding to impose a linear structure to the relationship and introduced dummies for each score using the best score as the baseline level.[26] Results remain unchanged.

8 Conclusions

During the crisis Italian banks remarkably increased their use of CCPs for their interbank funding. The financial stability implications of this growing role of CCPs in interbank markets may be very different: on the one side, it may reduce uncertainty and avoid the freezing of the interbank market; on the other side, it may allow riskier borrowers to escape market discipline increasing the counterparty risk borne by CCPs and as a consequence by the financial system as a whole. Overall, our analysis confirms that uncertainty and bank risk have both played a relevant role in interbank markets and have been both drivers of the recourse to CCPs. Our results suggest that only for the riskier borrowers the recourse to the CCPs during the crisis is likely driven by difficulties to borrow in the bilateral interbank market due to their risk. Our findings support the policy effort to ensure that CCPs put in place adequate risk control frameworks, and suggest an additional reason why this effort should remain high in the policy agenda.

[25] The two variables are always included simultaneously in order not to lose observations on non-rated banks while allowing the ad hoc dummy to control for non-rated banks so to avoid that the score "11" for missing banks is interpreted as a worse score than the actual score "10" (e.g., Angelini et al., 2011). The credit scores are taken from the agency Fitch through the database of Bloomberg as Angelini et al. (2011) find that Fitch ratings are more informative in the assessment of banks and financial firms. All the credit ratings are obtained as a monthly average of ratings available daily. We use the overall individual rating.

[26] We thank an anonymous referee for suggesting the alternative measure.

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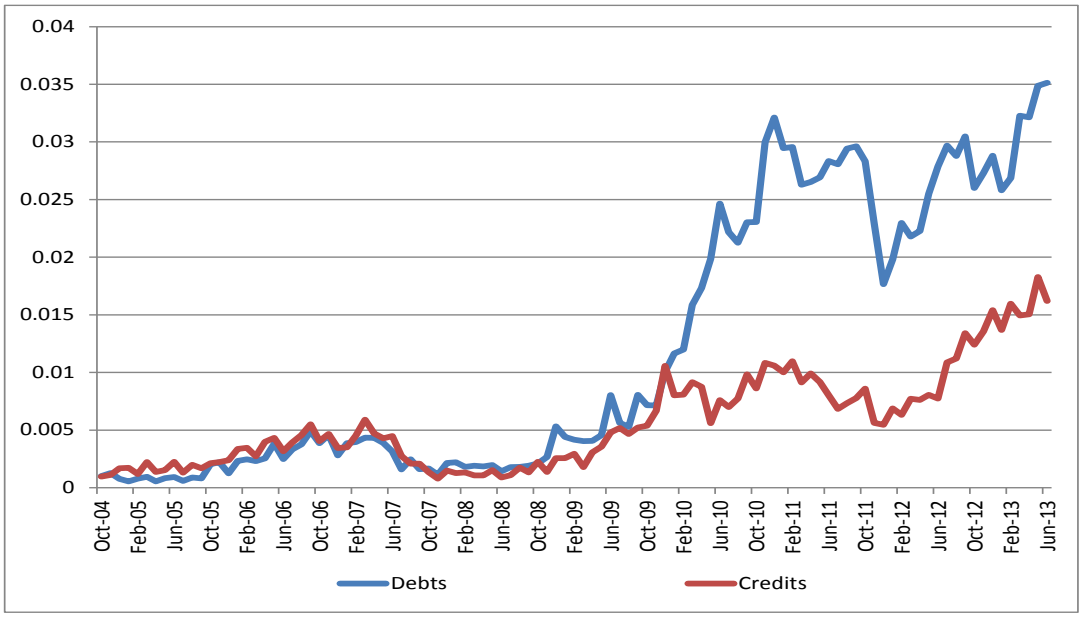
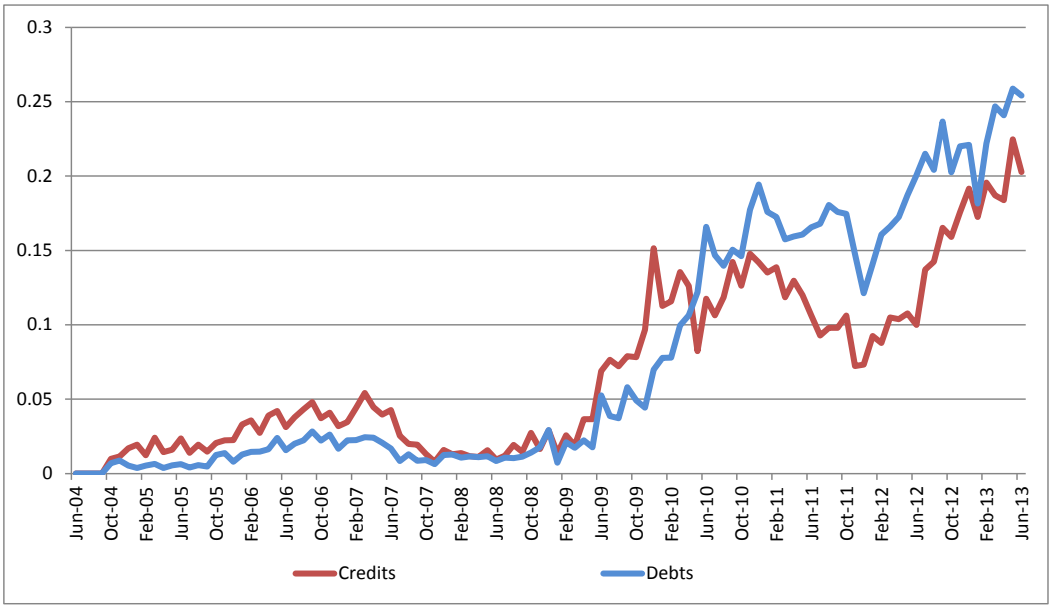
Figure 1. Interbank exposures through CCPs as shares of total assets



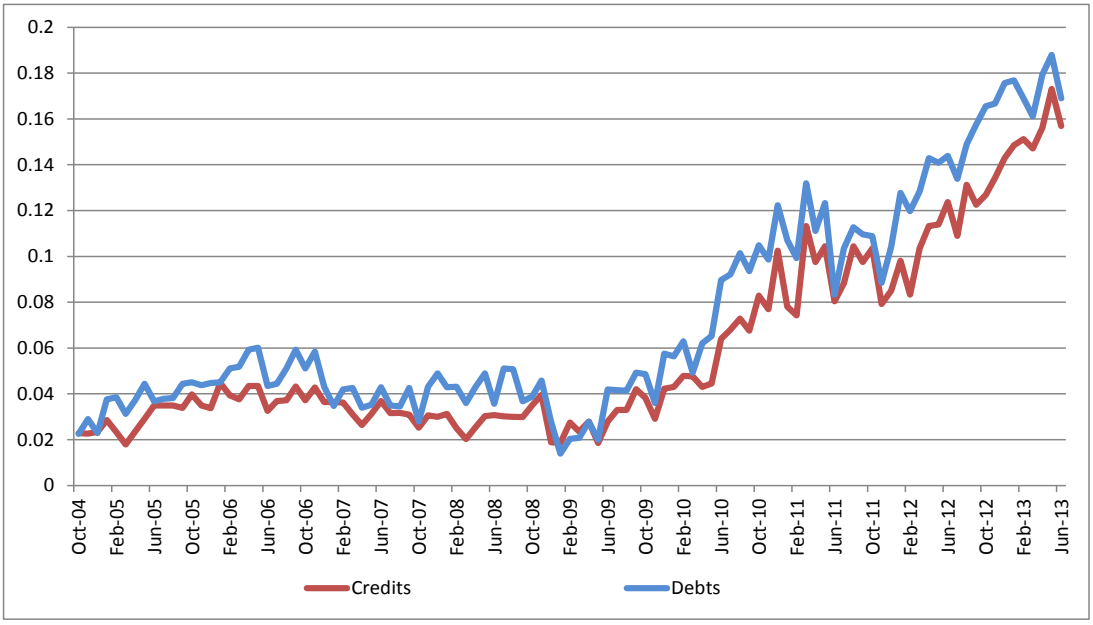
Source: authors' computations on Bank of Italy prudential supervisory reports.

Figure 2. Interbank exposures through CCPs as shares of total extra-group interbank exposures



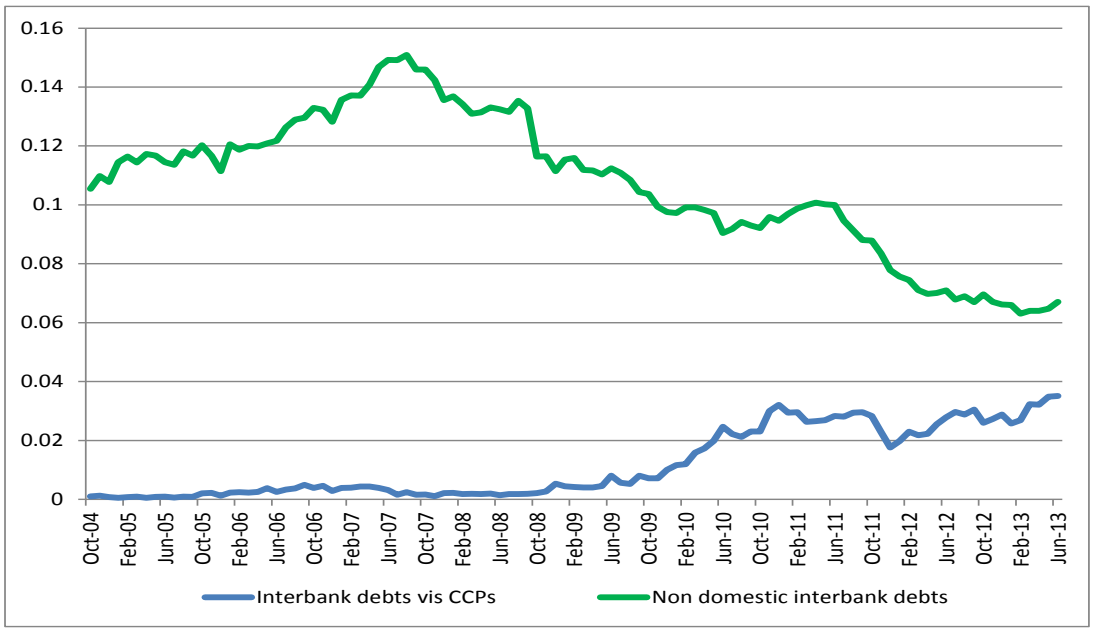
Source: authors' computations on Bank of Italy prudential supervisory reports.

Figure 3. The number of banks operating via CCPs as a share of the total number of banks operating in the extra-group interbank markets



Source: authors' computations on Bank of Italy prudential supervisory reports.

Figure 4. Interbank exposures through CCPs and abroad as shares of total assets



Source: authors' computations on Bank of Italy prudential supervisory reports.

Figure 5. Structure of two segments of interbank market: bilateral and via a CCP

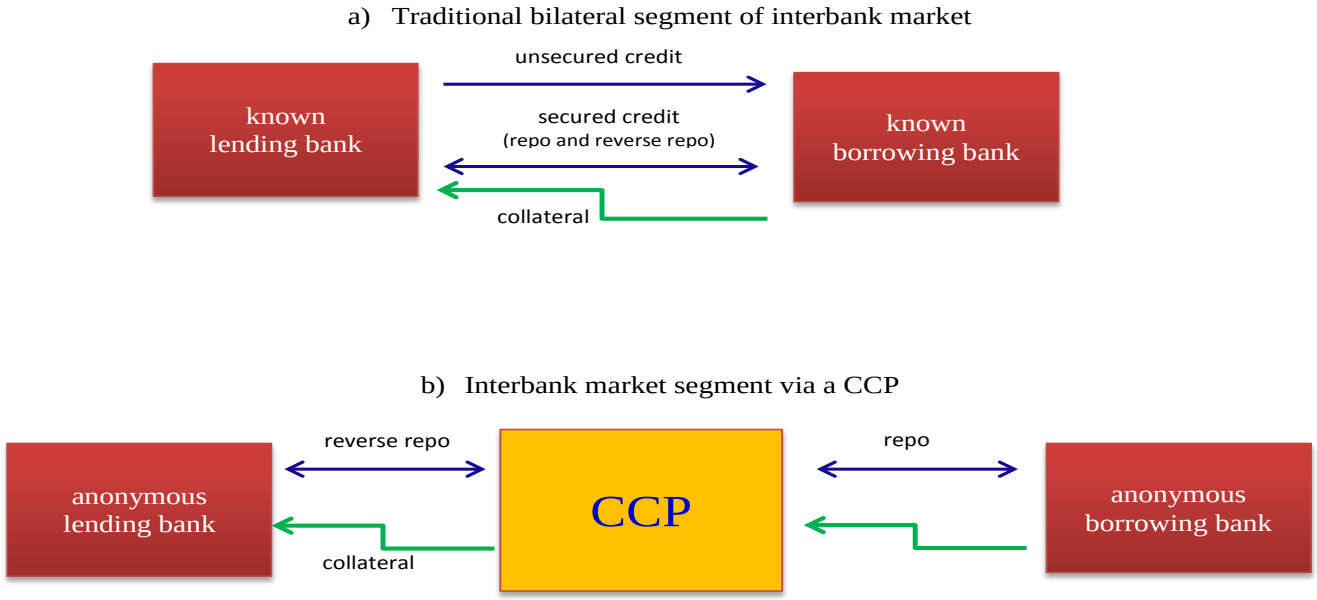
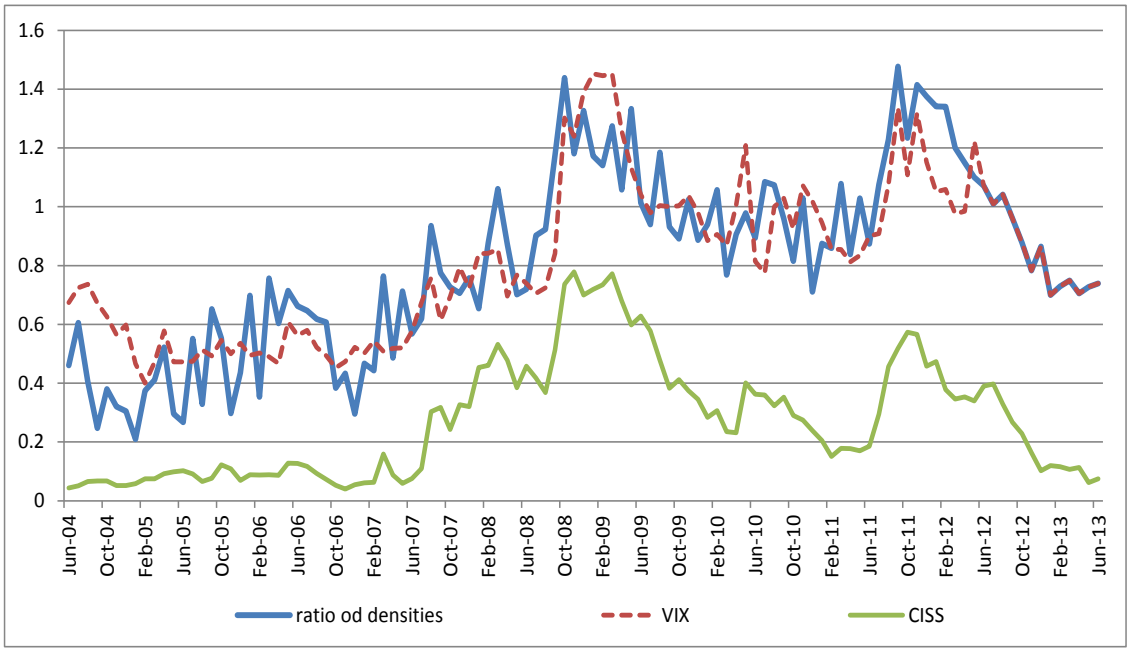


Figure 5 shows schematically the structure of interbank market: Panel (a) shows the typical structure of the bilateral segment; and Panel (b) shows the typical structure of the segment via a CCP. The traditional interbank bilateral transactions occur between pairs of banks, are nominative and may be secured or unsecured. Interbank transactions via CCPs occur usually through repos and are thus typically secured; and they are anonymous. The structure of the segment via a CCP typically works as follows: i) the borrowing bank enters into a repurchase agreement with the CCP, borrowing the required amount and providing collateral; ii) the lending bank enters into a reverse repo with the CCP; iii) the CCP acts as the direct counterparty to the seller and the buyer, thus assuming the risk of borrower default, and manages the transaction and the collateral. In addition, collateral management is highly standardized in terms of profiling and margining, which enhances transparency, and the administrative burden for borrower and lender is significantly lower than in a bilateral repo.

Figure 6. Alternative measures of general market uncertainty and risk aversion



Source: for the ratio of densities: Jackwerth (2000) and Tarashev et al. (2003); for VIX: VSTOXX, the index based on EURO STOXX 50 options prices according to VIX methodology; for CISS: Holl et al. (2012).

Table 1. Definition of variables and summary statistics

Variables' notation	Variables' content	Definition	N	mean	sd	min	p50	max
SH_{jt}	CCP Debts	Interbank debts through CCPs / Total interbank debts	15,279	0.02	0.10	0.00	0.00	1.00
UNCt	Uncertainty	ratio between density estimated using historical data from the benchmark index for the Italian stock exchange and the risk-neutral density derived from the options on the index	15,279	0.84	0.30	0.21	0.86	1.48
$Risk_{jt}$	Bad loans	Bad loans / Total loans	15,279	0.03	0.03	0.00	0.02	0.12
	Rating	Rating agency scores	15,279	9.87	2.47	2.00	11.00	11.00
	Banks without rating (0-1)	Banks without rating (0-1)	15,279	0.82	0.38	0.00	1.00	1.00
$Bilateral\ Relationships_{jt}$	Interbank Counterparties Concentration ICC_{jt}	Log (degree of concentration of interbank debts)	15,279	0.44	0.36	0.00	0.34	1.00
	Interbank Relationship Duration IRD_{jt}	Weighted average length of all interbnk borrowing relationships	15,279	2.80	1.50	0.00	3.28	5.14
	Foreign interbank debts	Interbank debts from abroad / Total interbank debts	15,279	0.20	0.32	0.00	0.02	1.00
$Bilateral\ Network\ Centrality_{jt}$	Interbank network Degree	the number of interbank connections of each bank	15,279	2.60	1.04	0.69	2.40	6.57
	Interbank network Betweeness	an index of interbank centrality of each bank that seizes the banks that each bank has to go through in order to reach another bank in the minimum number of hops	15,279	3.25	3.12	0.00	2.82	12.41
	Interbank network Closeness	an index of interbank centrality of each bank that captures the length of shortest path to all others	15,279	0.36	0.04	0.25	0.35	0.60
$Control\ variables\ KR_{jt}$	Retail Fundsraising	Total retail deposits and bonds / Total assets	15,279	0.47	0.30	0.00	0.57	1.00
	Central Bank Loans	Total loans form central bank / Total Assets	15,279	0.02	0.05	0.00	0.00	0.36
	Tier1	Tier1 / Risk weighted assets	11,606	0.17	0.13	0.02	0.13	1.00
	ROE	Net profits / Capital	15,279	0.06	0.17	-0.89	0.05	0.90
	Size	Log (Total assets)	15,279	7.79	1.96	1.95	7.72	13.67
	Loans to Private Sector	Loans to Private Sector / Total Assets	15,279	0.57	0.24	0.00	0.63	0.99
	Portfolio of Government Bonds	Portfolio of Government Bonds / Total Assets	15,279	0.06	0.09	0.00	0.03	0.86

Table 2. Intensive and extensive margins of interbank exposures through CCPs
(*millions of euros and as a share of total assets*)

	total		**intensive**		**extensive**	
		%		%		%
2009 - 2008	10.955	*0,31*	10.923	*0,31*	32	*0,00*
2010 - 2009	52.841	*1,53*	46.741	*1,36*	6.100	*0,18*
2011 - 2010	20.602	*0,59*	20.209	*0,58*	393	*0,01*
2012 - 2011	-885	*-0,02*	-4.033	*-0,11*	3.148	*0,09*
2013 - 2012	17.246	*0,45*	13.726	*0,36*	3.521	*0,09*
2013 - 2008	**100.759**	***2,64***	**87.564**	***2,29***	**13.194**	***0,35***

The extensive margin is computed as the sum of the current year average interbank exposure through CCPs of each bank whose previous year average interbank exposure through CCPs is equal to zero. The intensive margin is computed as the sum of differences of the current and previous year average interbank exposures of each bank whose previous year average interbank exposure through CCPs is larger than zero.

Table 3. Correlations among variables

	CCP Debts	Foreign interbank debts	Borrowing IRD	Borrowing ICC	Interbank network betweeness centrality	Interbank network degree	Interbank network closeness centrality	Size	Loans to Private Sector	Portfolio of Government Bonds	Retail Fundsraising	Central Bank loans	Bad loans	Tier1	ROE	Rating	Banks without rating (0-1)	Uncertainty
CCP Debts	1																	
Foreign interbank debts	-0.1***	1																
Borrowing IRD	0.1***	-0.3***	1															
Borrowing ICC	-0.09***	-0.069***	0.09***	1														
Interbank network betweeness centrality	0.2***	-0.3***	0.4***	-0.3***	1													
Interbank network degree	0.2***	-0.3***	0.4***	-0.3***	0.8885***	1												
Interbank network closeness centrality	0.2***	-0.1***	0.3***	-0.2***	0.7***	0.82***	1											
Size	0.2***	-0.02*	0.4***	-0.2***	0.62***	0.7***	0.61***	1										
Loans to Private Sector	-0.1***	0.1***	0.03***	0.02*	-0.2***	-0.2***	-0.1***	-0.09***	1									
Portfolio of Government Bonds	0.1***	-0.3***	0.07***	0.085***	0.07***	0.03***	-0.0066	-0.064***	-0.3***	1								
Retail Fundsraising	0.04***	-0.7***	0.2***	0.0602***	0.1***	0.1***	-0.01	0.03***	0.009	0.3	1							
Central Bank loans	0.1***	-0.1***	0.1***	-0.02	0.2***	0.1***	0.2***	0.1***	-0.1***	0.3***	-0.005	1						
Bad loans	0.1***	-0.3***	0.2***	0.02	0.1***	0.2***	0.1***	0.1***	0.2***	0.1***	0.3***	0.1***	1					
Tier1	0.067***	-0.082***	-0.2***	0.1***	-0.1***	-0.2***	-0.1***	-0.2***	-0.3***	0.1***	-0.2***	0.04***	-0.1***	1				
ROE	-0.082***	0.2***	-0.002	-0.081	-0.009**	0.01	0.02***	0.089***	0.1***	-0.0861***	-0.1***	-0.07***	-0.0882***	-0.2***	1			
Rating	-0.1***	0.2***	-0.2***	0.2***	-0.5***	-0.602***	-0.5***	-0.5***	0.069***	-0.02*	-0.1***	-0.09***	-0.2***	0.1***	-0.005	1		
Banks without rating (0-1)	-0.1***	0.2***	-0.2***	0.2***	-0.5***	-0.602***	-0.5***	-0.5***	0.07***	-0.01	-0.1***	-0.09***	-0.2***	0.1***	0.0003	0.9***	1	
Uncertainty	0.05***	0.01	-0.07*	0.01*	0.0082***	-0.061***	0.04***	-0.02	0.03***	0.02	-0.02	0.1***	0.062***	0.05***	-0.09***	0.0669***	0.05***	1

***, **, and * denote statistical significance at 1, 5 and 10 % level.

Table 4. Determinants of interbank exposures through CCPs: determinants of *participation* to CCPs (the dependent variable is a dummy 0,1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Foreign interbank debts	29.372 ***	29.296 ***	31.281 ***		26.693 ***	28.257 ***	28.619 ***	28.885 ***			26.343 ***
	9.117	*8.995*	*11.089*		*9.301*	*8.268*	*8.065*	*9.427*			*8.815*
Delta (foreign interbank debts)				6.925 **					7.577 **	14.173 ***	
				3.241					*3.543*	*4.488*	
UNC	3.604 **	2.604	4.704 *	4.713 **	4.324 ***	3.513	2.983	5.279 *	3.954	2.769	4.276
	1.543	*1.826*	*2.614*	*1.831*	*1.390*	*2.877*	*2.371*	*3.180*	*3.034*	*2.065*	*3.221*
UNC x crisis 1						-3.474 *	-6.093 ***	-3.701 ***	-3.733	-2.362 ***	-10.006 ***
						2.087	1.730	1.429	2.389	0.732	3.156
UNC x crisis 2						-5.715 **	-8.240 ***	-5.781 **	-5.968 **	-4.539 ***	-11.956 ***
						2.390	*2.004*	*2.292*	*2.617*	*1.143*	*1.982*
ICC	3.510 ***	3.940 ***		4.089 *		8.051 ***	8.345 ***		8.250 ***	7.285 **	
	1.330	*1.410*		*1.701*		*2.525*	*2.714*		*2.531*	*3.170*	
ICC x crisis 1						-5.577 **	-5.208 **		-5.527 **	-5.204 *	
						2.402	*2.417*		*2.257*	*3.248*	
ICC x crisis 2						-5.540 **	-5.421 *		-5.310 **	-4.524	
						2.721	*2.825*		*2.470*	*3.255*	
IRD	0.072		0.121	0.180		0.554		0.316	0.737		
	0.177		*0.161*	*0.178*		*0.556*		*0.355*	*0.613*		
IRD x crisis 1						-0.432		-0.259	-0.505		
						0.789		*0.681*	*0.799*		
IRD x crisis 2						-0.478		-0.157	-0.582		
						0.599		*0.437*	*0.638*		
Betweeness centrality					*23.707*						*-0.856* ***
					19.636						*0.311*
Betweeness centrality x crisis 1											*0.707* ***
											0.207
Betweeness centrality x crisis 2											*0.775* ***
											0.295
Bad loans	0.121	0.555	1.455	-5.391	-0.116	-74.133 **	-53.878 *	-40.811 **	-88.955 **	-83.777 **	-40.329 *
	16.099	*14.094*	*12.543*	*15.185*	*0.194*	*30.873*	*30.244*	*19.594*	*37.926*	*35.374*	*22.620*
Bad loans x crisis 1						76.181 ***	58.478 **	60.182 ***	83.550 **	85.862 **	44.331
						27.454	*26.642*	*22.615*	*35.108*	*33.891*	*31.459*
Bad loans x crisis 2						87.453 ***	71.118 **	65.933 ***	99.470 **	91.362 **	67.692 **
						31.551	*30.413*	*24.623*	*38.703*	*37.325*	*29.272*
Size	-2.772 **	-3.103 **	-2.960 **	-3.015 **	-3.479 **	-2.355 ***	-2.551 **	-2.780 **	-2.297 **	-0.998	-2.634
	1.177	*1.358*	*1.347*	*1.490*	*1.698*	*0.920*	*0.998*	*1.324*	*0.893*	*1.325*	*2.213*
Retail Fundsraising	-8.753 ***	-9.549 ***	-9.505 ***	-8.542 ***	-20.609 ***	-6.666 **	-7.713 **	-6.755 **	-6.511 *	-4.651	-18.342 ***
	3.072	*3.179*	*3.434*	*3.584*	*4.917*	*3.363*	*3.274*	*3.416*	*3.827*	*3.644*	*4.547*
Loans to Private Sector	8.517 *	7.962 *	7.652 *	8.217 *	12.504 **	11.691 ***	11.498 **	8.336 *	11.919 ***	15.654 ***	15.936 **
	4.859	*4.929*	*4.716*	*4.850*	*5.327*	*4.464*	*4.812*	*4.635*	*4.168*	*4.430*	*6.649*
Central Bank loans	7.848	8.490	5.753	5.495	-2.623	5.764	6.947	4.591	3.423	4.219	-4.684
	9.806	*9.819*	*9.464*	*9.864*	*9.082*	*9.804*	*9.848*	*9.409*	*9.627*	*9.460*	*9.674*
Portfolio of Government Bonds	-0.863	-0.762	-0.202	-1.775	1.805	-0.880	-0.680	-1.868	-2.088	-2.896	4.263
	5.479	*5.494*	*4.928*	*6.178*	*5.130*	*5.632*	*5.708*	*6.245*	*6.122*	*5.800*	*6.531*
ROE	0.725	0.705	1.489	0.859	1.449	0.284	0.523	1.357	0.471	-0.202	1.070
	1.250	*1.181*	*1.311*	*1.153*	*0.985*	*1.271*	*1.273*	*1.332*	*1.247*	*1.449*	*1.309*
Constant	28.862 **	38.277 **	32.536 **	33.971 **	46.047 **	24.817 **	32.157	30.773 *	26.889 **	7.738	44.672
	14.173	*16.841*	*15.783*	*17.651*	*22.900*	*12.240*	*13.367*	*16.178*	*12.519*	*16.414*	*28.556*
Number of observations	15,279	15,279	15,279	13,766	15,279	15,279	15,279	15,279	13,766	13,766	15,279

Table reports zero inflated beta regression model results of the first part of estimation: factors driving the choice to participate or not to CCP. Observations are clustered at banking group level (and at bank level for independent banks), thus obtaining heteroskedasticity-robust standard errors and controlling for possible autocorrelations across the same banking group. In the estimation of participation, a positive sign indicates a lower participation (more zeros) and a negative sign a higher participation (less zeros). Table reports regression coefficients and associated standard errors in italics. ***, **, and * denote statistical significance at 1, 5 and 10 % level.

Table 5. Determinants of interbank exposures through CCPs: determinants of the intensity of the recourse to CCPs conditional to participation (the dependent variable is a ratio)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	Marginal effects
Foreign interbank debts	-1.240	-0.879	-1.222		-0.170	0.693	0.814	-1.166			0.463	ns (-2.5)
	1.647	*1.692*	*1.614*		*1.375*	*1.699*	*1.748*	*1.488*			*1.027*	
Delta (foreign interbank debts)				0.377					0.478	1.028		
				1.354					*1.362*	*0.758*		
UNC	1.423	1.864	1.468	1.828 *	0.455	0.370	0.270	0.667	0.278	-0.782	-0.407	ns (5.7)
	1.075	*5.974*	*1.074*	*0.933*	*4.981*	*1.220*	*7.388*	*1.174*	*1.143*	*11.510*	*6.851*	
UNC x crisis 1						0.565	0.434	0.560	0.582	0.320	-0.508	ns (17.9)
						0.486	1.422	0.487	0.472	5.222	1.606	
UNC x crisis 2						0.487 *	0.336	0.534 **	0.510 *	0.218	0.188	15.3
						0.296	*1.697*	*0.213*	*0.290*	*5.604*	*1.874*	
ICC	0.013	0.017		-0.012		-3.175 ***	-2.847 ***		-2.939 ***	-2.133 **		-14.5
	0.303	*0.331*		*0.287*		*0.913*	*0.772*		*0.945*	*0.955*		
ICC x crisis 1						3.128 ***	2.683 ***		2.873 ***	2.047 **		13.9
						0.758	*0.658*		*0.836*	*0.976*		
ICC x crisis 2						3.423 ***	3.131 ***		3.188 ***	2.441 **		15.8
						0.952	*0.835*		*1.031*	*1.005*		
IRD	0.112		0.113	0.104		0.212		-0.226	0.226			ns (1.8)
	0.098		*0.099*	*0.102*		*0.235*		*0.288*	*0.253*			
IRD x crisis 1						0.024		0.493	0.012			ns (3.0)
						0.271		*0.318*	*0.286*			
IRD x crisis 2						-0.170		0.279	-0.182			ns (-1.4)
						0.260		*0.313*	*0.275*			
Betweeness centrality					*-0.230*						*0.195* ***	
					0.444						*0.075*	
Betweeness centrality x crisis 1											*-0.139* **	
											0.068	
Betweeness centrality x crisis 2											*-0.322* ***	
											0.076	
Bad loans	15.394 ***	16.063 ***	15.398 ***	15.444 ***	-4.830 **	-6.258	-2.149	-5.733	-6.315	-16.191	-4.410	ns (-3.0)
	3.515	*3.361*	*3.598*	*3.457*	*2.158*	*10.723*	*9.875*	*10.684*	*10.674*	*10.377*	*10.878*	
Bad loans x crisis 1						14.540 *	12.668 *	14.819 **	14.561 *	21.141 **	14.506 **	6.7
						7.940	*7.477*	*7.293*	*7.939*	*8.589*	*7.373*	
Bad loans x crisis 2						19.697 **	17.805 **	18.957 **	19.767 **	28.272 ***	18.435 **	9.0
						9.758	*8.896*	*9.501*	*9.681*	*9.692*	*7.457*	
Size	-0.541	-0.582	-0.552	-0.689 *	8.143 *	-0.232	-0.219	-0.354	-0.207	0.061	-0.028	ns (-4.2)
	0.578	*0.564*	*0.565*	*0.411*	*4.613*	*0.654*	*0.591*	*0.676*	*0.581*	*0.620*	*0.515*	
Retail Fundsraising	0.016	0.086	0.020	0.081	5.450 ***	0.223	0.279	0.193	0.222	-0.106	6.465 ***	ns (6.3)
	0.920	*0.832*	*0.930*	*0.947*	*1.133*	*0.941*	*0.877*	*0.945*	*0.930*	*0.927*	*1.195*	
Loans to Private Sector	-1.252	-1.342	-1.269	-1.680	3.150	0.100	0.101	-0.119	0.217	0.357	-5.034 ***	ns (3.5)
	2.215	*2.173*	*2.210*	*1.821*	*2.525*	*2.271*	*2.151*	*2.446*	*2.090*	*2.166*	*1.616*	
Central Bank loans	1.114	1.349	1.120	1.053	-0.008	1.342	1.683	1.194	1.382	1.584	4.772 **	ns (1.0)
	1.729	*1.793*	*1.727*	*1.672*	*0.062*	*1.580*	*1.688*	*1.678*	*1.597*	*1.602*	*2.186*	
Portfolio of Government Bonds	5.954 ***	5.916 ***	5.968 ***	6.097 ***	2.543 **	6.325 ***	6.238 ***	6.179 ***	6.284 ***	6.303 ***	1.521 *	5.6
	1.349	*1.403*	*1.271*	*1.339*	*1.055*	*1.333*	*1.405*	*1.247*	*1.303*	*1.505*	*0.828*	
ROE	0.016	0.044	0.018	0.016	-0.060	0.193	0.193	0.236	0.199	0.168	-0.088	ns (1.9)
	0.380	*0.404*	*0.360*	*0.383*	*0.376*	*0.357*	*0.369*	*0.351*	*0.359*	*0.341*	*0.366*	
Constant	1.811	1.084	1.933	3.521	-5.150 ***	-0.606	-0.565	0.470	-0.925	-1.965	-5.150 ***	
	7.041	*0.754*	*6.910*	*4.926*	*0.755*	*7.688*	*0.754*	*8.049*	*6.853*	*1.754*	*0.755*	
Number of observations	15,279	15,279	15,279	13,766	15,279	15,279	15,279	15,279	13,766	13,766	15,279	

Table reports zero inflated beta regression model results of the second part of estimation: factors influencing the intensity of the recourse to the CCPs, conditional on being a member. Observations are clustered at banking group level (and at bank level for independent banks), thus obtaining heteroskedasticity-robust standard errors and controlling for possible autocorrelations across the same banking group. Table reports regression coefficients, associated standard errors in italics, and marginal effects. ***, **, and * denote statistical significance at 1, 5 and 10 % level. The marginal effect of each determinant is computed for specifications 6 measuring the percentage change of the dependent variable (the share of CCP exposures on total interbank exposures) moving from the 25th to the 75th percentile of each regressor. Outcomes are very similar in the other specifications.

Table 6. Determinants of Δ(interbank exposures through CCPs)

	(1)	(2)	(3)	(4)	(5)	(6)
Foreign interbank debts	0.010	0.012	0.015	0.016	0.017	0.023
	0.043	*0.043*	*0.043*	*0.043*	*0.044*	*0.040*
UNC	-0.004	-0.003	-0.004	-0.004	-0.009	0.024
	0.006	*0.006*	*0.006*	*0.006*	*0.008*	*0.018*
Size	0.031 ***	0.030 ***	0.031 ***	0.031 ***	0.029 ***	0.017 **
	0.009	*0.009*	*0.009*	*0.009*	*0.009*	*0.008*
Retail Fundsraising	0.056	0.055	0.056	0.057	0.062	0.038
	0.086	*0.085*	*0.086*	*0.085*	*0.086*	*0.081*
Loans to Private Sector	0.003	-0.004	0.003	0.001	-0.004	-0.028
	0.040	*0.040*	*0.040*	*0.040*	*0.040*	*0.043*
Central Bank loans	0.041	0.041	0.041	0.042	0.022	-0.009
	0.086	*0.084*	*0.085*	*0.085*	*0.083*	*0.084*
Portfolio of Government Bonds	0.352 ***	0.345 ***	0.349 ***	0.349 ***	0.336 ***	0.378 ***
	0.129	*0.127*	*0.129*	*0.128*	*0.127*	*0.135*
ROE	-0.018	-0.017	-0.018	-0.018	-0.013	-0.016
	0.013	*0.013*	*0.013*	*0.013*	*0.013*	*0.012*
Δ(IRD)	-0.004 **	0.002	-0.001	-0.001	0.002	0.003
	0.002	*0.002*	*0.003*	*0.003*	*0.003*	*0.003*
Δ(IRD) x crisi 1		*-0.004* *			*0.001*	*-0.001*
		0.002			*0.002*	*0.002*
Δ(IRD) x crisi 2		*-0.017* **			*-0.003*	*-0.007* *
		0.007			*0.003*	*0.004*
Bad loans	0.316	0.302	0.336	0.348	-0.039	Inluded as deciles, and unreported. See the note under the table.
	0.243	*0.242*	*0.244*	*0.244*	*0.252*	
Bad loans x crisi 1					*0.253*	
					0.185	
Bad loans x crisi 2					*0.486* *	
					0.288	
Δ(IRD) x Bad loans			*-0.162* *	*0.029*		
			0.085	*0.085*		
Δ(IRD) x Bad loans x crisi 1				*-0.162* *		
				0.084		
Δ(IRD) x Bad loans x crisi 2				*-0.335* **		
				0.159		
Δ(IRD) x Bad loans (2° quartile) x crisi 1					-0.004	
					0.007	
Δ(IRD) x Bad loans (2° quartile) x crisi 2					-0.024	
					0.021	
Δ(IRD) x Bad loans (3° quartile) x crisi 1					-0.002	
					0.005	
Δ(IRD) x Bad loans (3° quartile) x crisi 2					-0.016	
					0.013	
Δ(IRD) x Bad loans (4° quartile) x crisi 1					-0.012 *	
					0.006	
Δ(IRD) x Bad loans (4° quartile) x crisi 2					-0.021 *	
					0.012	
Δ(IRD) x Bad loans (7° decile) x crisi 1						0.002
						0.005
Δ(IRD) x Bad loans (7° decile) x crisi 2						0.006
						0.007
Δ(IRD) x Bad loans (8° decile) x crisi 1						0.011
						0.007
Δ(IRD) x Bad loans (8° decile) x crisi 2						*-0.027*
						0.037
Δ(IRD) x Bad loans (9° decile) x crisi 1						*-0.024* **
						0.011
Δ(IRD) x Bad loans (9° decile) x crisi 2						-0.004
						0.008
Δ(IRD) x Bad loans (10° decile) x crisi 1						*-0.017* **
						0.008
Δ(IRD) x Bad loans (10° decile) x crisi 2						*-0.032* *
						0.016
Constant	-0.287 ***	-0.278 ***	-0.287 ***	-0.289 ***	*-0.266* ***	*-0.160* **
	0.075	*0.072*	*0.074*	*0.074*	*0.075*	*0.069*
Rho	0.37	0.36	0.37	0.38	0.35	0.32
Number of observations	11,008	11,008	11,008	11,008	11,008	11,008

Table reports fixed effects panel results, where fixed effects are for banks; time fixed effects also are always included. Observations are clustered at banking group level (and at bank level for independent banks), thus obtaining heteroskedasticity-robust standard errors and controlling for possible autocorrelations across the same banking group. Partial interaction terms are always included even if unreported; in specification (6), the other deciles' results are not reported. Table reports regression coefficients and associated standard errors in italics. ***, **, and * denote statistical significance at 1, 5 and 10 % level.

Table 7. Robustness checks. Determinants of interbank exposures through CCPs: determinants of *participation* to CCPs (the dependent variable is a dummy 0,1) and intensity of the recourse to CCPs conditional to participation (the dependent variable is a ratio)

	participation				intensity			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	using CISS instead of the ratio of densities as a measure of uncertainty		dropping time fixed effects		using CISS instead of the ratio of densities as a measure of uncertainty		dropping time fixed effects	
Foreign interbank debts	26.925 ***	28.246 ***	26.111 **	20.682 ***	0.383	0.688	-6.184 ***	0.458
	9.241	*8.258*	*11.354*	*7.482*	*1.353*	*1.699*	*2.377*	*1.531*
UNC	16.825 ***	12.989	1.034 *	2.674 *	5.080 ***	0.733	0.206	-0.046
	3.449	*8.493*	*0.522*	*1.370*	*1.481*	*0.830*	*0.245*	*0.372*
UNC x crisis 1		-8.876 ***		1.019		1.334		0.620 *
		2.936		*1.296*		*1.620*		*0.367*
UNC x crisis 2		-17.161 *		-2.565 *		1.781 *		0.849 **
		8.928		*1.376*		*1.003*		*0.360*
ICC	4.090 **	8.049 ***	1.336	8.688 ***	-0.012	-3.179 ***	0.286	-4.337 **
	1.701	*2.528*	*1.094*	*3.303*	*0.287*	*0.913*	*0.389*	*1.698*
ICC x crisis 1		-5.572 **		-8.310 ***		3.134 ***		5.189 ***
		2.407		*3.112*		*0.758*		*1.617*
ICC x crisis 2		-5.538 **		-7.225 **		3.428 ***		4.622 ***
		2.725		*3.050*		*0.952*		*1.655*
IRD	0.180	0.552	0.256	0.419	0.104	0.210	0.017	0.161
	0.178	*0.556*	*0.171*	*0.570*	*0.102*	*0.235*	*0.100*	*0.329*
IRD x crisis 1		-0.430		-0.236		0.026		-0.006
		0.789		*0.729*		*0.271*		*0.348*
IRD x crisis 2		-0.477		-0.149		-0.168		-0.099
		0.599		*0.594*		*0.260*		*0.367*
Bad loans	-5.389	-74.071 **	-54.600 ***	-83.642 ***	15.452 ***	-6.302	19.071 ***	-5.593
	15.186	*30.875*	*10.702*	*27.304*	*3.460*	*10.735*	*5.088*	*8.889*
Bad loans x crisis 1		*76.260* ***		*11.408*		*14.578* *		*20.174* **
		27.455		*22.088*		*7.945*		*7.919*
Bad loans x crisis 2		*87.526* ***		*51.961* **		*19.745* **		*21.031* ***
		31.572		*25.883*		*9.765*		*7.705*
Size	*-3.015* **	*-2.328* **	*-4.688* ***	*-4.861* ***	*-0.681* *	*-0.224*	*-0.443* **	*0.867*
	1.490	*0.918*	*1.086*	*1.262*	*0.412*	*0.654*	*0.500*	*0.720*
Retail Fundsraising	-8.542 **	-6.656 **	-10.097 ***	-9.872 ***	0.081	0.222	-0.120	0.392
	3.584	*3.361*	*3.486*	*3.535*	*0.947*	*0.941*	*1.523*	*1.134*
Loans to Private Sector	8.219 *	11.764 ***	-3.952	-2.755	-1.665	0.118	1.949	2.841 *
	4.850	*4.467*	*3.088*	*3.229*	*1.825*	*2.271*	*1.330*	*1.460*
Central Bank loans	5.497	5.766	-7.237	-2.283	1.046	1.338	0.512	0.179
	9.865	*9.803*	*6.292*	*6.697*	*1.673*	*1.581*	*1.905*	*1.784*
Portfolio of Government Bonds	-1.775	-0.881	-5.702	-5.435	6.091 ***	6.320 ***	5.808	4.432 ***
	6.179	*5.633*	*4.631*	*4.276*	*1.340*	*1.333*	*2.461*	*1.556*
ROE	0.859	0.283	0.469	0.816	0.015	0.193	0.114	0.160
	1.153	*1.272*	*1.163*	*0.928*	*0.384*	*0.357*	*0.381*	*0.357*
Constant	33.507 *	24.077 *	63.927 ***	63.451 ***	3.399	-0.681	-9.789	-13.724
	17.809	*12.288*	*13.119*	*16.436*	*5.028*	*7.917*	*6.622*	*8.866*
Number of observations	15,279	15,279	15,279	15,279	15,279	15,279	15,279	15,279

Table reports some robustness checks on the first step of our analysis. Specifications (1) and (3) replicate with changes specification (1) of Tables 4 and 5; while specifications (2) and (4)) replicate with changes specification (6) of Tables 4 and 5. Estimation results are zero inflated beta regression model results of both first and second part of estimation (i.e., factors driving the choice to participate or not to CCP and factors influencing the intensity of the recourse conditional on being a member). Observations are clustered at banking group level (and at bank level for independent banks), thus obtaining heteroskedasticity-robust standard errors and controlling for possible autocorrelations across the same banking group. Table reports regression coefficients and associated standard errors in italics. In the estimation of participation, a positive sign indicates a lower participation (more zeros) and a negative sign a higher participation (less zeros). ***, **, and * denote statistical significance at 1, 5 and 10 % level.

Table 8. Robustness checks. Determinants of Δ(interbank exposures through CCPs)

	(1)	(2)	(3)	(4)	(5)	(6)
	using CISS instead of the ratio of densities as a measure of uncertainty	dropping time fixed effects			IV estimations	
Foreign interbank debts	0.010	-0.001	0.000	0.000	0.013	0.029
	0.043	*0.042*	*0.044*	*0.042*	*0.042*	*0.054*
UNC	-0.007	-0.003	-0.005	-0.001	0.343	0.330
	0.009	*0.008*	*0.010*	*0.007*	*1.116*	*1.119*
Size	0.031 ***	0.032 ***	0.033 ***	0.032 ***	0.030 ***	0.029 ***
	0.009	*0.010*	*0.010*	*0.009*	*0.009*	*0.009*
Retail Fundsraising	0.056	0.068	0.067	0.067	0.054	0.061
	0.086	*0.085*	*0.097*	*0.085*	*0.085*	*0.088*
Loans to Private Sector	0.003	0.030	0.024	0.027	0.000	-0.001
	0.040	*0.037*	*0.037*	*0.037*	*0.040*	*0.040*
Central Bank loans	0.041	0.039	0.008	0.046	0.043	0.047
	0.086	*0.080*	*0.079*	*0.079*	*0.086*	*0.085*
Portfolio of Government Bonds	0.352 ***	0.362 ***	0.334 ***	0.359 ***	0.353 ***	0.351 ***
	0.129	*0.121*	*0.113*	*0.119*	*0.129*	*0.129*
ROE	-0.018	-0.019	-0.017 *	-0.017	-0.018	-0.018
	0.013	*0.012*	*0.011*	*0.011*	*0.013*	*0.013*
Δ(IRD)	-0.004 **	-0.004 **	0.002	0.002	-0.004 **	-0.004 **
	0.002	*0.002*	*0.002*	*0.003*	*0.002*	*0.002*
Δ(IRD) x crisi 1			-0.003	0.002		
			0.002	*0.002*		
Δ(IRD) x crisi 2			-0.017 ***	-0.008 *		
			0.006	*0.004*		
Bad loans	0.316	0.451 **	0.459 **	Inluded as deciles, and unreported.	0.270	0.308
	0.243	*0.223*	*0.221*		*0.270*	*0.237*
Δ(IRD) x Bad loans (7° decile) x crisi 1				0.000		
				0.005		
Δ(IRD) x Bad loans (7° decile) x crisi 2				0.006		
				0.007		
Δ(IRD) x Bad loans (8° decile) x crisi 1				0.006		
				0.005		
Δ(IRD) x Bad loans (8° decile) x crisi 2				-0.034		
				0.036		
Δ(IRD) x Bad loans (9° decile) x crisi 1				-0.025 **		
				0.012		
Δ(IRD) x Bad loans (9° decile) x crisi 2				-0.002		
				0.009		
Δ(IRD) x Bad loans (10° decile) x crisi 1				-0.018 **		
				0.008		
Δ(IRD) x Bad loans (10° decile) x crisi 2				-0.031 **		
				0.017		
Constant	-0.288	-0.323 ***	-0.294 **	-0.322 ***	-0.512	-0.507
	0.075	*0.083*	*0.102*	*0.081*	*0.804*	*0.803*
Rho	0.37	0.41	0.38	0.42	0.35	0.35
F test (first stage)					19.48	22.45
Number of observations	11,008	11,008	11,008	11,008	11,008	11,008

Table reports some robustness checks on the second step of our analysis. Specifications (1), (2), (5) and (6) replicate with changes specification (1) of Table 6; specification (3) replicates with changes specification (2) of Table 6; while specification (4) replicates with changes specification (6) of Table 6. In specifications (1)-(4), Table reports fixed effects panel results in where fixed effects are for banks; time fixed effects are included unless it is indicated differently. In specifications (5)-(6) Table reports IV estimation results alternating instrumental variables. Observations are clustered at banking group level (and at bank level for independent banks), thus obtaining heteroskedasticity-robust standard errors and controlling for possible autocorrelations across the same banking group. Partial interaction terms are always included even if unreported; in specification (4), the other deciles' results are not reported. Table reports regression coefficients and associated standard errors in italics. ***, **, and * denote statistical significance at 1, 5 and 10 % level.

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