Always Look on the Bright Side? Central Counterparties and Interbank Markets during the Financial Crisis*

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This paper joins the literature on the growing use of central counterparties (CCPs) in interbank markets by analyzing a scarcely explored source of risk, namely that CCPs may provide riskier banks that are cut off from the bilateral segment of the market with an alternative channel to access interbank funds, thereby eluding peer monitoring and potentially increasing the risks borne by the financial system. We investigate this issue using monthly granular data on Italian banks from June 2004 to June 2013 and we 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 the heightened attention to counterparty risk in the bilateral segment of the market. More tellingly, we show that, *for riskier banks only*, this increase was associated with a decline in the *duration* of bilateral relationships, indicating that longer-standing counterparties, typically those with more information, tended to withdraw from relationships with those banks. This suggests that during our sample period the pool of banks operating via CCPs may have become riskier, confirming, from a novel perspective, the importance of the policy efforts to ensure that CCPs have a proper risk-management framework.

JEL Codes: G01, G21, G23.

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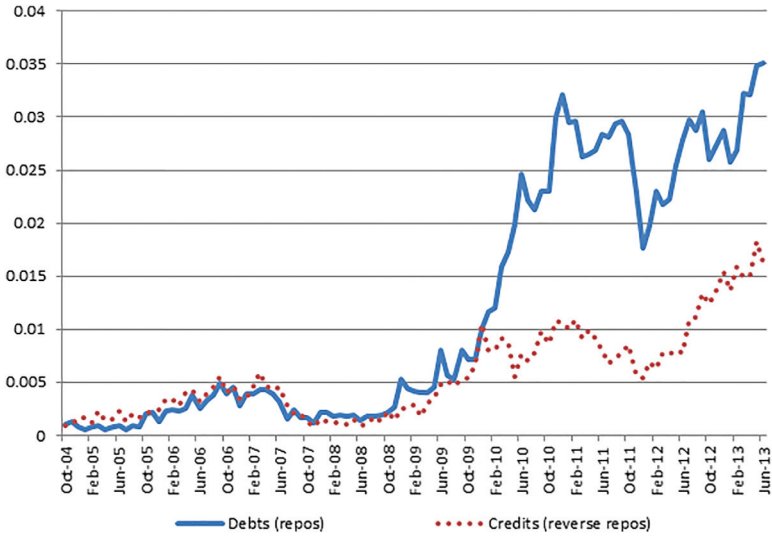
1. Introduction

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., Allen, Carletti, and Gale 2009; Brunnermeier 2009; Taylor and Williams 2009; Freixas, Martin, and Skeie 2011; Garcia-de-Andoain et al. 2016). In some countries, interbank activity did not freeze but showed, however, a remarkable change in its characteristics with a significant surge in secured lending, notably via central clearing counterparties (CCPs). While in the traditional interbank market transactions occur between pairs of banks (*bilateral* interbank market), may be secured or unsecured, and are nominative, in interbank transactions via CCPs lending and borrowing banks are no longer direct counterparties to each other, but all of them have the CCP as their counterparty. Moreover, exposures are secured (because they take place as repurchase agreements) and, at least in the European interbank market, anonymous (Mancini, Ranaldo, and Wrampelmeyer 2016).[1] CCPs are therefore third parties that stand between banks for the purpose of mitigating counterparty credit risk: according to some views, this transfer of counterparty risk to CCPs is precisely what makes acceptable the anonymity of (ultimate) counterparties which, in turn, allows for expanding the set of possible trades.[2]

[1] A CCP can be generally defined as an entity that interposes itself between (two or more) counterparties, becoming the buyer to every seller and the seller to every buyer. While in the bilateral transactions of interbank markets there is one contract, in the transactions involving a CCP there are more contracts: one between the buyer and the CCP and another one between the seller and the CCP. The CCP transforms the risk exposure among interbank counterparties into a risk exposure of each counterparty with the CCP. While repo activity via CCPs is in principle not limited to banks, in Europe, during our sample period "practically all counterparties involved in repos via CCPs have been euro area MFIs or non-euro area residents" (European Central Bank 2012). Note also that non-euro-area residents were basically banks, at least in the Italian case. This continued to be the case also in more recent periods.

[2] The reduction of counterparty risk in transactions via CCPs occurs through loss mutualization, high levels of collateralization, and multilateral netting. To manage the risk borne by the CCPs, members post initial margins and make contributions to the CCPs' default fund. CCPs are active in several markets in addition to repo transactions, notably in derivative markets. CCPs' functions for

Figure 1. Interbank Exposures through CCPs as Shares of Total Assets

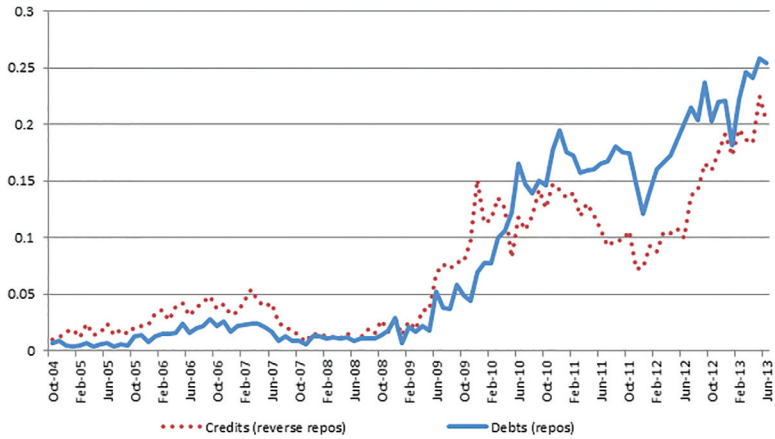


Source: Authors' computations on Bank of Italy prudential supervisory reports.

In Italy domestic banks stepped up their interbank funding via CCPs in a striking way since 2009, just after a key event of the global crisis (the Lehman Brothers default), 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 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 during the crisis (Banca d'Italia 2013a, 2013b; International Monetary Fund 2013, Garcia-de-Andoain et al. 2016).

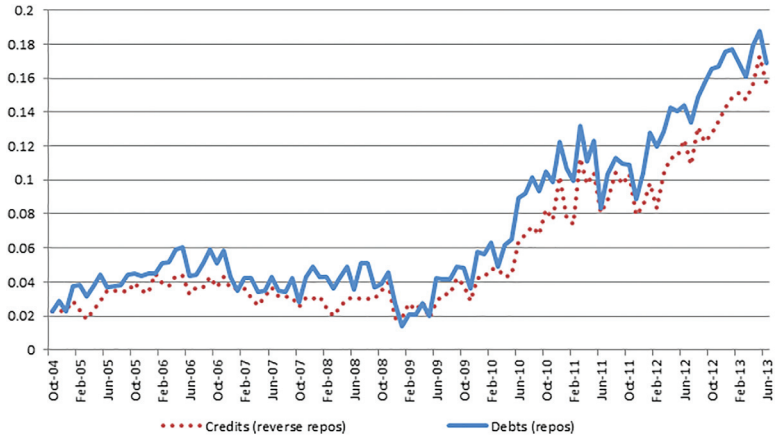
derivatives and for wholesale short-term funding present relevant differences and serve different economic purposes, as the former pursues a goal of insurance and the latter pursues a goal of funding. More institutional details are provided in section 2.

Figure 2. Interbank Exposures through CCPs as Shares of Total Extragroup Interbank Exposures



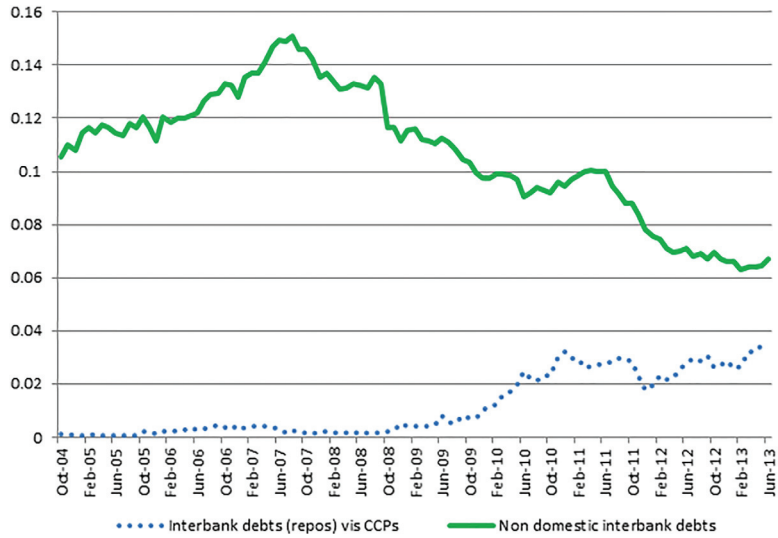
Source: Authors' computations on Bank of Italy prudential supervisory reports.

Figure 3. Number of Banks Operating via CCPs as a Share of the Total Number of Banks Operating in the (extragroup) 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.

The Italian experience seems to lend support to the thesis that "jurisdictions that had CCPs for their repo markets in place before the crisis were relatively less affected than those that did not" (Chatterjee, Embree, and Youngman 2012). A number of papers (e.g., Cappelletti et al. 2011; Heider, Hoerova, and Holthausen 2015; Mancini, Ranaldo, and Wrampelmeyer 2016; Cappelletti and Guazzarotti 2017) refer to the benefits that a CCP may bring to the functioning of interbank transactions in periods of turmoil. A key aspect is that the increasing role of 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.

This larger role, however, may conceal a possible drawback in terms of financial stability, which has been scarcely explored so far. In fact, 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. In this case, the discipline exercised by peer monitoring in the bilateral interbank market could be lost, with a potential impact on financial stability.[3]

Investigating the possibility that the CCPs may be taking risks that would not be accepted on the bilateral segment of the market is relevant for three different reasons. First, as mentioned, it is important to analyze if the risk borne by the financial system may increase unintendedly, ceteris paribus, due to weakened peer monitoring. Second, an increase in the risk taken by CCPs may be potentially dangerous in light of their growing importance. Indeed, while the increased role of CCPs facilitates interbank activity and the related benefits, it may also increase the overall risk borne by the financial system, contributing to a general trend toward concentration of risks in CCPs that may turn them into institutions of systemic importance. In the words of policymakers, "CCP's criticality to the overall safety and soundness of the financial system means that authorities must take steps to ensure that CCPs do not themselves become a source of systemic risk" (Basel Committee on Banking Supervision et al. 2017). Third, 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 of sounder participants to centrally clear and potentially encourage a return to bilateral trading, losing the benefits of centrally cleared transactions.

For our analysis, we rely on a granular data set containing monthly data on all banks operating in Italy since 2004, when the Italian CCP started operating on the repo market, up until 2013. In addition to bank balance sheet variables, our data contain information on the identity of the parties and the duration of each interbank bilateral relationship, as customer relationships are quite relevant in the Italian interbank market (Affinito 2012). These data allow us (i) to identify banks that use CCPs, as well as

[3]Similar potential drawbacks of the use of CCPs may be found, for example, in Thompson (2010); Pirrong (2011); Stephens and Thompson (2011); Koeppl (2012); and Biais, Heider, and Hoerova (2013, 2016). Benefits and drawbacks of CCPs according to the literature are reviewed in sections 2 and 3.

when they started to do so; (ii) to connect choices in terms of participation in CCPs and intensity of their use to a large number of bank-specific characteristics and to bilateral interbank relationships; and (iii) to verify how the bilateral relationships were affected by the risk of borrowing banks and how this may have affected the use of CCPs.

Our empirical analysis runs in two steps. In the first step, we study 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.[4] 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 behavior of bilateral interbank counterparts, whether the use of centrally cleared transactions was associated with a loss of their usual interbank bilateral counterparties. In more detail, we examine 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 we test is whether, *for riskier banks*, an increase in the share of CCP transactions is significantly associated with a decrease in the duration of bilateral relationships, while for less risky banks the relationship is positive or nil. The underlying idea is that—due to the informational advantages of long-term relationships compared with short-term ones, a well-established result in the literature (reviewed in section 3)—long-standing counterparts should be more able to discriminate between banks and to preserve bilateral relationships with the less risky ones. This implies that older interbank relationships are affected relatively more than newer ones by bank-specific characteristics and risks.

In other words, for riskier banks (those in the upper deciles of the distribution of our risk indicators), increases in the share of CCP transactions and decreases in the duration of bilateral relationship

[4]The *participation* of riskier banks in 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 in our sample period is mostly explained, however, by the intensive margin.

would be a sign of the drying-up of interbank funding from longer-standing (i.e., 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 could use CCPs to replace newer counterparts that may be less able to recognize the low risk of these banks. This means that a null or positive relationship between increases in CCP use and duration could be expected for less risky banks. Such finding would suggest that the discipline exercised by interbank peer monitoring was in fact relaxed by the availability of anonymous CCP transactions.

Our empirical approach also allows us to disentangle our hypothesis that riskier banks may prefer anonymous trades to elude peer monitoring, with a possible detrimental effect on financial stability, from the alternative hypothesis that the shift to transactions via CCPs is simply driven by the desire to avoid a stigma.[5] In our framework, the latter hypothesis would imply no differential impact on *existing, long-standing* relationships while, to the contrary, in our hypothesis long-standing counterparts would be those better placed to first exercise peer monitoring and refrain from transactions with the riskiest counterparties.

Our results show that different banks may have indeed different motivations behind their recourse to CCPs. We show that, *for riskier banks only*, the increase in the use of CCPs was associated with a decline in the *duration* of bilateral relationships, indicating that longer-standing counterparties, typically those with more information, tended to withdraw from relationships with those riskier banks. This is not the case for less risky banks. The policy implication of our results supports, from a novel perspective, the ongoing effort to ensure that CCPs put in place adequate risk control frameworks, an essential corollary to the growing importance of CCPs promoted by financial reforms in the aftermath of the global financial crisis, with the aim of improving market transparency, mitigating systemic risk, and preventing market abuse (Committee on Payment

[5]This stigma would be related to the fact that, in a period of uncertainty, interbank market participants could identify additional borrowing in that market as a sign of financial difficulties.

and Settlement Systems (CPSS) and International Organization of Securities Commissions (IOSCO) 2012; Committee on Payments and Market Infrastructures (CPMI) and IOSCO 2016; Basel Committee on Banking Supervision et al. 2017).[6]

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 4–7 describe respectively the data, our empirical strategy, the main results, and the robustness checks. Section 8 concludes.

2. Institutional Background

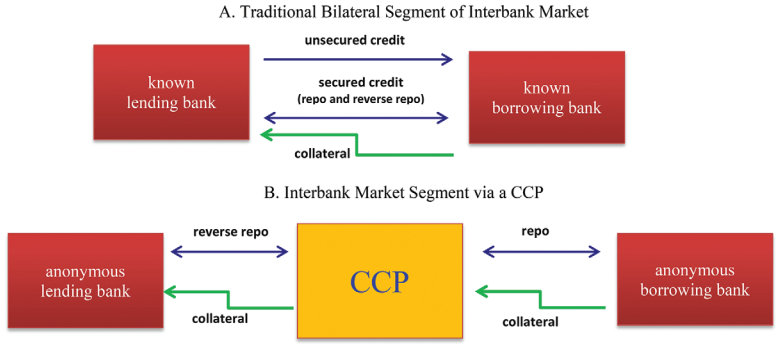
The use of CCPs to clear interbank repurchase agreements has strongly increased since the financial crisis. Repurchase agreements with CCPs quickly became a sizable alternative to bilateral transactions, reaching an outstanding amount of almost 300 billion in the euro area already in July 2012 "as repo operations through CCPs provide better protection against counterparty risk than bilateral repo transactions" (ECB 2012). In addition to reducing counterparty risk, recourse to CCPs may bring several other benefits, including saving collateral, through greater netting efficiency, and promoting transparency.[7]

The typical structure of interbank transactions via CCPs in the euro area can be broadly described as follows (figure 5): (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; and (iii) the CCP acts

[6]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 (FSB, formerly Financial Stability Forum, FSF) in 2008 and the ensuing G-20 commitments in Pittsburgh in 2009 (FSF 2008; FSB 2013). As of mid-2017, 17 of 24 FSB member jurisdictions have a legislative framework in force for mandatory central clearing requirements (FSB 2017).

[7]See, for example, ECB (2007), FSF (2008), Cecchetti, Gyntelberg, and Hollanders (2009), Leitner (2012), Biais, Heider, and Hoerova (2012, 2016), FSB (2013, 2017), Acharya and Bisin (2014), Loon and Zhong (2014), Duffie, Scheicher, and Vuillemey (2015); Baklanova, Dalton, and Tompaidis (2017).

Figure 5. Structure of Two Segments of the Interbank Market: Bilateral and via a CCP



Notes: The figure shows schematically the structure of the 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 secured), and in Europe they are typically 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.

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 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.

[8]If lending and borrowing banks or one of them are not clearing members of the CCPs, 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. For more details, see European Securities and Markets Authority (2017).

In Italy only one central counterparty is authorized: Cassa di compensazione e garanzia S.p.A. (CC&G).[9] Italian intermediaries can however decide to (also) adhere to foreign CCPs, and symmetrically CC&G accepts foreign intermediaries 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.[10] 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.[11]

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

On the other hand, the rising importance of CCPs may be associated with a number of side effects, such as a concentration of

[9] 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.

[10] As mentioned, in the European interbank repo market the majority of repos are traded anonymously via CCPs. Furthermore, the interoperability agreements between the Italian and French CCP imply that parties in the repo transaction may carry out their side of the transaction with a different CCP, adding a further reason why (ultimate) parties in the repos may be unaware of the identity of their counterparties in the transaction and accordingly not exercise any monitoring on them.

[11] For this reason, the ECB decided in 2012 to exclude, retroactively from June 2010, repos with CCPs from the reference monetary aggregate M3, considering de facto this activity as part of the interbank activity.

risks that may assume systemic importance and potential contagion effects (in terms of losses and liquidity shortfalls). Typically, CCPs adopt a multi-level system of safeguards to protect themselves and their members from losses. 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, and it 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 mark-to-market changes in their portfolio. 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 even be marked to market intradaily. CCP risk control usually entails stricter rules on the posting of collateral than those used in bilateral markets.[12] 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 mutualized insurance for uncollateralized 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, 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, 2016).

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

[12]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.

the bilateral world" (Cœure 2014). However, there were also dissenting views, at least in the initial phase of CCPs' activity.[13]

Whatever the judgment about the CCPs' risk control frameworks, as long as the resources provided by the *defaulting member* (either margins or contributions to the default fund) are enough to compensate the lender, centrally cleared transactions are not different in substance from secured bilateral transactions. However, if and once these specific resources are no longer sufficient, the quality of the pool of borrowers starts to matter, and this is what motivates our paper.

3. Related Literature

Our work is related to a wide literature that explores benefits and risks of CCPs, usually in comparison with 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. Biais, Heider, and Hoerova (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. Another benefit pointed by the literature is the saving of collateral: a number of empirical works have assessed

[13]For example, Pirrong (2011) claimed that "CCP margins typically depend on product risk characteristics, rather than the creditworthiness of the clearing member" and that "margins that do not vary meaningfully [. . .] underprice the risks of less creditworthy firms and overprice the risks of more creditworthy firms, which tends to lead the former to trade too much, and the latter too little." Furthermore, he also adds that CCPs "monitor the creditworthiness of their members, but this monitoring is largely based on standards and information (e.g., accounting statements) that do not reflect variations in creditworthiness among members in a discriminating way" and that "the CCP typically does not impose differential capital or margin requirements on members that meet a certain creditworthiness threshold."

changes in collateral demand due to mandatory central clearing (Heller and Vause 2012; Sidanius and Zikes 2012; Duffie, Scheicher, and Vuillemey 2015) and conclude that mandatory central clearing substantially lowers systemwide collateral demand, unless there is significant proliferation of CCPs. According to Cappelletti and Guazzarotti (2017), the benefit of CCPs is that the perception of a substantial stigma effect may lead borrowers to prefer anonymous to transparent markets for interbank transactions: having in place anonymous trades via CCPs could be therefore welfare increasing, as it reduces some harmful effect of imperfect information.

The literature more closely related to our paper, however, 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 the mutualization of losses, that weakens or cancel participants' incentives to find and monitor solid counterparties, in comparison with what happens in the bilateral market. The second type of moral hazard is due to the CCPs themselves, which counting on their systemic relevance (i.e., on being too big or too interconnected to fail) could fail to properly monitor counterparts (Stephens and Thompson 2011; Jones and Perignon 2013; Biais, Heider, and Hoerova 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, Heider, and Hoerova (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 risk-bearing capacity of the CCP. Hansen and Moore (2016) show that mandatory central clearing is welfare improving thanks to the mutualization of counterparty credit risk, but only if initial margin requirements are set optimally, due to the tradeoff between the default insurance that a CCP provides and the incentive for market participants to trade too much when default losses are mutualized through the CCPs' default fund.

Finally, our work relates to the literature on peer monitoring among banks, which points out that interbank borrowing may serve, through peer monitoring, to monitor and discipline borrowing banks. This discipline effect may work through three channels. First, banks are better informed on the standing of their peers than retail depositors and they have more incentives to monitor them, as exemplified by the absence of deposit insurance for interbank deposits. Second, this literature applies to the relationships among banks the same underlying concepts developed in the literature on the relationships between banks and firms. In particular, it shows that a closer relationship among banks allows lending banks to obtain more information about the borrowing bank because it increases lenders' incentives to gather information and monitor borrowers. Third, the interbank funding assumes a disciplining role because, while retail depositors tend to show a high degree of inertia in their behavior, interbank exposures are typically at very short maturities and lending banks may promptly decide not to roll them over. This literature includes both theoretical and empirical works (e.g., Calomiris and Kahn 1991; Rochet and Tirole 1996; Furfine 2001; Huang and Ratnovski 2008; King 2008; Cocco, Gomes, and Martins 2009; Angelini, Nobili, and Picillo 2011; Affinito 2012; Distinguin, Roulet, and Tarazi 2013).[14]

4. Data

Our sample period extends from June 2004, when centrally cleared repo transactions started in Italy, to June 2013. With the exception of the measures of uncertainty and the rating scores, all our data are drawn from the Bank of Italy prudential supervisory reports. These data include granular information on interbank transactions with both domestic and foreign banks. Since liquidity management

[14]Some doubts have been raised (for example, by Duffie 2019) on the effectiveness of market discipline as opposed to the use of a stricter regulation and supervision. We share the view that interbank peer monitoring, like other forms of market discipline, cannot be considered a substitute for effective supervision. Our focus is rather in stressing that peer monitoring may be a (timely) complement to supervision and that eluding it may contribute to create additional financial stability risks. We thank an anonymous referee for helping us to clarify the point.

is typically centralized at the group level, data of intermediaries that are part of a banking group are consolidated at each point in time (considering the group as a single entity) and we do not consider intragroup transactions.[15] This is done for all variables in our data set, and in the paper we refer to both banking groups and stand-alone banks in our sample as "banks."[16] While data were available for each resident bank, 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. Our final sample is an unbalanced panel including about 200 banks on average in each of our 109 monthly periods. The banks in our sample represent on average about 90 percent of the total assets of the Italian banking system along our sample period. Tables 1–3 describe our explanatory variables and provide summary statistics.

We use end-of-month outstanding amounts for all types of interbank exposures. Common to other contributions in the literature (e.g., Furfine 2004, 2009; King 2008; Cocco, Gomes, and Martins 2009; Dinger and von Hagen 2009; Affinito 2013), we do not have data on prices for over-the-counter transactions, which are very relevant in the interbank market. While this is clearly a limit, it is important to remark that, according to the majority of the accounts of developments during the financial crisis, prices were basically moving in response to changes in quantities.[17] The use of end-of-month outstanding amounts is likewise explained by data availability. In

[15]Intragroup transactions tend to fit into a group-specific scheme and are likely to be decided by the parent bank (e.g., Houston, James, and Marcus 1997; de Haas and van Lelyveld 2010). In order to eliminate the intragroup 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 analyzed their effective extragroup relationships in each period.

[16]We consider all *extragroup* secured and unsecured transactions executed both on regulated and over-the-counter markets.

[17]The extreme 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. Also note that even with data on interest rates, it would not be easy to assess 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.

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
UNC_t	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 interbank 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 Fundraising	Total retail deposits and bonds / Total assets	15,279	0.47	0.30	0.00	0.57	1.00
	Central Bank Loans	Total loans from central bank / Total assets	15,279	0.02	0.05	0.00	0.00	0.36
	Tier 1 Capital	Tier 1 / 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***

Notes: 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 greater than zero.

fact, micro bank-by-bank data with the details of our data set do not exist with a 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 toward specific counterparties (Affinito 2012, 2013; Affinito and Pozzolo 2017).

5. 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), since the ultimate lenders are mostly foreign intermediaries.[18]

[18]Based on available evidence, Italian borrowers—and foreign lenders—operating via CCP were both almost exclusively banks, as discussed in section 2.

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
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 Betweenness 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	–0.0064***	–0.3***
Retail Fundraising	0.04***	–0.7***	0.2***	0.0602***	0.1***	0.1***	–0.01	0.03***	0.009
Central Bank Loans	0.1***	–0.1***	0.1***	–0.02	0.2***	0.1***	0.2***	0.1***	–0.1***
Bad Loans	0.1***	–0.3***	0.2***	0.02	0.1***	0.2***	0.1***	0.1***	0.2***
Tier 1 Capital	0.067***	–0.082***	–0.2***	0.1***	–0.1***	–0.2***	–0.1***	–0.2***	–0.3***
ROE	–0.082***	0.2***	–0.002	–0.081	–0.009**	0.01	0.02***	0.089***	0.1***
Rating	–0.1***	0.2***	–0.2***	0.2***	–0.5***	–0.602***	–0.5***	–0.5***	0.069***
Banks without Rating (0–1)	–0.1***	0.2***	–0.2***	0.2***	–0.5***	–0.602***	–0.5***	–0.5***	0.07***
Uncertainty	0.05***	0.01	–0.07*	0.01*	0.0082***	–0.061***	0.04***	–0.02	0.03***

(*continued*)

Table 3. (Continued)

	Portfolio of Government Bonds	Retail Fundraising	Central Bank Loans	Bad Loans	Tier 1 Capital	ROE	Rating	Banks without Rating (0–1)	Uncertainty
Portfolio of Government Bonds	1								
Retail Fundraising	0.3	1							
Central Bank Loans	0.3***	–0.005	1						
Bad Loans	0.1***	0.3***	0.1***	1					
Tier 1 Capital	0.1***	–0.2***	0.04***	–0.1***	1				
ROE	–0.0861***	–0.1***	–0.07***	–0.0882***	–0.2***	1			
Rating	–0.02*	–0.1***	–0.09***	–0.2***	0.1***	–0.005	1		
Bans without Rating (0–1)	–0.01	–0.01***	–0.09***	–0.2***	0.1***	0.0003	0.09***	1	
Uncertainty	0.02	–0.02	0.1***	0.062***	0.05***	–0.09***	0.0669***	0.05***	1

Note: ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively.

5.1 First Step: Determinants of the Use of CCPs

We start by exploring the determinants of the use of centrally cleared transactions through the following equation:

$$\begin{aligned} SH_{jt} = {} & \alpha_0 UNC_t + \beta_0 Risk_{jt} + \gamma_0 Bilateral_{jt} + \alpha_1 UNC_t * CR1_t \\ & + \alpha_2 UNC_t * CR2_t + \beta_1 Risk_{jt} * CR1_t + \beta_2 Risk_{jt} * CR2_t \\ & + \gamma_1 Bilateral_{jt} * CR1_t + \gamma_2 Bilateral_{jt} * CR2_t + \delta' KR_{jt} \\ & + \zeta' b_j + \eta' p_t + \epsilon_{jt}, \end{aligned} \tag{1}$$

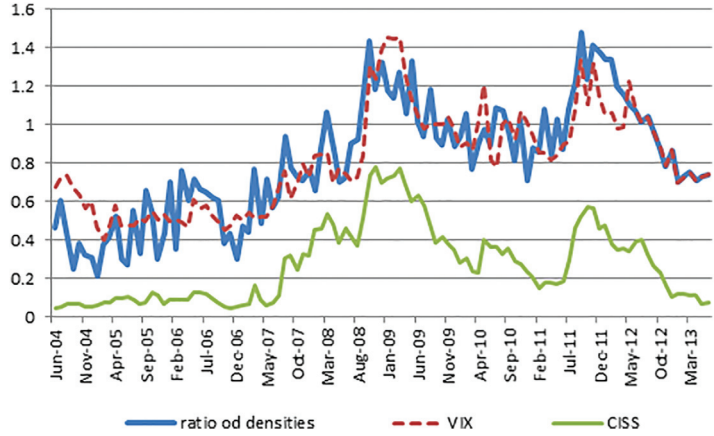
where SH_{jt} is the share of bank borrowing via CCPs over total interbank borrowing (including bilateral transactions, secured and unsecured, domestic and abroad) of bank j at time t, in each month from June 2004 to June 2013.

Explanatory variables are grouped in four categories (table 1), described in more detail below: (i) general market uncertainty and risk aversion (UNC_t); (ii) individual risk of borrowing banks ($Risk_{jt}$); (iii) banks' relationships in the bilateral segment of interbank market ($Bilateral_{jt}$); and (iv) control variables (KR_{jt}). Bank-specific dummies b_j are also included to account for unobservable structural bank characteristics. Time fixed effects p_t and dummies for the crisis periods (CR) are also included.

UNC_t accounts for the role of general market uncertainty and risk aversion, and it is proxied by three different measures, used alternatively for robustness purposes. Our main 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.[19] We also use alternative measures of UNC_t, such as VSTOXX and CISS (figure 6), as described in more detail in the section on robustness checks (section 7).

[19]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.

Figure 6. Alternative Measures of General Market Uncertainty and Risk Aversion



Sources: For the ratio of densities: Jackwerth (2000) and Tarashev, Tsatsaronis, and Karampatos (2003); for VIX: VSTOXX, the index based on Euro Stoxx 50 options prices according to VIX methodology; for CISS: Holló, Kremer, and Lo Duca (2012).

$Risk_{jt}$ represents 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.[20] This variable, while available in the supervisory returns used in this analysis, is not known by counterparties on a continuous-time basis (as it is

[20]According to Italian regulation in force during our sample period, nonperforming loans were classified according to four categories: (i) 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; (ii) substandard loans: exposures to counterparty facing temporary difficulties—defined on the basis of objective factors—expected to be overcome within a reasonable period of time; (iii) 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; (iv) past-due loans: 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, focuses on the most impaired part of the loan portfolio of a bank, and it is computed as the ratio of bad loans over total loans.

usually published only in the financial statements), and it may be influenced by classification policies. However, it generally provides a fair approximation of the actual risk of each bank also considering that for Italian banks, credit risk typically represents 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 the section on robustness checks.

The third set of regressors, $Bilateral_{jt}$, looks at how the situation and the role of each bank in the bilateral segment of the interbank market affects the choice of recurring to CCPs. We include here two subsets of variables. The first subset, $Bilateral\ Relationships_{jt}$, estimates the effect of interbank bilateral customer relationships on the use of CCPs with two alternative variables which take advantage of our granular information on the identity of each counterpart (domestic and foreign) and the related gross bilateral positions and measure respectively the *strength* and *length* of relationships of each bank in the bilateral interbank market.

The first variable, *Interbank Counterparties Concentration*, ICC_{jt}, measures the degree of concentration of bilateral interbank borrowing of a bank j in period t. The second variable, *Interbank Relationship Duration*, IRD_{jt}, measures in each period the weighted average time length of all interbank relationships of each bank and is a weighted average to take into account the size of each exposure in addition to its duration.

The rationale for the two variables is in the vast literature that documents the advantages of relationship lending. According to this literature, a close relationship allows lenders to obtain more information about the borrower because it increases lenders' incentives to gather information and monitor borrowers. Similar arguments may be applied also to the relations between two banks (see, for example, Cocco, Gomes, and Martins 2009; Affinito 2012). Both our measures of the intensity of $Bilateral\ Relationships_{jt}$ are inspired by that literature, which measures the strength of the customer relationships either through the concentration of loans or through their duration.[21]

[21]For example, as far as the variable ICC_{jt} is concerned, Petersen and Rajan (1994) and Angelini, Di Salvo, and Ferri (1998) find that firms with more concentrated borrowing have better access to credit. Gobbi and Sette (2014) show that

ICC_{jt} is computed as a standard Herfindahl index: $ICC_{jt} = \sum_{i=1}^{N} s_{ijt}^2$, 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, provides a measure of the strength of interbank relationships of each bank j: higher values indicate that a bank tends to hold more exclusive relationships with few counterparts.

IRD_{jt} is computed as follows: $IRD_{jt} = \sum_{i=1}^{N} s_{ijt} * d_{ijt}$, 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.[22]

We also include foreign extragroup interbank funding (as a ratio to total interbank funding) as an explanatory variable, as the financial crisis triggered a significant retrenchment of foreign interbank bilateral funding (figure 4).

A second subset of variables, *Bilateral Network Centrality*$_{jt}$, measures the centrality of each bank in the network of bilateral links of the interbank market. We use three standard measures of centrality in the network literature which have been already widely used in

firms with more concentrated borrowing after Lehman's default suffer on average a smaller contraction in bank credit and have a lower probability of being credit rationed. Regarding the variable IRD_{jt}, Bodenhorn (2003) shows that borrowers with longer relations are more likely to have loan terms renegotiated during a credit crunch. Elsas (2005) shows that firms that preserve their relation for a relatively long period face lower financial constraints and experience better credit terms and conditions. Bonaccorsi di Patti and Gobbi (2007) show that longer relationships imply fewer costs and easier sources of finance. Gobbi and Sette (2015) show that the credit growth has been higher after Lehman's default for longer lending relations.

[22]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). 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 to these different specifications. Section 7 provides more details on this point.

the analysis of interbank markets, although mainly to analyze financial contagion. In this literature, 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 subset *Bilateral Network Centrality*$_{jt}$ complements *Bilateral Network Relationships*$_{jt}$ as it captures the role of each bank in the web of the bilateral market, which could be a central one even if the bank does not have concentrated and/or stable bilateral relationships. A bank could, for example, try to establish a ramified interbank network (e.g., by having multiple, albeit occasional, counterparties) precisely because it lacks strong bilateral relationships: the outcome of such a strategy would be precisely a high centrality measure and low ICC_{jt} and IRD_{jt}.

Other important bank-specific covariates are included as control variables in the matrix KR_{jt}. *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. All variables are described in table 1.

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 included, where possible, to take into account the impact of particular events, such as the impact of a change in CCPs' haircuts in November 2011 or the launch of the Long-Term Refinancing

Operations by the ECB, as well as other unobservable time-varying variables.[23]

While our analysis explores the demand (bank) side determinants of CCPs' use, supply factors such as changes in the risk-management policies of the Italian CCP or in its standards and conditions (e.g., fees, margins, collateral requirements) may be very relevant as well. As we have only one CCP operating in Italy, supply-side factors apply to all banks, and therefore either they have the same effect on all banks—and then they may explain a generalized increasing recourse to CCPs, but not a differential use across banks—or they have a different impact on banks but this impact would depend on (heterogeneous) bank characteristics (e.g., a change in CCPs' risk-management policy or collateral requirement can have differential effects on banks' participation due to specific bank riskiness or collateral endowment). In the first case (i.e., in the unlikely case that the effect had the same effects on all banks), supply factors are seized, from an econometric point of view, by the time fixed effects, which capture aggregate fluctuations of the dependent variable over time. In the second case (i.e., when the effect is bank specific), our analysis focusing on the determinants at bank level of the growing use of CCPs should be perfectly able to identify the effect.

We add, however, in some specifications a supply-side variable, $Margins_t$, computed as a monthly average of the margins applied by the CCP to several kinds of securities used as collateral in each month. An increasing value of the variable corresponds to a tightening of supply conditions. In addition to the covariate $Margins_t$, we interact it with each variable measuring banks' characteristics. Should supply-side factors be relevant, these interaction terms would result statistically significant, indicating that banks react heterogeneously to supply changes depending on their characteristics.

To estimate equation (1) we run a zero-inflated beta regression model. The model is made of two steps: in the first step (which explores the determinants of *participation* in CCPs) the dependent

[23]Instead of using time dummies, we also 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, with no significant impact on our results.

variable is a dummy 0,1; in the second step (which investigates the *intensity* of the recourse to CCPs conditional on participation) the dependent variable is a ratio. This model has two specific advantages with respect to alternative specifications, as it allows to take into account that (i) most banks do not use the CCPs for their funding (especially during the first part of the sample period); and (ii) our dependent variable is a ratio (the share of CCP exposures over the total interbank exposures).

The zero-inflated beta regression model aims to address the specification errors arising from (i) modeling a ratio variable as a linear function of the explanatory variables; and (ii) 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, Kieschnick, and McCullough 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. While most of the increase in the use of CCPs is driven in each year by the intensive margin, as expected, the data show 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). It is therefore important to have the possibility to look at both aspects as carefully as possible.[24]

5.2 Second Step: Use of CCPs by Riskier Borrowers

Our second step aims to investigate whether recourse to CCPs allowed riskier banks to elude peer monitoring, 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 with CCPs' share in the overall interbank transactions: a measure is needed to link the risk associated with each bank, as

[24] As a robustness check, we also carried out a standard panel regression for equation (1), obtaining fully consistent results, once the limitations of the panel approach in this specific setting were taken into account.

assessed by its bilateral interbank counterparties, to its recourse to CCPs. To evaluate if CCPs run the risk to fund a pool of borrowers that are shunned by (the most informed among) their bilateral interbank counterparties, we need an indicator able to capture the assessment of these bilateral interbank counterparties.

The measure we propose to summarize the assessment made by interbank peers, as revealed by their behavior, is the *change* in the weighted average duration of each intermediary's interbank relationships IRD_{jt}, where IRD_{jt} is the *Interbank Relationship Duration* for bank j at time t, defined above.

In formal terms, we estimate equation (2) with a fixed-effect panel estimation model:

$$\Delta SH_{jt} = \alpha_0 UNC_t + \beta_0 Risk_{jt} + \gamma_0 \Delta IRD_{jt} + \gamma_1 \Delta IRD_{jt} * Risk_{jt} + \delta' KR_{jt} + \zeta' b_j + \eta' p_t + \epsilon_{jt}, \quad (2)$$

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

As the literature on relationship lending shows that long-lasting partnerships are characterized by better information (see section 3), a positive ΔIRD_{jt} would signal 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. The relationship between changes in the share of funding via CCP and changes in the weighted average duration of bilateral interbank relationships should then have, ceteris paribus, a negative sign for riskier banks if CCP transactions replace older bilateral relationships (as the loss of these relationships shortens the weighted average duration of bilateral transactions). Using this measure addresses possible concerns about the precision and/or the observability by counterparties of the measures of risks used in our first step's regressions and it allows to tackle the issue of whether the CCPs are taking risks that are dodged by bilateral counterparts. Moreover, our measure of "duration" refers to the continuity of the relationship between two interbank counterparties, not to the maturity of the contract: this means that the fact that during the crisis long-term deals became increasingly unlikely makes our measure more able to timely record any change in the assessment

of the standing of a counterparty as shortened maturities implied a more frequent renegotiation of deals.

6. Results

6.1 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* in CCPs (the dependent variable is a dummy 0,1), while table 5 shows those related to the *intensity* of the recourse to CCPs, conditional on participation (the dependent variable is a ratio). It is important to note 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 (fewer zeros).

Starting from the interbank bilateral factors underlying the participation in 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 on the participation in the market (table 5): we find that strong bilateral relationships reduce the intensity of CCP use in normal conditions, but that this association disappeared during the crises.

As for foreign extragroup interbank funding (as a ratio to total interbank funding), we find that it has a negative impact on participation (i.e., banks with higher bilateral funding from abroad were less likely to resort to CCPs; table 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 with a higher use of CCPs.

Results on network indicators show that before the onset of the crisis, a higher centrality in interbank bilateral market favored both participation and intensity of use of CCPs, while during the crisis

Table 4. Determinants of Interbank Exposures through CCPs: Determinants of *Participation* in CCPs (the dependent variable is a dummy 0,1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
												Only Regressor	Interacted with Margins
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***		14.685*	−0.003
				3.241					*3.543*	*4.488*		*7.520*	*0.009*
UNC	3.604**	2.604	4.704*	4.713**	4.324***	3.513	2.983	5.279*	3.954	2.769	4.276	1.246**	
	1.543	*1.826*	*2.614*	*1.831*	*1.390*	*2.877*	*2.371*	*3.180*	*3.034*	*2.065*	*3.221*	*0.580*	
UNC × 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 × 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**		2.331**	0.001
	1.330	*1.410*		*1.701*		*2.525*	*2.714*		*2.531*	*3.170*		*1.189*	*0.001*
ICC × Crisis 1						−5.577**	−5.208**		−5.527**	−5.204*			
						2.402	*2.417*		*2.257*	*3.248*			
ICC × 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			−0.796	0.002
	0.177		*0.161*	*0.178*		*0.556*		*0.355*	*0.613*			*1.268*	*0.002*
IRD × Crisis 1						−0.432		−0.259	−0.505				
						0.789		*0.681*	*0.799*				
IRD × 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 × Crisis 1											0.707***		
											0.207		
Betweeness Centrality × Crisis 2											0.775***		
											0.295		
Margins												0.598	
												1.351	

(*continued*)

Table 4. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
												Only Regressor	Interacted with Margins
Bad Loans	0.121	0.555	1.455	−5.391	−0.116	−74.133**	−55.878*	−40.811**	−88.955**	−83.777**	−40.329*	−37.648	0.037
	16.099	*14.094*	*12.543*	*15.185*	*0.194*	*30.873*	*30.244*	*19.594*	*37.926*	*35.374*	*22.620*	*59.017*	*0.057*
Bad Loans × 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 × 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	1.465	−0.002**
	1.177	*1.358*	*1.347*	*1.490*	*1.698*	*0.920*	*0.998*	*1.324*	*0.893*	*1.325*	*2.213*	*3.863*	*0.001*
Retail Fundraising	−8.753***	−9.549***	−9.505***	−8.542***	−20.609***	−6.666**	−7.713**	−6.755**	−6.511*	−4.651	−18.342***	−23.194***	−0.009
	3.072	*3.179*	*3.434*	*3.584*	*4.917*	*3.363*	*3.274*	*3.416*	*3.827*	*3.644*	*4.547*	*8.149*	*0.008*
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**	20.191***	−0.006
	4.859	*4.929*	*4.716*	*4.850*	*5.327*	*4.464*	*4.812*	*4.635*	*4.168*	*4.430*	*6.649*	*6.999*	*0.009*
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	32.424	−0.055**
	9.806	*9.819*	*9.464*	*9.864*	*9.082*	*9.804*	*9.848*	*9.409*	*9.627*	*9.460*	*9.674*	*24.619*	*0.027*
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	44.872***	−0.052***
	5.479	*5.494*	*4.928*	*6.178*	*5.130*	*5.632*	*5.708*	*6.245*	*6.122*	*5.800*	*6.531*	*15.534*	*0.018*
ROE	0.725	0.705	1.489	0.859	1.449	0.284	0.523	1.357	0.471	−0.202	1.070	−12.528	0.012
	1.250	*1.181*	*1.311*	*1.153*	*0.985*	*1.271*	*1.273*	*1.332*	*1.247*	1.449	*1.309*	*13.232*	*0.019*
Constant	28.862**	38.277**	32.536**	33.971**	46.047**	24.817**	32.157	30.773*	26.889**	7.738	44.672	2.803	
	14.173	*16.841*	*15.783*	*17.651*	*22.900*	*12.240*	*13.367*	*16.178*	*12.519*	*16.414*	*28.556*	*47.040*	
No. of Obs.	15,279	15,279	15,279	13,766	15,279	15,279	15,279	15,279	13,766	13,766	15,279	13,766	

Notes: The table reports zero-inflated beta regression model results of the first part of the estimation: factors driving the choice to participate or not in the funding via CCPs. The results of the second part of the estimation (the intensity of the recourse to CCPs) are reported in table 5. 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 (fewer zeros). The table reports regression coefficients and associated standard errors in italics. ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. Results from specification (12) are reported in two columns even if obtained in a single regression: the first column of specification (12) reports the results of the variable $Margins_t$ in addition to the standalone variables of specification (4); the second column of specification (12) reports the interaction terms between the variable $Margins_t$ and each bank characteristic.

Table 5. Determinants of Interbank Exposures through CCPs: Determinants of the *Intensity* of the Recourse to CCPs (the dependent variable is a ratio)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)		Marginal Effects
												Only Regressor	Interacted with Margins	
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		−3.670***	0.006**	
				1.354					*1.362*	*0.758*		*1.348*	*0.002*	
UNC	1.423	1.864	1.468	1.828*	0.455	0.370	0.270	0.667	0.278	−0.782	−0.407	0.126		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*	*9.513*		
UNC × 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 × 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**		−0.086	0.002	−14.5
	0.303	*0.331*		*0.287*		*0.913*	*0.772*		*0.945*	*0.955*		*0.271*	*0.002*	
ICC × Crisis 1						3.128***	2.683***		2.873***	2.047**				13.9
						0.758	*0.658*		*0.836*	*0.976*				
ICC × 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			0.391	−0.001	ns (1.8)
	0.098		*0.099*	*0.102*		*0.235*		*0.288*	*0.253*			*0.274*	*0.000*	
IRD × Crisis 1						0.024		0.493	0.012					ns (3.0)
						0.271		*0.318*	*0.286*					
IRD × 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 × Crisis 1											*−0.139***			
											0.068			
Betweeness Centrality × Crisis 2											*−0.322****			
											0.076			
Margins												0.047		
												0.325		

(*continued*)

Table 5. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)		Marginal Effects
												Only Regressor	Interacted with Margins	
Bad Loans	15.394***	16.063***	15.398***	15.444***	−4.830**	−6.258	−2.149	−5.733	−6.315	−16.191	−4.410	−32.077*	0.005	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*	*16.594*	*0.018*	
Bad Loans × 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 × 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	0.107	0.000	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*	*0.760*	*0.000*	
Retail Fundraising	0.016	0.086	0.020	0.081	5.450***	0.223	0.279	0.193	0.222	−0.106	6.465***	0.104	0.010**	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*	*2.332*	*0.004*	
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***	−4.046	−0.004	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*	*3.566*	*0.003*	
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**	−2.384	0.007	ns (1.0)
	1.729	*1.793*	*1.727*	*1.672*	*0.062*	*1.580*	*1.688*	*1.698*	*1.597*	*1.602*	*2.186*	*6.061*	*0.008*	
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*	10.711**	−0.015**	5.6
	1.349	*1.403*	*1.271*	*1.339*	*1.055*	*1.333*	*1.405*	*1.247*	*1.303*	*1.505*	*0.828*	*5.459*	*0.007*	
ROE	0.016	0.044	0.018	0.016	−0.060	0.193	0.193	0.236	0.199	0.168	−0.088	−2.526	0.004	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*	*2.073*	*0.003*	
Constant	1.811	1.084	1.933	3.521	−5.150***	−0.606	−0.565	0.470	−0.925	−1.965	−5.150***	−0.147		
	7.041	*0.754*	*6.910*	*4.926*	*0.755*	*7.688*	*0.754*	*8.049*	*6.853*	*1.754*	*0.755*	*0.160*		
No. of Obs.	15,279	15,279	15,279	13,766	15,279	15,279	15,279	15,279	13,766	13,766	15,279	13,766		

Notes: The table reports zero-inflated beta regression model results of the second part of the estimation: factors influencing the intensity of the recourse to the CCPs, conditional on participation. The results of the first part of the estimation (determinants of *participation* in CCPs) are reported in table 4. 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. The table reports regression coefficients, associated standard errors in italics, and marginal effects. ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. Results from specification (12) are reported in two columns even if obtained in a single regression: the first column of specification (12) reports the results of the variable $Margins_t$ in addition to the standalone variables of specification (4); the second column of specification (12) reports the interaction terms between the variable $Margins_t$and each bank characteristic. The marginal effect of each determinant is computed for specification (6) measuring the percentage change of the dependent variable (the share of exposures via CCPs on total interbank exposures) moving from the 25th to the 75th percentile of each regressor. Outcomes are very similar in the other specifications.

banks more central in the bilateral interbank market showed less need to turn to CCPs.[25]

Turning to market uncertainty, we find that it was not a significant factor in driving banks to CCPs until the start of the financial crisis. Then, for both the crisis periods, it became significant and associated with both a larger participation and a larger share of CCPs' transactions, reflecting the general move toward secured transactions at times of heightened risk aversion.[26]

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.[27] Participation of riskier banks in CCPs is more likely before the crisis and becomes instead less likely in both the crisis periods. By contrast, for banks already using CCPs, individual bank risk becomes a significant positive determinant of the proportion of CCPs transactions during the crisis (coefficients are significant in both subperiods, slightly larger during the sovereign debt crisis phase), in line with the hypothesis that a more intense scrutiny took place in other segments of the interbank market.

Table 5 reports the marginal effects of each regressor on the dependent variable, other things being equal.[28] The total net impact of our measures of individual risk and general uncertainty are sizable 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 percent

[25]The results related to the pre-crisis period may reflect the fact that in the infancy of interbank activity on CCPs the banks more active on the interbank market were also experimenting with the new channel while, later on, the two channels may have been substitutes.

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

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

[28]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 specification (6). Outcomes are very similar in the other specifications. Marginal effects on the participation in CCPs (first stage of the zero-inflated beta regression model) are not reported because the dependent variable is a dummy 0,1.

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 percent.

Turning to the other covariates, we find that larger banks tend to participate more in CCPs. The share of centrally cleared transactions is also 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.

To test for the possible influence of supply factors on the use of CCPs, tables 4 and 5 include in specification (12) a supply-side variable, $Margins_t$.[29] In both tables, results from specification (12) are reported in two columns: the first column reports the results of the variable $Margins_t$ in addition to the variables of specification (4); the second column reports the interaction terms between $Margins_t$ and each bank characteristic. The coefficient associated with $Margins_t$ is not statistically significant (first column of specification (12)), while some interaction terms are statistically significant (second column), indicating that supply factors may have different impacts on banks according to their characteristics.[30] The interaction term with the individual risk of a bank is, however, not significant, suggesting that the impact of this variable on the use of CCPs is not channeled via supply factors.

6.2 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. In the second step we focus on the monthly changes of the weighted average duration of the bilateral interbank relationships of each borrowing bank, IRD_{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

[29] As mentioned in section 5, this variable is computed as a monthly average of the margins applied by the CCP to several kinds of securities used as collateral in each month.

[30] This is the case, in particular, for *Size, Retail Fundraising, Foreign Interbank Debts*, and *Portfolio of Government Bonds*.

shut down those with riskier banks. The latter could then be forced to recur to CCPs: accordingly, the relationship between changes in SH_{jt} and IRD_{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 with the interaction terms are negative and significant for the banks belonging to the upper deciles of the risk distribution while positive and/or nonsignificant for the lower deciles.

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) and (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) and (4). Results are supportive of our interpretation of the weighted average duration variable as the relationship between changes in SH_{jt} and IRD_{jt} becomes negative as we move from the lowest to the highest levels of banks' risk. In particular, interacting the changes in the weighted average duration with the deciles of our risk indicator (bad loans ratio), we find that the negative effect is limited to the highest deciles of the distribution by risk (the last two deciles in the first part of the crisis and the last one in the sovereign debt crisis).

For the riskiest borrowers, therefore, the negative and significant sign of the changes in average duration suggests that a relevant determinant 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 with that bank.

7. Robustness Checks

This section summarizes the main robustness checks we carried out.[31]

[31]For the sake of brevity, some checks are not reported in additional tables, but they are all available from the authors. In some of our estimations, the sample may vary due to missing values for some variables or due to the use of $\Delta variables$. As a further check, we restricted all estimations to the largest sample consistent across all specifications, and results remain the same.

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 Fundraising	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) × Crisis 1		−0.004*			*0.001*	−0.001
		0.002			*0.002*	*0.002*
Δ(IRD) × Crisis 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	Included as
	0.243	0.242	*0.344*	*0.244*	*0.252*	deciles, and
Bad Loans × Crisis 1					*0.253*	unreported.
					0.185	See notes at
Bad Loans × Crisis 2					0.486*	bottom of
					0.288	table.
Δ(IRD) × Bad Loans			−0.162*	*0.029*		
			0.085	*0.085*		
Δ(IRD) × Bad Loans × Crisis 1				−0.162*		
				0.084		
Δ(IRD) × Bad Loans × Crisis 2				*−0.335***		
				0.159		

(*continued*)

Table 6. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
Δ(IRD) × Bad Loans (2° Quartile) × Crisis 1					−0.004	
					0.007	
Δ(IRD) × Bad Loans (2° Quartile) × Crisis 2					−0.024	
					0.021	
Δ(IRD) × Bad Loans (3° Quartile) × Crisis 1					−0.002	
					0.005	
Δ(IRD) × Bad Loans (3° Quartile) × Crisis 2					−0.016	
					0.013	
Δ(IRD) × Bad Loans (4° Quartile) × Crisis 1					-0.012^{*}	
					0.006	
Δ(IRD) × Bad Loans (4° Quartile) × Crisis 2					-0.021^{*}	
					0.012	
Δ(IRD) × Bad Loans (7° Decile) × Crisis 1						0.002
						0.005
Δ(IRD) × Bad Loans (7° Decile) × Crisis 2						0.006
						0.007
Δ(IRD) × Bad Loans (8° Decile) × Crisis 1						0.011
						0.007
Δ(IRD) × Bad Loans (8° Decile) × Crisis 2						−0.027
						0.037
Δ(IRD) × Bad Loans (9° Decile) × Crisis 1						-0.024^{**}
						0.011
Δ(IRD) × Bad Loans (9° Decile) × Crisis 2						−0.004
						0.008
Δ(IRD) × Bad Loans (10° Decile) × Crisis 1						-0.017^{**}
						0.008
Δ(IRD) × Bad Loans (10° Decile) × Crisis 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
No. of Obs.	11,008	11,008	11,008	11,008	11,008	11,008

Notes: The 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. The table reports regression coefficients and associated standard errors in italics. ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively.

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 ran our regression with different definitions of the variable UNC_t. A first alternative measure to that presented in section 5.1 directly relies 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 (Holló, Kremer, and Lo Duca 2012).[32] The three measures used were moving in a very similar way during our sample period (figure 6) and results are equivalent. In table 7 (specifications (1) and (2)) 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)) using the CISS index instead of the ratio between the densities: results are unchanged.

As a second way to check the robustness of the variable UNC_t, we either dropped or changed time fixed effects. In tables 4–6 we reported results of equations (1) and (2) that included time fixed effects to allow for all 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 ran the same regressions dropping time fixed effects, and the coefficient associated with the variable UNC_t remained stable: table 7, specification (3) and (4), for the first step; and table 8, specifications (2), (3), and (4), for the second step.[33]

Regulatory Drivers to Use CCPs. An important reason for using CCPs may be the regulatory benefits they provide, as a consequence of the regulatory reforms promoted after the financial crisis.

[32] CISS is computed by applying basic portfolio theory to the aggregation of five market-specific subindexes created from a total of 15 individual financial stress measures. The aggregation accordingly takes into account the time-varying cross-correlations between the sub-indexes. 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.

[33] 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.

Table 7. Robustness Checks: Determinants of *Participation* in CCPs and Intensity of the Recourse to CCPs Conditional on Participation

	Participation (Dep. Variable: 0,1 Dummy)				Intensity (Dep. Variable: Ratio)			
	(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 × Crisis 1		−8.876***		1.019		1.334		0.620*
		2.936		*1.296*		*1.620*		*0.367*
UNC × 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 × Crisis 1		−5.572**		−8.310***		3.134***		5.189***
		2.407		*3.112*		*0.758*		*1.617*
ICC × 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 × Crisis 1		−0.430		−0.236		0.026		−0.006
		0.789		*0.729*		*0.271*		*0.348*
IRD × Crisis 2		−0.477		−0.149		−0.168		−0.099
		0.599		*0.594*		*0.260*		*0.367*

(*continued*)

Table 7. (Continued)

	Participation (Dep. Variable: 0,1 Dummy)				Intensity (Dep. Variable: Ratio)			
	(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	
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 × Crisis 1		*76.260***		*11.408*		14.578*		20.174**
		27.455		*22.088*		*7.945*		*7.919*
Bad Loans × 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 Fundraising	−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	−1.775	−0.881	−5.702	−5.435	6.091***	6.320***	5.808	4.432***
Government Bonds	*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*
No. of Obs.	15,279	15,279	15,279	15,279	15,279	15,279	15,279	15,279

Notes: The 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 the estimation (i.e., factors driving the choice to participate or not in CCP and factors influencing the intensity of the recourse conditional on participation). 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. The 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 (fewer zeros). ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively.

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 Fundraising	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) × Crisis 1			−0.003	0.002		
			0.002	*0.002*		
Δ(IRD) × Crisis 2			−0.017***	−0.008*		
			0.006	*0.004*		
Bad Loans	0.316	0.451**	0.459**	Included as	0.270	0.308
	0.243	*0.223*	*0.221*	deciles, and	*0.270*	*0.237*
				unreported		

(*continued*)

Table 8. (Continued)

	(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**	
Δ(IRD) × Bad Loans (7° Decile) × Crisis 1				0.000		
				0.005		
Δ(IRD) × Bad Loans (7° Decile) × Crisis 2				0.006		
				0.007		
Δ(IRD) × Bad Loans (8° Decile) × Crisis 1				0.006		
				0.005		
Δ(IRD) × Bad Loans (8° Decile) × Crisis 2				−0.034		
				0.036		
Δ(IRD) × Bad Loans (9° Decile) × Crisis 1				−0.025**		
				0.012		
Δ(IRD) × Bad Loans (9° Decile) × Crisis 2				−0.002		
				0.009		
Δ(IRD) × Bad Loans (10° Decile) × Crisis 1				−0.018**		
				0.008		
Δ(IRD) × Bad Loans (10° Decile) × Crisis 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
No. of Obs.	11,008	11,008	11,008	11,008	11,008	11,008

Notes: The 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; and specification (4) replicates with changes specification (6) of table 6. In specifications (1)–(4), the table reports fixed-effects panel results where fixed effects are for banks; time fixed effects are included unless it is indicated differently. In specifications (5)–(6), the 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. The table reports regression coefficients and associated standard errors in italics. ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively.

In particular, using CCPs can significantly reduce the size of the balance sheet items taken into account to compute regulatory requirements (Committee on the Global Financial System 2017). Our analysis is, however, not significantly affected by these requirements, for several reasons.

First, our sample period ends in June 2013 and while the Basel Committee on Banking Supervision mentioned the leverage ratio—the reform more relevant for repos—for the first time in December 2010 (as part of the Basel III package), the related proposal was then revised until January 2014. Moreover, even under the original package, new rules would apply only as from January 2014 (i.e., out of our sample period), with full implementation scheduled on January 2019. Bucalossi and Scalia (2016), indeed, confirm that banks started to adapt to the new requirement only in 2013 and 2014 and that there were no significant impacts on trading volumes on repo markets in the euro area in the period they examined.

To further corroborate our view that regulatory aspects were substantially irrelevant in our sample period, we checked for any evidence of "window-dressing" behavior due to regulation. This behavior would affect differentially both banks and months, as riskier banks would be those having more incentives to window dress and window-dressing would be concentrated at the end of a quarter when prudential requirements are computed. We interacted accordingly variables of banks' riskiness (*Bad Loans* or *Rating*) and bilateral relationship (ICC_{jt} and IRD_{jt}) with the time-dummy variables related to the months that are quarter-ends.[34] We added these interaction terms both in the analysis of the first step (determinants of the use of CCPs) and in the second step (use of CCP by riskier borrowers). In both cases, we found that results remain unaltered, and interacted terms are hardly significant and do not present any systematic patterns. Additionally, the fact that the Tier 1 ratio,[35] included among our independent variables, was not significant suggests that in our sample period regulatory requirements were not a main driver for the use of CCPs.

[34]We thank an anonymous referee for helping us to clarify the point and suggesting the exercise.

[35]The results are not reported in the tables but are available upon request.

Sample Split and Different Starting Dates for the Two Phases of the Financial 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 split repeating the same estimations before and after the onset of each crisis (regressions were run on three subperiods: up to 2008, from 2008 to 2011, and afterward). Results remain equivalent to those obtained with the interaction terms. In addition to time fixed effects, to test the sensitivity of results to different dates and periods, we altered the dating of the two crises with slightly different starting dates, bringing it forward and postponing it by one to four months.

Nonlinear Dynamics. Some of our results could be affected by nonlinear 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 Loans* and its square) remain statistically nonsignificant in the regression explaining participation in 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.

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, we used standard, although not necessarily very powerful, tests such as the Durbin and Wu test and the Hausman test. For both variables, regressors turned out not to be endogenous. Second, we reestimated

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.[36] 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 mentioned, we tested different definitions of our key 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 consider a relationship as ongoing does not lead to differences in our results.

Alternatively to the bad loans ratio, we measured the risk of each bank also with two additional 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.[37] Finally, for the pair of variables *Rating* and *Banks without Rating,* we used an alternative approach avoiding the imposition of a linear structure to the relationship and introducing dummies for each score using the best score as the baseline level.

[36]Following Cocco, Gomes, and Martins (2009) and Affinito (2012), 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 the volatility of balance sheet items measuring banking liquidity. Cocco, Gomes, and Martins (2009) and Affinito (2012) show that this variable matters for the existence and persistence of interbank customer relationships.

[37]The two variables are always included simultaneously in order not to lose observations on nonrated banks while allowing the ad hoc dummy to control for nonrated banks: this setting avoids the score "11" attributed to nonrated banks implying a worse assessment than the score "10" attributed to the riskiest banks receiving a rating (e.g., Angelini, Nobili, and Picillo 2011). Credit scores are taken from Fitch, as Angelini, Nobili, and Picillo (2011) find that Fitch ratings are more informative in the assessment of banks and financial firms. All credit ratings are obtained as a monthly average of the daily overall individual rating.

8. Conclusions

During the global financial crisis Italian banks remarkably increased their use of CCPs for interbank funding, a move that lessened uncertainty and avoided the substantial freezing of the interbank market experienced in other jurisdictions. The growing role of CCPs in interbank market might, however, add a specific risk, namely to allow riskier borrowers to elude peer monitoring, recurring to anonymous transactions via CCPs, and increase the counterparty risk borne by CCPs.

We focused our analysis on this issue, and we find that both uncertainty and banks' risk were significant drivers of the increased recourse to CCPs. Our results further suggest that for the riskiest banks the recourse to the CCPs during the crisis was likely driven by difficulties in borrowing in the bilateral interbank market due to their risk.

Overall, our findings support the policy efforts 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.

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